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International Scientific-Professional Symposium
"Textile Science & Economy"

Book of Proceedings
DIGITAL FASHION

University of Zagreb
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with the theme **"DIGITAL FASHION"**

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the 16th consecutive and the 6th international one with the theme
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Editors note

In 2008, the first scientific and professional conference, *Textile Science and Economy* (cro. TZG), was organized to strengthen cooperation with entrepreneurs, which should lead to the development of new projects and innovative products. Guest industry lecturers participated in and their results were presented at the scientific-professional symposium. Guest industry lecturers also participated in the consultation, and their achievements were presented at the scientific-professional symposium. Over the years, the national symposium has occasionally evolved into an international symposium, the first such event was organized in 2010.

A unique contribution of the conference *Textile Science and Economy* (TZG) is the *Book of Proceedings*, which has peer-reviewed technical and scientific contributions from the field of the respective annual topic. This year, the 16th and sixth *International Conference Textile Science and Economy* (TZG) is dedicated to the theme of 'DIGITAL FASHION' in the atmosphere of new technologies and the ever-increasing debate on the role of artificial intelligence in the market and production. As the Faculty of Textile Technology closely follows the market trends and tries to integrate them into the educational process, this year's conference was organized to gather lecturers with market experience in digital fashion. Their knowledge and observations will help better define the quality of the new study program guidelines. The theme of digital fashion at the conference was presented in the poster section under different aspects of the application of new technologies in design and textile science. At the same time, the abstracts were published in the *Book of Abstracts*.

However, the focal point of the consultation is the *Book of Proceedings*, which contains scientific and professional papers subjected to a double international peer review. Its content is structured around two solid backbones, clearly divided into chapters. The first chapter, *Digital Fashion*, includes fifteen papers: four scientific, four reviews and seven professional; it provides examples of the stages of design, production, ways of archiving, digitization and education in the field of digital fashion. The second chapter, entitled *New Technologies in Fashion and Textile Science*, consists of nineteen contributions, seven scientific, two review and ten expert contributions, dealing with the stages of designing garment solutions, production methods using new technologies and the application of new technologies in dyeing, restoration and textile analysis processes. The result is a *Book of Proceedings* with contributions on interdisciplinary research approaches in the field of fashion and textiles, on which the strategy of the Faculty of Textiles and Technology is based. We hope that the lectures and the scientific and technical work presented will provide new impetus and further develop the degree programs with which the Faculty of Textiles and Technology will respond to the market's needs in the field of digital fashion.

Katarina Nina Simončič and Petra Krpan

In Zagreb, January 22nd 2024

Riječ urednica

Godine 2008. organizirano je prvo po redu znanstveno-stručno savjetovanje *Tekstilna znanost i gospodarstvo* (TZG) s ciljem jačanja suradnje s gospodarstvenicima, a koja bi dovela do razvoja novih projekata i inovativnih proizvoda. Savjetovanje je obuhvatilo gostujuće predavače iz područja gospodarstva čija dostignuća su prezentirana na znanstveno-stručnom simpoziju. Tijekom godina domaći simpozij povremeno je prerastao u međunarodni. Prvi takav organiziran je 2010. godine. Izniman doprinos savjetovanja *Tekstilna znanost i gospodarstvo* (TZG) je i Zbornik recenziranih stručnih i znanstvenih radova, s radovima u području zadane godišnje teme. Ovogodišnje 16. po redu savjetovanje *Tekstilna znanost i gospodarstvo* te šesto međunarodno, u ozračju novih tehnologija i sve intenzivnijeg tržišnog i proizvodnog preispitivanja uloge umjetne inteligencije, posvećeno je temi 'DIGITAL FASHION'. Kako Tekstilno-tehnološki fakultet pažljivo osluškuje tržišne trendove te ih nastoji implementirati u procese obrazovanje, ovogodišnje *Savjetovanje* organizirano je s intencijom okupljanja predavača s tržišnim iskustvom u području digitalne mode. Njihova saznanja i opažanja pomoći će u kvalitetnijem postavljanju novih smjernica studijskih programa. Tema digitalne mode na savjetovanju prezentirana je u i poster sekciji, kroz različite aspekte primjene novih tehnologija u dizajnu i tekstilnoj znanosti, dok su sažeci objavljeni Knjizi sažetaka (*Book of Abstracts*). Ipak, žarišnu točku savjetovanja čini Zbornik sa znanstvenim i stručnim radovima (*Book of Proceedings*) podvrgnutim dvostrukoj međunarodnoj recenziji. Sadržajno uobličen je oko dvije čvrste okosnice, jasno podijeljene poglavljima. Prvo poglavlje *Digital Fashion* obuhvaća petnaest radova, četiri znanstvena, četiri pregledna te sedam stručnih i donosi primjere faza oblikovanja, produkcije, načina arhiviranja, digitalizacije i obrazovanja u području digitalne mode. Drugo poglavlje naziva *New Technologies in Fashion and Textile Science* čini devetnaest radova, sedam znanstvenih, dva pregledna i deset stručnih, koji obrađuju teme faza dizajniranja odjevnih rješenja, zatim načina proizvodnje uz pomoć novih tehnologija te primjenu novih tehnologija u postupcima bojanja, restauriranja i analize tekstila. Rezultat je Zbornik s prikazom interdisciplinarnih pristupa istraživanja područja mode i tekstila, a na kojima se temelji i strategija Tekstilno – tehnološkog fakulteta. Slijedom izloženih predavanja te predstavljenih znanstvenih i stručnih radova, nadamo se novom zamahu i oplemenjivanju ishodišta studijskih programa, a kojima će Tekstilno – tehnološki fakultet odgovoriti na potrebe tržišta u području digitalne mode.

Katarina Nina Simončič i Petra Krpan

U Zagrebu, 22. siječnja 2024. godine

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We want to express our gratitude to our patrons and donation companies, who helped tremendously in organising this year's International Scientific-Professional Symposium, "Textile Science & Economy", in Zagreb on January 26th 2024. Without them, this symposium would not be possible.

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papers

THE TECHNOSPHERE AS POST-DIGITAL FASHION ABOUT CREATIVE BODY DESIGN

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Abstract: *The author derives his statements about the relationship between the technosphere and post-digital fashion by analyzing the philosophical assumptions of the origin and development of artificial intelligence as a condition for the possibility of realizing what he calls creative body design. It is a definition that gives the concept of fashion autonomy and the possibility of distinguishing it not only from other areas of design and contemporary art but also a direction towards the coming future, which assumes the reign of the hyperreal event of technological fetishism. The problem is that contemporary fashion in the post-digital form of appearance finds its space of a performative-conceptual turn of life itself as a total spectacle through the elevation of the narcissistic subject to the highest stage of transgression. The final liberation of fashion from all historical restraints and repressive structures of society, politics, and culture simultaneously opens an uncertain area of overlap between the virtual actualization of life and its artificial staging, as in McQueen's last fashion event Plato's Atlantis.*

Keywords: *technosphere, post-digital fashion, creativity, body design, narcissism, transgression*

1. Introduction

Alcheringa denotes an aboriginal term for what Hesiod in *Theogony* called *the golden age.* Heidegger analyzed the Greek term *arché* reached the so-called first beginning, without which he could not say that metaphysics as nihilism is followed by a future 'second beginning' (*andere Anfang*). (Heidegger, 2005). What does all this tell us but that in both mythic and philosophical narration we have the same thing, namely, the idea of perfection in the newly born, the newly created. Everything after that is doomed. Horace in his *Odes,* Book Six, sang thus: *Aetas parentum worse avis tullit / nos nequiores, mox daturos / progeniem vitiosorem. (Our fathers, worse than our grandfathers, gave birth to us, even more depraved, and we will give birth to an even weaker tribe.)* When we celebrate progress in modern times, then we have only one word that surpasses everything that has ever been in history, and anything else becomes the fruit of silent continuity and even noisy cultural decadence. In my thinking, it is a word that, as of 2023, represents the end of metaphysics as nihilism and the end of history. It is the Great Wall, and, unlike Hegel's speculative-dialectical fortress, the Absolute is no longer the realization of the subjective, objective, and absolute spirit. The t*echnosphere* is the word as a conceptual-performative-installational event of the reign of the visualization of *autopoiesis.* It cannot be reducible only to artificial intelligence but also to artificial intuition, which will inevitably come soon in the era of quantum computers. Instead, *Alcheringa*, there is no doubt, that our age *is the age of silicon* and the end of the Anthropocene, which means that the word is completely inappropriate. To illustrate this, I will use an image from *Plato's Atlantis* fashion show from 2009 at Paris Fashion Week on October 6 as a kind of manifesto of what is stated in the title of my book, namely, *The Posthuman Condition* (Paić, 2011: 367-427).

These are digital cameras on both sides of the so-called catwalks that are like those embarrassing *Aliens* from the films of Ridley Scott, James Cameron, and others, they record everything that happens on the scene in the constant movements of their fluid and moving stands. Without them, there is no possibility of this fascinating performative event, which in the 21st century represents the greatest reach of artistic imagination and vision of the upcoming era. After all, in that essay, using Bataille's concept of transgression and eroticism, I show why fashion as a creative design of the body goes at its end and why McQueen took myth and the apocalypse, *the golden age and the collapse of civilization as the symbolic and cognitive images of his allegory to thematize the corporeal turn*. Once again, in this fashion event, the key thing, to make the paradox complete, is not his design of posthuman bodies with that eccentric fetishism of high-heeled shoes, nor the New Age music of the birth of the first man in the pain and pleasure of the heavenly state, in that fantastic *deep blue* an atmosphere of serpentine bodies in an interweaving of monstrous fear and sublimity. No, the culmination *of Plato's Atlantis* occurs after the end *of Alcheringa*, when everything becomes transparently lit on the stage where the trans-meta-body models from beyond the human are walking. Cameras are the most monstrous thing in general, the completely inhuman and foreign thing in the world as a primordial event of the transgression of death and eroticism as techno-fetishism. These are cyclopean apparatuses or devices of artificial memory, which is the only thing left to us as the last guarantee of the so-called reality that happened, is happening, and will happen

in the coming future like *Plato's Atlantis.* By the way, the philosopher Plato mentions the mythical Atlantis only twice, in the dialogues *Timaeus* and *Critias.* The civilization which, according to the legend, was superior to everything that had ever existed among the Greeks experienced a catastrophe and disappeared into the deep sea. What is more permanent than material monuments can only be an idea, which for Plato means also of divine origin, and that is why it is a condition for the possibility of being. The myth of the golden age designates therefore always a sign of perfection because the world in the age of the first beginning is necessarily an event of the primordial order as the all-encompassing immediacy of life. We know how Nietzsche mocked in his work *Philosophy in the Tragic Age of the Greeks* this apology of mythical calmness, but also the pre-Socratic philosophers and their thoughts of chaos from the cosmological perspective of insight into the magma of battle. What is missing in the mythical story about the perfection of the world is human chaos and passion, what will be from the Legacy of McQueen in the fashion exhibition *Savage Beauty* from 2011 and 2015 to be a kind of testament of Dionysian resistance to this world of post-human homogeneity ruled by the technosphere.

2. Fashion and *Corporeal Turn*

The Golden Age is therefore not the one that once existed in the real history of the world, like our wonderful mystification of the Greeks and the Renaissance. No, the dream of *Alcheringa* always appears at the end of history, when the idea has been realized, and when history itself has become what McQueen's allegory means is the visualization of posthuman bodies moving along the catwalk. This denotes the origin of the thought of *arché* as the saving one. *The connection becomes necessary precisely because the fashion event with McQueen reached the extreme limits of expression and visibility of beauty, death, and apocalypse is nothing more than a philosophical question about the meaning of being and time in an age of radical emptiness and anxious abandonment of the world.* The body cannot be a gap and meaninglessness, but a lived experience of designing existence, because only in the body can we still think and feel humanly; because only in the body do we still die both humanly and inhumanly; because only without a body can there be that thought for which we do not have adequate language because it could be such language from beyond our dreams and visions, a pure sign of a total *anti-Alcheringa.*

The end of metaphysics does not end with modern technology because it denotes only a conditional path from logos to information. Namely, in modern technology, we should consider a reproduction, not a simulacrum. It copies reality as already existing and that is why logos is always technologically determined as a thought about technique at the highest level of abstraction. On the other hand, the technosphere becomes, by analogy, the absolute, but the one of 'immanent transcendence', which means that at the center is the fractalization and contingency of thinking that thinks itself and produces “techno-genetic thought” instead of human thought, because it is a bond of techno-rationality and techno-intuitions. The model for the technosphere cannot be the metaphysical thinking of either a scientist or an artist, but a thinking machine as an artificial brain that in the process of individuation does not enter the body through the process of embodiment-embedment, which requires God or nature, but through the process of embedding and assembling chips and encoding thoughts as an experimental cosmos-techno-genesis of events. In my opinion, the only philosopher who before Deleuze opened this up as a problem of a new ontology was the mathematician and philosopher of science Alfred N. Whitehead with the book *Process and Reality* from 1929. In this sense, he deserves trust for opening the possibility of different philosophical thinking about the hyper-plasticity of the technosphere as an event with which we enter the uncertain field of the end of this cosmic epoch. What is the last word of the “appearance of future philosophy” if not the fundamental event of the openness of one possible and another history that begins 'here' and 'now' as experimental freedom to ask what is thinking at all in the age of absolute visualization and self-production of artificial reality and what is this language at all on which we write what we dream and on which we dream what is beyond every imaginable reality but in itself the event of the creation of this only life, this astonishing singularity which has its meaning in the fact that everything happens simultaneously and differently in the mystery of space-time.

In fragment 178 of his *Book of Disquietude,* the poet inspired by the philosophy of Fernando Pessoa writes:

> *We inhabit dreams, we are shadows wandering through impossible forests in which the trees are houses, customs, ideas, ideals, and philosophies***.**

So, what does mean artificial intelligence? *It is 'what' becomes self-awareness in the process of thinking as machine learning. It is based on Leibniz's idea of infinity, the cybernetic notion of information, autopoiesis, and the infinite speed of heterogeneity of algorithms in the construction of virtual reality*. By analogy with metaphysics, artificial intelligence should be understood as the rise of the natural mind to self-awareness through other technical means (Kurzweil 2000, Bostrom, 2014). These means or instruments, however, are no longer understood within the logic of the principle of reason in the sense of a function for some external or internal purpose. AI ontology, conditionally speaking, assumes the thinking of an “open machine”, one that

thinks of its thought process as a realized synthesis of *noesis* and *noema.* Such an opinion becomes necessarily a new triad of a new absolute and connects calculation-planning-construction in an assembly. Artificial intelligence cannot be a being as in ancient metaphysics. It is an assemblage, and the technosphere is not a being, *einai.* Instead, we should talk about the difference between a state/condition that tends to be posthuman-transhuman and an event as a process of constant heterogeneity (Deleuze, 2011, Paić, 2023b). Metaphysics is truly realized in cybernetics, and the *technosphere* as the realization of the rule of the fourth of information-feedback-control-communication, represents the absolute event of the transformation of the state itself into infinity. Beings can be shared, but states can be creatively and destructively copied because they are not a necessity of being, but a contingency of events, like the Epstein-Barr virus that causes mononucleosis or leukemia depending on the network of triggered causes. Nothing is unidirectional but multidirectional. Besides, everything happens once and irreversibly, and what is repeated cannot be the reproduction of Being in its singularity, but the simulation of the event in its singularity. Disposability designates the life-as-death of the individual, and singularity becomes the technological immortality of superintelligence as an individualized collectivity. The best example of this is seen in the TV series *Star Trek: The New Generation*. It is about the difference between a human, a humanoid robot-android, and the superior technological civilization BORG, which has no awareness of individuation. So, what denotes the technosphere? It is the civilization of the Borgian-oriented artificial self-awareness of Human after loading into the technological singularity that post-i-transhumanists explicitly speak of. So, not the rule of the Super-Ego over the individual, but the rule of *the homo kybernetes* over the Ego of metaphysically understood man (Paić, 2018-2019, Paić, 2002a, Paić, 2023a).

Artificial intelligence means therefore a posthuman condition, not a contingent event. The moment when these two merge in the tendency-latency, the absolute self-awareness of the cosmos-technosphere emerges, which creatively and destructively becomes 'that' which is no longer being, nor beings, nor the essence of Human, nor is it any reduction of the God to the Astro-physically and cosmologically singular One, but the complete openness of autopoiesis as thought and as the event of new creation (Paić, 2002b: 1-36). With artificial intelligence, we are entering the era of creative cosmo-techno-hetero-genesis, and that has nothing to do with metaphysics, cybernetics, or transhumanism. The man played his part, as the young Arthur Rimbaud prophetically sang in the poem *Soleil et char*. With this event, the game itself became the secret of the transition between 'up' and 'down', and this transition is precisely this 'now' and 'here', which happens as the fascination, indifference, and boredom of a completely new experimentum mundi.

My book *Vertigo in Fashion: Towards to the Visual Semiotics of the Body,* has articulated a completely new and different approach to fashion in general from the multitude of sociology and anthropology of fashion and clothing, cultural and visual studies, semiotics of fashion, psychoanalytical and feminist theories of fashion, and even the so-called failed philosophies of fashion (Paić, 2007). After all, in the last fifth volume of *the Technosphere* which deals with the destruction of body ontologies in contemporary times and talks about *design as thinking and autonomous objects and their transformations,* one chapter is expressly dedicated to the phenomenon of contemporary fashion (Paić 2019: 191-219). The main assumption I am advocating remains unchanged to this day. Fashion denotes the creative design of the body, not the dressing of the body by the traditional-modern scheme of the appearance of the body as an image in the mode of mimesis and representation of social class, gender-gender, lifestyle, etc. This is a fundamental-radical turn in the essence of metaphysics as a fundamental thought structure of Western and world history in general, which takes place at the end of the 20th century with the entry into the digital age. Therefore, fashion in the age of the technosphere as a triad of calculating -planning-constructive thinking no longer 'is there', because the concept of fashion as a way of spiritualized life of the body in the meaning of the Italian-French term modus and the meaning of the English term fashion as a sign of belonging to the spirit of the times, the absolute actuality=newness of capitalism has lost its credibility. Neither elite nor mass fashion, nor haute couture and the anti-fashion revolt against the canon of modernity that inaugurated the high criterion of beauty, elegance, and extravagance are no longer terms for contemporary fashion that takes place in the space of absolute virtualization of life as a creative design of the body. Since the 1980s and the style of radical Japanese deconstruction, fashion no longer appears as the so-called real fashion from the streets and edges of the metropolitan underground (Kawamura, 2004). Its true place of representation and appearance lies in the triad of terms of contemporary art such as installation-performatives-conceptuality, and paradigmatic fashion designers of contemporary fashion like McQueen, Galliano, and Chalayan only prove that fashion becomes a research-experimental event of freedom of absolute transparency of the body as a conceptual image.

3. Singularity and Posthuman Body

What makes the difference between my definition of fashion and all the traditional-modern theories of fashion that understand fashion in a non-autonomous, reductive way, mixing the concepts of clothing and fashion, I think that this probably gives fashion legitimacy by including it in the corpus of the so-called of applied arts and

performing its styles from the concept of artistic styles such as surrealism, suprematism, neo-avant-garde deconstruction, etc.? My definition of fashion is not at all a descriptive or analytical analysis of the phenomenon of fashion throughout the history of culture and civilization from prehistory to perhaps neo-gothic punk. Rather, it is about understanding how the 'essence' of what marks a radical change in the understanding of language-image-body lies beyond the metaphysical framework of Western thought. That is why the position on creative body design assumes the absolute autonomy of fashion, which since the 1990s and the entry into the age of the technosphere has become a self-organization of life and a self-production of one's system and environment of society and culture in the figuration of life tables, as the German sociologist Norbert Elias called it in his capital work about the process of civilizing (Elias, 1976). Fashion, therefore, cannot be something already existing in the world that refers to social processes and the creation of new cultural patterns of life. Instead, it should be clearly stated that fashion has become an absolute phenomenon of digital constructivism and that its 'essence' exists in the process of continuous transformation of the identity of all existing social-cultural relations in the global order of capitalism, which is determined by the corporate-informational-cognitive way of interaction between the subjects-actors of the performances, as demonstrated, for example, by Alexandre McQueen's performative events such as *Savage Beauty* and *Plato's Atlantis*. When the creative and liberated body in its transformations, the so-called essentialistically understood identity celebrates the experience of differences and through shock and provocation experiments with what belongs to the idea of existential freedom of the project of one's own life beyond all existing moral and political boundaries, then fashion designates in its essence a triad of *narcissism, transgression, and fetishism* as signs of positive-negative emancipation from all of the model of an unfinished past that returns to the contemporary world of the 21st century through the restoration of the patriarchal order of values and through new forms of political-cultural fundamentalism.

The creative design of the body is not, therefore, any neutral and innocent idea and practice of contemporary fashion life, but rather something that transcends with its radicality all previous politicization and aestheticization of fashion in general. The revolt and engagement of this narcissistic – transgressive-fetish orientation, which shows its own new identity with its own body as a digital image, has by no means disappeared. On the contrary, contemporary fashion bears the burden of this struggle for the freedom of the physical performance of life in public and on stage even more impulsively and extravagantly than it was in the anti-fashion era with Vivienne Westwood’s design, for the simple reason that the 21st century becomes a sign of the pseudo-synthesis and revival of all the dark ideologies of the counter-enlightenment that sought to subjugate and destroy the Other by all means of totalitarian repression. Proof of this condition represents the fashion performance of an experimental design by Iris van Herpen. Therefore, when we talk about digital fashion in a non-problematic way, we always think that fashion from reality has become fashion in virtual reality, as if it is a question of 'relocation' from one Kantian category of modality, such as reality, to another Deleuzian category. virtual actualization and as if this fundamental 'ontological difference' is only external. Well, it's not, neither external nor internal, but rather a fundamental change in the very 'essence' of fashion as such. Why? Digital fashion goes beyond the rootedness and permanence of fashion as a decoration or ornament of a static-dynamic body at the service of what Georg Simmel called as early as 1903 the social form of fashion determined by the framework of capitalist modernization of the world. The same applies to its function in movements of cultural subversion and the rebellion of bodies against systematic repression in the 1960s when anti-fashion movements arose in agreement with countercultures and subcultures in the USA and Western Europe (Paić, 2002c: 1-32). Therefore, digital fashion represents the immersion of the image of the body itself, which no longer displays or represents anything else and does not symbolize anything else outside of fashion itself as an autopoietic logic of self-organization and self-management of life as the existential freedom of an eccentric individual. This is what I call in connection with one notion of Umberto Eco’s theory a *body iconograms* (Paić, 2002c: 52-98).

In the middle exists the event of singularity, which pictorially and textually precedes both reflection and recursion. This should be the point of my divergence with thinking of the contemporary German art philosopher Dieter Mersch, who also says this in the text:

"Creativity and artistic practice have reflexivity as a terminal. The act of ingenuity, the shrewd intuition of the creative impulse, is largely based on the discovery or undiscovered cognitive inhibitions or obstacles that need to be overcome to make room for other thoughts. It is not their novelty that is decisive, but the act of opening. This, however, presupposes 'thinking thoght' which does not end in recursion, but is always threefold completed as object thinking (what), act thinking (that), and thinking mode thinking (how) or *met* '*hodos* and its medium. The interaction and triangulation of these three and the constant shifting and mixing of levels cannot be reconstructed in algorithmic mode. Where thinking breaks with one's own experience, where it abandons its opacity and co-optation in inherent dogma, logic, and mathematics are at a loss" (Mersch, 2023: 251).

The famous "creativity" becomes the most important philosophical mantra of contemporary thinking. Let's be completely honest, the credit for such currentness should be given as recognition to digital constructivism as the thinking of the ontology of becoming and the difference by Gilles Deleuze. His conceptual "creationism" opened the possibility of giving this Heideggerian "dualism" of thinking as calculation (*Rechnen*) and telling (*Dichten*) a completely new meaning by now emphasizing the finding of *an image of thinking* with which concepts are no longer a reflection of reality, but a construction of artificial reality. Mersch, of course, lucidly defends the last stronghold of post-metaphysics, which, in contrast to mathematics and logic, has its justification in what belongs to the realm of irreducible imagination as the central concept of aesthetic thinking. However, a "thinking thought" that can evaluate and judge another thought because it distinguishes good from bad in the ethical-political and aesthetic sense, is not as holy as it seems. In the second volume *of Technosphere* I showed that the artificial brain, through the process of advanced learning in the neurocognitive sense, must necessarily come to the point where, in the difference between program and vision, calculation and planning-construction, through the process of visualizing events, it creates the conditions of possibility for the third thing of thought (Paić, 2018). It will no longer be creativity from the essence of language, but a synthetic construction from the essence of an image. In any case, Mersch made precious philosophical contributions to the debate about art and artificial intelligence, starting from the consideration of language in Heidegger and Wittgenstein. In the book *Ereignis und Aura*, he gave convincing arguments for performative art through syncretism and the difference in the thinking of Heidegger and Benjamin (Mersch, 2002). My intervention in that circle of reflection was already clearly directed from the very beginning of the book *Picture Without a World*, and this meant that the logic of the technosphere draws in and processes both *the event and the aura*, and through the synthetic act of *autopoiesis* creates the possibility that what is the last will finally come into being. the goal of this post-metaphysical history without a first cause and a final purpose (Paić, 2006). It can only be a technological singularity. *Artificial intelligence accelerates its path toward self-awareness by starting from rational intuition and trying to produce algorithms of new creativity, for which the last limit represents the concept of artificial intuition.*

4. Conclusion

Fashion becomes an absolute construction of events within the framework of the creative design of the body at the moment when it no longer has anything to do with the referential framework or shackles of society and culture, and this is also implied for politics, which in the modern and postmodern “age” have reduced it to the non-autonomous and always peripheral and secondary, even blasé and extremely superficial and banal and that time evaporated into the ether like stale air from the Duchamps *bottle dryers.* Digital fashion becomes a corporeal twist in the very essence of the metaphysics of the body, (Kalbaska, Sadaba, Cominelli, Cantoni, 2019) because it is a dematerialized and highly aestheticized assemblage of all possible, real, and necessary interventions 'on' the body, as expressed by David Bowie's 1990 album called truly “uncanny”, namely, *Scary Monster (And Super Creeps)*. Fashion finally becomes complete in its openness simply because it has become what it always aspired to be, to be the perfect “artificial life”. In the age of the technosphere, when *AI* constructs an abundance of artificial bodies in real life that are synthetically singular, and no longer divisible into virtuality and reality, creative body design rises to unimagined heights of the apocalyptic-utopian- dystopian dimension of fashion that in his last show *Plato’s Atlantis* created by Alexander McQueen. There is no true digital fashion in its essence because everything has become post-digital and hyperreal and as such determines what is left of the trauma of the Real. Fashion becomes an aesthetic pleasure in life as a sublime feeling of the ineffability of existence. You can't be in fashion. Fashion becomes like a little eccentric *alien in you* and follows you even in death. Remember, stranger, Bowie's last music video *Lazarus* and everything will suddenly open to you like a great bright abyss of the upcoming future.

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TEHNOSFERA KAO POST-DIGITALNA MODA
O KREATIVNOME DIZAJNU TIJELA

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Sažetak

Autor izvodi svoje postavke o odnosu tehnosfere i post-digitalne mode kroz analizu filozofijskih pretpostavki nastanka i razvitka umjetne inteligencije kao uvjeta mogućnosti realizacije onog što naziva kreativnim dizajnom tijela. To je definicija koja podaruje pojmu mode autonomnost i mogućnost razlikovanja ne samo od drugih područja dizajna i suvremene umjetnosti, već i usmjerenost spram nadolazeće budućnosti koja pretpostavlja vladavinu hiperrealnoga događaja tehnološkoga fetišizma. Problem je u tome što suvremena moda u post-digitalnoj formi pojavljivanja pronalazi svoj prostor performativno-konceptualnoga obrata samoga života kao totalnoga spektakla kroz uzdizanje narcističkoga subjekta do najvišeg stadija transgresije. Konačno oslobođenje mode od svih povijesnih stega i represivnih struktura društva, politike, kulture istodobno otvara neizvjesno područje preklapanja virtualne aktualizacije života i njegove umjetne inscenacije kao u McQueenovu posljednjem modnome događaju Platonova Atlantida.

Ključne riječi: *tehnosfera, post-digitalna moda, kreativnost, dizajn tijela, narcizam, transgresija*

1. Uvod

Alcheringa je aboriđinski izraz za ono što Hesiod u *Teogoniji* naziva *zlatnim dobom.* Heidegger je analizom grčkoga pojma *arché* dospio do tzv. prvoga početka bez kojeg ne bi mogao kazati da nakon metafizike kao nihilizma slijedi spasonosni 'drugi početak' (*andere Anfang*) (Heidegger, 2005). Što nam sve to govori negoli da i u mitskoj kaži i filozofijskome kazivanju imamo ono isto, naime, ideju savršenstva u onom tek rođenome, tek nastalome. Sve je nakon toga u znaku propasti. Horacije je u svojim *Odama,* knjiga 6, pjevao ovako: *Aetas parentum peior avis tullit / nos nequiores, mox daturos / progeniem vitiosorem. (Naši očevi, gori od naših djedova, izrodiše nas, još izopačenije, a mi ćemo izroditi još slabije pleme.* Kad slavimo napredak u suvremenosti, onda imamo samo jednu riječ koja sve što je ikad bilo u povijesti nadilazi, a sve drugo je plod tihog kontinuiteta, pa čak i bučne kulturne dekadencije. To je riječ koja od 2023. godine predstavlja po mojem promišljanju stvari konačan kraj metafizike kao nihilizma i konačan kraj povijesti. Ona je Veliki Zid svih zidova i za razliku od Hegelove spekulativno-dijalektičke tvrđave Apsoluta više nije realizacija subjektivnog, objektivnog i apsolutnoga duha. Ta riječ kao konceptualno-performativno-instalacijski događaj vladavine vizualizacije autopoiesisa jest *tehnosfera*, a ona nije svediva tek na umjetnu inteligenciju već i na umjetnu intuiciju, što će neminovno doći ubrzo, vidjet ćete, čim nastupi era kvantnih računala. U odnosu na *Alcheringu* naše je doba, u to nema nikakve sumnje, *doba silicija* i kraja antropocena, što znači da je i riječ zakašnjelost već posve neprimjerena. Da bih to ilustrirao, poslužit ću se slikom iz modnoga događaja *Platonova Atlantida* iz 2009. godine na Paris Fashion Weeku 6. listopada kao svojevrsnome manifestu onog što u mojoj knjizi stoji u samome naslovu, naime, *Posthumano stanje – Kraj čovjeka i mogućnosti druge povijesti* (Paić, 2011).

Riječ je o digitalnim kamerama s obje strane tzv. catwalka koje poput onih zazornih *Aliensa* iz filmova Ridleya Scotta, Jamesa Camerona i drugih snimaju u stalnim pokretima svojih fluidnih i pokretnih stalaka sve što se događa-na-sceni. Bez njih ne postoji mogućnost ovog fascinantnog performativnoga događaja koji je u 21. stoljeću najveći doseg umjetničke imaginacije i vizije nadolazećega doba. Uostalom, u tom ogledu koristeći se Batailleovim pojmom transgresije i erotizma pokazujem zašto je moda kao kreativni dizajn tijela na svojem kraju i zašto je McQueen uzeo za tematiziranje korporalnoga obrata upravo mit i apokalipsu, *zlatno doba i propast* civilizacije kao simboličke i kognitivne slike svoje alegorije. Još jednom, u tom modnome događaju ključna stvar, da paradoks bude potpun, nije njegov dizajn posthumanih tijela s onim ekscentričnim fetišizmom cipela s visokim potpeticama, a niti New Age glazba rađanja prvog čovjeka u mukama i užitku rajskoga stanja, u onom fantastičnome *deep blue* ozračju zmijolikih tijela u preplitanju što bude čudovišni strah i uzvišenost. Ne, kulminacija *Platonove Atlantide* nastaje nakon kraja *Alcheringe*, kad je sve transparentno osvijetljeno na sceni kojom hodaju modeli trans-meta-tijela s onu stranu ljudskoga. Kamere su ono najčudovišnije uopće, ono posve neljudsko i strano u svijetu kao iskonskome događaju transgresije smrti i erotizma kao tehno-fetišizma. To su kiklopski aparati ili dispozitivi umjetnoga pamćenja koji nam još jedino preostaje kao posljednje jamstvo tzv. stvarnosti koja se dogodila, događa se i dogodit će se u nadolazećoj budućnosti kao *Platonova Atlantida.* Usput, filozof Platon spominje mitsku Atlantidu samo dva puta, i to u dijalozima *Timej* i *Kritija.* Civilizacija koja

je prema kaži bila nadmoćna svemu što je u Grka ikad postojalo doživjela je katastrofu i nestala u dubokome moru. Ono trajnije od materijalnih spomenika može biti samo ideja koja je i za Platona božanskoga podrijetla i zato je uvjet mogućnosti svekolikoga bitka uopće. *Mit o zlatnome dobu uvijek je stoga u znaku savršenstva zato što je svijet u doba prvoga početka nužno događaj iskonskoga reda kao posvemašnje neposrednosti života uopće.* Znamo kako se Nietzsche rugao u svojem spisu *Filozofija u tragičnome razdoblju Grka* ovoj apologiji mitske nepomućenosti, ali isto tako i filozofima predsokraticima i njihovu mišljenja kaosa iz kozmologijske perspektive uvida u magmu bitka. Ono što nedostaje u mitskoj kaži o savršenstvu svijeta jest ljudski kaos i strast, ono što će iz Ostavštine McQueena u fashion-izložbi *Divlja ljepota (Savage Beauty)* iz 2011. i 2015. godine biti svojevrsni testament dionizijskoga otpora ovom svijetu post-humane homogenosti vladavine tehnosfere.

2. Moda i *corporeal turn*

Zlatno doba nije stoga ono koje je nekoć postojalo u zbiljskoj povijesti svijeta, poput naše divne mistifikacije Grka i renesanse. Ne, san o *Alcheringi* pojavljuje se uvijek na kraju povijesti, kad je ideja realizirana i kad je sama povijest postala ono što u McQueenovoj alegoriji znači vizualizacija posthumanih tijela u kretanju catwalkom. To je ishodište za misao o *arché* kao onome spasonosnome. Sveza je nužna upravo zato što je događaj mode koji je s McQueenom dospio do krajnjih granica iskazivosti i vidljivosti ljepote, smrti i apokalipse ništa drugo negoli filozofijsko pitanje o smislu bitka i vremena u doba radikalne praznine i tjeskobne napuštenosti svijeta. Tijelo nije zazor i besmisao, već proživljeno iskustvo osmišljavanja egzistencije, jer samo u tijelu još uvijek možemo misliti i osjećati ljudski, jer samo u tijelu još umiremo i ljudski i neljudski, jer samo bez tijela može biti onog mišljenja za koje nemamo prikladni jezik jer je takav jezik s onu stranu naših snova i vizija, čisti znak jedne totalne *anti-Alcheringe.*

Kraj metafizike ne završava s modernom tehnologijom jer je to samo uvjetno put od *logosa* do informacije. Naime, moderna je tehnologija reprodukcija, a ne simulakrum. Ona kopira stvarnost kao već postojeću i zato je logos svagda tehnologijski određen kao mišljenje o tehnici na najvišoj razini apstrakcije. Tome usuprot, tehnosfera je po analogiji apsolut, ali onaj 'imanentne transcendencije', što znači da je posrijedi fraktalizacija i kontingencija mišljenja koje samo sebe misli i proizvodi umjesto misli tehnogenetske 'mišljevine' jer je sveza tehno-racionalnosti i tehno-intuicije. Model za tehnosferu nije metafizičko mišljenje ni znanstvenika ni umjetnika, već misleći stroj kao umjetni mozak koji u procesu individuacije ne ulazi u tijelo procesom utjelovljenja-otjelovljenja za što je potreban Bog ili priroda, već procesom ugradnje i sklapanja čipova i kodiranja mišljenja kao eksperimentalne kozmo-tehno-geneze događaja. Po mojem mišljenju, jedini filozof koji je prije Deleuzea ovo otvorio kao problem nove ontologije bio je matematičar i filozof znanosti Alfred N. Whitehead s knjigom *Proces i realnost* iz 1929. godine. U tom smislu njemu pripada zasluga što je otvorio i mogućnost drukčijeg filozofijskoga mišljenja hiperplastičnosti tehnosfere kao događaja s kojim ulazimo u neizvjesno polje kraja ove kozmičke epohe. Što je posljednja riječ 'izgleda buduće filozofije' ako ne fundamentalni događaj otvorenosti jedne moguće i druge povijesti koja počinje 'ovdje' i 'sada' kao eksperimentalna sloboda pitanja čemu mišljenje uopće u doba apsolutne vizualizacije i samoproizvođenja umjetne stvarnosti i čemu uopće još ovaj jezik na kojem pišemo ono što sanjamo i na kojem sanjamo ono što je onkraj svake zamislive zbilje već samo o sebi događaj stvaranja ovog jednog-jedinog života, ove zadivljujuće singularnosti koja svoj smisao ima u tome da se sve događa simultano i različito u misteriju prostora-vremena. U fragmentu 178. svoje *Knjige nemira* pjesnik nadahnut filozofijom Fernando Pessoa piše:

> *Nastanjujemo snove, sjene smo što lutaju kroz nemoguće šume u kojima su stabla kuće, običaji, ideje, ideali i filozofije*.

Što je, dakle, umjetna inteligencija? To je 'ono' što postaje samosviješću u procesu mišljenja kao strojnoga učenja, a temelji se na Leibnizovoj ideji beskonačnosti, kibernetičkome pojmu informacije, autopoiesisu i beskonačnoj brzini heterogeneze algoritama u konstrukciji *virtualne stvarnosti*. Umjetna je inteligencija po analogiji s metafizikom uspon prirodnoga uma do samosvijesti drugim tehničkim sredstvima (Kurzweil, 2000, Bostrom, 2014). Ova sredstva ili instrumenti, međutim, nisu više pojmljeni unutar logike načela razloga u smislu funkcije za neku izvanjsku ili unutarnju svrhu. Ontologija AI, uvjetno kazano, pretpostavlja mišljenje 'otvorenoga stroja', onog koji misli svoj vlastiti proces mišljenja kao realiziranu sintezu *noesisa* i *noeme*. Takvo je mišljenje nužno nova trijada novoga apsoluta i povezuje računanje-planiranje-konstrukciju u sklop. Umjetna inteligencija nije biće kao u drevnoj metafizici, to on, a tehnosfera nije bitak, *einai*. Umjesto toga, valja govoriti o razlici između stanja koje je u tendenciji posthumano-transhumano i događaja kao procesa stalne heterogeneze (Deleuze, 2011, Paić, 2023b). Metafizika se uistinu realizira u kibernetici, a tehnosfera kao realizacija vladavine četvorstva informacije-povratne sprege-kontrole-komunikacije predstavlja apsolutni događaj preobrazbe samoga stanja u beskonačnost. Biće se, doduše, može dijeliti, ali stanja se mogu stvaralački i razaralački kopirati jer nisu nužnost bitka, već kontingencija događaja, poput Epstein-bar virusa

koji izaziva bolest mononukleoze ili leukemije ovisno o mreži pobuđenih uzroka. Ništa nije jednosmjerno, već višesmjerno. No, sve se događa jednom i ireverzibilno, a ono što se ponavlja nije reprodukcija bitka u njegovoj jednokratnosti, već simulacija događaja u njegovoj singularnosti. Jednokratnost je život-kao-smrt individuuma, a singularnost tehnološka besmrtnost superinteligencije kao individualizirane kolektivnosti. Najbolji primjer za rečeno je TV-serija *Star Trek: The New Generation*. U njoj je riječ o razlici čovjeka, humanoidnoga robota-androida i nadmoćne tehnološke civilizacije BORG, koja nema svijest o individuaciji. Što je, dakle, tehnosfera? To je civilizacija borgijanski usmjerene umjetne samosvijesti čovjeka nakon njegova učitavanja u tehnološku singularnost o kojoj izričito govore post-i-transhumanisti. Dakle, ne vladavina Super-Ega nad individuumom, već vladavina *homo kybernetesa* nad Egom metafizički shvaćenoga čovjeka (Paić, 2018-2019, Paić, 2022, Paić, 2023b).

Umjetna inteligencija je, dakle, posthumano stanje, a ne kontingentni događaj. Onog trenutka kad se ovo dvoje u tendenciji-latenciji spoje, nastaje apolutna samosvijest kozmo-tehnosfere koja stvaralački i razaralački postaje 'ono' što više nije ni bitak, ni biće ni bit čovjeka, a nije ni bilo kakva redukcija boga-Boga na ono astro-fizikalno i kozmologijski singularno Jedno, već posvemašnja otvorenost *autopoiesisa* kao mišljenja i kao događaja stvaranja novoga (Paić, 2022b: 1-36). *S umjetnom inteligencijom ulazimo u eru stvaralačke kozmo-tehno-hetero-geneze i to više nema nikakve veze ni s metafizikom, ali ni s kibernetikom, a niti s transhumanizmom. Čovjek je svoje odigrao, kako je to proročanski pjevao mladi Arthur Rimbaud u poemi Solleil et char. S ovim događajem je i sama igra postala tajna prijelaza između 'gore' i 'dolje' i taj prijelaz je upravo ovo 'sada' i 'ovdje' što se događa kao fascinacija, ravnodušnost i dosada jednog posve novoga experimentum mundi.*

U mojoj knjizi *Vrtoglavica u modi: Prema vizualnoj semiotici tijela* već je radikalno izveden posve novi i drukčiji pristup modi uopće od mnoštva tzv. sociologija i antropologija mode i odijevanja, kulturalnih i vizualnih studija, semiotika mode, psihoanalitičkih i feminističkih teorija mode, pa čak i tzv. promašenih filozofija mode. (Paić, 2007) Uostalom, u posljednjem petom svesku *Tehnosfere* koja se bavi destrukcijom ontologija tijela u suvremenosti i govori o *dizajnu kao mišljenju i autonomnim objektima i njihovim preobrazbama* jedno je poglavlje izričito posvećeno fenomenu suvremene mode (Paić, 2019: 191-219). Glavna postavka koja zagovaram jest nepromijenjena do danas. Moda je kreativni dizajn tijela, a ne odijevanje tijela u skladu s tradicionalno-modernim sklopom pojavljivanja tijela kao slike u modusu mimezisa i reprezentacije društvene klase, roda-spola, životnoga stila itd. Ovo je fundamentalno-radikalan obrat u biti metafizike kao temeljne misaone strukture zapadnjačke i uopće svjetske povijesti koji se zbiva na kraju 20. stoljeća ulaskom u digitalno doba. Stoga mode u doba tehnosfere kao trijade računajućega-planirajućega-konstrukcijskoga mišljenja više 'nema', jer je pojam mode kao načina produhovljenoga života tijela u značenju talijansko-francuskoga izraza modus i u značenju engleskoga izraza fashion kao znaka pripadnosti duhu vremena posvemašnje aktualnosti=novosti kapitalizma izgubio svoju vjerodostojnost. Ni elitna ni masovna moda, ni haute couture ni antimodni revolt protiv kanona modernosti koji je inaugurirao visoki kriterij ljepote, elegancije i ekstravaganciie nisu više ključne riječi-pojmovi za suvremenu modu koja se odvija u prostoru apsolutne virtualizacije života kao kreativni dizajn tijela. Moda se već od 1980ih godina i stila radikalne japanske dekonstrukcije više ne pojavljuje kao tzv. stvarna moda s ulica i rubova velegradskoga podzemlja (Kawamura, 2004). Njezino je istinsko mjesto reprezentacije i pojave u trijadi pojmovlja suvremene umjetnosti kao što su to instalacija-performativnost-konceptualnost, a paradigmatski modni dizajneri suvremene mode poput McQueena, Galliana i Chalayana samo dokazuju da moda postaje istraživačko-eksperimentalni događaj slobode apsolutne transparencije tijela kao konceptualne slike.

3. Singularnost i posthumano tijelo

U čemu je razlika između moje definicije mode i svih tradicionalno-modernih teorija mode koje su odreda modu shvaćale ne-autonomno, reduktivno, miješajući pritom pojmove odijevanja i mode, misleći da time valjda modi podaruju legitimnost što je uvrštavaju u korpus tzv. primijenjene umjetnosti i izvodeći njezine tzv. stilove iz pojma umjetničkih stilova poput primjerice nadrealizma, suprematizma, neoavangardne dekonstrukcije itd.? Odgovor je sljedeći. Moja definicija mode nije uopće nikakva deskriptivna niti analitička analiza fenomena mode kroz povijest kulture i civilizacije od prapovijesti do valjda neo-gothic-punka. Umjesto toga, riječ je o shvaćanju kako je 'bit' onoga što označava radikalnu promjenu u razumijevanju jezika-slike-tijela izvan metafizičkoga okvira zapadnjačkoga mišljenja. Zato postavka o kreativnome dizajnu tijela pretpostavlja apsolutnu autonomiju mode koja od 1990ih godina i ulaska u doba tehnosfere postaje samo-organiziranje života i samo-proizvođenje vlastita sustava i okoline društva i kulture u figuraciji životnih stolova, kako je to imenovao njemački sociolog Norbert Elias u svojem kapitalnome djelu *O procesu civiliziranja* (Elias, 1976). Moda, dakle, nije nešto već opstojeće u svijetu što se referira na društvene procese i stvaranje novih kulturnih obrazaca života. Umjesto toga, valja jasno kazati da je moda postala apsolutni fenomen digitalnoga konstruktivizma i da je njezina 'bit' u procesu neprestane preobrazbe identiteta svih postojećih društveno-

kulturalnih odnosa u globalnome poretku kapitalizma kojeg određuje korporativno-informacijsko-kognitivni način interakcije između subjekata-aktera izvedbe, kako to pokazuju, primjerice, performativni događaji Alexandrea McQueena poput *Savage Beauty* i *Plato's Atlantis*. Kad kreativno i oslobođeno tijelo u svojim preobrazbama tzv. esencijalistički shvaćenoga identiteta slavi iskustvo razlika i kroz šok i provokaciju eksperimentira s onim što pripada ideji egzistencijalne slobode projekta vlastita života onkraj svih postojećih moralno-političkih granica, onda je moda u svojoj biti trijada *narcizma, transgresije i fetišizma* kao znakova pozitivno-negativne emancipacije od svih modela nedovršene prošlosti koja se vraća u suvremeni svijet 21. stoljeća kroz obnovu patrijarhalnoga poretka vrijednosti i kroz nove oblike političko-kulturalnih fundamentalizama.

Kreativni dizajn tijela nije, dakle, nikakva neutralna i nevina ideja i praksa života suvremene mode, već ono što nadilazi svojom radikalnošću sve dosadašnje politizacije i estetizacije mode uopće. Nije nipošto nestao revolt i angažman ove narcističko-transgresivno-fetišističke orijentacije koja svojim vlastitim tijelom kao digitalnom slikom pokazuje vlastiti novi identitet. Naprotiv, suvremena moda nosi teret ove borbe za slobodu tjelesne izvedbe života u javnosti i na sceni još impulzivnije i ekstravagantnije no što je to bilo u doba antimode s dizajnom Vivienne Westwood, iz jednostavnog razloga što je 21. stoljeće u znaku pseudo-sinteze i *revivala* svih mračnih ideologija protuprosvjetiteljstva koje su Drugoga nastojale pokoriti i uništiti svim sredstvima totalitarne represije. Dokaz su tome modne izvedbe eksperimentalnoga dizajna Iris van Herpen. Kad, dakle, neproblematski govorimo o digitalnoj modi uvijek se pritom misli kako je valjda moda iz prave stvarnosti postala moda u virtualnoj stvarnosti, kao da je riječ o 'preseljenju' iz jedne kantovske kategorije modaliteta kao što je to zbilja ili stvarnost u drugu delezovsku kategoriju virtualne aktualizacije i kao da je ta temeljna 'ontologijska razlika' samo izvanjske naravi. E, nije, ni izvanjske ni unutarnje naravi, već je posrijedi fundamentalna promjena u samoj 'biti' mode kao takve. Zašto? Zbog toga što digitalna moda nadilazi ukorijenjenost i postojanost mode kao ukrasa ili ornamenta statično-dinamičnoga tijela na usluzi onome što Georg Simmel još 1903. godine naziva društvenom formom mode određene okvirom kapitalističke modernizacije svijeta, a isto vrijedi i za njezinu funkciju u pokretima kulturalne subverzije i pobune tijela protiv sustavne represije 1960ih godina kad nastaju antimodni pokreti u suglasju s kontrakulturama i subkulturama u SAD-u i zapadnoj Europi (Paić, 2022c: 1-32). Stoga digitalna moda predstavlja uronjenost slike samoga tijela koje više ne prikazuje niti predstavlja nešto drugo i ne simbolizira nešto drugo izvan same mode kao autopoietičke logike samo-organizacije i samo-vođenja života kao egzistencijalne slobode ekscentričnoga individuuma. To je ono što nazivam u svezi s jednim pojmom Umberta Ecoa *ikonogramima tijela* (Paić, 2022c: 52-98).

Posrijedi je događaj singularnosti koji slikovno-tekstualno prethodi i refleksiji i rekurzivnosti. Ovo je točka mojeg razlaza s mišljenjem suvremenog njemačkoga filozofa umjetnosti Dietera Merscha, koji u tekstu kaže i ovo:

„Kreativnost i umjetnička praksa imaju refleksivnost kao terminal. Čin domišljatosti, oštroumna intuicija kreativnoga impulsa, uglavnom se temelji na otkriću ili neotkrivenim kognitivnim inhibicijama ili preprekama koje je potrebno prevladati kako bi se napravilo mjesta za druge misli. Nije odlučujuća njihova novost, već čin otvaranja. Ovo, međutim, pretpostavlja 'razmišljajuće mišljenje' koje ne završava u rekurzivnosti, nego je uvijek trostruko završeno kao: mišljenje objekta (što), mišljenje čina (to) i razmišljanje načina mišljenja (kako) ili *meť hodos* i njegov medij. Interakcija i triangulacija ovo troje i stalno pomicanje i miješanje razina ne mogu se rekonstruirati u algoritamskom načinu rada. Tamo gdje razmišljanje prekida s vlastitim iskustvom, gdje napušta svoju neprozirnost i kooptaciju u inherentnoj dogmi, logika i matematika su na gubitku“ (Mersch 2023: 251).

Famozna „kreativnost“ postaje najznačajnija filozofijska mantra suvremenoga mišljenja i budimo krajnje pošteni, zaslugu za takvu kurentnost valja odati kao priznanje digitalnome konstruktivizmu kao mišljenju ontologije postajanja i razlike Gillesa Deleuzea. Njegov konceptualni „kreacionizam“ otvorio je mogućnost da se ovom hajdegerijanskome „dualizmu“ mišljenja kao računanja (*Rechnen*) i kazivanja (*Dichten*) podari posve novo značenje time što je sada naglasak premješten na pronalazak *slike mišljenja* s kojim pojmovi više nisu preslika stvarnosti, već konstrukcija umjetne zbilje. Mersch, naravno, lucidno brani posljednju utvrdu postmetafizike koja naspram matematike i logike ima svoje opravdanje u onome što pripada području nesvodive mašte kao središnjeg pojma estetičkoga mišljenja. No, „razmišljajuće mišljenje“ koje može vrednovati i suditi o drugome mišljenju zato što razlikuje dobro od lošega u etičko-političkome i estetskome smislu, nije toliko sakrosanktno kao što se to čini. U drugome svesku *Tehnosfere* pokazao sam da umjetni mozak kroz proces naprednoga učenja u neurokognitivnome smislu nužno mora prispjeti do toga da u razlici programa i vizije, računanja i planiranja-konstrukcije procesom vizualizacije događaja stvori uvjete mogućnosti za treću stvar mišljenja (Paić, 2018). To više neće biti kreativnost iz biti jezika, već sintetička konstrukcija iz biti slike. Mersch je u svakome slučaju dao iznimno vrijedne filozofijske priloge raspravi o umjetnosti i umjetnoj inteligenciji polazeći od promišljanja jezika u Heideggera i Wittgensteina, a u knjizi *Događaj i aura*, kroz sinkretizam i razlikovanje u mišljenju Heideggera i Benjamina, podario je uvjerljive argumente za tzv. performativnu umjetnost (Mersch, 2002). Moja je intervencija u tom krugu promišljanja već od samoga početka bila jasno usmjerena u knjizi *Slika bez svijeta*, a to je značilo da logika tehnosfere u sebe uvlači i prerađuje i

događaj i auru i sintetičkim činom *autopoiesisa* stvara mogućnost da konačno nastane i ono što je posljednji cilj ove postmetafizičke povijesti bez prvoga uzroka i posljednje svrhe. (Paić, 2006) To može biti samo tehnološka singularnost. *Umjetna inteligencija ubrzava svoj put spram samosvijesti tako što polazeći od racionalne intuicije nastoji proizvesti algoritme nove kreativnosti za koju je posljednja granica pojam umjetne intuicije.*

4. Zaključak

Moda postaje apsolutna konstrukcija događaja u okviru kreativnoga dizajna tijela onog trenutka kad više nema ništa s referencijalnim okvirom ili okovima društva i kulture, a to se podrazumijeva i za politiku, koje su ju u moderno i postmoderno 'doba' reducirale na ono ne-autonomno i svagda periferno i sekundarno, čak i blazirano i krajnje površno i banalno. To je vrijeme isparilo u eteru poput ustajaloga zraka iz Duchampovih *sušila za boce.* Digitalna moda postaje korporalni obrat u samoj biti metafizike tijela, (Kalbaska, Sadaba, Cominelli, Cantoni, 2019) jer je dematerijalizirani i krajnje estetizirani asemblaž svih mogućih, zbiljskih i nužnih intervencija 'na' tijelu kao onome što iskazuje album Davida Bowieja iz 1990. godine imenovan uistinu 'uncanny', naime, *Scary Monster (And Super Creeps).* Moda je dovršena u svojoj otvorenosti naprosto zato što je postala ono čemu je oduvijek i težila, da bude savršeni 'umjetni život'. U doba tehnosfere kad *AI* konstruira svekolikost umjetnih tijela u stvarnome životu koji je sintetički singularan, a ne više djeljiv na virtualnost i zbilju, kreativni dizajn tijela uzdiže se do neslućenih visina one vrste apokaliptičko-utopijsko-distopijske dimenzije mode koju je u svojem posljednjem showu *Platonova Atlantida* stvorio Alexander McQueen.

Nema stoga u svojoj biti istinske digitalne mode jer je sve postalo post-digitalno i hiperrealno i kao takvo određuje ono što je još preostalo od traume Realnoga. Moda je estetski užitak u životu kao uzvišenome osjećaju neizrecivosti egzistencije. Ne možeš biti-u-modi. Moda je u tebi poput malog ekscentričnoga *aliena* i prati te i u smrti. Sjeti se, stranče/strankinjo, posljednjeg Bowiejeva spota *Lazarus* i sve će ti se nenadano otvoriti kao veliki svijetli bezdan nadolazeće budućnosti.

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DIGITAL ARCHIVES OF CONTEMPORARY FASHION PHOTOGRAPHY

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Abstract: *With the transition from classic illustration in fashion magazines to the first fashion photograph, there is a radical shift in the reconciliation of the body, dress and fashion. In this research, we will present the significant shift from fashion illustration to fashion photography at the end of the 19th and beginning of the 20th century and their mutual connection on a global scale. Moreover, we will explore how illustrations and photographs are kept within specific digital archives in today's new media environment. This paper focuses on the concept of 'archives' to investigate the history of dress and clothing and present new digitally manipulated archives of contemporary fashion. With the shift from analogue to digital photography, fashion became a global digital archive, a platform for researching, viewing, preserving and studying dress and fashion. The term 'archive' implies organization and systematization. However, in modern times, thanks to new media and innovative digitization possibilities, fashion is transformed into a complex digital form, often interactive. Contemporary fashion photography includes postmodern collage concepts and the combination of various digital techniques. Furthermore, the collage process occurs in digital form, and the photograph takes on complex levels of multiple meanings, as Barthes explained in exploring the polysemy of images (Barthes, 1964). In addition, this way, photographs become digital collages, attaching various visual and textual codes and symbolic meanings. There is a significant change in the process and methodology of photography, but also the relationship with the clothing object. In this paper, we argue how, in contemporary fashion photography, there is a visible transformation of the body and dress and their mutual relationship in the photograph. Thus, we introduce the term 'covered body' instead of 'clothed body' (Calefato, 2004) for specific bodily transformations occurring in fashion photographs from the 1980s onwards. Fashion photographs are thus not only 'representations' of fashion but rather the creators of today's fashion content. Furthermore, this work explores how digital archives of contemporary fashion photography have significantly changed, how we observe and understand fashion and the reasons for the increasing archiving of fashion and clothing artefacts.*

Keywords: *fashion illustration, fashion photography, digital archives, covered body, digital collage*

1. Introduction: From Fashion Illustration to Fashion Photography – A Historical Overview of the 20th Century

Throughout the 20th century, fashion photography evolved as a specific art form with commercial intent, reflecting changes in each era's cultural and social landscapes. Fashion served as a platform for viewing and imitating fashion styles and reflecting the time's cultural, political and sociological changes. The influence of iconic photographers and designers, technological advancements, and cultural attitudes contributed to fashion photography's diverse and dynamic evolution and history. Through photography, we witnessed the changes in fashion, style, and dress, as well as the development of each fashion designer and their particular approach to fashion. While photography has primarily taken over as the primary means of presenting fashion in fashion magazines, many fashion illustrators and later photographers have left a lasting impact on fashion's visual history. Their work not only documented the styles of their influential eras but also contributed to the artistic and cultural legacy of magazines, such as Vogue and Harper's Baazar, as leading fashion magazines of today. To explore how fashion was represented, we must first highlight how fashion illustration influenced fashion's visual representation in magazines. Like photography, fashion illustration was a platform to witness new fashions and styles. To begin unfolding the complexity of fashion archives, we must address the emergence of fashion illustration, without whom we would be unable to comprehend this transition – from illustration to photography. Firstly, we must address these significant changes in fashion representation before we explore the importance of fashion photography and the concept of 'digital archives' in contemporary fashion.

Fashion illustration has a rich history and has evolved alongside changes in art, technology, and the fashion industry itself. Moreover, fashion illustration is closely connected to fashion journalism. As the British author Kate Nelson Best highlights in her book 'The History of Fashion Journalism': 'Despite widespread academic and public interest in fashion itself, fashion journalism – with the exception of fashion photography and illustration – has somewhat remained marginalized' [1]. The evolution of fashion illustration to fashion photography is directly associated with fashion magazines and specialized publications. Without them, we would be unable to fully collect and organize fashion's digital archives, which we have today. As Croatian art and fashion historian Katarina Nina Simončič highlights, 'Specialized publications devoted to the study of

fashion, for example, clothing styles determined by the gender, vocation, status and age of the wearer, and within a particular space and period, are recorded from the 16th century onwards. Intended for well-to-do potential consumers, they featured black and white illustrations with short Latin descriptions and depictions of contemporary fashion styles' [2]. Hence, fashion illustrations have been an essential part of fashion history. For example, the British Victoria and Albert Museum and its archive of fashion and dress is primarily focused on gathering artefacts (including drawings, illustrations and photographs) of each era with a short comment and text about the object or illustration. The V&A is renowned for its extensive fashion archive and one of the world's most comprehensive and influential collections of dress and textiles. The archive encompasses many garments, accessories, and related items, spanning centuries of fashion history. This extensive collection includes objects and pieces from various cultures and periods, offering a diverse and comprehensive view of fashion history. Most of the objects are organized in a digital archive form, displayed for the public to use and research. Thus, fashion archives are crucial in today's new media-saturated environment in terms of research, study, conservation and preservation of dress and clothing.

Furthermore, the late 19th century and early 20th century are considered the golden age of fashion illustration. Illustrators like the American artist and illustrator Charles Dana Gibson created the famous 'Gibson girl', an iconic representation of American womanhood. His work profoundly affected the 'images' of women of the time and shaped women's visual representation in magazines. Moreover, French illustrator Georges Augustin Barbier gained prominence at the time as well with his immaculate drawing style, realistically depicting fashion and fashion styles. His approach, much different from Gibsons', presented women in outdoor scenery, often associated with nature and in romantic indoor environments. Barbier's illustrations often reflected the geometric patterns, bold colours, and stylized forms associated with Art Deco. Advances in printing technology allowed the mass reproduction of fashion illustrations in magazines like Vogue and Harper's Bazaar. These magazines showcased the work and intentions of textile and fashion designers and their vision for fashion and style. Fashion illustration played a significant role in the early 20th-century editions of Vogue magazine, capturing the spirit and style of the times. During this period, from roughly the early 1900s to the 1930s, Vogue was evolving into a leading fashion publication, and fashion illustration was a crucial element in conveying the latest trends and designs, both in fashion and textile design. In the early 1900s, fashion illustration in Vogue was characterized by intricate, detailed drawings featuring the latest couture designs. Vogue continued to feature detailed fashion illustrations in the 1910s, often accompanied by short descriptions or captions. Artists such as George Barbier and Georges Lepape, known for their Art Deco style, began making significant contributions, bringing a sense of modernity and sophistication to the pages of Vogue. Artists like American illustrator and industrial designer Helen Dryden and American illustrator George Wolfe Plank were among the notable contributors to Vogue during this time, providing illustrations that reflected the elegance and opulence of the *Belle Époque*. In the 1920s and 1930s, Dryden became a highly sought-after illustrator, working for major publications such as Vogue and Vanity Fair. Her fashion illustrations were known for their elegance and sophistication, capturing the style and spirit of the Jazz Age. In addition to her work in fashion illustration, Dryden made significant contributions to industrial design. She became one of the first prominent female industrial designers, creating designs for products like radio cabinets and packaging for cosmetics. Her ability to blend art and design made her a trailblazer in the male-dominated field. Furthermore, Plank's illustrations appeared in popular magazines, including Collier's, Harper's Bazaar, and Vanity Fair. Plank was famous for his ability to capture the essence of the Jazz Age and the Roaring Twenties, creating images that epitomized the glamour and sophistication of the era. Just before the end of the 1920s, another illustrator incorporated new representation styles in fashion magazines. American illustrator Kenneth Paul Black and his versatile approach to fashion visual representation changed how we perceive fashion. Black gained prominence as a fashion illustrator, creating detailed and expressive drawings that captured the essence of haute couture and ready-to-wear fashion. His work was characterized by its elegance, precision, and ability to convey the movement and style of clothing. His approach to fashion representation still influences today's illustrators and designers with his mixed techniques. A dynamic and gestural style often characterized block's illustrations. He used a variety of mediums, including pencil, ink, and watercolour, to bring his illustrations to life. His work was known for its attention to detail and the fluidity with which he depicted fabric and movement. The work of illustrators of the 1920s and the 20th century strongly influenced today's visual representation in fashion.

In this paper, we focused on the 20th century to see this transition from fashion illustration to fashion photography since that era was rich in examples in fashion and fashion magazines, and we shall present how fashion photography changed the way we 'look' at fashion in general. Another reason for this approach is the profound development of photography as a medium in the 20th century, which changed human perception and introduced the idea of inscribing content on film. Collecting and digitalizing fashion illustrations and mapping fashion styles of various decades in the 20th century has helped profoundly to see this significant transition from illustration to photography.

1.1. The Evolution of Fashion Photography – From Analogue to Digital Photography

According to the 'Encyclopedia of World Dress and Fashion', fashion photography refers to photographs taken to display or, in some cases, resemble clothing and fashion to accessories, to document or sell [3]. The history of fashion photography is closely intertwined with the evolution of photography as a medium and the fashion industry itself. The early 20th century saw the rise of fashion magazines like Vogue and Harper's Bazaar, which played a crucial role in popularizing fashion photography. Photographers like Edward Steichen and Baron Adolphe de Meyer contributed to fashion photography's artistic and stylistic development. De Meyer, in particular, is often credited as one of the first fashion photographers and worked for publications like Vogue and Harper's Bazaar. He was well known for his artistic approach and experimented with soft focus and natural light, departing from the formal studio portraiture of the time. Steichen was another pioneer in early fashion photography. He contributed to the innovative use of lighting and atmosphere in his images and played a vital role in shaping the visual aesthetic of Condé Nast publications. That is when fashion photography was crucial in shaping fashion magazines and their visual representation. The early 20th century saw the rise of influential fashion magazines, which became a fashion authority of the time. Fashion magazines were crucial in popularizing fashion photography and showcasing the latest fashions and styles.

The early 20th century marked a significant period in the evolution of fashion photography as the medium transitioned from static studio portraits to more dynamic and expressive images. This process was challenging for fashion photographers as they were limited by the technical aspects of the time's cameras. The vital transition to fashion photography occurred in the 1930s, when photographs appeared in dark black and white, highlighting women's bodies in long, sleek dresses. The 1930s saw a gradual shift from illustration to photography as the primary means of showcasing fashion in various fashion magazines. Advancements in printing technology and the increasing use of photography allowed for a more realistic representation of dresses and models. Although illustration did not disappear entirely, the influence of artists like American illustrator Carl Erickson and French illustrator René Bouët-Willaumez diminished compared to earlier decades. During this period, fashion illustration, particularly in Vogue magazine, documented the evolving styles and trends and contributed to creating a visual culture around fashion. At the same time, photography became the means to present fashion in all aspects. The transition to photography marked a shift toward a more immediate and realistic representation of clothing and dress, reflecting the changing tastes and preferences of consumers, readers and the fashion industry. This period, marked by the works of fashion photographers such as Cecil Beaton, Paul Tanqueray, and Ted Allen, was characterised as the dark age of fashion photography because of their strong photographic contrast. Their work encapsulates the era with the enhancement of the subject in the photograph, highlighting the dress and drape.

Furthermore, fashion photography began to evolve in the post-war era. Photographers like Richard Avedon and Irving Penn brought a new level of creativity and innovation to the field. Avedon, for example, introduced movement and energy into his images in comparison to previous eras where subjects seemed static. During the 1940s and 1950s, photography was connected to a specific typology of female and male actresses and actors. At the time, photography was associated with specific subjects and retained similar aesthetics. Fashion photography shifted from studios to the outdoors, thus radically changing the aesthetics of the time. With the widespread adoption of colour photography in the 1950s, fashion photography entered a new era. Colourful and vibrant images became a hallmark of the fashion industry, remaining paradigmatic till today. Nevertheless, fashion photographers like Penn and Avedon continued to work in black and white alongside *haute couture* designers. Fashion photography began to embrace diversity in the late 20th century, often highlighting the concept of otherness. German-Australian photographer Helmut Newton and American photographer Herb Ritts challenged conventional notions of beauty and gender in their work. Newton introduced multiple subjects in his photographs and shifted away from traditional, static body expressions. Ritts continuously photographed celebrities, and his black-and-white photographs introduced some of the first images of a covered body. The term 'covered body' differs from the term 'the clothed body' by Italian fashion theorist Patrizia Calefato [4]. By 'covered', we mean a sculptural, voluminous body which always appears with a hidden face, revealing the body's state and changing the body's identity. Moving away from the traditional understanding of how the body has cultural context inscribed into it, the 'covered body' refers to the shaping of the body in fashion photography and especially fashion performance. Numerous examples of this process are visible in fashion photography. For example, Croatian fashion photographer Romano Grozić had a very similar approach in his editorial 'Gommatex' for Vanity Fair from 1986. Grozić, who worked for Vanity Fair and Vogue, experimented in his work with the concept of covering the facial expressions of the subject and revealing the body's intentions in the photograph. Ritts had the same methodology, often covering the whole body of the subject. This is visible in his Versace-Veiled Dress from the 'El Mirage' series (1990), where we see the shape of the body but not the body itself. The 1970s and 1980s had a very different approach and aesthetic, and colour was predominant.

Black and white photography was still very much present but not in the focus of fashion magazines. Towards the end of the 1970s, French photographer Guy Bourdin transformed fashion photography into a vibrant, colourful experience. Bourdin often juxtaposed the body of the subject with architecture. Bourdin's significance lies in his inversions of the female body, again covering and not revealing the subject's face. Photographers like Peter Lindbergh, Mario Testino, Patrick Demarchelier and Steven Meiselas marked the contemporary fashion photograph. Experimenting with analogue and digital mediums, they often turned to the 1930s aesthetics of black-and-white body representation. Of course, their work was often connected to a particular magazine, such as Meiselas's aesthetics to Italian Vogue or Lindbergh's famous photographs of supermodels. These photographers used magazines to create their body of work and thus created a digital archive within the magazine's archive. The idea of digitalizing archives, in terms of fashion photography, consequentially meant gathering a collective 'memory' of the time's fashions. What would we, as researchers, students or the general public, be without archives? Thus, the term itself transformed its meaning. Digital archive in contemporary fashion photography refers to an interactive, reachable and searchable body of work. Today, digital fashion photography remains a powerful and influential medium for conveying style, trends, and artistic expression, allowing the viewer to deconstruct the meaning of each photograph. The importance of digitalizing each photographer's work and collecting them into a systematic archive, such as foundations (for example, Herb Ritts Foundation contains his whole photographic work), is of great significance in various fields – from academia to fashion journalism.

2. Methodological Approach and Framework: Decoding Images – From Barthes to Berger

To frame our research, we used the semiotic approach, based on the work of the French philosopher and literary theorist Roland Barthes and his innovative thinking, which still applies to today's decoding of the 'true' meaning of images and photographs. Semiotics is the study of signs and symbols and their interpretation or meaning. When decoding images, especially photographs, a semiotic approach involves analyzing the signs and symbols within the image to uncover the underlying meanings and messages conveyed by the visual elements. This approach is often associated with the work of scholars such as Ferdinand de Saussure, Charles Sanders Peirce, and Roland Barthes. Barthes tried to decode what lies behind the image and what the true intentions and meanings of images are. A semiotic approach to decoding images involves analyzing the visual elements, recognizing the signs and symbols, understanding their cultural context, and exploring both the denotative and connotative meanings to uncover the rich layers of interpretation within visual communication. Barthes wrote extensively on various topics, including semiotics, literature, fashion and culture. One of his notable works is 'Camera Lucida' (French; *La Chambre Claire*), originally published in 1980, where he reflects on photography and the nature of images. While 'Camera Lucida' does not focus specifically on fashion photography, some of Barthes' ideas can be applied to understanding the role and impact of fashion photography. In this work, Barthes introduces the concepts of the 'studium' and the 'punctum' to analyze photographs [5]. The studium refers to a photograph's cultural, linguistic, and political interpretation, while the punctum is a more personal and emotional element that pricks or punctuates the viewer's experience [5]. Regarding fashion photography, one can consider the dress and fashion context as part of the studium. Barthes also discusses the notion of the 'essence' of a subject captured in a photograph [5]. This essence is not necessarily directly related to the subject's identity but is a quality that evokes an emotional response, and this is directly related to revealing what fashion photography is. In fashion photography, this could be the way a garment is presented, the composition of the photograph, or the overall aesthetic that conveys a certain mood or style. While Barthes did not extensively write about fashion photography specifically, his semiotic approach and his reflections on the nature of photography provide a theoretical platform that can be applied to analyze and understand the visual language of fashion photography. Barthes wrote about commercial images (or the intent behind those images) and presented the three levels of meaning in each commercial image: linguistic, iconic and symbolic [6]. A basic premise of semiotics is the concept of signs, which consist of a signifier (the form the sign takes) and a signified (the concept it represents). In an image or a photograph, the signifiers are the visual elements, and the signified is the meaning or idea behind those elements. As fashion theorist Petra Krpan notes: 'Recognizing the fashion language, as well as the sign system of fashion, is essential in the field of fashion photography research because it is an attempt to create a new identity of the subject, gender/sex differentiation within the fashion and a new structure of visuality of contemporary fashion practice' [7].

In a contemporary context, this paper relies on Eugenie Shinkle's approach to fashion photography as a visual essay [8]. Photographs often contain cultural codes – shared meanings and symbols within a particular culture. However, fashion photographs often have multiple meanings, referred to as polysemy. In the context of images, different viewers may interpret the same image in various ways based on their individual experiences,

cultural backgrounds, and perspectives. Decoding an image may involve understanding these cultural codes to grasp the intended message. Cultural codes can vary across societies and historical periods, so what is meaningful in one context may not be in another. The context in which a photograph is presented or viewed is crucial for interpretation. The same image may carry different meanings in different contexts. Furthermore, denotation refers to an image's literal, explicit meaning or what is directly represented. Connotation involves the additional meanings or associations that go beyond the literal representation, often present in fashion photography. These can be cultural, social, or personal associations that viewers bring to the image. John Berger, an English art critic, theorist, and novelist, also engaged with the subject of photography in his extensive work. One of his notable contributions is the essay 'Understanding a Photograph', which is part of his collection of essays published in 1972. In this book, Berger offers insights into the nature of photography and its impact on perception and culture. Berger emphasizes that photographs are not neutral records of reality but interpretations created by the photographer [9]. Furthermore, Berger challenges the notion that photography provides an objective and truthful representation of reality and argues that every photograph is a result of choices made by the photographer, and these choices are subjective and interpretative [9]. The act of framing, choosing a particular moment, and deciding what to include or exclude all contribute to the photographer's interpretation of the subject.

In exploring contemporary fashion, the methods mentioned above apply to decoding and extracting the true levels of meaning(s) in photographs. However, the complex form of contemporary fashion photography demands further methodological framing. Even though the semiotic approach is largely accepted and applied, digital fashion photography represents a more complex form with various visual and textual narratives. British theorist Eugenie Shinkle thus writes about the concept of 'photography as a visual essay' and refers to the idea of using a series of photographs to tell a story, convey a message, or explore a particular theme or concept [8]. Instead of relying on individual images, the visual essay utilizes the cumulative impact of a sequence of images to create a narrative. This approach often involves a deliberate and thoughtful arrangement of photographs to guide the viewer through a specific visual story. Shinkle's approach can be applied to experimental fashion magazines, such as the bimonthly British i-D magazine, a global digital platform for fashion photography. In this sense, British photographer Nick Knight established SHOWStudio, a digital platform that can be accessed through three key terms: designer, season, and location. This platform, now known not only for fashion photography but fashion film as well, represents a rich digital archive not related to a specific institution. In addition, Knight incorporates fashion illustrations in a digital form, drawing back to their importance and combining these two mediums of expression in fashion. Knight, known for his experimental work for Yohji Yamamoto in the 1980s, first introduced the 'collage' approach to fashion photography. Around the same time, in 1988, Croatian photographer Boris Berc also played with various collage elements in his work, experimenting with double negatives, drawing and paper applications. The notion of 'collage' in the postmodern context, as art historian Miško Šuvaković explains it, is 'placing objects, elements of objects, existing ideological, religious and theoretical messages, fragments of everyday speech and expressions of popular culture in a new creation in order to create a work that shows the most diverse interruptions, and thus complex ambiguity, incompleteness, inconsistency of thinking, and representations in postmodern art and culture' [10]. This type of representation in fashion photography is visible in the work of David LaChapelle, whose fashion photographs form different narratives, combining elements of paradox and surrealism. Decoding fashion photographs means not only decoding textual and visual elements but also deconstructing the context of the storytelling aspect of what is behind the photograph itself. Including the semiotic approach, detaching the semiotic trinity proposed by Barthes, interlaying it with Shinkle's notion to regard fashion as a visual essay, creates a clear and precise framework to understand the complexity of contemporary fashion photography today.

3. Technological Aspects of Fashion Photography: Digitalization of Archives and 'Materiality'

When it comes to digital photography, the digitalization of photography has had a profound impact on the way we capture, store, and share images, especially in documentary photography. This transformation began in the late 20th century and has continued to evolve, shaping the photography industry and changing how individuals interact with photographs and photographic material. The digital shift has influenced the photography industry, from equipment manufacturers to photography laboratories. Traditional film companies had to adapt or transition to digital technologies to remain competitive, and the digitalization of photography has democratized the art form, making it more accessible to a broader audience while presenting new challenges and opportunities for photographers and the industry. However, the digitalization of fashion illustrations and photographs serves as an archive platform for academics, researchers and students, as well as the general public. Knight's SHOWStudio is a perfect example of how digital archives function and serve the public. Through archives, we are witnesses of specific times and, in this case, fashions. The technological

aspects of collecting, creating, organizing and managing a fashion archive require immaculate knowledge of photography as a media form and recognizing why today, more than ever, we need digital archives. According to the State Archive in Croatia, there are several crucial steps to follow and manage whilst collecting and creating photographic archives in general. The first one refers to photographic techniques and procedures, types, purpose and structure of photographic devices. Furthermore, in photographic recording, various factors influence the parameters and quality of the image and adjust the parameters in photographs. The focus is on the types and properties of photographic material, development, copying and processing of photographic material, equipment and technological procedures in the photographic laboratory, and analogue photography. Protection and preservation of photographic material, maintaining storage conditions, types and sources of damage and decay are some of the main stages of the archival process in general, not just in terms of photography archives. The last stage refers to new technologies and media, as well as digitalization and digital image processing. All images, or to be precise, photographs, go through these complex digital processes in analogue and digital photography [11]. In terms of using traditional film in the past, photography used light-sensitive emulsions on celluloid film to capture images. The main problem with emulsions and developers is their expiration date and storage. In analogue photography, the materiality of the film's negative could not be reproduced indefinitely, and yet, the fine nuances between white, grey and black are more visible on film. The depth field of a subject, for example, gains a more detailed and natural look. Although tools such as Adobe Photoshop or Adobe Lightroom access those same nuances, the analogue film increases the fine details in photographs, especially portrait photography. Furthermore, in the last ten years, there has been an increase in analogue photography in general and the production of film. In the early 2000s, many film companies, such as Kodak and Japanese Nikon, stopped manufacturing most of their films. Digital photographs are stored on hard drives, or cloud storage, and memory drives thus losing the material aspect. Nevertheless, this lack of materiality has led to an increase in the digitalization of fashion photographs. Digital software helps photographers organize, categorize, and retrieve their vast digital image libraries efficiently. Digital negatives in fashion photography refer to digital files equivalent to traditional film negatives in the analogue photography era. Most fashion photography today is searchable simply by binary code (0 or 1), but all of those images, often found in the vast media space, are not regarded as fashion photography archives.

4. Conclusion – Photographic Collage of Contemporary Fashion & Mapping Fashion Collections

Through digital fashion photography archives and their interactive nature, we can precisely map fashion collections. These collections do not exclude fashion illustration; on the contrary, they incorporate all aspects of various fashion representations throughout history. Hence, archives of contemporary fashion photography led to the awareness and importance of preserving photographic material, noting the valuable work of both designers and photographers. This mutual relationship resulted in fascinating images, which we are able to see due to digital archives. Furthermore, through the medium of photography today, we are able to collect and map fashion and textile collections. Britain's V&A Museum is an excellent example, and there are many more, such as FCDR or 'The Fashion Calendar Research Database', a research and visual database, including fashion and textile collections index and interactive map, using various media. This overlap of different forms of media has affected the process of gathering archival material and presenting it in a digital form. Of course, there is one negative side effect of this process, and that is the lack of tactility. When exploring archives, including photographic ones, the material aspect can't be replaced. However, in today's new media-saturated world, archives are more than needed since they form a platform where one can research, learn and look. Photographic 'collage' of contemporary fashion is thus visible because of these digital archives and platforms, which also help form complex narratives around artists' work, collections and exhibitions. Through digitalizing archives of fashion illustration and fashion photography, we gain insight into fashion history, and we are able, as viewers and researchers, to contextualize the work of each fashion designer and photographer. As a result, fashion collections are digitalized, forming specific maps of local and global contexts.

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DIGITISATION OF HISTORICAL DRESS AND TEXTILE COLLECTIONS: FACILITATING PLATFORMS FOR ACCESSIBILITY, PRESERVATION, AND RESEARCH OF MATERIAL CULTURE

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Abstract: *By adopting new museological functions, surviving artefacts open up the possibility of illuminating complex interrelations between the lifecycle of humans and objects. Imbued with a unique and intimate material memory, historical textiles encapsulate evidence surrounding their conceptualisation, production, and consumption, as well as their distinct participation in the construction of social and cultural identities. Encouraged by conservation-related requirements and challenges posed by the traditional mechanics of storage and display, collections and archives have embraced a range of advanced technologies in order to strengthen their role as repositories of material information. The potentially unlimited virtual space of digital representations contributes to the specific goals of individual collections by enabling enhanced accessibility and widespread dissemination of content, thus allowing the values embedded within the physical structure of objects by both their makers and users to cross the barriers of institutional settings. Furthermore, considering the fragile nature of historical textiles and their susceptibility to deterioration, the development of digital collections lowers the risks of excessive handling while providing unprecedented opportunities for scholarly research and alternative pathways to artefact investigation. In order to address the diverse implications of the digitisation process, this paper will explore the relationship between physical and digital collections of dress and textile objects as material remnants of the past, the ability of digital representations to convey authentic cultural meaning and value, as well as the ongoing demand for the standardisation of data and its interoperability within the digital environment.*

Keywords: *digitisation; dress; textiles; preservation; collections; material culture*

1. Introduction

Transferred to the environment of collecting institutions, the physical structure of surviving objects preserves their historical existence while allowing them to acquire new roles as primary evidence of material conditions in which they were initially made, circulated, and consumed. As carriers of meaning with the ability to articulate historical processes and patterns belonging to the broader field of social and cultural history, collected and preserved artefacts open up the possibility of a direct, object-attentive methodological approach to scholarly investigations in a variety of disciplinary and interdisciplinary fields, ranging from art history and anthropology, to craft and design studies. Within the specific sphere of material culture research, the analysis and interpretation of extant objects, as well as the focus on their position within a range of community settings, expands the perspectives obtained through the study of visual and documentary sources by enabling archival remains to uncover encapsulated cultural beliefs and expressions of value [1]. In addition, historical abilities of objects to enter new cycles of consumption, extend their life expectancies as commodities, and transform their cultural biographies [2] highlight the ways in which interactions with the material world shape relationships between humans and objects, including the construction and communication of social and economic issues related to personal and collective circumstances.

By taking on various semiotic roles, dress and textile objects act as exemplary tools in expressing patterns of taste, negotiations of individuality and distinction, as well as compliance with societal standards surrounding rituals of birth, maturation, marriage, and death [3,4]. Moreover, while encapsulating prevailing aesthetic principles, manufacturing techniques, and pathways of global trade, detailed readings of their material properties open up the potential to approach textiles as specific "sites" of memory [5] invested with physical and emotional experiences linked to personal consumption practices and imbued with amicable and intergenerational meanings of social interchange. In order to carefully interpret intricate ties between the lives of humans and objects, artefact-based investigations require the adoption of a complex research methodology combined with the application of historical knowledge and professional skills that enable a closer look at evidence related to the processes of making and embodying textile objects. However, along with collection management and display, excessive handling for the purpose of scientific enquiry may further exacerbate deterioration and cause irreparable damage to their, already vulnerable, physical existence [6]. Made of natural fibres, historical textiles belong to the category of artefacts with the highest degree of fragility whose safekeeping for future generations should be accompanied with the implementation of a range of preventive

conservation measures. Despite being stored in controlled environments to minimise further degradation caused by light, humidity, inadequate temperature, dust, and contamination [7], opportunities to fulfil some of the central missions of collection-holding institutions concerning the dissemination of knowledge through public presentations of cultural heritage require an equal level of control along with the avoidance of indefinite displays. As a result, guidelines stipulated by the ICOM Committee for Museums and Collections of Costume in relation to accessioning, storage, conservation, and display of historical textiles, indicate the importance of documenting dress and textile collections as a valuable pathway towards the reduction of harmful effects associated with conventional hands-on practices [8].

2. Collecting institutions and technology

Although traces of information technology have been observed throughout the organisational processes of cultural institutions since the 1960s [9], unprecedented opportunities for the publication of textual information stored within museum databases and collection management systems started to emerge with the advent of institutional websites. Such novel avenues for scholarly research and public exploration of archival material opened up the opportunities to transform institutional conventions and substantially alternate contemporary interactions with the past. Marked by the adoption of digital technologies, the last decades have continued to experience exponential shifts in the accessibility of material culture objects through the unlimited space of the virtual sphere, with diversified ways of publicising knowledge managing to challenge and enhance some of the elementary functions of museums and material culture collections. While the increase in opportunities to document extant artefacts through digital repositories should be asserted as a tool instead of objective sui generis [10], digital re-contextualisation of information pertinent to museological afterlives of objects appears to be of crucial importance both in relation to the introduction of individual dress and textile artefacts to global audiences as well as with regard to their ability to serve as vehicles for historical analysis.

Within a number of collecting institutions, closer examinations of the materiality of textile objects can be commonly restricted due to preservation-related considerations and their physical unavailability in times of display. As the object-based study of fibres, decorative patterns, construction techniques, and practices of wear demands detailed observation and application of a discipline-specific methodology, careful interpretations of garments and textiles are inevitably linked to viewing appointments, whereas handling needs to be performed by specialised museum professionals. Due to limitations imposed by their high sensitivity, the demand for first-hand examinations may, in most institutions, lead to substantial waiting times based on staff availability and may be accompanied by the need to locate relevant artefacts in disparate institutional settings. In addition, issues related to collection management, insufficient space, and limited funding, may keep a large percentage of artefacts permanently in storage, away from fulfilling their core museological function to communicate historical narratives to broader audiences. In cases such as these, as well as during the time spent on loan or undergoing conservation, previously mentioned documentation processes suggested by ICOM, including photography, pattern-taking, drawings, and written descriptions, may indeed significantly supersede the amount of repeated handling of historical textiles. In order to open the door for research in dress and textile history through representational material, additional steps are required to enable access to accumulated information. To this end, continuous and long-term assimilations of technological advancements within the structure of historical collections have managed to introduce museums and other collection-holding institutions towards their current position within the evolving context of digital culture.

3. Digital representations and issues of authenticity

Through their ability to facilitate interaction with digital images rather than with sensitive or remotely located physical objects, digital databases have brought profound changes to the study of dress and textile history. Despite the material absence of a textile object, textual information concerning its provenance records, including origin and cultural practices surrounding ownership [11], as well as other inventory content in relation to curatorial, educational, or conservation-related material [12], can now been remotely discovered alongside digital images of the object’s physical form. This way, digital projects enable historical details surrounding dress and textile artefacts preserved in institutions such as the Costume Institute collection of the Metropolitan Museum of Art, where access by prior appointment requests may be limited to scholars, students, and designers, to extend their existence beyond the physical boundaries of institutional settings as exclusive guardians of materially embedded information. Aside from increasing the visibility of collection holdings, digital renderings encompass various sets of functions. As discussed by Anne Beaulieu and Sarah de Rijcke, integrated in databases, digital images take on new roles as interfaces leading users to change their habitual interactions with historical information as well as to adopt, what the authors term, "networked practices of seeing." In order to facilitate new ways of looking at objects, particularly when it comes to professionals with specific skills in working with digital material culture, digital representations should be sufficiently reliable, fulfilling a set of requirements in relation to their size, quality, and the implementation of the digitisation process.

Rather than focusing on their quantity, digital images should be understood as active objects that enable detailed viewing possibilities without the direct interaction with objects. To meet these goals, digital museum objects should be accompanied by a high level of interactive functionality, such as the ability to zoom in to detect details invisible to the human eye or accommodate changes in resolution [13]. According to ICOM, the process of photographing historical dress and textiles necessitates utmost care and prior experience in museum photography. In order to obtain sharp images with accurate colours without repeated handling and prolonged exposure to light and heat, the documentation process should be accompanied by curators and conservation experts and conceptualised in advance in terms of the desired documentation of details, angles, and background [8]. With regard to challenges related to traditional mechanics of displaying historical garments that demand materialised substitutes for the human body or, as postulated by Mark B. Sandberg, "effigies - not simply the mannequin kind but an entire range of recorded and digital bodies" [14], complex three-dimensional visualisations with rotating figures and multiple points of view may maximise the use of digital technology by seamlessly creating an illusion of the key missing element of public exhibition - the human body.

Since the emergence of online databases and as part of an ongoing interest in the implementation of digitisation projects, digital objects have proven themselves as invaluable tools in scholarly research. However, discussions of the relationship between original objects and various types of museological substitutes [15] call attention to the complexity of issues surrounding the levels of authenticity provided by indirect, mediated engagement with archival content. Material culture scholarship highlights the importance of sensory, tactile, and affective experience in dealing with objects with the purpose of uncovering their full potential as repositories of meaning. In a similar way, Walter Benjamin reminds us that "in even the most perfect reproduction, *one* thing is lacking" and by referring to the "unique existence" of a work of art, Benjamin stresses the importance of its ability to carry "the mark of the history to which the work has been subject," a history that covers "changes to the physical structure of the work over time, together with any changes in ownership" [16]. Benjamin's words expressed in relation to his concept of aura resonate with investigative aims of the interdisciplinary field of material culture studies, its focus on the study of man-made objects, as well as the adoption of artefact-based methodology. This may lead to assumptions that digital representations of historical dress and textile objects may not possess the ideas of materiality equal to those uncoverable in direct interaction with surviving artefacts. Within the established field of dress history, object-attentive investigation requires a particularly meticulous involvement with the extant object in order to observe all relevant information pertinent to its fabric, cut, construction, and style, to analyse details such as buttons, zippers, hooks, and trims, as well as to elucidate signs of wear, alterations strategies, and other physical interactions with the artefact that can identify individual circumstances of its previous owners [17,18].

As postulated by Ingrid Mida and Alexandra Kim within their "Slow Approach to Seeing," a methodological phase that requires a distinctive, thorough approach when examining historical dress as material evidence, images taken during the research process may be beneficial, but are not to be used as a primary research method of object-based analysis [19]. On a similar note, while discussing the accessibility of historical artefacts, in their introduction to *Writing Material Culture History*, Anne Gerritsen and Giorgio Riello indicate the invaluable contributions of online catalogues, databases, and digitisation projects, as well as the importance of the integration of textual and visual information for material culture enquiries, ending on a note that "online access to digital images is one of the tools available to researchers and cannot substitute the engagement with material artefacts" [20]. However, as argued by contemporary museological scholarship, to ensure the fulfilment of their potential, digital museum objects should be released from imposed hierarchies of value established in relation to their physical counterpart in which they may occupy a lower position [21] and should be seen as objects in their own right, with their own aura that actualises, confirms, and enhances the historical authority of the original object [22]. Most importantly, having in mind that aging and deterioration processes may affect textile artefacts regardless of conservation-related efforts, digital images possess the unique quality to capture a particular state of materiality and "solidify" the features of physical objects within a specific moment in time, excluding future marks of museological afterlives from their original historical biographies [23].

4. Metadata schemas, interoperability, and searchability of digital collections

The encounter of relevant archival material by dress and textile history scholars, museum professionals, and non-professional users remains largely dependent upon the institutional adoption of controlled vocabularies and standardised metadata schemas [24]. Responsible for the discovery of information, structured vocabularies describing textile objects, including their title, provenance, makers, date, and related concepts, facilitate access to digitised collections in relation to specific user enquiries and professional work in database settings. While focusing on the relationship between textiles and digital technology, Amanda Sikarskie offers insights into the Michigan State University's Quilt Index, an immense digital repository of quilts collected by private and public institutions across the globe developed as part of a university's digital humanities research and education project. By correlating the success of digitisation projects in archival preservation with the quality of selected metadata schemas, Sikarskie positions the adoption of internationally recognised standards for

indexing and retrieval of visual culture and decorative objects such as the Dublin Core and VRA Core in relation to custom vocabularies. Sikarskie argues that metadata schemas should reflect the specificities of the collection and asserts that, despite their high interoperability with other collections, standard vocabularies may not necessarily represent the most appropriate solution due to their limitations in describing the abundance of details embedded in historical textiles [25].

Along with the study of material evidence, methodological approaches in dress and textile history indicate the importance of integrating object-attentive research with a range of primary visual and textual sources, such as paintings, photographs, illustrations, periodicals, inventories, diaries, and personal correspondence [7,26]. Given that this material may be located in distant museums, archives, and libraries, engagements with digital databases can be enhanced by aggregators with the power to connect multiple repositories, thus instigating novel pathways for scholarly insights, curating opportunities, and juxtaposition of knowledge [12, 27]. Significant contribution to the aggregation of dress and textile collections has been made by Europeana, a European Union project with the aim of creating a shared digital environment to empower Europe's rich cultural heritage sector. By joining aggregators whose scopes are marked by cultural domains, themes, nations, and regions, Europeana interconnects thousands of organisations, with the European Fashion Heritage Association acting as the world's largest fashion heritage network that provides a link between more than 50 private and public cultural heritage institutions from 15 European countries [28]. Established in 2014, the Association accompanied the Europeana Fashion project funded with the purpose of connecting geographically dispersed, heterogenous digital collections and building a thematic aggregator to supply the Europeana website with fashion-related content, including historical dress, accessories, photographs, magazines, drawings, catalogues, and videos [29]. In collaboration with brand archives, such as Salvatore Ferragamo, Missoni, and Pucci, as well as prominent museums, such as the Victoria and Albert Museum, Fashion Museum Antwerp (MoMu), Musée des Arts Décoratifs Paris, and Pallais Galliéra, among others, the Association has managed to develop the largest existing digital fashion heritage repository and expand access to fashion heritage data through the Europeana website.

With an extensive collection of over 1.2 million objects, the Victoria and Albert Museum continually implements strategies to redesign its online collections in order to facilitate the exploration of temporal and geographic contexts surrounding the original lives of objects and enhance the needs and experience of users by improving searchability and discoverability of its digital content. The museum's "Explore the Collections" portal enables visitors to enter their queries into the search field as well as to filter objects by category, maker (person or organisation), collection, gallery, style, place, type, technique, material, and date, allowing them to make further comparisons with similar artefacts via buttons available on the information page of each object. Discussing its goals to make collections discoverable through a search service that is both efficient and accurate [30], the Victoria and Albert Museum indicates an awareness of difficulties encountered by users during the digital search process. According to Joan Beaudoin, these issues may be commonly associated with search functions, field labels, order of retrieved items, as well as general differences in descriptions and terminology used by professional staff and external visitors [31]. In this sense, encounters with digital dress and textile collections and success in the retrieval of information belonging to relevant material may be enhanced through improvements in the use of structured metadata schemas and nomenclature standards [32]. Yet, the accomplishment of such goals may be limited by the complexity of the digitisation process itself as part of which issues of expertise, time, and funding cannot be overlooked. In the United States, only a third of art museums have made their collections available online [31] and new projects related to the digitisation of cultural heritage are still being developed and supported within the network of Europeana. While Marie Riegels Melchior differentiates between the concepts of "dress museology," delineated as a practice that underpins the study of dress history based on the ICOM handling and preservation guidelines, and "fashion museology," described as its extension focusing on the cultural phenomenon of fashion with links to fashion industry, designers, and celebrity culture [33], this paper has considered and integrated "dress" and "fashion" as discussed by Mida and Kim whose object-based methodology outlined in *The Dress Detective: A Practical Guide to Object-Based Research in Fashion* covers objects defined by both terms, including within the notion of dress "all clothing and accessories that exist in material form" [19]. Understood as carriers of meaning, surviving artefacts have the power to act as texts and, in a distinctive way, enrich the exclusive analysis of written documents by drawing attention to the complexity of human voices that would otherwise remain absent from historical scholarship [34]. To this end, the paper aimed to approach the ways in which advanced technologies opened up new chapters in the history of material culture collecting by enhancing the visibility of the vast human experience of making, using, and embodying textiles through the means of a democratised and inclusive networked environment.

5. Conclusion

As a continuously evolving process, the digitisation of dress and textile collections has thoroughly transformed institutional practices by supporting a range of strategies that combine efforts related to the preservation of delicate archival material with innovative approaches towards the exploration of social and cultural history. Observed through the framework of material culture studies, along with their numerous advantages, the potential of digital museum objects to replace tangible, unmediated contact required for scholarly analysis in the field of dress and textile history has been positioned within the dichotomy of authenticity and representation. While object-based approaches in the study of dress and textiles demand direct insights into the complex physicality of artefacts to uncover narratives surrounding human engagement with the material world, ranging from details of manufacture to consumption patterns and negotiations of identity, it can be argued that interactions with digital counterparts have the unique power to confirm the authenticity of surviving objects, their historical existence, and aura, as well as to strengthen the ability of digital collections to support novel modes of academic enquiry and curatorial initiatives. Most importantly, the wide-ranging opportunity to investigate dress and textile artefacts through digital repositories crosses the necessary boundaries imposed by their museological afterlives, allowing objects to communicate their physical presence outside the limits imposed by time and geographic proximity, thus forging a diversified participatory experience in the production of knowledge.

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DIGITAL DESIGN AND DEVELOPMENT OF A NON-STANDARD 3D FASHION CLOTHING PRODUCT

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Abstract: *In today's modern world, digital fashion has become one of the priorities in the fashion industry. It offers enormous opportunities in all areas of the value cycle, from design to sales, and the technologies used are evolving rapidly, especially in the context of sustainable approach to the product development process. The publication presents the research conducted in the field of 3D visualization of non-standard spatial modeling of fashion clothing products using the CAD systems. The possibilities of 3D visualization of these types of custom products have not yet been thoroughly explored, but they could be a huge step towards in the development of digital fashion and sustainability. The research includes the design of a garment model with a spatial 3D element, the construction and modeling of garment pattern and the development of a 3D prototype. In that demanding process, the possibilities of simulating such a complex spatial elements were investigated in terms of modifying the simulation and fabric parameters in order to obtain targeted 3D visualization. In the final stage developed 3D model was rendered in different variations of fabric colours and textures.*

Keywords: *digital design; 3D fashion; non-standard clothing; virtual clothes; CAD system; sustainability*.

1. Introduction

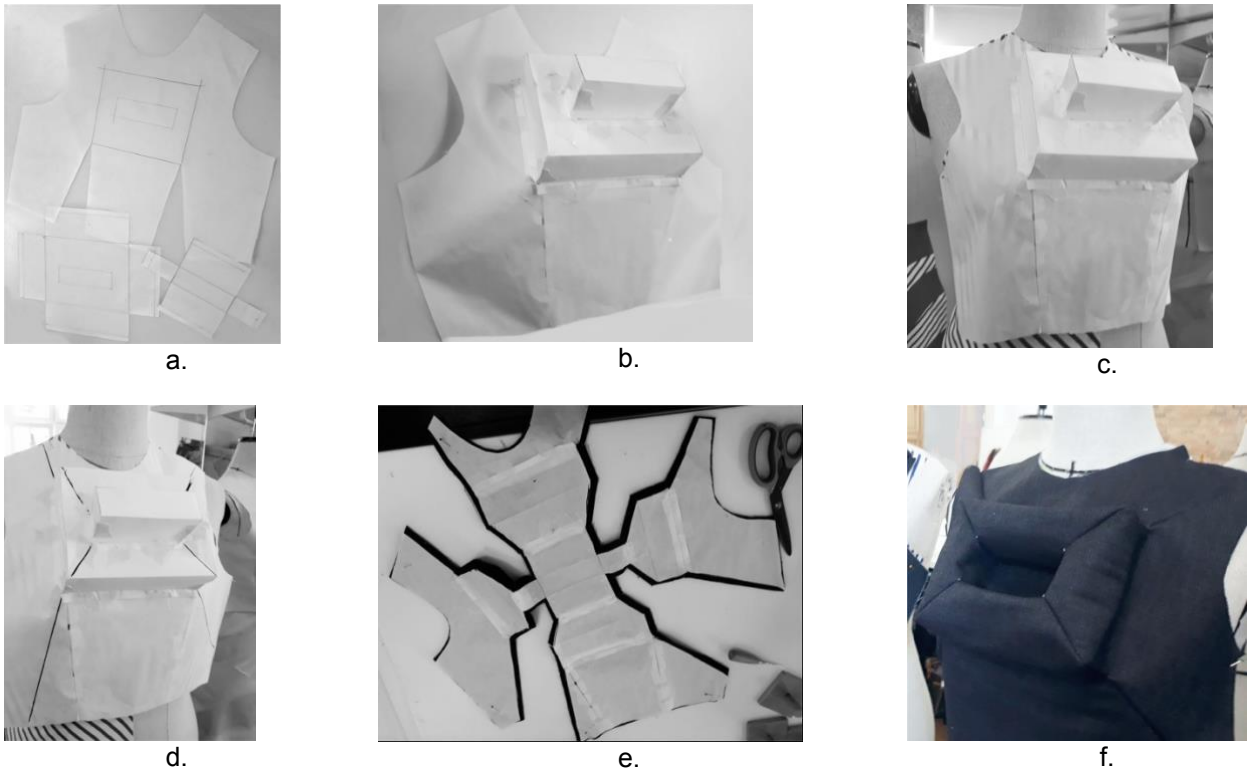
The main problem of digital fashion is the creation and visualization of 3D non-standard spatial modeling of clothing products using CAD systems. These types of clothing products with a large spatial form are usually created directly on the mannequin by actually building a prototype on the mannequin. This is a very labor-intensive process and requires knowledge and skills in using the spatial modeling technique in building such forms of clothing, but above all, skillful selection of textile materials for a given project so that a given form of clothing can build a spatial form. The current possibilities of 3D visualization of this type of custom product have not yet been thoroughly explored. Still, they can represent a huge step towards the development of digital fashion and sustainability. The visualizations so far include a standard, body-hugging garment that may have multiple layers that adhere to the body. In the available literature, there are many examples of the use of 3D visualization in CAD systems, mainly in the visualization of standard clothing [1-5]. The authors of the article [3] attempted to visualize a women's clothing collection with complex, structural sleeve forms. Using the 2D/3D CAD systems for computer clothing design, 15 models of women's clothing with structural sleeve forms were constructed and modeled. The ability to visualize spatial designs provides great opportunities in the cycle of producing non-standard spatial structures of projects. This fits into the current trend of personalizing clothes. A digital approach from design to sales provides an opportunity for a sustainable approach to the product development process, especially for spatial non-standard patterns [6].
In this article, the process of digitization and construction was carried out for patterns. The computer clothing design included all stages of developing a 3D computer prototype, the aim of which was to explore the possibilities of 3D modeling and simulation of complex non-standard structures of geometrized spatial forms. The influence of 3D simulation parameters was investigated in correlation with the applied Structural, physical, and mechanical properties of the textile material to obtain complex 3D forms of simulated clothing models. Real variants of fabric colors and patterns were introduced in computer-designed 3D models to obtain a realistic visualization of the designer clothing collection.

2. Experiment

The following subsections present the stages of the process of developing a design for the spatial construction of clothing, from the actual design on a mannequin to digital visualization. The experiment aims to check the possibility of visualizing spatial designs in CAD systems.

2.1. TR Spatial modeling technique – creative moulage of geometric spatial forms on the blouse

The experiment was started by creating the project of the geometrical spatial form of two cubes stacked on top of each other and placed on the front of the blouse. This project was made by Technik's spatial modeling name creative moulage on workshop with Transformational Reconstruction (TR) Cutting techniques world famous Japanese couture designer SHINGO SATO Fig. 1.



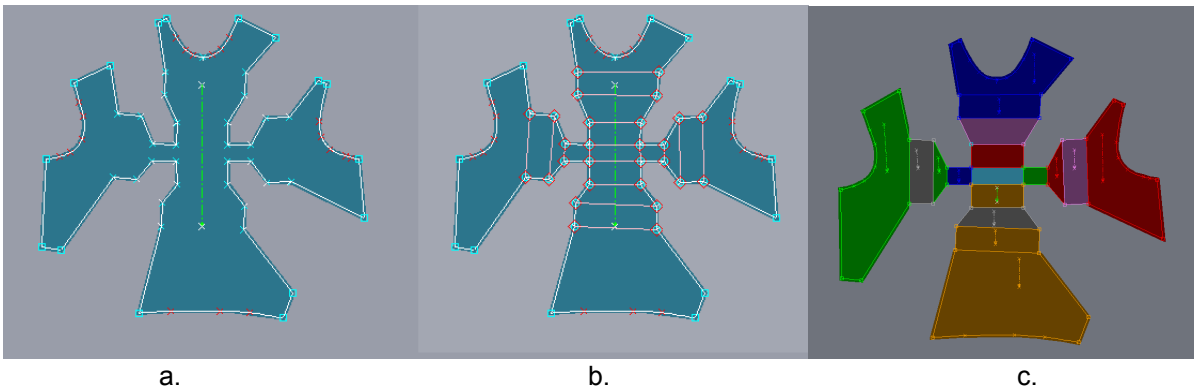
a. b. c.

d. e. f.

Figure 1: Process of moulage spatial modeling of geometry two elements on the front blouse: a. patterns to spatial modeling, b. connection to every pattern on spatial forms, c. spatial forms putting on the mannequin, d. drawing the main cutting line, e. cutting the forms by adding from textile material, f. realization.

2.2. Digital process with spatial modeling patterns

The digital process started from the digitalization of the patterns formed from spatial modeling. This process was made in the Modaris CAD Lectra system Fig. 2. This process shows that geometrical elements are not parallel and particular. It is the effect of the manual preparation of forms from very thin paper, which causes the deformation of geometric elements in the process of gluing individual elements. At the same time, the digital patterns in the CAD ASSYST system started from drawing construction of every element in a particular and parallel direction Fig.3.



a. b. c.

Figure 2: Digital process of spatial modeling form: a. digitalization of pattern,
b. selection on small rectangle elements, c. separation on small patterns in the Modaris CAD Lectra system.

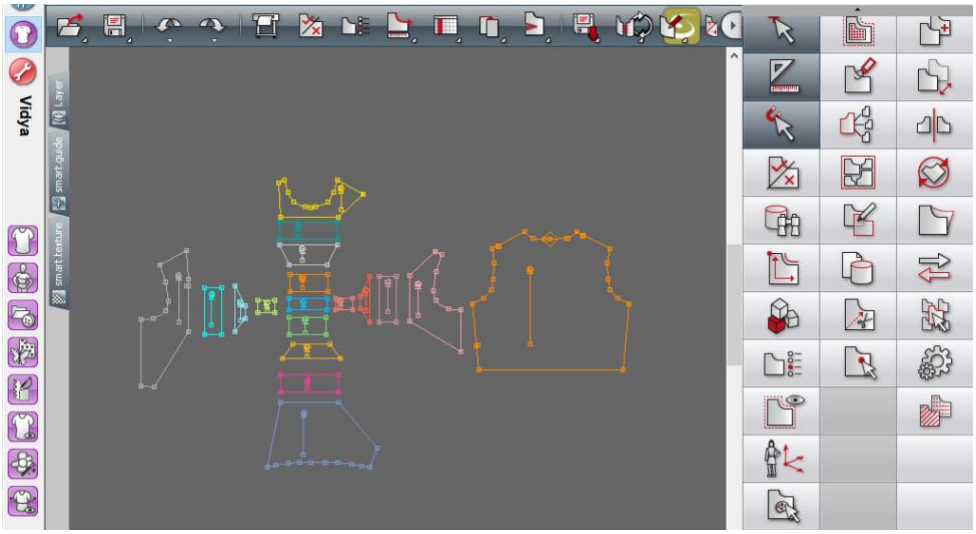


Figure 3: Process of pattern construction in the CAD ASSYST system.

2.3. Preparation for digital 3D spatial visualization of a non-standard clothing product

The next step after pattern construction was setting the levels of every pattern element. Two variants assumed positions on different levels. The first variant was used 5 levels. The second variant used only 3 levels, where 0 is the background and 2 or 4 is the most distant level from the body Fig.4.

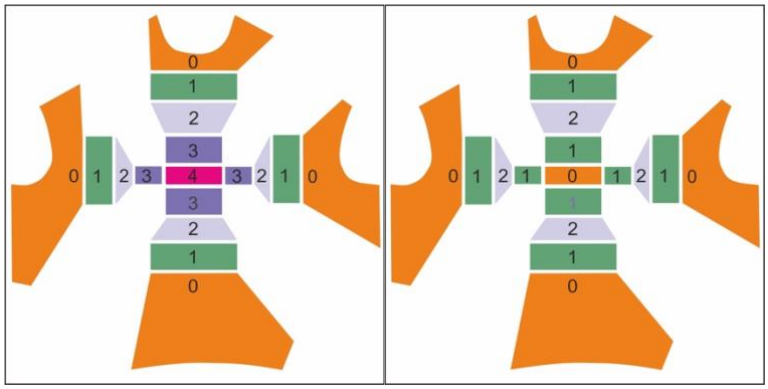


Figure 4: Process of patterns setting on the level for simulation in the CAD ASSYST system: a. variant 1., b. variant 2.

Preparing patterns for 3D visualization requires assigning properties related to the size table, straight threads, seams, and sewing. The correct setting of sewing lines guarantees correct simulation Fig. 5.

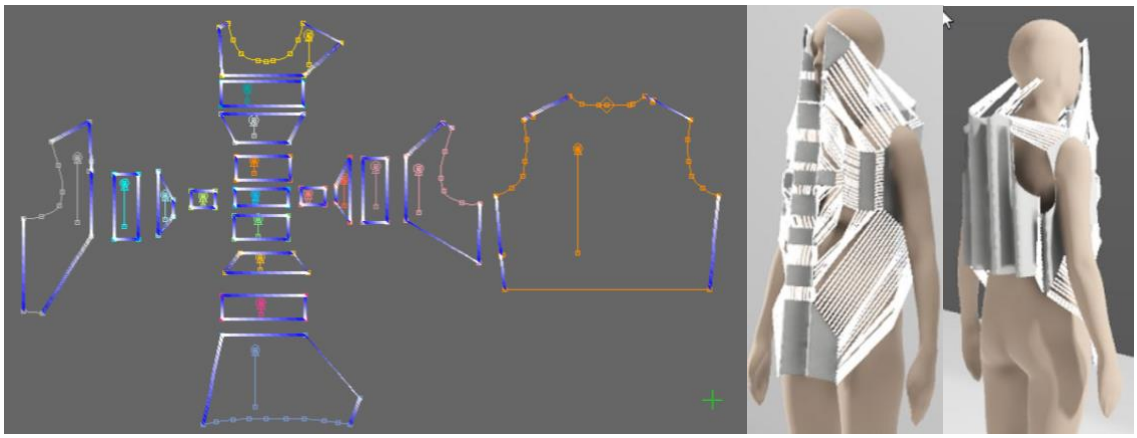


Figure 5: Process of pattern sewing in the CAD ASSYST system.

2.4. Materials

For the experiment 3 fabrics: F1 Chino, Fa Jeans, F3 GenuaCord were taken. These fabrics come from the waste of clothing factories. These fabrics are made from Cotton with Elastane Fig. 6. Table 1 presents the properties of these fabrics, which were researched from the KES system. In addition, for comparison, a visualization of the Denim fabric from the Vidya CAD ASSYST system with specific properties given in Table 1 is presented.

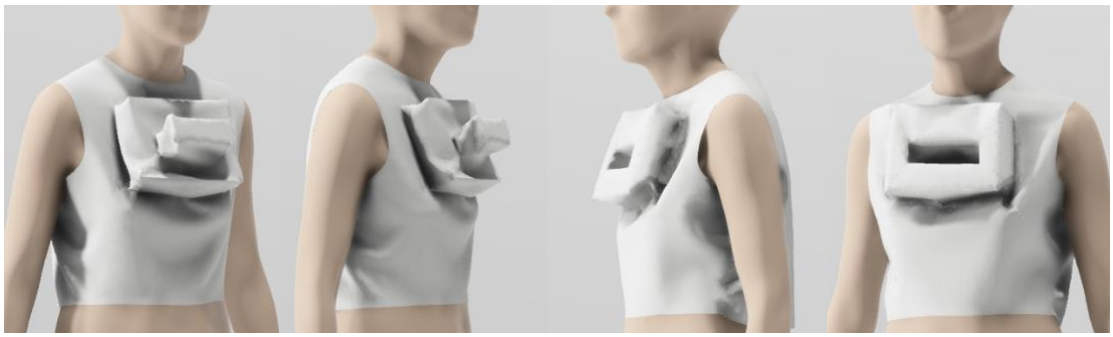
Figure 6: Image of real textile fabrics to visualization in the CAD ASSYST system.

Table 1: Structural, physical, and mechanical characteristics of the textiles used for simulation.

Types of fabrics	Raw material	Type of weave	Fabric area density [g/m^2]	Thick-ness [mm]	Elongation [%]		Bending stiffness [cNcm2/cm]		Shear property [N/m]
					warp	weft	warp	weft	
F1 Chino	Cotton+ Elastan	Twill	234.35	0.581	1.9	14.66	29.28	6.30	0.02
F2 Jeans	Cotton+ Elastan	Twill	394.73	0.811	5.32	8.05	37.76	15.86	0.06
F3 Genua Cord	Cotton+ Elastan	Velvet	275.88	1.016	1.46	16.59	19.06	7.72	0.04
X/CAD DENIM	Cotton	Twill	840	1,54	0,2	0,5	36	7.2	0.06

2.5. Digital 3D spatial visualization of a non-standard clothing product

In the first step, the visualization of the variant 1 and variant 2 patterns in the Vidya CAD systems was made using the raw materials from this system to show correct sawing Fig. 7a. In the second step was made the visualization using the main fabrics F1-F3. Our goal was to present real materials. Therefore, photographs and scans were taken to digitalize the real textures. For this, a scanned image of the real fabrics was taken into the system for the best real visualization Fig. 7 b-d.



a.

Figure 7: The visualization in the Vidya CAD ASSYST system using: a. raw material from the system -variant 1 and 2 of the patterns, b. fabric F1 CHINO, c. fabric F2 Jeans, d. fabric F3 GenuaCord.

The third step was preparing the sample of different visualizations using the different images of fabrics using the XCAD sample from the Vidya Cad system Fig. 8.

Figure 8: The visualization in the Vidya CAD ASSYST system with using X/CAD DENIM fabric properties.

On the end of this experiment was made the chart from warp elongation of these patterns Fig. 9.

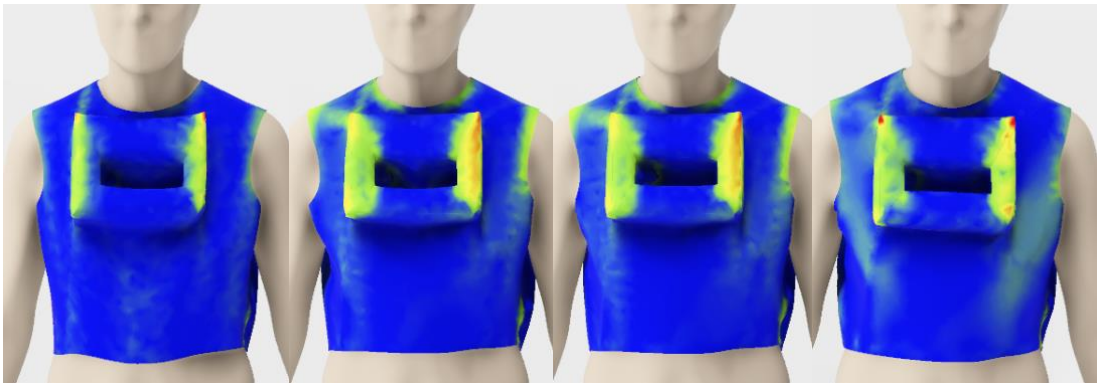


Figure 9: Warp elongation in the fabrics: F1, F2, F3, XCAD.

4. Summary

The experiment allowed us to check the possibilities of constructing and visualizing non-standard, spatial forms of clothing in the Vidya CAD ASSYST system. The research carried out shows that it is possible. The individual stages of this experiment show that in the case of geometric forms, digitization of ready-made forms resulted in less accurate forms, which required a correction process and matching individual sections. A better solution is to draw the structure in a system where we can determine the size of individual form elements with an accuracy of one-hundredth of a millimeter. For digital visualization close to the real one, you need to prepare an image of real fabrics, as well as determine the structural, physical, and mechanical properties of the fabrics used for simulation. The Vidya CAD ASSYST system allows you to enter textile property parameters such as Fabric area density [g/m2], Thick-ness [mm] and Elongation [%], Bending stiffness [cNcm2/cm] Shear property [N/m] in warp and weft direction. For visualization, it is necessary to indicate layers of elements to be located at different levels. The layers 0-4 for variant 1 patterns and 0-2 for variant 2 adopted in the experiment allowed for correct visualization. For visualization, it is necessary to determine the attachment point to the avatar's body. In the case of the upper body, it is the 7th cervical vertebra. The weft elongation distribution shows the textile properties' differences. The difference is significant in the case of F1 fabric, which is the thinnest. However, for F2 and F3 the difference is invisible, which shows that for the simulation a significant parameter of textile properties is Thickness [mm] (for F2 0.811 [mm] for F3 1.016 [mm]). Visualization in a 3D CAD system is a huge opportunity for prototyping non-standard spatial forms of clothing, which has not been tested so far.

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DIGITAL FASHION AND ARTIFICIAL INTELLIGENCE

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Abstract: *By digital fashion, we understand clothing made using computer technology and 3D software, but the term itself denotes new and unlimited possibilities of fashion and clothing in the digital environment. Unlike traditional fashion, which requires real materials and fabrics, digital fashion requires data and code, meaning there are no limits to what can be designed or created. Thus, contemporary fashion becomes a platform for transferring from the traditional understanding of fashion and clothing to an entirely digital object. In this context, fashion does not have to be 'tactile'; it is recognized by a specific visual, fashion and digital code. Therefore, the concept of 'tactile transmediality' is of great importance in researching the concept of digital fashion and its significant influence on the change of society and the creation of metamorphic identities. Furthermore, everything can be tailored in fashion digitally, according to particular tastes and needs. This paper will explore the relationship between digital fashion and artificial intelligence (required to create products with complex social and technical software), considering the complex relationship between AI and fashion as a model for shaping fluid identities in contemporary digital visual culture.*

Keywords: *digital culture, artificial intelligence, identity, fashion object, intermediality, tactile transmediality, visual culture*

1. Introduction

Digital fashion represents a revolutionary step in the evolution of the fashion industry, allowing designers and consumers to experience unique flexibility and adaptability in designing and wearing clothes. This paper explores how artificial intelligence contributes to the development of digital fashion, enabling increasingly complex forms of design that reflect the contemporary world's broader cultural and social dynamics. Reviewing research and industry examples, this paper explores how "AI" is being used to optimize the manufacturing process, personalize user experience, and create unique design identities that adapt to individual preferences. The digital technologies and fashion industry shift has opened up a new era of creative and transformative potential. Digital fashion, characterized by a reliance on data and code rather than traditional materials, has seen a surge of interest in recent years [1]. This paper sheds light on the transformative nature of digital fashion, focusing specifically on the indispensable role of artificial intelligence in shaping the fashion industry. By understanding the implications of artificial intelligence in the design and production of digital fashion, we can gain insight into the significant impact this permeation has on contemporary fashion and visual culture. The concept of digital fashion has pushed the traditional boundaries of the fashion industry, enabling an unprecedented level of creativity and customization. In the past, the restrictions imposed by physical materials and production processes often limited fashion design. However, digital technologies and 3D software have significantly expanded the boundaries of what can be designed and created in fashion. Digital fashion has transferred from conventional industry norms, paving the way for a more fluid and adaptable approach to clothing design. The symbiotic relationship between artificial intelligence and digital fashion serves as a model for understanding the role of fluid identities in contemporary digital visual culture. In his work: 'Digital Fashion: Transforming the Industry through AI and Virtual Reality', Smith [2] explains how the integration of artificial intelligence and virtual reality has not only transformed the industry but also redefined how individuals perceive and express their identity through dress and dressing. This union has led to the democratization of fashion, allowing individuals to express their unique identities and preferences in a previously unimaginable way.

Digital fashion, therefore, becomes a tool for identity, self-expression and interoperability. People have always sought new ways to express their identity. New generations demand that virtual spaces be inclusive and accept options for different races, ethnicities, ages, and gender identities, often very limited in real life. A key benefit of digital fashion is that it gives users more control over their online presence than ever before, as digital fashion platforms offer users more ways to express themselves, even more than the physical world offers. For example, they allow them to create clothes using different combinations of colours, patterns, shapes and textures. Furthermore, digital fashion allows users to express their style while creating new trends for other users to follow. Despite these significant advances, the industry has struggled to address issues such as interoperability, scalability, and individual privacy in AI. Digital fashion is also changing the way we think about clothing. People no longer buy a specific item of clothing; they buy the experience or emotion they gain by shopping [3]. Because of this, digital fashion is no longer limited to science fiction; with the drastically rapid

development stages in this relatively new research field, it is only a matter of time before digital fashion becomes a part of our everyday life, and it will indeed become a reality as virtual and augmented reality advances in the coming years. Overall, various forms of digital fashion can bring numerous short-term and long-term benefits. In addition, new markets and borders worldwide will open up for modern people and companies. So, while we may not all be walking fashion catwalks, the trend toward high-tech fashion seems inevitable.

2. Methodological Framework, Field and Application: Contemporary Fashion Practice, Technology and the Concept of Tactile Transmediality

In the last ten years, contemporary fashion practice has experienced a significant turn in understanding these crucial terms: the body, physicality, materiality and tactility. Thanks to the influence of new media and digital technologies, fashion is at a theoretical and practical crossing, as was the case with fashion in the early 1990s, when fashion moved to the "edge" and became "traumatic" [4]. Fashion research has moved from traditional theoretical questions about identity and "style" to questions about materiality, tactility and the possibility of building new identity positions through new-media digital tools. The usage of "intelligence" in fashion raises questions similar to the application of intelligence in communicative machines: Can there be an intelligent object that does not need to convey the passing of time with an increased need for beauty? [5] New ways of creating, applying, and digitally marketing clothes and meaningful changes that affect the construction of body image and identity are now occuring. The Austrian designer and author Sabine Seymour coined the term "fashionable technology" in 2000 when she noticed the increasingly strong connection between design, science, fashion and technology [6]. Seymour writes about the importance of fashionable wearables in collaboration with technology and emphasizes: ''Fashionable wearables are 'designed' garments, accessories, or jewellery that combine aesthetics and style with functional technology''. As designers of modern wearables, we view users as modern beings who pay attention to the style and powerful potential of wearable technology. Our design philosophy is based on the idea that garments are a direct interface with the environment and, therefore, a constant transmitter and receiver of emotions, experiences and meanings [6]. An excellent example of this fashion practice is the work of Croatian experimental designer Jadranka Hlupić Dujmušić and her 3D body accessories (Figure 1).

Furthermore, the British theorist and philosopher Malcolm Barnard, discussing the functions of clothes, points out: "Technology can improve the functions of clothes and define new ones. Material or physical functions are protection, concealment and attraction. Cultural functions (including social and psychological) are communication, individual expression, social or economic status, political or religious affiliation'' [7]. The functions of clothing, therefore, are various and versatile, but when it comes to digital fashion, "function" goes further. In the context of contemporary fashion, the Dutch fashion designer Iris van Herpen observed the changes in making and designing garments and used new technologies to build her vision of the "body" and dress of contemporary fashion. Van Herpen achieves a recognizable voluminous silhouette and artificial look of the material thanks to 3D software and printing. Technology becomes a platform for creating high-fashion fashion objects, and artificially constructed material becomes a fundamental element of the body [8]. However, the process of designing materials through new technologies is followed by assembling and constructing the garment and observing how the garment behaves on the body. The transformative nature of digital fashion fully matches its nature and the state in which it finds itself. New digital technologies strongly influence the development and practice of fashion design and the creation of the identity of the new digital society. Although fashion and technology are closely connected, the development of artificial intelligence has enabled the adoption of new methods, tools and approaches to design: from materials to new production process, technological advances have changed our understanding of the aesthetics, style and functionality of clothing and fashion accessories. Nevertheless, as artificial intelligence technologies have become more prevalent over the past decade, trend forecasting agencies are turning to quantitative results generated by machine learning for help. These AI tools can detect patterns within large data sets of fashion show photographs, social media notifications, search data, and online and in-store sales data. All of these tools can help forecast what will be in fashion next. Artificial intelligence has multiple benefits in contemporary fashion as it provides a detailed overview of digital developments in fashion, including 3D design, virtual prototyping, on-demand manufacturing, AI-driven trend research and new digital marketing and sales methods. Van Hepren noticed these trends and 'pushed' the boundaries of fashion by presenting her collections in digital form through various new media tools (e.g. fashion process film). In collaboration with scientists, artists and theorists, her fashion house combines design, fashion, science and art in one synthesis.

British fashion designer Alexander McQueen also noticed this, staging the British fashion model Kate Moss as a "hologram" in 2006's autumn-winter collection, "Widows of Culloden" in Paris. Inside a large, glass, pyramidal structure, McQueen places the figure of Moss, who floats in a silk dress resembling Victorian ghost depictions [9]. This hologram performance is also reminiscent of the paradigmatic scene from the Lumiere brothers' silent

film *Annabelle Serpentine Dance* (1896), in which the importance of body movement and clothing is visible in order to bring viewers closer to the nature of the material that wraps the body. McQueen often explored the idea of man versus machine or nature versus technology. He confirmed the importance and prevalence of new technologies and artificial intelligence with his fashion performance "No. 13" (spring-summer) 1999. British ballerina Shalom Harlow was dressed in a voluminous white sleeveless dress, placed in the centre of the stage, and surrounded by two robots. Robots, borrowed from the Italian Fiat company, determined the dress design's final result. This designer's work was marked by ideas of the connection between man, nature and technology, or more precisely, machines. In science fiction films such as *Tron* (dir. Steven Lisberger, 1982) and *Abyss* (dir. James Cameron, 1989), McQueen saw the importance of computer-generated reality reflected in fashion. The last example of this innovative and experimental thinking was in his last fashion show, "Plato's Atlantis", from 2010. In this context, Croatian philosopher, sociologist and theorist Žarko Paić writes: "It was clear to the most radical contemporary fashion designer, Alexander McQueen when in his last performative event called Plato's Atlantis, staged a set of digital technologies, an experiment with the transformation of the human body ("the third skin") and a new aesthetic object such as women's shoes with high heels on the other side of the so-called of everyday life" [10].

Furthermore, the relationship between the body and dress has been at the centre of research since the emergence of Japanese fashion deconstruction in Paris in the 1980s. In the contemporary and primarily digital fashion era, theoretical and practical research has moved to materiality and tactility. In the case of digital fashion, another research area that is very significant for fashion studies is tactile transmediality. However, it is first necessary to highlight the concept of intermediality, that is, the multiplication of one medium into another. The term's history originates from the term "intertextuality" (French: *intertextualité*) of the French structuralist Roland Barthes and his thesis that every text is an intertext. Thus, texts are interweaved into other texts [11], and from the idea that there are fragments of previous texts in each text. Furthermore, intermediality arose in the 1960s and spread to many areas in science and art. The term "intermediality" was first used by Samuel Taylor Coleridge in 1812, and it meant "being between something". However, the term introduced by Coleridge did not refer to the medium in the modern context but to the allegory that interposes itself as an intermediate between person and personification. For him, intermedia means a narratological phenomenon, not a conceptual fusion of different media [12]. Finally, American theoretician W. J. T. Mitchell believes that there is no "pure" media but that each media multiplies into other media and becomes intermediate [13]. Therefore, logically, it is not easy to define terms from these two areas - media and fashion. Although intermediality and transmediality may seem related, they can differ in meaning.

The term transmediality (more precisely transmedial narratology), by the American author Henry Jenkins, refers to the transfer, translation and transposition of one medium into another. In contrast, the term tactility has become the focus of contemporary fashion practices in the age of new media and digital technologies. Jenkins introduced the term transmedia narratology in 2003 as a continuation of post-classical narratology, and in this sense, states: "the flow of content through multiple media platforms, cooperation between media industries and migratory behaviour of the audience that will search almost anything in search of experience or entertainment" [14]. Croatian communication theorist of transmedia narratology and film Sunčana Tuksar compares intermediality and transmediality, highlighting: "The problematic approach now suggests a classification touching the area or intermediality. Narratology transfers or transcends the means of narrative prose to other media, including film. Transmediality, or intermediality, is inevitable because semiotics is broadly understood and interpretatively connected to other disciplines such as sociology, psychology or anthropology [15]. Croatian art historian Krešimir Purgar further states that it is a question of inter-semiotic transitions and how: "seeing with the help of the text", "seeing through the text", or "reading the image" acquires its whole meaning through cultural signifiers realized, therefore, in the interaction of visual and textual [15] [16].

As a result of new technologies, communication in digital fashion has changed its original meaning. Therefore, Italian fashion theorist Patrizia Calefato points out: "Communication exposes the body to contact with others and expands its boundaries. While the T-shirt is the meeting point between the body, clothing and language (in the form of a letter), new information and communication technologies open communication possibilities for a different body type. They not only introduce new media for information but also "think" and programs and manage the communication itself; they produce values, simulate body functions, and improve organic ones [17]. The digital age is undoubtedly visual, where we "work" with our eyes. However, with the help of artificial intelligence, the spectacle of digital fashion is trying to develop other possibilities for fashion and clothing. For example, in collaboration with the French designer Adeline Andre, the British scientist Jenny Tillotson created the "SmartSecondSkin" project in 2002. The garment is developed as a creative prototype to illustrate a future intelligent fabric interacting with human emotions and the brain, where the element of smell is an integral part of the sensory experience of the end user. Mimicking the human body - specifically the circulatory system, senses and scent glands - the idea is that scents are dispersed from micro transmitters embedded in the fabric, depending on the wearer's moods and emotions. A fragrance delivery system that gives function to a garment by mimicking the body's senses, scent glands and circulatory system. Fragrance chemicals flow freely through

the garment while the fabric selects and emits a scent depending on the wearer's mood. The SmartSecondSkin project has a pseudo-nervous system, which allows the garment to control the wearer's emotional state through olfactory stimulation. Such a project aims to offer direct help to improve everyday life and help, soothe, relax, stimulate or empower the user through different mechanisms. Digital fashion and artificial intelligence have pushed the boundaries of thinking about fashion and the body. Fashion is becoming a central research focus as technology moves from portable to wearable [18] [19]. Artificial intelligence and fashion form an inseparable bond in the digital age. Including artificial intelligence in the complex fashion process - from garment preparation, manufacturing, visualization and final presentation, creates a new body system with different possibilities for constructing a metamorphic identity - one that is constantly changing.

Figure 1. Designer Jadranka Hlupić Dujmušić and her 3D print fashion accessory, photo by: Tomislav Marić, model: Nastja Štefanić, Zagreb, 2018.

3. Conclusion

The fusion of digital fashion and artificial intelligence represents a transformative force in the fashion industry, enabling a departure from traditional norms and paving the way for a more dynamic and inclusive approach to fashion design. In contemporary digital fashion, new media tools with artificial intelligence push the boundaries in understanding the body, clothes and their relationship. The synergy between artificial intelligence and digital fashion has revolutionized the design and production process and redefined the concept of identity and self-expression in contemporary digital culture. As this symbiosis continues to evolve, it is up to scholars and practitioners in the industry to recognize and harness the immense potential this convergence holds for the future of fashion and visual culture. Of course, digital fashion does not only benefit the digital realm; it opens up new ways of innovation for various industries and provides unique advantages that the traditional fashion industry could never offer. Classic fashion design processes require physical samples and re-adjustments to create the final product. On the other hand, digital fashion allows designers to experiment with infinite variations of patterns, colours and textures through virtual platforms, which speeds up the creation process and lowers production costs. Accordingly, artificial intelligence becomes a key component in optimizing this process, providing tools to analyze large data sets on consumer preferences and trends and predict future market demands.

Personalization is a critical aspect of attracting consumers in the digital fashion world. By integrating artificial intelligence, companies can adapt products according to each customer's specific needs. For example, AI can analyze data about an individual's preferences and styles to create unique fashion templates or even fully customized garments. This improves the customer experience and provides an opportunity for differentiation in a saturated fashion market. Identity is undoubtedly a key concept in contemporary fashion. Artificial intelligence enables the creation of fashion identities that are fluid and adaptable, reflecting complex social dynamics and the diversity of individual identities. Through data analysis on consumer behaviour and trends, "AI" can create fashion identities that change and adapt to different situations and contexts. This explores new forms of self-expression through clothing, reflecting the subtle nuances of identity in today's digital environment. Digital fashion, therefore, represents a revolution in today's fashion industry, enabling new ways of creating, adapting and wearing clothes. The integration of artificial intelligence further enhances this development, enabling personalization, production optimization and shaping fluid fashion identities. Through this process, fashion becomes more than clothing - a powerful channel for expressing and shaping individual identities in contemporary digital visual culture.

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DIGITALNA MODA I UMJETNA INTELIGENCIJA

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Sažetak: *Digitalnom modom označavamo odjeću izrađenu pomoću računalne tehnologije i 3D softvera, ali sam pojam označuje nove i neograničene mogućnosti mode i odjevnoga predmeta u digitalnom okružju. Za razliku od tradicionalne mode koja zahtijeva stvarne materijale i tkanine, digitalna moda zahtijeva podatke i kôd, što znači da ne postoje ograničenja za ono što se može dizajnirati ili stvoriti. Suvremena moda postaje platforma za odmak od tradicionalnog razumijevanja odjevnog predmeta u odjevni objekt koji u potpunosti može biti u digitalnoj formi. U tom kontekstu moda ne mora biti "taktilna" već se prepoznaje po specifičnom vizualnom, modnom i digitalnom kodu. Stoga je pojam "taktilna transmedijalnost" od velike važnosti u istraživanju pojma digitalne mode i njezinog velikog utjecaja na promjenu društva i stvaranje metamorfnih identiteta. U digitalnoj modi sve se može posebno skrojiti prema određenom ukusu i potrebama. U ovom radu ukratko ćemo istražiti odnos između digitalne mode i umjetne inteligencije (potrebne za stvaranje proizvoda sa složenim društvenim i tehničkim softverom), s obzirom na složen odnos'AI-a i mode kao modela oblikovanja fluidnih identiteta u suvremenoj digitalnoj vizualnoj kulturi.*

Ključne riječi: *digitalna moda, umjetna inteligencija, identitet, modni objekt, intermedijalnost, taktilna transmedijalnost, vizualna kultura*

1. Uvod

Digitalna moda predstavlja revolucionarni korak u evoluciji modne industrije, omogućavajući dizajnerima i potrošačima da iskuse jedinstvenu fleksibilnost i prilagodljivost u procesu stvaranja i nošenja odjeće. Ovaj rad istražuje kako umjetna inteligencija doprinosi razvoju digitalne mode, omogućavajući sve kompleksnije oblike kreacija koji odražavaju širu kulturnu i društvenu dinamiku suvremenog svijeta. Kroz pregled relevantne literature i primjera u industriji, istražujemo kako se "AI" koristi za optimizaciju proizvodnih procesa, personalizaciju korisničkog iskustva te kreiranje jedinstvenih dizajnerskih identiteta koji se prilagođavaju individualnim preferencijama.

Konvergencija digitalnih tehnologija i modne industrije otvorila je novu eru kreativnih mogućnosti i transformativnog potencijala. Digitalna moda, koju karakterizira oslanjanje na podatke i kôd, a ne na tradicionalne materijale, posljednjih je godina doživjela porast interesa [1]. Ovaj rad nastoji rasvijetliti transformativnu prirodu digitalne mode, posebno se fokusirajući na neizostavnu ulogu umjetne inteligencije u oblikovanju ove industrije. Razumijevanjem implikacija umjetne inteligencije u procesima stvaranja, dizajna i proizvodnje digitalne mode, možemo steći uvid u veliki utjecaj koji ovo prožimanje ima na suvremenu modu i vizualnu kulturu. Koncept digitalne mode pomaknuo je tradicionalne granice modne industrije, omogućivši neviđenu razinu kreativnosti i prilagodbe. U prošlosti je modni dizajn bio limitiran ograničenjima nametnutim fizičkim materijalima i procesima proizvodnje. Međutim, dolaskom digitalnih tehnologija i 3D softvera, granice onoga što se može dizajnirati i kreirati značajno su proširene. Digitalna moda predstavlja odmak od konvencionalnih normi industrije, utirući put fluidnijem i prilagodljivijem pristupu dizajnu odjeće. Simbiotski odnos između umjetne inteligencije i digitalne mode služi kao model za razumijevanje uloge fluidnih identiteta u suvremenoj digitalnoj vizualnoj kulturi. Smith u "Digitalnoj modi: transformacija industrije putem umjetne inteligencije i virtualne stvarnosti" [2] objašnjava kako je integracija umjetne inteligencije i virtualne stvarnosti ne samo transformirala industriju, već je i redefinirala način na koji pojedinci percipiraju i izražavaju svoj identitet kroz odjeću. Ovo spajanje dovelo je do demokratizacije mode, dopuštajući pojedincima da izraze svoje jedinstvene identitete i preferencije na način koji je prije bio nezamisliv.

Digitalna moda stoga postaje alat za identitet, samoizražavanje i interoperabilnost. Ljudi su uvijek tražili nove načine izražavanja svog identiteta, a nove generacije zahtijevaju da virtualni prostori budu inkluzivniji i da prihvate opcije za različite vrste rasa, etničkih pripadnosti, dobi, rodnih identiteta itd., koje su često vrlo ograničene u stvarnom životu. Ključna prednost digitalne mode je da korisnicima daje veću kontrolu nad svojom online prisutnošću nego ikad prije, budući da digitalne modne platforme korisnicima nude više načina samoizražavanja, čak i više nego što nudi fizički svijet. Na primjer, omogućuju im da kreiraju odjeću koristeći različite kombinacije boja, uzoraka, oblika i tekstura. To omogućuje korisnicima da izraze svoj stil dok stvaraju nove trendove koje će potom drugi korisnici slijediti. Unatoč ovom značajnom napretku, industrija je pokušavala riješiti probleme poput interoperabilnosti, skalabilnosti i privatnosti pojedinca u svijetu umjetne inteligencije. Digitalna moda također mijenja način na koji razmišljamo o odjeći. Ljudi više ne kupuju određeni

odjevni predmet; oni kupuju iskustvo ili emociju koja im se sviđa [3]. Zbog toga digitalna moda više nije ograničena na područje znanstvene fantastike; uz drastično brze razvojne faze u ovom relativno novom području, samo je pitanje vremena kada će digitalna moda postati dio naše svakodnevice. To će zasigurno postati stvarnost kako virtualna i proširena stvarnost budu napredovali u nadolazećim godinama. Općenito, razni oblici digitalne mode mogu donijeti brojne koristi, kako kratkoročne tako i dugoročne. Osim toga, otvorit će se nova tržišta i granice diljem svijeta za moderne ljude i tvrtke. Dakle, iako možda nećemo svi uskoro šetati modnim pistama, trend prema modi visoke tehnologije u ovom se trenutku čini neizbježnim.

2. Metodološki okvir, područje i primjena: Suvremene modne prakse, tehnologija i taktilna transmedijalnost

Suvremene modne prakse u zadnjih deset godina doživljavaju velik zaokret u kontekstu razumijevanja tijela, tjelesnosti, materijalnosti i taktilnosti. Zahvaljujući velikom utjecaju novih medija i digitalnih tehnologija, moda se nalazi na teorijskom i praktičnom rascjepu, kao što je to bio slučaj s modom početka 1990-ih godina 20. stoljeća, kada se moda preselila na "rub" i postala "traumatična" [4]. Istraživanje o modi preselilo se s klasičnih teorijskih pitanja o identitetu i "stilu" na pitanja o materijalnosti, taktilnosti i mogućnosti gradnje novih identitetskih pozicija kroz novo-medijske digitalne alate. Primjena "inteligencije" u modi izaziva slična pitanja kao i primjena inteligencije u komunikativnim strojevima: može li postojati inteligentan objekt koji ne treba prenijeti prolaznost vremena s povećanom potrebom za ljepotom [5]? Zahvaljujući novim načinima izrade, primjene i plasiranja odjevnih predmeta u digitalnoj modi odvijaju se važne promjene koje utječu na konstrukciju slike tijela i identiteta. Austrijska dizajnerica i autorica Sabine Seymour, skovala je stoga pojam "fashionable technology" (hrv. *modna tehnologija*) 2000. godine, kada je uočila sve jaču vezu dizajna, znanosti, mode i tehnologije [6]. Seymour piše o važnosti modnih nosivih predmeta u suradnji s tehnologijom (engl. *fashionable wearables*) te naglašava: "Modni nosivi predmeti su 'dizajnirani' odjevni predmeti, dodaci ili nakit koji kombiniraju estetiku i stil s funkcionalnom tehnologijom. Kao dizajneri modernih nosivih proizvoda, na krajnje korisnike gledamo kao na moderna bića koja obraćaju pozornost na stil i snažan potencijal nosivih tehnologija. Naša filozofija dizajna temelji se na ideji da su odjevni predmeti neposredno sučelje s okolinom i stoga stalni prijenosnik i primatelj emocija, iskustava i značenja [6]. Dobar primjer ove prakse jest rad hrvatske eksperimentalne dizajnerice Jadranke Hlupić Dujmušić i njezinih 3D dodataka za tijelo (Slika 1).

Nadalje, britanski teoretičar i filozof Malcolm Barnard, govoreći o funkcijama odjeće, ističe: "Tehnologija može poboljšati funkcije odjeće i definirati nove. Materijalne ili fizičke funkcije su zaštita, prikrivanje i privlačnost. Kulturne funkcije (uključujući društvene i psihološke funkcije) su komunikacija, individualni izraz, društveni ili ekonomski status, politička ili vjerska pripadnost" [7]. Funkcije odjeće, dakle, su mnogostruke, no kada je riječ o digitalnoj modi, tada "funkcija" odlazi korak dalje. U kontekstu suvremene mode, nizozemska modna dizajnerica Iris van Herpen jasno je uočila promjene koje se odvijaju pri izradi i stvaranju odjevnog predmeta te je iskoristila nove tehnologije za gradnju svoje vizije "tijela" i odijela suvremene mode. Prepoznatljiva voluminozna silueta i artificijelan izgled materijala, Van Herpen dobiva zahvaljujući upotrebi 3D softvera i tiska. Tehnologija postaje platforma za stvaranje modnog objekta visoke mode i umjetno konstruiran materijal postaje temeljni element tijela [8]. Polazna točka za digitalnu modu nije više odabir materijala i tkanina, već stvaranje materijala putem novih tehnologija, potom slaganje i gradnja odjevnoga predmeta te uočavanje kako se odjevni predmet ponaša na tijelu. Transformativna priroda digitalne mode u potpunosti odgovara njezinoj prirodi i stanju u kojem se nalazi. Nove digitalne tehnologije snažno utječu na razvoj i praksu modnog dizajna, ali i na stvaranje identiteta novog, digitalnog društva. Iako su moda i tehnologija u svezi, razvoj umjetne inteligencije omogućio je usvajanje novih metoda, alata i pristupa dizajnu: od materijala do novih proizvodnih procesa, napredak u tehnologiji promijenio je naše razumijevanje estetike, stila i funkcionalnosti odjevnih predmeta i modnih dodataka. No, kako su tehnologije umjetne inteligencije postale sve više prisutne u posljednjih deset godina, agencije za predviđanje trendova, sada se okreću kvantitativnim rezultatima koje generira strojno učenje za pomoć. Ovi alati umjetne inteligencije mogu otkriti uzorke unutar velikih skupova podataka fotografija s modnih revija, potom obavijesti na društvenim mrežama, podataka o pretraživanju i podataka o internetskoj prodaji i prodaji u trgovinama. Svi ti navedeni alati mogu biti od pomoći pri prognoziranju onoga što će sljedeće biti u modi. Umjetna inteligencija ima mnogostruke prednosti u suvremenoj modi jer daje detaljan pregled digitalnog razvoja u modi, uključujući 3D dizajn, virtualnu izradu prototipova, proizvodnju na zahtjev kupca, istraživanje trendova vođeno umjetnom inteligencijom te nove načine digitalnog marketinga i prodaje. Van Hepren je uočila ove trendove, ali je i sama pomaknula granice mode, u smislu prezentacije njezinih kolekcija u digitalnom obliku putem raznovrsnih novomedijskih alata (na primjer, modni procesni film). U suradnji s znanstvenicima, umjetnicima i teoretičarima, njezina modna kuća harmonično spaja područja dizajna, mode, znanosti i umjetnosti.

Precizno je to uočio i britanski modni dizajner Alexander McQueen, prikazujući britansku manekenku Kate Moss kao "hologram", 2006. godine, u svojoj kolekciji za jesen-zimu, "Widows of Culloden" u Parizu. Unutar velike, staklene, piramidalne strukture, McQueen smješta lik Moss, koja lebdi u svilenoj haljini i nalikuje

viktorijanskim prikazima duhova [9]. Ovaj hologramski performans podsjeća i na paradigmatsku scenu iz nijemog filma braće Lumiere, *Annabelle Serpentine Dance* (1896) u kojem je jasno vidljiva važnost pokreta tijela i odjevnoga predmeta, kako bi se gledateljima približila priroda materijala koji obavija tijelo. McQueen je često istraživao ideju čovjeka naspram stroja ili prirode naspram tehnologije. Upravo je on, važnost novih tehnologija i umjetne inteligencije, potvrdio svojim modnim performansom "No. 13" (proljeće-ljeto) iz 1999. godine. Britanska balerina Shalom Harlow odjevena u voluminoznu bijelu haljinu bez rukava, smještena u centralni dio pozornice, okružena s dva robota. Roboti, posuđeni iz tvornice automobila "Fiat", odredili su kakav će biti konačan rezultat dizajna haljine. Rad ovoga dizajnera obilježile su ideje veze između čovjeka, prirode i tehnologije, ili preciznije mašine. Referirajući se na filmove znanstvene fantastike, poput filma "Tron" (r. Steven Lisberger, 1982.) i "Abyss" (r. James Cameron, 1989.), McQueen uvidio važnost kompjutorski generirane stvarnosti koja se odražava u modi. Posljednji primjer ovoga inovativnog i eksperimentalnog razmišljanja, prikazan je u njegovoj posljednjoj modnoj reviji "Plato's Atlantis" iz 2010. godine. Kako navodi hrvatski filozof, sociolog i teoretičar Žarko Paić: "Bilo je to jasno najradikalnijem modnome dizajneru suvremenosti Alexanderu McQueenu, kada je u svojem posljednjem performativnome događaju nazvanom Platonova Atlantida postavio na scenu sklop digitalnih tehnologija, eksperiment s preobrazbom ljudskoga tijela ("treća koža") i novi estetski objekt kao što su ženske cipele s visokim potpeticama s onu stranu tzv. svakodnevnoga života" [10].

Nadalje, odnos između tijela i odijela u središtu je istraživanja od pojave japanske dekonstrukcije 1980-ih godina 20. stoljeća u Parizu. U doba suvremene, a poglavito digitalne mode, teorijska i praktična istraživanja preselila su se na područje materijalnosti i taktilnosti. U slučaju digitalne mode, otvara se još jedno područje istraživanja, vrlo značajno za teorije i prakse mode – područje taktilne transmedijalnosti. Međutim, najprije je važno istaknuti pojam intermedijalnosti, odnosno umnažanja jednog medija u drugi. Povijest pojma potječe od pojma "intertekstualnost" (franc. *intertextualité*) francuskog strukturalista Rolanda Barthesa i njegove teze kako je svaki tekst – intertekst ili međutekstovlje. Dakle uplitanje tekstova u druge dijelove i njihovo često kolažiranje [11] te od ideje kako se u svakom tekstu nalaze fragmenti prijašnjih tekstova. Nadalje, pojam intermedijalnosti nastaje 1960-ih godina 20. stoljeća i proširio se na mnoga područja u znanosti i umjetnosti. Pojam "intermedijalnost" prvi je upotrijebio Samuel Taylor Coleridge 1812. godine, i označavao je "biti između nečega". Međutim, termin koji je uveo Coleridge nije se odnosio na medij u modernom kontekstu, već na alegoriju koja se ugurava kao intermedij između osobe i personifikacije. Intermedij kod njega, označava naratološki fenomen, a ne konceptualnu fuziju različitih medija [12]. Naposljetku, američki teoretičar W. J. T. Mitchell, smatra kako ne postoje "čisti" mediji, već da se svaki medij umnaža u drugi mediji i postaje intermedijalan [13]. Stoga se logički nameće i poteškoća pri definiranju pojmova iz ovih dvaju područja – medija i mode. Iako se pojmovi intermedijalnosti i transmedijalnosti mogu činiti srodnima, značenjem se ipak mogu razlikovati.

Pojam transmedijalnosti (preciznije transmedijalne naratologije), američkog autora Henry Jenkinsa (engl. *transmediality*) odnosi se na prijenos, prijevod i transpoziciju jednog medija u drugi, dok pojam taktilnosti, u doba novih medija i digitalnih tehnologija, postaje fokus suvremenih modnih praksa. Jenkins je pojam transmedijalne naratologije uveo 2003. godine, kao nastavak jednog dijela postklasične naratologije i u tom smislu navodi: "protok sadržaja kroz višestruke medijske platforme, kooperacija između medijskih industrija i migracijskih ponašanja publike koja će pretraživati gotovo sve u potrazi za iskustvom ili zabavom" [14] dok komunikologinja iz područja transmedijske naratologije i filma Sunčana Tuksar, uspoređujući pojam intermedijalnosti i transmedijalnosti ističe: "Problemski pristup sada sugerira klasifikacijsko dodirivanje područja ili intermedijalnost. Poznato je da naratologija sredstva pripovjedne proze prenosi ili prekoračuje u druge medije pa tako i film. Područje transmedijalnosti, odnosno intermedijalnosti neizbježno je jer je pritom semiotika široko shvaćena i interpretativno povezana s drugim disciplinama poput npr. sociologije, psihologije ili antropologije [15]. Povjesničar umjetnosti i teoretičar Krešimir Purgar dalje navodi kako je riječ o intersemiotičkim prijelazima te kako: "gledati pomoću teksta", "gledati kroz tekst" ili "čitati sliku" zadobiva puni smisao putem kulturnih označitelja ostvarenih, dakle, u interakciji vizualnog i tekstualnog [15] [16].

Nadalje, komunikacija u digitalnoj modi, mijenja svoje izvorno značenje, zahvaljujući novim komunikacijskim tehnologijama. Talijanska teoretičarka mode Patrizija Calefato stoga ističe: "Komunikacija izlaže tijelo kontaktu s drugima i proširuje njegove granice. Dok je majica kratkih rukava točka susreta između tijela, odjeće i jezika (u obliku pisma), nove informacijsko komunikacijske tehnologije otvaraju komunikacijske mogućnosti za tijelo drugačijeg tipa. Oni ne samo da uvode nove medije za informiranje, već "razmišljaju", programiraju i vode samu komunikaciju; proizvode vrijednosti, simuliraju tjelesne funkcije i poboljšavaju organske [17] Digitalno doba zasigurno je vizualno, ono u kojem "radimo" očima, no spektakularnost digitalne mode, uz pomoć umjetne inteligencije, pokušava razviti i druge mogućnosti mode i odjeće. Na primjer, britanska znanstvenica Jenny Tillotson u suradnji s francuskom dizajnericom Adeline Andre, osmislila je projekt "SmartSecondSkin" 2002. godine. Odjevni predmet razvijen je kao kreativni prototip za ilustraciju buduće inteligentne tkanine u interakciji s ljudskim emocijama i sustavom u mozgu, pri čemu je dimenzija mirisa sastavni dio osjetilnog iskustva krajnjeg korisnika. Oponašanjem ljudskog tijela - posebno cirkulacijskog sustava, osjetila i mirisnih žlijezda - ideja je da se mirisi raspršuju iz mikro transmitora ugrađenih u tkaninu, ovisno o različitim

raspoloženjima i emocijama korisnika. Sustav za isporuku mirisa koji daje funkciju odjevnom predmetu, oponašanjem tjelesnih osjetila, mirisnih žlijezda i krvožilnog sustava. Mirisne kemikalije slobodno teku kroz odjevni predmet dok tkanina odabire i emitira miris ovisno o raspoloženju osobe koja je nosi. Projekt "SmartSecondSkin" ima svoj vlastiti pseudo-živčani sustav, koji dopušta odjevnom predmetu da kontrolira, emocionalno stanje nositelja, putem mirisne stimulacije. Svrha ovakvog projekta jest ponuditi izravnu pomoć za poboljšanje života i svojevrsnu pomoć kroz različite mehanizme dok istovremeno umiruje, opušta, stimulira ili osnažuje korisnika. Digitalna moda i umjetna inteligencija pomaknule su granice razmišljanja tijelu mode. Moda postaje središnji fokus istraživanja, kako se tehnologija pomiče s prijenosne na nosivu [18] [19]. Umjetna inteligencija i moda, u suvremeno, digitalno doba, tvore neraskidivu vezu. Integrirajući umjetnu inteligenciju u mnogostruke složene procese mode - od pripreme odjevnoga predmeta, izrade, vizualizacije i završne prezentacije – tvori se novi sustav tijela s različitim mogućnostima konstrukcije metamorfnog identiteta – onoga koji jest u stalnoj promjeni.

Slika 1. Rad dizajnerice Jadranke Hlupić Dujmušić, 3D *print* modnog dodatka za tijelo, fotografija Tomislav Marić, model Nastja Štefanić, Zagreb, 2018. godina

3. Zaključak

Spoj digitalne mode i umjetne inteligencije predstavlja transformativnu snagu u modnoj industriji, omogućujući odmak od tradicionalnih normi i utirući put dinamičnijem i inkluzivnijem pristupu dizajnu odjeće. U suvremenoj digitalnoj modi, novo-medijski alati uz prisustvo umjetne inteligencije pomiču granice u razumijevanju tijela, odijela i njihovog odnosa. Sinergija između umjetne inteligencije i digitalne mode ne samo da je revolucionirala procese dizajna i proizvodnje, već je i redefinirala koncept identiteta i samoizražavanja u suvremenoj digitalnoj kulturi. Kako se ovaj odnos nastavlja razvijati, na znanstvenicima i praktičarima u industriji ostaje da prepoznaju i iskoriste golemi potencijal koji ova konvergencija nosi za budućnost mode i vizualne kulture. Naravno, digitalna moda ne donosi samo koristi za digitalno područje: ona otvara nove načine inovacija za razne industrije i pruža jedinstvene prednosti koje tradicionalna modna industrija nikada ne bi mogla ponuditi. Klasični procesi dizajna mode zahtijevali su fizičke uzorke i ponovno prilagođavanje kako bi se stvorio konačni proizvod. S druge strane, digitalna moda omogućuje dizajnerima da eksperimentiraju s beskonačnim varijacijama uzoraka, boja i tekstura putem virtualnih platformi, što ubrzava proces stvaranja i smanjuje troškove proizvodnje. Sukladno tome, umjetna inteligencija postaje ključna komponenta u optimizaciji ovog procesa, pružajući alate za analizu velikih skupova podataka o preferencijama potrošača i trendovima, te predviđanje budućih zahtjeva tržišta.

U svijetu digitalne mode, personalizacija postaje ključni aspekt koji privlači potrošače. Kroz integraciju umjetne inteligencije, kompanije su u mogućnosti prilagoditi proizvode prema specifičnim potrebama svakog kupca. Na primjer, "AI" može analizirati podatke o preferencijama i stilovima pojedinca kako bi kreirao jedinstvene modne predloške ili čak potpuno prilagođene odjevne komade. Ovo ne samo da poboljšava korisničko iskustvo, već pruža i mogućnost diferencijacije u zasićenom tržištu mode. Identitet je nedvojbeno ključni koncept u suvremenoj modi. Umjetna inteligencija omogućuje stvaranje modnih identiteta koji su fluidni i prilagodljivi,

odražavajući složene društvene dinamike i raznolikost individualnih identiteta. Kroz analizu podataka o ponašanju potrošača i trendovima, "AI" pruža mogućnost stvaranja modnih identiteta koji se mijenjaju i prilagođavaju različitim situacijama i kontekstima. Ovo otvara vrata novim oblicima samoizražavanja kroz odjeću, reflektirajući suptilne nijanse identiteta u suvremenom digitalnom okruženju. Digitalna moda, dakle, predstavlja revoluciju u modnoj industriji, omogućavajući nove načine kreiranja, prilagođavanja i nošenja odjeće. Integracija umjetne inteligencije dodatno pojačava ovaj razvoj, omogućujući personalizaciju, optimizaciju proizvodnje i oblikovanje fluidnih modnih identiteta. Kroz ovaj proces, moda postaje više od jednostavnog odijevanja - postaje snažan kanal za izražavanje i oblikovanje individualnih identiteta u suvremenoj digitalnoj vizualnoj kulturi.

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DIGITAL CLOTHING INSPIRED BY STREETWEAR

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Abstract: *This paper shows the production of a digital garment inspired by streetwear. The digital garment was developed based on a conceptual sketch. The basic pattern was constructed and tested on an avatar. The avatar was previously adapted to the measurements used for the construction of the basic pattern. The basic pattern was virtually tested and corrected. The pattern prepared in this way served as the basis for modeling the pattern according to the given sketch. The modeled pattern was applied to the avatar and the movement was simulated.*
The construction of the basic pattern, the modeling and the computer simulation were carried out with the computer program package Clo 3D. In this way, a digital garment was created that can be adapted to the user's measurements and wishes. A digital garment is not physically produced and is therefore intended exclusively for use in a virtual environment.

Keywords: *digital clothing, streetwear, Clo 3D, 3D computer construction and modeling*

1. Introduction

Digital fashion was made possible by a rapidly growing community of gaming and metaverse enthusiasts. In recent years, the transition of fashion to a digital environment has accelerated tremendously, offering infinite freedom of self-expression and creation to the wearers of digital clothing, but also to all designers and brands. Digital clothing can be made from amazing, unrealistic fabrics and textures and does not have to follow the laws of physics [1, 2].

Digital fashion is virtual 3D clothing designed for humans and digital avatars. Digital clothing is created using 3D computer software packages such as Blender and Clo 3D. Digital clothing is a virtual representation of real clothing created from pixels using 3D computer programs and rendered by computer [1, 3].

The process of creating a digital garment is similar to the usual process of developing a new product. To create a digital garment, you need to master the techniques of garment construction and garment pattern modeling. In addition, you should understand the laws of 3D rendering to produce high-quality content [1, 2, 4].

Clo 3D is one of the computer software packages for creating digital garments that have found numerous applications in the textile industry, including digital fashion. The apparel industry is already familiar with the benefits of 3D visualization in the design and development of real garments. An additional value of high-quality computer visualizations of garments is the possibility of their application in marketing and sales, e.g. in e-commerce or for the needs of wholesale buyers [1].

Compared to traditional clothing production, digital fashion is cheap and sustainable and is not subject to any creative or production constraints. Many digital garments are result of the opportunity to design garments that cannot be produced under real conditions [1, 5].

2. Streetwear

Streetwear is a style of casual clothing that became popular worldwide in the 1990s. Street fashion clothing incorporates elements of Japanese street fashion, sportswear and pop culture and has become a global symbol of comfortable, aesthetic fashion. Street fashion brands draw inspiration from punk, surfer and skater culture. The influence of brands, designers, musicians and other big names inspiring each other and influencing each other's work is visible in the evolution of street fashion [1, 6].

The concept and growth of the street fashion trend began in the 1980s when Shawn Stussy of Stüssy, a small surf company, started printing T-shirts with logos in Los Angeles, California. Since then, street fashion has been integrated into New York hip-hop fashion and adopted by the surfer and skater community in California. Today, street fashion has a diverse personality, mixing casual looks, ready-to-wear fashion and often luxury combined with exclusivity. Street fashion represents the people, their taste in music, art and fashion, expresses solidarity and at the same time emphasizes individuality. A unique feature of street fashion is the power and

different meaning that each piece of clothing has. Each garment contains a special meaning and represents a special lifestyle [1, 7].

Streetwear style has a wide range of influences and subcultures. It encompasses skate and surf culture, athleisure, haute couture fashion and technical clothing. The consumer base is very diverse and spans across all income levels, socio-economic statuses and corners of the world [1].

3. Digital fashion

Daniella Loftus is the founder of the digital fashion blog This Outfit Does Not Exist. She categorizes digital fashion as a spectrum with different physical and digital characteristics. According to Loftus' definition, digital fashion is any wearable item created in the digital world. This includes items designed on a computer or digital collectible copies of physical items; virtual clothing worn or applied to photos and videos of real people; and fully digital clothing for avatars created in collaboration with video game or social network developers [1, 5].

Digital dressing is the most practical way for customers to show off their digital style. Consumers can wear their digital clothes by applying them to photos and using advanced technologies such as augmented reality and artificial intelligence. The digital fashion market works very simply: a digital garment is selected on one of the digital fashion markets, a photo is uploaded to the digital platform, the garment is paid for and the customer receives a photo with a professionally created digital fashion garment within a few days. For influencers on social networks, wearing digital fashion offers a much more effective and profitable alternative than the usual way of following fashion trends [1, 3].

Recently, digital fashion has often been discussed in the context of the metaverse, a science fiction concept touted as the future of the internet. The metaverse is a digital reality that combines elements of social networks, online gaming, augmented reality, virtual reality and cryptocurrency. One example: In Mark Zuckerberg's metaverse, everyone will have their own avatars that exist in the digital environment. Virtual avatars work in virtual jobs, fulfill virtual social obligations and wear virtual clothes [1, 8].

The first Metaverse Fashion Week took place in March 2022 and showcased some of the most innovative brands and styles, including Tommy Hilfiger, Paco Rabanne, Dolce & Gabbana and Etro, as well as popular Web 3.0 brands such as DeadFellaz, The Sevens, 8SIAN and Fang Gang [1, 8].

The first digital clothing collection was designed by the Scandinavian brand Carlings in 2018. The Neo X digital collection sold out within a few hours and became extremely popular with bloggers and influencers. To understand the importance of digital fashion, one must first understand the desire for digital identity and ownership. Among the digitally dependent generations, there is a great demand for digital ownership and the ability to express one's identity in the same way as in real life [1, 8].

4. Experimental part

Fig. 1 shows a sketch of the model on the basis of which the digital clothing is produced using the 3D computer program Clo. The outfit is inspired by street fashion and consists of a T-shirt and a pair of pants. To create the digital clothing, it is necessary to computerize the basic pattern and test the fit (Fig. 2 and 3).

Figure 1: Sketch of digital clothing, inspired by streetwear [1]

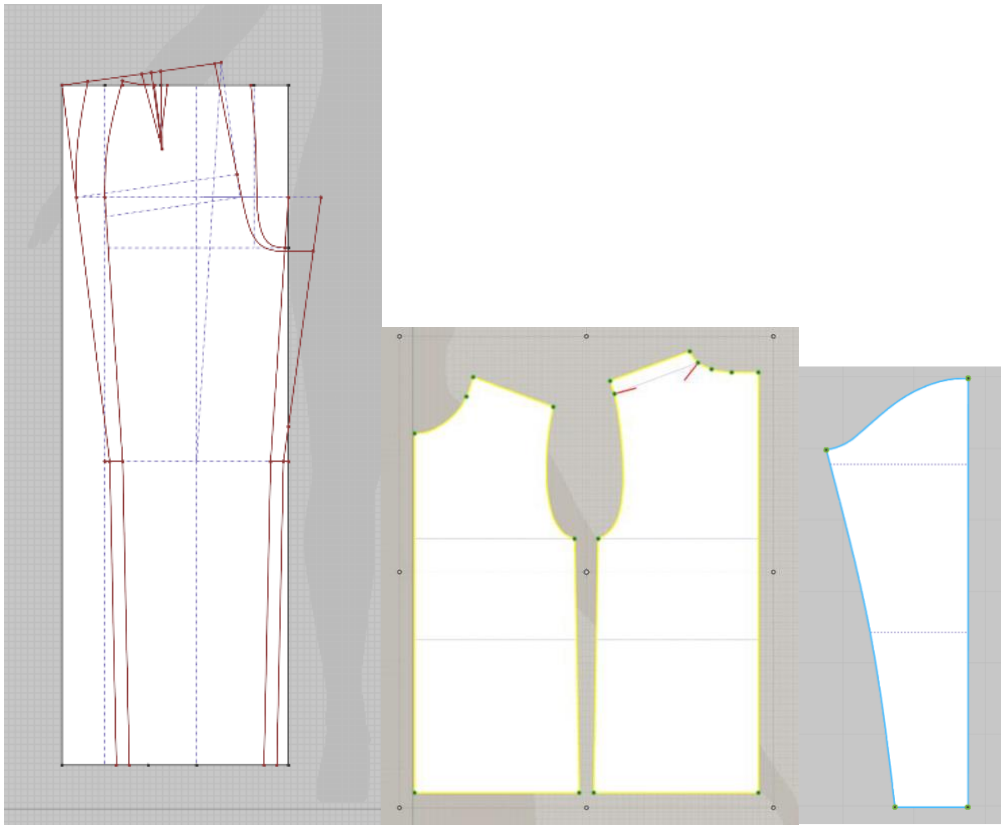

Figure 2: Basic construction created with the computer program Clo 3D [1]

The fit of the garment is tested virtually on the avatar. The avatar is compared with the body measurements used to construct the basic pattern (Fig. 3). The pattern is tested after both the pattern and avatar have been prepared by defining the placement points. The pattern pieces are joined together by sewing simulation.

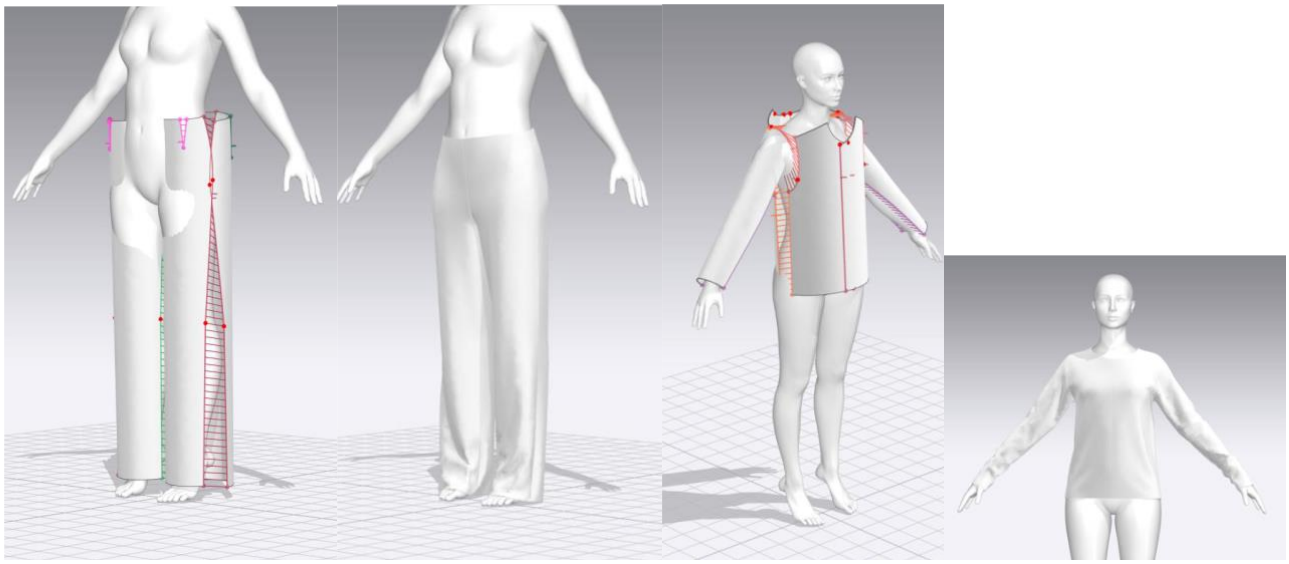

Figure 3: Virtual testing of the fit of the basic pattern of digital clothing with the computer program Clo 3D [1]

Once the basic pattern has been checked and corrected, the pattern pieces are computer modeled according to the model sketch. The modeling of the pattern pieces with the computer program Clo 3D is shown in Figure 4, whereby symmetrical pattern pieces were created.

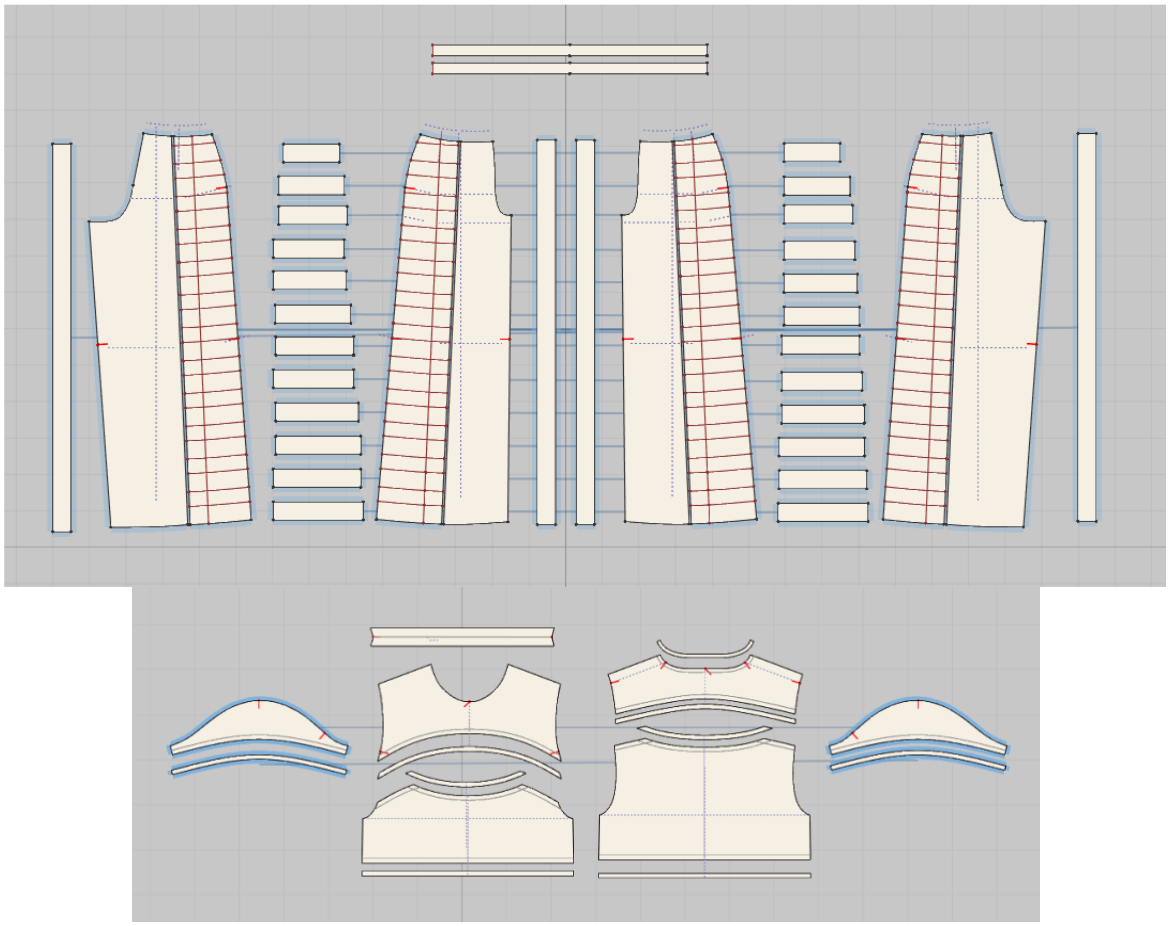

Figure 4: Modeling of basic pattern of digital clothing with the computer program Clo 3D [1]

The fit of the modeled patterns is checked virtually on the avatar (Fig. 5) in the same way as when testing the fit of the basic pattern.

Figure 5: Virtual examination of the modeled pattern of digital clothing with the computer program Clo 3D [1]

5. Results and discussion

The digital clothing was created on the basis of the presented procedure according to predefined color and texture settings (Fig. 6). Using the computer program Clo 3D, it is possible to create a large number of variations of the garment in terms of color and texture. After defining the final model of the digital garment, a high-quality computer representation of the garment is created, which can be animated with or without an avatar. In this way, the digital garment is prepared for sale.

Figure 6: Digital clothing made with the Clo 3D computer program [1]

6. Conclusion

Fashion is a part of our being, be it physical or digital. It serves as one of the purest forms of self-expression as an expression of emotions and beliefs. Given the fact that we spend more and more time in virtual environments, it is to be expected that this is also reflected in the virtual world [1, 3, 5, 8].
Digital garment manufacturing uses digital representations of garments that are created as stand-alone products using advanced technologies. There is a market for digital garments produced in this way, even if the

garment does not physically exist. Digital garments are intended for use in a virtual environment, e.g. in various applications or in computer games, where they are applied to the customer's photo by computer.

Clo 3D is a software package that enables creation of digital garments. In addition to the creation of a digital garment intended for sale, it offers the possibility of computer design and modeling of garment patterns as well as 3D simulation of garments on an avatar. The program package enables the creation of a 3D garment with applied digital fabrics, auxiliary materials and elements that are an integral part of the garment. The digital 3D garment can be used in a variety of ways in the structural preparation of the clothing industry. It can be used both to create a mock-up or prototype of a garment and to create a customized garment, as the avatar can be adapted to the customer's measurements. This reduces the time and materials needed to prepare the pattern for industrial production.

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DIGITALNA ODJEĆA INSPIRIRANA ULIČNOM MODOM

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Sažetak: *U radu je prikazana izrada digitalnog odjevnog predmeta inspiriranog uličnom modom. Digitalni odjevni predmet je razvijen na temelju idejne skice. Konstruiran je temeljni kroj te ispitan na avataru. Avatar je prethodno prilagođen mjerama prema kojima je izrađena konstrukacija temeljnog kroja. Temeljni kroj je virtualno ispitan i korigiran. Tako pripremljen kroj poslužio je kao temelj za modeliranje kroja prema predviđenoj skici. Modelirani kroj je apliciran na avatar te je izvedena simulacija kretanja.*
Konstrukcija temeljnog kroja, modeliranje i računalna simulacija provedene su primjenom računalnog programskog paketa Clo 3D. Na taj način je izrađen digitalni odjevni predmet koji se može prilagođavati mjerama i željama korisnika. Digitalni odjevni predmet se fizički ne izrađuje i stoga je namijenjen isključivo korištenju u virtualnom okruženju.

Ključne riječi: *digitalna odjeća, ulična moda, Clo 3D, 3D računalna konstrukcija i modeliranje*

1. Uvod

Digitalnu modu je omogućila brzorastuća zajednica zaljubljenika u računalne igre (gaming) i metaverzum (metaverse). Posljednjih nekoliko godina iznimno se ubrzala tranzicija mode u digitalno okruženje jer pruža beskrajnu slobodu za samoizražavanje i stvaranje za one koji nose digitalno, kao i za sve dizajnere i brendove. Digitalna odjeća može biti izrađena od nevjerojatnih, nerealnih tkanina i tekstura te ne mora slijediti zakone fizike [1, 2].

Digitalna moda je virtualna 3D odjeća dizajnirana imajući na umu ljude i digitalne avatare. Digitalna odjeća izrađuje se pomoću 3D računalnih programskih paketa poput Blendera i Clo 3D. Digitalna odjeća virtualni je prikaz stvarne odjeće koja je izrađena od piksela pomoću 3D računalnih programa te računalno prikazana [1, 3].

Proces kreiranja digitalnog odjevnog predmeta sličan je uobičajenom procesu razvoja novog proizvoda. Za izradu digitalnog odjevnog predmeta potrebno je vladati tehnikama konstrukcije odjeće i modeliranja krojeva odjeće. Pored navedenog treba razumjeti zakonitosti 3D prikaza da bi se producirao visokokvalitetan sadržaj [1, 2, 4].

Clo 3D jedan je od računalnih programskih paketa za kreiranje digitalnih odjevnih predmeta koji su u tekstilnoj industriji našli višestruku primjenu od kojih je digitalna moda. Odjevna industrija već je upoznata sa benefitima korištenja 3D prikaza u procesu dizajna i razvoja realnih odjevnih predmeta. Dodatna vrijednost kvalitetnih računalnih prikaza odjevnih predmeta je mogućnost njihove primjene u marketingu i prodaji kao npr.: u e-trgovini tako ili za potrebe kupaca na veliko [1].

U odnosu na tradicionalnu proizvodnju odjeće, digitalna moda je jeftina i održiva, bez kreativnih ograničenja ili ograničenja proizvodnje. Mnogi digitalni odjevni predmeti iskorištavaju priliku za stvaranje odjevnih predmeta koje nije moguće izraditi u realnim okolnostima [1, 5].

2. Ulična moda

Ulična moda (streetwear) je stil ležerne odjeće koji je postao globalan 1990-ih. Odjeća ulične mode uključuje elemente japanske ulične mode, sportske odjeće i pop-kulture te je postala globalni simbol udobne, estetske mode. Brendovi ulične mode vuku inspiraciju iz punk-a, surferske i skejterske kulture. U razvoju ulične mode vidljiv je utjecaj brendova, dizajnera, glazbenika i drugih velikih imena koja nadahnjuju i utječu na rad jedni drugih [1, 6].

Koncept i rast trenda ulične mode započinje 1980-ih kada je Shawn Stussy iz Stüssyja, male tvrtke za surfanje, počeo tiskati majice s logotipom u Los Angelesu u Kaliforniji. Od tada je ulična moda uključena u njujoršku hip hop modu i prihvaćena od strane zajednice surfera i skejtera u Kaliforniji. Ulična moda danas ima višestruku osobnost, miješajući ležeran izgled, konfekcijsku modu, a često i luksuznu u kombinaciji s ekskluzivnošću. Ulična moda predstavlja ljude, njihov ukus za glazbu, umjetnost i modu, izražavajući pritom povezanost ujedno

naglašavajući individualnost. Jedinstvena karakteristika ulične mode je moć i različito značenje koje ima svaki odjevni predmet. Svaki odjevni predmet sadržava posebno značenje i životni stil [1, 7].

Stil ulične mode ima širok raspon utjecaja i subkultura. Uključuje kulturu skejtanja i surfanja, athleisure, haute couture modu, i tehničku odjeću. Baza potrošača je prilično raznolika, proteže se na svim razinama dohotka, socioekonomskog statusa i kuta svijeta [1].

3. Digitalna moda

Daniella Loftus je osnivačica digitalnog modnog bloga This Outfit Does Not Exist, kategorizira digitalnu modu kao spektar s različitim fizičkim i digitalnim svojstvima. Prema Loftusovoj definiciji digitalna moda je svaki nošeni artikl stvoren u digitalnom svijetu, uključujući pri tome predmete računalno dizajnirane ili digitalne kolekcionarske kopije fizičkih predmeta; virtualnu odjeću koja je nošena ili aplicirana na fotografijama i video zapise stvarnih ljudi, kao i potpuno digitalna odjeća najmenjena avatarima, razvijena u suradnji sa programeri videoigara ili društvenih mreža [1, 5].

Digitalno odijevanje najpraktičniji je način za kupce da pokažu svoj digitalni stil. Potrošači mogu nositi svoju digitalnu odjeću aplikacijom na fotografije i korištenjem naprednih tehnologija poput proširene stvarnosti i umjetne inteligencije. Tržište digitalne mode funkcionira vrlo jednostavno: odabire se digitalni odjevni predmet na jednom od digitalnih modnih tržišta, na digitalnu platformu prenosi se fotografija, plati odjevni predmet i kupac za nekoliko dana prima fotografiju sa profesionalno apliciranim digitalnim modnim odjevnim predmetom. Za influencere na društvenim mrežama nošenje digitalne mode nudi mnogo učinkovitiju i isplativiju alternativu od uobičajenog načina praćenja modnih trendova [1, 3].

U posljednje vrijeme često se raspravlja o digitalnoj modi u tandemu sa metaverzumom, znanstveno-fantastičnim konceptom koja se reklamira kao budućnost interneta. Metaverzum je digitalna stvarnost koja kombinira elemente društvenih mreža, online igara, proširene stvarnosti, virtualne stvarnosti i kripto valuta. Tako npr.: u metaverzumu Marka Zuckerberga će svi imati svoje avatare koji egzistiraju u digitalnom okruženju, virtualni avatari raditi će na virtualnim poslovima, ispunjavati virtualne društvene obveze i nositi virtualnu odjeću [1, 8].

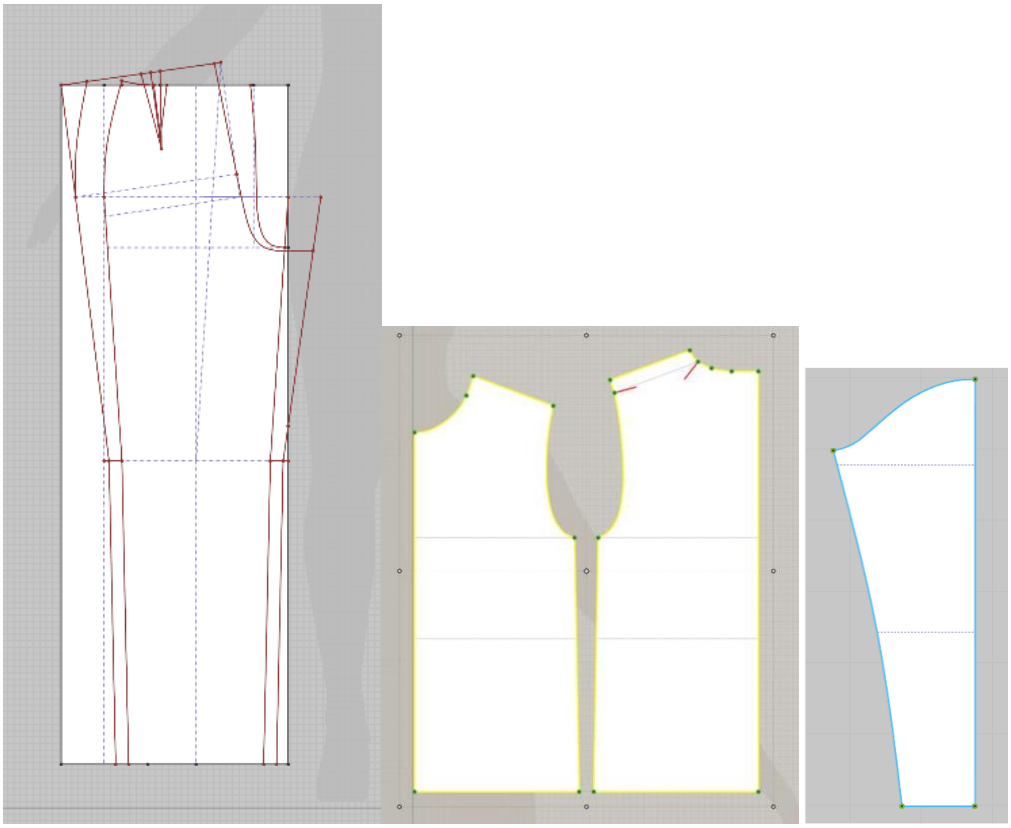
Prvi Metaverse Fashion Week održan je u ožujku 2022. i na njemu su predstavljeni neki od najsuvremenijih brendova i stilova, uključujući Tommy Hilfiger, Paco Rabanne, Dolce & Gabbana i Etro, kao i popularni Web 3.0 brendovi kao što su DeadFellaz, The Sevens, 8SIAN i Fang Gang [1, 8].

Prvu digitalnu kolekciju odjeće kreirao je skandinavski brend Carlings 2018. Neo X digital collection, rasprodana je u nekoliko sati i postala je iznimno popularna među blogerima i utjecajnim osobama. Da bi u potpunosti shvatili važnost digitalne mode, prvo je potrebno razumjeti želju za digitalnim identitetom i vlasništvom. Među digitalno ovisnim generacijama postoji velika potražnja za digitalnim vlasništvom i sposobnošću izražavanja vlastitog identitet na isti način kao u stvarnom životu [1, 8].

4. Eksperimentalni dio

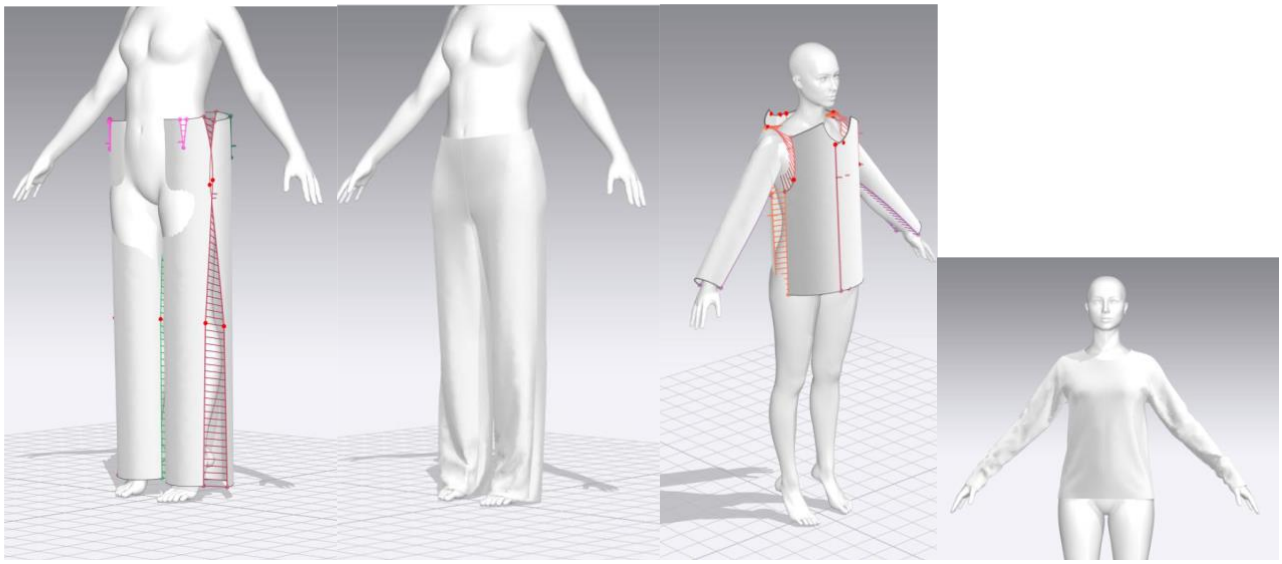
Na sl. 1 prikazana je skica modela na temelju koje se izrađuje digitalna odjeća primjenom računalnog proograma Clo 3D. Odjeća je inspiriranara uličnom modom te se sastoji od majice i hlača. Za potrebu izrade digitalne odjeće potrebno je računalno konstruirati temeljni kroj te ispitati njegovu pristalost (slika 2 i 3).

Slika 1: Skica digitalne odjeće inspirirane uličnom modom [1]



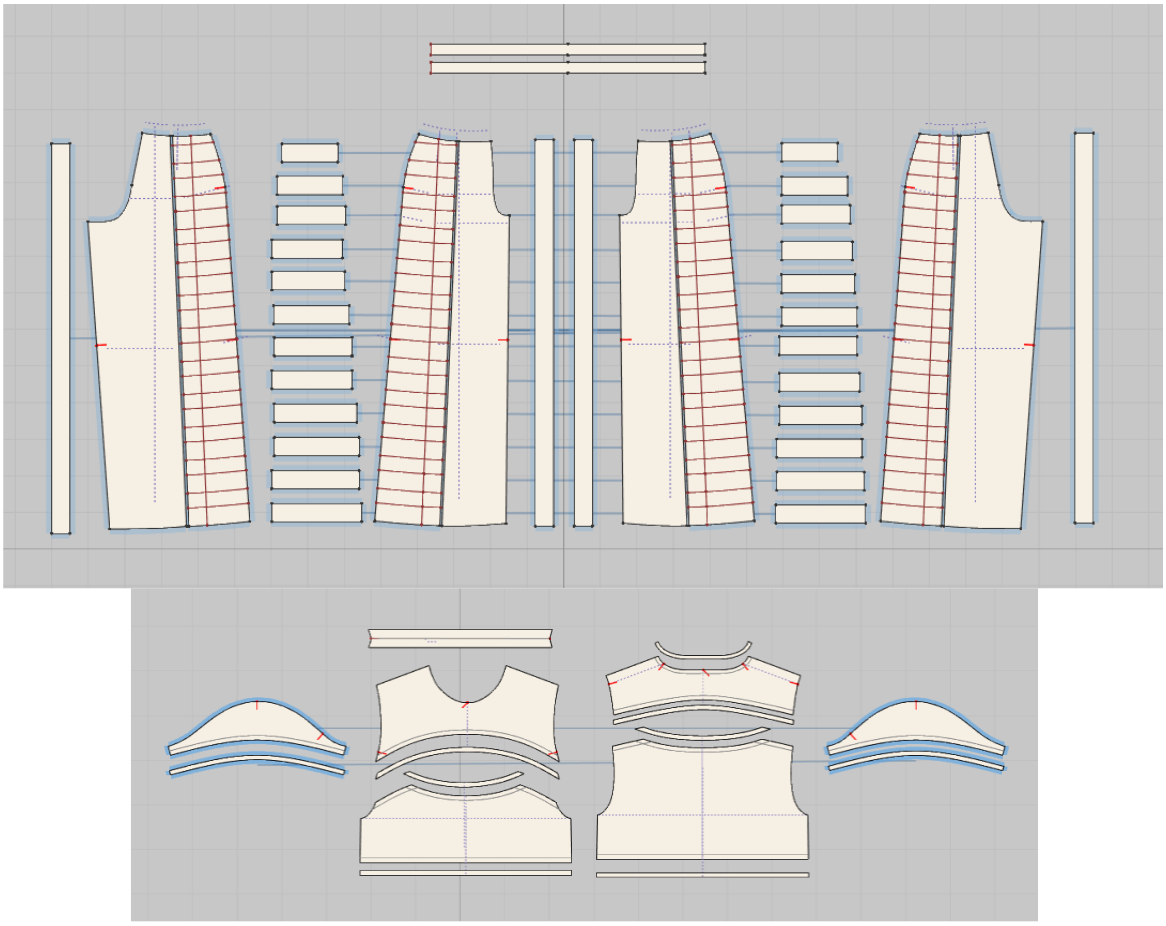
Slika 2: Temeljna konstrukcija izrađena primjenom računalnog programa Clo 3D [1]

Pristalost odjevnog predmeta ispituje se virtualno na avataru. Avatar je usklađen s tjelesnim mjerama koje se koriste pri konstrukciji temeljnog kroja (sl.3). Ispitivanje kroja se provodi nakon prethodne pripreme kroja i avatara definiranjem spojnih točaka. Dok se krojni dijelovi međusobno spajaju simulacijom šivanja.



Slika 3: Virtualno ispitivanje pristalosti temeljnog kroja digitalne odjeće primjenom računalnog programa Clo 3D [1]

Nakon ispitivanja i korekcije temeljnog kroja provodi se računalno modeliranje krojnih dijelova prema skici modela. Modeliranje krojnih dijelova primjenom računalnog programa Clo 3D prikazano je na slici 4, pri čemu su izrađeni simetrični krojni dijelovi.



Slika 4: Modeliranje temeljnih krojeva digitalne odjeće primjenom računalnog programa Clo 3D [1]

Provjera pristalosti modeliranih krojeva provodi se virtualno na avataru (sl.5) na isti način kao kod ispitivanja pristalosti temeljnog kroja.

Slika 5: Virtualno ispitivanje modeliranog kroja digitalne odjeće primjenom računalnog programa Clo 3D [1]

5. Rezultati i rasprava

Na temelju prikazanog postupka izrađena je digitalna odjeća prema unaprijed određenim postavkama boja i tekstura (sl.6). Primjenom računalnog programa Clo 3D moguće je izraditi velik broj varijacija odjevnog predmeta obzirom na boju i teksturu. Nakon definiranja završnog modela digitalnog odjevnog predmeta izrađuje se visokokvalitetni računalni prikaz odjeće koji može biti animiran sa avatorom ili bez njega. Na taj način se digitalni odjevni predmet pripremljen za prodaju

Slika 6: Digitalna odjeća izrađena pomoću računalnog programa Clo 3D [1]

6. Zaključak

Moda je dio našeg bića bila ona fizička ili digitalna. Služi kao jedan od najčišćih oblika samoizražavanja kao izraz emocija i uvjerenja. Obzirom da sve više vremena provodimo u virtualnim okruženjima, očekuje se da će se odraziti i u virtualnom svijetu [1, 3, 5, 8].

U proizvodnji digitalnih odjevnih predmeta koriste se digitalni prikazi odjevnih predmeta kreirani kao samostalni proizvodi primjenom naprednih tehnologija. Digitalni odjevni predmeti izrađeni na prikazani način imaju tržište

iako odjevni predmet fizički ne postoji. Digitalna odjeća je namijenjena za korištenje u virtualnom okruženju poput raznih aplikacija ili u računalnim igrama, pri čemu se računalno aplicira na fotografiju kupca.

Clo 3D je programski paket koji je prikladan za izradu digitalnih odjevnih predmeta. Osim izrade digitalnog odjevnog predmeta namijenjog prodaji, pruža mogućnost računalnog konstruiranja i modeliranja krojeva odjeće, te 3D simulaciju odjevnih predmeta na avataru. Programski paket omogućuje kreiranje 3D odjevnog predmeta sa apliciranom digitalnom tkaninom, pomoćnim materijalima i elementima koji su sastavni dio odjevnog predmeta. 3D digitalni odjevni predmet ima višestruku primjenu u konstrukcijskog pripremi odjevne industrije. Može se koristiti za izradu probnog modela ili prototipa odjevnog predmeta kao i za izradu odjeće po mjeri jer se se avatar može prilagoditi mjerama kupca. Na taj način se se smanjuje vrijeme i utrošak materijala koji je potreban za pripremu kroja za industrijsku proizvodnju.

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THE INFLUENCE OF ARTIFICIAL INTELLIGENCE ON FASHION INDUSTRY

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Abstract: *Artificial intelligence and its elements are powerful tools that can be applied in many processes, including the fashion industry, from concept and design to material sourcing, production, logistics and retail. The application of artificial intelligence can contribute to various improvements such as speeding up and scaling processes, handling large amounts of data that humans are not capable of, and offering consumers new ways of experiencing retail. This paper aims to show how artificial intelligence is changing the fashion industry. The specifics of artificial intelligence are described, including machine learning, computer vision, robotics, and natural language processing. It is described how clothes can be designed and produced using elements of artificial intelligence and two examples from the practice of sewing and handling textiles are presented.*

Keywords: *artificial intelligence, computer vision, robotics, sewing, handling*

1. Introduction

The fashion industry has always been at the forefront of innovation and technology, adapting to changing consumer preferences, new trends and advances in production processes. With the development of artificial intelligence, the fashion industry is once again undergoing a transformation that is changing the way products are designed, manufactured and sold. From design to marketing and sales, artificial intelligence affects all segments of the finished product and offers companies new opportunities to simplify operations and achieve new achievements. One of the biggest impacts of artificial intelligence on fashion is in the area of supply chain management. With artificial intelligence models that can be trained on known inventory levels and sales performance to predict future sales, companies can make better decisions about what to stock and when. This can help reduce waste, improve customer satisfaction and increase profits [1].

2. Concept of artificial intelligence

In order to understand whether a machine can think like a human - or, rather, whether it can imitate human behaviors and reactions - the British scientist Alan Turing created the Turing Test in 1950, which consisted of a game with two people (one who examines and one who corresponds) and one computer. The examiner would ask questions to both the person and the computer, and later he was asked to identify based on the answers who is the human and who is the machine [2].

The point of this so-called imitation game was to get the computer to trick the examiner into not being able to tell the two apart, and if the machine managed to fool them, it would pass the test and prove its intelligence. This ability of a computer to react like a person is possible thanks to natural language processing (NLP), a form of artificial intelligence that understands human language - which is completely different from language based on machine code.

Artificial intelligence is an umbrella term and there are many ways to realize it. With it, it is possible to make machines feel, think and act on given stimuli. To start talking about artificial intelligence, it is first essential to understand the concept of data, since artificial intelligence relies heavily on data collection and analysis. According to Luce Leanne (2019), data is generally "a raw set of information that requires some processing in order to have concrete meaning" and can be structured - when organized, making it easier for machines to make sense of organized or unstructured or unorganized free-form data, such as posts on the blog or email. A company may have a large set of data that can be either internal, generated within the organization such as the company's website or purchase orders, or external, which are those generated outside the company, such as social media or macroeconomic indicators.

The four main areas of artificial intelligence that are particularly relevant to the fashion industry include machine learning, computer vision, natural language processing and robotics. If the ultimate goal of artificial intelligence is to make machines think, behave and react like humans, they should have the ability to learn from past experiences and apply that knowledge in future processes, just as human beings do. This is possible through machine learning, an extremely important field of artificial intelligence that aims to identify patterns in data

previously fed into a machine, predicting the value of non-existent data, allowing machines to learn without manual programming [3].

There are two ways in which computers learn: supervised and unsupervised learning. Supervised learning takes existing data (input) and already known data responses (output), training the machine to predict other future outputs in cases of uncertainty, all based on evidence. When there is only input data and no prior responses, the machine learns through unsupervised learning, relying only on underlying patterns and inferences from the data set. The applications of each learning method will depend on the nature of the data available. The power of vision is given to machines through computer vision, which allows them to recognize, interpret and process digital images and videos, Figure 1. Through image recognition, a machine can analyze the pixels and their numerical values in a given image, recognizing them as an object, person, animal, etc.

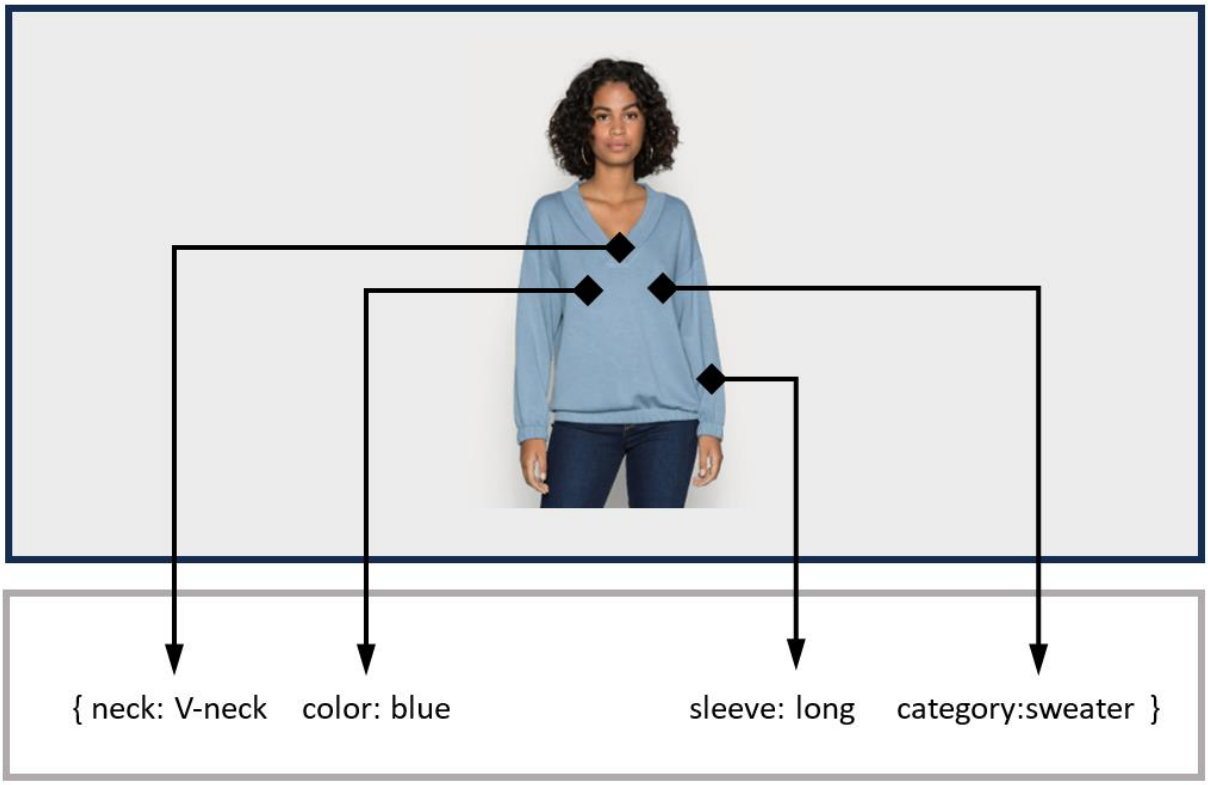

Figure 1: An example of recognizing clothing details using computer vision [2]

The field of natural language processing studies and analyzes texts, oral and written, that arise naturally, without being done for the purpose of analysis and with the limitation that it is text that human beings use to communicate with other people. Using natural language processing, it was possible to develop applications such as Amazon Alexa, Apple Siri and Google Home [4].

Robots have been present in popular imagination and culture for a long time. When science fiction imagined what the future would look like, it was often filled with robots living among humans, performing various tasks, socializing, and even falling in love as if they were humans themselves. But the reality is that robotics and the way it is applied today is much less scenic than that [5, 6]. Robots are used from the manufacturing industry, performing automated tasks assisting or replacing workers in the field, to medicine, performing surgery or helping to rehabilitate patients. In the fashion industry, robotics can help in the supply chain, with warehousing tasks of picking and packing, or in production processes - such as automated sewing and knitting.

3. Designing of clothes using artificial intelligence

Traditionally, clothing design is a creative process that involves a lot of trial and error. With the help of artificial intelligence, stylists can create new designs more efficiently and accurately. Artificial intelligence algorithms can analyze large amounts of data from social media, fashion blogs and consumer shopping habits to identify new trends and predict which styles and colors will be popular in the coming seasons, enabling designers and retailers to stay on top of fashion trends.

Artificial intelligence can also generate design concepts based on specific inputs, such as color, textile material and style, saving designers significant time and effort while allowing them to focus on refining designs rather than starting from scratch. Artificial intelligence is currently being applied in concept and design through trend forecasting research and generative design methods. Trend is a common jargon in the fashion industry. The color of the year, the jacket of the season, the bag of the month, these are all called trends, or fashion trends. But the term trend is much deeper and broader than that, it is a pattern of change, or the direction in which something develops and changes.

Figure 2: An example of how artificial intelligence can visually and textually analyze a post on Facebook [7]

Data collected from Instagram, Pinterest, Facebook and other social media can provide insight into emerging trends and their place on the trend propagation curve, meaning whether they are only popular among trendsetters and innovators, have already peaked, or are on the decline. With this information, it is possible to predict the future of that trend with a fair degree of certainty and make informed decisions about the project. But collecting millions of images, videos and texts creates a huge amount of data that, if not organized, grouped and analyzed, is simply not useful. To solve this, data mining can be used, a process that discovers patterns in a large set of data and extracts useful knowledge from these large repositories, allowing filtering and obtaining only the desired information. The data can then be scanned using computer vision to analyze visual content and natural language processing for textual content [8, 9]. For example, an image posted by an influencer on Instagram can generate a lot of insights, both visually, such as clothing colors, prints, lengths, textures and materials, and textually, with the analysis of captions, hashtags and emojis, Figure 2.

The computer knows that it is a jacket, a pair of boots, a color or a type of material because it has learned from a previously introduced dataset of photographs tagged with clothing attributes. One example of a dataset of this type is the DeepFashion initiative [10] developed at the Chinese University of Hong Kong. It includes more than 800,000 images, tagged with "massive attributes, clothing landmarks and image correspondences captured in a variety of scenarios, including shop, street and consumer footage." The dataset is available to the public for research purposes.

With deep learning, it is possible to train a machine to apply these attribute classifiers to all future images without human supervision. The combination of deep learning, computer vision and natural language processing enables grouping of images with similar attributes, understanding characteristics such as relevance and geographic occurrence. Moreover, it allows trend forecasters to track these clusters and their evolution over time, which allows assumptions to be made about the future of the trend of which that cluster is a component. This AI method can be applied not only to social media posts, but also to runway photos from

fashion weeks, street style images, and e-commerce images. Cross-platform analysis can be particularly interesting to understand how a trend can affect consumers and brands in different ways.

4. Production of clothes using artificial intelligence

Artificial intelligence is also transforming the clothing production process in the fashion industry. Algorithms can optimize production lines, reducing waste and increasing efficiency. Artificial intelligence can also predict demand for certain products and adjust production schedules accordingly, reducing over- and under-production. There is also a physical change that occurs due to artificial intelligence. Typical manufacturing robots that have been used for decades are now powered by artificial intelligence, completing work in a fraction of the time with greater accuracy. New, more intelligent robots are being used to perform tasks that are too repetitive or dangerous for workers, such as cutting and sewing fabrics, and not only improve worker safety, but also reduce production costs.

Although the applications of artificial intelligence have been present for a long time in many fields, its contributions to the textile industry are quite new and not yet widespread. Applications are mainly concentrated on quality control, samples, colors and defects. In the knitting and weaving processes, it is possible to identify errors in the fabric pattern through computer vision and machine learning, a process that, if done manually, will take longer and be subject to human error. The same applies to color shade control. Traditionally, to make sure that the color of the finished product matches the original design, companies establish color tolerance parameters - called instrumental tolerance systems - that are agreed between manufacturers, suppliers and customers and set how much color difference is acceptable in a sample. However, this method can generate false positives, requiring human intervention and slowing down the process. An AI-driven controller can learn from past inspections and create tolerances in a much more efficient way. When it comes to textile production itself, there are experimental applications on knitting. Through deep learning, computers can generate knitting patterns and instructions based on an image of a knitted garment, in a sort of automated knitting machine. Although not yet widely used, these experiments are interesting to imagine a future with artificial intelligence-driven textile production.

An innovative solution in the clothing industry brought about by the development of artificial intelligence is robots for sewing and handling textiles. Until recently, machines struggled to match the dexterity and skills humans have when handling soft materials like fabric. With the evolution of technologies such as machine learning, computers are beginning to be trained to perform such tasks efficiently.

In the paper, we will present two examples of innovative solutions for clothing production that have been designed and are already applied in some limited cases.

The first is SoftWear from Atlanta, USA [11] which created a solution for autonomous sewing using computer vision and robotics. The company claims that with their technology, manufacturers can produce locally, moving the supply chain back to their areas, while maintaining high quality and lower costs. According to the company, their sewing robot "Sewbot work-line", Figure 3, is capable to produce nearly twice as many finished t-shirts an an eight-hour shift as manual sewing can run 24 hours a day. It is 80 percent more efficient. In addition to the Sewbot, they also offer a fully operational system which can make one T-shirt every 22 seconds. Other products that can be sewn with the company's robot include pillows, rugs, towels, shoes, mattresses and bags. So far, the technology is available for sale exclusively in the US. In 2017, a Chinese supplier to Adidas announced a partnership with SoftWear, where they planned to produce 800,000 T-shirts per day for the sportswear brand using Sewbots at their factory in Arkansas - USA, reducing labor costs for each T-shirt to 33 cents.

Figure 3: SoftWear's sewing robot that can handle the textile material, position it correctly and sew.

Another example is Sewts [12], a new German startup developing advanced robots for handling textiles. Their goal is to fully automate clothing production using computer vision and robotics.

Figure 4: Sewts' robot, designed to perform advanced textile handling for various tasks

Cameras integrated into robots are able to "see" the fabric and handle it as needed. This is possible thanks to sophisticated material simulations that reproduce the behavior of textiles and help develop appropriate algorithms to solve their softness and flexibility. Until now, the application of their robotic technology for textile handling, Figure 4, has been used in industrial laundries. In this industry, the steps of washing, drying and folding clothes are already automated, but human labor is still required at the machines to fold and properly place the pieces piece by piece to avoid wrinkles. The startup is fairly new and in the early stages of product development, and the founders envision future solutions that will include robotic technology in other areas of fabric handling to achieve the desired fully automated garment production. In addition to robotic sewing technology, the company aims to design technology that can produce custom-made garments, using data generated by body scans and sent to robots that produce them in a short period of time.

5. Conclusion

The fashion and textile industry is a sector in which new technologies are still not so pervasive. Many processes still rely heavily on human labor, and changing this approach to a more technological one could cause many adverse effects on the lives of millions of garment workers in key countries. In other parts of the fashion and textile industry chain, such as concept and design, material procurement and logistics and distribution, there are some innovative solutions powered by artificial intelligence, but they are not yet an

industry standard. From a consumer perspective, as observed in some research, there is still a certain level of resistance to the use of artificial intelligence solutions for clothing retail, which can be caused by multiple reasons, such as privacy concerns or lack of awareness. The pandemic crisis of 2020 has changed some facts that have been present for years, and now companies must adapt not only to the new reality imposed by the pandemic, but also to consumers who are increasingly informed.

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UTJECAJ UMJETNE INTELIGENCIJE NA MODNU INDUSTRIJU

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Sažetak: *Umjetna inteligencija i njeni elementi moćni su alati koji se mogu primijeniti u mnogim procesima pa tako i i modnoj industriji, od koncepta i dizajna do izvora materijala, proizvodnje, logistike i maloprodaje. Primjena umjetne inteligencije može doprinijeti različitim poboljšanjima poput ubrzanja i skaliranja procesa, rukovanja velikim količinama podataka za šta ljudi nisu sposobni te može ponuditi potrošačima nove načine doživljavanja maloprodaje. Ovaj rad ima za cilj prikazati kako umjetna inteligencija mijenja modnu industriju. Opisane su specifičnosti umjetne inteligencije, uključujući strojno učenje, računarsku viziju, robotiku i obradu prirodnog jezika. Opisano je kako se odjeća može dizajnirati i proizvoditi upotrebom elemenata umjetne inteligencije i prikazana su dva primjera iz prakse šivanja i rukovanja tekstilom.*

Ključne riječi: *umjetna inteligencija, računarska vizija, robotika, šivanje, rukovanje*

1. Uvod

Modna industrija uvijek je bila na čelu inovacija i tehnologija, prilagođavajući se promjenjivim preferencijama potrošača, novim trendovima i napretku u proizvodnim procesima. S porastom umjetne inteligencije, modna industrija ponovno prolazi kroz transformaciju koja mijenja način na koji se proizvodi dizajniraju, proizvode i prodaju. Od dizajna do marketinga i prodaje, umjetna inteligencija utječe na sve segmente izrade gotovog proizvoda i nudi tvrtkama nove prilike za pojednostavljenje poslovanja i postizanje novih dostignuća. Jedan od najvećih utjecaja umjetne inteligencije na modu je u području upravljanja opskrbnim lancem. Uz modele umjetne inteligencije koji se mogu obučavati prema poznatim razinama zaliha i uspješnosti prodaje kako bi se predvidjela buduća prodaja, tvrtke mogu donositi bolje odluke o tome što skladištiti i kada. To može pomoći u smanjenju otpada, poboljšanju zadovoljstva kupaca i povećanja profita [1].

2. Koncept umjetne inteligencije

Kako bi shvatio može li stroj razmišljati kao čovjek - ili, bolje rečeno, može li oponašati ljudska ponašanja i reakcije - britanski i znanstvenik Alan Turing je 1950. godine napravio Turingov test koji se sastojao od igre s dva čovjeka (jedan koji ispituje i jedan koji odgovara) i jednog računara. Ispitivač bi postavljao pitanja i osobi i računara, a kasnije se od njega tražilo da na temelju odgovora identificira tko je čovjek, a tko stroj [2].

Smisao te takozvane igre oponašanja bila je natjerati računar da zavede ispitivača da ne može razlikovati to dvoje, a ako ih je stroj uspio prevariti, prošao bi test i dokazao svoju inteligenciju. Ova sposobnost računara da reagira poput osobe moguća je zahvaljujući obradi prirodnog jezika (NLP), obliku umjetne inteligencije koja razumije ljudski jezik - koji je potpuno drugačiji od jezika koji se temelji na kodovima strojeva.

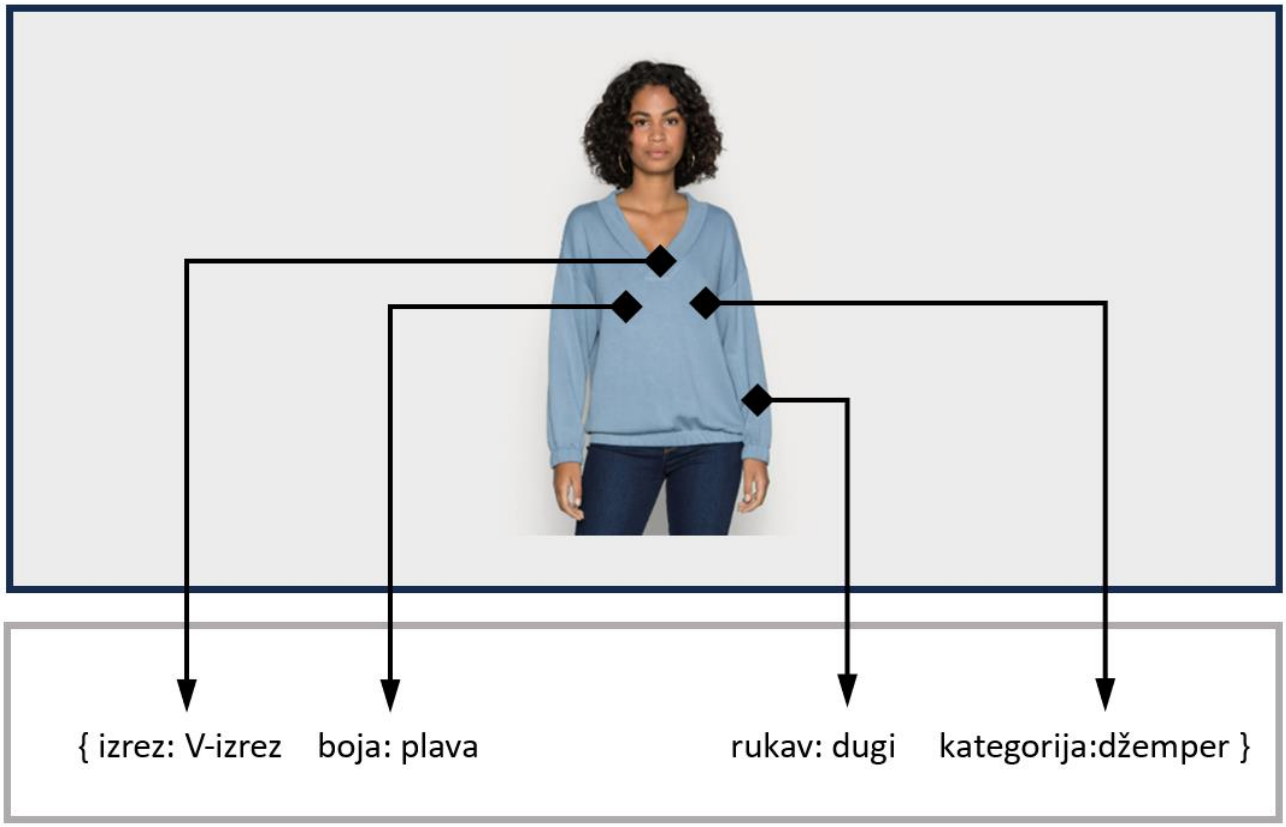
Umjetna inteligencija je krovni pojam i postoji mnogo načina da se ona realizira. S njoim je moguće natjerati strojeve da osjećaju, razmišljaju i djeluju na zadane podražaje. Da bismo počeli govoriti o umjetnoj inteligenciji, prvo je bitno razumjeti koncept podataka, budući da se umjetna inteligencija uvelike oslanja na prikupljanje i analizu podataka. Prema Luce Leanne (2019), podaci su općenito "sirovi skup informacija koji zahtijeva određenu obradu kako bi imali konkretno značenje" i mogu se strukturirati - kada su organizirani, što olakšava strojevima da shvate smisao organiziranih ili nestrukturiranih odnosno neorganiziranih podataka slobodnog oblika, poput postova na blogu ili elektronske pošte. Tvrtka može imati velik skup podataka koji mogu biti ili interni, nastali unutar organizacije poput web stranice tvrtke ili narudžbenica, ili vanjski, koji su oni koji su nastali izvan tvrtke, poput društvenih medija ili makroekonomskih pokazatelja.

Četiri glavna područja umjetne inteligencije koja su posebno relevantna za modnu industriju uključuju strojno učenje, računarsku viziju, obradu prirodnog jezika i robotiku. Ako je konačni cilj umjetne inteligencije natjerati strojeve da razmišljaju, ponašaju se i reagiraju poput ljudi, trebali bi imati sposobnost učenja iz prošlih iskustava i primijeniti to znanje u budućim procesima, baš kao što to čine ljudska bića. To je moguće kroz strojno učenje, iznimno važno polje umjetne inteligencije koje ima za cilj identificirati obrasce u podacima koji su prethodno uneseni u stroj, predviđajući vrijednost nepostojećih podataka čime se strojevima omogućuje učenje bez ručnog programiranja [3].

Dva su načina na koje računari uče: nadzirano i nenadzirano učenje. Nadzirano učenje uzima postojeće podatke (ulaz) i već poznate odgovore podataka (izlaz), osposobljavajući stroj za predviđanje drugih budućih

izlaza u slučajevima neizvjesnosti a sve na temelju dokaza. Kada postoje samo ulazni podaci i nema prethodnih odgovora, stroj uči kroz nenadzirano učenje, oslanjajući se samo na temeljne obrasce i zaključke iz skupa podataka. Primjene svakog načina učenja ovisit će o prirodi dostupnih podataka.

Moć vida data je strojevima putem računarske vizije, što im omogućuje prepoznavanje, tumačenje i obradu digitalnih slika i videa, slika 1. Putem prepoznavanja slike, stroj može analizirati piksele i njihove numeričke vrijednosti na datoj slici, prepoznavajući ih kao objekt, osobu, životinju itd.



Slika 1: Primjer prepoznavanja detalja odjeće računarskom vizijom [2]

Područje obrade prirodnog jezika proučava i analizira tekstove, usmene i pisane, koji nastaju prirodno, a da nisu učinjeni u svrhu analize i uz ograničenje da se radi o tekstu koja ljudska bića koriste za komunikaciju s drugim ljudima. Pomoću obrade prirodnog jezika je bilo moguće razviti aplikacije kao što su Amazon Alexa, Apple Siri i Google Home [4].

Roboti su već dugo prisutni u narodnoj mašti i kulturi. Kada je znanstvena fantastika zamišljala kako će budućnost izgledati, često je bila ispunjena robotima koji žive među ljudima, obavljaju razne zadatke, druže se, pa čak i zaljubljuju kao da su i sami ljudi. Ali realnost je da je robotika i način na koji se ona danas primjenjuje puno manje scenografski od toga [5, 6]. Roboti se koriste od proizvodne industrije, obavljajući automatizirane zadatke pomažući ili zamjenjujući radnike na terenu, do medicine, izvodeći operacije ili pomažući u rehabilitaciji pacijenata. U modnoj industriji robotika može pomoći u opskrbnom lancu, sa skladišnim zadacima skupljanja i pakiranja ili u proizvodnim procesima - poput automatiziranog šivanja i pletenja.

3. Dizajniranje odjeće pomoću umjetne inteligencije

Tradicionalno, dizajn odjeće je kreativan proces koji uključuje puno pokušaja i pogrešaka. Uz pomoć umjetne inteligencije stilisti mogu stvarati nove dizajne učinkovitije i točnije. Algoritmi umjetne inteligencije mogu analizirati velike količine podataka s društvenih medija, modnih blogova i kupovnih navika potrošača kako bi identificirali nove trendove i predvidjeli koji će stilovi i boje biti popularni u nadolazećim sezonama, omogućujući dizajnerima i trgovcima da budu u toku sa modnim trendovima.

Umjetna inteligencija također može generirati koncepte dizajna na temelju specifičnih inputa, kao što su boja, tkanina i stil, štedeći dizajnerima značajno vrijeme i trud dok im omogućuje da se usredotoče na usavršavanje

dizajna umjesto da počnu od samog početka. Umjetna inteligencija se trenutno primjenjuje u konceptu i dizajnu kroz istraživanje predviđanja trendova i metode generativnog dizajna. Trend je uobičajeni žargon u modnoj industriji. Boja godine, jakna sezone, torba mjeseca, sve se to zovu trendovi, odnosno modni trendovi. Ali pojam trend je puno dublji i širi od toga, to je obrazac promjene odnosno smjer u kojem se nešto razvija i mijenja.

Slika 2: Primjer kako umjetna inteligencija može vizualno i tekstualno analizirati objavu na Facebook-u [7]

Podaci prikupljeni s Instagrama, Pinteresta, Facebooka i drugih društvenih medija mogu dati uvid u trendove u nastajanju i njihovo mjesto na krivulji širenja trendova, što znači jesu li popularni samo među trendseterima i inovatorima, jesu li već dosegli svoj vrhunac ili ako su u padu. S ovim informacijama moguće je predvidjeti budućnost tog trenda s priličnom razinom sigurnosti i donijeti informirane odluke o projektu. Ali prikupljanje milijuna slika, videa i tekstova stvara ogromnu količinu podataka koji, ako nisu organizirani, grupirani i analizirani, jednostavno nisu korisni. Kako bi se to riješilo, može se upotrijebiti rudarenje podataka, proces koji otkriva obrasce u velikom skupu podataka i izvlači korisno znanje iz tih velikih repozitorija omogućujući filtriranje i dobivanje samo željenih informacija. Podaci se tada mogu skenirati pomoću računarske vizije kako bi se analizirao vizualni sadržaj i proces prirodnog jezika za tekstualni sadržaj [8, 9]. Na primjer, slika koju je influencer objavio na Instagramu može generirati puno uvida, kako vizualno, poput boja odjeće, printeva, duljina, tekstura i tkanina, tako i tekstualno, uz analizu naslova, hashtagova i emojija, slika 2.

Računar zna da se radi o jakni, paru čizama, boji ili vrsti materijala jer je naučio iz prethodno uvedenog skupa podataka fotografija označenih atributima odjeće. Jedan primjer skupa podataka ove vrste je inicijativa DeepFashion [10] razvijena na Kineskom sveučilištu u Hong Kongu. Uključuje više od 800.000 slika, označenih s "masivnim atributima, orijentirima na odjeći i korespondencijom slika snimljenih prema različitim scenarijima, uključujući radnju, snimku ulice i potrošača". Skup podataka dostupan je javnosti u svrhu istraživanja.

Dubinskim učenjem moguće je istrenirati stroj da primijeni ove klasifikatore atributa na sve buduće slike bez ljudskog nadzora. Kombinacija dubokog učenja, računarske vizije i obrade prirodnog jezika omogućuje grupiranje slika sa sličnim atributima, razumijevanje karakteristika poput relevantnosti i geografske pojave. Štoviše, omogućuje predviđateljima trendova da prate te klastere i njihovu evoluciju s vremenom, što omogućuje stvaranje pretpostavki o budućnosti trenda čiji je taj klaster sastavni dio. Ova metoda umjetne inteligencije može se primijeniti ne samo na objave na društvenim mrežama, već i na fotografijama s pisti s

tjedana mode, slikama uličnog stila i slikama e-trgovine. Analiza više platformi može biti posebno zanimljiva za razumijevanje kako trend može utjecati na potrošače i robne marke na različite načine.

4. Proizvodnja odjeće pomoću umjetne inteligencije

Umjetna inteligencija također transformira proces proizvodnje odjeće u modnoj industriji. Algoritmi mogu optimizirati proizvodne linije, smanjujući otpad i povećavajući učinkovitost. Umjetna inteligencija također može predvidjeti potražnju za određenim proizvodima i prilagoditi rasporede proizvodnje u skladu s tim, smanjujući prekomjernu i nedovoljnu proizvodnju. Postoji i fizička promjena koja se događa zbog umjetne inteligencije. Tipične proizvodne robote koji su se koristili desetljećima sada pokreće umjetna inteligencija, dovršavajući posao u djeliću vremena uz veću točnost. Novi inteligentniji roboti koriste se za obavljanje zadataka koji se previše ponavljaju ili su opasni za radnike, kao što je rezanje i šivanje tkanina i ne samo da poboljšavaju sigurnost radnika, već i smanjuju troškove proizvodnje.

Iako su aplikacije umjetne inteligencije prisutne već duže vrijeme u mnogim područjima, njezini su doprinosi tekstilnoj industriji prilično novi i još nisu široko rasprostranjeni. Primjene su uglavnom koncentrirane na kontrolu kvalitete, uzorke, boje i nedostatke. U procesima pletenja i tkanja moguće je identificirati pogreške u uzorku tkanine putem računarske vizije i strojnog učenja, proces koji će, ako se izvodi ručno, trajati dulje i bit će podložan ljudskoj pogrešci. Isto vrijedi i za kontrolu nijansi boja. Tradicionalno, kako bi bili sigurni da boja gotovog proizvoda odgovara izvornom dizajnu, tvrtke uspostavljaju parametre za toleranciju boja - koji se nazivaju instrumentalni sustavi tolerancije - koji su dogovoreni između proizvođača, dobavljača i kupaca i postavljaju kolika je razlika u boji prihvatljiva u uzorku . Međutim, ova metoda može generirati lažno pozitivne rezultate, zahtijevajući ljudsku intervenciju i usporavajući proces. Kontrolor vođen umjetnom inteligencijom može učiti iz prošlih inspekcija i stvarati tolerancije na mnogo učinkovitiji način. Kada je riječ o samoj proizvodnji tekstila, postoje eksperimentalne primjene na pletivu. Kroz dubinsko učenje, računari mogu generirati uzorke i upute za pletenje na temelju slike pletene odjeće, u nekoj vrsti automatiziranog stroja za pletenje. Iako se još uvijek ne koristi u velikoj mjeri, ti su eksperimenti zanimljivi za zamisliti budućnost s proizvodnjom tekstila vođenom umjetnom inteligencijom.

Inovativno rješenje u industriji proizvodnje odjeće koje je donio razvoj umjetne inteligencije su roboti za šivanje i rukovanje tekstilom. Sve do nedavno, strojevi su se borili za spretnost i vještine koje ljudi imaju pri rukovanju mekim materijalima poput tkanine. S evolucijom tehnologija kao što je strojno učenje, računari se počinju osposobljavati za učinkovito obavljanje takvih zadataka.

U radu ćemo prikazati dva primjera inovativnih rješenja za proizvodnju odjeće koja su dizajnirana i već se primjenjuju u nekim ograničenim slučajevima.

Prvi je SoftWear iz Atlante, SAD [11] koji je stvorio rješenje za autonomno šivanje pomoću računarske vizije i robotike. Iz ove kompanije tvrde da, uz njihovu tehnologiju, proizvođači mogu proizvoditi lokalno, premještajući lanac opskrbe natrag u svoja područja, a istovremeno održavati visoku kvalitetu i niže troškove. Prema podacima tvrtke, njihov robot za šivanje "Sewbot", slika 3, sposoban je sastaviti i sašiti jednu majicu za 2,5 minute, povećavajući učinak dva puta po osmosatnoj smjeni i ima sposobnost smanjenja radne snage za 90%. Osim toga, samo jedan operater može nadzirati do 6 robota za šivanje. Osim Sewbota, oni također nude punu radnu liniju za šivanje, automatizirajući cijeli proces i smanjujući vrijeme za šivanje majice na samo 22 sekunde. Ostali proizvodi koji se mogu sašiti s robotom tvrtke uključuju jastuke, prostirke, ručnike, obuću, madrace i torbe. Do sada je tehnologija dostupna za prodaju isključivo u SAD-u. Godine 2017. kineski dobavljač za Adidas najavio je partnerstvo s tvrtkom SoftWear, gdje su planirali proizvoditi 800.000 majica dnevno za marku sportske odjeće korištenjem Sewbota u svojoj tvornici u Arkansasu - SAD, smanjujući troškove rada za svaku majica do 33 centa.

Slika 3: SoftWearov robot za šivanje koji može rukovati tkaninom, pravilno je postaviti i izvesti šivanje.

Drugi primjer je Sewts [12], novi njemački startup koji razvija napredne robote za rukovanje tekstilom. Njihov cilj je u potpunosti automatizirati proizvodnju odjeće korištenjem računarske vizije i robotike.

Slika 4: Sewtsov robot, dizajniran za obavljanje naprednog rukovanja tekstilom za različite zadatke

Kamere integrirane u robote sposobne su "vidjeti" tkaninu i rukovati njome u skladu s potrebama. To je moguće realizirati zahvaljujući sofisticiranim simulacijama materijala koje reproduciraju ponašanje tekstila i pomažu u razvoju odgovarajućih algoritama za rješavanje njihove mekoće i fleksibilnosti. Do sada je primjena njihove robotske tehnologije za rukovanje tekstilom, slika 4, korištena u industrijskim praonicama. U ovoj su industriji koraci pranja, sušenja i slaganja odjeće već automatizirani, ali još uvijek je potreban ljudski rad kod strojeva za slaganje i pravilno postavljanje komad po komad kako bi se izbjegli nabori. Startup je prilično nov i nalazi se u ranoj fazi razvoja proizvoda, a osnivači predviđaju buduća rješenja koja će uključivati robotsku tehnologiju u drugim područjima rukovanja tkaninama kako bi postigli željenu potpuno automatiziranu proizvodnju odjeće. Pored robotske tehnologije za šivanje, cilj tvrtke je dizajnirati tehnologiju koja može proizvesti odjevne predmete po mjeri, putem podataka koji se generiraju skeniranjem tijela i šalju robotima koji ih proizvode u kratkom vremenskom razdoblju.

5. Zaključak

Modna i tekstilna industrija je sektor u kojem nove tehnologije još uvijek nisu toliko prodorne. Mnogi se procesi još uvijek uvelike oslanjaju na ljudski rad, a promjena ovog pristupa na više tehnološki mogla bi izazvati mnoge štetne posljedice na živote milijuna radnika u proizvodnji odjeće u ključnim zemljama. U drugim dijelovima modnog i tekstilnog industrijskog lanca, kao što su koncept i dizajn, nabava materijala te logistika i distribucija,

postoje neka inovativna rješenja koja pokreće umjetna inteligencija, ali ona još nisu standard za industriju. S gledišta potrošača, kao što je uočeno u nekim istraživanjima, još uvijek postoji određena razina otpora prema korištenju rješenja umjetne inteligencije za maloprodaju odjeće, što može biti uzrokovano višestrukim razlozima, kao što su zabrinutost za privatnost ili nedostatak svijesti. Pandemijska kriza iz 2020. promijenila je neke činjenice koje su bile prisutne godinama, a sada se kompanije moraju prilagoditi ne samo novoj stvarnosti koju je nametnula pandemija, već i potrošačima koji su sve više informirani.

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AI'S TRANSFORMATIVE IMPACT ON DIGITAL FASHION: INNOVATIONS AND ETHICAL CONSIDERATIONS

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Abstract: *This article explores the transformative impact of Artificial Intelligence (AI) in the field of digital fashion. It critically examines innovative initiatives, including the "AI Generated" magazine by Sevda Albers and the Adidas SPEEDFACTORY concept. It also highlights recent and notable examples where designers (Daria Shapovalova, Irina Raicu, Marco Simonetti, Maison Meta) drew inspiration from the legacies and aesthetics of renowned fashion brands like: Adidas, Jacquemus, Monklet, Nike, and Tommy Hilfiger. These designers have skillfully integrated AI technology into their work, resulting in some of the best AI-driven projects that pay homage to the brands' legacies. The study provides an overview of the distinctive features of collaborations between designers and AI. These collaborations can customize fashion experiences for individuals by using AI to consider personal preferences, enhancing both creative design and overall product quality. Furthermore, the article addresses ethical considerations, including privacy, transparency, consumer autonomy, and job displacement, associated with AI integration in the fashion industry. It emphasizes the central role of responsible AI implementation in achieving personalized fashion excellence. As the digital fashion landscape evolves, this article presents the considerable potential of AI to enhance personalization, design innovation, and product quality.*

Keywords: *Artificial Intelligence (AI); Digital Fashion; Fashion Technology; Fashion Design*

1. Introduction

Artificial intelligence (AI) refers to the capacity of digital machines or computer-controlled robots to perform tasks that typically require human intelligence [1]. This includes processes such as reasoning, meaning discovery, generalization, and learning from past experiences [2]. AI was developed as a scientific field and a set of computer technologies inspired by the way humans use their nervous systems and bodies to feel, learn, reason and act [3].

The intersection of Artificial Intelligence (AI) and the fashion industry represents a dynamic and transformative partnership [4]. AI technologies have infiltrated various aspects of the fashion ecosystem, from personalization and design innovation to manufacturing and retail experiences. Some of the most intriguing examples of AI's impact on product personalization and design creativity in the fashion industry are seen when designers build on the legacies and identities of renowned brands like Moncler, Adidas, H&M, and Jacquemus, showcasing the potential of AI technology. These brands were chosen due to their prominence in the fashion industry and their noteworthy engagements with artificial intelligence. By analyzing these specific brands, the article aims to provide concrete examples and insights into how AI is actively shaping various aspects of the fashion landscape, from design processes to personalized consumer experiences. This focused approach allows for a detailed examination of real-world applications and showcases the diverse ways in which AI is integrated into the practices of influential fashion entities.

However, as AI integrates with the fashion landscape, significant ethical concerns surface, including issues of privacy, transparency, consumer autonomy, and the potential for job displacement [5,6]. The responsible implementation of AI is crucial for preserving personalized fashion excellence while ensuring ethical standards. The integration of Artificial Intelligence (AI) into the fashion industry introduces transformative possibilities but also raises significant ethical concerns. Balancing the potential benefits of AI-driven innovations with ethical considerations becomes a key challenge for the industry.

2. Method

This article employs a qualitative research approach to comprehensively explore the transformative impact of Artificial Intelligence (AI) on the fashion industry, focusing on renowned brands such as Moncler, Adidas, H&M, and Jacquemus. The qualitative analysis involves an examination of case studies, content analysis, and in-depth exploration of collaborations and initiatives where AI intersects with the fashion landscape. By leveraging qualitative methods, the article provides a nuanced understanding of the unique strategies and approaches

each brand adopts in integrating AI into their practices, particularly in the realms of product personalization and design creativity.

To establish a theoretical framework, this article also incorporates a literature review that situates the research within the existing body of knowledge on AI in the fashion industry. The review encompasses relevant academic articles, industry reports, and scholarly publications, offering insights into the broader context of AI applications in fashion. This literature review ensures a scientifically grounded exploration of the selected brands and their AI-driven initiatives.

3. Results

Exploring the transformative impact of AI on fashion highlights case studies that exemplify the dynamic interplay between technology and creativity. These case studies emphasize the fusion of AI with renowned fashion brands such as Moncler, Adidas, Jacquemus, and Tommy Hilfiger and show how AI technology is improving creativity, innovation and consumer experience in the fashion industry.

AI-Driven Design Innovation - Case Studies Enhancing Creativity and Quality in Fashion

In examining how AI transforms fashion, we focus on case studies illustrating the dynamic interaction between technology and creativity. Moncler is recognizable for its unique blend of luxury and functionality, prioritizing high-quality materials and expert craftsmanship in its designs. The brand's iconic outerwear, particularly its quilted jackets, has taken center stage in an AI campaign in collaboration with Maison Meta and Creative Agency WeSayHi [7]. This resonates with the collaboration between Adidas and Moncler, illustrating the fashion industry's incorporation of technology, luxury, NFTs, and AI to craft a distinctive retail experience. Both examples underscore the creative and innovative potential of AI, particularly when applied to fashion's timeless elements.

Moncler Collaboration with Adidas Originals, FRGMT and Roc Nation by Jay-Z can be found on the following link:
• TL Team. (2023) Moncler Genius First AI Campaign.
url: https://trendland.com/moncler-genius-first-ai-campaign/

Jacquemus is a renowned name in the fashion world, celebrated for its avant-garde approach to design and its unique blend of modern minimalism with a touch of Mediterranean influence, best known for its clean lines, playful silhouettes, and bold colors. Designer Marco Simonetti has introduced an AI-powered pop-up concept that combines the distinctive aesthetics of Jacquemus and Nike [8]. The concept showcases the potential of AI in shaping modern fashion experiences while highlighting the sculptural quality and unique silhouettes associated with Jacquemus' designs. This example demonstrates the innovative use of AI in the fashion industry, emphasizing practical applications and the potential for AI to enhance consumer engagement and data insights.

Nike X Jacquemus Collaboration by Marco Simonetti can be found on the following link:
• Weibo. (2023) Marco Simonetti updates the AI concept of the Nike x Jacquemus joint series.
url: https://weibo.com/7062972489/MnanDaZiy?from=page_1002067062972489_profile&wvr=6&mod=weibotime

Tommy Hilfiger hosted an AI design contest, in which Irina Raicu's design emerged as the winning entry [9]. Irina Raicu's innovative project for Tommy Hilfiger evolves with a bold and oversized silhouette with padded patterns. While reminiscent of a classic padded jacket, this design elevates the familiar aesthetic with a futuristic edge, exemplifying a union of contemporary fashion and timeless comfort. These winning designs were transformed into digital wearables, available for purchase on the virtual fashion platform DressX, further demonstrating the brand's forward-thinking approach to fashion and technology. By using AI to create digital wearables, Tommy Hilfiger enhances its aesthetic while venturing into new territories in the fashion realm. This collaboration marks a significant step towards a digitally integrated and AI-enhanced future for the industry.

Figure 1: Digital wearables designed with AI by Irina Raicu for Tommy Hilfiger x MVFW23.
Photo available from: https://www.irinaraicu.com/tommy-hilfiger,
Accessed: 2023-11-13

Adidas SPEEDFACTORY was an innovative concept in the fashion world, representing a fusion of cutting-edge technology and design [10]. This high-tech facility utilized automation, 3D printing, robotics and automated assembly lines to revolutionize the production process, delivering sneakers with precision and speed. In Adidas SPEEDFACTORY, advanced algorithms helped create personalized designs and experiences, exemplifying how technology was redefining the way we created, designed, and experienced fashion, much like AI was transforming the industry. One of the primary goals of SPEEDFACTORY was to enable greater customization of athletic footwear by allowing customers to personalize certain aspects of their shoes, such as color, design, and fit. SPEEDFACTORY aimed to bring production closer to the consumer by establishing small, automated factories in key locations. This allowed for quicker turnaround times in creating and delivering customized or limited-edition footwear. The original concept of Adidas SPEEDFACTORY was groundbreaking in its streamlined and automated approach to shoe production. However, in 2019, Adidas announced the shutdown of its SPEEDFACTORY operations as part of a broader effort to optimize production and reduce costs [11]. Despite the physical closure of the SPEEDFACTORY facilities, the innovative technologies and insights gained from the concept continue to influence the industry, serving as a valuable case study on how technology could reshape traditional fashion processes, even after the specific facilities ceased operations.

Sevda Albers is a creative director and photographer known for her work in AI technology. Her portfolio encompasses a wide range, from AI-generated images to traditional photography, showcasing an attention to detail and a dedication to innovation. Albers believes in the transformative power of storytelling through design, aiming to evoke emotions and create a lasting impact. Her collaborative approach is tailored to the unique needs and goals of each client, ensuring that every project is executed with excellence and precision. Recognizing the significance of visual storytelling, Albers is dedicated to producing authentic and captivating content that captures the essence of brands, maintaining a genuine and non-pretentious aesthetic even when leveraging AI technology. Sevda Albers conceived the idea for a magazine called "*AI Generated*" where she features her work created using Midjourney (AI tool and platform used by artists and designers to create and improve visual content like images and designs). The editorials in the magazine exhibit a strikingly realistic appearance, showcasing the incorporation of AI technology into the field of fashion photography.

Visual Stories from the AI-Generated Magazine by Sevda Albers can be found on the following link:
• Sevda Albers. (2023) AI-Generated Magazine.
url: https://www.sevdaalbersai.com

Ethical Considerations in AI Fashion

Ethical considerations play a central role in the integration of Artificial Intelligence (AI) [12] in the fashion industry, addressing issues such as privacy, transparency, consumer autonomy, and job displacement [13]. In terms of privacy, as AI systems process vast amounts of personal data, safeguarding individual privacy becomes crucial. Transparency in AI-driven decision-making is essential, requiring fashion brands to openly communicate how algorithms influence personalized recommendations and design processes. For instance, disclosing how an AI system tailors fashion suggestions based on user data adds a layer of transparency. The ethical use of AI should empower consumers rather than replace their autonomy [12]. AI-driven personalization should provide individuals with informed choices about their fashion preferences. A case in point is ensuring that AI-based recommendations consider individual tastes without imposing predefined styles. Job displacement concerns, a common ethical consideration, necessitate strategies such as reskilling the workforce [14]. For example, initiatives focused on training employees in AI-related skills can mitigate job displacement risks. Addressing these ethical considerations is imperative for the responsible and sustainable integration of AI in the fashion industry, fostering an environment where AI enhances the industry while respecting individual rights and choices.

4. Conclusion

The intersection of Artificial Intelligence (AI) and the fashion industry presents a compelling landscape where technology, creativity, and ethical considerations merge. The exploration of AI-driven initiatives within renowned fashion brands, illustrated by collaborations and innovative photography by Sevda Albers, vividly demonstrates the potential for AI to revolutionize personalization, design innovation, and product quality. However, as AI becomes integrated into fashion, ethical concerns surrounding privacy, transparency, consumer autonomy, and job displacement emerge as critical focal points. Addressing these ethical considerations is pivotal for the responsible and sustainable implementation of AI in fashion, ensuring a balance between technological advancements and ethical standards. The analysis undertaken in this article underscores the use of AI in reshaping the fashion landscape. Considering these findings, future research in this field should aim to predict the trajectory of AI in fashion, delving into its evolving role and potential impact. This exploration is crucial to understanding the evolving role and potential impact of AI in shaping the future landscape of the fashion industry.

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PHYGITAL FASHION PRACTICE
CASE STUDY: TRIBUTE BRAND

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Abstract: *The text is based on the research into the role of digital fashion in the production and dissemination of phygital fashion products. The research offers insight into digital fashion through several key terms (uchronic time, skins, digital skin, Internet of Things, Metaverse, sustainability and inclusivity). Digital space gives the possibility of constantly recreating and performing a digital body whose existence crosses the boundaries between digital and physical context. The research is based on a case study analysis of the digital fashion project ODDS by Tribute brand that further examines the potential for critical transformation of user experience in the online context.*

Keywords: *digital fashion; fashion system; phygital fashion product; digital body; Tribute Brand*

1. Digital fashion system in making

In the new, now of the post covid reality fashion system has been drastically challenged by more visibly present phenomenon of digital fashion and metaverse. Different fashion media have been extensively familiarising audiences with new possibilities of the fashion system expanding in the digital sphere. This introduction is focused on clarifying several key terms (uchronic time, skins, digital skin, Internet of Things, Metaverse, sustainability, inclusivity) relevant for the research of digital fashion and this will further be used in analysing one of the products of the digital fashion label Tribute brand.

In the book *Time in Fashion: Industrial, Antilinear and Uchronic Temporalities* Caroline Evans and Alexandra Vaccari write about different temporal concepts embedded in the fashion system. For the research into the relevance of digital fashion their concept of uchronic time is very significant. Uchronic time is characterised by fiction, fantasy, myths, innovations and imaginations of the fashion system. This concept refers to the fictionality of time, but at the same time it enables the projection and invention of the fashion future. Uchronic time implies the absence of a defined and determined time. Participation in the fashion system therefore imposes creative work in imaginary time, working with concepts, materials and bodies that do not yet physically exist but will have a future responsible role in directing fashion trends and the market. In the practice of the fashion system, uchronic time becomes, for example, tangible through the phenomenon of trend forecasting and similar commercially motivated predictions in fictional time. The context of digital fashion culture (especially fashion blogs, digital fashion, AR and VR fashion practices, online shopping and digital fashion media) is a key framework for understanding immersion in uchornic times. Fashion online radically questions the seasonality of fashion (fashion trends) and the dependence on the fast fashion industry. In this sense, uchronic time additionally dissolves the relationship with spatial and temporal fashion strongholds, dematerialises the relationship with the body and clothes, and accelerates time simultaneously transforming the personal and collective fashion image [1].

The consumers are more explicitly confronted with the new realm of phygital fashion production that enters the sphere of everyday life mainly through social media. Phygital products create the bridge between physical and digital worlds by enhancing consumer experiences. Within fashion system that often means embracing interactive screens, augmented reality (AR), and virtual reality (VR) to create immersive consumer experiences. Before consuming and performing digital fashion most users of online apps such as Instagram or Snapchat were already deeply engaged with different filters to modify their personal bodily image. This first contact with the digital possibility to alter our online image lays ground for future implementation of digital fashion practice. Another important precedent of digital fashion is rooted in the gaming context and it mainly refers to different looks the avatars or items can have in

the gaming environment. These looks are called skins and they account for the largest profits in the gaming industry. In many cases games can be downloaded for free but the customisation and visual curation of it requires extra investments. Personalisation of different digital entities enhances the gaming experience but also fosters different approaches to identity representation in the digital context. Representation of diversity in the gaming environment can challenge the players to act outside dominant cultural/social/economic perspectives but also to envision their avatars in more than human ways. This approach to creating one's visual identity in the gaming setting is a good reference base to understand what might also be possible to recreate in the digital fashion context.

Another related concept often discussed in relation to skins practice in digital fashion is d*igital skins* that actually translate contemporary and future technologies of the co called *Internet of Things* (IoT). An IoT ecosystem consists of web-enabled smart devices that use embedded systems (such as processors, sensors and communication hardware) to collect, send and act on data they acquire from their environments [2]. The IoT is structurally comparable to *digital skins*, because surfaces become sensitive, smart and highly connected, just as a skin is the medium to connect the nervous system with the outer world. Digital *skin* covers both technologies becoming life-like and humans incorporating artificial devices. The term *digital skin* implies alternate forms of embodiment and poses the question of the importance of the body. *A*pplied to the human body or clothes digital skin will alter perception, allowing for different ways of moving and acting as well as pushing for novel user experiences [3].

The rise of digital fashion was also heavily dependent on the new metaverse market for showcasing digital products. Metaverse can be described as the "other" world - the Internet megastructure in the making. The term metaverse refers to the multiplicity of virtual experiences, environments, capital and relationships in the online sphere that has gained new momentum during the pandemic. It represents the new phase of life on the Internet that also requires a new technological and organisational vocabulary to understand all the implications of it. Fashion descended into the metaverse in 2022 when the first ever Metaverse fashion week was organised on Decentraland (3D online platform where users can purchase different virtual goods such as clothes, accessories or buy property). Besides digital fashion brands such as Dressex and The Fabricant many physical luxury brands have also taken part (Dolce and Gabbana, DKNY, Coach etc) together with fast fashion brands (Adidas, Tommy Hilfiger or Diesel). Many brands recognised the necessity for immersing more directly in the digital wear industry and therefore extending their product placement strategies. The metaverse fashion week format was sadly not truly challenging the already established norms of the IRL fashion systems (the logic of the online experience actually mimicked the retail shopping experience).

Digital fashion practice promises a potential alternative to the dominant IRL fashion system and this is mainly pushed through two criteria: sustainability and inclusivity. Fast fashion overproduction and the excess of textile waste have been massively burdening fashion system so the digital alternative have been offering a drastically *cleaner* products with less carbon print. Digital fashion uses 97% less carbon than physical garments in its production. For example the carbon footprint of a basic T-shirt is 6.5 kilograms and a digital version is 250 grams [4]. The future predictions foresee the effect of digital fashion is in reducing the production of physical garments and therefore relieving the fashion system of it’s disastrous consequence on the environment and human lives that are affected by the sweatshop fast fashion production. Digital fashion also allows more inclusivity allowing individuals to experiment with multiple ways of self-expression, therefore embracing and performing different visual takes on race, ethnicity, age, size, gender identities that can often be very limited in real life [5].

Taking into account all of the previously mentioned characteristics of digital fashion practice the next chapter delves into approaches and products of Tribute Brand and tries to unpack how digital fashion can critically transform our experience of fashion in the online context.

2. Phygital wear

Tribute brand was initiated by designer Gala Marija Vrbanić in 2020 and is described as an *innovative company that makes digital clothing which consumers can buy and "paste" onto themselves* [6]. Prior to Tribute Brand Gala Marija Vrbanić had already successfully run another fashion brand called Price on Request which was focused on criticising fashion consumption and using irony to reflect on the fashion systems’ norms. Tribute Band appeared as a direct response to dominantly digital Covid reality and was immediately internationally recognised as one of (then rare) projects dedicated to reshaping the domain of fashion production.

Long term Tribute brand aims to redefine digital fashion beyond the idea of the garments attached to human bodies but rather multiple different identities we can digitally embody and consume in the future. In this sense fashion should be outside of the tight terminology and practice of clothing: *In the virtual space, we don't need clothing on our bodies to define who we are. Fashion in digital ecosystems will soon not look like physical clothing but take on a completely different form* [7].

The experience of digital fashion already embeds more then clothing products as it includes so called Tribute brand asset that is technically an NFT (non-fungible token), a unique digital token that can be transferred, bought or sold. These assets function as digital records of authenticity, product origin and ownership. Full Tribute Brand experience therefore intertwines physical garments, digital garments and NFTs.

Their most recent product ODDS is chosen here as an example to showcase several key characteristics of contemporary digital fashion practice.

Image 1. Screenshot of Instagram post advertising ODDS, 19/6/2023

ODDS is a project based on generative sweaters done in collaboration with Waste Yarn Project and Chrome Squiggle. The partnership results in unique zero waste physical sweaters from surplus yarns derived from the source code of Chromie Squiggle. This collaboration combines sustainable fashion initiative, digital art project and digital fashion production. Customers are invited to create their own unique sweater using the ODDS generator based on randomised Chromie Squiggle code. The full ODDS asset includes a digital sweater blueprint and a physical sweater. The ODDS digital blueprint is a pixel-style visual instruction for the production of the sweater. This token stores all the information necessary to produce the physical sweater as well as digital garment (skins). This project brings together several keywords mentioned in the introduction: digital skins, sustainability, inclusivity and Internet of Things (NFC chip) in direct interaction.

The Waste Yarn project is a sustainable initiative that repurposes the surplus yarn accumulated in different factories. This yarn is then turned into new garments instead of becoming textile waste. The slow process of making the sweaters is ensured as each garment is handmade and it is knitted by methods that ensure the quality and longevity of the garment. Chromie Squiggle is, on the other hand, one of the first NFT digital art project that opens space for creative coding translated into digital visual art that can be further traded with. ODDS is basically the perfect example of phygital product - it entails the sustainable physical product that exists also as a digital asset. Additionally the physical garment includes the NFC chip (it is used for contactless communication similar to the one used for paying by card) which enables wireless communication with different devices (for example it connects to owners phone and Tribute brand mobile application but it also contains all the digital asset info on it too).

ODDS sweater surface is multilayered and digitally interactive second skin that enables post human clothing experience inextricably linked to digital devices and additional digital information existing between digital and physical worlds. Such presence speculates about possible novel user experiences and new expanded approach to wearing these hybrid garments. Wearing digital fashion in this case means fully grasping the potential of digital skin weaved into the physical garment. Sensorial experience of clothing intertwines with sensorial content uncovered through digital devices. The experience of wearing is a tangible one which mediates garment's materiality by the human skin [8]. In the phygital context that same skin is a bridge to the digital world that is now an inseparable part of our everyday existence.

3. More then business of digital fashion

Vogue Business recently published a report on the relevance of digital fashion for Gen Z generation and the results show the consumer behaviours that strongly intertwines digital experience with the physical one. Digital native generation more organically absorbs digital fashion trends and prioritises their digital presence (that actually only later influences their IRL looks) [9]. A lot of other online discourse around digital fashion today is centred on predictions focused on its profitability which further underlines intense capitalist consumer agenda of digital products. Fast fashion has also already switched to different online shopping models that enhance the shopping experience through diverse digital experiences (such as VR or AR) and this change has resulted in decreasing the number of IRL stores. The rise of digital fashion is on the other hand a potential opportunity to challenge the dominant fashion system and more radically rethink the potential of fashion besides blindly driving capitalist realities. The development of the digital fashion system will require a more concrete reinvention of fashion vocabularies, different models of visual fashion existence (beyond human bodies and conventional garments) and finally redefinition of social relation between diverse actors in the system. Multifaceted products like previously mentioned ODDS are paving way for these new fashion realities which will in the near future hopefully also create space for critical practices that can envision a more subversive fashion system. Taking into consideration the uchronic temporal aspect of fashion these new visions should go beyond replicating the existing system towards crafting possibilities for transformative self-expression.

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PERSONAL SPACE BETWEEN PHYSICAL AND VIRTUAL

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Abstract: *The fashion and textile industry has been fascinated by digitalisation for decades. But it was not until the 21st century, and especially with the outbreak of the COVID-19 pandemic, that digitalisation in the fashion industry really took off. Digital tools offer new, innovative and creative approaches in which many brands recognise sustainable and commercial benefits. The use of virtual prototyping can shorten the work process. It can also reduce the amount of physical sampling, which is important for production but very damaging to the environment. Fashion brands are increasingly using digital fashion, virtual reality and 3D animations to present their stories and new collections. By using interactive technologies, they are luring fashion enthusiasts into the fantasy world of fashion magazines and inspiring virtual shows.*
Digital tools and virtual sampling also enable retailers to offer more personalisation and customization with the help of configurations and virtual fittings. Virtual and augmented reality help customers visualise how garments will look on them before they buy and can help customers engage with fashion through other digital channels, such as gaming. In the fashion industry, the acceleration of digitalisation is expected mainly from the next generations, who have more digital experience, and education systems play an essential role in promoting skills and the use of digitalisation.
From September 2022, the Department of Textile and Clothing Design at the Faculty of Natural Sciences of the University of Ljubljana is included in the international Erasmus + Me-You-Us project. The project focuses on the development of digital 3D competences in the field of textile and clothing design for diversity, inclusion and the green transition. The Erasmus+ Me-You-Us project involves a three-year collaboration between three higher education institutions: Designskolen Kolding (DK), Willem de Kooning Academy (NL) and the University of Ljubljana (SI). The project aims to develop nine freely accessible educational modules in the field of textile and clothing design, which will include various digital tools. In the first year, the University of Ljubljana explored the synergy between manual and digital design as part of the "ME" modules, which ended at the end of the 2023 summer semester. It developed the module "Personal space between physical and virtual". The students used CLO3D and explored the processes of digital design, virtual prototyping, digital development of clothing and export of 2D patterns for the physical implementation of clothing. The students created digital collections and physical garments that represent a close connection between the real and the virtual.

Keywords: *fashion and textile design; digital design; education; virtual prototyping; synergy between manual and digital design.*

1. Introduction

Creative fashion practise has traditionally been strongly associated with specialised craft processes, materiality and skills that have relied on tactility and principles of learning by doing. However, contemporary methods of fashion design and production increasingly rely on digital ways of working. This shift involves the use of tools and technologies to enable innovative developments in the design and production of clothing. Recent technological advances are therefore blurring the lines between physical and digital practises in the fashion industry [1]. The increasing digitalisation of fashion design and production processes paved the way for the development of digital fashion, as technological advances enabled designers to create and market clothing entirely in the digital world. Digital fashion thus emerged as a response to the growing need for innovative, sustainable, and virtual self-expression in an increasingly digitalised world. There are numerous interpretations and definitions of digital fashion and the terms associated with it. The term "digital fashion" entered the fashion industry at the beginning of the 21st century [2].

The fashion industry has always been interested in technology, but a pandemic has made the need for digital design even more urgent. Brands have been forced to quickly adopt technologies that allow them to continue operating despite challenges such as shipping restrictions and limited physical interactions. Digital design is replacing traditional methods with software that allows designers to create and modify designs without physical

production. The properties of fabrics are measured and digitally recreated, while avatars serve as fit models and show how the clothes will fit in real life. This digital approach also allows designers to test and experiment

with materials and prints and create virtual collections. The introduction of a digital supply chain is seen as a strategy to reduce waste and increase production speed. This is a double benefit for companies looking to become more sustainable and reduce costs at the same time.

Digital design is therefore becoming a key tool for the industry, allowing brands to create items quickly and remotely. Once created, 3D assets - realistic virtual objects - can be used in various scenarios, from marketing materials and virtual showrooms to enhancing e-commerce sites for customers and augmented reality experiences [3].

1.1. Sustainable and commercial benefits of digital fashion

The fashion industry is witnessing a widespread adoption of 3D design and virtual sampling, with brands, including those in footwear and luxury, leveraging these technologies to accelerate processes, cut costs, and enhance sustainability. This shift is part of a broader digital transformation within the industry. The use of 3D design and virtual sampling has increased significantly in recent years, with brands like Macy's, Hugo Boss, and Adidas incorporating digital prototypes into their development processes. The technology has proven to be particularly successful in categories like footwear, where it helps eliminate the need for producing physical samples for every design iteration. Despite its growing popularity, the technology has not completely replaced physical samples, especially in luxury fashion where the tactile experience of materials on a real body is crucial.

In addition, some companies use virtual reality in the design process to gain a better understanding of product dimensions. The use of 3D assets in marketing and e-commerce is also on the rise, with brands considering adapting these assets for virtual environments and virtual try-ons [4]. Recent advances in augmented reality (AR) technology for trying on clothes are making them more realistic and accessible. Given the rapid pace of development, experts expect benefits for fashion brands, such as an increase in digital sales of clothing, higher conversion rates and fewer returns in e-commerce. With AR clothing try-on, digital clothing appears automatically and in real time on a person, primarily via smartphones, but also on laptops and other devices [5]. Despite the positive aspects, there are challenges, including the need for training and a cultural change in companies to fully integrate these technologies into their processes.

Fashion schools are also gradually incorporating 3D into their curricula, but the skills are still in short supply among designers. Companies introducing 3D design have had positive experiences: they have attracted new talent and realised significant time and cost savings [4].

1.2. Digital design in fashion education

Current studies on textiles and garments integrated with digital technology are not only concerned with technical aspects, but also emphasise their potential for aesthetic expression and playful experimentation. Teaching digital design in higher education institutions (HEI) goes beyond imparting technical skills and knowledge; it also plays a crucial role in fostering students' creativity. In the field of fashion, it is about cultivating innovative approaches to overcoming technical obstacles - an area where virtual prototyping proves invaluable. Furthermore, the use of virtual prototyping software also encourages imaginative visual solutions and aesthetics. The creative potential extends to various image and design applications and offers students a wide range of opportunities to develop innovative solutions. In fashion education, digital design serves as a dynamic platform for students to explore new technologies, encourage a forward-thinking mindset and drive innovation in line with industry trends.

Higher education institutions play an important role in disseminating and raising awareness of sustainable development in fashion. In this context, it is important to emphasise digital technologies. The study by D'Itria and Vacca explores the overlap between fashion design education and sustainability and shows a strong link with digital media. The synergy between sustainability and digital innovation in higher education revolves around holistic practises, technology integration, interdisciplinary approaches and the promotion of transformative education models [6]. Transformative education, which is becoming increasingly important, promotes the change of ingrained ways of thinking and behaviour. This approach challenges individuals to rethink their existence and collectively question moral values for the benefit of our interconnected society. By encouraging us to reassess our impact, this transformative education aims to contribute to the creation of a more sustainable society [7]. In discussions that call for a re-evaluation of assumptions and values and the promotion of critical thinking and new creativity, the concept of transformative learning is therefore becoming increasingly important. It is the responsibility of higher education institutions to think ahead and rethink their approach in order to move towards transformative, socially engaged and future-orientated models of teaching and learning. These models should promote positive personal and social development [8].

In terms of the use of digital tools, HEI are increasingly integrating 3D software into their curricula to prepare students for the evolving demands of the fashion industry. The integration of 3D design tools aims to provide students with the essential skills for the digital future of fashion. In addition to 3D software, these institutions take a comprehensive approach to preparing students for the industry. The programmes cover a wide range of skills that include traditional techniques such as pattern cutting by hand as well as modern digital skills such as 3D printing, laser cutting and body scanning. Some institutions go further and offer specialised programmes that cover the entire fashion industry value chain, including material design, marketing and virtualisation.

Furthermore, the need to expose students to broader technological aspects is recognised, as seen in MBA programmes that include elements such as programming and artificial intelligence. This approach recognises the increasing importance of diverse skills that combine traditional craftsmanship with cutting-edge digital competencies to succeed in the modern fashion world [9].

2. Erasmus+ project Me-You-Us

The Chair of Textile and Fashion Design at the Faculty of Natural Sciences and Engineering, University of Ljubljana has been participating in the international Erasmus+ project Me-You-Us since September 2022. The project is a collaboration between three HEIs: Design School Kolding from Denmark, Willem de Kooning Academy from the Netherlands and the University of Ljubljana from Slovenia. At the heart of the project initiative is the realisation that digital tools offer a crucial opportunity to promote transformative change in fashion and textile design practise. We strongly believe that digital technology can serve as a starting point for a more sustainable future in fashion. Our methodology is based on improving existing teaching practices within HEIs.

By thoughtfully integrating digital tools into pedagogy, we aim to equip fashion educators and students with the knowledge and skills essential to adopting sustainable practises and promoting inclusion and diversity in the industry. The overarching goal is to develop nine course modules that demonstrate the effective use of digital tools and technologies, including 3D virtual prototyping, body scanning, artificial intelligence (AI), virtual reality (VR) and augmented reality (AR), specifically tailored to promote sustainable design in the context of artistic fashion education. The results of our three-year collaboration will consist of online resources tailored for fashion educators and students. These resources will include video tutorials, downloadable and printable teaching materials and clear descriptions of course modules, a library of examples of student work, articles and learning and teaching tools.

2.1. Introduction to Virtual Prototyping: Personal Space within Physical and Virtual

The Chair of Textile and Fashion Design at the University of Ljubljana is developing three modules. The first module ME: Personal Space within Physical and Virtual, which emphasises the synergy between conventional and digital approaches in textile and clothing design, was completed at the end of May 2023. The name "ME" sums up the core of this initiative and symbolises the empowerment of students in the context of complex digital transformation. This empowerment is inextricably linked to the values of inclusivity, diversity and sustainability, which serve as fundamental principles for the project.

The first module promotes the digital transformation of the design process. In testing the module, four subjects (Fashion Design, Textile Design, Digital Design and Garment Pattern Development) were brought together and practised with first year textile and fashion design students. It was taught by five mentors and three technical assistants, each with specific expertise. The students learnt new skills in using digital tools to develop their creativity and create sustainable projects. Using CLO3D software, they learned about digital pattern creation, digital product development, 3D visualisation and exporting 2D patterns for physical garment production.

The module took students through the process of developing a virtual garment inspired by an A-line dress. They learnt four different techniques to add volume to a dress and were encouraged to be creative with their newly acquired skills. The students learnt how to create their own print and use its repeat in the virtual garment. The process began and ended manually to better understand the benefits of digital technology. The module demonstrated the sustainable side of digital garment development with less waste of time and materials and consists of six key milestones where manual and digital processes seamlessly merge. Starting with 'Manual Pattern Development', where students learnt the techniques of manual pattern making, they created five 1:4 scale models (Figure 1).

Figure 1: Adding volume on patterns in the scale 1:4 - teaching material. Photo: Uroš Batič.

In the transition to the digital sphere, steps two to five focussed on digital design principles. In Step 2 they worked on digitally prepared prints and embroidery (Figure 2) and in Step 3 they learnt about CLO3D. In Step 4 'Digital pattern cutting' the students learnt the same techniques they had created in Step 1 (manually). This time, however, in a virtual environment with CLO3D. In Step 5, the students were asked to work with different virtual materials and apply their embroidery and prints (Figure 3). Our associated partner TRONOG played an important role in this step by providing the professionally scanned textile materials.

The final step is a combination of manual and digital work, where students learnt how to prepare virtual garments that were then printed and produced in the physical world. The result was digital collections and physically produced garments that represent a close connection between the real and virtual worlds (Figure 4).

The teaching method included: presentations ('Digital fashion industry', 'History of the A-line dress', 'The A-line dress in Slovenian textile and clothing heritage'), seminars ('Prints and stripes as an artistic element'), tutoring (refreshing manual pattern cutting techniques), teaching (step-by-step digital pattern cutting and virtual sampling), self-study (creative exploration of digital tools, teamwork and discussion among peers), analysis (final virtual and physical garment). Students worked in groups of two and four, which led to a significant learning effect as they supported each other in discussions. The entire module is presented through teaching materials: screen recordings, videos, PDFs, tutorials, manuals, etc. on the website: me-you-us.education.

Figure 2: Digitally added and deformed stripe patterns on garments created at 1:4 scale. *Author: Julija Potočnik.*

Figure 3: Clo3D visualisation of the garments, experimenting with prints.
Authors: Tara Urbanč, Eva Strnad, Zala Marolt and Taja Sejdić.

Figure 4: Top row – Clo3D visualisation of the garment, bottom row – physical garment. Photo: Marijo Županov. Model: Maja Gazvoda. *Authors: Larisa Gregor, Urban Dereani, Ema Cestnik and Ida Križnič.*

3. Conclusion

Students used CLO3D to learn different ways of digitally manipulating patterns, virtual sampling, 3D design, digital product development and exporting digital patterns for physical garment assembly. Sustainability was a recurring theme, sensitising students to its relevance and showing them how digital tools contribute to greener design. The aim of the module was to explore the synergy between manual and digital and to understand the process of product development. By giving students the opportunity to design virtual clothing using digital technologies, the goal was to promote innovation and sustainability in the fashion industry. The focus was on bridging the gap between virtual and physical garment production. The module effectively integrated theory and practise by combining theoretical discussions with practical activities such as virtual prototyping, pattern making and sewing. This integration deepened students' understanding, enabled them to apply their knowledge in practise, empowered them to critically analyse the fashion industry and promote innovation, democratic design and new business models. The module fostered students' critical thinking by encouraging them to question digitalisation, sustainability and inclusivity in the fashion industry. This critical perspective leads to the development of analytical skills and a deeper understanding of the subject matter.

In summary, the module and outcomes represent a significant step forward in fashion education as they address the needs of the industry and prepare students for the digital future of the industry. The success of the module is reflected in the performance of students achieving their learning objectives and increasing their creativity through virtual prototyping.

Acknowlegments
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DIGITAL TOOLS IN THE DESIGN OF A COLLECTION AND A FASHION PORTFOLIO

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Abstract: The work *Digital tools in the design of a collection and a fashion portfolio* explains the concept of a fashion portfolio as an irreplaceable presentation document in contemporary fashion, with a particular focus on the role of the portfolio in digital fashion. Using relevant examples from the world of contemporary fashion, the digital tools used to create the fashion collection and the associated digital portfolio for the *KOVARI 22/23* by Croatian designer Alison Ivašić are analyzed. Using the example of the analysis of parts of the designer's portfolio, we follow the example of the digital design of a fashion project from the definition of the fashion concept to the production of garments with special emphasis on the role of the digital tools used for the simulation of 3D visualizations.

Keywords: *fashion portfolio; fashion collection; digital fashion; CLO 3D*

1. Introduction

1.1. Portfolio – definition of the term

The fashion portfolio deals with the way of fashion communication and the forms of fashion presentation in the process of working on a fashion collection and its presentation to the public. The portfolio is therefore an irreplaceable presentation document and communication medium in the field of fashion design. The portfolio plays an irreplaceable role in communication between the fashion designer and the public, potential customers, clients or employers. Depending on whether it is created by professional designers or fashion design students, the appearance and character of a fashion portfolio varies and ranges from professional to thematic portfolios [1]. The student portfolio generally falls into the thematic portfolio category, which is determined by a predetermined theme in the form of a mentoring exercise, the theme of a fashion competition. Regardless of the type of fashion portfolio, the portfolio represents a selection of the highest quality work and is a form of "personal branding" [2] and identification of the designer. In terms of the different techniques for creating a portfolio, a distinction is made between a traditional paper portfolio and a digital and/or online portfolio. The paper version of the portfolio can be used in the direct presentation of the fashion collection in addition to the digital portfolio, enriched with handmade drawings or other original attachments to illustrate the design process and the concept of the collection.

1.2. Digital fashion and digital portfolio

When talking about contemporary fashion, one cannot avoid mentioning digital fashion, which is increasingly present in today's fashion world. Whether physical or digital, fashion is a form of self-expression of our personality and emotions. As we spend more and more time in the virtual environment created by social networks and globalization, it is a logical consequence that fashion is also being transferred to the virtual world. Programs such as Adobe Indesign and presentation programs as well as programs for text and image editing are used in the design of digital fashion portfolios. With the development of digital tools, the number of Internet platforms on which you can create an online fashion portfolio consisting of a series of images (Behance) or publish a created portfolio on Internet platforms such as a digital book or magazine (ISSUU) is also growing. Contemporary fashion houses understand the importance of digital platforms and tools for designing digital portfolios that validate the idea of digital fashion. Using the example of major fashion brands' campaigns from season to season, we follow how digital fashion appears in the digital fashion world and how major fashion brands present digital clothing and how they use 3D programs for their design and advertising. It is fair to say that digital fashion is not the future, but a reflection of the times we live in. Digital 3D clothing is a completely new concept that is made up of data and the imagination of the creator, who designs a photorealistic 3D product with the help of special computer programs such as CLO 3D, Marvelous Designer, Blender and other 3D programs. CLO 3D and Marvelous Designer are 3D design software programs that create virtual, realistic visualizations of garments and accessories using the latest simulation technologies for the fashion industry. Instead of using traditional methods to create garments, these programs enable the formation of pattern pieces, patterns, materials, colors, 3D image rendering, simulation, animation, fitting the garment model to different silhouettes and many other elements to form 3D garments. Digital clothing is based on a combination of virtual 3D, computer technology and animation techniques to make the character of garments more realistic.

Many major fashion brands such as Balenciaga, Prada, Adidas and others use 3D renderings in their campaigns for clothing, shoes and accessories. It is likely that life as we know it today will change in the next ten years with the advent of new technologies. The emergence of Blockchain5, Web36, NFTs and Metaverse will change the way we live, shop, play and create our digital content and identities. There are already digital fashion houses creating innovative 3D garments and fashion narratives that are completely intangible. The Fabricant is the world's first digital fashion house, and shortly after other platforms such as DRESSEX, Replicant, Tribute Brand, Placebo, etc. appeared. By using some artificial intelligence, with the software still being controlled by humans today, consumers can wear their digital clothes by uploading their photo to one of the platforms. The digital clothing is then applied to the uploaded photo and altered to create a finished product. Interestingly, the garments in the collection have no identity, no body and no face. Only when they return to reality is the image recorded on the model's body and the digital clothing takes on its final material form.

1.3. The video game becomes a form of digital fashion portfolio

The video game Afterworld – The Age of Tommorow by Balenciaga is proof that anti-fashion elements not only appear in the physical world, but also in the digital world. The game takes place in the year 2031 in different locations and spaces of the world of dystopian aesthetics: in the Balenciaga store, in a post-apocalyptic city, in different neighbourhoods, in a forest, on a mountain, where the avatars are dressed with the Fall/Winter 2021 collection. The clothes the avatars wear are designed to look worn and worn out, which alludes to the fact that we should wear clothes that do not fall apart and raises awareness of sustainable and smart consumption. What stands out in the game is that many of the clothes are anti-fashion: black men's suit, work suit, jeans and t-shirt and members of subcultures. Also interesting is the fact that the avatars in 2031 are wearing clothes that are current in 2021/2022, proving the game's mission from Balenciaga that we should buy less and wear the same clothes until they fall apart. In the same way, it can be said that fashion always returns after a few years and anti-fashion always stays the same. In the future, clothing that has only one function - to protect the body - will find a new purpose and a new form of presentation, going beyond the primary function of protection and becoming a means of communication of today. Together with the video game Afterworld – The Age of Tomorrow, fashion house Balenciaga has teamed up with Fortnite1, for which it is designing several outfits for the game inspired by authentic archive looks from the luxury fashion house. Taking the partnership one step further, Fortnite and Balenciaga have also designed a limited-edition collection of physical apparel that includes a variety of t-shirts, hoodies, jackets, hats and backpacks. With the increasing digitization of the design process and the acceptance of social media, the pioneers of 3D fashion design today are exploring the difference between digital and handmade goods by creating and selling digital forms of clothing that are only used in the virtual world, through which personalities are expressed and trends are shared on social networks and other internet platforms.

1.4. Fashion collection KOVARI 22/23 – an example of the digital design of a fashion project

Using the example of the fashion collection by Croatian designer Alison Ivašić, we analyzed an example of digital fashion design in the Croatian fashion practice of designers of the younger generation. The KOVARI 22/23 collection was created as part of the research for the thesis Antimodal elements of Labin miners' work clothes in fashion collection design. The starting point of the research is the analysis of the role of mining anti-fashion clothing and its contribution to contemporary fashion design. The KOVARI 22/23 collection was designed with the aim of highlighting the importance of anti-fashion clothing and the mining culture that shaped and built the identity of Labin and the designer through the design of fashion clothing. The result of the research is the KOVARI fashion collection, consisting of women's and men's clothing, in which the work and ceremonial clothing of the Labin miners is revived in a more modern way through the reconstruction of the tailoring image and the use of graphic elements such as symbols, slogans and signals, pointing out the importance of anti-fashion clothing and mining culture. A digital and physical portfolio was created for the international fashion competition Mittelmoda International Lab (Milan, 2023), where the collection was presented. The analysis of parts of the digital fashion portfolio will show how the traditional activity of mining and the associated anti-fashion character of clothing can be interpreted using modern methods of digital design of clothing and fashion portfolios.

2. The method used

The collection KOVARI 22/23 deals with the analysis of anti-fashion clothing, explores he concept of uniform and the anti-fashion uniform elements in the design of the garments. The collection consists of women's and men's clothing in which the work and service clothing of the miners in Labin is revived in a more modern way by reconstructing the image of tailoring and using graphic elements such as symbols and signals as well as specially made buttons and labels. When creating the collection, the aim was to create garments that have a meaning and an independent identity, which is why the name of the collection itself uses the local name for

miners kovari (Ital. cava – *mine*). When designing the collection, special attention was paid to digitally modeled cuts, laser-cut buttons, buckles and tags with plexiglass numbers, as well as labels with greetings, facts, symbols and people that are important to the concept of mining in Labinština.

2.1. Systematization of image material for digital mood board

The fashion portfolio for the KOVARI 22/23 collection documents the course of the above-mentioned research, which consisted of several phases. In the first phase of the research, a briefing on the topic was created in which the primary forms of research such as initial sketches, notes and photographs and the secondary forms of research such as literature and archive research were defined. The analysis of the collected materials and their influence on the design of the clothing collection led to the creation of a pictorial mood board, from which key terms were defined, the systematization of which led to the definition of the fashion concept (Figure 1).

Figure 1: Alison Ivašić, Digitally created mood board for the KOVARI 22/23 collection

2.2. Digital preparation of the technical drawing and the cut

After defining the key concepts and visuals on which the fashion concept of the collection was based, the creation of design drawings and then technical drawings for each planned garment that would eventually be produced was started (Figure 2). The Adobe Illustrator program was used to create linear technical drawings, while the CLO 3D program was used to create patterns and prepare the work on garment prototypes to make it easier to combine the final design and appearance of the garments. The patterns are based on work clothes in order to fulfill the utility function of the garments. The pattern pieces were modeled in the CLO 3D program, seam allowances were added and the pattern pieces were saved as a full-size file that can be printed on a 1:1 scale. In addition to the practical function, the collection also pays attention to the esthetic design of each outfit. Oversized cuts and pockets, regulators, water-repellent materials that create a reflective moment with their coatings, associated with the shiny surface of the Labiner coal as one of the main features, are integral esthetic segments of the collection. Thanks to the digital tools of the CLO 3D program, it was possible to simulate and verify the character, shine and texture of the proposed materials for the production of garments on the resulting digital images (Figure 3).

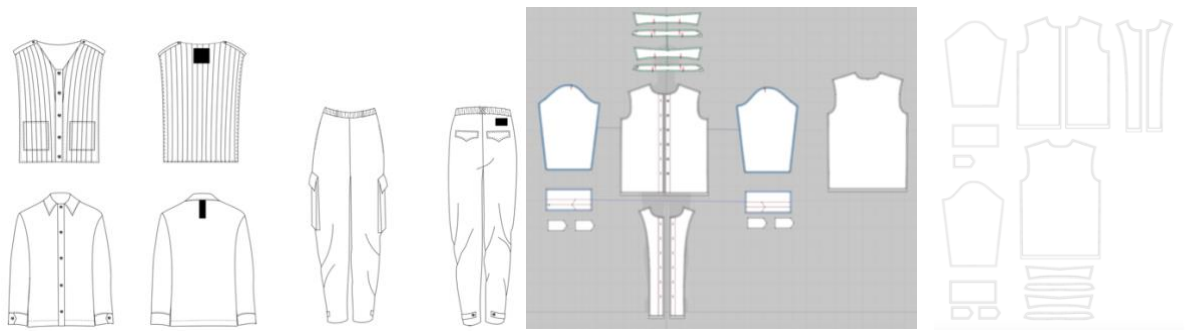

Figure 2: Alison Ivašić, Examples of digital technical drawing and editing preparation for the KOVARI collection 22/23

Figure 3: Alison Ivašić, Digital simulations of garment combinations for the KOVARI collection 22/23Digital preparation of labels, buttons and textile patterns for printing

2.3. Digital preparation of labels, buttons and textile patterns for printing

In the KOVARI 22/23 fashion collection, details such as buttons and labels play an important role in illustrating the concept of the collection. The design of these details adopts the rich aesthetics of signals and symbols found in non-verbal communication in mining. The buttons are based on the mining symbol of crossed hammers, while the meaning of the numbers refers to the numbering of miners and mining equipment.

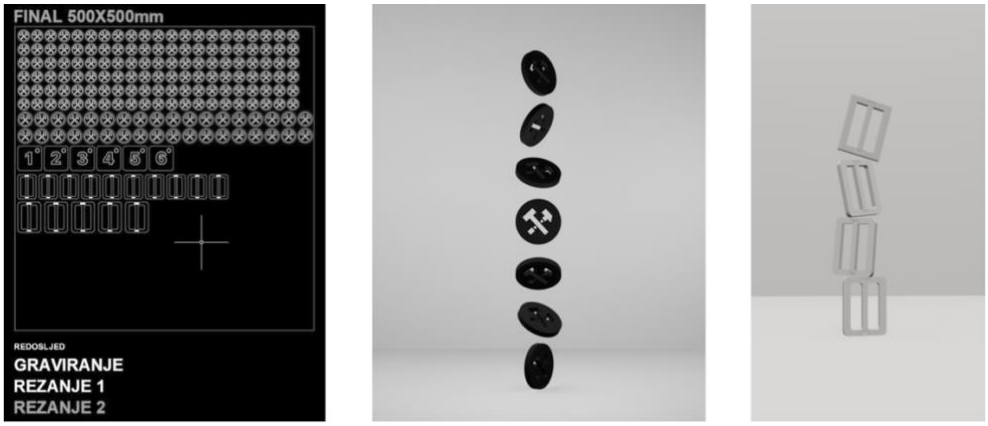

Figure 4: Alison Ivašić, Digital preparation and simulations of buttons and buckles for the KOVARI 22/23 collection

The labels, which are embroidered and sewn on all the garments in the collection, depict important events, people and facts related to the term miner.

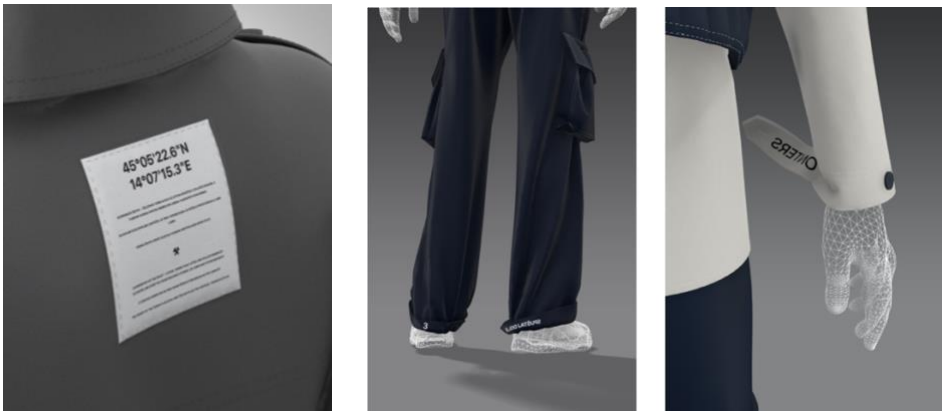

Figure 5: Alison Ivašić, Digital preparation and simulations of inscriptions on labels for the KOVARI collection 22/23

The templates for the textile patterns were created in Adobe Illustrator. Their design was based on the aesthetic value of knitwear originally used to make cotton T-shirts, which were an integral part of miners'

clothing. The knitting pattern is digitised and converted into linear patterns with a knitting motif, which is then used as a template for a textile pattern produced using the bud printing process (Figure 6).

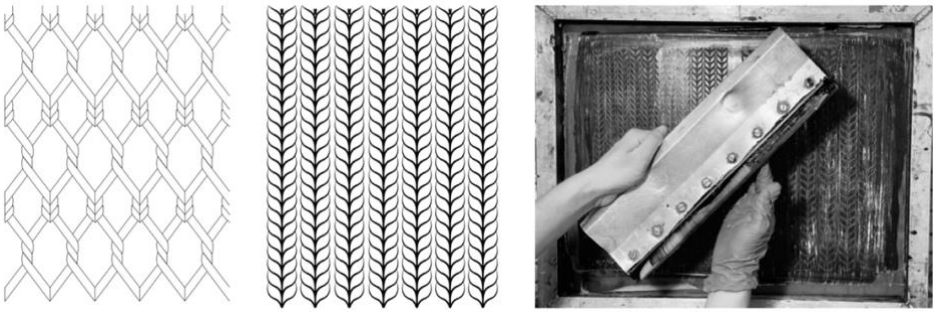

Figure 6: Alison Ivašić, digital preparation of the textile pattern and creation of the source print for the KOVARI 22/23 collection

3. Results

As mentioned in the second chapter, the CLO 3D program was used for the preparation of the KOVARI 22/23 collection in order to better predict the final design of the garments in the collection and the position of the labels, the final appearance and the position of the buttons. The buttons are made of matt Plexiglas in black color with the laser engraving and cutting technique with the recognizable motif of two crossed hammers, which are a symbol of mining. The same Plexiglas was used to make labels with numbers symbolizing the numbers worn by the miners when they lifted their equipment and drove into the mine, as well as belt buckles engraved with the year the Republic of Labin was founded. The design of the labels was created in Adobe Illustrator. The labels were UV printed on polyester fabric (Figure 7).

Figure 7: Alison Ivašić, Final look of the clothes and details in the KOVARI 22/23 collection (Photo: Denis Butorac, © Alison Ivašić)

On the renderings of the T-shirts and dresses, symbols are printed using the bubble printing technique, and patterns imitating knitting, also made using the bubble printing technique, extend over the entire surface of the fabric (Figure 8).

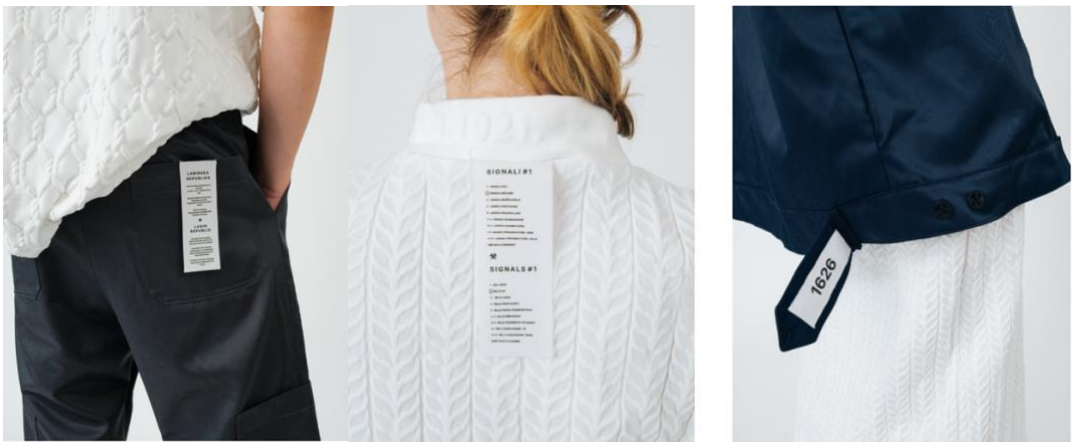

Figure 8: Alison Ivašić, Final appearance of the garments and swell print in the KOVARI 22/23 collection (Photo: Denis Butorac, © Alison Ivašić)

4. Conclusion

Based on the research conducted while working on designer Alison Ivašić's KOVARI 22/23 fashion collection, the design process from the first handmade sketches to the final fashion production was recorded. The handmade sketches were digitized and translated into the language and esthetics of the CLO-3D program, deliberately eliminating the representation of the human body from the sketches, which contributed to the erasure of identity and hints of styling when the focus was not exclusively on modernizing the anti-fashion format of the mining uniform, the look of the garment silhouette and material simulation. Using the research findings as an example, it was concluded that the language of anti-fashion clothing is a manifesto for the coming decades within the fashion industry, as we can see from the appropriation of anti-fashion elements and garments in contemporary fashion. What is changing significantly in the new era in which anti-fashion operates is the way in which anti-fashion is presented. Anti-fashion garments are basic, unchanging pieces, they characterize the role and form of clothing, but also the cultural affiliation. They do not so much change their form as their meaning and role in a particular temporal context. With the development of digital clothing and anti-fashion, it becomes part of the virtual future of the world.

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DIGITALNI ALATI U OBLIKOVANJU KOLEKCIJE I MODNOG PORTFOLIA

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Sažetak: U okviru rada *Digitalni alati u oblikovanju kolekcije i modnog portfolia* objašnjen je pojam modnog portfolia kao nezamjenjivog prezentacijskog dokumenta u suvremenoj modi s posebnim osvrtom na ulogu portfolia u digitalnoj modi. Uz relevantne primjere iz svijeta suvremene mode, analiziraju se i digitalni alati upotrijebljeni za oblikovanje modne kolekcije i pratećeg digitalnog portfolia za modnu kolekciju KOVARI 22/23 dizajnerice Alison Ivašić. Na primjeru analize dijelova dizajneričina portfolia pratimo primjer digitalnog oblikovanja modnog projekta od definiranja modnog koncepta do produkcije odjevnih predmeta s posebnim naglaskom na ulogu upotrijebljenih digitalnih alata za simulaciju 3D vizuala.

Ključne riječi: *modni portfolio; modna kolekcija; digitalna moda; CLO 3D*

1. Uvod

1.1. Portfolio – definicija pojma

Budući da modni portfolio obrađuje načine modne komunikacije i oblike modne prezentacije u procesu rada na modnoj kolekciji te njenom predstavljanju javnosti, portfolio je nezamjenjiv prezentacijski dokument i komunikacijski medij u području modnog dizajna. Portfolio ima nezamjenjivu komunikacijsku ulogu između modnog dizajnera i publike, potencijalnog kupca, naručitelja ili poslodavca. S obzirom na to izrađuju li ga profesionalni dizajneri ili studenti modnog dizajna, izgled i karakter modnog portfolia varira u oblikovanju te se kreće u rasponu od profesionalnih do tematskih portfolia [1]. Studentski portfolio uglavnom ulazi u kategoriju tematskog portfolia određenog zadanom temom u formi mentorske vježbe, temom modnog natječaja i sl. Bez obzira o kojoj se vrsti modnog portfolia radi, portfolio predstavlja izbor najkvalitetnijih radova te predstavlja oblik dizajnerova „osobnog brendiranja“ [2] i iskaznicu dizajnerova identiteta. S obzirom na raspon tehnika za oblikovanje portfolia razlikujemo tradicionalno rađen portfolio u papirnatom mediju i digitalni i/ili online portfolio. Papirnata verzija portfolia može se koristiti na izravnim predstavljanjima modne kolekcije uz digitalni portfolio obogaćen s crtežima izrađenim rukom ili drugim izvornim prilozima kao dodatno pojašnjenje dizajnerskog procesa i koncepta kolekcije.

1.2. Digitalna moda i digitalni portfolio

Govoreći o suvremenoj modi, nemoguće je ne dotaknuti se digitalne mode koja je danas sve više zastupljena u modnom svijetu. Bilo fizička ili digitalna, moda jest jedan od oblika samoizražavanja naše osobnosti i emocija. Provodeći sve više i više vremena u virtualnom okruženju nametnutim društvenim mrežama i globalizacijom, logičan je slijed da se i moda pretoči u virtualni svijet. U oblikovanju digitalnih modnih portfolia koriste se programi kao što su Adobe Indesign te prezentacijski programi i programi za obradu teksta i slike. Razvojem digitalnih alata povećava se i broj internetskih platformi na kojima je moguće online oblikovati modni portfolio koji se sastoji od niza vizuala (Behance) ili se izrađeni portfolio poput digitalne knjige ili časopisa objavljuje na internetskim platformama (ISSUU).Suvremene modne kuće shvaćaju važnost digitalnih platformi i alata u oblikovanju digitalnih portfolia u kojima se afirmira ideja digitalne mode. Na primjeru kampanja velikih modnih brendova iz sezone u sezonu pratimo kako se digitalna moda pojavaljuje u digitalnom modnom svijetu te kako veliki modni brendovi prezentiraju digitalnu odjeću i na koji je način koriste 3D programa za njeno oblikovanje i promociju. S pravom se može reći kako digitalna moda nije budućnost već prikaz vremena u kojem živimo. Digitalna 3D odjeća u potpunosti jest novi koncept sastavljen od podataka i mašte stvaraoca koja izražena kroz kreativnost tvori 3D fotorealističan proizvod uz potporu posebnih računalnih programa poput CLO 3D-a, Marvelous Designera, Blendera i drugih 3D programa. CLO 3D i Marvelous Designer su softverski programi za izradu 3D dizajna putem kojih se stvara virtualna, realistična vizualizacija odjevnih predmeta i dodataka s najsuvremenijim tehnologijama simulacije za modnu industriju. Umjesto korištenja konvencionalnih metoda stvaranja odjeće, navedenim se programima omogućuje formiranje krojnih dijelova, uzoraka, materijala, boja, renderiranja 3D slike, simulacije, animacije prilagođavanje modela odjevnog predmeta raznovrsnim siluetama i mnogim drugim elemenata kako bi se oblikovali 3D odjevni predmeti. Digitalna odjeća se zasniva na kombinaciji 3D virtualne i računalne tehnologije te tehnika animacije u svrhu stvaranja što realističnijeg doživljaja karaktera odjevnih predmeta. Mnogi veliki modni brendovi poput Balenciage, Prade, Adidasa i drugih koriste 3D prikaze u svojim kampanjama odjevnih predmeta, obuće i modnih dodataka. Za pretpostaviti je da

će se u sljedećem desetljeću pojavom novih tehnologija promijeniti život kakav danas poznajemo. Pojava *blockchaina*5*, Web3-a*6*, NFT-a* i *Metaversa* dovest će do promjene načina na koji živimo, kupujemo, igramo se i stvaramo svoje digitalne sadržaje i identitete. Već postoje digitalne modne kuće koje izrađuju inovativne 3D odjevne predmete i modne narative koji su u potpunosti neopipljivi. The Fabricant je prva svjetska digitalna modna kuća, a nedugo zatim pojavile su se i druge platforme poput DRESSEX-a, Replicanta, Tribute Branda, Placeba i sl. Korištenjem jednim dijelom umjetne inteligencije, s danas još uvijek ljudski upravljanim softwerom, potrošači mogu nositi svoju digitalnu odjeću na način da učitaju svoju fotografiju na neku od platformi. Potom se digitalna odjeća aplicira i modificira na učitanu fotografiju čime se dobiva gotov proizvod. Zanimljivo je da odjeća u kolekciji lišena identiteta, bez tijela i lica. Tek u povratku u realnost snima se na tijelu modela te digitalna odjeća poprima svoj konačni materijalni izgled.

1.3. Video igra postaje oblik digitalnog modnog portfolia

Dokaz da se antimodni elementi ne pojavljuju samo u fizičkom svijetu, već i onom digitalnom jest Balenciagina video igrica *Afterworld – The Age of Tommorow.* Igrica se odvija u 2031. godini na različitim lokacijama i prostorima diljem svijeta distopijske estetike; Balenciaginoj trgovini, postapokaliptičnom gradu, raznim četvrtima grada, šumi, planini i dr., u kojoj su avatari odjeveni u kolekciju jesen/zima 2021. Odjeća koju avatari nose napravljena je tako da izgleda iznošeno i istrošeno aludirajući na to kako trebamo nositi odjeću dok se ne raspadne pobuđujući svijest o održivoj i pametnoj potrošnji. Ono što se može primijetiti u igrici jest to da je mnogo odjevnih predmeta antimodno; muško crno odijelo, radničko odijelo, traperice i majica te pripadnike supkultura. Zanimljiva je i činjenica da avatari u 2031. godini nose odjeću koja je aktualna u 2021./2022. što dokazuje Balenciaginu misiju igrice kako trebamo kupovati manje i nositi istu odjeću do stanja njenog raspadanja. Isto tako, može se reći kako se moda uvijek vraća nakon nekoliko godina, a ono antimodno je uvijek nepromjenjivo. U budućnosti, odjeća kako služi jednoj funkciji – da štiti tijelo, pronalazi novu namjenu i oblik prezentacije, nadilazi primarnu funkciju zaštite te prelazi u komunikacijsko sredstvo današnjice. Uz video igricu *Afterworld – The Age of Tommorow,* modna kuća Balenciaga udružila je snage s Fortniteom1 za koji osmišljava nekoliko odjevnih kombinacija za igricu inspiriranih autentičnim arhivskim lookovima luksuzne modne kuće. Podižući partnerstvo korak dalje, Fortnite i Balenciaga izradili su i ograničenu kolekciju fizičke odjeće, koja sadrži mnoštvo majica kratkih rukava, majica s kapuljačom, jakni, šešira i ruksaka. Sve većom prisutnošću digitalizacije dizajnerskog procesa i prihvaćanjem društvenih medija, pioniri današnjeg 3D modnog dizajna istražuju distinkciju između digitalno i ručno proizvedene robe kreirajući i prodajući digitalne oblike odjeće koji se koriste samo u virtualnom svijetu i kroz koje se izražavaju osobnosti i razmjenjuju trendovi na društvenim mrežama i drugim internetskim platformama.

1.4. Modna kolekcija KOVARI 22/23 – primjer digitalnog oblikovanja modnog projekta

Na primjeru modne kolekcije dizajnerice Alison Ivašić analizirat ćemo primjer digitalnog modnog oblikovanja u hrvatskoj modnoj praksi dizajnera mlađe generacije. Kolekcija KOVARI 22/23 je nastala kao dio istraživanja unutar diplomskog rada *Antimodni elementi radničke odjeće rudara labinštine u oblikovanju kolekcije modne odjeće*. Polazište istraživanja jest analiza uloge rudarske antimodne odjeće i njezin doprinos suvremenom modnom dizajnu. Kolekcija KOVARI 22/23. nastala je s ciljem da se kroz oblikovanje modne odjeće ukaže na važnost antimodne odjeće i kulture rudarenja koja je obilježila i izgradila labinski i dizajneričin identitet. Rezultat istraživanja jest modna kolekcija *KOVARI*, formirana od ženskih i muških odjevnih predmeta, u kojoj se na suvremeniji način rekonstrukcijom krojne slike i korištenjem grafičkih elemenata poput simbola, slogana i signala revitaliziraju radna i svečana odjeća labinskih rudara te ukazuje na važnost antimodne odjeće i kulture rudarenja. Za kolekciju je izrađen portfolio u digitalnom i fizičkom obliku za međunarodno modno natjecanje Mittelmoda International Lab (Milano, 2023.) na kojem je kolekcija i predstavljena. Analizom dijelova digitalnog modnog portfolia bit će prikazan način kako tradicionalnu djelatnost rudarenja te pripadajući antimodni karakter odjeće interpretirati suvremenim metodama digitalnog oblikovanja odjeće i modnog portfolia.

2. Korištena metoda

Kolekcija KOVARI 22/23 bavi se analizom rudarske antimodne odjeće, problematizira pojam uniforme i antimodnih uniformnih elemente u oblikovanju odjevnih predmeta. Kolekcija je formirana od ženskih i muških odjevnih predmeta, u kojoj se na suvremeniji način rekonstrukcijom krojne slike, korištenjem grafičkih elemenata poput simbola i signala te posebno izrađene dugmadi i etiketa revitaliziraju radna i svečana odjeća labinskih rudara. Pri stvaranju kolekcije težilo se stvaranju odjevnih predmeta koji imaju značenje i autonomni identitet pa se tako i za sam naziv kolekcije koristi lokalni naziv za rudare *kovari* (tal. *cava* – rudnik). Posebna pažnja pri izradi kolekcije bila je na krojevima koji se digitalno modeliraju, laserski izrađenoj dugmadi, kopčama i pločicama s brojevima od pleksiglasa te etiketama s pozdravima, činjenicama, simbolima i osobama važnima za pojam rudarstva Labinštine.

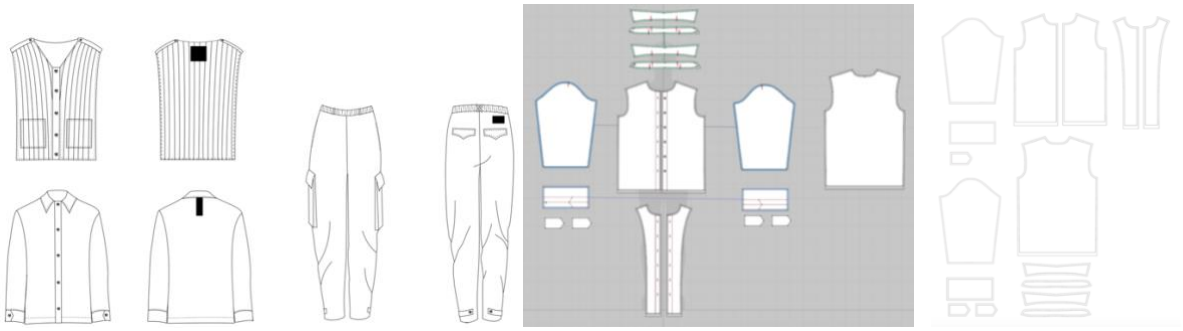
2.1. Sistematizacija slikovnog materijala za digitalni moodboard

Modni portfolio za kolekciju KOVARI 22/23 bilježi tijek navedenog istraživanja koji se sastojao od nekoliko etapa. U prvoj etapi istraživanja zabilježeno je brifiranje teme unutar kojeg su definirani primarni oblici istraživanja kao što su prve skice, zabilješke, fotografije te sekundarni oblici istraživanja poput istraživanja literature i arhivske građe. Analiza prikupljenih materijala i njihova utjecaja na oblikovanje kolekcije odjeće rezultirala je oblikovanjem slikovnog *moodboarda* iz kojeg su definirani ključni pojmovi čijom se sistematizacijom došlo do definiranja modnog koncepta (Slika 1).

Slika 1: Alison Ivašić, Digitalno izrađen moodboard za kolekciju KOVARI 22/23

2.2. Digitalna priprema tehničkog crteža i kroja

Nakon definicije ključnih pojmova i vizuala na kojima se temelji modni koncept kolekcije, pristupilo se izradi dizajnerskih crteža, a potom i tehničkih crteža za svaki predviđeni odjevni predmet koji će u konačnici biti produciran (Slika 2). Za izradu linearnih tehničkih crteža korišten je program Adobe Illustrator dok je za izradu krojeva i pripremu rada na prototipovima odjeće korišten program CLO 3D kako bi se lakše iskominicirao konačni dizajn i izgled odjevnih predmeta. Krojevi su izrađeni po uzoru na radničku odjeću kako bi se zadovoljila utilitarna funkcija odjevnih predmeta. Krojni dijelovi su izmodelirani u programu CLO 3D, dodani su im šavni dodaci te su se krojni dijelovi pohranili kao datoteka u izvornoj veličini koju je moguće tiskati u mjerilu 1:1. Uz utilitarnu funkciju posebna pažnja u kolekciji pridaje se i estetskom oblikovanju svake odjevne kombinacije. Predimenzionirani krojevi i džepovi, regulatori, vodoodbojni materijali koji svojim premazima stvaraju reflektirajući moment asocirajući na sjajnu površinu labinskog ugljena kao jedne od glavne karakteristike, sastavni su estetski segmenti kolekcije. Zahvaljujući digitalnim alatima unutar CLO 3D programa, na dobivenim digitalnim slikama bilo je moguće simulirati i provjeriti karakter, sjaj i teksturu predloženih materijala za izradu odjevnih predmeta (Slika 3).

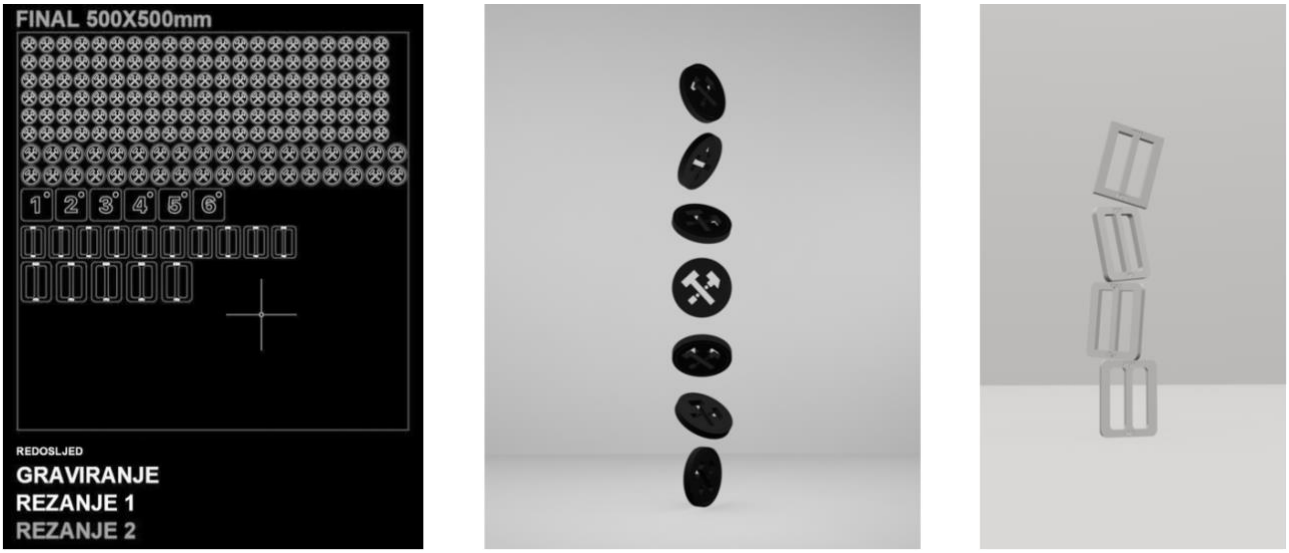


Slika 2: Alison Ivašić, Primjeri digitalnog tehničkog crteža i pripreme kroja za kolekciju KOVARI 22/23

Slika 3: Alison Ivašić, Digitalne simulacije odjevnih kombinacija za kolekciju KOVARI 22/23

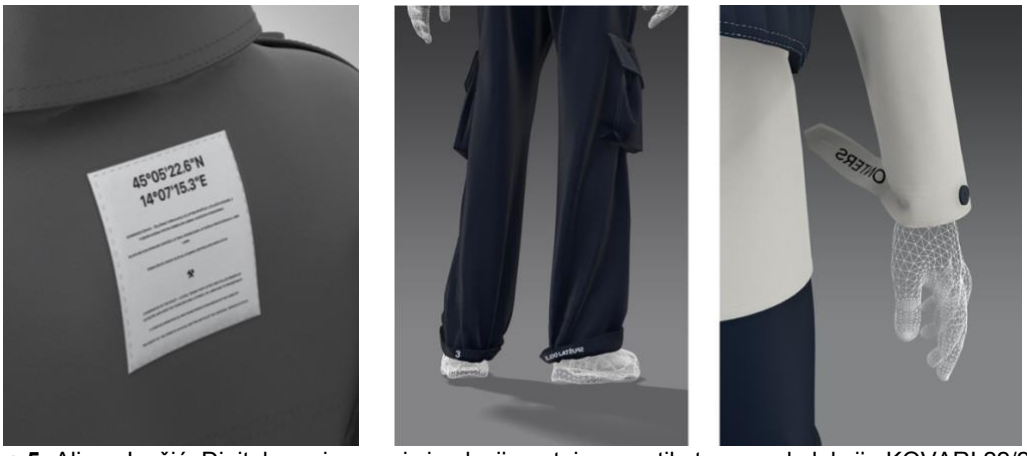
2.3. Digitalna priprema etiketa, dugmadi i tekstilnih uzoraka za tisak

U modnoj kolekciji KOVARI 22/23 detalji poput dugmadi i etiketa imaju ključnu ulogu u pojašnjavanju koncepta kolekcije. Oblikovanje ovih detalja baštini bogatu estetiku signalizacije i simbola na koje nailazimo u rudarskoj neverbalnoj komunikaciji. Dugmad je dizajnirana po uzoru na rudarski znak ukrštenih čekića dok značenje brojeva govori o numeraciji rudara i rudarske opreme.



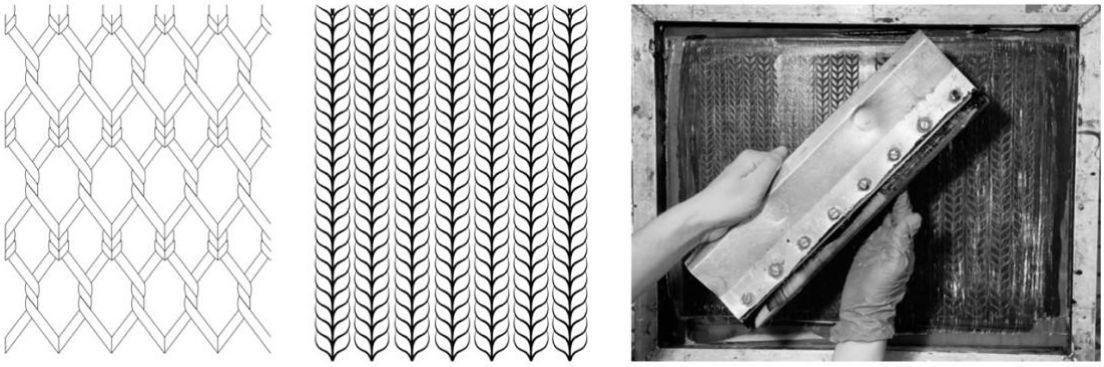
Slika 4: Alison Ivašić, Digitalna priprema i simulacije dugmadi i kopči za kolekciju KOVARI 22/23

Etikete koje su našivene i ušivene na svim odjevnim predmetima u kolekciji predstavljaju bitne događaje, osobe i činjenice vezane uz pojam rudara. Dizajn etiketa rađen je u programu Adobe Illustrator.



Slika 5: Alison Ivašić, Digitalna priprema i simulacije natpisa na etiketama za kolekciju KOVARI 22/23

Predlošci za tekstilne uzorke izrađeni su u programu Adobe Illustrator. U njihovu oblikovanju vodilo se estetskom vrijednošću pletenine koja je izvorno korištena za izradu pamučnih majica koje su bile sastavni dio odijevanja rudara. Pleteni uzorak je digitaliziran i pretvoren u linearne uzorke s motivom pletiva koje se potom koristi kao predložak za tekstilni uzorak izrađen u tehnici bubrećeg tiska (Slika 6).



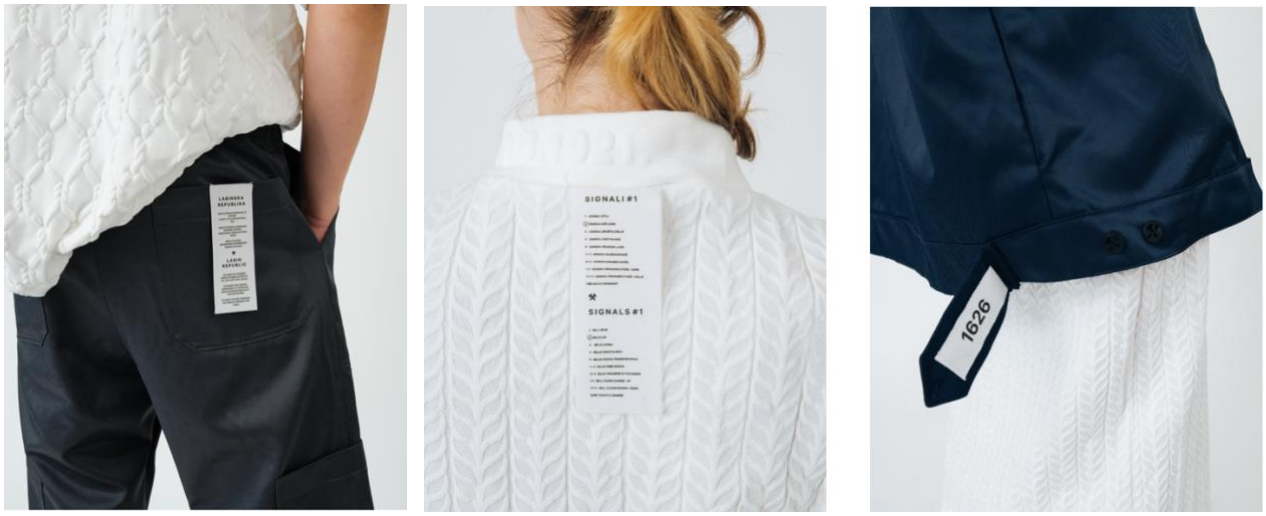
Slika 6: Alison Ivašić, Digitalna priprema tekstilnog uzorka i izrada bubrećeg tiska za kolekciju KOVARI 22/23

3. Rezultati

Kao što je bila riječ u drugom poglavlju, za pripremu kolekcije KOVARI 22/23 koristio se program CLO 3D kako bi se lakše predvidio konačni dizajn odjevnih predmeta u kolekciji te pozicije etiketa, konačni izgled i pozicija dugmadi. Dugmad je izrađena od matiranog pleksiglasa u crnoj boji tehnikom laserskog graviranja i rezanja s prepoznatljivim motivom dva dva ukrštena čekića koji su simbol rudarstva. Od iste vrste pleksiglasa izrađene su i pločice s brojevima koje simboliziraju brojeve koje su rudari imali kada su podizali opremu i odlazili u rudnik te kopče za pojas na kojima je ugravirana godina početka Labinske republike. Dizajn etiketa rađen je u programu Adobe Illustrator. Etikete su ispisane na poliestersko platno UV oblikom ispisa (Slika 7).

Slika 7: Alison Ivašić, Finalni izgled odjevnih predmeta i detalja u kolekciji KOVARI 22/23 (fotografija: Denis Butorac, Alison Ivašić ©)

Tehnikom bubrećeg tiska na renderima majica i haljine ispisani su simboli, a duž cijele površine materijala protežu se uzorci koji imitiraju pletivo te su također napravljeni tehnikom bubrećeg tiska (Slika 8).



Slika 8: Alison Ivašić, Finalni izgled odjevnih predmeta i bubrećeg tiska u kolekciji KOVARI 22/23 (fotografija: Denis Butorac, Alison Ivašić ©)

4. Zaključak

Na temelju istraživanja provedenih tijekom rada na modnoj kolekciji KOVARI 22/23 dizajnerice Alison Ivašić bilježen je dizajnerski proces od prvih rukom rađenih skica do finalne modne produkcije. Rukom rađene skice digitalizirane su i prevedene u jezik i estetiku koju nudi program CLO 3D pri čemu se iz skica namjerno eliminirao prikaz ljudskog tijela što je pridonijelo brisanju identiteta i naznake bilo kakvog stajlinga ne bi li se fokus stavio isključivo na pomodnjavanje antimodnog formata rudarske uniforme, izgled odjevne siluete i simulaciju materijala. Na primjeru dobivenih rezultata istraživanja, zaključilo se da je jezik antimodne odjeće manifest za iduća desetljeća unutar modne industrije što vidimo i po aproprijaciji antimodnih elemenata i odjevnih predmeta u suvremenoj modi. Ono što se ključno mijenja unutar novog vremena u kojem antimoda djeluje jest način antimodne prezentacije. Antimodni odjevni predmeti su bazni, nepromjenjivi komadi, karakteriziraju ulogu i formu odjeće, ali i kulturološko pripadanje. Oni ne mijenjaju svoj oblik koliko značaj i ulogu u određenom kontekstu vremena. Razvojem digitalne odjeće i antimoda postaje dio virtualne budućnosti svijeta.

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DESIGN AND DEVELOPMENT OF DIGITAL CLOTHING WITHIN THE STUDY PROGRAMS AT THE UNIVERSITY OF ZAGREB FACULTY OF TEXTILE TECHNOLOGY

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Abstract: *The digitalization of fashion design and the development of digital clothing is a process that has intensified significantly in recent years, although various digital technologies for the design and development process have already been in use in the fashion industry for more than two decades. Digital prototyping, or the development of 3D garment models, is the basis of digital clothing development and is primarily used to develop new collections in the fashion industry. Development and implementation of various types of digital clothing in numerous areas was encouraged with the intensive development and application of artificial intelligence and various computer platforms for the marketing and sale of real or digital clothing, development in the film and games industry, development of the Metaverse and with the rapidly growing interest for the use of digital clothing in social networks. In this context, the educational processes and teaching content in the field of design and development of clothing models should be continuously modernized so that students acquire the necessary knowledge and digital skills during their studies and have the necessary skills for competitive inclusion in the labor market after graduation. The paper provides an overview of the gradual introduction of computer technologies and CAD systems used within the study programs at the University of Zagreb, Faculty of Textile Technology, with a focus on digital design and development of digital fashion products, as well as functional clothing for special purposes and historical costumes. The process of developing a digital 3D garment and teaching methods in various courses of the Textile Technology and Engineering and Textile and Fashion Design study programs is explained. The results of students' work achieved through the teaching process and master's thesis are presented, in which digital fashion collections and individual digital garments were realized.*

Keywords: *digital clothing, design, 3D prototype, study programs, Faculty of Textile Technology*

1. Introduction

The beginnings of digitalization in the clothing industry are linked to the development of CAD (Computer Aided Manufacturing) systems for the computer clothing construction and marker making, which were introduced in the 1980s. The capabilities of the first generations of CAD systems were limited to the digitization and grading the cuts and marker making. With the further development of computer technologies and computer graphics evolved, more sophisticated versions of CAD systems and software packages were gradually developed for different segments of 2D textile and clothing design and garment pattern development in the clothing industry. Scientific research in this area at the University of Zagreb Faculty of Textile Technology began to be carried out in parallel with the appearance of the first CAD systems for the pattern preparation, which was followed by the installation and introduction of the CAD system for the structural preparation of cuts produced by Lectra Systemes into the teaching process at the Department of Clothing technology. The founder of scientific-research and teaching work in this area was M.Sc. D. Rogale, and younger colleagues at the Department also dealt with this area later on [1]. This laid the foundation for the further development of this area at the Faculty. The need for continuous investment in IT equipment and computer-aided technology was also recognized in the field of textile and clothing design and computer clothing construction was also recognized, which later led to the establishment of the Laboratory for computer clothing construction, the Laboratory for CAD/CAM systems for clothing engineering and the Studio for 3D body scanning [HATZ, Textiles]. These laboratories were equipped with state-of-the-art equipment and CAD systems in 2003, which enabled the further development and raising of the level of scientific research and teaching activities as well as professional cooperation with the clothing industry [2]. Further equipment for the modernization and expansion of the Laboratory for computer clothing construction was made in 2009, when licenses for the CAD system for 2D/3D computer design were acquired from the world's leading manufacturer Optitex.

The existing, already conventional CAD system Lectra for 2D pattern preparation was upgraded with a system that enables 3D simulations and the development of digital 3D clothing models. The purchase of this system was initiated by the then asist. prof. S. Petrak, Ph.D. which in 2007 prof. D. Rogale, Ph.D. was appointed as a head of the established laboratories, and it was financed from the funds of the technological project "Clothing with adaptive thermo-insulating properties", financed by the Croatian Institute of Technology, manager: prof.

D. Rogale, Ph.D. This enables further scientific research to be carried out in line with current research directions in the field of digitization of textile materials and the development of digital clothing, as well as the connection of the CAD system with the 3D body scanning system in the context of anthropometric research, design and development of digital clothing adapted to individual body shapes and measurements. In parallel with the implementation of scientific research, in the teaching process of the study programs Textile Technology and Engineering and Textile and Fashion Design, new contents were introduced in the courses that cover the field of computer construction and clothing design, within which the teaching units in digital design and development of digital clothing were elaborated. Based on the established cooperation with the Optitex representative office, the licenses of the Optitex software package were renewed in 2015, and with a further investment in 2018, the Laboratory was equipped with new modern computers and new licenses of the CAD software package for textile and clothing design and computer clothing construction Lectra [1]. This has significantly improved the quality of the teaching process and enables students to acquire digital skills that meet the current requirements of the labor market. The pandemic period as well as the further development of modern CAD systems for the development of digital clothing encouraged the use of the Clo 3D program in the work with students.

2. Design and development of digital clothing

Digital fashion is 3D virtual clothing designed for both humans and digital avatars. Instead of using fabrics, digital clothes are created with specialized 2D/3D computer programs. Until a few years ago, the fashion industry was slower to embrace digital transformation compared to other industries. For many years, the development of digital clothing was focused on the development of patterns and the analysis of model fit based on the selection of textile materials with different mechanical properties, considering that this is a very important segment of work in the fashion and clothing industry. But, the Covid-19 pandemic significantly accelerated the transition to online business and especially online sales of fashion products. As the main drivers of digitization in the fashion industry, we can highlight: consumer demand, efficiency, sustainability and innovation. Consumers are increasingly calling for more personalized and interactive experiences, and digital technologies can provide new ways to engage with them. Digital technologies can help streamline and accelerate the design and production process, reducing costs and improving efficiency. They can help reduce waste and improve the overall sustainability of the industry and they are also opening up new possibilities for design and production, allowing companies to create new and innovative products. Technological innovations and digital tools are significantly changing the approach to fashion design, from the conventional expression of a fashion designer through 2D drawings of fashion products to a process that combines design and parallel development of new ideas and products using digital technologies and specialized CAD systems, to digital communication with business partners, other team members and the presentation and sale of a digital or real fashion product to customers through computer platforms [3].

3.The results of the development of digital clothing in the framework of the teaching process and final theses

Over the past ten years, the approach to working with students, teaching methods and teaching content have been continuously improved and renewed in the context of teaching and supervising students' theses in line with the development of the subject area, but also with the adaptation of the content for students to the learning outcomes of the individual degree programs, i.e. the individual courses. A particular challenge was the time of the Covid 19 pandemic, when the proven contact method of working with students in the laboratory had to be implemented in an online environment with insufficient resources. During this time, interactive digital content and new teaching methods were developed to make it easier for students with different prior knowledge and abilities to master the course content and acquire the necessary digital skills. In addition, over the years, numerous final theses of students at Bachelor's and Master's level in the field of computer design, pattern construction, modeling and grading, design and development of digital fashion clothing or special purpose clothing. A wide range of topics have been covered and students have significantly enhanced their knowledge and skills acquired as part of the learning outcomes in each course through the theses. Fig. 1 to Fig. 6 show only selected examples of the results of students work realized as part of final theses, highlighting different approaches to the design and development of digital models.

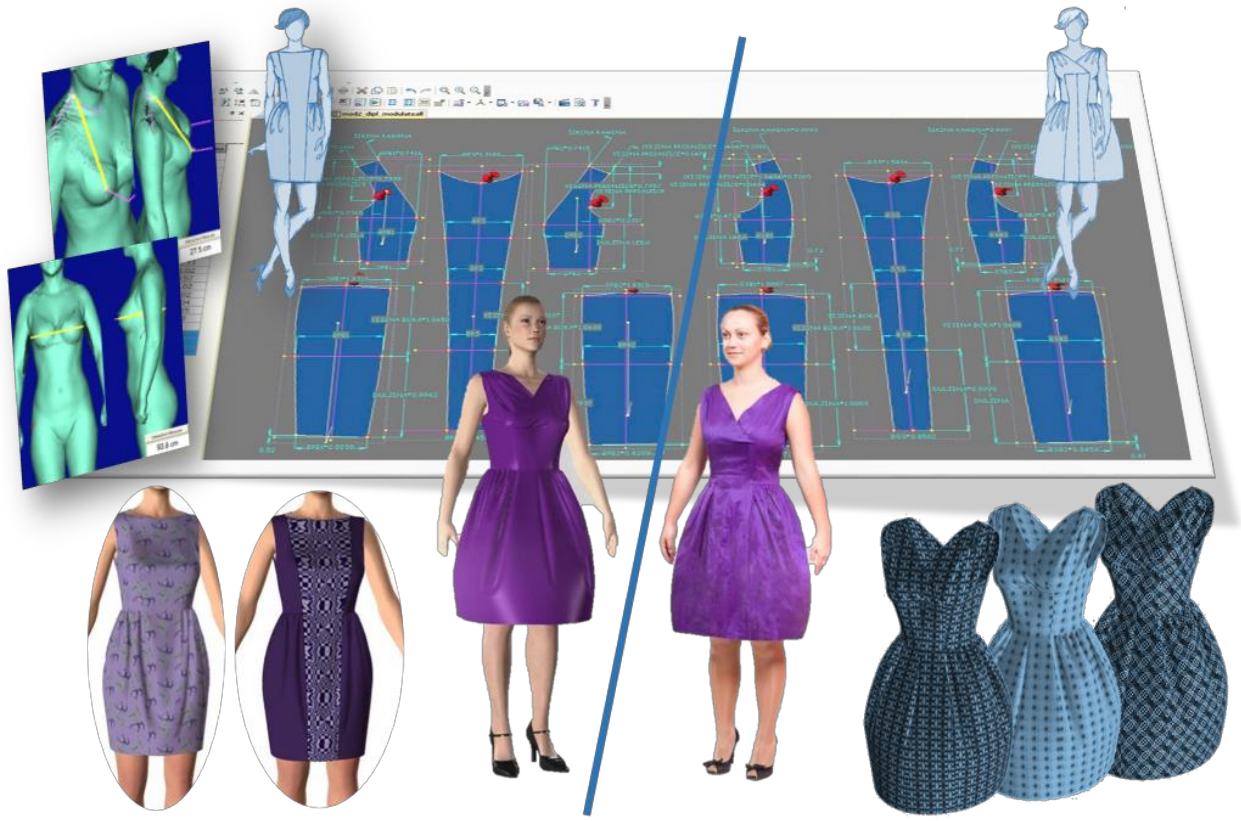

Figure 1: Development of a computer parametric garment prototype [4]

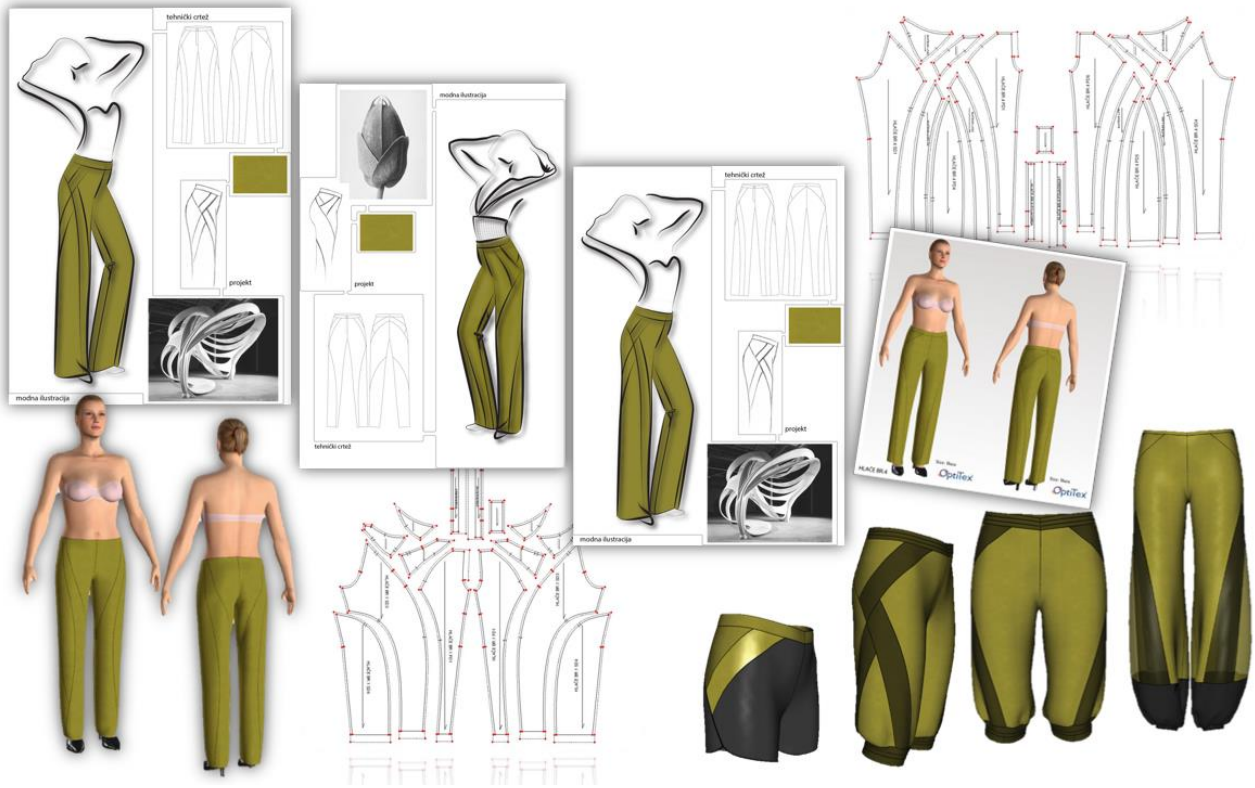

Figure 2: Computer-aided pattern design of unique women's pants collection [5]

Figure 3: Computer 3D designing of historical costumes [6]

Figure 4: A collection of digital women's clothing with structured sleeve designs [7]

Figure 5: Variations of textures and details of the digital model with the structural form of the sleeve [7]

Figure 6: A collection of digital women's clothing with elements of multiplication [8]

4. Conclusion

Digital clothing, which has been gradually developing for more than two decades, focusing on the development of digital prototypes of garments for the development of new collections, has led to very big changes in the fashion and apparel industry on a global scale in recent years. The increase in the general level of digitalization as well as the development of specialized CAD systems, augmented and virtual reality technologies, computer platforms, as well as the new generation of the Internet and the development of parallel virtual worlds, have opened up numerous new possibilities for the implementation of digital clothing. Also, the need to transform the fashion industry into a sustainable ecosystem, social changes and new generations of digital media users, social networks, the intensive development of the gaming industry and the beginnings of the development of the metaverse, as well as the application of artificial intelligence in the processing of large amounts of data generated during the online business and sale of clothing and other fashion products, are some of the drivers for the further development and implementation of digital clothing in various areas of business and social life.

In this sense, raising the level of digital knowledge and skills for all players involved in the fashion and textile industry is extremely important in order to improve business models and apply digital technologies in the development of fashion brands, but also in all segments of the supply chain. Educational processes should be continuously adapted to new development trends, current and future needs of the labor market, not only in the context of acquiring professional knowledge and skills, but also through the intensification of interdisciplinary research and starting study programs in interdisciplinary fields. The scientific research and teaching materials on digital clothing at the University of Zagreb Faculty of Textile Technology have been continuously developed and improved over the last two decades, in parallel with the development of this field at other internationally recognized universities. This is evidenced by numerous published scientific and professional papers, public presentations and workshops, as well as theses of many students who, during their studies, realized the importance and potential of this field, which is particularly important for successful employment in the development teams of the fashion industry after graduation, not only in the Republic of Croatia, but also to a much greater extent in globally represented fashion brands. In order for the continuity of the improvement of the teaching process in the field of digital clothing to continue successfully in the coming period, it is necessary to intensify interdisciplinary research in this field, as it is the basis for the development of future innovative teaching content.

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THE TRANSFORMATION OF FASHION MAGAZINES FROM PRINT TO DIGITAL FORMATS

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Abstract: *This research will show how printed media fashion magazines have adapted to new technologies, that is, how the digital platform has expanded their influence and reshaped the content. The subject of the research are the fashion magazines Vogue, Marie Claire and Elle, which used to be published exclusively as a printed edition, but today they also have digital platforms. Fashion magazines thus managed to enter a new phase of growth and adapted to the new times. The concept of a fashion magazine in the printed edition and on the digital platform is different, which will be shown by researching their concepts. The goal of the research is to emphasize the difference between the fashion magazine in print and the version on the digital platform, and to prove how concepts have developed in numerous new directions in the midst of the Internet environment. Also, the goal is to show how a one-way fashion magazine that was published only in print turned into a 'multi-way' magazine that allows and requires reader interaction. It will also be shown how the content, as well as the commercial side of the fashion magazine, has changed, because content is marketed differently on the Internet and in print, and advertising on the Internet provides a number of other opportunities than those in print. With the change in content formatting, the trends have also changed, and it will be shown how the new digital frameworks have influenced the diversity of styles in this century.*

Keywords: *fashion magazine, Internet, digital media, media, print, content, fashion*

1. Introduction

The technological advancement has enabled the transformation of fashion magazines from print to digital formats, changing the way we consume media and information. Fashion trends, traditionally presented in print through weekly or monthly fashion editorials shot in the studio depending on the magazine's publication frequency, have become more frequent with the shift to digital formats. In other words, trends now come and go faster, with a short lifespan before being replaced by new ones. While print is limited by the number of pages, digital platforms offer more 'space' for content. Therefore, fashion magazines have introduced more topics on their digital platforms, addressing various trends and shortening the duration of a specific trend. The proliferation of small trends provides more opportunities for creating diverse fashion identities. Today's media icons indicate this change and the transience of identities that depend on consumer trends and their media representations—advertisements, fashion, and, again, identities, as highlighted by Danijela Pantić Conić in her work 'Identities and the Future of Media?' [1]. The fragmentation of trends and the fast-paced way fashion is presented through media, i.e., magazines and their digital platforms, give us the possibility of endless recycling of personal appearance, turning us into superficial fashion spectators racing forward like an avalanche. This leads us to Marshall McLuhan's thesis that a medium is hot when it has high definition, and the digital platform invites us to 'enter' it. Using McLuhan's paradigm [2], we can say that a fashion magazine in digital form is extremely hot, almost boiling. Consuming fashion content on digital platforms can quickly lead to saturation, transforming fashion content from the cold medium of print to the era of hot fashion media. A hot medium extends one sense in 'high definition,' which is a state of information saturation, a part of McLuhan's media theory [3]. Žarko Paić in the book 'Visual Communications - Introduction' states that media are more than means and purposes of visual communications. They are deconstructed reality of technical images constructing the world as a media space-time of hyperproduction and hyperconsumption of information [4]. This new reality allows constant connection with the ideas and productions of fashion designers, brands, and, in general, immersion in their construction of styles and stylization. While print content offers only photography and textual descriptions, digitized content introduces innovations that provide a new experience of fashion and stylistic games. Publication for print and digital platforms is not identical, even though the content is the same. The article needs to be adapted depending on where it is published. Editors and journalists do not copy it from the print program to the digital platform but create content in different forms. Fashion magazines, by transitioning to digital platforms, have introduced various forms, including video media that showcase clothing in motion, unlike static photography. Clothing, fashion shows, and collections gain dynamics on the screen. The actors in the videos are not only people from the world of fashion but also celebrities and influencers. Video is a medium through which fashion magazines provide readers, viewers, and consumers with a better insight into the functioning of the fashion scene. Fashion magazines gain the opportunity for better communication with the audience through comments and 'likes.' The audience provides information to publishers about what they like, directly influencing content creation. In the digital edition, a fashion magazine has become a virtual store. Digital ads are interactive and clickable, leading to another digital page or a virtual sales location for that fashion product. Thus, the magazine has a direct line to what the reader likes, making

them a potential or ultimate customer. In printed magazines, advertisers and publishers, i.e., those who pay for the ad and those who publish it alongside the content, are not aware of what the reader bought after seeing the ad. They can only speculate, taking the number of copies sold as relevant. However, this does not guarantee that any of the readers will became a customer of the item advertised in print media. The concept is different on the digital platform. Fashion magazines in print depend heavily on advertisers, more than on the number of copies sold. Publishers discontinue a magazine if there are not enough advertisers and sold copies, but its digital version remains. The sale of ads for digital platforms is becoming more intense, while the sale of print ads is simultaneously decreasing. Key elements also include how fashion magazines obtain information about the reader, as digital platforms allow magazines to collect data on preferences and what interests the reader, depending on what they click on. This information is used to personalize content and advertising recommendations. Content on the digital platform is not free, and users pay a subscription to access it. This paper will elaborate on the stages and elements of the development of a fashion magazine from print to digital platforms. Fashion magazines Vogue, Elle, and Marie Claire have gradually become digital platforms, but numerous print editions continue to be released, although some have been discontinued. The method of analyzing the development of digital platforms of leading global fashion magazines has been applied in this work, changing the ways we use, experience, and consume fashion content. Before creating a digital platform, Vogue, Elle, and Marie Claire were leading in the world of fashion print media, and now they are among the leaders on the Internet. While text is the primary communication medium in print, in the digital medium of the same topic, it is an image. Žarko Paić in 'Visual Communications' states that communication is universally understood; it is a way of expressing messages, signs, and understanding signs in a real-virtual community [5]. A fashion magazine in print is easily understandable in its digital variant, with much greater content creation possibilities through numerous formats and hybrid formats.

2. Magazines

Vogue, Elle, and Marie Claire are leading fashion magazines that influence public opinion, shape attitudes towards trends, fashion, and generally construct the relationship to dressing. Everyday styles change based on the content of these media.

2.1. Vogue

Vogue is a monthly fashion magazine that has defined the culture of fashion, dressing, and the overall approach to everyday styling of the real body. It covers various fashion categories, from High Fashion through beauty and culture to fashion shows and trends. The magazine got its name from the term 'in vogue,' which was published in the American Century Dictionary in 1889. It states that the term is used as 'in vogue,' meaning a particular style of dressing that was desirable at that time, as published by Alison Matthews David in 'Fashion Theory: The Journal of Dress, Body & Culture' [6]. Although the word 'vogue' has a French origin, the magazine quickly became an American cultural phenomenon. It was launched by Arthur Baldwin Turnure, an American businessman, as a weekly newspaper based in New York, with the first issue on December 17, 1892. [7] In 1909, the magazine was acquired by Condé Nast, the company that still owns it today. Over time, the company became one of the largest publishing houses globally and has a range of publications besides Vogue. Businessman Condé Nast gradually developed the publication, turning it into a women's magazine, initiating the era of cultural imperialism, and launching new editions, such as the British (1916), French (1920), and even the Argentine (1924), as written by Alison Matthews David. [8]. The largest printed edition was in September 2012, with a whopping 900 pages, inspiring the documentary film 'The September Issue.' There are currently 28 international editions [9]. Soon, another one is coming, Vogue Adria, covering Serbia, Croatia, and Slovenia, announced for spring 2024. The editor-in-chief of the American edition of Vogue, Anna Wintour, is one of the most powerful women in the fashion world. She has discovered numerous talents and supported many designers who later became global names. Also, in 2003, she joined the Council of Fashion Designers of America in creating a fund that donates money every year and selects new future fashion stars, as published by Michelle Orecklin in the article 'The Power List: Women in Fashion, No 3 Anna Wintour' [10]. The first digital version of Vogue was launched by Condé Nast in 1995, for the British edition of the magazine. Although the dot com version of American Vogue was also available, it existed on Style.com, launched by Condé Nast in 2000, as stated in the article 'Headerbidding team, Becoming Vogue' [11].

2.2. Elle

Elle is a women's magazine born in France that covers fashion and topics on beauty, culture, and social life. The title means 'she' in French. The publisher is the Lagardère group based in Paris. It was founded in Paris in 1945 by Hélène Gordon-Lazareff and her husband, writer Pierre Lazareff. The readership of the magazine continuously grew from its foundation, reaching 800,000 throughout France by the 1960s. Elle's editions have multiplied since then, creating a global network of publications and readers. The first international edition of Elle was launched in the United States and the United Kingdom in 1985. Spain followed in 1986, then editions

in Italy and Hong Kong in 1987. In 1988, the magazine was launched in Germany, Brazil, China, Sweden, Greece, and Portugal. The following year, the Netherlands and Quebec joined the international Elle community. Versions for Australia and Taiwan were launched in 1990, Mexico and Argentina in 1994, and the Russian edition (now closed) was launched in 1996. The digital version was launched in 2007. [12] The digital version was launched in 2007. [12]

2.3. Marie Claire

Marie Claire was founded by Jean Prouvost (1885-1978) and Marcelle Auclair (1899-1983) in 1937 as a weekly magazine. The first international edition was launched in the United Kingdom in 1941 when Évelyne, the daughter, took over the leadership. Since then, various editions have been published in many countries and languages, but some of them have been discontinued. The themes focus on fashion, style, but also the position of women in society and global issues. Marie Claire also covers topics on health, beauty, fashion, politics, finance, and careers. The website was launched in 2006. [13]

3. Development of digital platforms

Since 1995, when Vogue launched its first website, fashion magazines have evolved into multimedia projects. A significant project of the magazine is Voguepedia, launched in 2011, a digitized archive of the American edition of Vogue from 1892. In 2013, the magazine launched a video channel accessible through its website. [14] The channel was launched together with Condé Nast's multi-platform media initiative, introducing thematic mini-series. Fashion film on the platform becomes a key element, bringing more than just clothing. A fashion film can be characterized as a short film produced by fashion institutions (e.g., fashion houses, magazines, designers, and filmmakers), distributed digitally (e.g., on websites, Vimeo, YouTube), and intended to mediate fashion by focusing on experiences, storytelling, aesthetics, and the character of clothing beyond their physical forms, as emphasized by Jinyi Wang and Oskar Juhlin in the article 'Unpacking Fashion Film for Digital Design' [15]. In 2015, Vogue introduced a series of podcasts, discussing fashion, beauty, and celebrities. A year later, Vogue introduced an application to better adapt the magazine to mobile devices. [16]. The application allows personalization and publishes content according to user preferences. Additionally, it enables saving topics for later or reading offline. The brand is owned by the Lagardère group from France, with the official company headquarters in Paris and licensed publishers in 42 other countries. [17] Fashion magazines have introduced subscriptions, with Elle being the first to adopt the payment model in November 2020, priced at 4.99 euros per month. Subscriber benefits include unlimited access to all content on the website and app, a digital magazine every Wednesday at 6 pm, newsletters exclusively for subscribers, with editorial selections and comfortable reading due to limited advertising, as written by Madeleine White in the article 'How the fashion magazine ELLE is using a dynamic paywall and continuous optimization to improve conversion rates' [18]. Vogue also offers a subscription, with the American edition priced at $24.99 annually, including the delivery of the printed magazine to the home address and unrestricted access to the digital platform. Digital platforms are available for reading and viewing for users without a subscription, but not entirely. Some articles are available partially, and some exclusively with payment. Marie Claire magazine has developed a platform to encourage shopping within its digital platform. While browsing content, users have access to products they can buy directly through a link to the digital store. The user enters key terms into the search, receiving available links to items they might like, depending on the keywords they search. The platform was developed in-house to create a better connection between the magazine's readership and editorial staff, as emphasized by Clare McDonald in the article 'Marie Claire develops a shopping platform within the digital magazine.' [19] The service benefits both readers and merchants, with readers receiving more specific product recommendations and merchants establishing a direct connection with the large readership of the Marie Claire magazine. The digital platform transforms readers into buyers. Marie Claire uses digital tools to categorize products based on product descriptions. This business model results in the same type of product appearing to consumers on the Google search engine and its ads. Marie Claire's digital platform and consumers are thus connected with merchants' websites and digital stores, as published by Clare McDonald in the article 'Marie Claire develops a shopping platform within the digital magazine.' [20]

4. Diversity, inclusivity, and fashion identities

As a consequence of the accessibility of fashion content on digital platforms, inspiration has become a global phenomenon. The removal of real boundaries in the virtual world provides us with the freedom and opportunity to create various fashion identities. Fashion audiences now have the chance to incorporate different aesthetic influences into their daily style and move beyond the confines of trends offered in traditional print media. Print media trends are primarily tailored for local audiences, depending on where they live and consume the print medium. In contrast, digital media knows no bounds and is accessible to everyone, addressing a global audience. The globalization of fashion media consumption is evident in leading digital magazines such as Vogue, Elle and Marie Claire, which are consumed by audiences worldwide. This has resulted in content that

is less locally emphasized and more globally oriented. The impact of digital media content has led to the emergence of diverse style icons and contributed to inclusivity in the fashion industry. Some fashion companies have adapted their business practices by introducing offerings that cater to various body types, heights, and shapes. Models of various races take center stage on digital platforms, with a focus on celebrating diversity, originality, and the authenticity of physical appearance.

Digital media has democratized the fashion landscape, transforming the world into a digital "global village." This term, coined by Marshall McLuhan in his book 'Understanding Media: The Extensions of Man,' is reflected in the absence of national borders in the digital world, a fact often unnoticed by users. Our screens serve as gateways to another world—a brave new world where trends are equally accessible to everyone. McLuhan's insights on clothing as our second skin resonate in this context. If our second skin is an expansive sea of various fashion elements, garments, styles, trends and tendencies, it is clear that we are faced with an extremely vast choice. Our second skin has numerous faces and identities, each person finding their own. The overwhelming array of clothing items and details has contributed to the rise in popularity of stylists—individuals who guide readers on how to navigate the fashion chaos and the spectacle of visually appealing elements. As a result, digital platforms publish advice columns to assist the audience in navigating the vast selection. The fashion houses' way of doing business and plans that include ever-increasing profits have led to the fact that people unknowingly become 'victims' of styling and finding their own identity and personality. Žarko Paić cites a comment by a Spanish textile magnate in his book 'Vertigo in fashion', according to which we see how fashion trends have become important precisely for the sake of sales. Namely, a businessman from a large fashion company, José Maria Castellano, in an interview for 'Der Spiegel', a leading German weekly, which was published on June 21, 2006, stated: 'There are no more fashion styles in fashion, and there is no fashion either. We live in a globalized world, where, thanks to the media, fashion connoisseurs with educated taste naturally have an advantage. We offer consumers what they want, in the same way, anywhere. There are still only tendencies in fashion'.[22] As there are no more great styles, we are recycling ideas from the last century, pastiche is the basis of style, the audience feels an atmosphere of loss, which is additionally reinforced by a somewhat utopian idea of individuality and identity that we must find, as constantly emphasized by the advertising messages of fashion companies via digital fashion platforms. Individuality is one of the buzzwords in the world of fashion advertising, 'find your own style' has become a mantra. Of course the audience has to look for something, because there are too many things. Fashion houses have big profits in their plans, they produce more and more and faster, and we are the 'victims' of that process and the 'tragic' final destination for all their 'ideas'. Fashion companies almost demand that we adopt all their clothing items, as if they are searching for us through digital platforms of fashion magazines, providing us with a vision of a daily spectacle in which clothing and fashion accessories take center stage. In doing so, we create the identity we desire; we just need to discover it. The symbiotic relationship between digital platforms and shopping condemns us to an eternal search in the circular world of fashion products, which constantly arrive and depart without being thoroughly utilized and worn. Mass fashion production increasingly fails to inspire the audience, despite constant emphasis on the expanding choices and the individual's ability to choose, as if this were excellent news that the audience had been waiting for. Fashion houses almost compel us to chase after the new, a rhythm that is almost impossible to keep up with. Print media implies a uniformly visible 2D layout, a harmonious graphic visual that was easy to follow—especially for a buyer 'consuming' a monthly magazine. In contrast, the digital fashion platform is an infinitely vast world where micro-trends, getting lost in a multitude of choices, and a Sisyphean search for identity prevail. As digital fashion media have increased the array of fashion items, identity has started to erode. In her work 'The Decay of the Body: Contemporary Fashion and New Media,' Petra Krpan interprets how the body adopts codes that directly influence an identity fragmented due to the inability to find an original body and reality. The deterritorialization of the body through new media is one of the key issues in contemporary fashion. Since contemporary fashion lacks a fixed object or time of realization, it is determined, much like the body, by actuality and virtuality. The metamorphosis of the identity of contemporary fashion seems to be its main characteristic. [23]

5. The decline of print and the rise of digital content

Marshall McLuhan, in 'Understanding Media,' commented that if an alternative source of easily accessible diverse daily information were found, the press would decline. He was referring to advertisements and stock market information, which were once the foundation of the press. Originally published in 1964, this statement actually forecasted the scenario that is currently unfolding—the decline of print media [24]. Today, digital platforms are more accessible than print magazines, right at our fingertips. Elle has ceased operations in certain editions: in Malaysia and South Africa in 2019, and in Russia in 2022. Marie Claire UK discontinued its print publication in 2019 after 31 years, opting to focus on a digital platform with more content, as reported by Mark Sweney in the article 'Marie Claire UK to cease print publication after 31 years' [25]. In the U.S., Marie Claire ended its print edition after 27 years in September 2021, simultaneously announcing a more active engagement on digital platforms [26]. As print editions shut down, publishers announce a shift to digital content, which offers various possibilities for presenting and shaping content, trends, and fashion offerings. Additionally,

tools that transform readers into customers are becoming increasingly sophisticated, making the marketing advantage of digital platforms over print content significant.

6. Conclusion

Digital platforms of Vogue, Elle, and Marie Claire have accelerated changes in fashion trends and amplified their influence on readers through diverse forms. McLuhan argued: "The press is daily action and fiction or made thing, being practically made of anything and everything in the community. Through mosaic, the press turns into an image or cross-section of the community" [27]. In the digital environment, the image has become the primary mode of communication. According to Žarko Paić in 'Visual Communications,' the image, based on durability, artificiality, symbolism, and other layers of meaning, is primarily a communication medium. We communicate uniquely through images, as they signify and point to something beyond themselves in material and formal aspects [28]. The image has become our fundamental reference for experiencing and consuming fashion and its trends. Smartphones provide us with the ability to have it at our fingertips whenever we desire. Visitors to the digital platform of a fashion magazine can consume a variety of multimedia content. The broad spectrum of activities on digital platforms distances us from the cold content on paper where readers have no participation opportunities. Media are a means of communication, but communication itself is simultaneously a means of media. The message arising from the ambiguous nature of media is a coded sign/letter/image of an epochally determined space/time in which human relationships are defined by the power of media as a technique/technology and as a function, structure, and sign of communication [29]. Print and digital platforms address similar topics, but each in its own way. The virtual environment enables magazine editors to create content in various forms, dealing with new information, trends, and fashion collections. Digital platforms have led to numerous possibilities for creating individual identities, but also to getting lost in a sea of clothing and fashion accessories and an endless supply of clothing forms. Trends in the classical sense, as they were in the last century, no longer exist; instead, tendencies constantly change, transforming the reader into a consumer of fashion that becomes 'larger than life' and a purpose unto itself. In the constant search for style, the individual is no longer essential; clothing becomes an end in itself, serving a faster circular system. All of this happens through digital platforms of fashion magazines, which play an active role in consuming the fashion system.

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TRANSFORMACIJA MODNIH ČASOPISA IZ TISKANIH U DIGITALNE FORMATE

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Sažetak: *U ovom istraživanju pokazat će se kako su se modni časopisi tiskanog medija prilagodili novim tehnologijama, odnosno kako je digitalna platforma proširila njihov utjecaj te preoblikovala sadržaj. Predmet istraživanja su modni časopisi Vogue, Marie Claire i Elle, koji su nekada izlazili isključivo kao tiskano izdanje, no danas uz to imaju i digitalne platforme. Modni su časopisi time uspjeli ući u novu fazu rasta te se prilagodili novom vremenu. Koncept modnog časopisa u tiskanom izdanju i na digitalnoj platformi je drugačiji, što će se pokazati istraživanjem njihovih koncepata. Cilj istraživanja je naglasiti različitost modnog časopisa u tiskanoj i verziji na digitalnoj platformi te dokazati kako su se usred internetskog okruženja razvili koncepti u brojnim novim smjerovima. Također, cilj je pokazati kako je iz jednosmjernog modnog časopisa koji je izlazio samo u tisku nastao 'višesmjerni' časopis koji dopušta i zahtijeva interakciju čitatelja. Pokazat će se i kako se promijenila sadržajna, ali i komercijalna strana modnog časopisa jer na Internetu i u printu drugačije se plasira sadržaj, a oglašavanje na Internetu pritom daje niz drugih mogućnosti od onih u printu. Promjenom oblikovanja sadržaja promijenili su se i trendovi te će se pokazati kako su novi digitalni okviri utjecali na raznolikost stilova u ovom stoljeću.*

Ključne riječi: modni časopis, internet, digitalni mediji, mediji, tisak, sadržaj, moda

1. Uvod

Transformaciju modnih časopisa iz tiskanih u digitalne formate omogućio je tehnološki napredak, čime se promijenio način na koji konzumiramo medije i informacije. Modni trendovi koji su u tisku prezentirani isključivo putem tjednih ili mjesečnih modnih editorijala snimljenih u studiju, ovisno o periodici izlaženja časopisa, prelaskom medija u digitalne formate postali su više frekventni. Odnosno, trendovi brže dolaze, imaju kratak rok trajanja, da bi ih zamijenili neki drugi trendovi. I dok je tisak limitiran brojem stranica, na digitalnim platformama za sadržaj ima više 'mjesta'. Stoga su modni časopisi na svoje digitalne platforme uveli više tema koje obrađuju te skratili vrijeme trajanja određenog trenda. Više malih trendova daje nam više mogućnosti kreiranja raznih modnih identiteta. Današnje medijske ikone nagovještavaju, upravo tu promjenu i prolaznost identiteta koji ovise o potrošačkim trendovima i njihovim medijskim reprezentacijama – reklame, mode i opet, identiteta, ističe Danijela Pantić Conić u svom radu 'Identiteti i budućnost medija?. [1] Usitnjavanje trendova te jureći način na koji se moda prezentira kroz medije, odnosno časopise i njihove digitalne platforme daje nam mogućnost beskrajnog recikliranja osobnog izgleda te time postajemo površni gledatelji mode koja poput lavine juri naprijed. Dolazimo do McLuhanove teze koja kaže da je medij vruć, kada ima visoku definiciju, a digitalna nam platforma nudi poziv da u nju 'uđemo'. Stoga možemo, ako koristimo McLuhanovu paradigmu [2], reći da je modni magazin u digitalnom obliku izuzetno vruć, gotovo kipi. Upravo zato, konzumiranjem modnog sadržaja na digitalnoj platformi imamo mogućnost brzo postati zasićeni, stoga je sada modni sadržaj iz tiska koji je hladni medij, ušao u eru vrućeg modnog medija. Vrući medij je onaj koji produžuje jedno osjetilo u 'visokoj definiciji', a to je stanje zasićenosti podacima, dio je McLuhanove teorije o medijima [3]. Žarko Paić u knjizi Vizualne komunikacije - Uvod navodi da su mediji više od sredstva i svrhe vizualnih komunikacija. Oni su dekonstruirana realnost tehničke slike koja konstruira svijet kao medijski prostor–vrijeme hiperprodukcije i hiperpotrošnje informacija. [4]. Ta naša nova realnost daje nam mogućnost konstantne povezanosti s idejama i produkcijama modnih dizajnera, brendova i općenito uranjanje u njihovu konstrukciju stilova i stiliziranja. I dok sadržaj za tisak nudi samo fotografiju i tekstualni opis, digitalizirani sadržaj inovacija je čija zavodljivost donosi novi doživljaj mode i stilskih igara. Objava za tisak i digitalnu platformu nisu identične, iako je sadržaj isti. Članak treba prilagoditi ovisno o tome gdje se objavljuje. Urednici i novinari ga ne kopiraju iz programa za tisak u program za digitalnu platformu, već rade sadržaj različite forme. Modni časopisi su prelaskom na digitalne platforme uveli razne forme, među njima i medij videa koji predstavlja odjeću u pokretu, za razliku od statične fotografije. Odjeća, modna revija i općenito kolekcije dobile su dinamiku na zaslonu. Akteri videa su ne samo ljudi iz svijeta mode, već i zvijezde te slavne osobe i Influenceri. Video je medij putem kojeg modni časopis čitateljima, gledateljima i konzumentima daje bolji uvid u sam proces funkcioniranja scene. Modni časopisi ovime dobivaju mogućnost bolje komunikacije s publikom. Putem komentara i 'lajkova' publika daje informaciju izdavačima što im se sviđa te time izravno utječu na kreiranje sadržaja jer se ljudi zaduženi za vodstvo časopisa vode i prema informacijama koje otkrivaju što se točno čitateljima sviđa. Modni časopis u digitalnom izdanju postao je ujedno virtualni dućan. Digitalni oglasi su interaktivni te se na njih može kliknuti. Klik vodi na drugu digitalnu stranicu, odnosno na virtualno prodajno mjesto tog modnog proizvoda. Time časopis ima direktnu liniju do onoga što se čitatelju sviđa, on postaje potencijalni ili krajnji kupac. Kod časopisa u tiskanom izdanju oglašivač i izdavač, odnosno onaj koji plaća oglas i onaj koji taj oglas objavljuje uz sadržaj,

nisu upoznati s time što je čitatelj kupio nakon što je vidio oglas. To mogu samo pretpostavljati, a kao relevantnu uzimaju brojku prodanih primjeraka. No, to ne znači sa sigurnošću da je ijedan čitatelj postao kupac predmeta koji je u oglasu u tisku. Na digitalnoj platformi koncept je drugačiji. Modni časopisi u tiskanom izdanju ovise uvelike o oglašivačima, više nego o prodanom broju primjeraka. Izdavači ukidaju časopis ako nema dovoljno oglašivača i prodajnih primjeraka, no ostaje njegova digitalna inačica. Prodaja oglasa za digitalne je platforme sve intenzivnija, dok se prodaja oglasa u tisku istovremeno smanjuje. Ključni su i elementi kojima modni časopis dolazi do informacije o čitatelju, jer digitalne platforme omogućuju časopisima prikupljanje podataka o preferencijama i onome što čitatelja zanima, ovisno na što klikne. Te informacije koriste za personalizaciju preporuka sadržaja i reklama. Sadržaj na digitalnoj platformi nije besplatan te korisnici, kako bi mu pristupili, plaćaju pretplatu. Ovaj rad će elaborirati faze i elemente razvoja modnog časopisa od tiska do digitalne platforme. Modni časopisi Vogue, Elle i Marie Claire postepeno su postali digitalne platforme, no istovremeno brojna tiskana izdanja izlaze i dalje, iako su neka ugašena. U radu je primjenjena metoda analize razvoja digitalnih platformi vodećih svjetskih modnih časopisa, koje su promijenile načine na koji koristimo, doživljavamo i konzumiramo modni sadržaj. Prije nego su kreirali digitalnu platformu, časopisi Vogue, Elle i Marie Claire bili su vodeći u svijetu modnog tiska, a sada su među liderima i na Internetu. I ako je u tisku tekst primarni komunikacijski medij, u digitalnom mediju iste tematike to je slika. Žarko Paić u 'Vizualnim komunikacijama' navodi da se komunikacija razumije univerzalno, to je način iskazivanja poruka, znakova i razumijevanja znakova u realno–virtualnoj zajednici [5]. Modni magazin u tisku lako je razumljiv i u digitalnoj varijanti, uz mnogo veću mogućnost kreiranja sadržaja, kroz brojne formate i hibride formata.

2. O magazinima

Vogue, Elle i Marie Claire vodeći su modni magazini koji utječu na javno mijenje te oblikuju stavove publike o trendovima, modi i općenito grade odnos prema odijevanju. Svakodnevni stilovi mijenjaju se ovisno o sadržaju ovih medija.

2.1. Vogue

Vogue je mjesečni modni časopis koji je definirao kulturu mode, odijevanja i općenito odnosa prema svakodnevici stiliziranja stvarnog tijela. Obrađuje razne modne kategorije, od Visoke mode preko ljepote i kulture do modnih revija i trendova. Časopis je ime dobio po izrazu ' in vogue', koji je objavljen u američkom Century Dictionary iz 1889. godine. U njemu stoji da se pojam koristi kao 'in vogue', odnosno 'u modi', kao poseban stil odijevanja koji je tada bio poželjan, objavila je Alison Matthews David u 'Fashion Theory: The Journal of Dress, Body & Culture' [6]. Iako sama riječ vogue ima francuski izvor, časopis je u kratko vrijeme postao američki kulturni fenomen. Naime, pokrenuo ga je Arthur Baldwin Turnure, američki biznismen, kao tjedne novine sa sjedištem u New Yorku, s prvim izdanjem 17. prosinca 1892. [7] 1909. časopis je kupio Condé Nast, a njegovo ime kompanija, koja je vlasnik časopisa, nosi i danas. S vremenom je kompanija postala jedna od najvećih izdavačkih kuća na svijetu te ima niz publikacija osim časopisa Vogue. Biznismen Condé Nast je postupno razvio publikaciju te je pretvorio u ženski časopis, započeo eru kulturnog imperijalizma te pokrenuo nova izdanja, kao što su britansko (1916.), francusko (1920.), pa čak i argentinsko (1924.), piše Alison Matthews David. [8]. Najveće tiskano izdanje bilo je ono iz rujna 2012. godine, od čak 900 stranica, po kojemu je napravljen i dokumentarni film 'Septemper issue'. Do danas postoji 28 međunarodnih izdanja [9]. Uskoro stiže još jedno, pokreće se Vogue Adria koji obuhvaća države Srbiju, Hrvatsku i Sloveniju te je najavljen za proljeće 2024. godine. Glavna urednica američkog izdanja časopisa Vogue, Anna Wintour, jedna je od najmoćnijih žena u svijetu mode. Otkrila je niz talenata te podržala mnogo dizajnera koji su kasnije postali svjetska imena. Također, 2003. se pridružila Vijeću modnih dizajnera Amerike u stvaranju fonda koji svake godine donira novac i bira nove buduće modne zvijezde, objavila je Michelle Orecklin u članku 'The Power List: Women in Fashion, No 3 Anna Wintour' [10]. Prvu digitalnu verziju časopisa Vogue kompanija Condé Nast pokrenula je 1995. godine, na adresi Vogue.co.uk, za britansko izdanje časopisa. Iako je dot com verzija američkog Voguea također bila dostupna, postojala je na Style.com, koju je Condé Nast pokrenuo 2000. godine, objavljeno je u članku 'Headerbidding team, Becoming Vogue' [11].

2.2. Elle

Elle je ženski časopis nastao u Francuskoj te obrađuje modne i teme o ljepoti, kulturi i društvenom životu. Naslov znači 'ona' na francuskom. Izdavač je Lagardère grupe sa sjedištem u Parizu. Osnovali su je u Parizu 1945. Hélène Gordon-Lazareff i njezin suprug, pisac Pierre Lazareff. Čitateljstvo časopisa kontinuirano je raslo od njegova osnutka, povećavši se na 800.000 diljem Francuske do 1960-ih. Izdanja Elle od tada su se umnožila, stvarajući globalnu mrežu publikacija i čitatelja. Prvo međunarodno izdanje Ellea pokrenuto je u SAD-u i Velikoj Britaniji 1985. godine. Španjolska je uslijedila 1986., a onda i izdanja u Italiji i Hong Kongu 1987. Godine 1988. časopis je pokrenut u Njemačkoj, Brazilu, Kini, Švedskoj, Grčkoj i Portugalu. Sljedeće godine, Nizozemska i Quebec pridružili su se međunarodnoj Elle zajednici. Verzije za Australiju i Tajvan

pokrenute su 1990., Meksiko i Argentina 1994., a rusko izdanje (sada zatvoreno), pokrenuto je 1996. Digitalna je verzija pokrenuta 2007. godine. [12Digitalna je verzija pokrenuta 2007. godine. [12]

2.3. Marie Claire

Marie Claire pokrenuli su Jean Prouvost (1885-1978) i Marcelle Auclair (1899-1983) 1937. kao tjedni časopis. Prvo međunarodno izdanje pokreću Ujedinjenom Kraljevstvu 1941., kad vodstvo preuzima kći Évelyne. Od tada se objavljuju različita izdanja u mnogim zemljama i na mnogim jezicima, no neka od njih su u međuvremenu ukinuta. Teme su fokusirane na modu, stil, ali i položaj žene u društvu te globalna pitanja. časopis Marie Claire također pokriva teme o zdravlju, ljepoti, modi, politici, financijama i karijeri. S vremenom je postao modni časopis angažiran na temama društva, položaja žene u poslovnom svijetu i ravnopravnosti. Web stranica pokrenuta je 2006. godine.[13]

3. Razvoj digitalnih platformi

Od 1995. godine, od kad je Vogue pokrenuo prvu web stranicu, modni časopis pretvorio se u projekt multimedije. Značajan projekt časopisa je i Voguepedia, pokrenuta 2011. godine, digitalizirana arhiva američkog izdanja Voguea od 1892. godine. Godine 2013. časopis je pokrenuo video kanal kojem se može pristupiti putem njihove web stranice.[14] Kanal je pokrenut zajedno s multiplatformskom medijskom inicijativom kompanije Condé Nast te su uvedene su tematske mini serije. Modni film na platformi postaje jedan od ključnih elemenata, jer donosi više od odjeće. Modni film se može okarakterizirati kao kratki film koji proizvode modne institucije (npr. modne kuće, časopisi, dizajneri i filmaši), distribuiraju digitalno (npr. na web stranicama, Vimeo, YouTube) i namijenjeni su posredovanju mode fokusirajući se na iskustva, pripovijedanje, estetika i karakter odjevnih predmeta izvan njihovih fizičkih oblika, ističu Jinyi Wang i i Oskar Juhlin u članku 'Unpacking Fashion Film for Digital Design' [15]. 2015. godine Vogue uvodi seriju podcasta, odnosno razgovora na temu mode, ljepote i slavnih. Godinu dana kasnije Vogue predstavlja aplikaciju, kako bi časopis još bolje prilagodili mobilnim uređajima. [16]. Aplikacija ima mogućnost personalizacije te objavljuje sadržaj po želji korisnika. Osim toga, aplikacija omogućuje spremanje tema za kasnije ili čitanje izvan mreže. Brend je u vlasništvu grupe Lagardère iz Francuske, službeno sjedište kompanije je u Parizu, a licencirani izdavači nalaze se u 42 druge zemlje. [17] Modni su časopisi uveli pretplatu, Elle je prvi model plaćanja uveo u studenom 2020. godine, za cijenu od 4,99 eura mjesečno. Pogodnosti pretplatnika uključuju neograničen pristup svim sadržajima na stranici i aplikaciji, digitalni časopis svake srijede u 18 sati, bilteni samo za pretplatnike, s uredničkim odabirima i udobnost čitanja zahvaljujući ograničenom oglašavanju, piše Madeleine White u članku 'How the fashion magazine ELLE is using a dynamic paywall and continuous optimization to improve conversion rates'.[18] Vogue također ima pretplatu, američko izdanje nudi je za 24,99 američkih dolara godišnje te ona uključuje dostavu tiskanog izdanja časopisa Vogue na kućnu adresu i čitanje digitalne platforme bez ograničenja. Digitalne platforme dostupne su za čitanje i gledanje i korisnicima koji nemaju pretplatu, no ne u potpunosti. Neki su tekstovi dostupni djelomično, a neki isključivo uz plaćanje. Časopis Marie Claire razvio je platformu za poticanje kupovine unutar njihove digitalne platforme. Dok pregledavaju sadržaj, korisnici imaju dostupne i proizvode koje mogu kupiti direktnim linkom na digitalni dućan. Korisnik digitalne platforme unosi ključne pojmove u pretraživanje te uz to dobiva dostupne linkove na predmete koji bi mu se mogli svidjeti, ovisno o ključnim riječima koje pretražuje. Platforma je razvijena unutar kuće s ciljem da stvori što bolju vezu između čitatelja i uredništva časopisa, ističe Clare McDonald u članku 'Marie Claire razvija platformu za kupovinu unutar digitalnog magazina'. [19] Usluga koristi čitateljima i trgovcima, pri čemu čitatelji dobivaju konkretnije preporuke za proizvode, a trgovci dobivaju izravnu vezu s velikim čitateljstvom Marie Claire časopisa. Digitalna platforma čitatelja time pretvara u kupca. Marie Claire koristi digitalne alate za kategorizaciju proizvoda na temelju opisa proizvoda. Taj način poslovanja rezultira time da će se ista vrsta proizvoda potrošaču pojaviti i na Google tražilici te njihovim oglasima. Digitalna platforma Marie Claire i potrošači time idu su povezani sa stranicama i digitalnim dućanima trgovaca, objavila je Clare McDonald u članku Marie Claire razvija platformu za kupovinu unutar digitalnog magazina. [20]

4. Raznolikost, inkluzivnost i modni identiteti

Kao posljedica dostupnosti modnog sadržaja na digitalnoj platformi, inspiracija je postala globalna. Brisanje realnih granica u virtualnom svijetu daje nam slobodu i mogućnost kreiranja raznih modnih identiteta. Modna publika ima priliku u vlastiti dnevni stil integrirati različite estetike utjecaje te izaći iz okvira trendova koji se nude u tiskanom mediju. Trendovi u tiskanom mediju namijenjeni su u velikoj većini lokalnoj publici te su plasirani ovisno o tome gdje publika živi i konzumira taj tiskani medij. Digitalni medij, za razliku od tiskanog, nema granica te je dostupan svima, pa se svima i obraća. Globalizacija je očita u konzumiranju modnih medija. Vodeće digitalne časopise Vogue, Elle i Marie Claire konzumira publika diljem svijeta te time sadržaj više nema toliko naglašeni lokalitet, a sadržaj postaje globalni. Digitalni je medijski sadržaj time utjecao na pojavu raznolikosti ikona brojnih stilova te doveo do inkluzivnosti. To je utjecalo na pojavu raznolikosti modne forme te su neke od modnih kompanija promijenile način poslovanja te uvele ponudu ovisno o građi, visini i obliku

tijela. Manekenke na digitalnim platformama modnih magazina raznih su rasa, u fokusu ljepote su raznolikost, originalnost i autentičnost fizičkog izgleda. Digitalni su mediji time demokratizirali modnu ponudu, svijet je postao digitalno 'globalno selo'. Taj izraz skovao je Marshall McLuhan u svojoj knjizi 'Gutenbergova galaksija', a danas se očituje u tome što u digitalnom svijetu granice država ne postoje te ih mi ne osjetimo. Naši zasloni ulaz su u drugi svijet, vrli novi svijet u kojemu su trendovi svima jednako dostupni. Mcluhan je komentirao i odijevanje - ono je kao naša druga koža. [21] A ako je naša druga koža zapravo nepregledno more raznih modnih elemenata, odjevnih predmeta, stilova, trendova i tendencija, jasno je da je riječ o ekstremno velikom izboru. Naša druga koža ima niz lica i identiteta, svatko ga pronalazi za sebe. Kako i što odabrati te izuzetno velika ponuda odjevnih predmeta i detalja dovela je do popularnosti stilista, ljudi koji čitateljima savjetuju kako se odjenuti i snaći tom modnom kaosu, spektaklu mode, cirkusu vizualno privačnih elemenata. Posljedično, digitalne platforme objavljuju rubrike sa savjetima jer se time publika lakše nalazi u velikom izboru. Način poslovanja modnih kuća i planovi koji uključuju sve veći profit doveli su do toga da ljudi ni ne sluteći postaju 'žrtve' stiliziranja i pronalaska vlastitog identiteta i osobnosti. Žarko Paić u 'Vrtoglavici mode' navodi komentar španjoskog tekstilnog magnata, po kojemu vidimo kako su modni trendovi postali važni upravo radi prodaje. Naime, biznismen iz velike modne kompanije José Maria Castellano u intervjuu za 'Der Spiegel', njemački vodeći tjednik, koji je objavljen 21. lipnja 2006. godine izjavio je: 'U modi više nema modnim stilova, a nema ni mode. Živimo u globaliziranome svijetu, gdje zahvaljujući medijima modni znalci odgojenoga ukusa, naravno, imaju prednost. Potrošačima nudimo ono što oni žele, i to bilo gdje na isti način. U modi postoje još samo tendencije'.[22] Kako nema više velikih stilova, već recikliramo ideje iz prošloga stoljeća, pastiš je osnova stila, publika osjeća atmosferu izgubljenosti, koja je dodatno pojačana pomalo utopijskom idejom o individualnosti i identitetu kojeg moramo pronaći, kako nam konstantno naglašavaju reklamne poruke modnih kompaija putem digitalnih modnih platformi. Individualnost je jedna od glavnih riječi u svijetu modnog oglašavanja, 'pronađite vlastiti stil' postala je mantra. Naravno da publika mora nešto tražiti, jer stvari je previše. Modne kuće u planovima imaju velike profite, proizvode sve više i brže, a mi smo 'žrtve' tog procesa i 'tragična' finalna destinacija za sve njihove 'ideje'. Udomite sve naše odjevne predmete, kao da nas traže modne kompanije putem digitalnih platformi modnih magazina, dajući nam viziju svakodnevnog spektakla u kojemu odjeća i modni dodaci imaju centralno mjesto. Jer, time ćemo stvoriti identitet baš kakav želimo. Samo ga treba otkriti. Digitalna platforma i kupovina kreirane su kao simbioza, podržavaju jedno drugo, stoga smo osuđeni na vječitu potragu u tom cirkularnom svijetu modnih proizvoda koji nam konstantno dolaze i odlaze, a bez da ih dobro iskoristimo i iznosimo. Masovna modna proizvodnja publiku sve manje inspirira, iako nam se konstantno naglašava da je izbor sve veći i da pojedinac može birati, kao da je to neka odlična vijest na koju je publika čekala. Modne kuće gotovo nas prisiljavaju da jurimo za novim, ritam je gotovo nemoguće pratiti. Tisak podrazumijeva svima jednako vidljiv 2D prelom, odnosno skladan grafički vizual, koji je bilo jednostavno pratiti - naročito ako kupac 'konzumira' mjesečni magazin, dok je digitalna modna platforma beskrajno velik svijet je u kojemu vrijede pravila mikro trendova, gubljenja u masi izbora te sizifovska potraga za identitetom. Kako su digitalni modni mediji povećali ponudu modnih predmeta, tako se identitet počeo gubiti. Petra Krpan u svom radu 'Raspad tijela: suvremena moda i novi mediji' tumači kako tijelo usvaja kodove koji izravno utječu na identitet koji je fragmentiran zahvaljujući nemogućnosti pronalaska izvornog tijela, ali i realiteta. Deteritorijalizacija tijela putem novih medija jedno je od ključnih pitanja suvremene mode. Budući da suvremena moda nema svoj fiksan predmet ni vrijeme realizacije, određuje ju kao i tijelo - aktualitet i virtualitet. Metamorfoza identiteta suvremene mode čini se glavnom njezinom odrednicom. [23]

5. Sve manje tiska, sve više digitalnog sadržaja

Pronađe li se kakav alternativni izvor lake dostupnosti tako raznovrsnih svakodnevnih podataka, tisak će propasti, komentirao je McLuhan u 'Razumijevanju medija', pritom misleći na oglase i informacije s burze koji su nekada bili temelj tiska. Originalno objavljena 1964. ova rečenica zapravo je najavila scenarij koji se sada dešava, a to da tisak 'nestaje' [24]. Digitalna platforma danas nam je dostupnija nego tiskani časopis, imamo je na dlanu. Elle je ugasio neka izdanja: u Maleziji i Južnoj Africi u 2019., u Rusiji u 2022. godini. Marie Claire UK prestaje izlaziti 2019. godine, nakon 31 godine. Nastavljaju s digitalnom platformom na kojoj će objavljivati više sadržaja, piše Mark Sweney u članku 'Marie Claire UK to cease print publication after 31 years. [25] Marie Claire nakon 27 godina ukinuo je tiskano izdanje u SAD-u, u rujnu 2021. godine. Istovremeno je objavljeno da će se okrenuti aktivnijem angažmanu na digitalnoj platformi. [26] Kako gase svoja tiskana izdanja, izdavači najavljuju okretanje digitalnom sadržaju koji im pruža niz mogućnosti prezentacije i oblikovanja sadržaja, trendova i modne ponude. Uz to, alati koji čitatelja pretvaraju u kupca sve su više sofisticirani, stoga je marketinška prednost digitalne platforme nad sadržajem u tisku također vrlo bitna.

6. Zaključak

Digitalne platforme časopisa Vogue, Elle i Marie Claire ubrzale su promjene modnih trendova te pojačale utjecaj na čitatelja svojim raznolikim formama. McLuhan je tvrdio: Tisak je svakodnevna akcija i fikcija ili napravljena stvar, a napravljena je praktički od svega i svačega u zajednici. Posredstvom mozaika, tisak se pretvara u sliku ili poprečni presjek zajednice. [27] U digitalnom okruženju slika je postala primaran način

komunikacije. Prema kriteriju trajnosti, artificijelnosti, simboličkog i drugim slojevima značenja, slika je prije svega komunikacijski medij, naglašava Žarko Paić u 'Vizualnim komunikacijama'. Slikom se sporazumijevamo na osobit način. Ona označava i ukazuje na nešto drugo izvan sebe u materijalnome i formalnome aspektu. [28]. Slika postaje naša osnovna referenca za doživljaj i konzumaciju mode i njezinih trendova, pametni telefoni daju nam mogućnost da je imamo na dlanu, kad god poželimo. Posjetitelj digitalne platforme modnog časopisa može konzumirati niz različitih multimedijalnih sadržaja. Široki spektar aktivnosti na digitalim platformama udaljava nas od hladnog sadržaja na papiru u kojemu čitatelj nema mogućnosti sudjelovanja. Mediji su sredstvo komunikacije. No i sama je komunikacija kao svrha istodobno sredstvo medija. Poruka koja proizlazi iz dvoznačne prirode medija kodirani je znak/pismo/slika epohalno određenog prostora/vremena u kojem ljudske odnose određuje moć medija kao tehnike/tehnologije i kao funkcije, strukture i znaka komunikacije, naglašava Paić u 'Vizualnim komunikacijama'. [29] Tisak i digitalna platforma obrađuju slične teme, no svaka na svoj način. Virtualno okruženje urednicima časopisa omogućuje niz drugih formi kreiranja sadržaja koji obrađuje nove informacije, trendove i modne kolekcije. Digitalne platforme dovele su do niza mogućnosti kreiranja vlastitih identitea, no i gubljenja u moru odjeće i modnih dodataka te nepresušne ponude odjevnih formi. Trendovi u klasičnom smislu, kao što je to bilo prošloga stoljeća, više ne postoje, već tendencije se konstantno izmjenjuju pretvarajući čitatelja u konzumenta mode koja postaje 'veća od života' i sama sebi svrhom. Čovjek u konstantnoj potrazi za stilom u svemu tome više nije bitan, odjeća je sama sebi svrha, kako bi služila sve bržem cirkularom sistemu i sve to putem digitalnih platformi modnih magazina, koji imaju aktivnu ulogu u konzumiranju modnog sistema.

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PROBLEMS OF MAKING COSPLAY COSTUMES

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Abstract: *Cosplay is intended for special occasions such as various sci-fi conventions. The costumes are usually tailored according to the chosen character from the favorite game, comic, movie or similar. Making costumes based on game characters is challenging, as the starting point is a drawing of a costume that often does not work completely in reality. For this reason, a lot of experience and experimentation is required to make the costume as true to the original as possible. In the experimental part, two cosplay costumes based on characters from PlayStation games were created. The first is the costume of Aloy from the game Horizon Forbidden West, and the second is the character of Freya from the game God of War Ragnarok. The costumes were made by students of the University of Zagreb, Faculty of Textile Technology, with the help of mentors and in cooperation with PlayStation Croatia. The aim of the work is to bring the production of cosplay costumes closer to a wider audience and to draw attention to the challenges involved. As a result of the work, you can see two costumes made for the selected characters.*

Keywords: *cosplay, PlayStation, Freya, Aloy, making cosplay costumes*

1. Introduction

The term "cosplay" (jap. シャック) as an abbreviation means a combination of the terms "costume" and "play". Owes its name to Japanese journalist Nobuyuki Takahashi of the manga studio Hard and became more widely promoted and began to develop in the seventies of the 20th century. Cosplay has its humble beginnings in the 1970s in Japan, but today it has evolved into a global cultural phenomenon and has become a way to pay tribute to relevant popular culture. Embodying the common concept of costume and play, enthusiasts of "cosplay" recreate their favorite characters from manga, anime, movies, series, books and the like, making a costume themselves that is a faithful replica of the chosen character and then attempting to emulate the character of the eponymous character. Characters from video games are often recreated, but a character can also be one's own creation. A person who engages in cosplay is called a cosplayer. Cosplayers not only create authentic costumes, but also play the characters and are usually experts in the characters they are imitating. Cosplay can also be considered a performance, as cosplayers try to get into the character of the chosen character and sometimes take on the characteristics of the character they have brought to life [1]. Nowadays, making cosplay costumes according to the chosen game requires a lot of knowledge and skills in traditional garment making as well as using modern tools, such as a 3D printer. The design of the game characters and their clothing does not necessarily require knowledge of textile technology. This is especially evident when analyzing the individual parts of the costume and preparing to make the costume. The article will point out certain problems that a person making a costume may encounter and that should be solved and adjusted so that the costume is functional and true to the original idea.

2. Overview and development of cosplay

It is believed that the great inspiration for "cosplay" was Japanese culture, more specifically traditional Japanese Kabuki theater. Kabuki theater has been developing since the Edo period in the 17th century and is a combination of song, dance and performance art. The actors wear costumes and masks, make-up and facial expressions are emphasized, and much emphasis is placed on dance, acrobatics and choreography. Although it was initially reserved exclusively for the nobility, kabuki became accessible to the working class at the beginning of the 17th century and conveyed its social commentary in an artistic and dramatic way. In addition to the emphasized esthetics of the high-quality costumes, the connection between cosplay and kabuki also lies in the interaction with the audience. During the performance, the actors often assimilate into the audience and establish two-way communication with the viewers, similar to the cosplayers [2,3]. In addition to the fact that Japanese culture was a great inspiration for the development of cosplay, Western culture certainly had an influence on its development. As early as the 15th century, masked balls were very popular, especially during the Renaissance in Italy, where public celebrations were held in costume. Masquerade balls, where participants dressed up in traditional costumes or costumes with an abstract concept, were also very popular in Britain in the 19th century. With the development of popular culture conventions and sci-fi themes in America, cosplay receives its first references. American Myrtle Rebecca Douglas Smith Gray Nolan appeared at the first science fiction convention (1st World Science Fiction Convention (1st Worldcon)) in 1939 in a futuristic

green costume with a cape and became the first cosplayer. Rebecca and her partner at the time were the only people wearing masks and the only ones to make their own costumes, laying the foundations for cosplay culture. Since then, there hasn't been a single convention without masked participants [4,5].

Figure 1: Rebecca (as Marojo) and her partner Ackermann at the 1st World Science Fiction Convention [5].

After the 1st World Science Fiction Convention in New York and Rebecca Douglas as a pioneer, cosplay takes shape. The conventions are often held in Japan, where participants appear as popular characters in futuristic costumes, and anime cosplay is booming. Interest in cosplay continues to grow and is now one of the most creative ways to show your love and interest in a particular aspect of pop culture [4]. The first anime and cosplay conventions in the United States were held in the late 1970s and early 1980s. The earliest such themed convention was the Science Fiction, Fantasy and Comic Book Convention held in San Diego, California in 1970. Although this convention was not specifically anime or cosplay themed, it included programs related to Japanese pop culture, such as a panel on Japanese animated films, which later proved significant to the development of cosplay itself. Over time, in the 2000s, cosplay began to attract the attention of "mainstream" popular culture, and cosplayers began to appear in television shows and movies. With the development of social networks, cosplay as an art form is becoming increasingly popular, to the point of becoming a profession for individuals. With the development and popularization of video games and the greater availability of materials and more modern technologies such as 3D displays and 3D printing, cosplay costumes are becoming more complex, detailed, precise in production and creative, while cosplayers themselves are becoming top artisans [6]. In cosplay, the representation of the costume, the quality of the cosplay is measured by several factors: the skill in making the costume, the degree of fidelity of the replica compared to the original, and the character involved. Many cosplayers create their costumes based on reference photos or character renderings, paying close attention to detail and quality craftsmanship. They are often trained in the selection of materials and the production of additional costume in order to achieve the most faithful representation possible. Great attention to detail is evident in the use of unconventional materials such as EVA foam, 3D printing, wood, leather and the like in the production of fashion accessories or weapons, for example, but also in the physical appearance of the character. Self-styled wigs, colored or pupil-enlarging contact lenses (very popular in the portrayal of anime and manga characters) and special effects make-up are often used to faithfully represent tattoos, scars, wrinkles, moles and much more. Although there may be certain physical limitations to portraying an individual character (e.g. height, hair color, etc.), cosplay is suitable for any person, regardless of skin color, hair color or gender, and is a very good way to express one's authenticity and creativity while also connecting with people who share common interests [4,6].

2.1. PlayStation video games industry

As part of the Sony Interactive Entertainment industry, PlayStation represents a company that continues to push the boundaries of entertainment and innovation. It was founded in Tokyo on December 3, 1994. When it launched its first console, it changed the world of the gaming industry. Today, it has five video game consoles for home use, two portable consoles, a media center and numerous online services and magazines. Although it was founded in Japan, the company is headquartered in San Mateo, California, but there are numerous offices around the world - London, Tokyo, Malaysia and the rest of Europe. The original console went down in history as the first console to sell 100 million units in 10 years, helping PlayStation to take off and create the established name that PlayStation still carries today. Today, PlayStation strives to deliver innovative and exciting experiences to a global audience, encompassing a new generation of hardware, ground-breaking

online services and award-winning games. As the video games industry evolves with technology, PlayStation's slogan "Play has no limits" is more relevant than ever. This is evidenced by the fact that the PlayStation 5 console has sold 40 million units worldwide, the PlayStation Network currently has more than 107 million monthly users and popular video games such as "The Last of Us", the "Horizon" franchise and "God of War: Ragnarok" have sold 11to 37 million units [7,8]. "God of War" is an action-adventure series developed under the direction of David Jaffe at Santa Monica Studio. It was originally intended exclusively for the PlayStation 2 console, but can now be played on various platforms. It is based on ancient mythology. Greek mythology in earlier versions of the game and Norse mythology in later versions [9].

3. Experimental part

Making a cosplay costume according to the chosen game requires an analytical approach to costume development, which is primarily virtual. Given the popularity of cosplay, game developers have a guide to making costumes for individual characters, in which the costumes are broken down into parts. In addition, there are descriptions of the costume elements as well as the materials from which the game designer envisioned the costume. Based on a detailed analysis and examination of the drawings, the selected costume can be reconstructed quite faithfully. The final product depends on the skills of the person making the costume. To make a cosplay costume, it is necessary to first analyze all the parts of the costume and the materials needed for it. The procurement of the materials is the second step, followed by the creation of the costume parts, which are put together to form a whole. At this stage at the latest, all problems relating to costuming and functionality should be solved. Each costume has specific details and embellishments that need to be realized in order to be as similar as possible to the original. The production time depends on whether the costume is made by someone with experience or a beginner, whether all the materials are available immediately or whether you have to wait for them, etc. Cosplay costumes were made at the Faculty of Textile Technology as cooperation with PlayStation Croatia. The costumes are meant to promote the games and student education. The students who made the costumes came into contact with this type of costume for the first time, so it took a semester to make one costume.

3.1. Cosplay costumes for Aloy and Freya

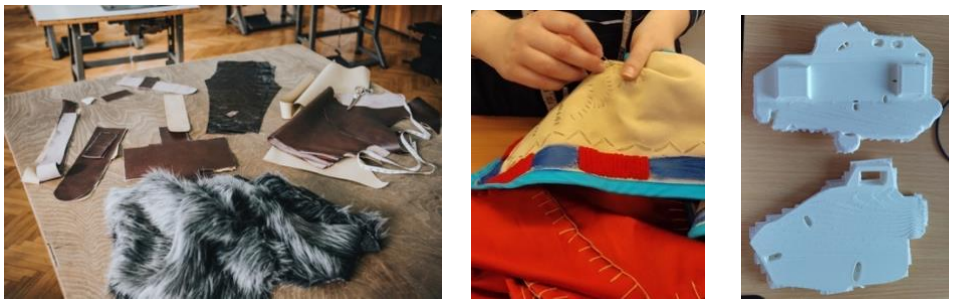
Each character in the game has several costumes, and at the beginning it is necessary to choose exactly which costume to make. For the character Aloy from the game Horizon Forbidden West, the costume shown in Figure 2 a was chosen [10,11], while for the character Freya from the game God of War Ragnarok, the costume shown in Figure 2 b was chosen. While both costumes have fairly detailed instructions for cosplayers [12,13], they still leave the person making the costume with a considerable number of details that are not clear or may not work in reality, so it is necessary to decide on each segment of the costume when making it. For each costume, it is necessary to find a solution how to put on the costume, how to fasten the individual elements of the costume so that they do not fall off, whether a material is knitted or fabric. There are also costume parts that are produced using a 3D printer, which poses an additional challenge for costume designers. For 3D printed items, there is a program that can be purchased so that the person making the costume can choose what suits them and print it. For the Aloy costume, the 3D printed elements were made at the Faculty of Textile Technology, while for Freya they were made at the National and University Library in Zagreb. The production of cosplay costumes requires great skill, but also good equipment with various materials, from leather to filaments for a 3D printer, i.e. also equipment with machines and devices for production. It also requires a lot of dedication and a lot of manual labor, which means that this type of costume, if you want to get the most faithful replica possible, takes a long time.

a. b.

Figure 2: Pictures of costumes from the game a) Aloy, b) Freya [10,11]

3.2. Making costumes for Aloy and Freya

For the character Aloy, mainly leather was used, as well as some faux fur, knitwear and fabric, and elements made with a 3D printer Figure 3c. at the Faculty of Textile Technology under the supervision of the associate professor. Ph.D. Slavica Bogović.



a. b. c.

Figure 3: a. Material used to make the Aloy costume, b. hand decoration of the costume, 3D printed elements used for the Aloy costume

All the decorative stitching was done by hand, which took a lot of time, Figure 4. The layering of the costume and many elements around the waist required detailed work to make the costume wearable. For example, several pieces of beige leather are attached to the belt that is tied around the waist to act as a skirt. The elements partially overlap, but if they were not fixed they would fall down, making it much more difficult to wear a costume consisting of several layers. It was a challenge to attach the 3D printed elements to the arms and legs as their weight causes them to slip on the arm or leg, so they need to be fixed regularly to keep them in place on the costume. For the costume of the warrior Freya, leather, faux fur, linen fabric, thick twine for the cloak and 3D-printed elements made in the National and University Library in Zagreb were used, Figure 4. The big challenge was the cloak made of twine, which had to be made according to the image. It was also necessary to age the leather and give it a worn appearance, as the acquired leather was new and uniformly colored. The layering of the upper part of the costume presents a particular challenge as it is leather. Stacking the layers of leather creates a thickness of material that cannot be machine stitched, so decisions had to be made about which parts to join and which to add later. This also affects the complexity of the cosplayer's clothing later on. Figure 5 a. shows the complexity of making a leather wallet painted with Nordic motifs. The coins are dyed and strung on a chain, and each chain is individually attached to the leather. the 3D-printed elements are finished with color and decorated with threads.

a. b.

Figure 4: a. Presentation of the material used for the Freya costume, b. 3D printed elements used for the Freya costume

a. b. c.

Figure 5: a. View of the finished layered belt and purse of the Freya costume, photo Nika Mokoš, b. Print of Nordic motifs on cotton fabric, c. View of the layered upper part of the costume, photo Nika Mokoš

The leather and textile bands that Freya has wrapped around her arms and legs are made of leather and cotton fabric decorated with a print of Nordic motifs. The problem with the straps is that they slip when you move, and the reason for this is the use of inelastic material. The print on the cotton fabric can be seen in Figure 5 b. and was used for the belt as well as the leg and arm bands. Figure 5 c. shows the complexity of making the upper part of the costume, which includes the T-shirt and the vest. The vest consists of several layers of leather, which are sewn by hand due to their thickness. To join the layers of leather together, they were drilled with a precision drill. The edges of the vest are decoratively stitched. The T-shirt is made of leather engraved with Nordic motifs and 3D-printed elements. An additional challenge was to preserve the worn look of the leather vest. This requirement was solved by fine sanding the leather in certain areas of the vest.

4. The results

The result of this work are two cosplay costumes for the PlayStation warriors Aloy and Freya Figure 6. and 7. As they are warriors from the popular PlayStation games "Horizon forbidden west" and "God of War Ragnarok", their popularity is great, so their production was demanding in order to achieve faithful replicas of the popular costumes.

a. b.

Figure 6: Completed cosplay costumes a. Aloy photo by Nika Mokoš, b. Freya photo by Nika Mokoš

a. b.

Figure 7: Cosplay costumes a. Aloy photo by Nika Mokoš, b. Freya photo by Nika Mokoš

5. Conclusion

Making a cosplay costume is a special challenge that requires time and a lot of knowledge and skills. Just a sewing machine and selected material are no longer enough; more and more often, costume parts that are included in costumes are 3D printed. Modern technologies make it possible to faithfully recreate the costumes of favorite game characters. The biggest challenge is to disassemble the parts of the costume in preparation for production. Each part must be adapted to the person who will wear the costume, problems with dressing and wearing the costume must be foreseen and solved, the right materials must be selected and the proportions adapted to the person wearing the costume. Despite the detailed instructions for making costumes, it should be noted that some details are only sketchy or even unrealistic in some cases, so an appropriate solution must be found to make the costume as true to the original as possible. Cosplay costume making is increasingly common among the new generations and can be both a life's work and a source of income for a serious connoisseur. It should be noted that costumes are getting better and better with time, and it is necessary to keep learning to improve skills and upgrade knowledge. In addition to traditional techniques, it is necessary to learn new technologies and production processes, without which the manufacture of some costumes would not be possible.

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DIGITAL FASHION - EXAMPLES OF IMPLEMENTATION IN HIGHER EDUCATION STUDY PROGRAMS AROUND THE WORLD

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Abstract: *The article presents examples of the implementation of the course "Digital Fashion" in the educational system of universities in the field of fashion design. It analyzes the outcomes and objectives of the course that develop new skills in students. When evaluating the above-mentioned course content and its implementation, special attention was paid to the importance of cooperation with various economic factors, especially with virtual sales platforms, fashion houses and artificial intelligence development laboratories. In line with the new educational requirements, the work points to the importance of developing and upgrading teaching skills that contribute to new educational models with the help of potential employers. Digital fashion, which has become an integral part of the textile and apparel industry, has disrupted historically established patterns of production and consumption and, above all, education. It has become a key indicator for the future of fashion. Fashion design courses should therefore adapt to this in order to be able to respond successfully to the new demands of the labor market.*

Keywords: *digital fashion; curriculum; higher education; implementation; new technologies; fashion design*

1. Introduction

Interest in hybrid approaches that incorporate new digital technologies into the production and finishing of fashion products has been very topical over the last twenty years. This dynamic has been characterised by 3D printing, digital printing and an ever-increasing focus by engineering teams on the development of smart textiles. In addition, new technologies have been used to analyse, test and archive textile, apparel and fashion items, providing completely new insights into production steps and presentation methods.

In the 1990s, fashion designer Alexander McQueen predicted the dominance of digital tools in contemporary fashion design. In 2007, Dutch fashion designer Iris Van Herpen took an innovative approach to making clothes when she used 3D printing and laser cutting instead of traditional cutting and sewing. Today, this is synonymous with a futuristic approach to the clothing and manufacturing industry. Using the *heat bonding* and 4D printing, the cut pieces are joined together instead of using threads, helping to give the impression of textiles in motion [1]. In the second decade of the twenty-first century, more emphasis was placed on conceptual approaches and reflections on the new technological age. The collections of fashion designers Jonathan Anderson and Alessandro Michele, for example, form and update a completely new fashionable digital language based on the relationship between clothing, the new body and multiple identities. However, due to the increasing influence of social activism on the fashion industry and the impact of pandemics on production, the technological and creative exploration of the potential of the "digital" is gaining momentum. The first topic was addressed more intensively after the serious accident in Bangladesh in 2013. The second is the result of the recent COVID-19 pandemic, when the rhythm of production changed drastically, but also led to new forms of consumption and presentation on digital platforms [2].

A new generation of young consumers, focused on cell phones and virtual internet stimuli, now requires new digital approaches that demand new knowledge and competencies in digital skills from future fashion designers. Digital approaches allow faster access, are more environmentally friendly, while the concept of Web3 and artificial intelligence applications (Midjourney and Dall-E) are contributing to major changes in the fashion supply chain as well as in the higher education sector. This paper, based on an analysis of the world's leading fashion design studios and an insight into their study programs available online, aims to highlight the widely accepted trend of implementing digital fashion into the curricula for future fashion designers.

2. Elaboration

The increasing adoption of digital fashion in the apparel and textile industry has implications for curriculum changes and adaptations in higher education. The world's leading fashion and educational institutions have already adapted to this trend. At the beginning of the 20th century, professional training in fashion design was based on the study of fine arts, which was used to research a fashion idea (fashion illustration) and, based on a beautiful drawing, to design first a prototype and then a garment on a dressmaker's dummy. Today, fashion

houses do business with cryptocurrencies, while the processes of idea generation and fashion concepts take place on the computer. When selling fashion brands, you can use digital identities (NFT), design digital clothes and create digital fashion in a larger context.

Thanks to new digital tools, the fashion design process can include 3D renderings in programs such as Clo3D, Blender, Daz and ZBrush, with much of the product presentation created through digital motion animation. Technological innovations such as 3D printing, virtual reality (VR), augmented reality (AR) and artificial intelligence (AI) offer fashion designers a handful of opportunities in design, advertising and production. For example, the use of raw materials can be haptic, but also digital. Since fashion today can be both digital and physical, the process of fashion design rejects the strict determinants of the outcome, which can only be material, and also accepts virtual, unreal products. The teaching programs try to adapt to these new areas of design.

In the ***Department of Fashion Design at the Swedish Textile College*** in 2022, a search was made for teaching models that correspond to the new competences. An attempt was made to design a program based on theoretical approaches, especially on the relationship to the body and the role of clothing in identity formation, but also on the application of new technologies and augmented reality technologies. From the 2023-2024 academic year, a digital fashion design course will be added to the fashion design program, with a focus on building design skills using the tools of new technologies. Bachelor students will study virtual design and explore its potential through the development of fashion collections. Great emphasis has been placed on improving knowledge and applying all the possibilities of the new technological tools, which has led to diverse results. The school management is aware of the uncertainty that digital fashion will bring in the future and therefore wants to familiarize students with as many computer programs and their application as possible. The Clo3d program is used in various contexts, in addition to drawing, fashion concepts are created according to the zero-waste approach, the same applies to VR and AR. Therefore, the basic model of the Swedish curriculum focuses on introducing students to different types of software [3].

In Denmark, ***VIA University College*** studied the needs of the market and industry before changing the curriculum, and then adapted the study program based on the results. In the last two years, more emphasis has been placed on teaching new technologies. Analyzing the most critical areas of fashion production, such as textile design, then the problem of clothing sizes and transportation, they concluded that new technologies are helpful in all categories. Thank you to them, it is possible to reduce waste in cutting, but also to influence delivery costs. They encouraged teachers to improve their skills and enriched the fashion design curriculum with courses on the following topics: Material Scanning, Body Scanning, 3D Rendering and Digital Printing. VIA University College also developed the SUSTAIN:AR application, an augmented reality platform to showcase the portfolios of design graduates [4, 5], and prepared a series of specialized courses for the need of additional training of already trained designers and professionals in the fashion industry. In this way, they are in close contact with the production sector and are a source of information and ideas for improving the quality of the curriculum. The close collaboration with the fashion industry means that students can be more easily employed by fashion companies after graduation.

The ***Royal College of Art*** in London is one of the best-known higher education institutions for art and fashion design. According to the head of the fashion design course, Zowie Broach, traditional production techniques were cultivated there until recently. After 2014, new approaches were introduced. Various lecturers, physicists, doctors, neuroscientists, video game authors and visual artists [5] are involved. Today, the course has a rather futuristic flair that pushes the boundaries of strictly prescribed curricula and teaching methods. Students are given a lot of freedom in their research, especially in the field of digital fashion. The director of Atelier Broach concludes that the Covid pandemic has also contributed to this dynamic, as the quarantine led to the abandonment of traditional forms of teaching in workshops and teaching in the virtual world with the help of the software program Clo [6]. The program proved to be an extremely high-quality tool for designing and reviewing different clothing identities, while taking into account current efforts to protect the environment. A look at the recent results of the fashion design program at the Royal College of Art shows an emphasis on student autonomy, both in the choice of fashion area and field of expression, and in the choice of medium to articulate ideas. According to Broach, thanks to this approach, there is an intense interaction between the students in which they learn from each other. The goal is for each student to find their narrow niche of interest, with work and approaches differing from one another. They explore their concepts using both digital and traditional media and learn about the knowledge of different scientific and artistic disciplines thanks to guest appearances by experts. Through their different interests, independent work and the medium in which they produce, the students collide with each other, complement each other, but also broaden their horizons, Broach notes.

In Italy, the most famous fashion institute and faculty, ***Polimoda*** in Florence, also has close links with the fashion industry. They have developed a model for involving external mentors from the fashion industry. Since the last academic year 2022/2023, part of the program has been carried out in partnership with Microsoft Garage, which has developed a project with a very broad thematic scope, creativity and experimentation [7]. The symbiosis between an Italian fashion school and an American technology company in the undergraduate program provides students with the skills for the jobs of the future. In addition to the Fashion Marketing Management course, the Fashion for Metaverse program for aspiring fashion designers was introduced, also in collaboration with the company, i.e. the digital studio *Monogrid* [8].

Central Saint Martins in London has also been involved in the further development of the fashion design curriculum, while ***Parsons School of Design*** in New York has launched a digital fashion course in collaboration with the gaming platform Roblox. On the aforementioned platform, more than 11.5 million designers participated in virtual clothing design in 2022 and created over 62 million virtual clothing combinations, including fashion accessories [9]. These figures point to the development of a completely new market, a form of fashion consumption that generates high profits. Given these facts, it is not surprising that the number of video game platforms has increased and that university curricula are trying to adapt to this. The collaboration between Parsons School of Design and Roblox introduced students to the world of cutting-edge technologies to design hyper-realistic and inclusive 3D digital clothing to fit any body type. Through very specific market assignments during the semester, students adopted Roblox's Creator Roadmap, engaged in video game modding, and designed prototypes for 3D clothing. The end result was a virtual fashion show presented on the Roblox platform, while the students' final concepts were sold on the Roblox avatar marketplace [10,11].

The ***Istituto Marangoni International School*** in London was one of the first to immerse itself in the metaverse, setting up its own virtual world and classroom called *The Talent District* in 2022. It consists of a series of futuristic building districts that visitors can explore via avatar. The starting point of the virtual visit is the *Infopoint* with information about the study programs at *Istituto Marangoni*, while the exhibition pavilion offers an insight into the best student projects. In addition, the virtual quarter also offers space for theater, conferences, lectures and discussions. To implement the project, Marangoni collaborated with the Italian company Igoodi, which specializes in designing realistic avatars based on the appearance of consumers. The igoodi avatar is integrated into Smart Body, a data set that contains anthropometric measurements of consumers. The igoodi avatars are unique among the metaverses on offer and are ideal for designing innovative digital fashion models. Another important partner of *The Talent District* project is Monogrid, a digital interactive agency from Florence that develops platforms at the highest technological level [12]. In its recent public appearances, *Istituto Marangoni* has emphasized the institution's strategy, which focuses primarily on the area of developing educational models for the digital fashion market.

The designers Olivier Rousteing and Simon Porte Jacquemus attended the ***Esmod*** fashion school in Paris. In 2022, the school launched the *Meta-Wear* course, which specializes in metaverses and NFTs. During their studies, students learn about the tools Clo 3D, Blender, Maya and Daz3d. However, Esmod continues to focus on teaching traditional production techniques and places particular emphasis on teaching students the importance of craft skills in understanding the complex processes involved in designing digital clothing. The emphasis is on the formal technical aspects of physical products that are conceptually represented in the virtual world [13].

All of the educational institutions listed show in different formulations of the study presentation how digitalization is shaping the cultural and creative industries and thus also fashion. However, digital technologies have also changed the field of activity of fashion, due to different spatial contexts, national policies, arrangements and power relations at the level of the global market. Digital fashion has changed considerably, especially in terms of its presentation. The formerly dominant fashion cities of London, Milan, New York and Paris, which have built their identity on fashion shows, now have new competitors thanks to digital fashion shows. They make it possible for anyone interested to follow the latest collections, a privilege previously reserved for a select few. The role of fashion bloggers, who are important social actors, promoters and "critics", is also crucial in this process. For this reason, there are numerous fashion design and fashion courses at universities that teach students another important aspect of digital fashion. Namely, people are constantly looking for new ways to express their identity, and the new generations in the virtual spaces promote inclusivity, the acceptance of differences based on race, ethnicity, age, size, the concept of beauty and gender identities, which are often very limited in real life. Fashion studies highlight the key benefits of digital fashion, which gives users much more control over presence and expression in virtual reality compared to the real world. In addition, digital fashion has also changed the way we think about clothes. You no longer choose a specific garment, you buy an experience or a feeling. This brief overview of fashion studies emphasises the need to integrate

them into fashion design studies so that the clothing product of the future can be better understood and produced accordingly in virtual or real reality.

3. Conclusion

Thirty years ago, the work of a fashion designer was compared to the work of an artist. One of the reasons for this is that aspiring fashion designers acquired skills in the visual arts during their training. Today, the imagination of fashion designers is no longer exclusively represented by drawings. New technologies make it possible for designers who have not developed artistic talent to create a much larger number of concept sketches in a short space of time. Artificial intelligence is increasingly finding its way into design and production. In this sense, there are already new incentives for adapting fashion design curricula. Indeed, young designers pursuing interdisciplinary approaches are interested in synergetic interaction models such as graphic design, programming, 3D development and generative artificial intelligence to change the parameters of traditional fashion practice. These are precisely the demands of the global market. The role of higher education institutions is to develop innovative study programs that offer students new creative models of learning and skill acquisition. Regardless of whether students focus on physical or virtual design, degree programs should provide the opportunity to develop visionary projects. In addition to students, there is also an extraordinary interest from fashion houses in the digital sphere. Not only in the form of presentations and adaptations to consumer needs, but also by hiring interns and designers with knowledge of digital fashion. It is up to the universities to adapt to the demands of the market and the new generation.

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DIGITALNA MODA – PRIMJERI IMPLEMENTIRANJA U VISOKOOBRAZOVNE STUDIJSKE PROGRAME U SVIJETU

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Sažetak: *Rad donosi primjere implementacije kolegija „digitalne mode" u visokoobrazovne nastavne programe s područja modnog dizajna. Pri tome se analiziraju ishodi i ciljevi predmeta, koji kod studenata razvijaju nove kompetencije. Poseban naglasak u procjeni navedenih studijskih sadržaja i njihove provedbe, stavljen je na važnost suradnje s različitim gospodarskim čimbenicima, naročito virtualnim prodajnim platformama, modnim kućama i laboratorijima za razvoj umjetne inteligencije. Sukladno novim obrazovnim zahtjevima, rad ukazuje na važnost razvijanja i nadogradnje nastavnih kompetencija, koje uz pomoć potencijalnih poslodavaca pridonose novim obrazovnim modelima. Naime digitalna moda postavši sastavni dio tekstilne i odjevne industrije, poremetila je dobro uhodane povijesne obrasce proizvodnje, načine potrošnje, a naročito obrazovanja. Postala je ključni pokazatelj modne budućnosti. Stoga mu se visokoobrazovni programi u području modnog dizajna trebaju prilagoditi kako bi uspješno odgovorili na nove zahtjeve potraživanja koje dolaze s tržišta rada.*

Ključne riječi: *digitalna moda; nastavni plan; visoko obrazovanje; implementacija; nove tehnologije; modni dizajn*

1. Uvod

Interes za hibridne pristupe koji uključuju nove digitalne tehnologije u produkciji i doradi modnih produkata vrlo su aktualni posljednjih dvadeset godina. Taj zamah obilježilo je 3D ispis (*3D print*), digitalni tisak te sve intenzivniji fokus na razvijanje inteligentnih tekstilija zahvaljujući inženjerskim timovima. Osim navedenog i u postupcima analize, ispitivanja i arhiviranja tekstilni, odjevnih i modnih predmeta, korištene su nove tehnologije koje omogućuju sasvim nove uvide u faze proizvodnje i načine prezentacije.

Devedesetih godina 20. stoljeća dominaciju digitalnih alata u suvremenom modnom dizajnu predvidio je modni dizajner Alexandera McQueena. Inovativan pristup produkcije odjeće 2007. godine upotrijebila je nizozemska modna dizajnerica Iris Van Herpen, kada je umjesto tradicionalnog krojenja i šivanja, primijenila 3D ispis (3D print) i lasersko rezanja. Danas je sinonim za futuristički pristup u odjevnoj formi ali i proizvodnji. Prilikom spajanja krojnih dijelova umjesto konca, koristi toplinsko spajanje (engl. *heat bonding*) i 4D tisak, koji pridonose dojmu tekstila u pokretu [1]. Tijekom druge dekade dvadeset prvog stoljeća veći naglasak stavljao se na konceptualne pristupe i razmatranja o *novom tehnološkom dobu*. Primjerice, modni dizajneri Jonathan Andersona i i Alessandra Michele kolekcijama oblikuju i aktualiziraju u potpunosti nov modno-digitalni jezik, temeljen na odnosu odjeće, *novog tijela* i mnogobrojnih identiteta. Međutim tehnološka i kreativna preispitivanja potencijala „digitalnog" svoj zamah bilježe i zbog sve utjecajnijeg društvenog aktivizma na modnu industriju i zbog utjecaja pandemija na proizvodnju. Prvi je intenzivnije pokrenut nakon velike nesreće u Bangladešu 2013. godine. Dok je drugi rezultat nedavne pandemije COVID-19, kada se ritam proizvodnje drastično promijenio ali i dovedo do novih načina konzumacije i prezentacije na digitalnim platformama [2].

Nova generacija mladih konzumenata, fokusiranih na mobilne telefone te virtualne internetske podražaje danas iziskuje nove digitalne pristupe, što iziskuje nova znanja i kompetencije digitalnih vještina kod budućih modnih dizajnere. Digitalni pristupi omogućuju brži pristup, ekološki su prihvatljiviji, dok koncept Web3 i aplikacije umjetne inteligencije (*Midjourney* i *Dall-E*), pridonose golemim promjenama u modnom lancu opskrbe, kao i unutar sektora visokog obrazovanja. Ovaj rad, temeljen na analizi vodećih studija modnog dizajna u svijetu te uvidom u njihove studijske programe dostupne u online obliku, nastoji ukazati na opće prihvaćen trend implementacije digitalne mode u nastavnim programima za buduće modne dizajnere.

2. Razrada

Sve snažnija implementacija digitalne mode u odjevnu i tekstilnu industriju utječe na promjene i prilagodbe nastavnim planova u visokom obrazovanju. Vodeće modno-obrazovne institucije u svijetu trendu su se već prilagodile. Naime početkom 20. stoljeća stručno obrazovanje u području modnog dizajna koncipirano je bilo na izučavanju likovnih vještina, pomoću koje se istraživala modna ideja (modna ilustracija) te na temeljima lijepog crteža izrađivao prvo prototip, a zatim odjevni predmet na krojačkoj lutki. Danas modne kuće posluju

kripto valutama, dok se procesi osmišljavanja idejno-modnih koncepata odvijaju na računalu. Prilikom prodaje modnih brandova mogu se koristiti digitalni identiteti (NFT), oblikovati digitalna odjeća i stvarati digitalna moda u širom kontekstu.

Zahvaljujući novim digitalnim alatima, proces modnog dizajna može uključivati 3D prikaze u programima kao što su *Clo3D*, *Blender*, *Daz* i *ZBrush* pri ćemu se oblikuje širok prostor prezentacije produkta animacijom digitalnog pokreta. Tehnološke inovacije poput 3D ispisa, virtualne stvarnosti (VR- *Virtual Reality*), proširene stvarnosti (AR- *Augmented Reality*) i umjetne inteligencije (AI - *Artifical intelligence*) modnim dizajnerima pružaju pregršt mogućnosti u oblikovanju, promociji i proizvodnji. Pa tako upotreba sirovina može biti taktilna, ali i digitalna. Budući da moda danas može biti digitalna i fizička, proces modnog dizajna odbacuje stroge odrednice rezultata koji isključivo može biti materijalnog stanja te prihvaća i virtualne, nestvarne produkte. Tim novim područjima oblikovanja nastavni programi nastoje se prilagoditi.

Na Odsjeku za modni dizajn ***The Swedish School of Textiles*** 2022 godine istraživali su nastavne modele, koji bi udovoljili novim kompetencijama. Pri tome su nastojali osmisliti program temeljen na teorijskim pristupima, naročito odnosu prema tijelu, zatim ulozi odjeće u izgradnji identiteta ali i primjeni novih tehnologija i tehnologija proširene stvarnosti. Od akademske godine 2023.-2024. na programu modnog dizajna dodan je kolegij digitalnog modnog dizajna s fokusom na izgradnju kompetencija u oblikovanju pomoću alata novih tehnologija. Prvostupnici izučavaju virtualnu konstrukciju, istražuju njezin potencijal kroz razvijanje modnih kolekcija. Velika pažnja stavljane je na usavršavanje znanja i primjenu i svih mogućnosti novih tehnoloških alata, koje dovode do raznolikih rezultata. Vodstvo je svjesno neizvjesnosti digitalne mode u budućnosti, stoga studente želi upoznati s što većem brojem računalnih programa i njihove upotrebe. Program Clo3d koristi se u različitim kontekstima, osim crtanja, oblikuju se modni koncepti temeljeni na *zero waste* pristupu, a slično je i s VR i AR. Stoga je temeljni model švedskog nastavnog plana, fokus na upoznavanje studenata s različitim vrstama softvera [3].

U Danskoj ***VIA University College*** prije promjene nastavnog plana, istražili su zahtjeve tržišta i industrije, a zatim na temelju rezultata prilagodili studijski program. U zadnje dvije godine veći naglasak stavili su na podučavanju studenata novim tehnologijama. Analizirajući najkritičnije dijelove modne proizvodnje, poput dizajn tekstila, zatim problem odjevnih veličina i transporta, zaključili su kako nove tehnologije pomažu u svim kategorijama. Zahvaljujući njima moguće je smanjiti otpad prilikom iskrojavanja ali i utjecati na troškove dostave. Potičući nastavnike u usavršavanju kompetencija studij modnog dizajna oplemenili su s kolegijima koje se bave sljedećim područjima: skeniranje materijala (engl. *material scanning*), skeniranje tijela (engl. *body scanning*), 3D renderiranje (engl. *3D-rendering*) i digitalni tisak. VIA University College također je razvio aplikaciju *SUSTAIN:AR*, platformu u proširenoj stvarnosti za predstavljanja portfelja diplomanta dizajna [4, 5] te priredio niz specijaliziranih tečajeva za potrebe dodatne edukacije već školovanih dizajnere i stručnjake, zaposlenih u modnoj industriji. Tim putem ostvaruju bliske kontakti s proizvodnim sektorom te su na izvoru informacija i ideja za podizanje kvalitete nastavnog programa. Bliska suradnja s modnom industrijom dovodi i do lakšeg uključivanja studenata u modne tvrtke nakon završetka studija.

Royal College of Art u Londonu, jedna je od najistaknutijih visoko obrazovnih institucija za umjetnost i modni dizajn. Diplomski studij modnog dizajna je po riječima voditeljice Zowie Broach, sve je do nedavno njegovao tradicionalne tehnike izrade. Nakon 2014. godine počinju se uvoditi novi pristupi. Uključuju se različiti predavači, fizičari, liječnici, neuroznanstvenici, autori video igara, vizualni umjetnici [5]. Danas studij ima donekle futuristički predznak, koji ruši granice strogo propisanih nastavnih planova i metoda podučavanja. Studentima se dopušta sloboda u istraživanju, naročito u području digitalne mode. Voditeljica studija Broach zaključuje da je tom zamahu pridonijela i pandemija Covida, kada su tradicionalni oblici podučavanja u radionicama morali biti zbog karantene napušteni, a nastava se održava u virtualnom svijetu s primjenom softverskog programa Clo [6]. Program se pokazao izuzetno kvalitetnim alatom za oblikovanje i preispitivanje različitih odjevnih identiteta te ujedno odgovarao aktualnim zalaganjima za zaštitu okoliša. Ako pogledamo recentne rezultate diplomskog studija modnog dizajna na *Royal College of Art,* vidimo da je naglasak na samostalnom studentskom radu, kako u izboru modnog područja i polja izražavanja tako i medija artikuliranja ideja. Po riječima Broach zahvaljujući tom pristupu, dolazi do intenzivne studentske interakcije, gdje studenti uče jedni od drugih. Cilj je da svaki student nađe svoju usku nišu interesa, dok se radovi i pristupi međusobno razlikuju. Svoje koncepte istražuju u digitalnom mediju ali i tradicionalnima, pri tome osluškujući znanja različitih znanstvenih i umjetničkih disciplina, zahvaljujući gostovanju stručnjaka. Zbog različitih interesa, samostalnog rada te medija u kojem produciraju, studenti se međusobno *sudaraju*, nadopunjuju ali proširuju svoje obzore, napominje Broach [5].

U Italiji najpoznatiji modni institut i fakultet ***Polimoda*** u Firenci također njeguje intenzivne odnose s modnom industrijom. Razvili su model uključivanja vanjskih mentora iz sektora modne industrije. Od prošle akademske godine 2022/2023 dio programa izvode u partnerstvu s *Microsoft Garage*, koji je osmislio projekt vrlo širokog

tematskog okvira, *kreativnost* i *eksperimentiranje* [7]. Simbioza talijanske modne škole i američke tehnološke tvrtke na preddiplomskom studiju pruža studentima kompetencije za *poslove budućnosti.* Osim naglašenog modno marketinškog menadžmenta (Fashion Marketing Management), budućim modnim dizajnerima uveden je kolegij *Fashion for Metaverse*, ponovo u suradnji s tvrtkom tj. digitalnim studijem *Monogrid* [8].

Oplemenjivanju nastavnog plana na diplomskom studiju modnog dizajna pridružio se i ***Central Saint Martins*** u Londonu, dok je ***Parsons School of Design*** u New Yorku pokrenuo kolegij digitalne mode u partnerstvu s *gaming* platformom *Roblox*. Na navedenoj platformi 2022. godine u oblikovanju virtualne odjeće sudjelovalo je više od 11,5 milijuna dizajnera te proizvelo preko 62 milijuna virtualnih odjevnih kombinacija, koje su uključivale i modne dodatke [9]. Brojčani podatak ukazuje na razvijanje sasvim novog tržišta, oblika modne konzumacije, koji donose visoku zaradu. U svjetlu tih činjenica ne iznenađuje stoga da se broj platformi video igra povećao, a nastavni planovi visokog obrazovanja tome nastoji prilagoditi. Suradnja *Parsons School of Design* i Robloxa studente je uvela u svijet najnovijih tehnologija za postizanje hiperrealističke i inkluzivne 3D digitalne odjeće koja pristaje svakom tipu tijela. Kroz vrlo konkretne tržišne zadatke tijekom semestra, studenti su usvojili Robloxov *Creator Roadmap*, bavili su se modificiranjem video igara i izrađivali prototipove 3D odjeće. Krajnji rezultat bila je virtualna modna revija predstavljena na Roblox-ovoj platformi, dok su se završni studentski koncepti prodavali na Robloxovom *Avatar Marketplace* [10,11].

Međunarodna škola ***Istituto Marangoni*** u Londonu bila je jedna od prvih koja je uronila u metaverzum, uspostavivši 2022. godine vlastiti virtualni svijet i prostor za podučavanje naziva *The Talent District*. U njemu se nalazi niz futurističkih okruga s zgradama, koje posjetitelji mogu istraživati putem avatara. Početna točka virtualnog posjete je *infopoint* s informacijama o studijskim programima na *Istituto Marangoni*, dok izložbeni paviljon pruža uvid u najbolje studentske projekte. Osim navedenog u virtualnom distriktu se nalazi i prostor za kazalište, konferencije, predavanje i razgovore. Za provedbu projekta Marangoni je uspostavio suradnju s talijanskom tvrtkom *Igoodi*, specijaliziranu za oblikovanje realističnih avatara po izgledu konzumenata. Igoodi avatar integriran je s Smart Bodyjem, skupom podataka koji uključuje antropometrijske mjere konzumenata. Jedinstveni u ponuđenim srodnim metaverzumima, Igoodi avatari su idealni za oblikovanje inovativnih digitalnih modnih modela. Drugi važan partner projekta *The Talent District* -a je *Monogrid*, digitalna interaktivna agencija iz Firence koja razvija platforme najviše tehnološke razine [12]. U recentnim javnim istupima *Istituto Marangoni* ističe strategiju institucije usredotočenu prije svega na područje razvijanja obrazovnih modela za tržište digitalne mode.

Modnu školu ***Esmod*** u Parizu pohađali su dizajneri Olivier Rousteing i Simon Porte Jacquemus. Godine 2022. škola je pokrenula program *Meta-wear*, specijaliziran za metaverzume i NFT-ove. Studenti se tijekom studija susreću s alatima Clo 3D, Blender, Maya i Daz3d. Međutim *Esmod* nastavlja svoju strategiju graditi i na podučavanju tradicionalnih tehnika proizvodnje, a naročito nastoji studente osvijestiti o važnosti zanata u razumijevanju složenih procesa oblikovanja digitalne odjeće. Pri tome za pažnja posvećuje formalnim tehničkim aspektima fizičkih produkata, idejno predočenih u virtualnom svijetu [13].

Sve nabrojane obrazovne institucije u različitim formulacijama predstavljanja studija ukazuje kako digitalizacija oblikuje kulturne i kreativne industrije, a time i modu. Međutim, digitalne tehnologije transformirale su i polje modnog djelovanja, uvjetovanog različitim prostornim kontekstima, nacionalnim politikama, uređenjima i odnosima moći na razini globalnog tržišta. Posebno značajan zaokret digitalna moda je učinila u prezentaciji. Do sada dominantni modni gradovi London, Milano, New York i Pariz, koji su svoj identitet gradili na modnim revijama, sada dobivaju nove konkurente zahvaljujući digitalnim modnim revijama. One su upravo omogućile da svi zainteresirani mogu pratiti najnovije kolekcije, privilegija do tada rezervirana samo za odabrane. U tom procesu ključna je i uloga modnih blogera, važnih društvenih aktera, promotora i „kritičara“. Stoga, znatan broj studija modnog dizajna na visoko-obrazovnim institucijama koegzistira uz modne studije, koji studentima ukazuju na još jedan važan značaj digitalne mode. Naime čovjek je i u konstantnoj potrazi za novim načinima iskazivanja identiteta, a nove generacije unutar virtualnih prostora potenciraju inkluzivnost, prihvaćanje različitosti na temelju rase, etničke pripadnosti, dobi, veličine, pojma ljepote i rodnih identiteta, koje su često vrlo ograničene u stvarnom životu. Kroz modne studije ukazuje se na ključne prednosti digitalne mode, koja korisnicima pruža puno veću kontrolu nad prisutnošću i izražavanjem u virtualnoj stvarnosti, za razliku od stvarnog svijeta. Osim toga digitalna moda je promijenila i naš odnos prema odjeći. Više se ne odabire određeni odjevni predmet, već kupuje iskustvo ili emocija. Ovaj kratki osvrt u kontekstu kolegija iz područja modnih studija, ukazuje na neophodnost njihove integracije u studije modnog dizajna kako bi se odjevni produkt budućnosti mogao kvalitetnije razumijete i shodno tome, proizvesti u virtualnoj ili realnoj stvarnosti.

3. Zaključak

Prije trideset godina rad modnog dizajnera uspoređivao se s radom umjetnika. Jedan od razloga je što su tijekom obrazovanja budući modni dizajneri gradili kompetencije u likovnim vještinama. Danas, ideja modnih dizajnera više se ne predočava isključivo u crtežu. Nova tehnologa je omogućila dizajnerima da ne posjeduju razvijen likovni talent, osim toga u kratkom vremenu mogu zahvaljujući novim tehnologijama iz producirati puno veći broj idejnih skica. Sve prisutnija u oblikovanju i produkciji je i umjetna inteligencija. Na tim tragovima već postoje recentni poticaji za prilagodbu nastavnih planova modnog dizajna. Naime mladi dizajneri usvajajući interdisciplinarne pristupe, željni su sinergijskih modela interakcije, poput grafičkog dizajna, kodiranja, 3D razvoja i generativne umjetne inteligencije – kako bi pomaknuli parametre tradicionalnih modnih praksi. Upravo to su i zahtjevi globalnog tržišta. Uloga visokoobrazovnih institucija je da budu predvodnici inovativnih studijskih programa, koji će studentima omogućiti nove kreativne modele učenja i stjecanja kompetencija. Bez obzira bili studenti usredotočeni na fizičko ili virtualno oblikovanje, programi bi trebali pružiti mogućnosti za razvoj vizionarskih projekata. Osim studentske populacije, izniman interes za digitalnu sferu, postoji i od strane modnih kuća. Ne samo u vidu prezentacije i prilagodbe potrebama potrošača, već i u zaposlenju pripravnika, dizajnera s kompetencijama iz područja digitalne mode. Na visoko obrazovnim institucijama je da se tržišnim i novo generacijskim zahtjevima prilagode.

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THE ART OF FASHION STORYTELLING: ANALYZING BRAND NARRATIVES IN CINEMATIC SHORT FILMS

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Abstract: *This paper explores the pivotal role of storytelling in the highly competitive fashion market, where brands strive to differentiate and connect with consumers. The focus is on cinematic storytelling through short films produced by renowned brands – Burberry, H&M and Nike. As traditional advertising shifts towards transmedia storytelling, this paper investigates how these brands strategically employ narrative techniques to create relatable, memorable, and emotionally resonant connections with their target audience. Central to this paper is the application of content analysis, a systematic examination of visual material. This method enables an in-depth understanding of storytelling techniques employed by the selected brands. The analysis covers Burberry's historical narrative, H&M's humor-based approach, and Nike's inspirational storytelling. In conclusion, while each brand employs unique strategies, they share common goals of building emotional connections, reinforcing brand identity, and fostering consumer loyalty. The research contributes to understanding the evolving dynamics of storytelling in the fashion industry and its implications for brand communication in the digital age.*

Keywords: *storytelling, fashion industry, cinematic narratives, content analysis, brand communication, transmedia storytelling*

1. Introduction

In today's highly competitive fashion market environment, fashion brands tend to differentiate in consumers perceptions. Here, storytelling became crucial in communicating with all potential consumers because it humanizes brands, making them relatable and memorable. It also helps to create an emotional connection by evoking consumers' feelings and their own experiences. Through narratives, complex ideas that fashion brands want to share can be simplified and made more understandable and engaging. Stories have the power to captivate attention, and at the same time to keep the audience interested and involved. Important is to mention that storytelling allows brands to differentiate themselves in a competitive market by establishing a unique identity that consumers can connect with on a personal level. The importance of storytelling in advertising is associated with the changes in consumer habits. Therefore; to maintain advertising effectiveness, many companies and advertising agencies have shifted from aggressive selling tactics to using storytelling in videos, which remains a highly effective medium for conveying brand narratives [1].

This paper explains the relation between cinematic storytelling and the fashion industry, and it provides insight into strategic use of narrative techniques with short films produced by esteemed brands such as Burberry, H&M and Nike. Reflecting on the effects of diversion from traditional forms of advertising to transmedia storytelling Jenkins was problematizing [2] through content analysis of the cinematic narratives, the authors of this paper wanted to understand how selected brands tell their stories and the message they are trying to share to connect deeply with their target audience.

2. Fashion communication and Storytelling

Changes in the media landscape driven by the expansion of social media have vastly influenced the understanding of users' behavior and the way they consume the media [3]. With the gradual transfer from consuming the content via traditional media and turning to the digital media mediated over the Internet, companies have started to change their approaches to advertising and the way they address their audiences. This has moved the focus in advertising from communicating content via single medium to multiple platforms, transforming the narrative to better engage the audience by providing a more meaningful experience in the process of transmedia storytelling. Nevertheless, in this new paradigm the emphasis is on narrative, and each medium involved in the storytelling practice is assumed to do what it does best [2]. This has vastly expanded the horizons of the advertisers and broadened their marketing approaches, but also the ways they address the audience as transmedia storytelling practices expand the potential market for a property by creating different points of entry for different audience segments [4]. Lower costs of content distribution via social media compared to, for example, television, has caused the gradual switch toward online media which provided

opportunities to extend the content duration. Reallocating some advertising budget away from higher cost traditional media such as television, radio and print media and towards lower cost online/social media platforms [5]. Instead of short TV commercials which were usually influenced by the high costs of advertising, companies have gotten an opportunity to produce and distribute the content for low-priced social media ads, companies' websites, their official YouTube channels, blogs, video podcasts, etc. limited only by the production costs and budget restraints.

Regarding that, fashion brands have also gradually moved their focus to the world of digital media. In such trend, one of their important tools are fashion films. Although it is used in a rather contemporary meaning and it is often linked to the digital age, the history of fashion films dates to the beginnings of film as mass medium. It was used periodically throughout the 20th century to refer to a range of different genres and film forms [6]. Uhlirova [6] underlines it as an umbrella term for short multifarious works that display current fashions, reinforce brand 'narratives' or tell 'stories' about wider fashion cultures with at least some degree of creative ambition.

In the past decade, some of the constituent elements of fashion have significantly changed. Models have been replaced as cover girls by celebrities, themselves central within fashion's changed topography; the most fashion-friendly celebrities are currently assured of a place on fashion's famous front rows, just as the photogenic dominate the lucrative luxury-brand advertising campaigns. Fashion magazines retain their status and influence, but they also need an online presence; in cyberspace they are joined by bloggers and street photographers, whose power within the industry has increased rapidly [7]. While the appearance of other celebrities than models in advertisements has shown discrete introduction of people who can convey the narrative in the advertisements they star in, while the move static images in fashion magazines were slowly to be replaced by the emerging motion content in the fashion films.

Fashion films are initially classified as the fashion films created for fashion shows and fashion films for digital media, based on channels they are communicated through [8]. While those made for fashion shows are visual-centered videos with no story, the fashion films meant for digital media are classified as short image-oriented videos or videos produced by filmmakers and film directors. The latter type has been closely analyzed in this paper.

The fashion film is considered a powerful strategic tool because it engages the viewer and works on defining and strengthening the visual identity of fashion brand – telling a story, drawing a personality and creating an atmosphere get stronger key concept, consumer and mood of the brand [9]. One of the key changes Khan [10] identified was the introduction of narrative and a shift from the viewer as consumer to the viewer as spectator. As Needham [11] underpins, this change marks the transformation from a still image, and a position of consumption, to a moving image and a position of spectatorship is brought about through the import of cinematic conventions of editing and narration, which render the once still fashion image is moving. This broadens the understanding of the changed approach that brands started to nurture aiming to connect with their audience on a new level.

In the early 90s, storytelling took a central stage in branding that led to an increment in product value through emphasizing stories over factual communication for generating more profit [12]. Today, luxury brands often use storytelling techniques to highlight their brands' history. Applying storytelling as a marketing tool influences the shopper's behavior and their actions related to their word of mouth to influence others purchase decisions [13]. It stands as a powerful tool that helps brands owner to be competent and enforce changes into the market. In fact, compelling storytelling in business significantly enhances the clarity, persuasiveness, and memorability of the message conveyed. Fashion brands, renowned for their exceptional videos, have emerged as pioneers in employing multimodal storytelling, especially during the COVID-19 pandemic, where online communication replaced physical interaction. Brands and companies adapted by enriching their website content and creating captivating videos, elevating the expectations for commercials to be more impressive, splendid, and magnificent [1].

3. Fashion storytelling content analysis

The following subchapters will present the analysis of storytelling based on three short films created by different fashion brands. Selected three different brands' approaches include various persuasive techniques and different narratives: the heritage-inspired approach of luxury fashion brand Burberry, the humorous approach in the marketing of the fast-fashion brand H&M, and the inspirational stories of athletes in the advertisements of the sports fashion brand Nike. The research method used in this paper is content analysis. Content analysis is defined as a technique that involves systematically examining written, spoken or, as in this research, visual material [14]. By using content analysis, this study seeks to closely examine the visual narratives in the

selected short films by Burberry, H&M, and Nike. The goal is to uncover the underlying themes, persuasive techniques, and storytelling strategies employed by these brands, exploring how they communicate with their target audience through a systematic evaluation of cinematic content.

3.1. Burberry

The Burberry's 2016 short film "The Tale of Thomas Burberry", created for the purpose of marking the 160th anniversary of the brand, has shown creative approaches that brought closer the film industry to the world of fashion industry. Engaging the Academy Award winning director Asif Kapadia and respected cast of actors like Domhnall Gleeson and Sienna Miller, the film presented a clear intention of moving the narrative from more advertising to the fully scripted storytelling of high-budget film production. The three-and-a-half-minute long video shows the narrative that introduces the literary techniques like flashback and flash-forward. Unlike linearly structured stories that do not prompt the viewer to reconstruct the original sequence of events in order to understand the story [15], the mentioned techniques help to break out the common straight-forward plot development, moving the story in multiple directions and maintaining the tension until the end. Meanwhile, the film plot still revolves around the story vastly relied on historical development of the brand through the introduction of fabrics that resist the most adverse weather, while the use of persuasive techniques like 'celebrities' (use of prominent people in advertising) and 'snob appeal', which persuades consumers that they will be part of a special group if they acquire the particular product or service [16]. As these techniques support the plot development, they show that the film does not allow compromise on the company's reputation of high fashion brand that has been built throughout its history. The focus of the film remains on demonstrating the quality of some of the revolutionary fabrics the brand has introduced in the past (e.g. gabardine) while making sure that they don't forget to put emphasis on the famous square pattern it is so well known by. Nevertheless, if we consider as accurate the Kapferer's claim that the luxury is part and parcel of humanity and of life in society [17], then it is easier to understand the narrative of how the fabrics presented in the video fit in the context of ordinary, like the one with the soldiers on the battlefield wearing Burberry trench coats.

3.2. H&M

H&M is another fashion brand that has used the celebrities in their advertisements to efficiently communicate the intended message to their target audience, however, with a different narrative. In his final season as a professional footballer, the English superstar David Beckham has signed a multiyear sponsorship with this Sweden-based company. The partnership resulted in production of several advertisements that vastly relied on the humor-based narratives with well-developed plots. Although these advertisements were still showing Beckham as celebrity, on the other hand, they started bringing him closer to the common people, mostly younger generations, which is considered to be the brand's main audience [18]. The 2013 commercial directed by Guy Ritchie in which Beckham runs through his neighborhood in Los Angeles in his underwear only, showed the witty marketing approach that relied on the combination of 'beautiful people' and 'humor' techniques, through a developed film narrative that reminded of action scenes. It also used a film technique of unresolved ending. Although the stories with this type of ending, in which the outcome is left open for the viewers interpretations, are generally not as appreciated as the ones with the resolved ending [19], the H&M's advertisement still delivers a fully conveyed message that derived from the plot development. Furthermore, the brand's 2016 H&M Modern Essentials commercial followed Beckham's everyday activities in a few days span, showing people around him wearing exactly the same clothes he was wearing on the particular day. The use of the 'bandwagon' technique, which 'instructs' to start using a product because everybody is using it [20], in this case was used to demonstrate how universal the clothes were, yet through a very engaging short video covered up with humor.

3.3 Nike

Profiled as a sports garment brand, Nike has introduced innovative and modern marketing by building a timeless brand through storytelling and purpose to reach unique audience [21]. This brand has become recognizable per their advertisements enriched by inspirational narratives that intend to empower the audience with inspirational stories of athletes overcoming challenges and prevailing toward success. Applying this concept many times in various commercials, Nike has been tailoring their ads per thematic requirements like, for instance, global sports events. This has affected Nike's narrative to be shorter, condensed by the time requirements of short commercial breaks during those events (for example, time-out breaks in sports like basketball, tennis and similar. Nevertheless, although Nike has produced dozens of these commercials on annual level with different plot, objectives, and purposes, there are two general approaches the company follows in its narrative.

The first one is built around general, inspirational, parallel stories of plain people (another common persuasive technique) with powerful storytelling, intended to move people with call-to-action technique. It usually doesn't follow any specific sport butgeneralizes the storyline to be applicable to any sport and life of any individual, in general. Nike's advertisements behind the campaign "Just Do It" focus on internal battles and determination that ultimately leads to heroism, further leaing to consumer loyalty [22].

In the second type, Nike's commercials are focused on a particular sport, particular message, particular event, or a particular athlete. Their clear purpose is to convey a message that will link their target audience to the specific objective of their campaigns.

Throughout its various narratives, the sports clothing added up to the visual quality of Nike's commercials. Nevertheless, the company's advertising is not about the product as much as it is about the message. Nike emphasizes the ethos – what they stand for – in their commercials [23]. The use of testimonials as persuasive technique as the narrative in their advertisements showed no space for compromise that the communicated message is what both the company and the athletes in them truly believed.

4. Conclusion

The presented analysis of storytelling techniques and approaches employed by the three prominent fashion brands – Burberry, H&M, and Nike – reveals distinct approaches to storytelling through various narrative strategies, persuasive techniques, and intended messaging to connect with their audiences.

Burberry's approach in "The Tale of Thomas Burberry" video combines cinematic storytelling with curated moments of the brand's rich history and adopting the literary techniques such as flashback and flash-forward to diverge from traditional advertising formats. By incorporating celebrities and inclining toward the intentional use of 'snob appeal' technique, the used narrative reinforces the company's reputation of high fashion brand without compromising its heritage. This strategic storytelling leans on the historical fabric innovations combined with the brand's iconic design, while maintaining the emphasis on its relevance in contemporary fashion contexts.

H&M takes a different route by using humor and relatable narratives, particularly in campaigns featuring football star David Beckham. By confronting his celebrity status with everyday situations, H&M aimed to bridge the gap between the superstar persona and its predominantly younger target audiences. The brand leverages humor and unresolved endings of the narrative to engage viewers. Simultaneously, the brand is employing the 'bandwagon' technique to emphasize the universal appeal of their clothing.

Nike's storytelling, bolstered by inspirational narratives and a purpose-driven approach, focuses on empowering individuals through sports. The brand crafts powerful stories, leveraging the "Just Do It" campaign to inspire and motivate universal and diverse audiences. Nike skillfully tailors the narratives to specific sports, events, or athletes, referring to their determination and internal battles that lead to heroism and ultimately foster consumer loyalty.

In conclusion, these analyses underline the diverse storytelling strategies utilized by fashion brands to communicate and connect with their audiences. While Burberry supports its heritage with cinematic narratives, H&M relies on humor and relatability, and Nike emphasizes inspiration and purpose. Despite their different approaches, all three brands employ storytelling not merely to promote products but to build emotional connections, reinforce brand identity, and ultimately propagate consumer loyalty in the dynamic landscape of the fashion industry.

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GREEN FASHION DESIGN EDUCATION – CASE STUDY

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Abstract: *Fashion design study programs provide a unique opportunity to equip graduates with the necessary knowledge, skills, and creative problem-solving approaches to reduce the negative environmental impact of current fashion manufacturing processes. The theme of sustainability is an opportunity for students to apply critical thinking skills in the creative process and experiment with concrete sustainable design practices. The aim is to integrate sustainability as a design standard, explore sustainable construction techniques, and find new solutions through design concepts, material selection, pattern development, assembly procedures, and the product life cycle (in accordance with ecodesign principles). In this case study, the use of the creative solution of zero waste patterning in the teaching of art lectures in bachelor and master courses in fashion design is presented. The article presents the principle in the process of a specific student project from the Design Department of the Faculty of Textiles of the Technical University of Liberec (FT TUL).*

Keywords: *ecodesign, fashion, zero waste pattern, sustainability, education, creative design*

1. Introduction

The global garment industry produces large amounts of waste and pollution at all stages of the production process [1]. Ecodesign is one of the important prevention-oriented voluntary regulatory instruments of environmental policy. In general, ecodesign can be defined as a systematic process of product design and development that, in addition to the classical characteristics such as aesthetics, functionality, economy, safety, ergonomics, technical feasibility, etc., places great emphasis on achieving a minimum negative environmental impact of the product in terms of its entire life cycle [2, 3].

Cutting the textile fabric to the size of the garment produces an estimated 10-12% waste [4]. This waste is mostly incinerated. This paper presents an educational approach to teaching ecodesign using student projects aimed at minimizing this waste. The goal of the project and the thematic task were freely formulated to provide sufficient artistic freedom and practical flexibility for the tutors and to allow the students a free design approach. The presented project was focused on the issue of zero waste fashion design. The topic was: "How can a designer influence the amount of waste through the creative design process?". The aim was to introduce students to sustainable methods of zero waste fashion design. The project was developed under the pedagogical guidance of two lecturers from the Department of Design. The purpose of this paper is to present the students' personal strategies and results and to share the knowledge gained from the educational process.

2. Materials and methods

The aim of the student's semester project was to design and realize a capsule collection based on zero waste techniques. The collection was to consist of at least three products derived from the cut shirt concept in a relaxed compositional structure with new inventive elements. The presented student project applies flat cut solutions with minimal waste based on geometry (symmetrical and asymmetrical). Individual cutting parts are laid out on material without cutting waste, so-called assembled cutting parts. When designing an innovative cutting template the designer uses the entire width of the material [4, 5]. Upcycling is often a moral choice for those who can afford clothing and an economic choice for those who cannot. The process of upcycling and the eco-friendly approach appeals to the younger generation, who are more in touch with manufacturers and designers [8-10]. The students' work was focused on the recycling of denim clothing waste. Due to its popularity and exceptional properties, denim clothing is produced in large quantities, so the production, use, and disposal of denim clothing has a major impact on the environment [11].

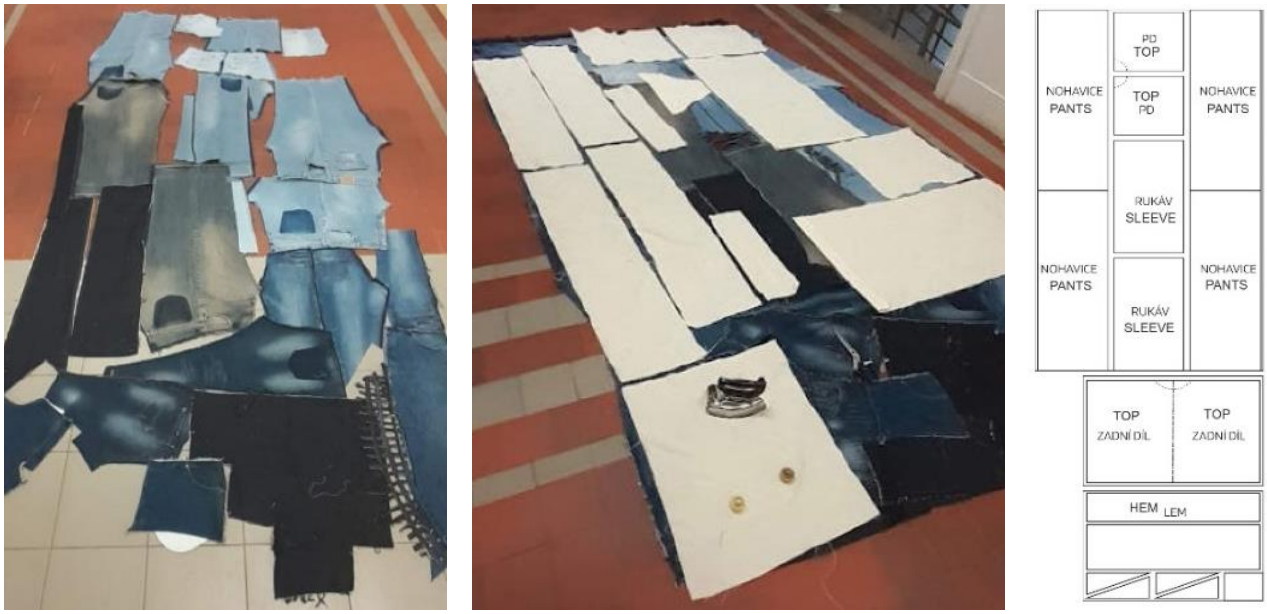
3. Results and discussion

In this case, the student used an artistic approach to assemble modular elements according to the principle of zero waste pattern design. The student used denim clothing in two forms for her project. Two sustainable

problems—the large quantities of denim clothing to be disposed of and the waste generated during patterning and cutting—inspired their solution.

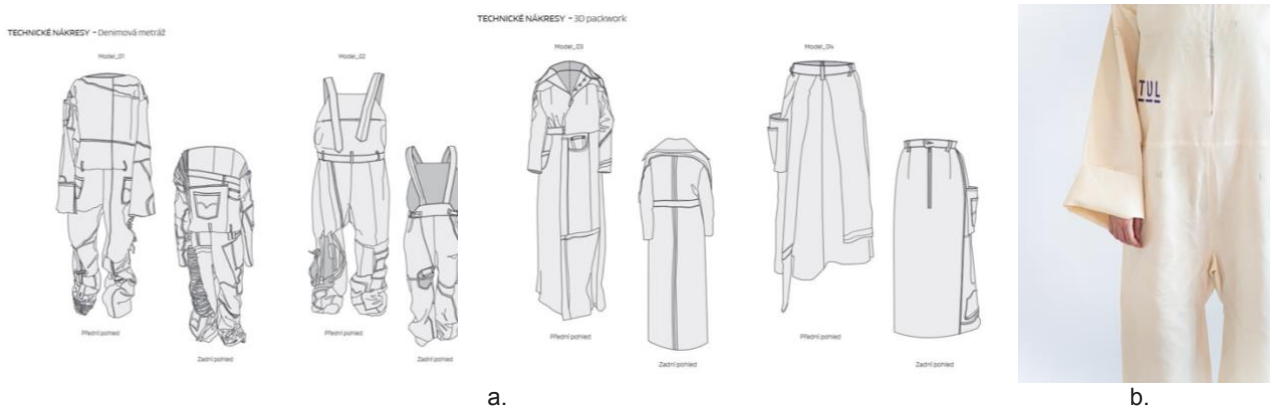
3.1 Reused denim and zero waste patterning

The first goal was to create a sustainable unisex denim fashion collection through a combination of upcycling and zero waste patterning. The direct way was to use the waste from whole products. Several "used" jeans were divided into flat parts (Figure 1a). The assembled parts were collaged into a new material (Figure 1b). Then the design and technical drawings of clothing were created based on a zero waste pattern solution (Figure 1c). The pattern solution was verified by making models in calico (Figure 2 a,b). The modeling in calico is used for the verification of the following questions: How can you improve the shape of a garment to reduce material consumption? Are the garments spacious and functional enough? Then the denim collage was cut, and a fashion collection was produced and performed.



a. b. c.

Figure 1: Work process - zero waste pattern on reused denim - top and pants; a. art composition, b. cutting plan, c. patterns



a. b.

Figure 2: Work process – verification of technical drawing by calico, a. technical drawing of clothing, b. calico

Individualized designs can be created thanks to the chosen designer's approach to the creation of a new textile. Although the material has a very good cut and an interesting appearance, it is necessary to fine-tune the production technology of designer textiles. The fabric made from waste material never has the same character as the newly produced yardage.

3.2 Recycled denim and zero waste patterning

The project was developed in parallel directions. During the previous "recycling" of jeans, very little waste was created. The ambition was to apply a completely waste-free process. The student found inspiration from the production of technical textiles, where textile waste is processed into non-woven textiles.

The goal was to create a sustainable unisex fashion collection through a combination of downcycled denim and non-woven technology. The question was whether this form could be used to create clothing. The denim clothes sorted into waste and residual denim were downcycled by mechanical shredding and fiber separation by carding at the RETEX company [12]. The fiber material was blended with 7.5% connective thermoplastic fibers, and a non-woven fabric was produced in the FT TUL workshops by carding. That non-wowen was used for the production of other garments in the collection by zero waste patterns developed in the previous part of the project. (Figure 3)

Figure 3: Garment created from dovncycled denim

Due to the mechanical shredding and carding of denim, the fibers are torn and shortened, and the final non-woven fabric lacks sufficient cohesion. Although the material has a very good hand and an interesting appearance, the non-woven fabric production technology needs to be fine-tuned. The overall fashion design of the product matches the character of the material and the selected cut solution.

Figure 4: Final products presented at the fashion show [13]

4. Conclusion

The collection was presented at Mercedes-Benz Prague Fashion Week 2023 (Figure 4). The results reflected a high level of student engagement with the task, which was further evidenced by the feedback after the project evaluation and final presentation at Mercedes-Benz Prague Fashion Week [13]. The zero waste fashion design project can be recommended to be applied in future semesters with more or less integration. Regardless of the project scope, the documentation of the individual student design process through photo documentation of the design and production process and the final presentation provides evidence of student engagement with this sustainable approach to garment design. The zero waste project is a challenge for each semester and provides an introduction to sustainable design thinking solutions (ecodesign) that are essential for all professionals working in the apparel industry in the 21st century.

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DOCUMENTING AND PRESERVING TEXTILE HERITAGE USING DIGITAL DOCUMENTATION TECHNIQUES: THE CONSERVATION AND RESTORATION OF HEADGEAR FROM THE BALTAZAR BOGIŠIĆ COLLECTION IN CAVTAT

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Abstract: *This paper focuses on methods of the Digitization of tangible cultural heritage, specifically on digital techniques used in recording the conservation and restoration process performed on a 19th century headgear from the Baltazar Bogišić collection in Cavtat. Tangible cultural heritage is in constant process of deterioration, so it is crucial to combine old and new technologies and digitization methods to improve our ability to preserve it. The methodological approach to conservation and restoration documentation of headgear includes written text, as well as different photographic and graphical records. The data comprises information related to the condition of object, material composition, manufacturing techniques, as well as data obtained during conservation and restoration treatment. Detailed and professionally made conservation and restoration documentation should provide all the key information relevant for the future researcher, curator, or conservator.*

Keywords: *tangible cultural heritage; Digitization; textile conservation and restoration; headgear*

1. Introduction

The primary goal of textile conservation and restoration is to ensure the preservation of fragile and valuable textile heritage for the future. Traditional conservation and restoration approach involves a material intervention to the object in question. Each cultural heritage object has its own unique characteristics and it is up to the expert to determine which type of analysis and documentation techniques are best to apply [1]. Conservation and restoration activities include examination, treatment, documentation, and preventive care, supported by research and education (Fig. 1).

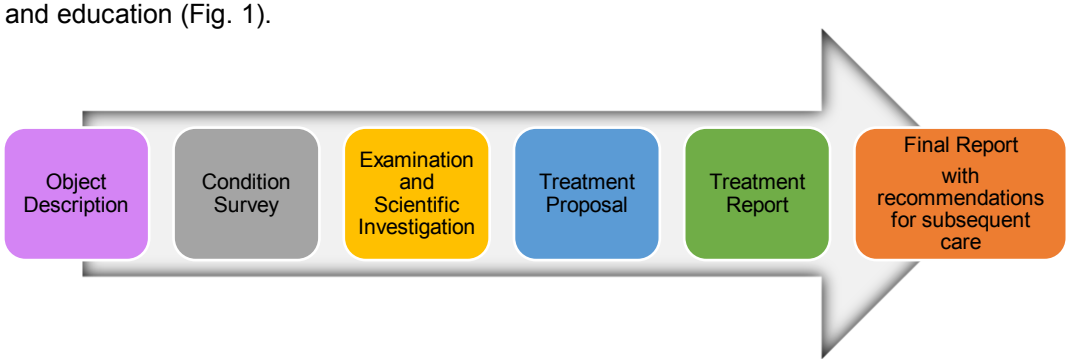

Figure 1: A methodical approach to the conservation and restoration process

Unlike written contemporary documentation, in modern documentation, a methodological approach largely depends on how crucial information is gathered. The use of digital technology in the field of textile conservation and restoration develops and improves documentation possibilities of textile cultural heritage which, as organic matter, is in a constant process of decay. Before performing any conservation and restoration treatment or introducing new materials, it is important to thoroughly investigate the object using a diverse range of techniques. The application of digital technology has a great advantage and benefit in this process. Conservation and restoration documentation can be defined as textual and visual records collected during the care and treatment of an object (Fig. 2).

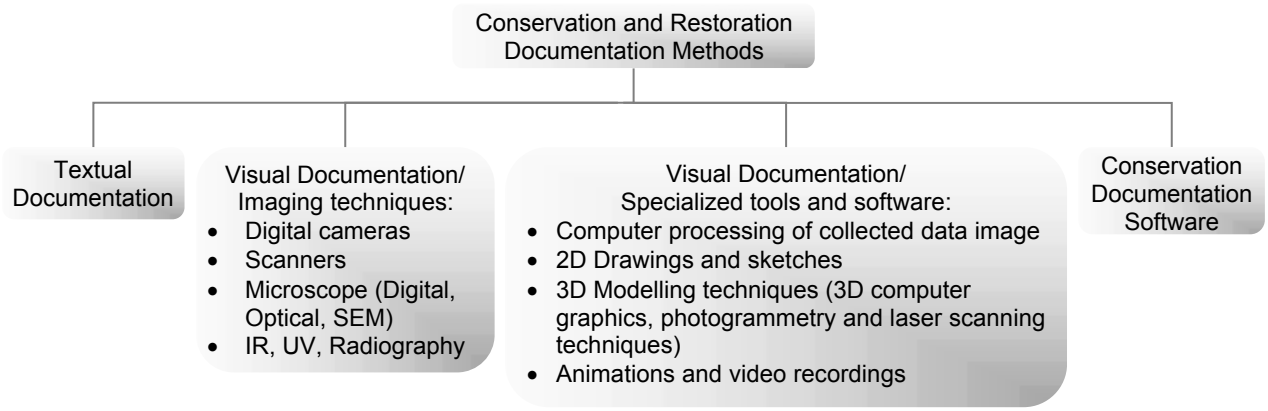

Figure 2: Different examination and documentation techniques used by conservators and restorers when observing the object in their care and recording the treatment performed

New digital technologies can be used for many purposes in the context of documenting the conservation of cultural heritage, namely historical interpretation, planning intervention, monitoring and supervision of the state of the object, comparison of different restoration phases, simulation of object's degradation, computer-assisted restoration, the application of virtual and augmented reality techniques, digital catalogs, etc. [2]. Nowadays, specialized software is being developed for museum conservators and restorers. This enables the creation of conservation reports with tailored templates, such as condition and treatment reports, treatment proposals, surveys, and others pertaining to the conservation and restoration area [3].

Conservators occasionally use fabric supports with digital and hand printing techniques to enhance the structural stability of objects and create a visual infill in missing areas. It is commonly used with patterned or textured fabrics to modify the appearance of supporting fabrics and improve the visual presentation of objects [4].

A multi-layered textile object composed of various fibers and materials has complex physical and chemical structures that present unique preservation challenges. One such object is the headgear from the Baltazar Bogišić Collection described in this paper. The object was examined, its condition recorded, and all treatments documented using non-invasive methods. All collected data was digitalized and combined in the final report, equipped with drawings, photographs, mapping, etc.

2. The Headgear from the Baltazar Bogišić Collection

The headgear from the holdings of the Baltazar Bogišić Collection in Cavtat is a 3D object in irregular oval shape, with approximate dimensions of 20 x 28 x 9 cm (Fig. 3a). The crown part of the hat is made from light white cotton fabric, arranged around a solid band via inverted pleats (Fig. 3b). The rim is decorated with black velvet ribbon and a row of white bobbin lace. The crown part of the hat is additionally decorated with a black velvet ribbon bow surrounded with rows of bobbin lace (Fig. 3c).

Photography is a basic tool for documentation of cultural heritage. Photographs with visible light taken with a high resolution digital camera are used to register, document and digitalize the images of the total and the detail of the object in question (Fig. 3).

a. b. c.

Figure 3: Photo-documentation of object before treatment: a. photography of total, b. and c. photography of detail

The study of cultural object with regards to shape, techniques and materials used in their production, help determine provenance and provide more context for an object's place in history. According to fashion

magazines from 19th C, smaller hats with relatively shallow crowns and without a solid brim, those richly decorated with lace, bows, ribbons and flowers, with or without embroidery, are characteristic mainly of the second half of the 19th century, mostly of 1870s [5,6]. The fact headgear this article considers is a part of the holdings of Blatazar Bogišić Collection in Cavtat may indicate its origin, given that Bogišić lived in Paris for 30 years of his life, but he also stayed in Odesa, Vienna, etc., so one must be careful when drawing definite conclusions [7,8,9]. Detailed written, graphic and pictorial documentation was carried out before, during, and after the conservation-restoration treatment of an object.

2.1. Technical study of three-dimensional headgear

The first steps carried out provided information on the material aspects of an object. Those include pattern analysis, the manner of assembly, and technical analysis of the fabric properties such as weave structure, yarn twist, and microscopic analysis of textile fibers.
The object is constructed of several cutting parts and types of fabric. For the sake of clarity, all elements have been divided into four segments. Those are crown, brim, velvet ribbon, and velvet ribbon and bobbin lace decorative detail. The manner of assembly of all four segments is graphically documented in great detail (Fig.4).

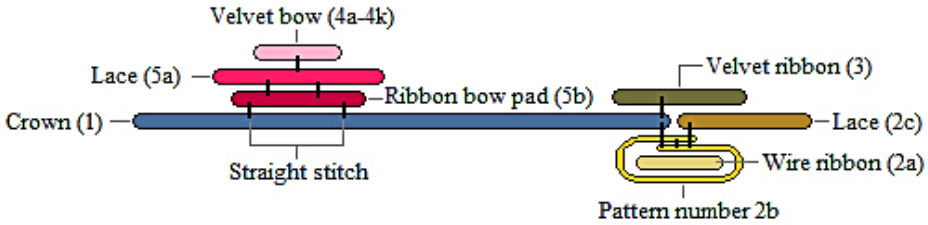

Figure 4: Graphic view of exact position of each element

The main aesthetic feature of the object is a black bow made of velvet ribbon. This intriguing piece is documented using various forms of digital documentation, including digital cameras, microscopes, and special software such as Photoshop, Paint and StreamStart (Fig. 5).

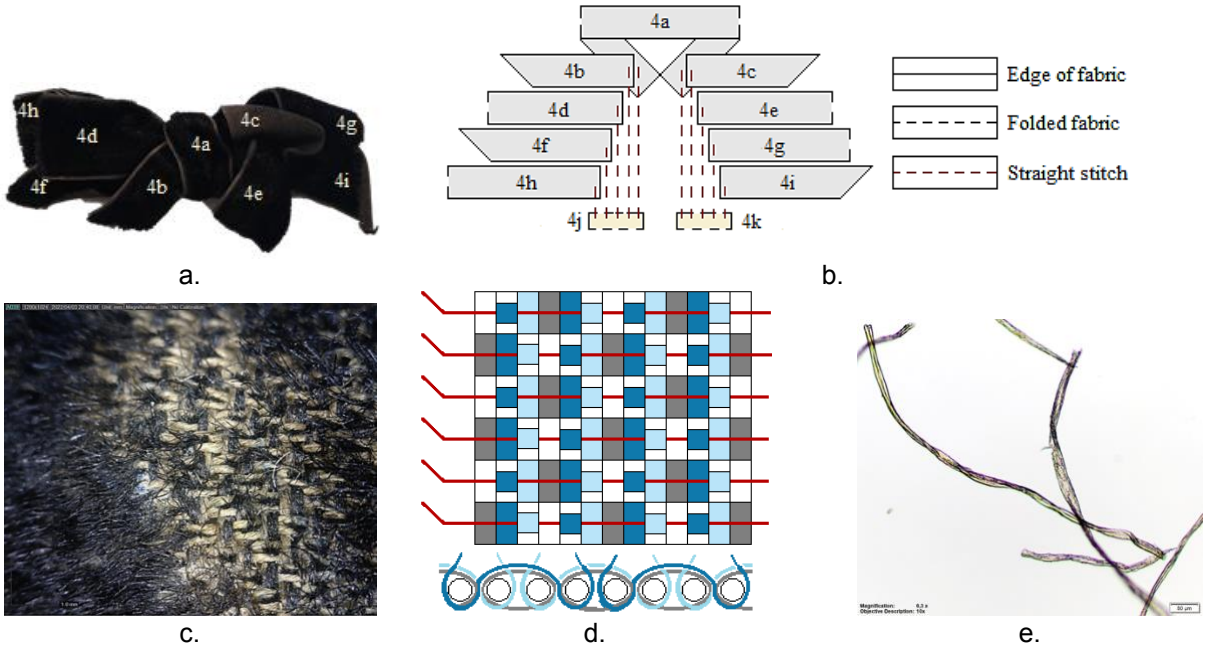

Figure 5: Documenting a bow made of velvet ribbon, a. Pattern cuts labeled with numbers and letters, b. schematic representation of layout of pattern cuts and sewing stitches, c. Velvet fabric recorded with Dino-Lite Pro Digital AM413T Microscope (magnification 59x), *DinoCapture 2.0* software, d. Ground construction weave: *Gros de Tours*; Pile weave: imitation of warp (warp density: 28 ends/cm; weft density: 56 picks/cm), e. Micrograph taken through Olympus BX40F4 light microscope and SC30 camera.

2.2. Condition survey

The object is in a very poor state of preservation. Due to the accumulated impurities, the fabric has darkened considerably, and a number of creases and wrinkles can be observed all over the object's surface. Another types of damages observed are holes, tears in seams, and gray and brown colored stains. Stains and holes are most pronounced on the upper part of the crown. All types of damages are documented descriptively, photographically, and graphically (Fig. 6).

Figure 6: Graphic representation of damage on the crown part of the headgear

The loss of material (from 1 to 3 cm in length) on the wire ribbon (pattern number 2a) and on the cotton fabric around the wire ribbon (pattern number 2b) is particularly noteworthy. The loss of material occurred due to the corrosion of the metal wire that acts as a warp in the cotton ribbon placed inside the brim of the hat.

2.3. Documentation of conservation and restoration treatment

Conservation and restoration treatment started by separating four segments of the headgear: crown, velvet ribbon, brim and decorative detail, apart (Fig. 7). This provided access to damages. The mechanical surface cleaning of the textile was carried out next. This was executed by vacuuming on low suction, through a nylon screen placed over the textile. Wet cleaning was used to remove the soil from the crown fabric (pattern number 1) and from bobbin lace (both on the brim and decorative detail). Crown fabric was washed on the suction table, while the bobbin lace was treated locally. In both cases a non-ionic detergent with a neutral pH was used. Rust stains found on pattern number 1 and on bobbin lace were removed with *ferrosolve*. The areas where textile was in a very poor state were not treated to prevent its disintegration and decay.

Figure 7: The brim of the hat after the removal of the seam used to attach the bobbin lace (pattern number 2c) to the cotton ribbon (pattern number 2b).

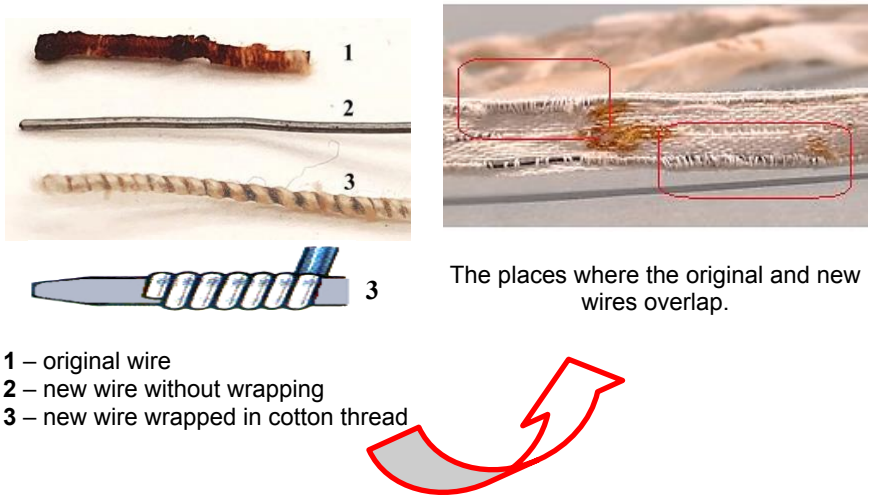

Figure 8: Making a replica of the metal wire used to substitute rusted parts. The central part consists of cotton ribbon with metal wire wrapped in cotton thread

During the conservation and restoration process, an interesting and inventive task was to preserve and create a replica of the original wire found in the object's structure. (Fig. 8). Because holes, rips, and loss of warp, or both warp and weft yarns, located on different materials and parts of the headgear, are of various intensities, they required a combination of two different stabilization techniques (Fig. 9.). Damaged areas were thus either secured to a support fabric placed underneath alone (underlay) or both underneath and above-treated areas (underlay and overlay). The stitches used were self-couching (for underlay) and straight stitches (for overlay). For illustration purposes, figure 10 shows the object before and after conservation-restoration intervention.

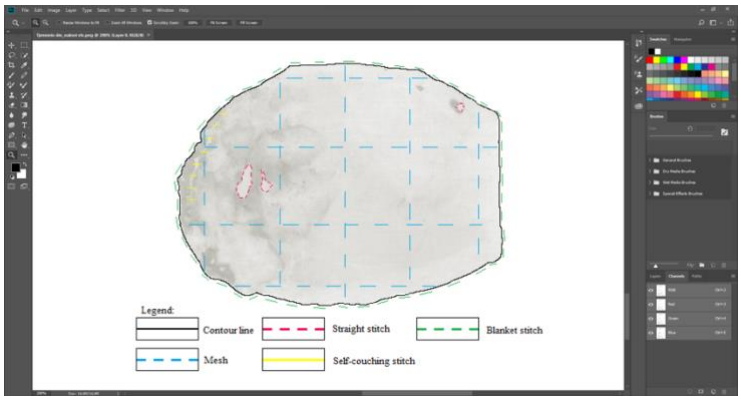

Figure 9: Graphic representation of the consolidation of mechanical damages located on the crown (pattern number 1) utilizing hand-sewn underlay (silk) and overlay (tulle) support fabrics, created using Photoshop photo editing and graphic design software.

Figure 10: Comparison of the object before and after a conservation-restoration treatment - photographed from above

2.4. Design and fabrication of mounts for the safe display, transport, and storage

Materials used in the construction of a mounting system include polyester batting (60 g/m2), polyester wool (*avos*), and white synthetic thread. Selected materials are non-toxic and do not interfere with the aesthetic appearance of the artifact. Pieces of polyester batting were manipulated into irregular oval shapes and hand-sewn together using a straight stitch. The lower part of a mount is bigger in size, and as such provides support for rows of bobbin lace, while the upper part is smaller in size in order to fit into the interior part of the hat (Fig. 11). Its shape is determined by the contour of the head. The archival storage box was made of unbuffered cardboard in dimensions that correspond to the base of the mounting system (Fig. 12). Careful handling is essential to preserve this delicate object and it must be kept to a minimum. Ideally, it should only be moved when placed inside the mounting system provided.

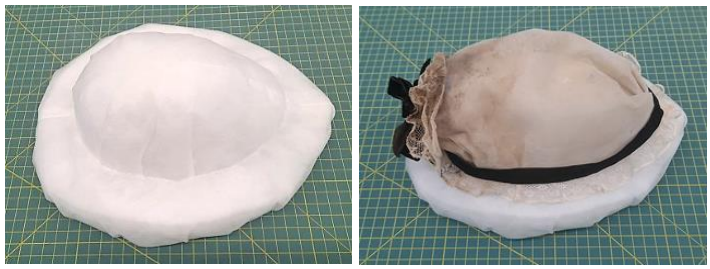

Figure 11: Mounting system to be used for storage and display; headgear placed onto the mounting system

Figure 12: Headgear fitted onto a mounting system and placed inside the archival storage box

3. Conclusion

The application of different documentation methods and digital technologies in the conservation-restoration process of headgear from the Baltazar Bogišić collection in Cavtat has enabled detailed and efficient documentation. Defining, mapping and assessing deterioration were done by digital documentation techniques. Using digital camera and digital microscope in combination with Adobe's Photoshop program and DinoCapture 2.0 software, a general view of the most common types of decay such as holes, tears in seams, different types of stains etc., was obtained. Digital photography and graphic documentation proved especially useful in providing a very detailed description of the materials, manufacturing techniques, information about the object's current physical state, as well as describing the conservation and restoration process. All the actions taken towards the long-term preservation of three-dimensional headgear were documented in the final report created as a digital document that enables easy storage, accessibility, sharing and usage. Documenting and transmitting cultural heritage to future generations is an important task and responsibility for experts involved in the field of textile conservation and restoration.

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COMPUTER DESIGN OF THE WORKPLACE IN THE TECHNOLOGICAL SEWING PROCESS USING THE ERGOPLAN PROGRAM

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Abstract: *In this paper, the computer design of the workplace was carried out using the ERGOPlan program, i.e. its modules ERGOMas and ERGOMan in the technological sewing process when performing the technological operation of fastening the seam on the sleeves, length and shoulder, which is performed on the universal sewing machine JUKI DDL-555-4. The ERGOMas module determines the sitting height, size and height of the work surface based on the worker's body height. The ERGOMan module was used to simulate the execution of a technological operation according to technological suboperations. From the presented dynamic and static simulation of technological operations at the workplace, it is evident that the work is performed in an ergonomically favorable working position, which results with lower workload and worker fatigue and leads to higher workplace productivity.*

Keywords: *technological sewing operation, computer design, ERGOPlan program.*

1. Introduction

In the technological processes of clothing production, the work is organized according to the number of technological operations depending on the type of garment, the application of the appropriate means of work and interphase transport. For this reason, in modern processes of garment production, great attention is paid to the organization of work with the aim of reducing the time of performing technological operations, achieving a higher degree of utilization of installed equipment and machines, ensuring a faster flow of workpieces in production, maintaining the required quality and reducing the workload and fatigue of workers [1].

The majority of the time, work in the technological sewing process is done while sitting. The worker uses the trunk and upper limbs to perform auxiliary and machine-hand technological suboperations while sewing, and the feet to achieve the required stitch speed. Due to the physical and mechanical properties of the product, careful handling is required, which requires very good motor skills that are expressed in the mobility of the fingers, hands, arms and feet and their coordinated action. The machine-hand suboperation of sewing and guiding the workpiece is conducted with a high degree of vision focus inside the center field of vision, which considerably loads the visual system and decreases the needed level of concentration for guiding the workpiece. In sewing processes, the dynamic work required often results in a forced posture of the body and head, unphysiological sitting, isometric loading of the lower limbs and considerable loading of the arms and legs [2, 3].

For effective work and high production, a harmonic interaction between the worker, the machine, and the environment is required, which is achieved through optimum workplace design based on ergonomic rules and the creation of favourable working conditions [4].

2. Computer method of work analysis ERGOPlan

With the advancement of sophisticated computer systems for virtual simulation of manufacturing processes, the entire flow of the manufacturing process may be observed. Such systems enable the analysis and suitable design or redesign of the workplace with the associated suitable work method for a particular technological operation, elaborated by a sequence of logically optimal motion sets with associated time norms, which are based on the system of predetermined normal times (MTM, WF, etc.). Computer-aided simulation of the functioning of production systems and workplaces facilitates the discovery and eradication of potentially ergonomically unfavourable workplaces and work methods early in the design process. The simulation identifies unfavourable work movements and postures that affect the psychophysical load and fatigue of workers and determines more suitable methods of performing the work. The basic features and possibilities of

such systems are demonstrated by the ERGOPlan computer system developed by Delta, which is used for work analysis and ergonomic design of workplaces in the field of clothing technology [5].

The ERGOPlan computer system enables a virtual simulation of the continuous flow of the entire production process with modules for:
- elaboration of the structure of the execution of technological operations,
- design of workplaces,
- ergonomic analysis of the workplace,
- runtime analysis,
- cost analysis and
- a virtual illustration of a specific workplace and the full production process.

ERGOPlan uses the integrated modules ERGOMas and ERGOMan for work analysis and workplace design. The ERGOMas module is used to analyze and design work in relation to the static characteristics of the workplace. The ERGOMas module analyzes the workplace in terms of the dimensions of the workplace's compliance with the worker's static and dynamic anthropometric measurements, as well as the required precision and visual concentration, as well as favorable zones of the field of vision and optimal reach of the hands. Furthermore, the laws of the sitting posture in terms of the favorable angles of the kinematic systems, the limit values of mass transfer via the hands in the sitting posture, and the maximum muscular load on the hands are calculated.

ERGOMan is a module for simulating the human kinematic system, where there are two 3D computer-supported models called ANTHROPOS and ERGOMan. The models are based on the human skeleton, complete with joints and degrees of freedom of movement, allowing a wide range of basic movements to be performed. The positions of the individual parts of the skeleton with the corresponding angles of the kinematic systems are determined by basic movements. The simulation of the work is carried out by determining the individual sets of movements of the skeleton according to the order of execution of the technological operations (taking, moving, positioning, etc.). The simulation of the work is carried out by determining the individual sets of motions of the skeleton accordingg to the order of execution of the technological operations (taking, moving, positioning, etc.) [6, 7]. The static analysis of the workplace makes it possible to assess the stability of the sitting position, the appearance of the spine, the mobility of the upper extremities in relation to the field of vision, the zones of normal and maximum reach of the hands and the mobility of the lower extremities.

The simulation of the execution of technological sewing processes enables the analysis of body posture types using methods for observing the body posture (e.g. OWAS), the calculation of maximum forces and moments acting on individual joints and the determination of the temporal duration of a specific posture type with the corresponding set of basic movements (e.g. MTM analysis).

Work postures of workers during work are most often analyzed and evaluated using the OWAS method. The matrix of the OWAS method matrix includes four postures of the spine, three postures of the arms, seven postures of the legs, and three postures for mass transfer, but not the head posture. The degree of workload is described with four different colors (green - redesign of the workplace is not necessary, yellow - redesign of the workplace is needed in the foreseeable future, orange - redesign of the workplace is needed soon, red - redesign of the workplace is needed immediately).

Computer analysis determines unfavorable body movements and postures within the technological suboperation and their duration. Depending on the kind of motion, the arrangement of working parts, the size of the workpiece, and the length of the motion, some technical suboperations, such as a set of motions, can be achieved by combining different fundamental motions. By choosing computer solutions, more favorable working movements and body postures are achieved, as well as a more favorably designed workplace. By finding a suitable work method with the selection of optimal sets of motions, the time of performing technological operations is reduced with less workload and worker fatigue.

3. Experimental part

In the experimental part of the work, computer modeling of the workplace in the technological process of sewing during the technological operation of bar tacking the seam on the sleeves, length and shoulder was performed using the universal sewing machine JUKI DDL-555-4. The machine will be operated by a worker with a height of 174 cm.

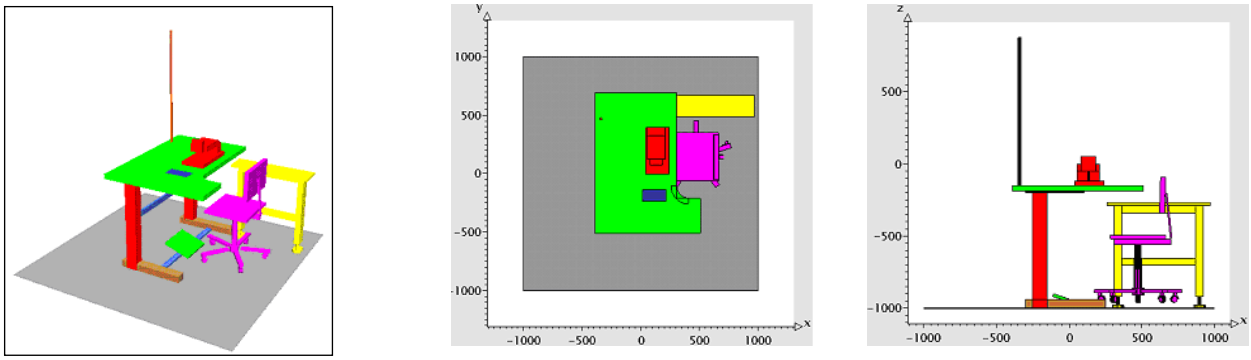
The computer-aided design of the workplace was carried out using the ERGOPlan program developed by Delta and its ERGOMas and ERGOMan modules, respectively. The ERGOMas module was used tdesign a

workplace, adjust the height of the work surface to the body height of the worker, determine the favorable zone of visual fields and optimal arm reach. ERGOMan was used to simulate the execution of technological sewing operations, while the OWAS method was used to determine the comfort of the working postures.

4. Results and discussion

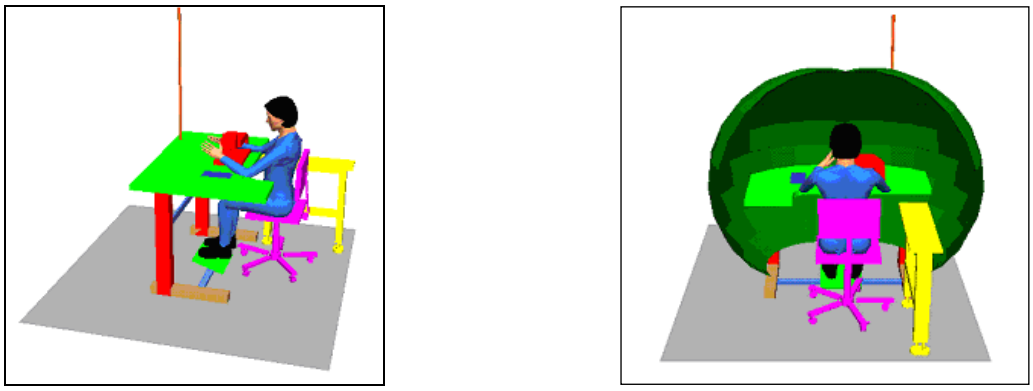
The ERGOMas computer method determined the height of the work seat to be 54 cm, which includes the height of the pedal (5 cm) and an allowance for light footwear (2 cm), and the height of the work surface to be 85 cm, based on the anthropometric measurements of the worker (height 174 cm) and the size of the workpiece (shirt length 55 cm). Due to the size of the workpiece, the work surface of the sewing machine needs to be increased from 1050 x 550 mm to 1250 x 850 mm on the left side. This is necessary for a comfortable sitting posture, and the viewing angle to the center of the working sewing zone is less than 40° when compared to the typical viewing angle from an eye distance of 400 to 450 mm. The movable stand on the right is used to lay off the workpiece.

Figure 1 shows a 3D (a), blueprint (b) and side view (c) of the designed workplace for the technological operation bartacking the seam on the sleeves, length and shoulder, obtained using the ERGOMas module.



a. b. c.

Figure 1: Designed workplace for the technological operation bartacking the seam on the sleeves, length and shoulder using the ERGOMas module: 3D view (a), blueprint (b) and side view(c).



a. b.

Figure 2: Designed workplace for the technological operation bartacking the seam on the sleeves, length and shoulder using the ERGOMas module: 3D view (a), blueprint (b) and side view(c).

Following the design of the workplace, a static analysis (initial working posture) was performed to determine if the height and size of the work surface, as well as the height of the seat, match to the worker's height. It has been discovered that the worker assumes a proper sitting posture, Fig. 2a, and that the location of the machine, tools, and workpieces at the workplace is within normal reach of the hands, Fig. 2b.

According to the designed optimal work method determined according to the MTM method, a sequence of logical movements was determined using the ERGOMan computer module, which simulates the execution of a technological operation. The execution of a technological operation according to technological suboperations is shown in Fig. 3. The technological suboperations of positioning together, positioning and machine-hand sewing are shown as one technological suboperation because they are performed in the same working

posture. An OWAS analysis of individual work postures is presented for each technological suboperation. The simulation of the execution of the technological operation shows that the worker works in a favorable working posture that does not lead to stress on the joint systems. Based on the computer design of the workplace, it can be seen that the height of the work surface and the height of the seat are adjusted to the height of the worker and that a favorable working method has been chosen that minimizes the workload and fatigue of the worker.

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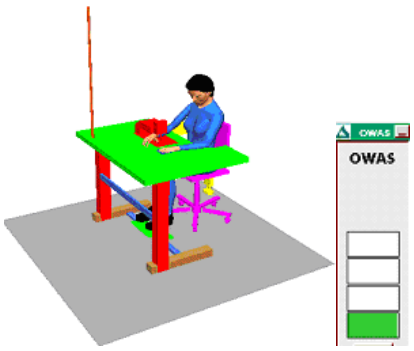
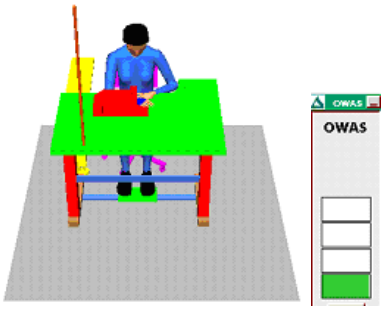
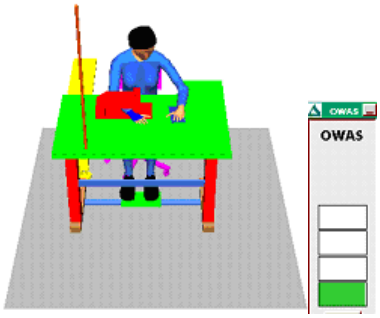
<tr><td>  </td><td>  </td><td>  </td></tr>
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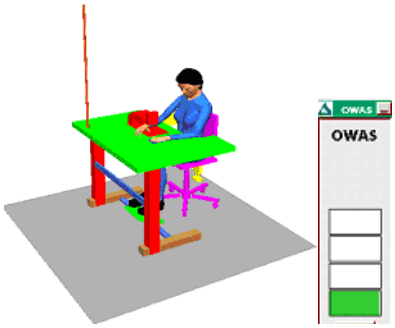
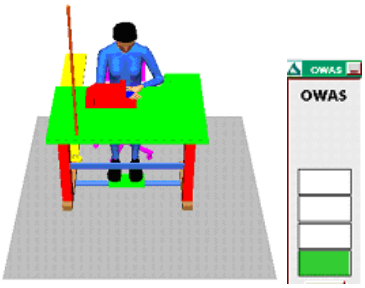
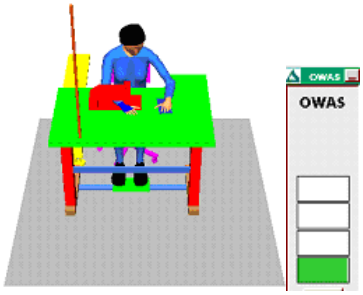
<tr><td>  </td><td>  </td><td>  </td></tr>
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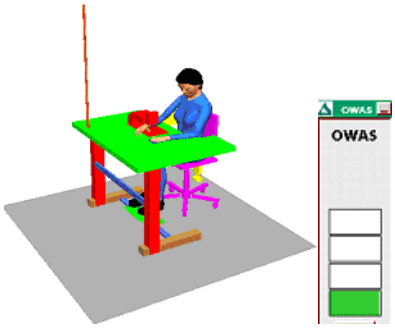
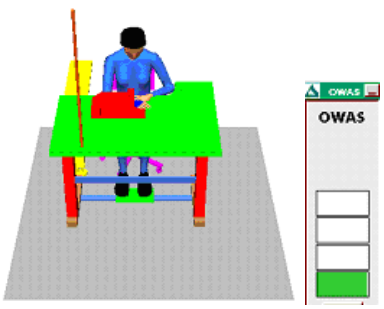
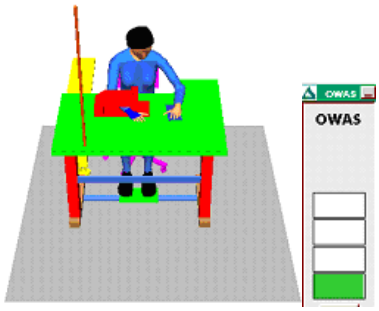
<tr><td>  </td><td>  </td><td>  </td></tr>
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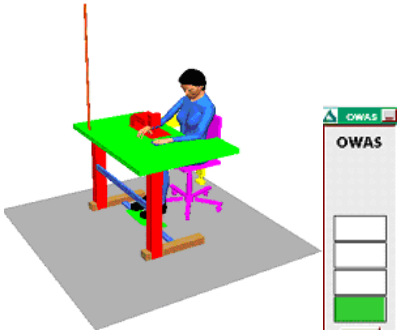
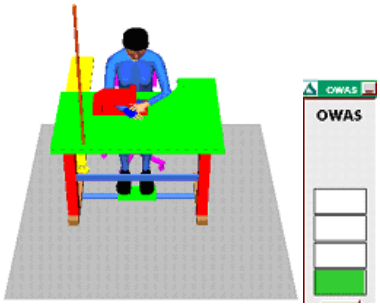
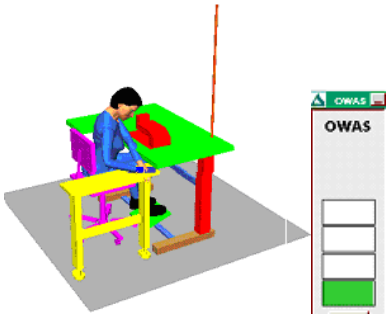
<tr><td>  </td><td>  </td><td>  </td></tr>
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Structure of the technological operation of bartacking the seam on the sleeves, length and shoulder a) taking one sleeve b) putting together, positioning and machine-hand sewing the sleeve c) laying off the sleeve on the work space d) taking the right sleeve e) putting together, positioning and machine-hand sewing the sleeve f) laying off the sleeve on the work surface g) taking the T-shirt h) putting together, positioning and machine-hand sewing the length i) laying off the T-shirt on the work surface j) taking the shoulder seam k) putting together, positioning and machine-hand sewing the shoulder seam l) laying off the workpiece on the movable stand

Figure 3: Dynamic analysis using the ERGOPlan program

5. Conclusion

When completing a technological operation of bartacking the seams on the sleeves, length, and shoulders, the ERGOPlan computer software and its ERGOMas and ERGOMan modules were used to design the workplace. The workplace was designed using the ERGomas module in accordance with the worker's anthropometric measurements, the height of the work surface, the height of the seat, the zones of normal reach of the hands, the viewing angles that allow suitable angles of the joint systems, and the position of the spine. A simulation of the execution of a technological operation was carried out using the ERGOMan module, and it was discovered that a favourable working method was chosen, in which the worker works in a comfortable working sitting posture with optimal horizontal and vertical viewing angles, and the working motions are carried out within the normal work reach (type III motions). The balance of the torso when sitting is achieved by both feet and the backrest.

As early as in the production system design phase, the ERGOPlan computer program may be used to redesign existing workplaces or create new ones. The design process is based on the worker's anthropometric measurements and the established harmonious human-machine interaction, as well as optimal work practices, which will result in increased workplace productivity and a reduced level of workload and worker fatigue.

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RAČUNALNO OBLIKOVANJE RADNOG MJESTA U TEHNOLOŠKOM PROCESU ŠIVANJA PRIMJENOM PROGRAMA ERGOPLAN

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Sažetak: *U radu je izvedeno računalno oblikovanje radnog mjesta primjenom programa ERGOPlan odnosno njegovim modulima ERGOMas i ERGOMan u tehnološkom procesu šivanja kod izvođenja tehnološke operacije učvršćivanja šava na rukavima, duljini i ramenici koja se izvodi na univerzalnom šivaćem stroju tt. JUKI oznake DDL-555-4. ERGOMas modulom utvrđena je visina sjedenja, veličina i visina radne površine na temelju tjelesne visine radnika. ERGOMan modul korišten je za simulaciju izvođenja tehnološke operacije prema tehnološkim zahvatima. Iz prikazane dinamičke i statičke simulacije izvođenja tehnološke operacije na radnom mjestu vidljivo je da se rad izvodi u ergonomski povoljnom radnom položaju što rezultira manjim radnim opterećenjem i zamorom radnika te dovodi do veće proizvodnosti radnog mjesta.*

Ključne riječi: *tehnološka operacija šivanja, računalno oblikovanje, program ERGOPlan*

1. Uvod

U tehnološkim procesima proizvodnje odjeće rad je organiziran prema broju tehnoloških operacija ovisno o vrsti odjevnog predmeta, primjeni odgovarajućeg sredstva rada i međufaznog transporta. Zbog toga se u suvremenim procesima proizvodnje odjeće velika pažnja poklanja organizaciji rada s ciljem smanjenja vremena izvođenja tehnoloških operacija, višeg stupnja korištenja instalirane opreme i strojeva, bržeg protoka materijala izradaka u proizvodnji, održavanju potrebne kvalitete te smanjenju opterećenja i zamora radnika [1].

Rad se u tehnološkom procesu šivanja izvodi najčešće u sjedećem položaju, pri čemu radnik tijekom šivanja koristi trup i gornje udove za izvođenje strojno-ručnih i pomoćnih tehnoloških zahvata, a stopala za postizanje potrebne ubodne brzine šivanja u strojno-ručnim zahvatima šivanja. Zbog fizikalno-mehaničkih karakteristika izratka potrebno je pažljivo rukovanje što zahtjeva izrazito dobre motoričke sposobnosti koje se očituju u pokretljivosti prstiju, šake, ruku i stopala te njihovog usklađenog djelovanja. Strojno-ručni zahvat šivanja i vođenje izratka izvodi se u okviru središnjeg vidnog polja s visokim stupnjem usredotočenosti vida, što znatno opterećuje vidni sustav i smanjuje potreban stupanj koncentracije za vođenje izratka. U tehnološkim procesima šivanja, zbog potrebe dinamičkog rada često dolazi do uvjetno prisilnog položaja tijela i glave, pojave nefiziološkog sjedenja, izometričnog opterećenja donjih udova i znatnog opterećenja ruku i nogu [2, 3].

Za uspješan rad i postizanje visoke proizvodnosti potrebno je ostvariti sklad međusobnog odnosa radnik-stroj-okolina što se postiže optimalnim oblikovanjem radnog mjesta na temelju ergonomskih zakonitosti te razradom povoljne radne metode [4].

2. Računalna metoda analize rada ERGOPlan

Razvojem suvremenih računalnih sustava za virtualnu simulaciju rada proizvodnih procesa, može se sagledati cjeloviti tok proizvodnog procesa. Takvi sustavi omogućuju analizu i pogodno oblikovanje ili preoblikovanje radnog mjesta s pripadajućom pogodnom metodom rada za pojedinu tehnološku operaciju, razrađeni slijedom logičkih optimalnih sklopova pokreta s pripadajućim vremenskim normativima, koji se temelje na sustavu unaprijed određenih normalnih vremena (MTM, WF i dr.). Računalnom simulacijom rada proizvodnih sustava i radnih mjesta osigurava se, već u fazi projektiranja, otkrivanje i uklanjanje mogućih ergonomski nepovoljno oblikovanih radnih mjesta i metoda rada. Simulacijom se prepoznaju nepovoljni radni pokreti i položaji tijela koji utječu na psihofizičko opterećenje i zamor radnika te određuju pogodnije metode izvođenja rada. Osnovne značajke i mogućnosti takvih sustava prikazani su računalnim sustavom ERGOPlan, tt. Delta, koji se koristi za analizu rada i ergonomsko oblikovanje radnih mjesta u području odjevnog inženjerstva [5].

Računalni sustav ERGOPlan omogućava virtualnu simulaciju kontinuiranog toka cjelovitog proizvodnog procesa korištenjem modula za:
- razradu strukture izvođenja tehnoloških operacija,
- oblikovanje radnih mjesta,
- ergonomsku analizu radnog mjesta,

- analizu vremena izvođenja,
- analizu troškova te
- virtualni prikaz pojedinog radnog mjesta i cijelog proizvodnog procesa.

ERGOPlan koristi integrirane module ERGOMas i ERGOMan za analizu rada i oblikovanje radnih mjesta. ERGOMas modul primjenjuje se za analizu i oblikovanje rada u odnosu na statičke značajke radnog mjesta. ERGOMas modul analizira radno mjesto s obzirom na usklađenost dimenzija radnog mjesta sa statičkim i dinamičkim antropometrijskim izmjerama radnika, određuje potrebnu preciznost i vidnu koncentraciju, te povoljne zone vidnog polja i optimalnog dosega ruku. Pored toga određuje zakonitosti sjedećeg položaja s obzirom na povoljne kuteve kinematičkih sustava, granične vrijednosti prijenosa mase rukama u sjedećem položaju te vrijednosti maksimalnog mišićnog opterećenja ruku.

ERGOMan je modul za simulaciju kinematičkog sustava čovjeka, gdje postoje dva 3D računalno podržana modela pod nazivom ANTHROPOS i ERGOMan. Modeli su izvedeni temeljem ljudskog kostura, s pripadajućim zglobovima i stupnjevima slobode kretanja, čime je omogućeno izvođenje velikog broja osnovnih pokreta. Položaji pojedinih dijelova kostura s pripadajućim kutevima kinematičkih sustava određeni su osnovnim pokretima. Određivanjem pojedinih sklopova pokreta kostura, prema redosljedu izvođenja tehnoloških operacija (uzimanje, premještanje, postavljanje i sl.) postiže se simulacija rada. Ergonomska analiza temelji se na tehničkoj i tehnološkoj opremljenosti projektiranog radnog mjesta, tjelesnim mjerama radnice u sjedećem položaju (koja radi ili koja će raditi) i metodi izvođenja tehnološke operacije [6, 7]. Statička analiza radnog mjesta omogućuje procjenu stabilnosti sjedećeg položaja, izgled kralježnice, pokretljivost gornjih ekstremiteta s obzirom na vidno polje, zone normalnog i maksimalnog dosega ruku, te pokretljivost donjih ekstremiteta.

Simulacija izvođenja tehnoloških operacija šivanja omogućava analizu tipova položaja tijela pomoću metoda za promatranje položaja tijela (npr. OWAS), izračun maksimalnih sila i momenata koji djeluju na pojedine zglobove te određivanje vremenskog trajanja pojedinog tipa položaja s pripadajućim sklopom osnovnih pokreta (npr. MTM analiza).

Radni položaji radnika tijekom rada najčešće se analiziraju i ocjenjuju OWAS metodom. Matrica OWAS metode sadrži četiri položaja kralježnice, tri položaja ruku, sedam položaju nogu, tri položaja kod prijenosa mase, dok se položaj glave ne analizira. Stupanj radnog opterećenja opisan je s četiri različite boje (zelena – preoblikovanje radnog mjesta nije potrebno, žuta - preoblikovanje radnih mjesta potrebno u doglednom vremenu, narančasta - preoblikovanje radnih mjesta potrebno uskoro, crvena - preoblikovanje radnih mjesta potrebno je odmah).

Računalnom analizom određuju se nepovoljni pokreti i položaji tijela unutar tehnološkog zahvata te njihovo vremensko trajanje. Pojedini tehnološki zahvat, kao određeni sklop pokreta, moguće je izvesti kombinacijom različitih osnovnih pokreta, ovisno o vrsti pokreta, rasporedu radnih elemenata, veličini izratka i dužini pokreta. Odabirom računalnih rješenja postižu se povoljniji radni pokreti i položaji tijela te povoljnije oblikovano radno mjesto. Iznalaženjem pogodne metode rada s odabirom optimalnih sklopova pokreta smanjuje se vrijeme izvođenja tehnoloških operacija uz manje opterećenje i zamor radnika.

3. Eksperimentalni dio

U eksperimentalnom dijelu rada izvedeno je računalno oblikovanje radnog mjesta u tehnološkom procesu šivanja kod izvođenja tehnološke operacije začvršćivanja šava na rukavima, duljini i ramenici koja se izvodi na univerzalnom šivaćem stroju tt. JUKI oznake DDL-555-4. Na radnom mjestu radit će radnica tjelesne visine 174 cm.

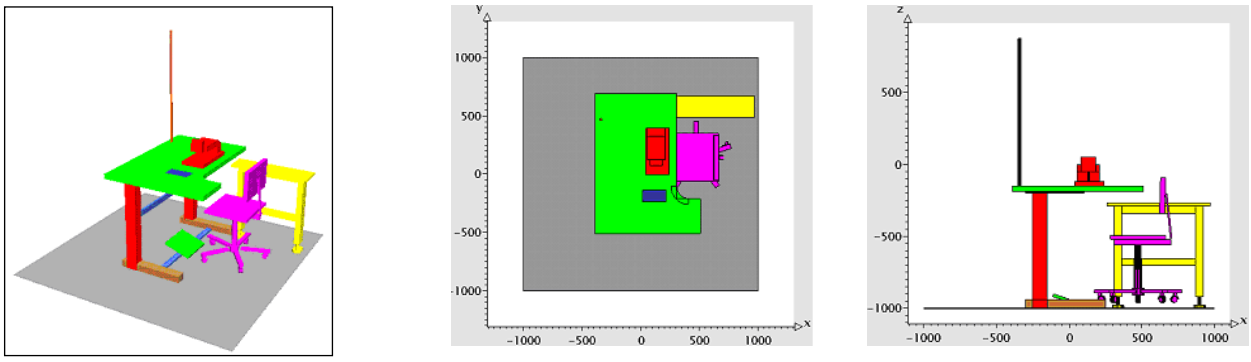
Računalno oblikovanje radnog mjesta izvedeno je korištenjem programa ERGOPlan tt. Delta odnosno njegovim modulima ERGOMas i ERGOMan. ERGOMas modul primijenjen je za izradu radnog mjesta, usklađivanje visine radne površine tjelesnoj visini radnice, određivanje povoljne zone vidnih polja i optimalnog dosega ruku. ERGOMan je korišten za simulaciju izvođenja tehnološke operacije šivanja, dok je OWAS metodom utvrđena udobnost radnih položaja.

4. Rezultati i rasprava

Prema antropometrijskom razmjeru radnice (tjelesna visina 174 cm) i veličine izratka (majica duljine 55 cm) računalnom metodom ERGOMas određena je visina radne sjedalice od 54 cm, koja uključuje visinu gazila (5 cm) i dodatak za laganu obuću (2 cm), a visina radne površine je 85 cm. Zbog veličine izratka radnu površinu stroja za šivanje potrebno je s lijeve strane povećati s dimenzije 1050 x 550 mm na 1250 x 850 mm. Time je

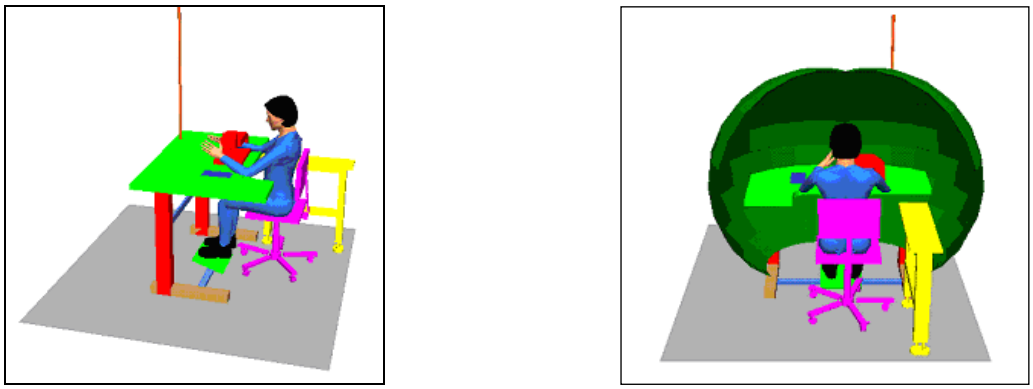
postignut preduvjet za ostvarivanje udobnog položaja pri sjedenju, a kut linija gledanja prema središnjoj radnoj zoni šivanja je manji od 40° s obzirom na standardnu liniju gledanja s udaljenosti očiju od 400 do 450 mm. Za odlaganje izratka koristi se pokretni stalak s desne strane.

Na sl.1 dan je 3D (a), tlocrtni (b) i bokocrtni (c) prikaz oblikovanog radnog mjesta za tehnološku operaciju začvršćivanja šava na rukavima, duljini i ramenici dobiven pomoću modula ERGOMas.



a. b. c.

Slika 1: Oblikovano radno mjesto za tehnološku operaciju začvršćivanja šava na rukavima, duljini i ramenici dobiven pomoću modula ERGOMas: 3D prikaz (a), tlocrtni prikaz (b) i bokocrtni prikaz(c).

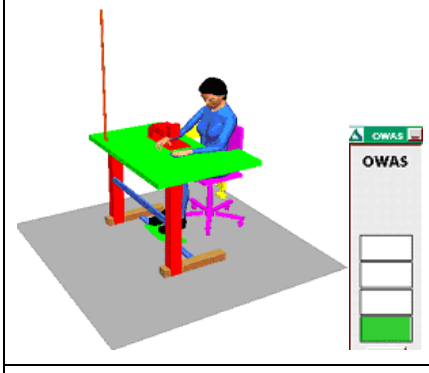
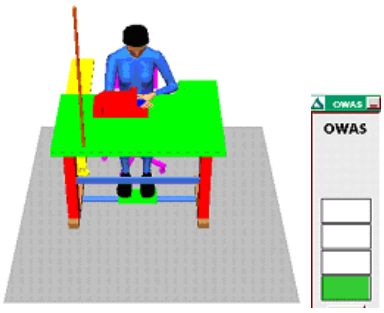
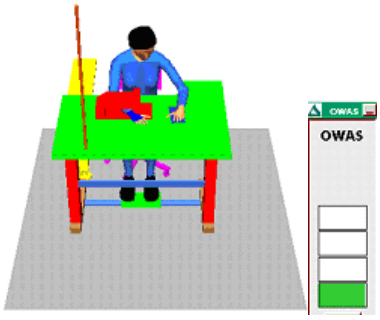


a. b.

Slika 2: Statička analiza radnog mjesta na oblikovanom radnom mjestu (a) te pripadajućim zonama normalnog i maksimalnog dosega ruku (b)

Nakon oblikovanja radnog mjesta izvedena je statička analiza (početni radni položaj) kojim je provjereno da li visina i veličina radne površine i visina sjedenja odgovaraju tjelesnoj visini radnice. Utvrđeno je da radnica zauzima pravilan sjedeći radni položaj, sl. 2a, te da se na radnom mjestu položaj stroja, alati i izratci nalaze u okviru zone normalnog dosega ruku, sl. 2b.

Prema projektiranoj optimalnoj metodi rada određenoj prema MTM metodi, određen je slijed logičkih pokreta pomoću računalnog modula ERGOMan kojim se simulira izvođenje tehnološke operacije. Izvođenje tehnološke operacije prema tehnološkim zahvatima prikazano je na sl. 3. Tehnološki zahvati međusobnog postavljanja, pozicioniranja i strojno-ručnog šivanja prikazani su kao jedan tehnološki zahvat jer se izvodi u istom radnom položaju. Za svaki tehnološki zahvat je prikazana OWAS analiza pojedinih radnih položaja. Simulacija izvođenja tehnološke operacije ukazuje da radnica radi u povoljnom radnom položaju koji ne dovodi do opterećenja zglobnih sustava. Na temelju provedenog računalnog oblikovanja radnog mjesta vidljivo je da je usklađena visina radne površine i visina sjedenja tjelesnoj visini radnice te je odbrana povoljna metoda rada kojom je postignuto minimalno radno opterećenje i zamor radnika.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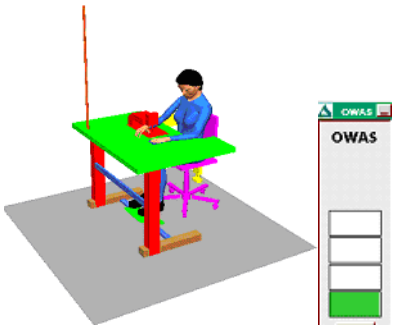	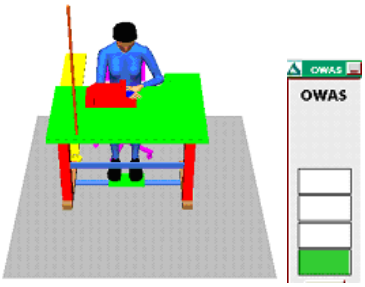	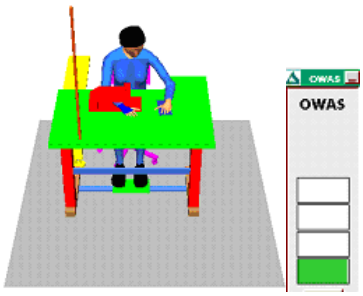
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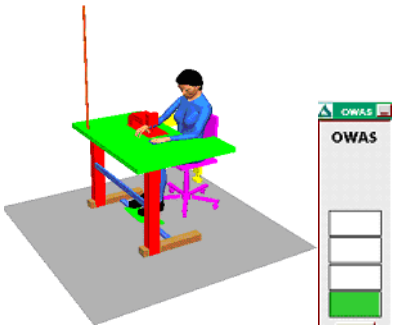	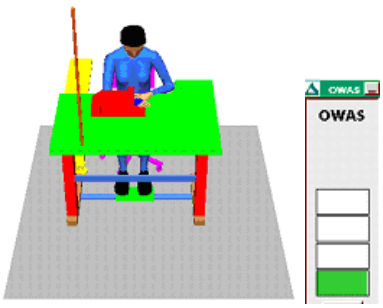	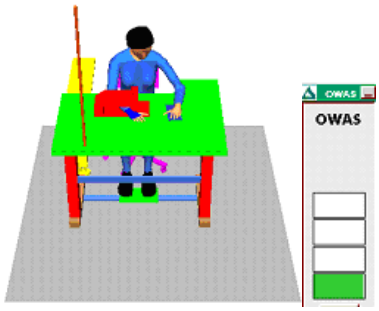
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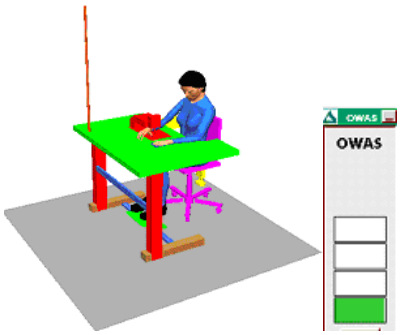	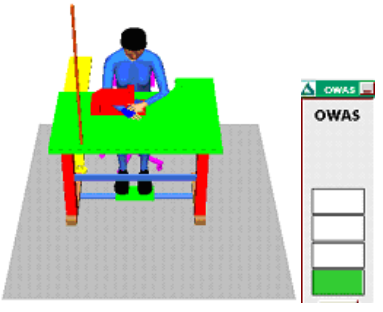	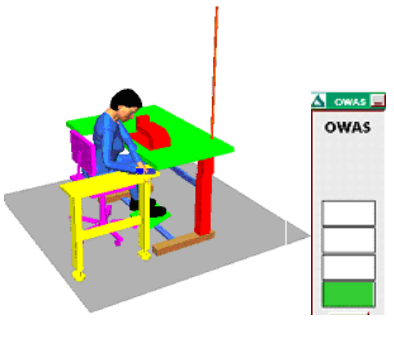
j.	k.	l.

Struktura tehnološke operacije začvršćivanje šava na rukavima, duljini i ramenici:

a. uzimanje lijevog rukava
b. međusobno postavljanje, pozicioniranje i strojno-ručno šivanje rukava
c. odlaganje rukava na radnu površinu
d. uzimanje desnog rukava
e. međusobno postavljanje, pozicioniranje i strojno-ručno šivanje rukava

f. odlaganje rukava na radnu površinu
g. uzimanje majice
h. međusobno postavljanje, pozicioniranje i strojno-ručno šivanje duljine
i. odlaganje majice na radnu površinu
j. uzimanje ramenog šava
k. međusobno postavljanje, pozicioniranje i strojno-ručno šivanje ramenog šava
l. odlaganje izratka na pokretni stalak

Slika 3: Dinamička analiza primjenom programa ERGOPlan

5. Zaključak

Primjenom računalnog programa ERGOPlan te njegovim modulima ERGOMas i ERGOMan oblikovano je radno mjesto kod izvođenja tehnološke operacije začvršćivanja šava na rukavima, duljini i ramenici. Primjenom ERGOMas modula oblikovano je radno mjesto u skladu s antropometrijskim razmjerom radnice, određena je visina radne površine, visina sjedenja, zone normalnog dosega ruku, vidni kutovi koji omogućuju pogodne kutove zglobnih sustava i položaja kralješnice. Modulom ERGOMan izvedena je simulacija izvođenja tehnološke operacije čime je utvrđeno da je odabrana povoljna metoda rada pri čemu radnica radi u udobnim radnim položajima sjedenja s optimalnim horizontalnim i vertikalnim vidnim kutovima, a radni pokreti se ostvaruju u okviru normalnog dosega (pokreti III vrste). Ravnotežno stanje trupa pri sjedenju se ostvaruje preko oba stopala i naslona za leđa.

Računalni program ERGOPlan može se koristiti za preoblikovanje postojećih radnih mjesta ili oblikovanje novih radnih mjesta već u fazi projektiranja proizvodnih sustava. Postupak projektiranja se temelji na antropometrijskom razmjeru radnice i postavljenom skladnom odnosu čovjek-stroj, te optimalnim metodama rada što će dovesti do povećanja proizvodnosti samog radnog mjesta i nižeg stupnja opterećenja i zamora radnika.

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ELECTRIC ENERGY FROM THE SOURCES INTEGRATED IN FOOTWEAR

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Abstract: *The paper presents the results obtained by researching the influence of walking speed and placed coils and permanent magnets at three positions in high boots. The measurements were carried out on a treadmill under controlled conditions in the Laboratory for Thermal Insulation Properties of Clothing, University of Zagreb, Faculty of Textile Technology. The experimentally obtained values indicate that the largest number of electric impulses is obtained from the inductive source at the position in the top of high boots (in the area of the upper leg), where is the greatest possibility of changing the magnetic flux when a permanent magnet passes near the coil in a shorter time than at the knee or foot position.*

Keywords: *electric energy; inductive sources; footwear; walking speed*

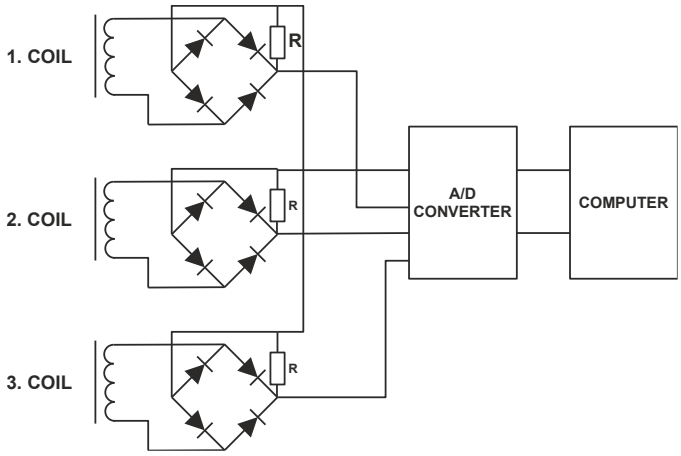
1. Introduction

Electrical devices that users carry with them every day require continuous power supply. The batteries of the devices need to be recharged, but a problem arises if there are no classic sources of electrical energy. Therefore, the idea arose to install the necessary electrical components in footwear as well as clothes. Even more, because even in the second half of the 20th century, simpler electrical and electronic components [1, 2] for different purposes (from communication devices to monitoring the wearer's location, state of health, physical activity) were more intensively incorporated into footwear. To make it easier for users to carry electronic devices, the goal is to make these devices as small and light as possible. Considering that the interest in the use of built-in components is increasing, it is strived to enable the wearer to continuously use the device, which will not interfere with its use in any way, be it through physical activity, performing the work the wearer is engaged in, or during rest. This problem is particularly pronounced among users "in the field", soldiers, foresters, or any user who does not have permanent access to the power grid, and therefore does not have the possibility of recharging the battery of portable devices [3]. To reduce this problem, efforts are being made to find new methods of charging portable electronic devices. The focus is on hitherto insufficiently used sources of energy, such as the kinetic energy generated when a person walks, or some other form of energy from the environment, without interfering with the normal functioning of a person in his environment and performing his duties. To achieve the collection of energy generated by a certain activity, it is necessary to design an energy storage tank, which will be constantly next to the person and available for use. Different bags and backpacks can be used for this purpose, but in recent times also footwear [4, 5, 6]. By installing various components in the soles [7], or in the case of high boots in boot tops, a new way of generating electrical energy by induction, sufficient to power portable devices used by the wearer, i.e. to power their batteries, can be realized.

2. Experimental part

In the experimental part, a measuring system was used for the purpose of measuring electrical quantities on the coils and determining the dependence of these quantities on the position of the coils and permanent magnets on the footwear, and the walking speed.

2.1. Test samples and measuring equipment



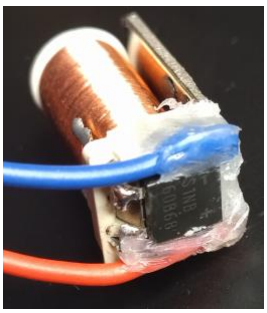
a.

b.

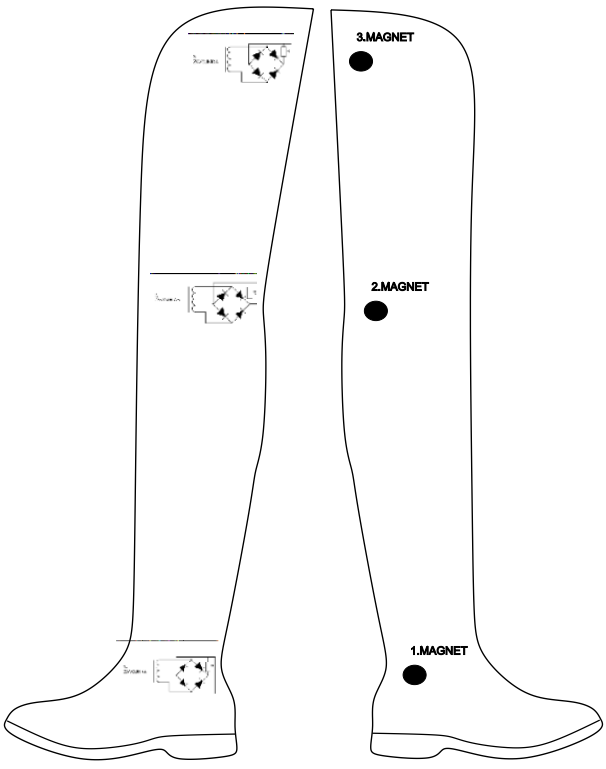
Figure 1: Measuring system: a) Schematic diagram of the measuring system connection, b) Treadmill

For the experimental part, the measuring system shown schematically in Figure 1a was used. The measuring system consists of: a treadmill, Figure 1b, a measuring computer with software maintenance and support, an A/D converter, Figure 2a, three full wave rectifiers, three coils with an iron core and three permanent magnets. Coils with an iron core and full wave rectifiers, Figure 2b, and permanent magnets are installed in the right and left boot, respectively, Figure 2c.

a.



b.



c.

Figure 2: Measuring system: a) AD Converter NI USB -6212 National Instruments; b) Coil with an iron core and connected full wave rectifier; c) Schematic diagram of permanent magnets and coils installed in the boots (right boot; 1st coil at ankle height, 2nd coil at knee height, 3rd coil above knee 3rd coil at upper leg height)

2.2. Method of conducting measurements

To determine the peak values of the induced voltage, 3 permanent magnets were installed in one boot, and 3 coils parallel to them (at magnet level) in the other boot. There is a full wave rectifier on each coil. The signal from each coil and rectifier is routed through an A/D converter to a computer for data recording and processing.

When a person walking or running on a treadmill (due to controlled conditions), that is, by changing the magnetic field of a permanent magnet by passing near the coil, an electric current is induced in the coil.

The peak values (amplitudes) of the induced voltage on each individual sample were determined with precise measuring equipment. The procedure was conducted so that the permanent magnets with their magnetic fields, while walking on the treadmill with different speed parameters, occasionally passed parallel to the coils, inducing an electric current.

3. Results and discussion

In this chapter, the results of measuring the induced voltage on each individual coil are graphically presented. Only a part of the numerical values is shown in the tables, because during each measurement, about 5,000 data were obtained for each position. The first measurement was made at a walking speed of 0.8 m/s, the second at 2.0 m/s, the third at a speed of 3.0 m/s, and the fourth at 4 m/s. For all four measurements the coils and magnets are placed in the same places in the boot, the only difference is the speed of walking on the treadmill. The difference in distance and path through the space between the foot, knee, and upper leg of the left and right leg during natural walking caused different results of induced voltage, Table 1 and Figure 3. Thus, the lowest voltage values were recorded at the foot, higher at the knee, and the highest at the upper leg, Table 2 and Figure 4.

Table 1: Average value of the peaks (measured voltage ≥ 1.2 V, measuring time 25 s).

	Position of coils and magnets		
walking speed (m/s)	foot	knee	upper leg
0.8	0	0	0
2	0.8126	1.1251	1.8339
3	1.9245	2.2826	2.6852
4	2.5456	2.9704	3.2923

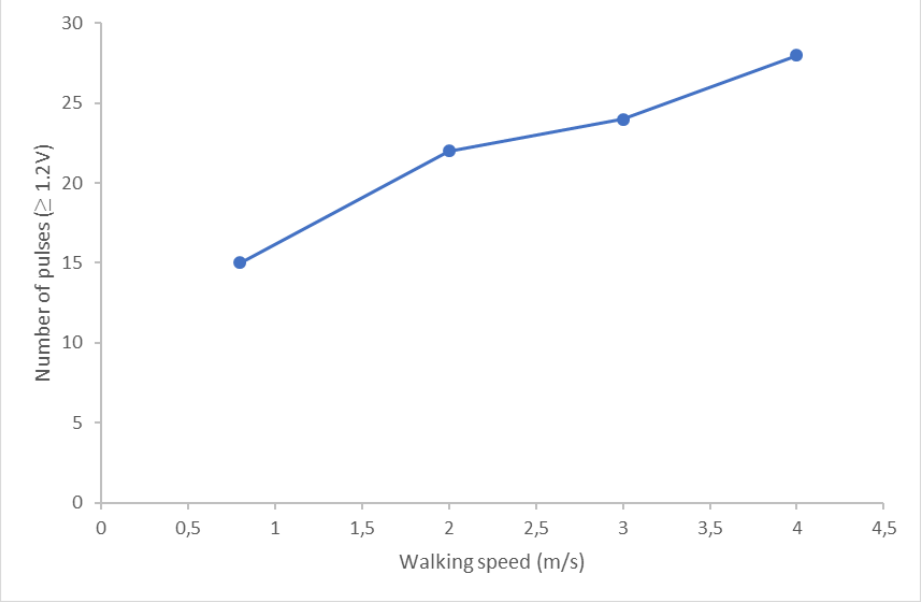


Figure 3: Diagram of the dependence of the number of pulses (voltage ≥ 1.2 V) on walking speed in the time of 25 s

Table 2: Number of pulses (voltage ≥ 1.2 V) for a measurement time of 25 s depending on the position of the coil and the permanent magnet

	Position of coils and magnets		
walking speed	foot	knee	upper leg
0.8	15	15	15
2	22	22	22
3	24	24	24
4	28	28	28

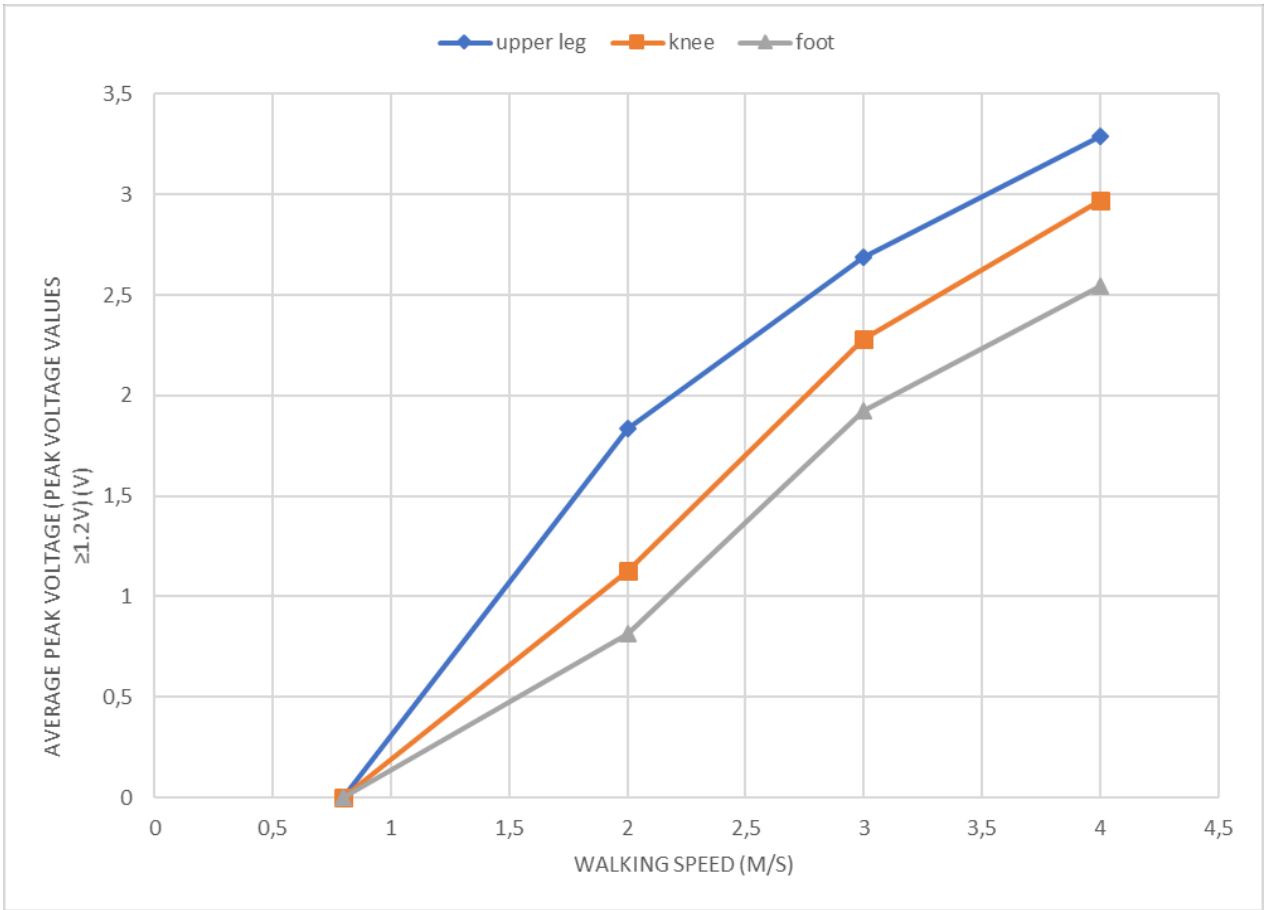


Figure 4: Diagram of the dependence of the number of pulses (voltage ≥ 1.2 V) during a measurement time of 25 s depending on the position of the coil and the permanent magnet

4. Conclusion

With the advancement of technology, acceptable possibilities of installing electrical components in footwear occure, because the components are smaller and smaller, and the ways of supplying them with electricity require reliable innovative autonomous solutions. As a result, the idea of applying the effect of electric current induction in coils moving in a magnetic field appeared. The idea is to use the movement of the legs to obtain electrical energy to charge the accumulator from which the devices installed in the footwear or in the clothes currently being worn would be powered.

The measurements were carried out under controlled conditions, in the laboratory on a treadmill, at different walking speeds. Analysis of the obtained data shows a dependence on the position of the permanent magnet and the coil on the leg, as well as the walking speed. It was observed that the lowest values were achieved with the coil and magnet placed above the foot, which is (probably) a consequence of the greater distance between the magnet and the coil during walking. As expected, higher values were obtained from coils placed near the knee and those above the knee. It is clear that a higher walking speed also contributes to higher values of the measured voltage.

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DETERMINATION OF THE WOVEN FABRICS POISSON'S RATIO BASED ON IMAGE ANALYSIS

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Abstract: *This paper presents a new method for measuring Poisson's ratio in uniaxial tensile tests, based on recording and analysis of a series of specimen images. Poisson's ratio changes over the fabric sample stretching due to the woven fabric's anisotropy and it results from the interaction between warp and weft and can be expressed in terms of structural and mechanical parameters of the system. The paper investigates the influence of the yarn count of fabric sample on the value of Poisson's ratio when the fabric is subjected to an axial load. For the purpose of testing, a regular dotted grid was drawn on fabric samples. Image analysis creates local maxima in the places where markers occur. Experimental testing was carried out on cotton woven fabrics in plain weave. Samples are stretched with tensile force in the weft and warp direction and based on different measured values of fabric stretching and lateral narrowing, Poisson's ratio in warp and weft direction is calculated. The obtained Poisson's coefficients are in accordance with literature data, which confirms the correctness of the developed method.*

Keywords: *woven fabric; Poisson's ratio; warp; weft; image analysis; digital camera.*

1. Introduction

Poisson's ratio is a fundamental mechanical property of materials that has been studied by many researchers. The mechanical properties of fabrics under tensile load began to be studied as early as 1937. [1]. Kilby [2] developed a simple grid model in the field of woven fabrics and analyzed the relationship between stress and deformation in-plane. He defined Poisson's ratio and measured the tensile properties of fabrics in an arbitrary direction of tensile force. The researchers determined the Poisson's ratio in the warp and weft direction based on the geometric model of the fabric and excluded the influence of the yarn Poisson's ratio. In this way, they concluded that the Poisson's coefficient in fabrics results from the interaction between the warp and the weft, and it can be expressed in terms of the structural and mechanical parameters of the system [3, 4]. Lloyd et al presented their proposals for measuring Poisson's ratio using the uniaxial tensile test method [5]. Due to the anisotropy of the fabric, the direction of tensile forces on the fabric has a great influence on the values of the Poisson's ratio [6]. Due to the inherent nature of textiles, accurate and reliable measurement of Poisson's ratio is demanding. Many researchers [7] investigated why measurement errors occur when measuring Poisson's ratio, when a uniaxial tensile load is applied to the fabric.

The values of the relative transverse deformation ε_p and the relative longitudinal deformation ε were measured in the uniaxial state of stress. The initial length of the sample is l_0 and the initial width is b_0. The final length of the fabric sample is l, and the final width is b. Poisson's ratio v was calculated using these values, expression (1):

$$\nu = \left|\frac{\varepsilon_p}{\varepsilon}\right| = \left|\frac{l_0}{b_0} \cdot \frac{b - b_0}{l - l_0}\right| \quad (1)$$

Based on the experimentally obtained values of Poisson's ratio of the woven fabric, it was determined that the uniaxial tensile method does not give reliable results due to defects in the geometry of the sample, and the biaxial test method should be applied [8]. Hursa et al. determined Poisson's ratio using the digital image correlation method [9].

The aim of this paper is to present a new method for determining the Poisson's ratio of fabrics in uniaxial tensile tests, which is based on image analysis.

2. Experimental part

In the experimental part of the paper, the elongations of the woven fabric samples and the belonging values of the tensile forces acting in the warp direction and in the weft direction were measured. The transverse (lateral) narrowing of the fabric was also read. Experiments are carried out under static load.

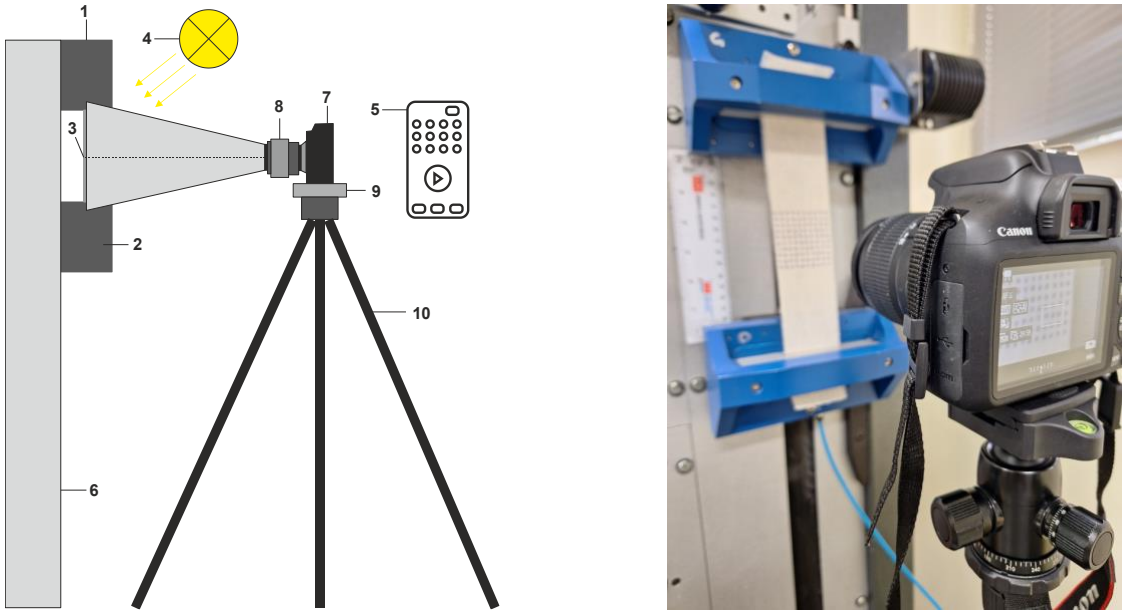
2.1. Test samples and measuring equipment

Tests were carried out on samples from two cotton fabrics in plain weave with constant warp densities and different weft densities, as shown in Table 1. The fabric samples with the above structural characteristics were woven on an air-jet loom OMNIplus 800 tt. Picanol in the textile industry Čateks d.d. Čakovec.

Table 1: Woven fabric samples for testing

Fabric tag	Fabric structure	Yarn count (tex)		Density (cm^{-1})		Fabric thickness d_0 (mm)	Weight (g/m^2)
		warp	weft	warp	weft		
T24	plain	30	30	24	24	0.48	149.94
T18	plain	30	30	24	18	0.47	147.75

For testing the breaking force and breaking elongation, for each fabric sample five measurements were performed on a tensile tester. The tensile properties of all samples were tested according to the ISO 13934-1:2013 standard using the test strip method. For testing, a tensile tester from the company Textechno was used, which registers data in the form of a diagram. Before testing, all samples were conditioned under standard atmospheric conditions (relative air humidity 65 ± 2%, temperature 20 ± 2°C). For this test, standard samples with dimensions of 300 x 50 mm were cut, clamped in the clamps of the tensile tester at a distance of l_0=200 mm, and exposed to a uniaxial tensile load at a pulling speed of 100 mm/min until breaking.



a. b.

Figure 1: Measuring system: a) schematic view: 1) upper clamp; 2) lower clamp; 3) fabric sample; 4) light source; 5) remote control; 6) testing machine; 7) camera; 8) macro lens; 9) slider; 10) tripod, b) photo

The measuring system, Figure 1, consists of a Textechno testing machine, Canon EOS 5D Mark IV full-frame DSLR camera with Canon MP-E 65mm f/2.8 1-5X macro lens. The camera is mounted on a tripod, and the illuminator provides constant lighting. Measuring local deformations is made possible using a macro lens. The camera has a 30.4-megapixel CMOS image sensor with pixels size 5.36 µm, and the size of the recorded images is 6720 x 4480 pixels. The camera records a series of images, and the series of captured images is saved on the memory card. Images are saved as RAW data to avoid distortion caused by JPEG compression. In order to monitor the deformation of the sample, a regular grid of dots is printed on the surface of the woven fabric using screen printing. The recording of a series of images is started before the beginning of the tensile test in order to synchronize the deformation measurement by the camera and the data from the tensile tester.

2.2. Image processing and analysis

A series of images taken during the measurement process is subjected to pre-processing and analysis. The individual steps of image preprocessing and analysis, which lead to finding a square dot grid is shown in Fig. 2.

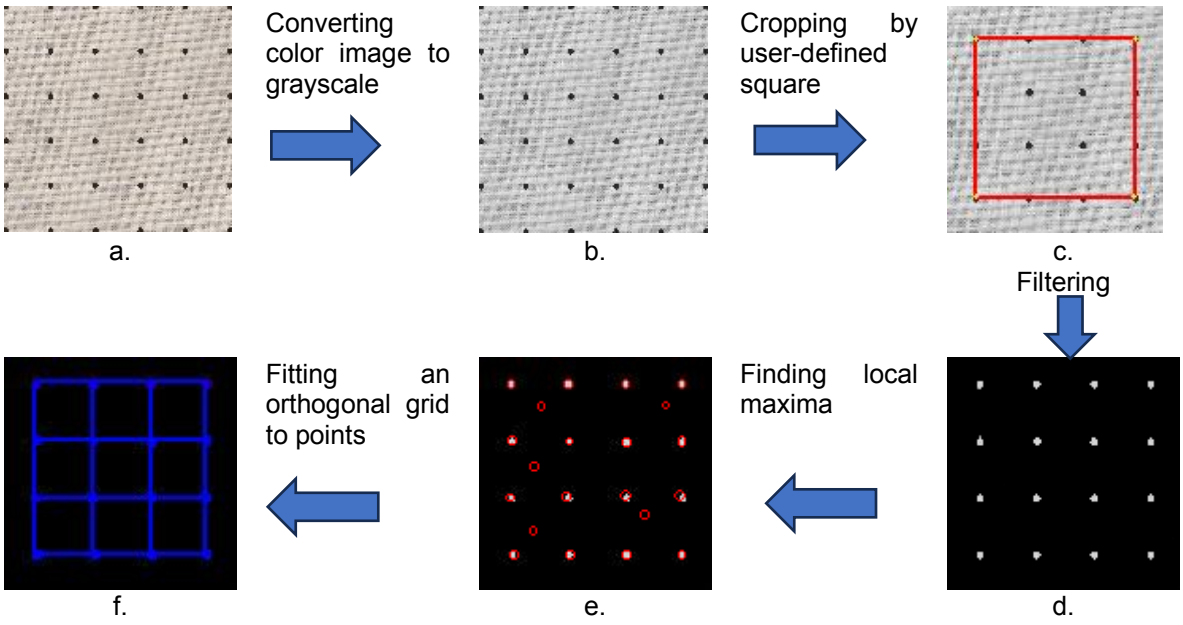


Figure 2: Stages of image processing and analysis and the resulting images: a) input image; b) grayscale image; c) image cropped; d) filtered image, e) local maxima on filtered image, f) best fitted to the regular grid in the first image.

Image analysis involves dot position operations on the woven fabric sample surface. The first stage is to determine the displacement in millimeters of the regular grid dots between the first (1) and last (n) images in the sequence according to the expression (1a) and (1b):

$$\mathrm{dx}(\mathrm{k},\mathrm{l},\mathrm{n}) = \mathrm{x}(\mathrm{k},\mathrm{l},\mathrm{n}) - \mathrm{x}(\mathrm{k},\mathrm{l},1) \quad (1a)$$

$$\mathrm{dy}(\mathrm{k},\mathrm{l},\mathrm{n}) = \mathrm{y}(\mathrm{k},\mathrm{l},\mathrm{n}) - \mathrm{y}(\mathrm{k},\mathrm{l},1) \quad (1b)$$

where:
dx – dot displacement (k, l) by x coordinate
dy - dot displacement (k, l) by y coordinate
k, l – the number of the column and row in the regular grid to which the given dot belongs.

The next stage of the analysis of the measurement data is to determine the local deformation at the grid dot (k, l), defined as the difference in the displacement of the dots located in the grid at positions that differ by m columns or rows:

$$\Delta\mathrm{x}(\mathrm{k},\mathrm{l},\mathrm{n}) = \mathrm{dx}(\mathrm{k}+\mathrm{m},\mathrm{l},\mathrm{n}) - \mathrm{dx}(\mathrm{k}-\mathrm{m},\mathrm{l},\mathrm{n}) \quad (2a)$$

$$\Delta\mathrm{y}(\mathrm{k},\mathrm{l},\mathrm{n}) = \mathrm{dy}(\mathrm{k},\mathrm{l}+\mathrm{m},\mathrm{n}) - \mathrm{dy}(\mathrm{k},\mathrm{l}-\mathrm{m},\mathrm{n}) \quad (2b)$$

According to expression (2a) and (2b), it is not possible to determine the deformation of the edge areas of the defined rectangle because it cannot be determined for dots less than m columns or rows from the edge. The values of the obtained deformations are expressed in millimeters and depend on the local base T value defined as the difference of x or y coordinates of points separated by 2m grid positions:

$$T_x(k,l) = x(k+m,l,1) - x(k-m,l,1) \quad (3a)$$

$$T_y(k,l) = \mathrm{y}(k,l+m,1) - \mathrm{y}(k,l-m,1) \quad (3b)$$

To make the deformation values independent of the measurement base, the local relative deformations expressed as dimensionless quantities (usually given in %) are defined as follows:

$$\varepsilon_x(k,l,\,n) = \frac{\Delta x(k,l,n)}{T_x(k,l)} \quad (4a)$$

$$\varepsilon_y(k,l,\,n) = \frac{\Delta \mathrm{y}(k,l,n)}{T_y(k,l)} \quad (4b)$$

On the basis of local deformations, the mean values of the deformations are determined for each image recorded in the measurement process $\overline{\varepsilon_x}\,(\mathrm{n})$ i $\overline{\varepsilon_y}\,(n)$ on the entire surface of the woven fabric sample. Using

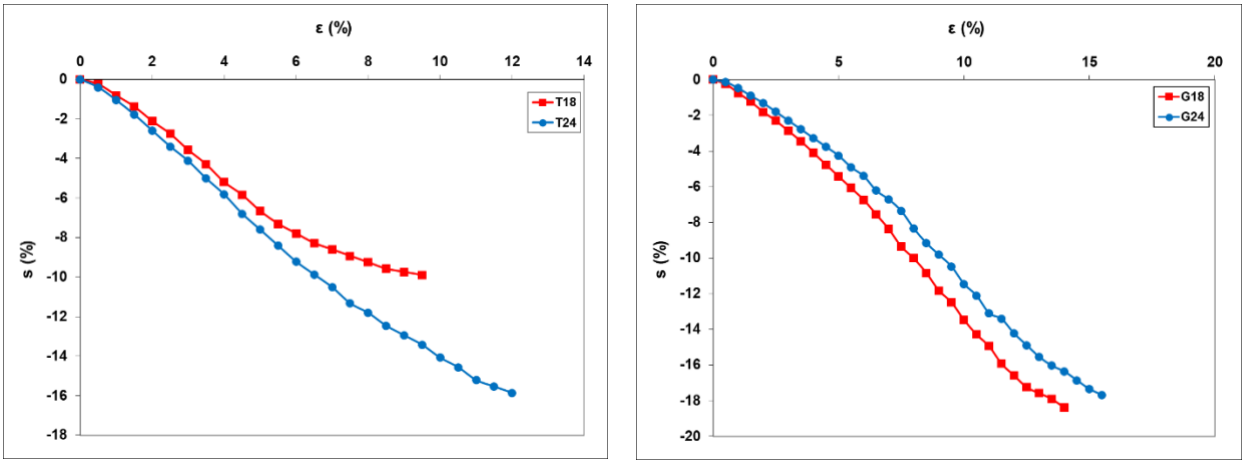
the results of deformation measurements, it is possible to determine the average value of Poisson's coefficient in the examined area of the woven fabric:

$$\overline{\nu}\,(\mathrm{n}) = \left|\frac{\overline{\varepsilon}_x(n)}{\overline{\varepsilon}_y(n)}\right| \tag{5}$$

The resulting value of Poisson's ratio is a function of n. It characterizes the state of the material at the moment the image is taken. Additionally, in measurements recorded near a fixed clamp, sample slip from the jaw can be analyzed by measuring the average value of the increase in the y coordinate of the bottom row of dots.

3. Test results and discussion

The diagram in Figure 3a shows the characteristic curves of the continuous change of the relative contraction s (%) of the fabric sample in relation to its relative elongation ε (%) when the force acts in the weft direction. Figure 3b shows the characteristic curves of the relative transverse contraction of the fabric sample in relation to its relative elongation when the force acts in the warp direction.



a. b.

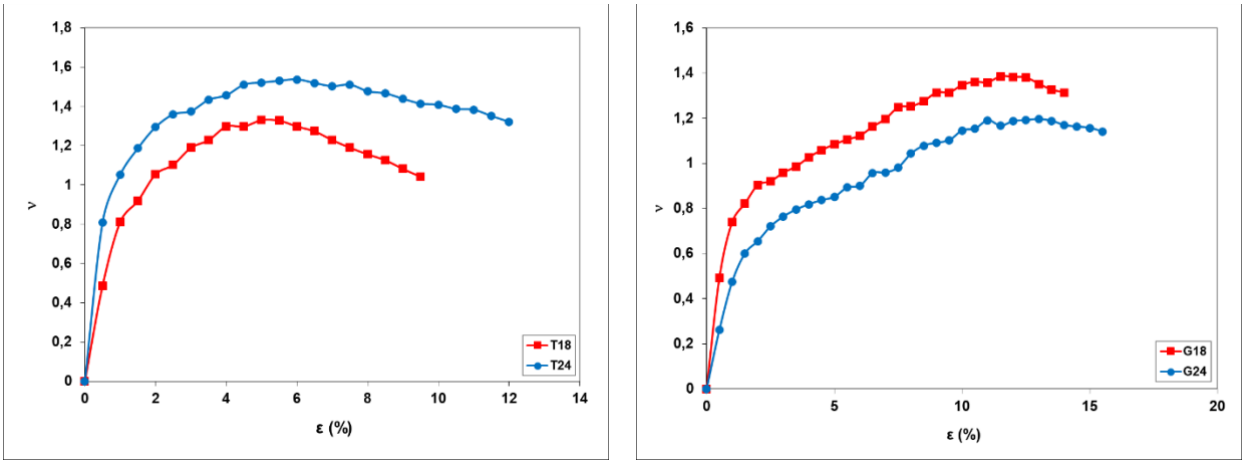
Figure 3: Diagram of relative contraction of fabric s (%) when force acts: a) in weft direction, b) in warp direction

When the force acts in the weft direction, depending on the weft density, a different number of yarns are in the clamp of the tensile tester. Increasing the weft density increases the number of yarns that enter the clamps of the tensile tester. This means that the number of pressure points on the warp yarns has increased, and this pressure is becoming more expressive. It is therefore expected that, when the force acts in the weft direction, for the same relative elongation ε, the fabric with the highest weft density has the highest relative contraction due to the highest warp tension during weaving, and the fabric with the lowest weft density has the lowest relative contraction due to the lowest warp tension weaving, Figure 3a. From the origin to the value of elongation ε=4% and to the value of relative contraction of the woven fabric s=-6%, Figure 3a, is a linear relationship between elongation and relative contraction.

When the force acts in the warp direction, given that the density of the warp is constant for all samples, i.e. the number of yarns that are in the grip of the clamps of the tensile tester is constant, which means that the total number of connection points in the sample grows and is the highest at the highest weft density, thus the woven fabric has the least empty space, and therefore the relative narrowing is the lowest. For the fabric with the lowest weft density (T18), the relative narrowing is the largest at each stretch value, Figure 3b. From the origin to the value of elongation ε=5% and to the value of relative contraction of the fabric s=-5.8%, Figure 3b, is a linear relationship between elongation and relative contraction.

From the diagrams in Figure 3a and Figure 3b, it is evident that at the beginning of elongation, the contraction of the woven fabric is very small. After that, with the increase in elongation, the fabric contraction values increase sharply. Using the values of relative contraction s and relative elongation ε, which are shown in the diagram in Figure 3a and 3b, the values of the fabric Poisson's coefficient v are calculated using expression (5).

The curves of the change in the value of Poisson's coefficient v depending on the relative elongation of the woven fabric are shown in Figure 4a when the force acts in the weft direction, and in Figure 4b when the force acts in the warp direction.



a. b.

Figure 4. Poisson's ratio of the fabric v when the force acts: a) in weft direction, b) in warp direction

The Poisson ratio curve consists of two zones. The first zone covers the area from the beginning to the highest peak of the curve. When the force acts in the weft direction, the highest value of Poisson's ratio is when the relative elongation of the fabric is between 5 and 6%, Figure 4a. When the force acts in the warp direction, the highest value of Poisson's ratio when the relative elongation of the woven fabric is about 12% Figure 4b. The second zone is from the highest peak of the curve to the end of the elongation limit, i.e. to the break.

An increase in the weft density causes an increase in the maximum value of the fabric Poisson's ratio when the force acts in the weft direction, Figure 4a. When the force acts in the warp direction, the value of Poisson's ratio of the woven fabric decreases with increasing weft density, Figure 4b.

4. Conclusion

The anisotropy of the woven fabric and the change in the density of the woven fabric have a great influence on the values of Poisson's ratio of the fabric. Before testing, a dotted grid was drawn on the fabric samples. Poisson's coefficient was determined by image analysis based on the recording and analysis of a series of sample images. The obtained Poisson's coefficients are in accordance with literature data, which confirms the correctness of the developed method.

By elongation the woven fabric in the direction in which the yarn density changes (in our case the weft direction), woven fabrics with a higher weft yarn density have higher values of Poisson's ratio.

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REVIVAL OF SERICULTURE IN SLOVENIA

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Abstract: *Despite the extraordinary development of synthetic fibres, silk is still the most valued textile fibre, representing luxury through softness, pleasant lustre, beautiful colours, high strength, and durability. Slovenia has favourable natural conditions for growing white mulberry Morus alba* L*. tree, the leaves of which are fed to the silkworm Bombyx mori* L*. On the territory of today's Slovenia sericulture was an important economic activity, which began already in 16th century. It included rearing and breeding of silkworms, reeling of cocoons and production of silk yarns and fabrics. The spread of sericulture started in Goriška, where it was implemented also until the middle of the twentieth century. Unfortunately, the knowledge was only preserved in written sources, but the experiences of our ancestors were entirely lost. A sericulture and silk industry in Slovenia in the past as derived from original professional and scientific literature is briefly presented. In the year 2018 an Institute of sericulture entilted "Inštitut za svilogojstvo in svilarstvo RLB« was established in Maribor by dr. Rebeka Lucijana Berčič. It is the only institution in Slovenia that offers professional help to silk rearers, who already practise sericulture by a large number of individuals and families from Koper to Goričko as the locally grown silk according to the guidelines of organic mulberry cultivation easily meets the criteria of a sustainable and environmentally friendly textile material. Today, it is used in a form of filament yarn for Idrija lace or for hand woven fabrics, and in a form of silk nonwovens for interior textiles. Silk mats are directly made by 2D spinning of silkworms. The process of silkworm flat spinning is shown in a digital material (video film) on the ISS_RLB website and is accessible via QR code. The process and the structure of the silk nonwoven material is described.*

Keywords: mulberry silk, raw silk; silk mat; flat spinning; decoration; digital media

1. Introduction

Today more than ever, humanity is faced with the question how to achieve prosperity for all without overtaxing the planet's natural resources [1]. The concepts of Industry 4.0 and Industry 5.0 focus on sustainable development with better resource management, reducing waste and minimising the impact of industrial processes on the environment. Industry 5.0 emphasises human well-being and job satisfaction [2]. In line with these strategies, the revival of sericulture in Slovenia took place.

Sericulture is a branch of agricultural activity encompassing rearing of silkworms and production of silk cocoons. Silk is the most valuable natural fibre and an environmentally friendly material. According to the United Nations International sericulture commission [3], global silk production in 2022 is estimated at 91,221 tonnes and accounts for only 0.2% of global textile fibre production, but its commercial value is much higher. It is a multi-billion dollar industry, with raw silk costing around twenty times as much as raw cotton [4].

China produces more than half of the world's silk, mainly fine mulberry silk used for clothing; India is the second largest silk producer in the world, with the most widespread production of wild silk; Italy is the largest silk importer in the world. The demand for silk will continue to increase due to the growing textile sector in developing countries, the increasing purchasing power of people and the user-friendly properties of silk [4].

In recent years global silk production declined [3] while prices of silk increased [4], mainly due to problems of sericulture in China, the largest producer of raw silk in the world [5]. The decline of production is mainly due to over intensified sericulture, concerning excessive use of artificial fertilizers and irrigation within cultivation of mulberry trees, abuse of antibiotics as growth promoters in the silkworm rearing, and the environmentally harmful transport of silk. The decrease of intensive Asian sericulture and silk textile industry as well as the question of the decent value of human labour contributed to the revival of this activity in Europe [6].

1.1. Sericulture in the territory of today's Slovenia in the past

In the territory of present-day Slovenia sericulture was already present from the 16th to the middle of the 20th century [7]. It was an important economic activity of our ancestors, as Slovenia has favourable natural conditions for the cultivation of the white mulberry tree *Morus alba* L., whose leaves are the exclusive food for the silkworm *Bombyx mori* L. In Goriška, sericulture began with the rearing of silkworms, reeling of cocoons and production of silk yarns and fabrics [8, 9] and continued until the middle of the 20th century. Sericulture

represented an important income for a large part of the local population of Goriška region[10]. At the end of the 19th century (1884), sericulture was abandoned in Kranjska, but continued in the Vipava Valley, Koroška and Štajerska [8]. After the First World War, when the Slovenian territory was occupied, sericulture and the silk industry in Goriška became part of the Italian economy. Italy had a highly developed mulberry silk production in Friuli. With the rise in silk prices on the world markets, sericulture in Friuli experienced a great boom, but after the Great Depression of 1929, prices for silk cocoons fell drastically on the world market. This led to the collapse of sericulture in Bovec, Kanal, Ajdovščina and the Vipava Valley. Sericulture existed in Prekmurje until 1938, when it was replaced by buckwheat cultivation and beekeeping. In order to meet the needs of the domestic market, after the Second World War there were attempts of revival of sericulture in the lower Vipava Valley in Renče, Bilje, Mirno and Vrtojba, in the immediate vicinity of Nova Gorica to Šempas, in Kras and in the valley between Lig and Kambreško.

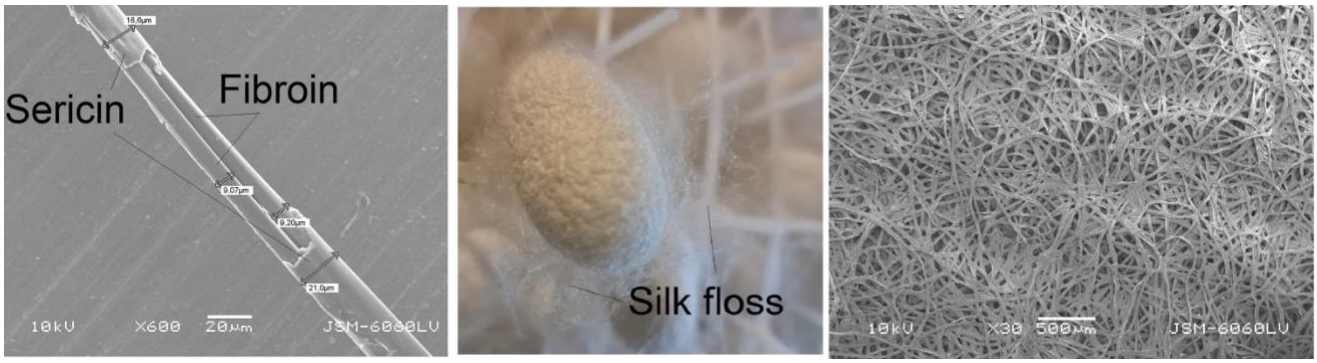
The price of the silk always greatelly affected sericultural activity, which requiring neither large investments nor expensive equipment, but above all intensive human labour. Compared to sericulture, the situation in the silk industry is quite different, involving evaluation of the quality of silk cocoons as well as reeling of cocoons and processing of silk fibre. These processes can be carried out manually, especially in the production of unique items. The use of machines for sorting and reeling of cocoons, spinning machines for silk yarns, looms and knitting machines were already common in the 18th century. The domestic silk cocoons were reeled into threads and woven into fabrics such as velvet and ribbons, and socks were knitted. Silk fabrics were used to make colourful handkerchiefs, dresses, traditional costumes, socks and fabrics for parasols, which are part of the Gorenjska costume. The processing of silk waste into floret yarns continued in Solkan until 1965, when the last purchase of cocoons took place [10]. Artificial silk materials such as nylon for shirts and women's socks came onto the market and replaced natural silk [11]. However, significant industrial production of silk goods began in 1928 with the founding of a textile factory in Maribor under the name Mehanična tvornica svilenih izdelkov Maribor. In 1947, the Slovenian government founded the United Silk Factories, which brought together the manufacturers Thoma & Co, the Maribor silk factory Radvanje and the Atama factory, the Maribor textile factory Košaki (1933−1947) [12]. They produced silk fabrics for loose clothing, such as crépe de Chine (fr. crépe de Chine, Chinese crepe) for women's dresses, blouses and linings, transparent georgette (fr. crepe de georgette) made of heavily twisted silk, which used to be produced in warp and weft yarns for blouses, thick, stiff and smooth taffeta for evening dresses and fine, light, shimmering satin in a satin weave. After modernization in 1978, Svila became the largest Yugoslav silk company for a few years, narrowly specializing in the production of silk fabrics, which was soon replaced by regenerated cellulose and synthetic fibers.

1.2. The beginnings of the revival of sericulture in Slovenia

The revival of sericulture in Slovenia is related to the bilateral project between Slovenia and Hungary in the period 2016–2018 [13]. Sericulture has already attracted the interest of numerous people - farmers and non-farmers throughout Slovenia - who, with the professional support of the Institute of Sericulture RLB [14], successfully produce cocoons, hand reel cocoons and produce threads for bobbin lace [15] and hand weaving [16].

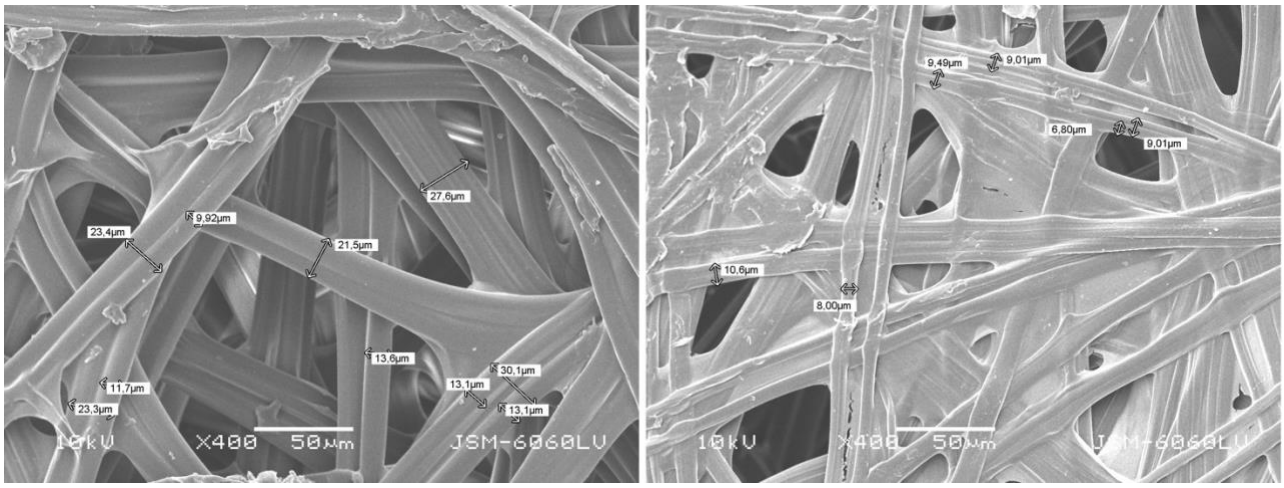
1.3. *Bombyx mori* L. silkworm cocoon formation

The development of the *Bombyx mori* L. silkworm takes 32–35 days (encompassing hatching of the larva from the egg and development-growth of the silkworm (including four moults)). After reaching full size and maturation (length of 8–10 cm and weight of 7–8 g [17]), a silkworm stops feeding and starts looking for a place to spin a cocoon. The silkworm has a spinning wart on its head, squeezing out a jet of a protein fluids stored in a silk gland. The secreted protein jet quickly hardens into a very fine and strong thread consisting of two fibroin microfilaments glued together with a sericin protein cement (Figure 1a). While spinning, silkworm moves its head backwards and forwards in a shape of figure eight movement [18]. It attaches the silk thread to the substrate and then with long head movements forms a soft wadding, so-called silk floss. This phase is followed with forming a cocoon (Figure 1b) where the silkworm performs shorter head movements in the shape of a loop (a figure eight). The outer layer of the cocoon (Figure 1c) is formed by placing the silk thread in compressed piles that cannot be reeled later. The middle layer of the cocoon (Figure 2a) can be reeled off. This layer is created by the rhythmic circular movements of the silkworm's head, depositing thread in the form of an irregular loop. The inner layer of the cocoon (Figure 2b) is made from finer thread from protein fluid, remained in the silk glands. This layer is loose and soft and cannot be reeled off. Formation of loops depends on a silkworm race (Figure 3a), environment temperature (Figure 3b) and the position of the layer in the cocoon (Figure 3c) [18].



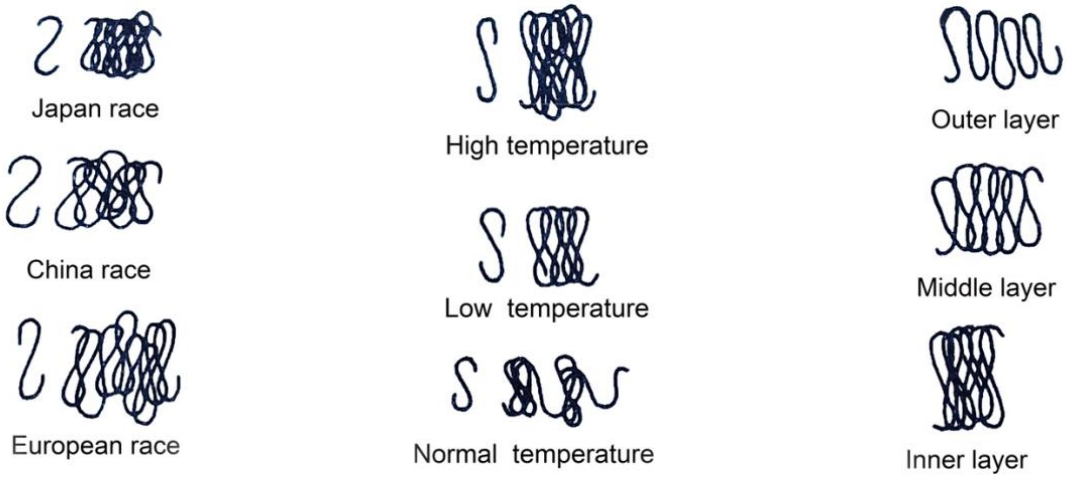
a. b. c.

Figure 1: a. Longitudinal view of extruded silk tread (Photo: Mirjam Leskovšek); b. *Bombyx mori* L. cocoon; c. surface of the cocoon upper layer (Photo: Mirjam Leskovšek)



a. b.

Figure 2: Surfaces of the cocoon layers: a. middle layer; b. inner layer (Photo: Mirjam Leskovšek)



f. g. h.

Figure 3: Loop shape of deposited silk thread in cocoon: a. influence of the type of race; b. influence of the environment temperature; c. influence of the layer in the cocoon [18]

Spinning of the silkworm and the formation of the cocoon strongly depend on the shape of the substrate into which the silkworm attaches the silk thread:

a) For a well-developed cocoon, the silkworm requires a fixation to three-dimensional framework. Various spatial shapes are suitable for this, from paper tubes to spiral strips to various brush-like substrates that

imitate plant branches. If two silkworms are too close to each other, they can become entangled in a common twin cocoon, which is large but cannot be unwound.

b) The silkworm cannot form a cocoon on a flat surface, but lays down the silk thread two-dimensionally and forms flat structures, a kind of nonwoven structure. The movement of the silkworm's head on a two-dimensional surface, if there is no support from neighbouring threads, is within a range of 2–4 cm. Using the flat spinning process, designers already created an ambient mobile [19], a flat silk scarf [19] and a dress [20]. The flat spinning is digitally performed on the website https://www.vickiessig.com/process-silkworms and https://svila.si/kabinet/.

Two dimensional silk mat made by a silkworms can be called a flat cocoon. Its structure is a kind of a nonwoven fabric with a potential applications in the field of technical textiles where silk is already used [21, 22]. Details of flat spinning and properties of these interesting silk mats have not yet been reported. The aim of our research was investigating the process of a two-dimensional spinning of silk mats (flat cocoons) by *Bombyx mori* L. silkworm and qualitatively evaluate their properties.

2. Methods

For the spinning silk mats nine frames were prepared on which a cross-linked surface structures were created by stretching the silk threads across the edges of the frames. The frame must be strictly two-dimensional, without corners or thicker layers in which the silkworms could insert a cocoon.
The cross-linked structure served as a walking aid for the *Bombyx mori* L. silkworms. The distances between silk threads in the cross-linked structures varied from a minimum of 3 mm to a maximum of 3 cm. The frames were set up horizontally and occasionally turned around for 360°, as the silkworms always prefer to move vertically up at the highest possible place. The mats on the frames were made by five to ten silkworms each within two days (out of four) of spinning (Figure 4).

For production of a high quality silk mat, it was very important to transfer manually to a spinning net only those silkworms that have already stop eating and exterminated themselves: we had to observed carefully the period when silkworms raise their heads with elongated "noses" and completely empty their intestines, becoming somewhat transparent and slightly wrinkled.

The silkworms were left on the spinning frames for about two days, so they still had enough liquid silk in silk glands that in the next two days on a suitable 3D surface they could spin also cocoon for themselves, where they could finally transform into a butterfly. This aspect is important mainly because of "activator" concerns.

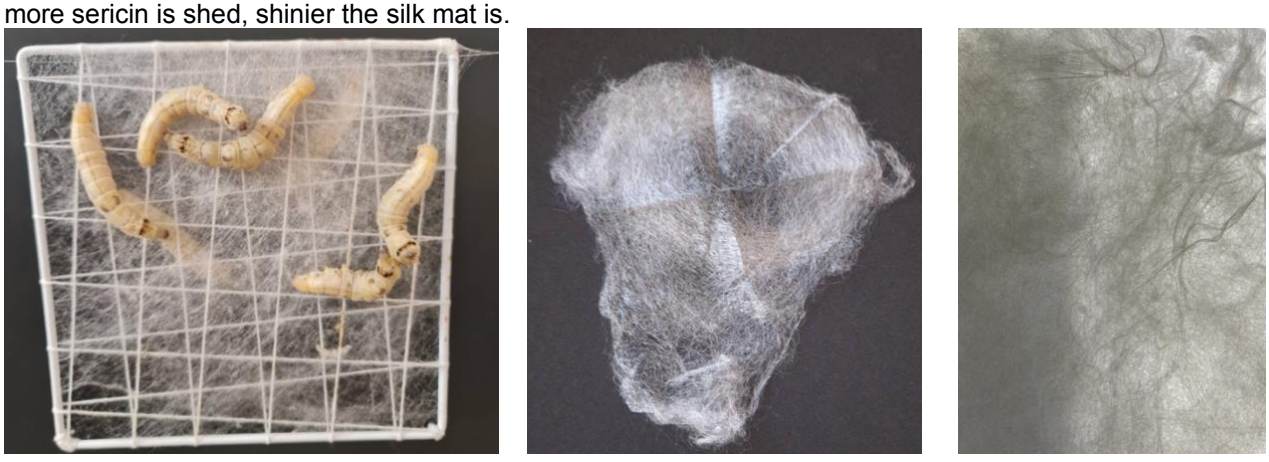
Figure 4: Flat spinning by *Bombyx mori* L. silkworms

3. Results and discussion

Almost all silkworms try to make a cocoon at the end of the fifth developmental stage. When a silkworm does not find a three-dimensional support where it could attach the silk thread and begin to form the cocoon for further transformation, it secretes silk on a surface on which it is located. A silkworm on a flat substrate moves its head left and right in a diameter of 3–4 cm in the form of a partial ellipse and forms a silk mate (Figure 5).

Figure 5: *Bombyx mori* L. silkworm at flat spinning with a head movement: a. shown on the gray paper; b. at making silk mat on the frames with stretched silk yarns; c. structure of a flat cocoon in making

At flat spinning (Figure 6a) the silkworms on the frames were moved between stretched silk threads and tried to fix their silk extrudate. Sometimes they spun the mat from both sides of the frame at once. At the beginning they formed very disordered structure with many openings. In order to fill the entire surface and create the most uniform structure of the silk mat, it was necessary to control the tracks and move them from the top of the frame to lower positions and to places where there were voids. On the Figure 6b is seen a silk mat made by one silkworm. Its surface was about one square decimetre and mass per unit area 45 g/m^2. The elliptical formation made by the silkworm with the movement of its head is also clearly visible on the Figure 6b. Silk mats are thin and soft materials with an interesting morphology. Because of a natural moving of silkworms over the surface in different ways the structure can be partly wrinkled and transparent for light (Figure 6c). The sericin gum attached on the fibroin fibres (Figure 1a) is brittle, it breaks easily and falls off the fibres. The more sericin is shed, shinier the silk mat is.



a. b. c.

Figure 6: a: *Bombyx mori* L. silkworms at flat spinning; b. Silk mat made by one silkworm; c. Morphology of raw silk mats

4. Conclusion

In the experiment silk mats were successfully made and analysed. They can be used mainly for interior decoration. A cleaning of items from silk mats should be investigated as they are made from raw silk fibre.

Locally produced silk according to the guidelines of organic mulberry cultivation fulfils the criteria of a sustainable and environmentally friendly textile material with a positive ecological balance. For better understanding and comparison of silk flat spinning and silk cocoon development, websites were developed where all the digital media, with digital images and videos, are available. on website https://svila.si/kabinet/.

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DIGITAL CATEGORIZATION OF TEXTILE MATERIAL TEXTURE

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Abstract: *The structure of the fabric, which depends on the geometrical structure of the fibers and yarns, affects the surface quality of the fabric, i.e. the texture and inevitably its perception which is ultimately defined by the weave of the fabric. The definition of texture depends on the particular application; there is no formal approach and completely precise definition of texture, but generally texture is perceived as a visual or tactile characteristic of the surface that determines the appearance of the surface (material). Although it is well known that texture can visually and instrumentally affect certain textile processes, such as textile printing, and consequently the colour characteristics, quantity and quality of this effect is not yet well understood. Furthermore, textile surface irregularities, non-uniformity and roughness determine the appearance of the material surface, but also affect the digital imaging and simulation of the texture of a certain textile material that can be applied within the digital fashion concept. Considering the complexity of the relationship between the structure and texture of textile material and their digitalization, this research deals with the analysis and categorization of digital fabric samples of different structures, i.e. the influence of the topography of the textile material on its digital imaging.*

Keywords: *texture, structure, textiles, digital imaging, GLCM, image analysis*

1. Introduction

The term 'texture' is applied in different media and can have visual, tactile and auditory features. The term originally referred to the art of weaving and the quality of fabrics, but has gradually expanded to include tactility, the material quality of objects in general, and the synesthetic interaction of tactile, visual, and auditory characteristics [1]. There are many different attempts to define texture, however there is no formal approach and completely precise definition of texture [2, 3]. Texture refers to properties that represent the surface and structure of the medium [4]; in the context of textile technology, it is determined by the characteristics of a certain textile material. Primary construction parameters of the fabric such as: yarn fineness, weave type, density of warp and weft threads are interdependent variables where the choice of one parameter affects other and consequently a construction of the fabric. Therefore, the fineness of the yarn affects the density of the fabric through the weave type, and the structure of the fabric affects its surface texture. The appearance of the fabric texture is related to the geometric structure of the fibers and yarns, and the texture of the fabric is ultimately determined by the weave of the fabric. In textiles, differences in texture are the result of differences in fibers and processes of spinning, weaving or knitting, i.e. textile texture is determined by fibers, yarns, structure (weaving or knitting, etc.) and finishing [5, 6]. Therefore, textures are surface quality of textiles determined by the surface characteristics defined by material's physical structure, construction, mechanical properties and surface characteristics of the material and are perceived as a whole through a combination of tactile and visual cognition [6, 7, 8, 9]. Surface textures are usually described as smooth or rough, coarse or fine, soft or hard, matt or glossy, and so forth [10]. Textile textures have visual and tactile attributes. Tactile texture is a real physical texture that provides information about the physical qualities of a certain objects or products, that can not only be seen but felt by touch as well [10, 11]. Visual texture (illusion of surface texture) refers to the appearance of tactile texture on a two-dimensional surface [12]. Visual textures give us an implied sense of surface composition related to local spatial variations of simple stimuli like colour, orientation, and intensity. Indeed, colour and design are primary visual effects in clothing, but textures also indicate a sense of touch. For any given textile cloth sample, visually perceived tactile properties may not always match actual haptic sensations [9]. In digital graphic design, texture is understood only visually and refers to digital images that may or may not represent tactile textures and indicators used to modify the interplay of lines, shapes, and colours in those images, in order to create the illusion of tactility in some cases. Nevertheless, understanding the proportionality between tactile and visual texture is important for researching the rise of the visual over the tactile in computer technology and for understanding how to evaluate texture mapping as a field of computer graphics that deals with the visual representation of tactile texture [13]. Interrelations of tactile and visual textures were studied by different researchers. Xiao et. al. investigated what visual information is important for tactile perception by using tactile perception to measure visual material perception. Tactile perception as ground truth was used to measure visual material perception. i.e. fabrics were used as a stimulus to measure how observers match what they see (photographs of fabric samples) with what they feel (physical fabric samples) [14]. Chen investigated how people express and verbalize their tactile feeling and how this expression will be affected by visual experience [15].

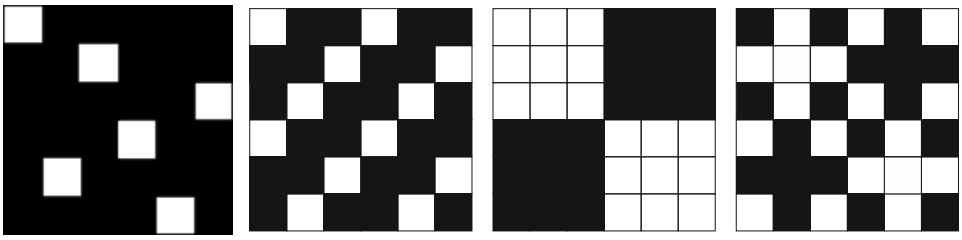
This paper analyses and compares the topography, i.e. the texture of the fabrics constructed of the same yarn, but of different structures using the statistical method of image analysis with the aim of approaching the issue of digital imaging of different textile textures for the purpose of perception of material's aspects of texture in digital media. Fabrics of the same raw material composition, but different structures scanned with a digital microscope become digital images for analysis and representation of the material surface characteristics, i.e. visual texture. *GLCM Texture* and *SurfCharJ 1q* plugins from ImageJ program were used to obtain data, i.e. parameters describing the texture of fabrics and their surface roughness. Binary images were used to calculate porosity of the samples. Digital fashion uses computer technologies to simulate the visual representation of clothing and the physical properties of clothing texture [16]. In the context of digitalization, different quality of the media surface requires a different (digital) representation of the (textile) material when it is applied in the concept of digital fashion; i.e. presentation of the tactile-visual characteristics of a specific fabric using digital tools. The texture parameters obtained by the method of image analysis in this research describe the surface appearance of the fabric with the purpose of digital categorization of textile materials.

2. Materials and methods

In this research a method of image analysis in the ImageJ program was used in order to obtain results on the parameters of texture, porosity and roughness. Samples of textile fabrics with a raw material composition of 100% cotton were used. The samples were purposefully produced by the Čateks d.d. factory, using identical yarns, but varying in construction characteristics, which resulted in fabrics of different structures and textures. Four different constructions are applied in the weaving process: Atlas 5/1, Twill 2/1 Z, Regular Panama 3/3 and Kanava. The structural-mechanical parameters of the fabrics are shown in Table 1, and the schematic view of the weave constructions is shown in Figure 1.

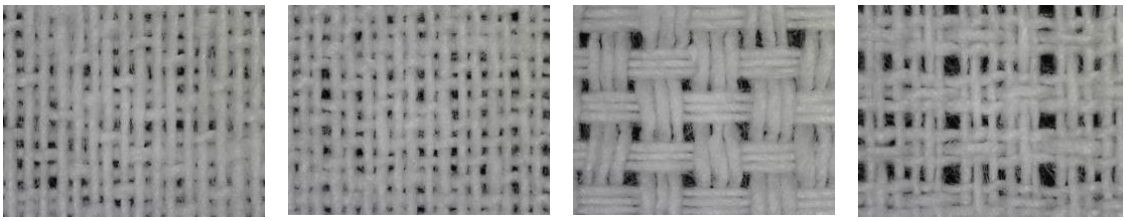
Table 1. Structural-mechanical parameters of selected fabrics

Samples	**The fineness of the warp [tex]**	**The fineness of the weft [tex]**	**Warp density [threads/cm]**	**Weft density [threads/cm]**	**Mass [g/m^2]**
Atlas 5/1 (a)	36	36	24	20	155,89
Twill 2/1 Z (b)	36	36	24	20	155,42
Regular Panama 3/3 (c)	36	36	24	20	154,12
Kanava (d)	36	36	24	20	155,52



a. b. c. d.

Figure 1. Construction weaves of selected fabrics: sample: a. Atlas 5/1; b. Twill 2/1 Z; c. Regular Panama 3/3; d. Kanava

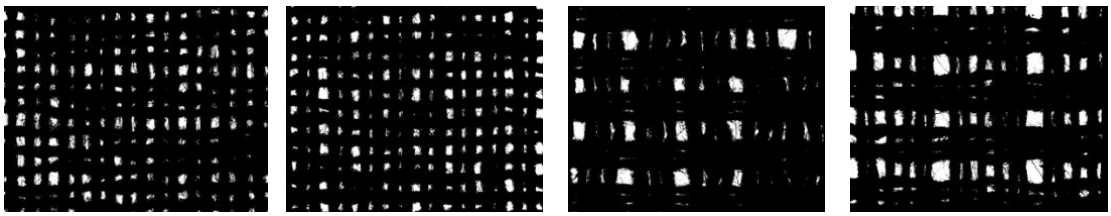


a. b. c. d.

Figure 2. Microscopic images of samples structure

The structure of the samples is observed, also, by digital microscope imaging. The microscopic images are shown in Figure 2.

In the next step, using the method of image analysis in the ImageJ program, results on fabric porosity, texture and roughness using experimental method were obtained. In order to do so, the digital images of the samples were converted into binary images to calculate the percentage of white surface (meaning yarn spacing i.e. porosity) and black surface (the fabric excluding yarn spacing).The results were obtained using the Analyze > Measure command. The binary images of the samples from ImageJ program are shown in Figure 3. The parameters that provide information about porosity are presented in Table 2.



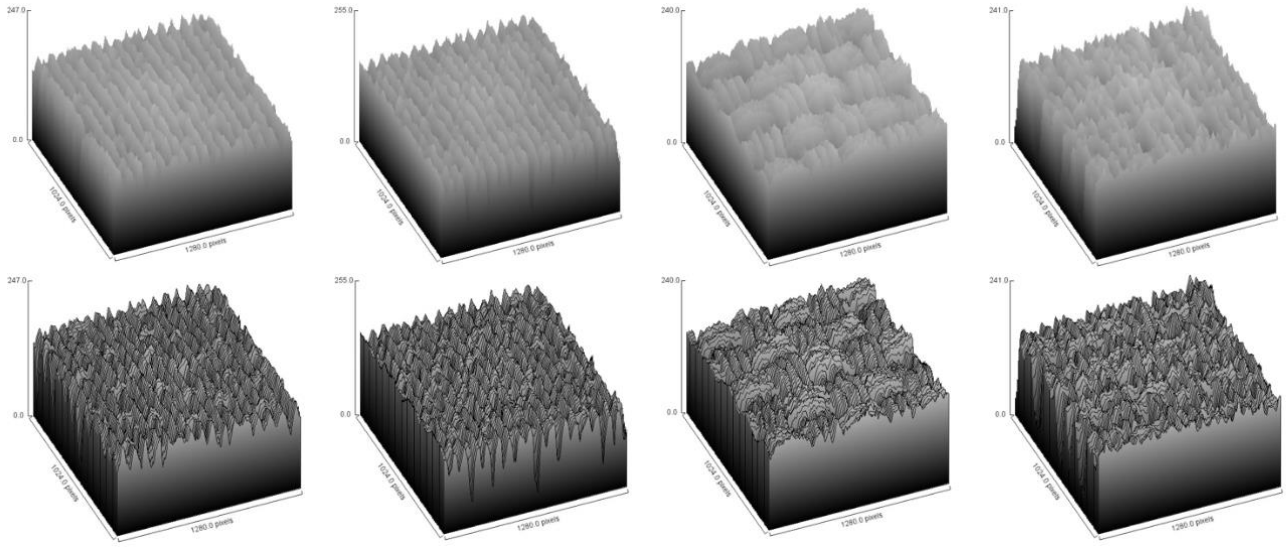
a. b. c. d.

Figure 3. Binary images of samples analysed in ImageJ program

GLCM Texture and *SurfCharJ 1q* plugins were used to obtain data, i.e. parameters describing the texture of fabrics and their surface roughness in ImageJ program. The parameters that provide information about the texture of the scanned fabrics, are presented in Table 3. The results of the parameters that describe the roughness of the samples are found in Table 4.

Results

In order to exclusively monitor the influence of the surface structural parameters of the fabric, the samples on which the test was carried out were purposefully produced from the same yarn, in a unique weaving process, changing only the structural parameters, i.e. the weave of the fabric, as it is shown in Table 1 and in Figure 1. Considering different structural characteristics, surface plot of the fabric samples are created in ImageJ program and shown in figure 5. Surface plot shows a 2D image of a fabric as a 3D plot.



a. b. c. d.

Figure 4: Surface Plot of the fabric samples: a. Atlas 5/1; b. Twill 2/1 Z; c. Regular Panama 3/3; d. Kanava from ImageJ program

By conducting an image analysis of the selected fabrics, an insight into the characteristics of their porosity, their parameters of textures and roughness were obtained. The results are shown in Tables 2, 3 and 4.

Table 2. White area percentage which presents yarn spacing i.e. porosity from ImageJ program

Samples	Area	Area (%)	Min Threshold	Max Threshold
Atlas 5/1 (a)	98795	7.5375	255	255
Twill 2/1 Z (b)	111865	8.5346	255	255
Regular Panama 3/3 (c)	78401	5.9815	255	255

Kanava (d)	130867	9.9844	255	255

Table 3. GLCM texture parameters from ImageJ program

Samples	ASM	Contrast	Correlation	IDM	Entropy
Atlas 5/1 (a)	0.0011	103.9155	0.0013	0.2177	7.5791
Twill 2/1 Z (b)	0.0011	100.2790	0.0011	0.2171	7.6146
Regular Panama 3/3 (c)	0.0012	86.6660	0.0012	0.2305	7.4600
Kanava (d)	0.0011	96.1447	0.0008	0.2230	7.6621

Table 4. Roughness parameters from ImageJ program

Samples	Rq	Ra	Rsk	Rku	Rv	Rp	Rt
Atlas 5/1 (a)	26.0158	16.9526	-2.4159	7.8235	0	247	247
Twill 2/1 Z (b)	28.4626	18.4636	-2.3636	6.7172	0	255	255
Regular Panama 3/3 (c)	27.7496	17.1916	-2.6817	8.8931	0	240	240
Kanava (d)	33.9274	22.2614	-2.1716	4.6744	0	241.3333	241.3333

According to results in table 2, when comparing samples in different structures, the highest porosity has sample d. Kanava. Table 4 shows the results of GLCM texture parameters from ImageJ software. According to Osapoetra: "Smoother image results in lower contrast, while coarser image produces higher contrast. Correlation represents linear correlation between neighbouring pixels. Energy (ASM) measures textural uniformity between neighbouring pixels, while homogeneity quantifies the incidence of pixel pairs of different intensities" [17]. According to Hladnik [18], when the image does not show high contrast, most pixels are identical to their neighbouring pixels. ASM (Angular second moment) or Energy (ASM) provides data on the distribution of the grey level of the image; images with fewer grey levels have more uniformity.
Table 5 shows the values that describe the roughness of the samples. Fabric texture patterns can be caused by physical surface characteristics such as roughness [18]. Roughness is the quality of the texture, it describes the texture of the surface [1]. It is quantified by the vertical deviations of the actual surface from its ideal shape. If these deviations are large, the surface is rough, if they are small, the surface is smooth. Ra is the average roughness of the surface – if the value of Ra is large – the surface is rough and if Ra value is small – the surface is smooth. According to Haralick, image texture can be qualitatively evaluated as having one or more of the properties of fineness, coarseness, smoothness, granulation, randomness, lineation, or being mottled, irregular, or hummocky. Each of these adjectives translates into some property of the tonal primitives and the spatial interaction between the tonal primitives. Unfortunately, few experiments have been done attempting to map semantic meaning into precise properties of tonal primitives and their spatial distributional properties [19]. Idrissi et. al. [20] in their study propose a new semantic approach for interpreting textures in natural terms, a new method for interpreting texture semantics based on the co-occurrence matrices (COM). The originality of the proposed approach stems from a reason that the intrinsic properties of the texture features extracted from the co-occurrence matrices have never been used before [20]. In their research, visual texture features retained include energy, entropy, variance and correlation. Based on its degree of appearance, each COM feature is interpreted as three semantic terms: ”weak, medium, high”. Based on previous research, they built a link between the purely neutral mathematical formula of each COM feature and its own semantic property. Semantic properties of COM texture features are shown in Table 5.

Table 5. Semantic properties of COM texture features from [20]

Index	COM feature	semantic property
1	energy	homogeneity
2	entropy	coarseness
3	variance	contrast
4	correlation	uniformity

According to the results from table 3, sample d. Kanava has the roughest surface, and sample a. Atlas 5/1 has the smoothest surface. When comparing surface plot images, strong difference among surfaces of the samples is evident which indicates the need of classification of textile materials into different categories when applied in texture visualization / texture simulation / digital imaging.

3. Conclusion

The paper analyses the influence of textile material of identical yarn, but different structure, on the properties of topographic characteristics of textiles, i.e. texture, porosity and roughness in digital medium. Four selected samples of different structures, but the same yarn, with visually very different surface textures were compared with regard to topographical parameters such as porosity, roughness and texture. Considering the results obtained from ImageJ program, it can be concluded that the sample categorized as d. Kanava has the highest roughness and the highest porosity. The digital imaging of the samples will therefore be different depending on the weave type. When comparing surface plot images, strong difference between surfaces of the samples is evident which indicates the need of classification of textile materials into different categories when applied in texture visualization / digital imaging, for example for texture mapping for realistic simulations in digital fashion. This work contributes to the categorization in understanding the significance of the presentation of texture and imaging of visual-tactile properties of the texture, i.e. the display in the context of digitalization in 3D programs. The results show the difference between the samples regarding the parameters of texture, roughness and porosity. In order to obtain a larger number of categories by which different samples could be classified according to the topographical parameters of textile materials, it is necessary to carry out additional research on a larger number of samples with different surface characteristics.

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INKJET PRINTING AND PLASMA IN THE DIGITAL FASHION CONCEPT

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Abstract: *Advanced technologies in the textile industry and the concept of digital fashion have changed the way clothing is designed, produced and consumed. Digital fashion, the result of this combination of technological innovations, is becoming omnipresent and offers a number of benefits. Design adaptability is a key element of digital fashion. Thanks to digital printing, inkjet technology and plasma surface modification, designers and manufacturers have more freedom to create different patterns and designs. With these tools, prints and shapes can be precisely applied to fabric, making it easier to customise clothing to meet customer's unique needs and preferences. Fast production is also a feature of digital fashion. Digital printing processes combined with plasma surface modification eliminate the need for time-consuming material preparation processes and chemical treatments. This significantly speeds up production and shortens product development time. Sustainability is becoming increasingly important in the fashion industry, the use of plasma and environmentally friendly surface modification methods reduces the environmental impact of the textile industry. Reducing waste and the need for large inventories, helps conserve resources and reduce the negative impact on the environment. Advanced technologies such as digital printing and the use of nanotechnology enable the production of garments with advanced features such as water resistance, antibacterial properties and reflective surfaces. All this makes digital fashion a combination of aesthetics, functionality and environmental responsibility. This concept meets the demands of the modern consumer who is looking for personalization, quick availability, high quality and environmental protection in the fashion industry. Digital fashion is thus becoming the future of the fashion industry, harnessing technology to create innovative, sustainable and adaptable products.*

Keywords: *Inkjet printing; plasma; digital fashion; advanced technologies.*

1. Introduction

Wettability is one of the basic properties of materials intended for printing, which depends on the chemical composition and morphology of the material, which in turn affects the hydrophilicity and quality of the print. Modification of the surface layer of the polymer is carried out to change the hydrophilicity of the material, increase its surface free energy, create new functional groups, change the surface morphology, roughness and cross-linking, as well as to remove impurities or, in the case of medical polymers, to sterilize or improve biocompatibility. Activation can be achieved by physical or chemical methods [1]. The former are considered more environmentally friendly as they do not require chemical solutions. Physical activation methods include corona, plasma, flame, laser, ultraviolet, X-ray and high-energy electron beam activation. Corona activation is a common industrial method due to the low cost and high efficiency of the process as well as the possibility of application directly in the production line. However, plasma treatment allows greater uniformity in the modification of the surface layer of the material. In addition, plasma activation is more efficient than corona activation, it enables a greater increase in surface free energy [1-7].

2. Plasma

A totally or partially ionized gas made up of electrons, ions, radicals, and high-energy neutrals is called plasma. It is considered the fourth aggregate state, which is the largest part of the matter of the universe [1, 2, 8, 9]. The capacity to apply plasma to any kind of material and the potential to get functional features without changing the fundamental properties of the textile material or having any negative environmental effects are its two key advantages. Since handling hazardous chemicals is not a part of plasma treatment, there are fewer chemical requirements for wet treatment following plasma treatment than with chemical treatments, and effluent issues are avoided. In addition, the technique can prevent ozone depletion by eliminating volatile organic compounds, controls pollution by having low emissions, and is safe for aquatic flora and fauna because there is no waste water generation [2-6, 8-12]. Numerous industries, including textiles, electronics, the automotive sector, medicine, etc., have used plasma technology. Plasma technology can also be used for various targeted surface effects, such as hydrophilicity, hydrophobicity, and adhesion, depending on the type of gas or gas mixture used and other processing parameters. Gases such as oxygen, air, nitrogen and argon can be used to improve the surface free energy, but on the other hand, gases such as fluorocarbons are polymerizing plasma gases that can be used to produce a hydrophobic surface [4].

The effects of the modifications we hope to accomplish, the costs we can afford, and the efficiency of the necessary process all play a major role in the type of plasma we choose. There are benefits and drawbacks to every kind of plasma, including atmospheric and low-pressure plasmas [1]. One of the most effective methods for altering a material's surface is low-pressure plasma processing, which is also safe and cost-effective from an environmental and financial standpoint. Targeted surface modifications, such as wettability, hydrophobicity, printability, dyeability, antimicrobial performance, flame retardant and adhesion properties, sterilization, antistatic properties, UV protection, etc., are among the numerous textile applications for which it is extensively used [4, 13].
Increasing the material's hydrophilicity is crucial to getting it ready for printing or other decorative processes. A decrease in C-C and C-H bonds and an increase in free radicals are indicative of changes in the surface polymer layer's chemical composition. The material's surface produces new functional groups. Polymer surface ablation, or surface destruction, is the outcome of intricate processes that occur when the material is exposed to plasma. During the activation process, components of the plasma react with the polymer chain, altering the surface properties and causing polymer degradation. Cross-linking may happen, and the top polymer layer (such as PLA and PP) produces low molecular weight and gaseous products. The gravimetric analysis method can be used to find the ablation rate. Eliminating weak domains and raising surface roughness are crucial for ablation because these factors greatly affect how well paint adheres to substrate, how strongly laminate bonds, etc. [1].

3. Plasma effects on the textile surface and its impact on digital printing

Plasma can be used to improve the print's qualities after it has been printed or to alter the surface before printing. In the first instance, it must enhance the substrate's printing qualities and permit high-quality printing, just like conventional corona activation. In contrast, the second scenario aims to achieve or enhance the printed image's usability. The plasma activation used before the printing process is primarily intended to improve the hydrophilicity of the substrate and can be performed using gases such as He, Ar, N_2, NH_3 and O_2, etc. Furthermore, certain kinds of plasma, like Ar, have the ability to drastically alter the substrates' roughness [1, 5].

The ion bombardment of the surface causes physical sputtering and chemical reactions of reactive plasma species. These reactions can result in: (a) cleaning of the surface in which the unwanted surface contamination is volatilized and removed; (b) activation, an enhancement of the surface energy by the generation of chemically reactive sites on the textile surface; (c) etching of the surface caused by the chemical reaction of plasma reactive species with active substrate groups which are desorbed from the surface and carried away from the substrate; and (d) coating or plasma polymerization using reactive and polymerizable gases which create a functional thin film on the textile surface (Figure 1.).

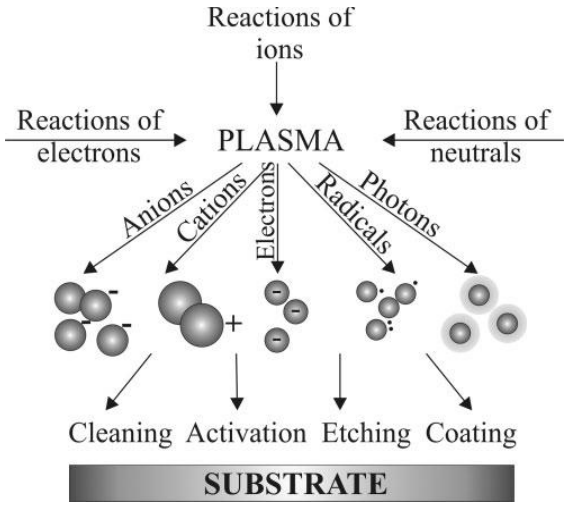

Figure 1: Plasma–substrate interactions [5]

The basic test parameters for determining the influence of activation on the surface layer of the polymer are the measurement of the contact angle with water or extended with other measuring liquids. Determining the surface free energy value requires knowledge of the contact angles of a minimum of two liquids. Energy dispersive X-ray spectrometers, X-ray photoelectron spectroscopy, and Fourier transform infrared spectroscopy can be used to assess chemical changes in the upper layer and identify emerging functional group types. Atomic force microscopy (AFM), optical microscopy, and scanning electron microscopy (SEM)

are used to analyze the changes in surface morphology. The adhesion and wettability of the material are impacted by changes in surface roughness, which can also be found out via AFM measurements. Occasionally, assessments are conducted on variations in dynamic mechanical thermal properties, polymer crystallinity, elongation and tensile strength, material barrier properties, etc. [1, 3-8, 10, 12, 17-20].

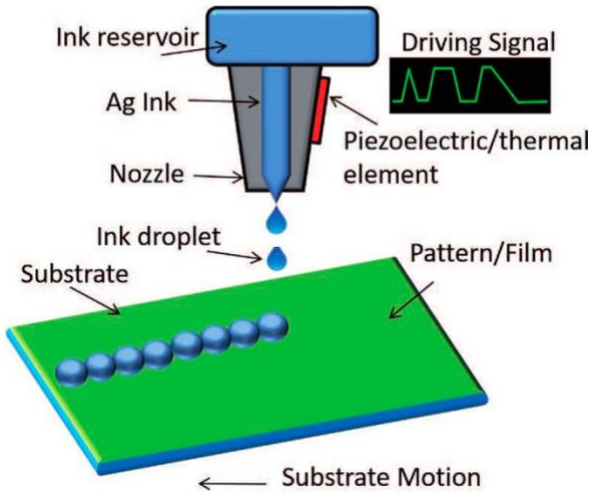

Figure 2: Schematic illustration of inkjet printing technology [18]

Inkjet is a digital printing technique that can be used for printing on all types of substrates, including various textile materials of different structures and shapes [2, 6, 14]. Inkjet technology uses less water, energy, chemicals, and waste than traditional production techniques like finishing and screen-printing [14, 15]. Advantages of inkjet printing on textile products include production purity, design pattern creativity, and flexibility [16]. Digital inkjet printing technology has demonstrated greater potential than traditional textile printing techniques due to its efficiency. These possibilities include superior sample quality, substantially reduced pollution, fast response to frequent changes in the textile market, and lower overall printing costs [13, 14, 17]. Additionally, inkjet printing makes possible visual effects that screen printing is not practical for, like tone transitions and infinite patterns for repeating sizes [12]. On figure 2 the schematic illustration of inkjet printing technology is shown. Digitally printed material and clothing from a fashion show is shown in Figure 3.

Figure 3: Digitally printed material and clothing from a fashion show [21, 22]

3.1. Cotton

In order to improve the quality of digital inkjet printing, the influence of low-pressure plasma processing on cotton knit samples was examined [6]. Cotton fabric was pretreated in one study using atmospheric pressure plasma that included helium and oxygen gas plasma for three seconds. Following that, before inkjet printing, the treated fabric was separately treated with chitosan, sodium alginate, and a paste made of chitosan and sodium alginate. A mixture of sodium alginate and chitosan gives better color values, fastness properties and antibacterial functionality with plasma treated fabric samples compared to untreated samples. In improved grooves on the fiber surface, shrinkage and cracks were observed in plasma treated cotton fabric samples under a scanning electron microscope. This enables a larger application of printing paste [4, 17]. The higher absorption of the resulting fabric can thus be attributed to the increase in polar functional groups. Comparing the untreated cotton fabric to the fabric treated with plasma, the surface contact angle decreased from 98° to 58° and the wetting time decreased from 6.3 to 4.5 seconds, suggesting that the plasma treatment greatly enhanced the fabric's wetting ability [4].

3.2. Wool

The wool fiber has a complex structure and surface morphology. Chemically, about 80% of wool consists of keratin proteins, which are condensed amino acids. The structure of the wool fiber consists of the outer cuticle layer (10%) and the inner cortex (85%). Scaly cuticle consists of epicuticle, exocuticle and endocuticle. The epicuticle is predominantly hydrophobic keratin and lipids which affects on absorption during subsequent dyeing and printing processes. Chlorination is the conventional process used to remove epicuticles, but it is not environmentally friendly [8]. As a result of the oxidation of the hydrocarbon chain by the application of plasma on the wool fibers, new hydrophilic groups such as –OH, –C=O and –COOH develop on the surface. The fatty acid chain length is also shortened, which enhances fiber cohesiveness, shrinkage resistance, weight fastness, and dyeing ability. In the exocuticle, the oxidation process also increases cysteine's oxidation, converting it to cystic acid and lowering the degree of fibrous plate cross-linking. Hence, plasma therapy alters the endocuticle complex and cell membrane, gets rid of the fatty acid layer that is covalently bound, and partially destroys the epicuticle. It was discovered that subjecting yarn to an oxygen plasma treatment for five minutes increased surface roughness. Wool fiber absorbency was enhanced by improved grooves brought about by shrinkage [2, 8].

3.3. Silk

Air plasma from the atmosphere is used to treat the silk's surface before it is used as an inkjet printing substrate. Consequently, the contact angle measurement showed a significant increase in the wettability of the silk fabric surface. A higher K/S value and a distinct print edge further demonstrated the superior properties of inkjet printing on silk. Experiments on the aging process on color strength and chemical composition demonstrate that while the surface property of silk fabric deteriorates over time during storage, it never completely recovers. As can be seen from the above, printing on silk fabrics can perform better and have better surface qualities when using atmospheric pressure plasma. The best results from ink-jet printing appear 24 hours after plasma treatment [7]. As a result of improved surface properties, printing directly on the fabric shows a clear print edge and a greater depth of coloration. Apart from atmospheric plasma, it has been verified that atmospheric multiple ambient gas plasma is also a highly efficient method for enhancing physico-morphological and chemical properties, thereby augmenting the printing performance on silk fabrics. The modified silk substrates are more hydrophilic than the unmodified ones, according to the contact angle measurement. To assess the qualities of direct printing on the fabric, tests were conducted on the spill resistance and color strength. The modified sample has a deeper color, a darker shade, and a higher saturation, according to a study of color intensity [19].

3.4. Polyethylene terephthalate, PET

The most affordable and widely used method in the industry for significantly increasing wettability is alkaline (sodium hydroxide) based PET hydrolysis, though it uses a lot of chemicals, water, and energy and may harm mechanical and aesthetic qualities in some situations. Although enzyme-based treatments (like cutinase) are a little more costly, they can greatly increase the wetting capacity while having less of an effect on the resources and physico-mechanical characteristics of PET fibers. Although it requires a relatively larger initial investment, atmospheric plasma can improve on the alkaline method in a similar way with less impact on mass properties and resource consumption [2, 12, 15]. The pretreatment results showed that, compared to alkaline and enzyme-based processes (cutinase), air-atmospheric plasma treatment can improve the wettability of PET without compromising other important physical properties [15].
SEM photographs show that the surface of the plasma-treated fibers becomes rougher than the surface of the untreated fibers. The roughness effect on the fabric's surface is thought to be the result of etching and ablation on the substrate caused by the plasma treatment. Measurements of contact angles show that plasma treatment reduced contact angles in comparison to the untreated sample. Furthermore, after plasma modification, the mechanical property results do not indicate a discernible decrease in breaking strength and breaking elongation in the warp and weft directions [10].
The oxygen plasma increased the number of polar groups on the polyester surface and roughened the fabric's surface. Following treatment with oxygen plasma, the treated fabric's contact angles decreased to zero degrees, indicating the phenomenon of expansion and suggesting the possibility of increasing the fabrics' hydrophilicity. A higher color yield is a result of the plasma treatment's increased surface roughness [17].

4. Conclusion

Plasma surface modification, as one of the most effective and economical surface treatment techniques, is widely used in the textile industry for fabric surface modification and activation. The review demonstrated that inkjet printing of textile substrates that had undergone plasma treatments in a brief amount of time increased

in wettability and improved in quality. The effect of increasing the polar functional groups C-O, C=O, and O-C=O was observed in various fabric substrates, including polyester, silk, cotton, wool, and others. Print sharpness, color fastness and functional properties for treated fabrics are improved. In general, plasma surface modification has facilitated the inkjet printing process. It can be concluded that the application of environmentally friendly technologies, plasma and digital inkjet printing, is essential for the development of sustainable materials and the sustainability of textile technology in order to reduce environmental pollution and the generation of unnecessary waste. Due to new demands on the market, the textile industry itself must develop new solutions with the aim of shortening product manufacturing time while increasing the level of quality and reducing the impact on the environment. Due to its efficiency, digital printing technology is increasingly used in the textile and fashion industry.

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REVOLUTIONIZING FASHION PROTOTYPING: THE POWER OF 3D TECHNOLOGY IN FIRST SAMPLE DEVELOPMENT

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Abstract: *The fashion design industry has undergone a significant transformation in recent years due to the adoption of 3D technology in pattern making and fashion design. Pattern makers and fashion designers are utilizing virtual prototyping to optimize the creation of initial samples, resulting in numerous advantages that extend beyond conventional fashion production. One of the most significant advantages of this innovative approach is the precision and efficiency it offers in pattern making. By constructing and modeling patterns within virtual 3D software programs and subsequently testing them on 3D avatars tailored to desired size and proportions, pattern makers can achieve an unparalleled level of accuracy. This ensures a flawless fit, minimizes errors in the final production, reduces the need for rework and material waste, and significantly enhances overall garment quality and consistency. The integration of 3D technology significantly reduces the need for physical prototypes, resulting in substantial cost savings. The accelerated development cycle ensures that garments reach the market faster than ever before, providing fashion brands with a competitive advantage in an ever-evolving industry to stay ahead of the competition. Furthermore, the use of 3D technology aligns with the ever-growing demand for sustainability in the fashion sector. The reduction in physical samples dramatically decreases material waste, contributing to a more environmentally friendly production process. Creativity is another area where 3D technology excels. The ability to visualize and experiment with designs on digital avatars allows designers to visualize their sketches and have max control over the design process. This enables creative exploration, allowing for the testing of a wide range of colors, textures, and styles with remarkable ease. In summary, this abstract underscores the pivotal role that 3D technology plays in reshaping the creation of initial samples in the fashion industry. Its implications extend far beyond the design studio, with significant benefits, including precision, cost-effectiveness, sustainability, and creative potential. The main goal of this thesis is to explore these subjects in greater depth and demonstrate the transformative impact of 3D technology on fashion prototyping, offering the potential for a future characterized by efficient, economical, and environmentally friendly fashion manufacturing.*

Keywords: *3D technology; prototype; first sample; sustainability; precision; efficiency*

1. Introduction

The clothing industry is driven towards a permanently accelerating fashion, offering its products faster, cheaper, and in bigger abundance than ever. This demand has resulted in the search for new techniques that will add value in the product development process [1]. The traditional methods in fashion design and pattern making have persistently faced challenges concerning inefficiencies, imprecisions, and significant material wastage, resulting in high production costs and extended lead times. Relying on physical prototypes and manual adjustments often leads to errors and needs significant additional work or adjustments. These challenges present obstacles in meeting the demands of an ever-evolving industry. However, the introduction of advanced 3D technology has emerged as a potential solution to address these longstanding issues. By leveraging virtual prototyping, pattern makers and designers can now create, refine, and test patterns on custom 3D avatars, promising precise fits and reduced errors, fundamentally reshaping the design and production processes.

The application of 3D technology in fashion design and pattern making serves as a revolutionary tool in optimizing the creation of first samples. This innovative technology has established a significant presence within the textile and fashion sector, notably influencing the work of pattern makers and designers.The adoption of virtual prototyping through 3D software programs has allowed for enhanced precision and efficiency, addressing critical challenges faced in the traditional pattern-making process. 3D virtual prototyping technology enables pattern makers to test the fit of products thus not only reducing the number of samples being made and reducing raw material and labor cost, but also reducing the amount of time it takes to get clothes to market. This means apparel companies can make the most of market trends, increasing profit by cutting down returns due to poor fit [2]. This application area serves as a pivotal arena for innovation, cost reduction, and environmental sustainability, positioning itself at the forefront of technological advancements within the fashion sector.

The core of this research is to analyze the transformative impact of 3D technology specifically in the creation of first samples or prototypes in pattern making and fashion design. This research delves into how virtual prototyping, using 3D technology, influences pattern accuracy, production costs, and environmental

sustainability within the textile and fashion industry. It seeks to understand the shift from conventional methods to advanced 3D technology, assessing its multiple advantages, including precision, efficiency, cost-effectiveness, and minimized material waste in the context of creating first samples. Moreover, the research aims to highlight the crucial role of pattern makers and designers in utilizing 3D technology to achieve unparalleled accuracy in the development of these first samples, thereby shaping the future landscape of fashion design and production.

2. Method used

3D software has revolutionized the textile and fashion industry, offering innovative solutions for design, production, and presentation. Specifically designed for the textile and fashion sector, these advanced tools, such as Clo3D, Browzwear, Optitex, and Style3D, bring a new dimension to design processes.

In the textile industry, 3D software allows for the creation of virtual fabric simulations, enabling designers and manufacturers to visualize how different materials will drape, fold, and behave in various garment designs. This digital representation of fabrics aids in decision-making during the design phase, reducing the need for physical samples and thus cutting down on material waste. The production of a digital garment yields 97% less CO2 than that of a physical garment, and the end product never ends up in a landfill. Many retailers are already experimenting with digital sampling of new designs to reduce wastage in the production process [3]. Moreover, 3D software offers tools for pattern making, facilitating the creation and adjustment of patterns before physical prototyping, enhancing precision and reducing production costs.

The 3D concept is an important development in the design process. It allows designers to unleash their creativity in a real-life visualization of designs that could previously only be imagined through 2D sketches [4]. Designers can visualize their concepts on virtual avatars, experimenting with colors, textures, and styles, leading to quicker iterations and more accurate representations of their creative vision. These tools have streamlined the design-to-production process, significantly reducing the time required to bring a product from concept to market. Furthermore, these innovative software have revolutionized the way fashion collections are presented, allowing for lifelike visualizations and dynamic animations. The advanced capabilities in virtual prototyping and realistic simulations have transformed the traditional fashion show into a digital and interactive experience, making it an ideal tool for researching the impact of 3D technology in the fashion design process.

Here, I will be using Style3D to provide insight into how first prototypes can be made using these advanced tools. Style3D proves to be a transformative tool for both pattern makers and designers in the creation of first samples. Pattern makers benefit from enhanced precision in crafting and testing patterns within a virtual 3D space, ensuring an accurate fit of the pattern before physical production. This precision drastically reduces material waste, as errors are identified and rectified at early stages. The software's real-time simulations allow swift adjustments, saving time and effort typically expended in manual modifications, streamlining the iterative process for pattern makers. For designers, Style3D fosters a realm of creative exploration. It empowers designers to experiment extensively with various styles, colors, and textures, encouraging innovation within a virtual environment. The software's high definition visualization enables designers to see how their creations will appear in real-world scenarios, refining designs before the production phase. Additionally, the direct cloud connection feature facilitates seamless sharing of 3D sketches among team members, fostering efficient collaboration and expediting the design-to-production cycle. Overall, Style3D significantly elevates the efficiency, precision, and collaborative potential for both pattern makers and designers, revolutionizing the creation of initial prototypes in the fashion industry.

3. Adjusting the virtual avatar

Adjusting the virtual avatar in 3D software for the first sample base size is the first step in the garment production process. The desired avatar (male, female, boy, girl, child) can be customized and tailored to match the desired body measurements, allowing for a more accurate representation of various body types. Designers and pattern makers can adjust specific measurements such as height, chest, waist, hips, and

more, providing a realistic base size for initial sample creation. This customization not only reflects diverse body shapes but also ensures that the clothing fits accurately and proportionately on the virtual avatar, resembling the intended real-world fit.

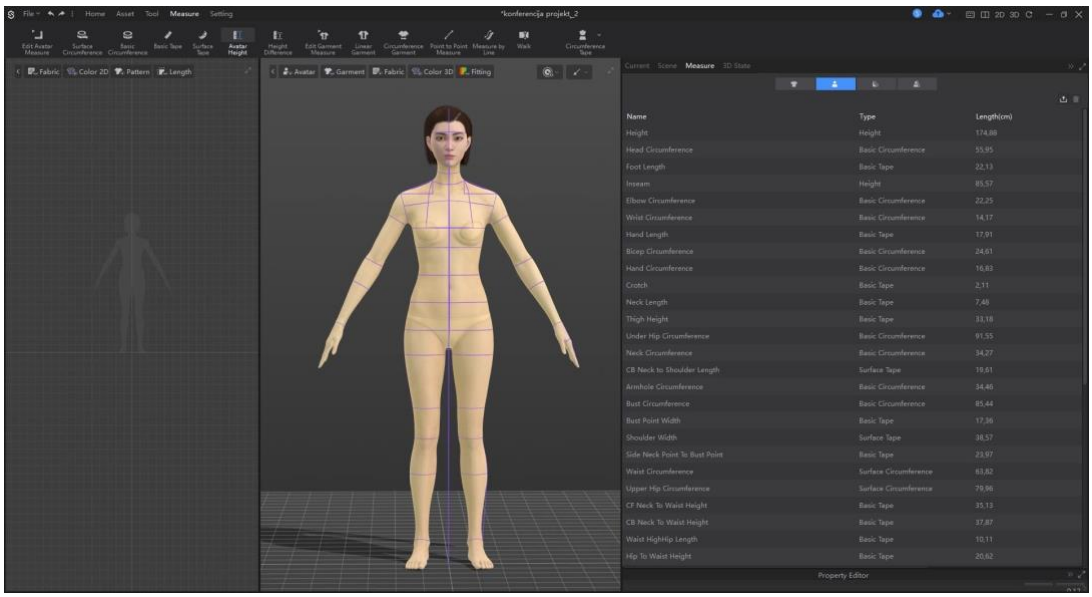

Figure 1: Style3D interface for adjusting the body measurements of the female avatar

Moreover, in Style3D, the capacity to modify the avatar's proportions and dimensions goes beyond basic measurements. Designers have the flexibility to fine-tune the smallest details, such as sleeve length, necklines, or specific body contours, offering a highly customizable and detailed representation. This level of customization facilitates a more comprehensive evaluation of how a garment will appear on the desired body type, contributing to better design precision and reducing the need for extensive adjustments during the physical sample creation stage. Adjusting the avatar to the initial sample base size in 3D software plays a fundamental role in ensuring accurate and well-fitted designs, thus streamlining the overall production process.

4. Pattern making in 3D software

Pattern making is one of the most vital parts of product development in the apparel or other textile industry. However, the traditional 2D pattern-making method is tedious, abstract, and time-consuming [5]. Pattern making in 3D software not only simplifies the design process but also plays a pivotal role in creating the first sample or prototype. Tools available in software like Style3D offer a comprehensive approach, allowing pattern makers to swiftly and accurately construct initial garment patterns in a virtual environment. The software provides an efficient platform for precise pattern development, enabling the customization of patterns according to various body sizes and styles. This digital tailoring ensures that the first sample closely aligns with the intended design, significantly reducing the need for extensive adjustments during physical prototyping.

Alongside pattern precision and swift adjustments, advanced features such as body pressure analysis, garment stress analysis, garment deformation analysis, and thermal insulation analysis empower designers and pattern makers to assess critical parameters and the fit of the garment on the digital avatar. These specialized tools offer in-depth insights into how a garment interacts with the digital model. Body pressure analysis allows for the examination of how the garment applies pressure on various parts of the body, ensuring optimal comfort and fit. Garment stress analysis enables a detailed evaluation of stress points, aiding in identifying potential weak areas in the garment's structure. Furthermore, garment deformation analysis provides a comprehensive understanding of how the garment drapes and moves on the avatar, offering crucial insights into the design's behavior in different positions and movements. In addition, thermal insulation analysis allows designers to assess the garment's insulation properties, crucial for performance or outerwear apparel. By simulating real-world conditions, these analysis tools not only refine the fit and functionality of the garment on the avatar but also contribute to the overall quality, comfort, and performance of the final product. This comprehensive approach in pattern making, with tools that analyze various

parameters and fit on the avatar, ensures that the design not only looks aesthetically pleasing but also functions optimally in practical use cases.

Moreover, the swift and responsive tools within 3D software expedite the pattern-making process, facilitating quick iterations and adjustments. Designers and pattern makers can efficiently manipulate pattern pieces, modify details, and make instant alterations that are simultaneously visible on the avatar. This accelerated process significantly reduces the time required for pattern creation, allowing for a faster transition from the initial design concept to a tangible prototype. The real-time visualization of these adjustments on digital avatars

ensures a more accurate representation, contributing to the creation of a well-fitted first sample, all while minimizing material waste and production costs. In essence, 3D software not only revolutionizes pattern making by enhancing speed and precision but also significantly contributes to the creation of accurate and well-fitted first samples in the fashion industry.

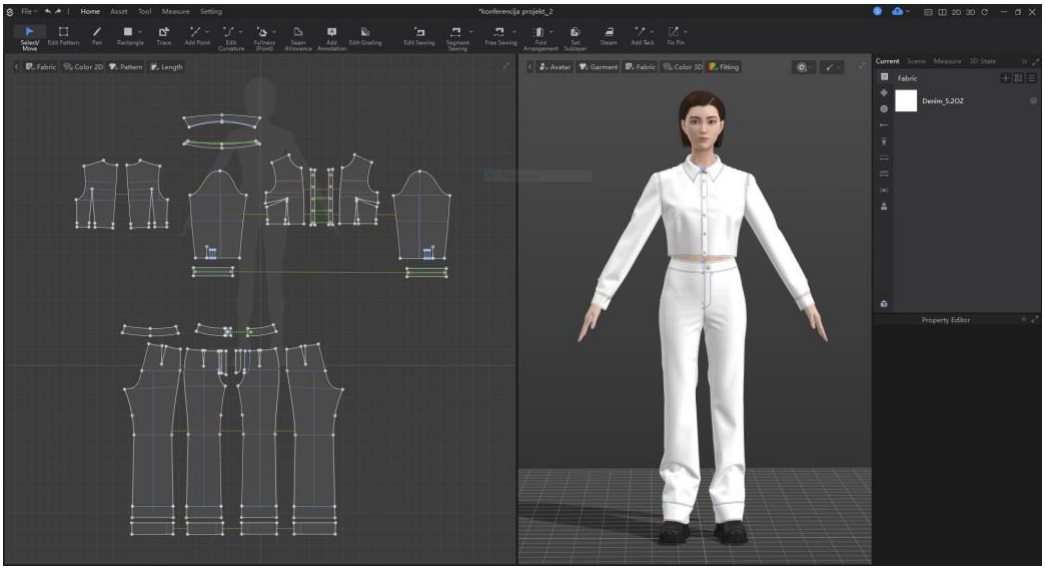

Figure 2: Style3D interface for pattern creation and real-time avatar adjustments

5. Design application in 3D software

In the fashion design process using 3D software like Style3D, after the construction of the first pattern, designers move on to apply colors, materials, and various design elements to create the final look of the garment. Style3D offers a diverse range of tools and features that facilitate this phase, allowing designers to experiment with an array of colors, textures, and materials to visualize the finished product.

The software provides a platform for designers to seamlessly apply different color schemes, experiment with fabric types, and test various textures on the digital garment model. It allows for the simulation of how the chosen materials will drape, fold, and interact with different designs. This virtual experimentation stage is instrumental in determining the visual aesthetics of the garment, aiding in the decision-making process for the final design. Furthermore, the ability to manipulate color, material, and other design elements in a virtual environment saves time by allowing swift adjustments without the need for multiple physical samples, thereby increasing efficiency in the design-to-production cycle.

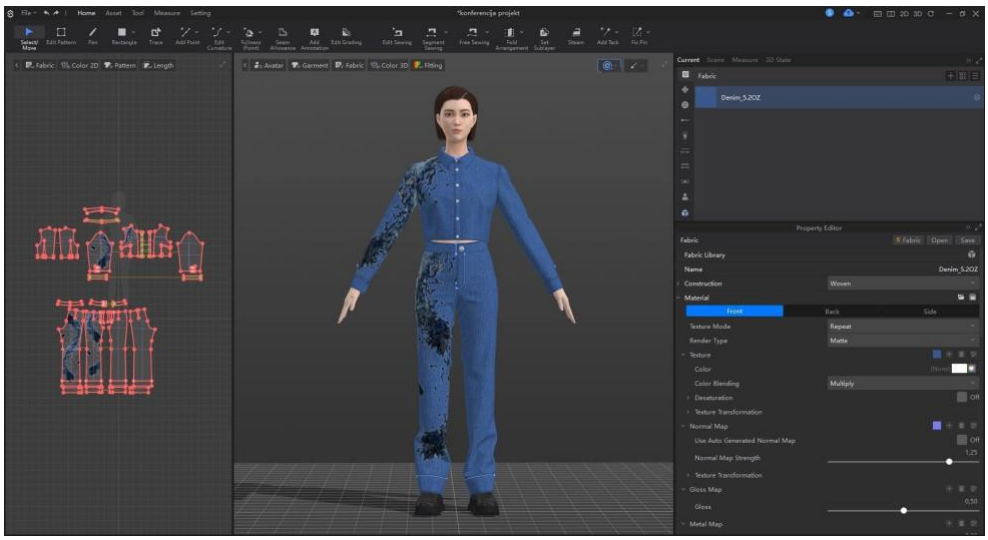

Figure 3: Style3D interface for selecting materials, textures, trims etc.in the designing process

In addition, Style3D enables designers to simulate various design elements, such as embellishments, prints, and trim details (buttons, eyelets, zippers etc.) on the virtual garment. This process allows for intricate detailing and accurate visualization of how these design elements will appear in the final product. By facilitating these design adjustments and detailing in a digital space, use of 3D significantly enhances the design process, contributing to a more accurate representation of the final garment and expediting the decision-making process for designers.

6. Strategic utilization of first samples using 3D

Brands, fashion or otherwise, have an incredible opportunity to improve relevance and longevity through unique applications of the latest technology [6]. The utilization of 3D technology, particularly in creating prototypes, extends beyond the production phase and enters the domain of promotional strategies. Using 3D software, the creation of visually striking first samples presents an invaluable promotional opportunity for fashion brands. These digital prototypes not only serve as the foundation for physical production but also act as powerful marketing tools.

Figure 4: Examples of showcasing 3D garments for promotional purposes

The accuracy and detailed representation of initial samples created in 3D software offer an exceptional advantage for promotional purposes. Brands can leverage these highly realistic digital models to showcase

their designs before the actual production, enabling them to engage audiences with a sneak peek into upcoming collections. Utilizing these detailed representations in marketing materials, such as lookbooks, digital campaigns, or interactive experiences and animations, provides consumers with a vivid visualization of the final product. The versatility of 3D models allows for easy adaptation to various marketing platforms, enhancing their accessibility for online stores, social media, and interactive presentations.

Furthermore, the efficiency of creating initial samples in 3D enhances the promotional timeline. Designers and brands can swiftly produce visually appealing representations and incorporate them into marketing materials much earlier in the production cycle. This early introduction of designs allows for increased anticipation and engagement from the audience, ultimately creating a sense of exclusivity and desire for the soon-to-be-released collection. By integrating the creation of initial samples with promotional strategies, 3D technology not only accelerates the design-to-production process but also serves as a potent promotional asset, influencing consumer perceptions and fostering excitement for upcoming fashion lines.

7. Conclusion

The integration of 3D technology in the fashion design and pattern-making process has irrefutably redefined the industry's traditional methods. This revolutionary shift addresses longstanding challenges present in the conventional approach, such as inefficiencies, imprecisions, and substantial material wastage. Through the implementation of virtual prototyping and 3D software tools like Style3D, pattern makers and designers can now create, refine, and meticulously test patterns on customized 3D avatars. This transformative approach significantly augments the precision and efficiency in pattern construction, assuring a flawless fit and considerably reducing errors, thereby reshaping the landscape of design and production processes within the fashion industry.

The great impact of 3D technology extends beyond the design studio, infiltrating promotional strategies with exceptional advantages. Utilizing these highly realistic digital prototypes as powerful marketing tools offers brands a unique edge in captivating their audience. The realistic and lifelike representations enable early glimpses of upcoming collections, creating anticipation and exclusivity, resonating across various marketing platforms. The efficiency in generating these first samples allows designers and brands to seamlessly incorporate them into marketing materials, providing consumer engagement through vibrant and creative previews.

In essence, the strategic union of creating first samples in 3D technology with promotional strategies has transformed the way fashion collections are introduced and received in the market. This combination not only accelerates the design-to-production cycle but also serves as a powerful promotional asset, influencing consumer perceptions and creating excitement for the upcoming fashion lines. The impact resonates throughout the industry, marking a significant leap forward, ensuring fashion design and production remains at the forefront of technological innovation and resonates with the ever-evolving demands of consumers and the industry.

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THE PATENT ZIPPER AS AN AESTHETIC AND FUNCTIONAL ELEMENT OF CLOTHING

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Abstract: *This article presents a zipper that was originally designed as part of the construction of a garment to make it quicker and easier to put on. However, its role was not limited to functionality, so that the zipper also gained aesthetic importance throughout history. A brief historical evolution of the zipper is described, from the moment it had a purely functional role to the moment it becomes part of haute couture and how it can contribute to the design of a garment and its aesthetics. In the experimental part of the work, a fashion collection for women's clothing is presented, created with the vector computer drawing programme Adobe Illustrator, inspired by the zipper used in fashion. In this collection, the zipper will play a primary role in the aesthetics, but at the same time its functionality will also be emphasised.*

Keywords: *zipper; clothing construction and modeling; fashion collection; Adobe Illustrator*

1. Introduction

The history of the zipper is more complex than its simple appearance at first glance. However, what every key moment and the goal of the story have in common is the creation of a practical and functional fastener. The first version of the zipper was invented by Elias Howe in 1851, and it took another 40 years for the modern version of the zipper to be developed by Whitcomb Judson and after him by Gideon Sundback. The exact reason for the invention of the zipper is not known, but what is certain is that the main aim was functionality, initially to fasten boots more quickly and later clothing in general. The development of the zipper itself went in a functional direction. Efforts were made to reach a level where the zipper was mechanically as easy to operate and use as possible. Until the 1930s, the zipper had only a functional role, until it entered the world of haute couture when Elsa Schiaparelli used it in her creations. The zipper can therefore be discreet and part of an expression or just for decoration. Today, it is used in clothing for different purposes: as a decoration that plays both an aesthetic and a functional role, as decoration only or as function only.

2. Historical development of the zipper

The American inventor Elias Howe, who is best known for his contribution to the invention of sewing machines, filed a patent for the so-called automatic, full-length garment fastener in 1851. This fastener was similar to a zipper, but differed considerably from the modern zipper. Whitcomb Judson was an American merchant and mechanical engineer. He had 11 approved patents before the shoe zipper and 14 before his death, but only one has made a lasting impression and that is the zipper. Whitcomb Judson filed his first patent for a zipper in 1891 and his second patent in 1893.

A turning point in the development of the zipper was the patent filed in Switzerland in 1911 by Catharina Kuhn-Moos and Henri Forster. In fact, the classic zipper as we know it was born here. Not only are the zipper links drawn in the patent still mostly used today in their basic form, but the slider also shows the basic form, which is of course still used today with appropriate refinements. However, neither the inventors themselves nor other parties interested in the patent recognized the true value of this invention. As no one was found who wanted to acquire a license or the patent itself, the patent expired after a few years (Figure 2b). Sundback made a revolutionary development in the development of the zipper according to which even today classic metal zippers are still produced according to this process [1,2].

3. Types of zippers – today

The main features that distinguish zippers are the type of teeth and their application. What they have in common is that they can be divisible and indivisible. In contrast to a non-separable zipper, a separable zipper can be opened completely, i.e. the two sides of the zipper can be separated and rejoined. The non-separable zipper has a clip on the underside that prevents separation. There are also fasteners that have 2 ends (upper stop) and those that have a connecting piece on both sides (lower stop). A zipper that has a connector on both sides represents the O design of an indivisible fastener,and the one that has ends on both sides represents the X design of an indivisible fastener. Both fasteners have 2 pendants (pullers). Their application is most common in the luggage industry.

There are three basic types of zippers that are used:

- Metal zippers - have metal teeth that are clamped against the zipper tape. They are most commonly used for projects that require the strength and flexibility of fasteners, such as jeans, leather goods, bags and the like. The most commonly used metals for manufacturing are gold, brass, nickel, aluminum and manganese.
- Injection molded closures - mainly made of polyoxymethylene extruded through a mold to form the teeth. The teeth extruded in this way are perfectly symmetrical, allowing the pendant to move in both directions. As the teeth are individually separated and injected directly onto the band, it is easier to maintain in terms of contamination. The material from which it is made is naturally "self-lubricating", which allows for long-term use. They are used for mattresses, jackets, thicker clothing, etc.
- Spiral fasteners - they are made by producing the tape separately from the elements or teeth. The teeth are obtained from monofilament that is "rolled up". The teeth formed in this way are sewn onto the tape to create the final product. The spiral closure makes it easier to correct the error between the teeth by simply passing the pendant over the teeth several times.

4. Examples of the zipper in high fashion in the role of aesthetics and function

The original role of the zipper is functional, i.e. it makes it easier and quicker to put on and take off the garment. After Elsa Schiaparelli was the first to popularize the use of zippers in a decorative function, fashion designers are still inspired by them today, for example collection of Haider Ackerman 2016, Ferragamo 2016., Alexander Wang 2018., Yohji Yamamoto 2019 The characteristics of the zipper such as symmetry and neatness, the even arrangement of the teeth, help designers to prevent the monotony of the design by adding extra lines as a design element, and it is practical to achieve this by sewing the zipper. The zipper has features that help to do just that, namely the flexible length, positions and directions in which it can be applied. In addition to haute couture, the zipper has also played a role in subcultures, the most significant of which is punk. They adorned their clothes with various accessories such as chains, badges, patches, pins, but also zippers, which contributed to their characteristic punk fashion movement. The use of patent zippers in *haute couture* is illustrated [3-6].

5. The collection inspired by the zipper as a basic element of the garment

The inspiration for the development of our own collection is based on the zipper, which is not only a functional and design element, but also serves as a stylistic accent and adds expressiveness in other clothing combinations. The collection presented is a combination of geometry and the use of a zipper. The geometric part of the collection is reflected in the structural parts of the garments and the zipper has the task of highlighting the same parts by providing a stylistic accent or playing a functional role, and sometimes both.

In order to achieve the practicality of the garments, the function of the zipper changes according to its application: varying the width of the garment, separating parts of the garment, forming voids in the garment as a style feature, varying the length of the slit of the garment, the role of the pocket, the convenience of wearing the garment (Figure 1).

Figure 1. Collection a) Model 1, b) Model 2, c) Model 3, d) Model 4, e) Model 5

5.1. Construction and modeling of Model 1

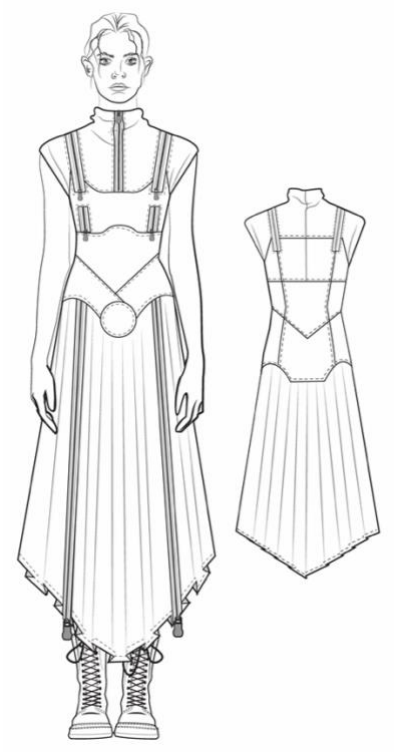
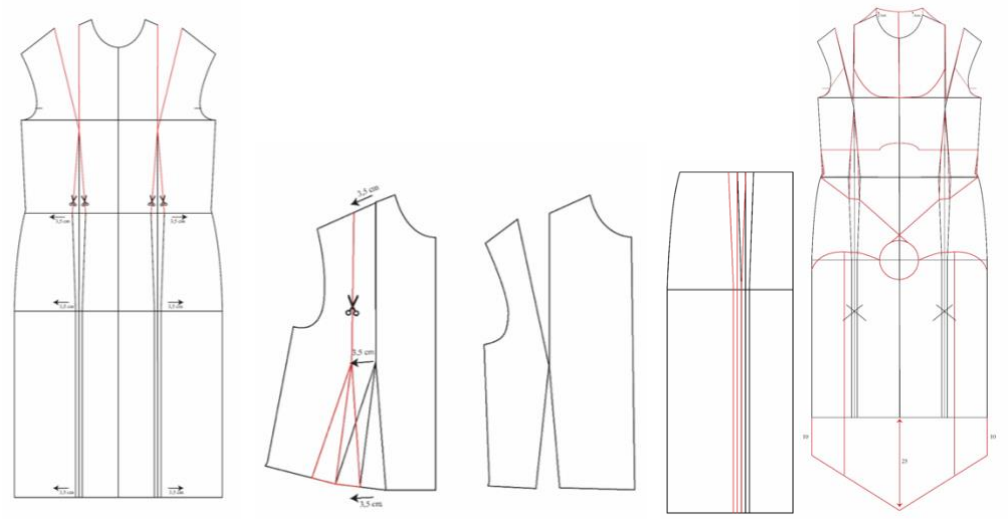
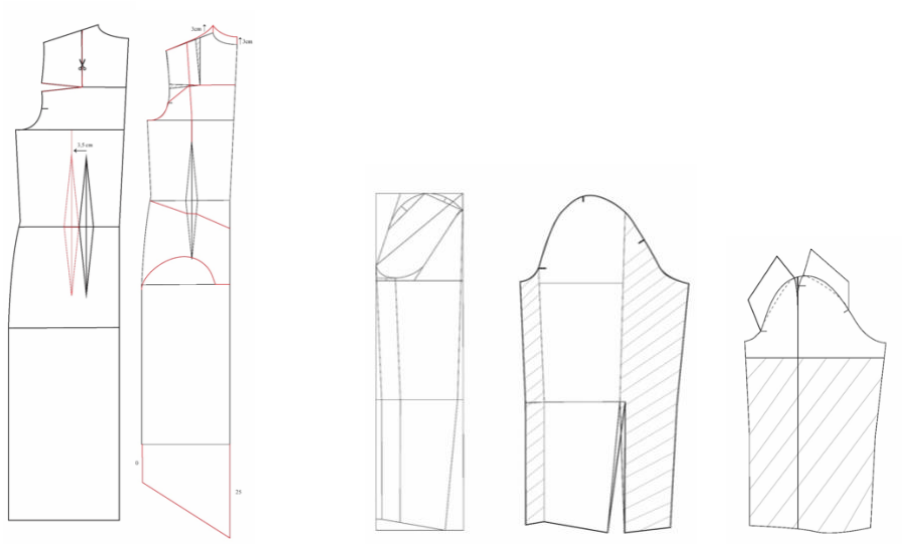


Figure 2. Sketch of Model 1 front and back side

Model 6 is designed in such a way that the zipper has the task of widening the garment in the shoulder area, making it easier to put on the dress and independently selecting the length of the slit on the skirt part [7]. The modeling and construction of the aforementioned style is shown in Figure 3.

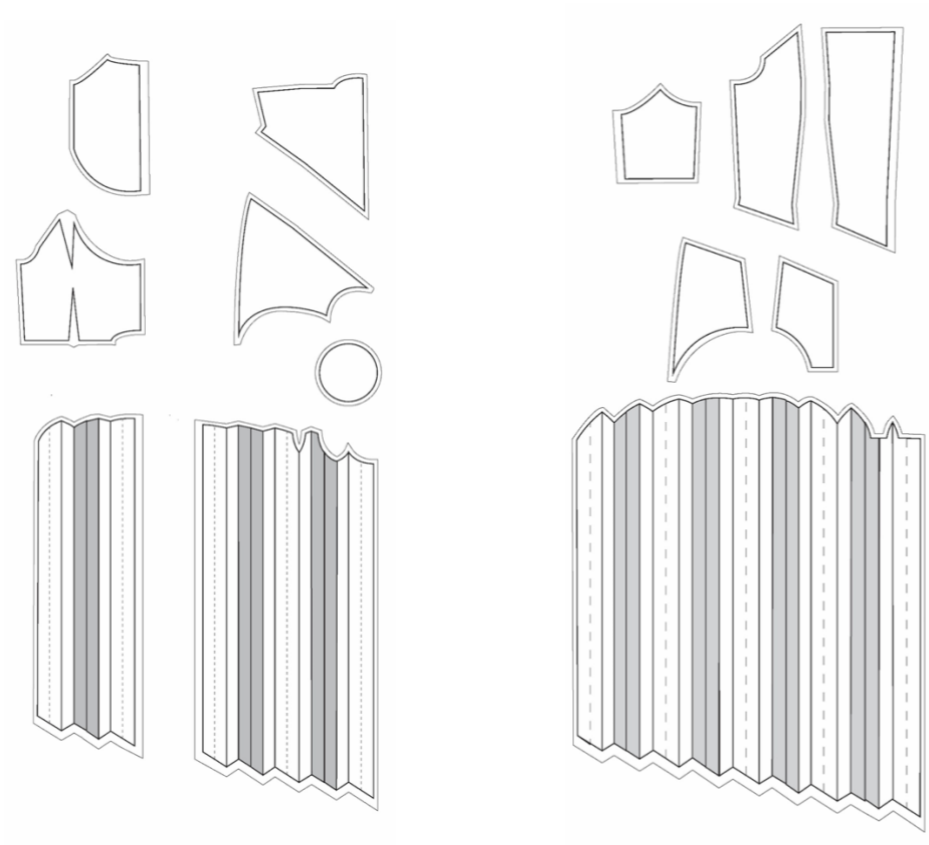


a)



a) c)

Figure 3. Construction and modeling Model 1 a) front side, b) back side, c) sleeve



a) b)

Figure 4. Tailoring parts of the a) front and b) back with seam allowance

6. Conclusion

The zipper is visually decorative, and in combination with all the functions the garment can have with it, they are exactly the inspiration for the design of a zipper- inspired fashion collection. This collection is a combination of using the zipper as a functional element, but also as a stylistic feature in conjunction with geometric lines. The main aim was to design garments that are visually attractive. This was attempted to be achieved through the application of geometric shapes and was guided by the principle of fitting a zipper in the same geometry, allowing the garment to be worn in at least two ways. The role of digital tools lies in the simplicity and precision in the construction and modeling of clothing. Digitization also offers the possibility of using a large number of possibilities in the application and representation of different elements in the construction and design of clothing, which are presented in this study.

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APPLICATION OF NON-DESTRUCTIVE INSTRUMENTAL METHODS FOR THE ANALYSIS OF BLACK YARN FROM A HISTORICAL LITURGICAL TEXTILE - PHELONION DEPICTING THE ASCENSION OF CHRIST

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Abstract: *The colour of historical textiles was created through the harmony of weaving techniques and the shades obtained with natural dyes. However, it is well known that many of the old textile dyeing methods are not environmentally acceptable due to the use of high concentrations of chemicals (pH regulators, mordants, etc). Apart from being environmentally unfriendly, chemicals also cause difficulties and challenges in the conservation and restoration of historic textile objects. One example is the use of green vitriol (iron(II) sulphate) to achieve black tones, which leads to great instability and sensitivity of the textile material. In this paper, a sample of black yarn obtained from a phelonion depicting the Ascension of Christ, owned by the Orthodox Dalmatian Diocese in Šibenik, restored at the Croatian Restoration Institute, was analysed. The phelonion is a Russian-made, in which fabrics of French origin were used, and it is dated to the 18th century. The analysis was carried out using remission spectrophotometry, Fourier-transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM). The images of the fibres in the SEM and the specific spectral braids in the FTIR confirmed that the silk was the raw material. The probability of the presence of iron is based on historical facts about the achievement of black tones by dyeing with natural dyes and on the FTIR analysis, i.e. the occurrence of peaks in the wavelength range 790 cm^{-1} and 1100-1110 cm^{-1}. Furthermore, due to the low reflectance values and the high values of the dyeing depth, it is assumed that a high mordant concentration was used. This fact can be confirmed by historical dyeing recipes in which significant amounts of iron salts are used in combination with different tannin sources to achieve a high depth of brown and black colouration. Ultimately, these salts are one of the main causes of the brittleness of textiles.*

Keywords: *natural dyes, mordants, historical textiles, VIS, FTIR, SEM*

1. Introduction

One of the greatest challenges in the conservation and restoration of historical textiles is their instability and sensitivity, which can be caused by numerous factors. One of the factors emphasised in this work is dyes. Considering the dating of the textile pieces, these dyes are mostly natural and belong to the group of vegetable mordant dyes [1-4]. They can promote the accelerated decomposition of textiles due to the use of various metals as wetting agents, which are used for the durability and brilliance of the colouring. Their presence and origin are difficult to detect by instrumental methods due to the often poor condition of the textiles. For this reason, conclusions often had to be based on subjective judgements and historical data and old recipes [1-4]. Today, however, there is a wide range of specialised instrumental methods, such as chromatographic, spectrophotometric and other analytical methods that can be used to characterise textile materials, dyes and other chemicals. Considering that several methods are required for the complete characterisation of the material, today we talk about the application of multi-analytical techniques [5,6]. A multi-analytical approach can be seen, for example, in the research of Han et al. [7], whose research represents the first attempt to use ultra-high performance liquid chromatography (UHPLC) in combination with photodiode detection (PDA) and electrospray ionisation mass spectrometry (ESI–MS) for the chemical characterisation of dyes characteristic of textiles in ancient China. However, the complete characterisation of the material requires the use of the following methods: X-ray fluorescence (XRF) [5,8], X-ray diffraction (XRD) [5,9], or energy dispersive X-ray spectroscopy (EDS or EDX) [5,10]. These are analytical methods in that X-rays are used to analyse samples and electrons are released from their atomic orbital positions. The energy they release is characteristic of a particular element and enables it to be identified.

It is interesting to note that recent scientific research has brought remission spectrophotometry back to the forefront, focusing on the UV-VIS-NIR regions using optical fibre reflectance spectroscopy (FORS) [5-7,11]. Reflectance spectrophotometry is a non-destructive and non-invasive method that has been used for around 80 years in the identification and characterisation of dyes and pigments [12] and is the most commonly used method alongside FTIR and Raman spectroscopy. Using FORS, de Ferri et al. [13] analysed historical textile fragments from the fifteenth to eighteenth centuries collected by a Venetian art dealer and identified indigo

and anthraquinone dyes. Han et al. [14] prepared silk fabrics dyed with different types of natural dyes and analysed their spectral properties in the ultraviolet range. Tamburini et al. analysed Dunhuang textiles using FORS based on a self-created reference spectral database [15]. Maynez-Rojas et. al. used a Mexican recipe for the preparation of a series of red dyeing reference materials (cochineal and Brazilian wood) to determine the FORS spectral properties of fresh and old dyed fibres [16]. Research by Rahaman et al. [17] presents a new approach to classify dyes for fibres as natural or synthetic classes based on the spectral reflectance of dyed fibres. The key principle is the determination of spectral bands that are characteristic of different colour classes.

When analysing natural dyes on historical textiles, an important fact is that most natural dyes belong to the group of mordant dyes, only a few belong to the vat dyes and a very small percentage to the direct and basic dyes [1-4]. Mordants are chemical substances, usually metal salts, which form a complex with the dyes, bind to the fibres and give them a certain colour. Without the presence of a metal salt, they do not bind as well to the fibre are they have poor fastness properites. These dyes are characterised, among other things, by polygenetic properties, which means that different colours can be produced depending on the type of metal salt used with the dye. The most commonly used salts are copper, iron, aluminium and tin salts. Mordant dyes are mostly used for protein fibres, although they can also be fixed and applied to cellulose fibres. Dyeing is carried out in such a way that the textile substrate can be primed before dyeing, at the same time as dyeing or afterwards after the dyeing process [1-4,18]. A common feature of plant sources with a black tone is that almost all of them contain tannins in a smaller or larger proportion together with various other chemical compounds. Tannins are natural organic compounds, mainly esters of aromatic hydrocarboxylic acids (phenols) with polyhydric alcohols or sugars [18]. They are large molecules that bind easily to proteins, cellulose, starches, and minerals, which favours their use in textile dyeing. Together with the corresponding mordant, these compounds are responsible for the black colouring of the material. Black colour tones are achieved by using iron salts as mordants, with iron(II) sulphate, i.e. green vitriol, being the most commonly used. In addition, the general dyeing process was based on the preparation of a solution by extracting dyes from various parts of plants. Depending on the recipe, the material could be added to the bath at the same time as the plants or a dye solution was first prepared, which sometimes had to mature, and then the material was treated. The treatment with mordants usually took place after the dyeing process, although the process varied depending on the recipe. Often several plants were combined to achieve a deeper colouring (e.g. gall, alder and sumac). Some of the sources of black dyes include spruce, galls, alder bark, sumac, catechu, black walnut, etc. [3,4].

2. Experimental part

2.1. General data on the historical textile item

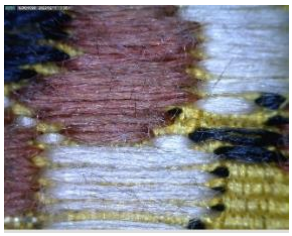
The sample of black yarn belongs to a phelonion depicting the Ascension of Christ (fig. 1) dated around 1770. A felon is a bell-shaped, closed cloak that the bishop wears over his other clothing.The author of the historical piece is unknown. It belongs to the Orthodox Dalmatian Diocese and is located in Šibenik. Various techniques were used to make the phelonion (sewing, embroidery, weaving, painting, papermaking, etc.). Silk, linen and cotton were used as fabrics and trimmings, paper served as the basis for the embroidery and the incarnate was painted with oil paints. The phelonion measures 136 x 172 cm. The basic fabric of the textile item is golden yellow laminated and brocaded silk lampas of French provenance. An embroidered insert of purple silk velvet, probably Italian manufacture, is sewn into the area of the neck and shoulders. The lampas is covered with decorative motifs of thin branches with small bouquets of flowers and silver-plated palm branches, which are wound around vertical gold ribbons with small flowers. The depiction of the apparition of the ascended Christ before Mother Mary and the apostles was embroidered on velvet over the padding using the technique of silk and gold embroidery. The embroidery is the work of a Russian workshop from the end of the 18th century. The main image is located in a baroque cartouche surrounded by branches and flowers. The landscape around the embroidered figures is decorated with silvered, gilded, frisé, and multicoloured silk threads. Incarnate, i.e. the colour of human skin, is painted with oil paints on ribbed silk fabric and lined with thin cardboard. Three types of metal braids are present on the phelonion and one gilded braid.

Almost all the warp and weft threads of the base fabric were in quite good condition. The exception was the weft thread with a black silk effect, which was only visible in traces on the surface of the fabric and fell apart when touched. For this reason, investigations were carried out to determine the possible cause of its poor condition. The black yarn tested on the base fabric creates a broché effect and emphasises the decorative motifs of thin branches with bouquets of small flowers and silver-plated palm branches. It is a combined silk yarn made from two single yarns, and each single yarn consists of two systems of threads in a Z-twist [19].

a. front side

b. back side

c. the inner part of the back



d. black yarn detail

Figure 1 Phelonion with a depiction of the Ascension of Christ, before conservation, a) front side, b) backside, c) the inner part of the back, d) black yarn detail (Archives HRZ-a, photos: I. Marinković, S. Lucić Vujičić, 2022.) [19]

2.2. Analytical methods

A subjective and objective analysis was carried out on a sample of black yarn extracted from a phelonion depicting the Ascension of Christ. The objective, instrumental analysis was carried out using three non-destructive methods:

- Remission VIS spectrophotometry - The measurement was performed on a DataColour 850 transmission spectrophotometer in accordance with the ISO 105-J02 standard in the wavelength range from 400 to 700 nm. The geometry of the illuminated sample was d/8. Five measurements were performed on the sample and the average spectral values were reported, represented by the numerical value of the spectral features and the graphical representation of the remission (fig. 2) and the depth of colour (fig. 3).
- Fourier transform infrared spectroscopy in the attenuated total reflectance technique (FTIR-ATR) - The physico-chemical characterisation of the sample was performed with the FTIR spectrometer using the ATR measurement technique. Four scans of the sample with a resolution of 4 cm^{-1} between 4000 and 380 cm^{-1} were recorded. The acquired data was processed using the Spectrum 100 software package from Perkin Elmer. The results obtained are presented graphically (fig. 4).
- *Scanning electron microscopy* (SEM) - The measurement was performed with a scanning electron microscope SEM - 6060 LV, JEOL. The sample was microscoped under a 1000x magnification with a depth of field of 10 µm, and the electron acceleration voltage was 10 kV (fig. 5).

3. RESULTS AND DISCUSSION

3.1. Subjective analysis

The subjective evaluation was based on an assessment of the colour and brittleness of the yarn. From this and from the basic data of the sample determined by the Croatian Restoration Institute, it can be concluded that the dyeing was carried out with a natural plant dye. This is confirmed by the fact that the object was dated to the 18th century, when natural dyes of vegetable or animal origin were the only source of raw materials for dyeing.Considering that most natural dyes belong to the group of mordants, it is very likely that the yarn was pretreated (wetted) with iron salts before the dyeing process. The assumption is that iron(II) sulphate ($FeSO_4$

x $7H_2O$), trivially known as green vitriol, was used in a concentration of 20% or more in relation to the total mass of the material. As the sample has a black in tone, it is possible that plants rich in tannin, which is characteristic of black tones, were used.

3.2. Objective instrumental analysis

Remission VIS spectrophotometry

The values obtained for the spectral properties (tab. 1) confirm that this is a dark sample with a low lightness value (L*), which is around 20 depending on the light source, and a low chromaticity (C*), which is around 5. From the value of the hue (h°), which is 63.82 with D65 illumination, it can be concluded that the basic tone of the colour belongs to the yellow-orange range, which proves the colouring with natural plant dyes. The remission value (R) is very low and its range over the entire wave range is between 2 and 6%, which, together with the horizontal course of the curve, is characteristic of black shades (fig. 2). Comparing the low value of the remission and the extremely high value of the colouring depth (K/S), 9-23 (fig. 3), it can be assumed that a high concentration of iron was used as a mordant.

Table 1 Values of spectral characteristics

Sample name	Lighting	L*	a*	b*	C*	h°
Svila_felon_crno	D65 10 Deg	19,93	2,08	4,24	4,72	63,82
	A 10 Deg	20,46	3,35	4,89	5,93	55,62
	F11 10 Deg	20,17	1,98	4,78	5,17	67,52

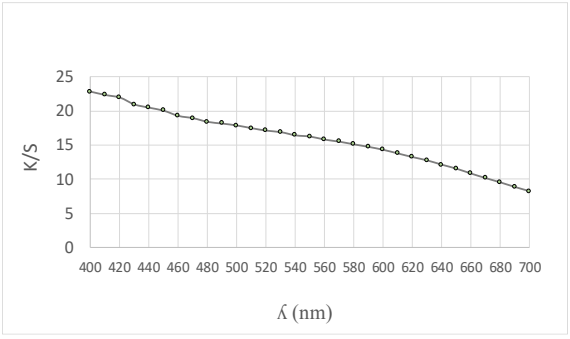


Figure 2 Graphic representation of the remission of the measured sample

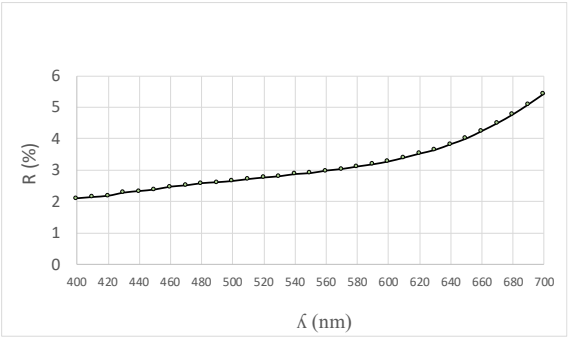


Figure 3 Graphic representation of the colour depth of the measured sample

FTIR spectroscopy

The spectral curve of the phelonion silk sample (b) was compared with the spectral braid of silk in the natural tone (a), and differences were found due to the occurrence of peaks in certain spectral ranges. The appearance of peaks may be due to the presence of dyes and metal salts used in the dyeing process. They may also be due to physicochemical changes caused by the decomposition of the primary polymer. Since no differences were observed in the peaks at wavenumbers 1619 cm^{-1} and 1519 cm^{-1} between the reference silk sample and the silk sample from phelonion, it can be concluded that the basic structure of the silk protein has not been altered.

The presence of iron in the form of oxide is thought to originate from $FeSO_4$ x $7H_2O$, as indicated by the appearance of the peak at wavenumber 791 cm-1, which indicates vibrations within Fe–O–OH, and in the 1100 – 1110 cm^{-1} wavenumber range, where these are visible peaks due to oscillations within Fe–OH groups [7, 8].

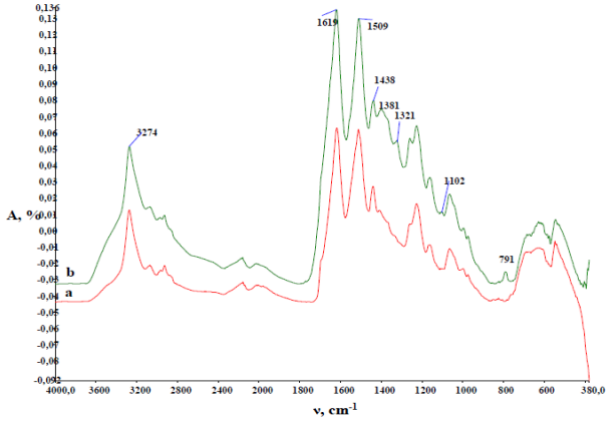


Figure 4 Graphic representation of spectral curves: a – representative sample, b – phelonion silk

Scanning electron microscopy (SEM)
The SEM images of the sample show that the sample consists of almost completely degummed silk, which means that the sericin has been largely removed. Small residues of sericin in the form of dots are recognisable, which can be concluded from the comparison of the images taken of the sample with the images found in the references. Figure 5a) shows raw silk consisting of sericin and fibroin. Sericin is responsible for the coarser and dull appearance of the fibre, but its removal results in finer, smoother and shinier fibres (fig. 5b)) [9].

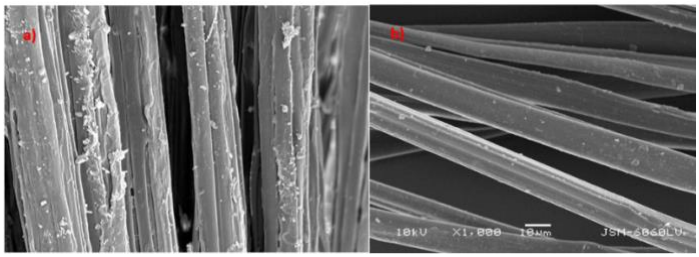


Figure 5 a) SEM view of raw silk thread [9], b) SEM view of degummed silk of black yarn from the examined sample, magnification 1000x

4. Conclusion

The analysis of the black silk yarn obtained from the felon depicting the Ascension of Christ, which is in the possession of the Diocese of Dalmatia in Šibenik, is a contribution to the restoration project of the aforementioned felon at the Croatian Restoration Institute. When drawing a conclusion, one must take into account the fragility of the black yarn, which disintegrated when touched. Considering the dating of the object to the 18th century and numerous literary facts related to the extraction of black tones from natural dyes, it was assumed that the dyeing was carried out with a plant rich in tannins with iron (II) sulphate mordant. With other plant sources and other liquids, it is not possible to achieve the depth of colour observed in the sample studied.

The values of the spectral properties are typical for black tones, i.e. low brightness and low colour intensity. However, it is the value of the hue (h°), which is 63.82 and confirms the yellow-orange tone of the colour, that suggests the presence of a tannin flavonoid pigment that typically forms tannin complexes of dark colour with iron ions. The analysis of the spectral bands of the FTIR spectroscopy in combination with the SEM analysis confirms that it is a silk yarn whose basic structure has not been changed at the level of the protein molecules and that the degradation of the yarn is caused by the high concentration of iron(II) sulphate used.

In the work, the applied methods of reflectance spectrophotometry, Fourier transform infrared spectroscopy and scanning electron microscopy have shown that they can have considerable advantages as preliminary methods in the field of historical textile research. The advantages include the possibility of analysing small quantities of yarn that disintegrate on contact, making decisions about further analytical instruments or deciding on methods of dye extraction that will be the subject of further research.

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DESIGN AND APPLICATION OF LUMINESCENCE YARNS IN TEXTILE INSTALLATION

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Abstract: *In this work, the luminescence of yarns was investigated in the context of artistic textile design. For this purpose, cotton yarns were modified to create an artistic collection of checkered fabrics. The yarns were treated with a commercially available optical brightener (FWA, Fluorescent Whitening Agent) and integrated into woven fabrics for the textile installation. This type of textile can be used in interior design and architecture as well as for individual exhibits in galleries. The study investigated the influence of the FWA on the design effect, namely the different visual effect during the day and at night, and showed the potential of using checkered fabrics in design objects.*

Keywords: *luminescence, optical brightener, textile design, textile architecture*

1. Introduction

The aesthetic factor has traditionally been of great importance in interior design, as no other furnishing element offers a greater range of aesthetic qualities than textiles and soft floor coverings. However, the definition of textiles for interiors is evolving and now often focuses on a technological aspect, i.e. textiles for interiors include functionality (e.g. fire resistance, electrical shielding, heat balancing or light emission), often combined with decorative and design elements [1]. Textile walls are becoming increasingly interesting for interior designers. These lightweight and easily transportable materials provide sound and light absorption in public spaces as well as in homes. The use of luminescent textiles with added value for interior design will lead to the development of innovative textiles in architecture in the future [2-4].

Therefore, in this paper, the design and application of luminescence yarns (treated with optical brightener that absorb UV light (340-380 nm) and re-emit light in the blue region of the spectrum (430-450 nm) by the fluorescence [5]) in textile installation was researched.

2. Idea

The original idea was to design large-format fabrics - colorful grids consisting of a colorful combination of colored stripes at the base of the fabric, in a combination of red, white and blue colors (Fig.1).

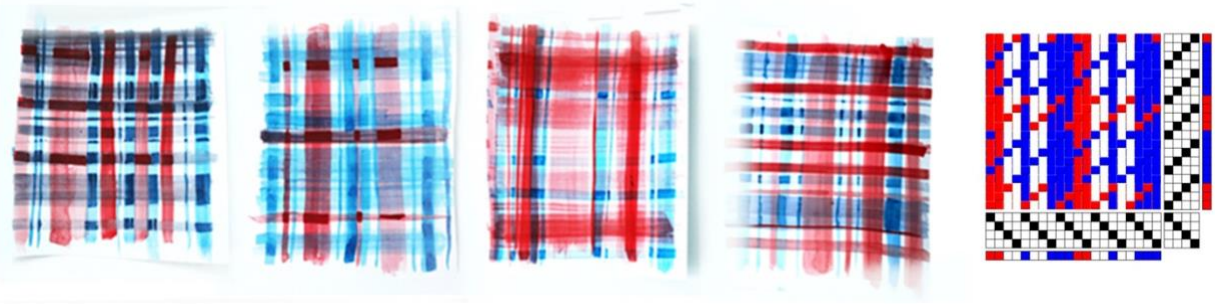


Figure 1: Designs of checked fabric patterns and weave designed by author T. Frasonski.

This form offers numerous possibilities for the subsequent combination of different types of surfaces, as the final form of this work is a polyptych, i.e. a multi-part combination of fabric forms stretched on surfaces of correspondingly different sizes. This work gives a lot of freedom in designing its final appearance. Each element can be combined in different ways, adding or removing elements according to the designer's vision.

3. Experimental part

Cotton yarns in the colors white, red and blue (T_t=16 Nm) from Ariadna S.A., Poland, were used as warp for the production of fabric samples. The same yarns were used for the weft, plus white yarn (T_t=16/2 Nm) from Unitas, Croatia, which was optically brightened. Optical brightening was performed in the dyeing machine Ahiba with bath ratio 1:20 at T=80°C for 60 min with diamino stilbene disulhonic acid derivative (Uvitex BHT), a FWA from Huntsman (Fig.2). The bath contained 1% owf Uvitex BHT and 2 g/l Na_2SO_4.

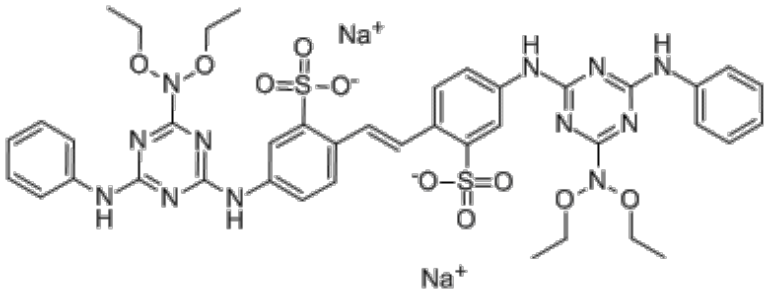


Figure 2: Uvitex BHT (CI Fluorescent Brightener 113) [5]

The fabrics were woven by hand on a loom (Fig.3) in twill weave 1/3 S and Z direction, with a yarn density of 12 cm^{-1}. Fabric mass per unit area was 210 g/m^2.

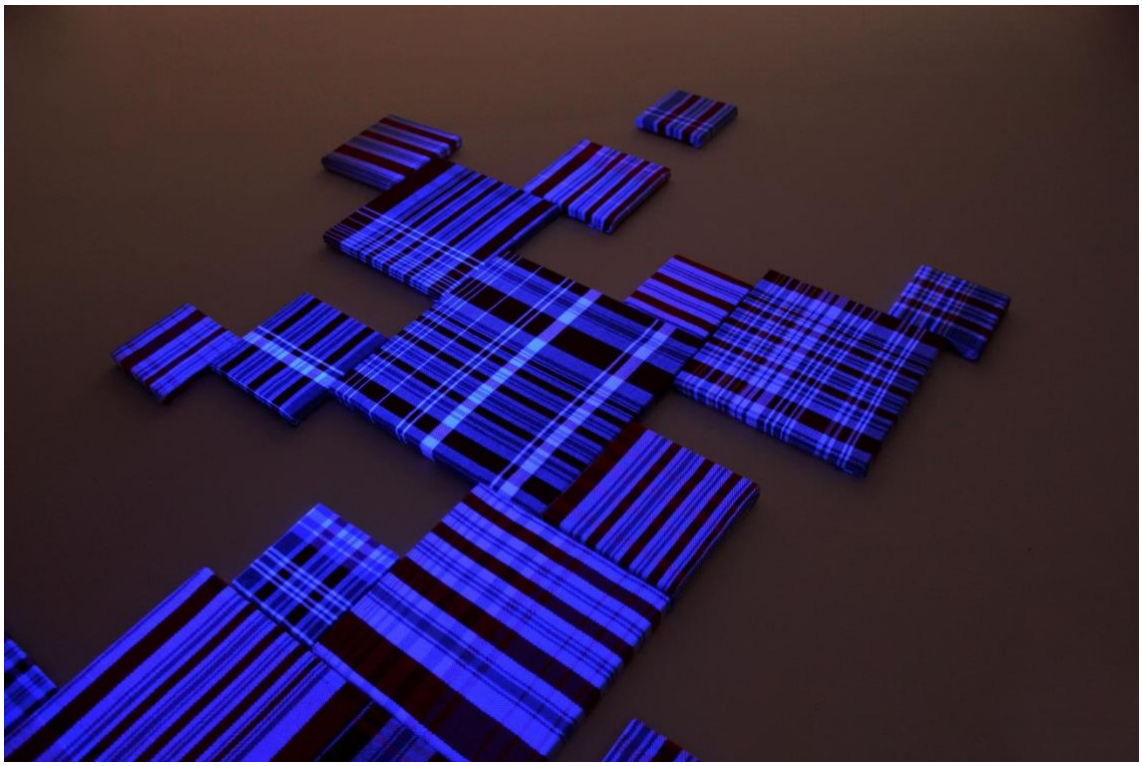
Figure 3: Weaving by the hand on the loom

Prior to weaving, on FWA treated yarns, the spectral remission, R [%] was measured on a spectrophotometer Spectraflash SF 300, Datacolor. The degree of whiteness according to CIE was automatically calculated (W_{CIE}) in accordance with ISO 105-J02:1997 *Textiles - Tests for color fastness - Part J02: Instrumental assessment of relative whiteness,* Yellowing Index (YI) according to DIN 6167:1980 *Description of yellowing of practically white or practically colorless materials,* as well as tint deviation from neutral white standard and its coloristic meanings according to Griesser [6].

4. Results and Installation

The patterns obtained by weaving are shown in Fig.3 and Fig.4.

a.



b.

Figure 4: Textile installation a. made with luminescent yarns, b. under the influence of UV light

The patterns are divided into longitudinal and transverse stripes, from which grids are eventually created. Longitudinal stripes in the weave are created by using a multi-colored warp and a single-colored weft. Transverse stripes are created by using a single-colored base and a multi-colored weft. The use of both systems results in a varied mesh. At the points where the single-colored yarns of both systems meet, purely colored patches are created, and at the points where the warp and weft threads intertwine, patches with secondary, mixed colors are created. The same pattern with multicolor fabrics can be perceived differently depending on the light. When making the fabrics, it was important to vary the weft yarn along the entire length of the fabric and to manipulate the size of the fabrics produced in the luminescent textile installation. As can

be seen, the fabrics take on a different appearance under the influence of UV light. By using yarn treated with FWA, it was possible to obtain a fabric with a varied appearance with expressive stripes and linear patterns.

To achieve such a result, it was necessary to investigate the effect of optical brighteners before weaving. The effect of FWA treatment of white cotton yarn was determined using standard methods. The results in Table 1 show that white cotton yarn is still yellowish even after removal of all impurities and has a whiteness W_{CIE} = 57.2 and YI 11.04, while the remission maximum at 700 nm is 84.8. A higher degree of whiteness was achieved by optical brightening. A low concentration of 1 % Uvitex BHT significantly increases the spectral reflectance to 117.3 and shifts its maximum to the blue part of the spectrum (440 nm), which masks the yellowness. Therefore, the degree of whiteness is 126.3 and the YI value is negative, namely -16.04, which results in a much whiter cotton yarn.

Table 1: Remission maximum (R_{max}), wavelength of achieved maximum remission (λ_{max}), degree of whiteness according to CIE (W_{CIE}), Yellowing Index (YI) and tint deviation (TD) from the white standard of white cotton yarn and FWA treated white cotton yarn

Yarn	R_{max}	λ_{max}	W_{CIE}	YI	TD	Coloristic meaning
White cotton	84.8	700	57.2	11.04	R2	Slightly redder than the white standard
FWA treated cotton	117.3	440	126.3	-16.04	R1	Trace redder than the white standard

5. Conclusion

The designs can be adapted to the production conditions of textiles. This installation consists of several dozen large-format objects that form a visually coherent object in a specific composition, which the author and the viewer are free to modify according to their own ideas. It offers freedom in shaping the final visual image, and the use of luminescent fibres enhances the appeal when UV light is used. The fluorescence contributes to a high degree of whiteness and to the beauty of the design.

Acknowledgments

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THE IMPORTANCE OF PRODUCTION SCHEDULING ON THE EXAMPLE OF MEN'S SHIRTS MANUFACTURING

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Abstract: *Production scheduling is a process of managing time slots in which certain work orders need to be produced. The implementation of production scheduling in the garment industry is based on finding an optimal schedule of machines and devices as well as of processing job operations in order to reduce the manufacturing cycle time. In the present paper is shown an example of scheduling a work order of 280 pieces of men's shirts with the purpose of indicating the importance of this process in the garment industry. Given example clearly illustrates that production scheduling can reduce the manufacturing cycle time, in other words time of cutting, sewing and finishing processes in the garment industry. With that kind of set and managed production time slots, the difficulties with meeting the delivery dates are avoided, which represents a great contribution to the organisation and the business of the garment industry.*

Keywords: *production scheduling; garment industry; manufacturing cycle time; delivery date*

1. Introduction

Fashion (lat. *facere*: to make, to do) can be defined as a change in clothing styles and appearance that is accepted by certain groups of people and which, from a sociological point of view, represents a pattern of signs, social values and norms as well as the way of acquiring collective and individual character [1]. Moreover, fashion symbolises one of the cultural and social phenomena involved in omnipresent individualisation of lifestyles by determining people's *modus viviendi* and, in a way, becoming part of their identity. This social trend and the constant increase in the speed at which fashion trends change, driven by the consumer society, demand a convenient and quick response from the garment industry.

Manufacturing companies are responding to these demands by increasing the number of product variants in their collections, reducing time to market, shortening production cycles and maintaining a high level of quality while minimising investment costs [2, 3].

A major role in this market-oriented production is played by production scheduling, which synchronises time slots in which certain work orders have to be produced and finds an optimal schedule for machines and devices as well as for the processing of job operations at workstations. Even so, the sequence of the technological operations in the production of a particular garment must be taken into account.

By shortening the manufacturing cycle time, production scheduling also shortens flow time, reduces production costs and eliminates possible tardiness or earliness of delivery.

This paper presents an example of production scheduling for a work order for a men's shirt (280 pieces).

2. Production scheduling

Production scheduling requires operation breakdowns and assembly plans for the three main technological processes of garment production (cutting, sewing and finishing). Due to the operation breakdown, the flow charts for each technological process of garment production – cutting, sewing and finishing – are created. The created flow charts of the operations provide a graphical insight into the interdependence of the operations, i.e. their immediate predecessors and successors. This paper demonstrates a flow chart of the technological operations for men's shirt manufacturing (Fig. 1), which must be defined in the computer system (Fig. 2). Table 1 shows the standard times of the technological operations for men's shirt production with the required machine and device type.

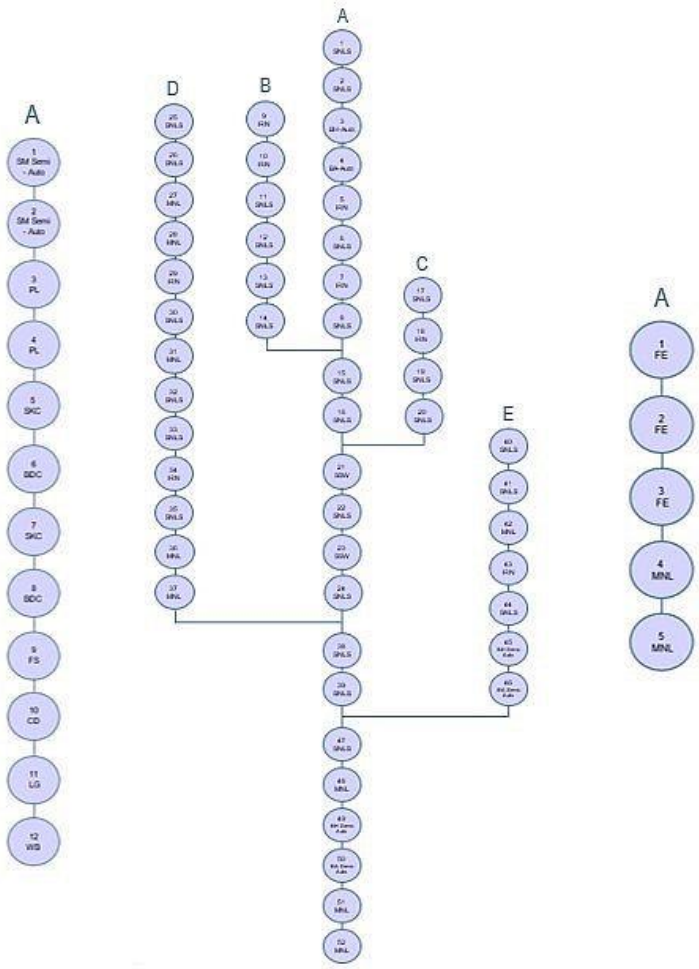
Table 1: The standard operation times for the production of men's shirt with the required type of machines and devices

Ope. No.	Type of machine	Standard operation time (s)	Ope. No.	Type od machine	Standard operation time (s)	Ope. No.	Type of machine	Standard operation time (s)
TECHNOLOGICAL PROCESS OF CUTTING			11.	SNLS	6	35.	SNLS	19
1.	SM Semi-Auto	35	12.	SNLS	31	36.	MNL	9
2.	SM Semi-Auto	20	13.	SNLS	33	37.	MNL	7
3.	PI	6	14.	SNLS	31	38.	SNLS	40
4.	PI	5	15.	SNLS	23	39.	SNLS	37
5.	SKC	18	16.	SNLS	28	40.	SNLS	16
6.	BDC	33	17.	SNLS	22	41.	SNLS	49
7.	SKC	6	18.	IRN	18	42.	MNL	15
8.	BDC	52	19.	SNLS	33	43.	IRN	15
9.	FS	20	20.	SNLS	52	44.	SNLS	18
10.	CD	2	21.	SSM	70	45.	BH Semi-Auto	9
11.	LG	66	22.	SNLS	50	46.	BA Semi-Auto	10
12.	WB	77	23.	SSM	45	47.	SNLS	53
TECHNOLOGICAL PROCESS OF SEWING			24.	SNLS	29	48.	MNL	7
1.	SNLS	24	25.	SNLS	14	49.	BH Semi-Auto	14
2.	SNLS	22	26.	SNLS	36	50.	BA Semi-Auto	14
3.	BH Auto	31	27.	MNL	14	51.	MNL	131
4.	BA Auto	26	28.	MNL	14	52.	MNL	58
5.	IRN	16	29.	IRN	20	**TECHNOLOGICAL PROCESS OF FINISHING**		
6.	SNLS	10	30.	SNLS	22	1.	FE	26
7.	IRN	18	31.	MNL	11	2.	FE	20
8.	SNLS	39	32.	SNLS	9	3.	FE	19
9.	IRN	18	33.	SNLS	28	4.	MNL	91
10.	IRN	3	34.	IRN	16	5.	MNL	13
TOTAL STANDARD OPERATION TIME FOR MEN'S SHIRT:						**1892 s**		

Legend of machines and devices:

Type of machine/device	Description
SM Semi-Auto	semi-automatic spreading mashine
PI	plate iron for adhesive paper
SKC	straight knife cutting machine
BDC	band knife cutting machine
FS	fusing press mashine
CD	cloth drill machine
LG	label gun
WB	working bench (for bundling)
SNLS	single needle lockstitch machine (plain sewing machine)
SSM	special sewing machine
BH Auto	automatic buttonhole sewing machine
BA Auto	automatic button attaching machine
IRN	ironing table with steam generator and steam iron for interphase ironing
MNL	manual
BH Semi-Auto	semi-automatic buttonhole sewing machine
BA Semi-Auto	semi-automatic button attaching machine
FE	finishing equipment

Figure 1 shows the assembly line of the technological processes of cutting, sewing and finishing men's shirt. In the cutting and finishing processes of men's shirt production, there is only one main assembly line (A), while in the sewing process, in addition to the main assembly line (A), there are also four auxiliary assembly lines (B, C, D and E) in which the main parts of the men's shirt are produced (back part, sleeves, collar and cuffs).



a. b. c.

Figure 1: Flow chart of technological operations for a. cutting, b. sewing, c. finishing of a men's shirt

Figure 2 illustrates how the technological operations for the production of a men's shirt are entered into the production scheduling computer system Term. For each technological operation, "successors" (technological operations that succeed) and "predecessors" (technological operations that precede) must be determined.

Nalog	Oznaka	Proizvod	Stanje	Akt.	---->	Nalog	Oznaka	Proizvod	Akt.	Pomak.	Od kada	Stanje
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	10		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	20	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	20		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	30	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	30		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	40	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	40		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	50	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	50		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	60	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	60		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	70	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	70		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	80	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	80		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	90	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	90		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	100	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	100		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	110	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	110		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	120	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	120		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	130	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	130		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	140	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	140		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	150	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	150		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	160	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	160		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	170	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	170		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	180	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	180		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	190	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	190		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	200	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	200		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	210	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	210		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	220	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	220		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	230	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	230		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	240	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	240		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	250	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	250		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	260	0.00	Od završetka	Novi nalog
68	FP (ASSEMB	Men's shirt (sewing and finishing)	Novi nalog	260		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	270	0.00	Od završetka	Novi nalog
72	BP	Back part	Novi nalog	10		72	BP	Back part	20	0.00	Od završetka	Novi nalog
72	BP	Back part	Novi nalog	20		72	BP	Back part	30	0.00	Od završetka	Novi nalog
72	BP	Back part	Novi nalog	30		72	BP	Back part	40	0.00	Od završetka	Novi nalog
72	BP	Back part	Novi nalog	40		72	BP	Back part	50	0.00	Od završetka	Novi nalog
72	BP	Back part	Novi nalog	50		72	BP	Back part	60	0.00	Od završetka	Novi nalog
72	BP	Back part	Novi nalog	60		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	90	0.00	Od završetka	Novi nalog
73	SL	Sleeves	Novi nalog	10		73	SL	Sleeves	20	0.00	Od završetka	Novi nalog
73	SL	Sleeves	Novi nalog	20		73	SL	Sleeves	30	0.00	Od završetka	Novi nalog
73	SL	Sleeves	Novi nalog	30		73	SL	Sleeves	40	0.00	Od završetka	Novi nalog
73	SL	Sleeves	Novi nalog	40		68	FP (ASSEMBLY)	Men's shirt (sewing and finishing)	110	0.00	Od završetka	Novi nalog
74	CL	Collar	Novi nalog	10		74	CL	Collar	20	0.00	Od završetka	Novi nalog
74	CL	Collar	Novi nalog	20		74	CL	Collar	30	0.00	Od završetka	Novi nalog

Figure 2: Interdependence of technological operations in the production of men's shirt in the computer system Term

In addition to the necessary technical documentation for the technological process of manufacturing men's shirts, it is important to define the time period, i.e. the time for processing the planned work order. Considering that the daily working time is 27,000 seconds (450 minutes or 7.5 hours) and the standard operation time for men's shirt is 1892 seconds, it is determined that 19.6 working days are required to complete a work order of 280 men's shirts.

In this paper is given an example of production planning and scheduling of a work order of 280 men's shirts for January 2024. With respect to two public holidays in this month (1.1.2024 New Year and 6.1.2024 Epiphany), a redistribution of working time was introduced in such a way that days off were introduced from 2.1.2024 to 5.1.2024. In order to compensate the working time fund, the working time was redistributed over four working Saturdays (Fig. 3), namely two working Saturdays in January and two working Saturdays in February. According to the calculation, 19.6 working days are required to complete the work order of 280 men's shirts, in such a way that the cutting of the work order is planned in the period from 8th January 2024 to 11th January 2024 (3.5 days), sewing in the period from 11th January 2024 to 29th January 2024 (14.3 days) and finishing from 30th January 2024 to 31st January 2024 (1.8 days).

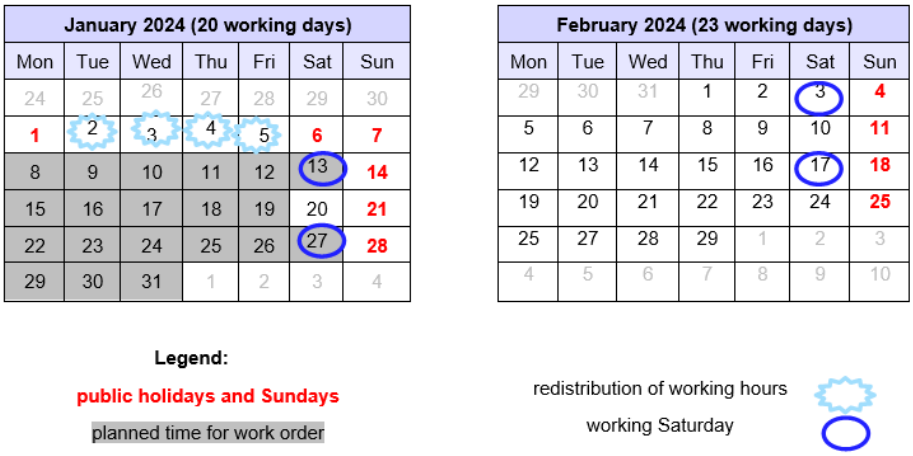
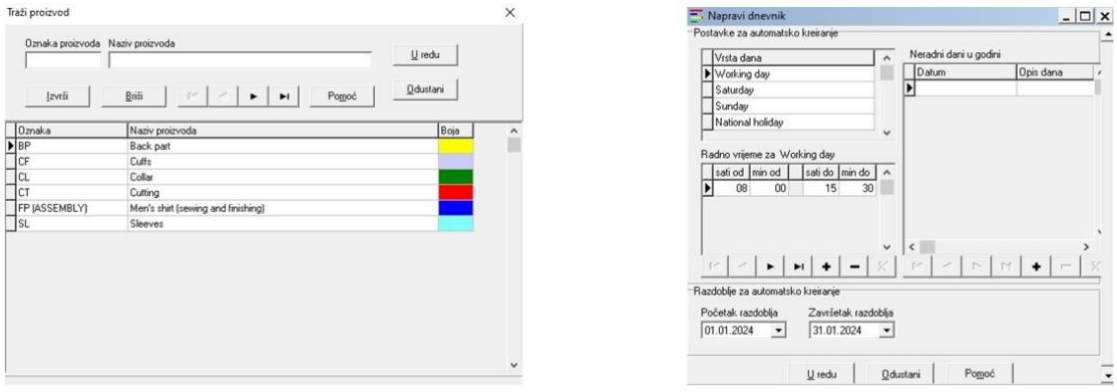


Figure 3: Production planning

Once all the necessary data has been calculated, the next step is to transfer it to the computer system Term intended for production scheduling (Fig. 4).



a. b.

Figure 4: Data input into the computer system for production scheduling Term: a. name of the main and auxiliary assembly lines, b. available machine and device capacities

3. Results

The results of production scheduling for a work order of 280 men's shirts are visualised through Gantt charts. Gantt charts are visual representations of sequences and time needed for completing each activity in a process or project over a given period of time, named after the American engineer Henry L. Gantt.

Gantt charts are generally used as:

- utilisation charts (human or machine resources),
- diagrams for planning and controlling the sequence of technological operations on machines and devices,
- load charts,
- tracking diagrams (execution of orders) [4].

Gantt charts, obtained by scheduling the production of work order of men's shirt, show the schedule for processing the technological operations on the machines and devices and the utilisation of the specific machines/devices. This data can be tracked for all resources (Fig. 5) or individually for each resource (Fig. 6).

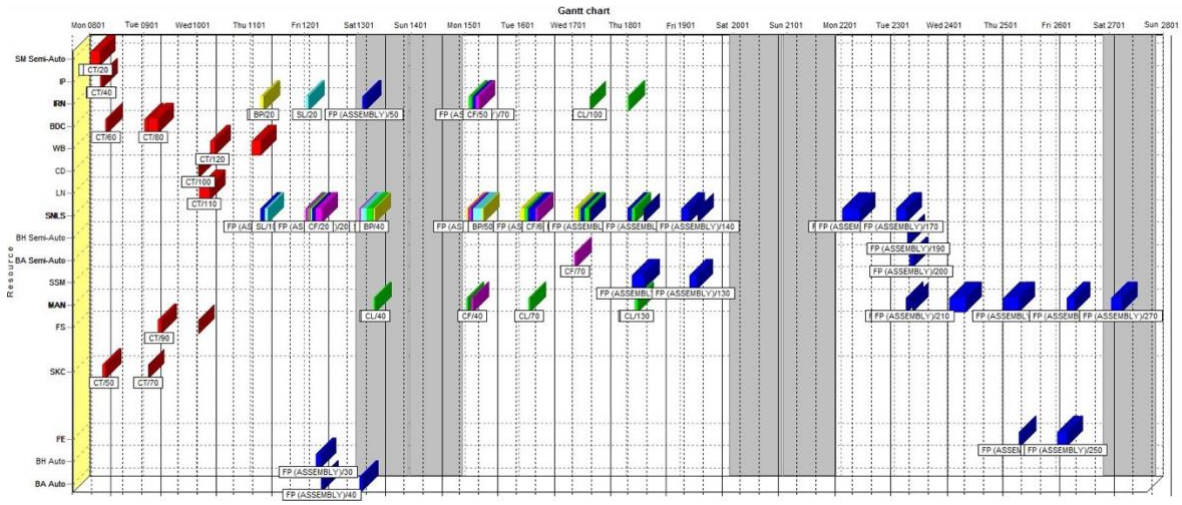


Figure 5: Gantt chart of the men's shirt production scheduling

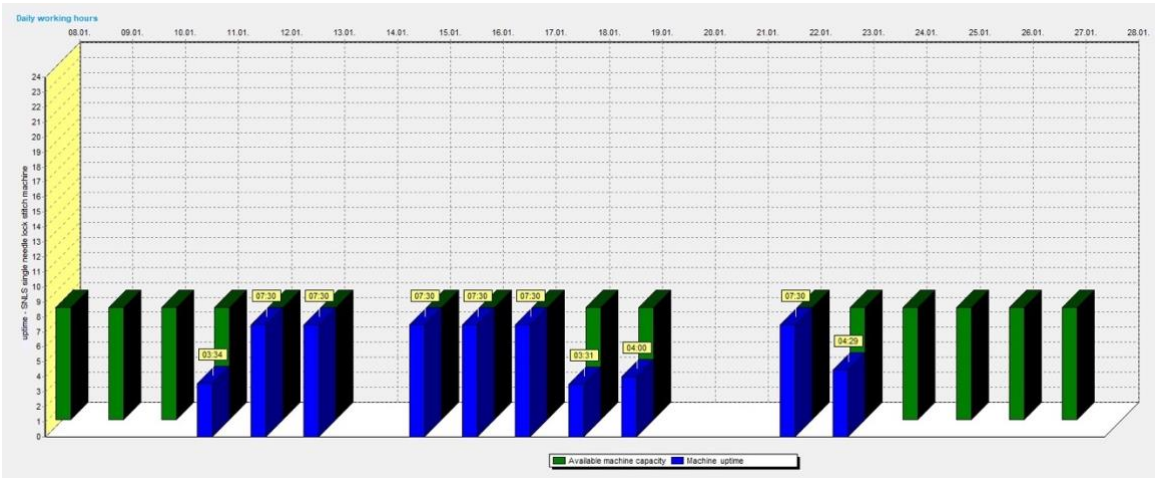


Figure 6: Gantt chart showing the utilisation of the single needle lockstitch machine

The results of this study show that after scheduling the production in the computer system Term, the time for the production of 280 men's shirts can be completed three days earlier then planned, i.e. 16.6 days are required to process the above mentioned work order (Fig. 5).

4. Conclusion

Scheduling the work order for 280 pieces of men's shirt has led to a reduction in the manufacturing cycle time, i.e. the time for cutting, sewing and finishing the men's shirts. Determining the dependencies between the technological operations and the order of their processing, as well as the attempt of computer system Term to optimise machine utilisation rate, led to the reduce of time needed to process the word order from

19.6 working days to an optimised 16.6 working days, which represents a major saving and an increase in profits.

The application of this process in the garment industry contributes to the optimisation of garment production and to meeting delivery deadlines for sale orders, which ensures the competitiveness of the production organisation, increases profits and ultimately, market conformity.

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VAŽNOST TERMINIRANJA NA PRIMJERU PROIZVODNJE MUŠKIH KOŠULJA

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Sažetak: *Terminiranje proizvodnje je postupak usklađivanja vremenskih termina u kojima određeni radni nalozi trebaju biti proizvedeni. Primjena terminiranja u odjevnoj industriji temelji se na pronalasku optimalnog rasporeda strojeva i uređaja te izvođenja tehnoloških operacija s ciljem smanjenja ciklusa proizvodnje. U radu je prikazan primjer terminiranja radnog naloga od 280 komada muških košulja s ciljem ukazivanja na važnost ovog postupka u odjevnoj industriji. Prikazani primjer jasno ukazuje kako se terminiranjem može skratiti ciklus proizvodnje odnosno postići kraće vrijeme izrade kroz pojedine tehnološke procese krojenja, šivanja i dorade. S tako postavljenim i usklađenim vremenskim terminima izbjegavaju se poteškoće sa zadanim rokovima isporuke što predstavlja velik doprinos organizaciji i poslovanju odjevne industrije.*

Ključne riječi: *terminiranje proizvodnje; odjevna industrija; ciklus proizvodnje; rok isporuke*

1. Uvod

Moda (lat. *modus*: način, mjera) se može definirati kao promjena stilova odijevanja i izgleda koje usvajaju određene skupine ljudi, a koja s gledišta sociologije predstavlja sustav znakova, društveni obrazac vrijednosti te način stjecanja kolektivnog i individualnog karaktera [1]. Također, moda predstavlja jedan od kulturnih i društvenih fenomena koji danas u sveprisutnoj individualizaciji životnog stila, sudjeluje u određivanju način života čovjeka te na neki način postaje dio njegova identiteta. Taj društveni trend zajedno sa stalnim ubrzanjem ritma modnih promjena koje diktira potrošačko društvo, zahtijeva od odjevne industrije prikladan i brz odgovor.

Odgovor proizvodnih organizacija na zadane zahtjeve tržišta očituje se u proširenju asortimana odjevnih predmeta, skraćenju vremena plasiranja odjevnog predmeta na tržište kao i vremena ciklusa proizvodnje uz istovremeno očuvanje visoke razine kvalitete proizvoda te smanjenih troškova ulaganja [2,3].

Značajnu ulogu u navedenom procesu ima terminiranje proizvodnje kojim se usklađuju vremenski termini u kojima određeni radni nalozi trebaju biti proizvedeni te pronalazi optimalan raspored strojeva i uređaja kao i izvođenja tehnoloških operacija na radnim mjestima. Pritom se treba poštivati redoslijed izvođenja tehnoloških operacija potrebnih za izradu određenog odjevnog predmeta.

Uz smanjenje ciklusa proizvodnje, terminiranjem se skraćuje i vrijeme protoka materijala kroz proizvodni proces, smanjuju se troškovi proizvodnje te uklanjaju moguća kašnjenja ili preuranjenost isporuke.

U ovom radu je prikazan primjer terminiranja proizvodnje na radnom nalogu muške košulje (280 kom).

2. Terminiranje proizvodnje

Za terminiranja proizvodnje potrebni su planovi tehnoloških operacija i planovi montaže za sve tehnološke procese (krojenje, šivanje i doradu). Na temelju plana tehnoloških operacija izrađuju se strukturni prikazi planova montaže za tehnološke procese krojenja, šivanja i dorade. Načinjeni strukturni prikazi planova montaže daju slikovni uvid u međusobnu ovisnost tehnoloških operacija, odnosno njihove neposredne prethodnike i sljedbenike. U radu je prikazan strukturni prikaz planova montaže za proizvodnju muške košulje (sl. 1) koje je potrebno definirati u računalnom sustavu (sl. 2). Tablica 1 prikazuje vremenske normative tehnoloških operacija za izradu muške košulje s oznakama sredstva rada.

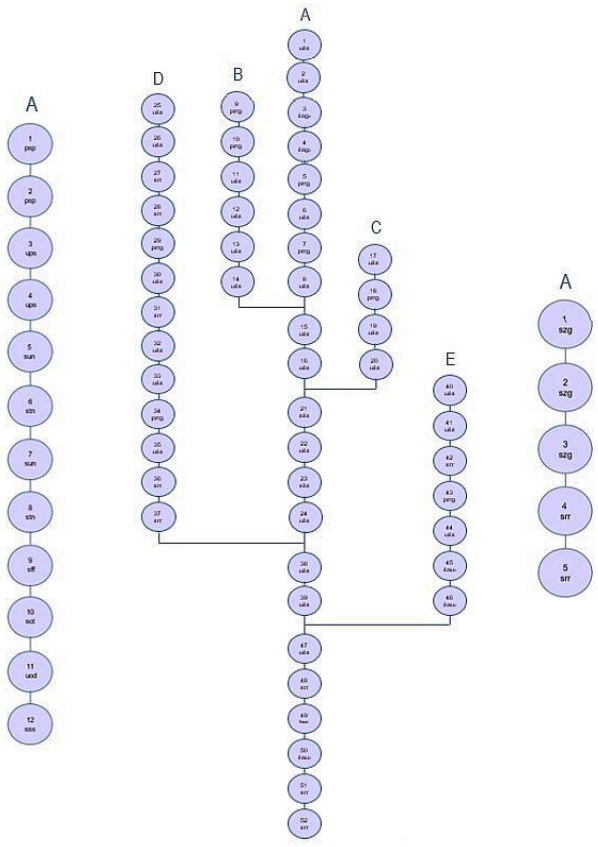
Tablica 1: Vremenski normativi tehnoloških operacija za izradu muške košulje s oznakama sredstva rada

Red. br. tehn. oper.	Oznaka sredstva rada	Vrijeme izrade (s)	Red. br. tehn. oper.	Oznaka sredstva rada	Vrijeme izrade (s)	Red. br. tehn. oper.	Oznaka sredstva rada	Vrijeme izrade (s)
TEHNOLOŠKI PROCES KROJENJA			11.	ušs	6	35.	ušs	19
1.	psp	35	12.	ušs	31	36.	srr	9
2.	psp	20	13.	ušs	33	37.	srr	7
3.	ups	6	14.	ušs	31	38.	ušs	40
4.	ups	5	15.	ušs	23	39.	ušs	37
5.	sun	18	16.	ušs	28	40.	ušs	16
6.	stn	33	17.	ušs	22	41.	ušs	49
7.	sun	6	18.	pmg	18	42.	srr	15
8.	stn	52	19.	ušs	33	43.	pmg	15
9.	sff	20	20.	ušs	52	44.	ušs	18
10.	sot	2	21.	sšs	70	45.	$šau_1$	9
11.	uod	66	22.	ušs	50	46.	$šau_2$	10
12.	sss	77	23.	sšs	45	47.	ušs	53
TEHNOLOŠKI PROCES ŠIVANJA			24.	ušs	29	48.	srr	7
1.	ušs	24	25.	ušs	14	49.	$šau_1$	14
2.	ušs	22	26.	ušs	36	50.	$šau_2$	14
3.	$šag_1$	31	27.	srr	14	51.	srr	131
4.	$šag_2$	26	28.	srr	14	52.	srr	58
5.	pmg	16	29.	pmg	20	**TEHNOLOŠKI PROCES DORADE**		
6.	ušs	10	30.	ušs	22	1.	szg	26
7.	pmg	18	31.	srr	11	2.	szg	20
8.	ušs	39	32.	ušs	9	3.	szg	19
9.	pmg	18	33.	ušs	28	4.	srr	91
10.	pmg	3	34.	pmg	16	5.	srr	13
UKUPNO VRIJEME ZA IZRADU MUŠKE KOŠULJE:						**1892 s**		

Legenda sredstva rada:

Oznaka sredstva rada	Vrsta sredstva rada
psp	poluautomatski stroj za polaganje krojnih slojeva
ups	uređaj za prijenos krojne slike na krojnu naslagu
sun	stroj s udarnim nožem
stn	stroj s tračnim nožem
sff	stroj za frontalno fiksiranje
sot	stroj za označavanje sastavnih točaka
uod	uređaj za obilježavanje iskrojenih dijelova
sss	stol za sastavljanje svežnjeva
ušs	univerzalni šivaći stroj
sšs	specijalni šivaći stroj
$šag_1$	šivaći agregat za izradu rupica
$šag_2$	šivaći agregat za našivanje gumbi
pmg	parni stol za međufazno glačanje
srr	sredstvo ručnog rada
$šau_1$	šivaći automat za izradu rupica
$šau_2$	šivaći automat za našivanje gumbi
szg	sredstvo za završno glačanje

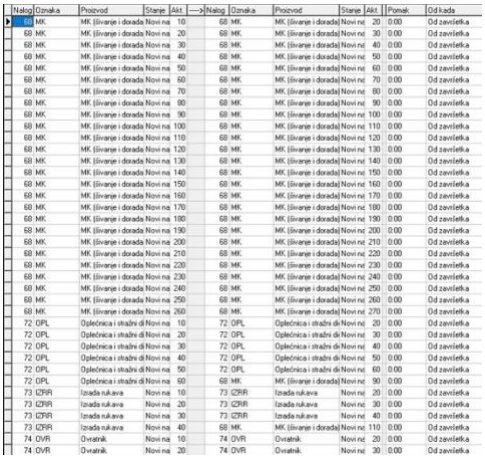
Struktura plana montaže muške košulje (sl. 1) prikazuje montažne linije u tehnološkim procesima krojenja, šivanja i dorade muške košulje. Tehnološki procesi krojenja i dorade imaju samo glavnu montažnu liniju (A), dok u tehnološkom procesu šivanja uz glavnu montažnu liniju (A), postoje i četiri pomoćne montažne linije (B, C, D i E) u kojima se izrađuju pojedini dijelovi muške košulje (oplećnica i stražnji dio, rukavi, ovratnik i orukvice).



a. b. c.

Slika 6: Struktura plana montaže tehnoloških procesa: a. krojenja, b. šivanja, c. dorade muške košulje

Na slici 2 prikazan je unos tehnoloških operacija izrade muške košulje u računalni sustav Term koji se koristi za terminiranje proizvodnje. Za svaku tehnološku operaciju definirani su „sljedbenici“ (tehnološke operacije koje slijede) i „prethodnici“ (tehnološke operacije koje prethode).



Slika 7: Prikaz međusobne ovisnosti tehnoloških operacija proizvodnje muške košulje u računalnom sustavu Term

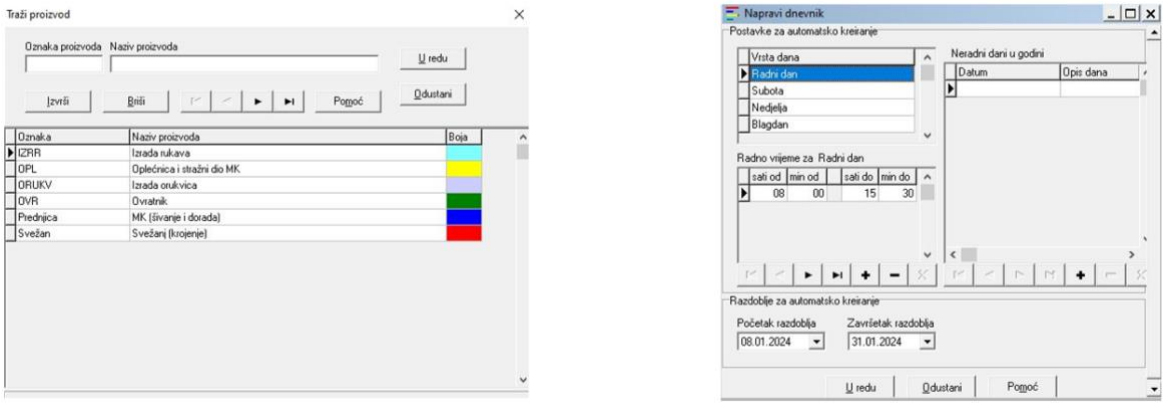
Uz potrebnu tehničku dokumentaciju za tehnološki proces proizvodnje muških košulja, nužno je definirati i vremensko razdoblje odnosno vrijeme za izradu radnog naloga. S obzirom da dnevno radno vrijeme iznosi 27 000 sekundi (ili 450 minuta ili 7,5 sati), a vrijeme za izradu jedne muške košulje 1 892 sekunde, shodno navedenom za završetak radnog naloga od 280 muških košulja potrebno je 19,6 radnih dana.

U radu je dan primjer planiranja i terminiranja proizvodnje radnog naloga od 280 muških košulja za mjesec siječanj 2024. godine. U navedenom mjesecu su dva državna praznika (1.1.2024. Nova godina i 6.1.2024. Sveta tri kralja) i zbog toga je uvedena preraspodjela radnog vremena na način da su uvedeni slobodni dani u razdoblju od 2.1.2024. do 5.1.2024. Kako bi se nadoknadio fond radnih sati radno vrijeme je preraspoređeno na četiri radne subote (sl. 3) i to dvije radne subote u siječnju i dvije radne subote u veljači. Prema navedenom

izračunu za proizvodnju radnog naloga od 280 muških košulja potrebno je 19,6 radnih dana, na način da je krojenje radnog naloga planirano u razdoblju od 8.1.2024. do 11.1.2024. godine (3,5 dana), šivanje u razdoblju od 11.1.2024. do 29.1.2024. godine (14,3 dana), a dorada u razdoblju od 30.1.2024. do 31.1.2024. godine (1,8 dana).

Slika 8: Planiranje proizvodnje

Nakon izračuna svih potrebnih podataka, slijedi unos u računalni sustav Term namijenjen terminiranju proizvodnje, (sl. 4).



a. b.

Slika 9: Unos podataka potrebnih za terminiranje proizvodnje u računalnom sustavu Term: a. naziv montažnih i predmontažnih linija, b. dostupnosti sredstava rada

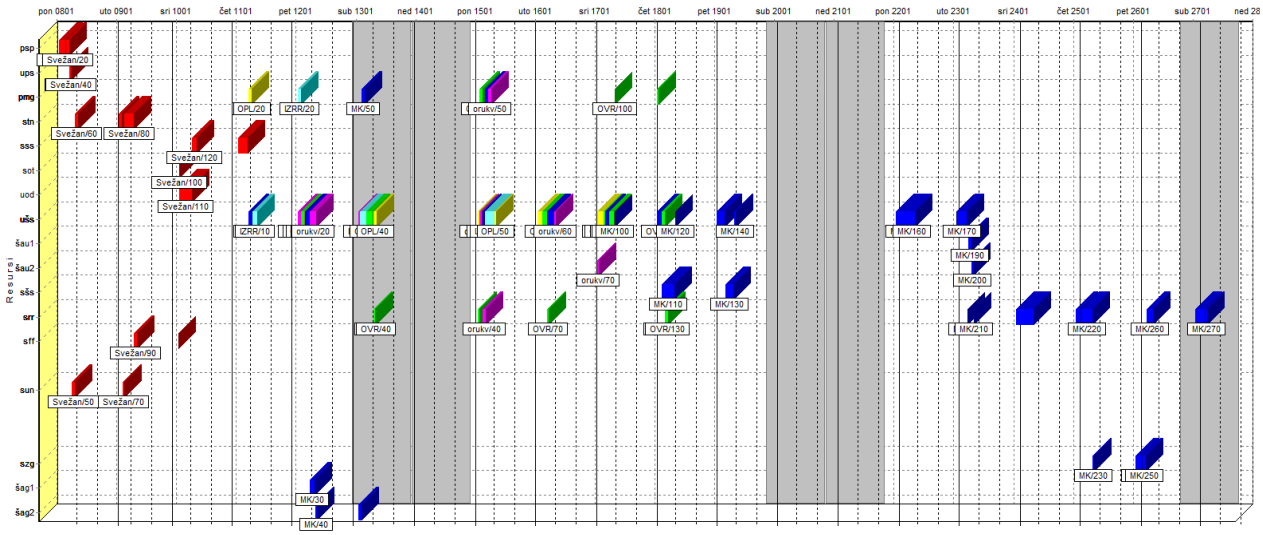
3. Rezultati

Rezultati terminiranja proizvodnje radnog naloga od 280 komada muških košulja prikazani su Ganttovim dijagramima (gantogramima). Ganttovi dijagrami su grafički prikazi redoslijeda i trajanja pojedinih aktivnosti nekog procesa ili projekta u određenom vremenskom razdoblju nazvani prema američkom inženjeru Henryju L. Ganttu.

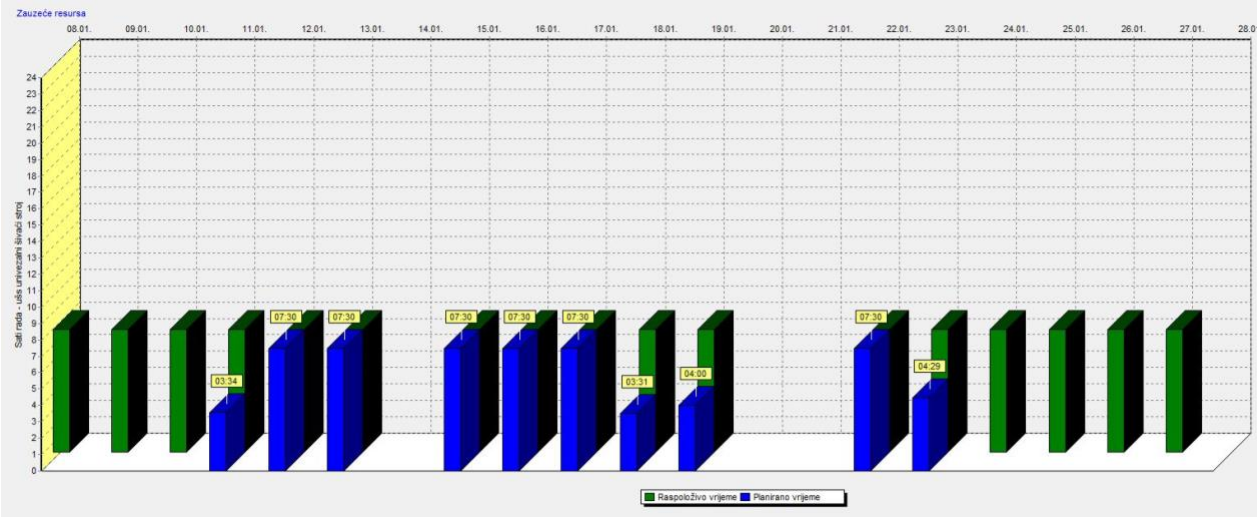
Gantogrami najčešće prikazuju:

- iskorištenje radnog vremena čovjeka i stroja,
- raspored tehnoloških operacija po strojevima,
- pregled opterećenja radnika,
- stupanj proizvodnosti [5].

Gantogrami dobiveni terminiranjem proizvodnje radnog naloga muških košulja prikazuju raspored izvođenja tehnoloških operacija po strojevima i stupanj iskorištenja sredstva rada. Navedeni podaci mogu se pratiti zbirno za sva sredstva rada (sl. 5.) ili pojedinačno po određenom sredstvu rada (sl. 6.).



Slika 10: Gantogram rasporeda izvođenja tehnoloških operacija



Slika 11: Gantogram stupnja iskorištenja univerzalnog šivaćeg stroja

Na temelju dobivenih rezultata može se uočiti kako je primjenom terminiranja u računalnom sustavu Term skraćeno vrijeme za proizvodnju 280 muških košulja u odnosu na planirano vrijeme za tri radna dana odnosno da je za izradu navedenog radnog naloga potrebno 16,6 radnih dana (sl. 5).

4. Zaključak

Terminiranje radnog naloga od 280 komada muških košulja rezultiralo je skraćenjem ciklusa proizvodnje odnosno smanjenjem trajanja tehnoloških procesa krojenja, šivanja i dorade. Određivanjem ovisnosti između tehnoloških operacija te njihovog slijeda izvođenja kao i nastojanje računalnog sustava Term da

optimizira stupanj iskorištenja svih strojeva, daje rezultat skraćenja planiranog vremena od 19,6 radnih dana na optimalnih 16,6 radnih dana što predstavlja veliku uštedu i povećava dobit.

Primjena ovog procesa u odjevnoj industriji pridonosi se optimizaciji procesa proizvodnje odjeće kao i ispunjenju ugovorenih termina isporuke, čime se osigurava konkurentnost proizvodne organizacije, povećanje dobiti i u konačnici opstanak na tržištu.

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“WHAT’S UNDER THE HOODIE?” REDESIGN OF A HOODIE AS AN INSPIRATION FOR STAGE CLOTHES

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Abstract: *This paper delves into the innovative redesign of a quintessential garment: The Hoodie intended for the dynamic requirements of stage performance. The reinvented hoodie stands out due to its multifunctionality, sustainability, and aesthetic appeal. With a commitment to close to zero percent textile waste, the design places a strong emphasis on environmentally conscious fashion, making it a responsible and forward-thinking choice. The redesigned hoodie is crafted to cater to the unique needs of stage performers, especially the band "Trivan." Beyond its visual appeal, the hoodie incorporates features that ensure mobility, durability, and comfort. Its multifunctional design includes advanced textiles for ergonomic fit, sweat-wicking properties for comfort, and integrated tech pockets for modern utility. Elements inspired by "Trivanizam" spiritual philosophy are subtly integrated, allowing the garment to communicate deeper narratives while maintaining its primary focus on functionality and design. The essence of this paper revolves around transforming the conventional hoodie into a stage-ready, multifunctional garment. By intertwining sustainable practices with advanced design techniques and multifunctionality, this redesigned hoodie promises optimal performance for artists on stage while also championing eco-conscious fashion.*

Keywords: *The hoodie; sustainable design*; *zero waste; multifunctionality; CLO3D; 3D printing*

1. Introduction

1.1. 3D tools in digital fashion design

Modern industrial society deals with the global problems of waste production and consequently waste reduction, hence tools that enable designers to address issues such as waste within the context of the design process are essential [1]. The emergence of disruptive innovations have changed business models used within the fashion industry, such as new technologies including 3D-printed fashion, zero-waste garments, and those designed for circularity [2]. 3D-printing can best be defined as an automated additive manufacturing process that builds a product by depositing material into successive layers until it is complete; products are built on a layer-by-layer basis, through a series of cross-sectional slices. The 3D machine dispenses a thin layer of liquid resin and uses a computer-controlled ultraviolet laser to harden each layer in the specified cross-section pattern. The process uses CAD software and additive manufacturing-based technologies to print objects through fusing a variety of materials with a laser using such raw materials as plastics; resins; super alloys, such as nickel-based chromium and cobalt chrominium; stainless steel; titanium; polymers; and ceramics. Within the fashion industry automated additive manufacturing (3D-printing) is predominantly used to visualise and test new product developments for fit and form [2]. The advantages of 3D printing include the ability to economically build custom products in limited production runs, the ability to share designs and outsource manufacturing, and the speed and ease of designing and modifying products [3]. The term Digital fashion refers to a practice that produces three-dimensional virtual clothing as prototypes/sample simulations for possible physical garments, datafied digital representations, or end-products in themselves, worn only in virtual spaces where dressed avatars are fluidly enmeshed with our physical bodies and identities [4]. Digital tools used for clothing visualisation and simulation such as CLO3D fashion design software combine the processes of patternmaking, imagery production, and fashion design in order to visualize the garment [5, 6]. Therefore, 3D simulation technology can improve the technical aspects of the design process, assisting both designers as well as manufacturers when it comes to the evaluation of fit and size by using the same virtual models.

1.2. A Hoodie

A hoodie is a type of clothing associated with the history of the styles of a number of subcultures that have had a profound influence on today's music and style culture; from rap and hip hop musicians to skate, snowboard and urban culture in the 1990s [1, 7] The word 'hoodie' as a slang word meaning 'a hooded garment' officially entered The Oxford English Dictionary and The Collins English Dictionary in 2005 and 2007, respectively [1, 8, 9]. The hoodie has its roots in sports clothing and workwear – according to their utilitarian function – providing warmth and comfort to the wearer [7, 10]. The hoodie as we know it today was promoted by The Champion in the 1930s as a practical solution for athletes [7]. Hooded clothing has a long and varied

history within fashion history, appearing within different cultures and religions. Lou Stoppard, curator of the exhibition *The Hoodie* (1 December 2019-23 August 2020, Nieuwe Instituut, Rotterdam), which addresses contemporary debates and issues surrounding the hoodie, while also contextualizing the hoodie in fashion history and highlighting the different legacies of garments with hoodie, points out: "As a garment, the hoodie defines our times – it tells many stories about social inequality, subcultures, police brutality, racism, privacy, fear and, in turn, fashion. It is fashion's last truly political garment – a garment that you can lose your life for wearing, a garment that can incite fear, jealously, comradery and even fury in others [7]."
”It is perhaps the only garment that causes such publicized levels of agitation now that formerly provocative items such as slogan t-shirts and black leather jackets have become ubiquitous across the high-street [7].” It is ironic that parallel to stories in the media connected the hoodie with violence and gang culture, magazine covers promote the item as an ideal style choice for men and women, i.e. the hoodie is a symbol of the wide-spread casualization of fashion, where trainers, streetwear and sportswear are key items, and the tracksuit is as relevant and accepted as a luxury look at the suit [7]. This research deals with the redesign and interpretation of a hoodie, i.e. a redesign of the iconic garment into clothes for the heavy metal band stage performance according to their preferences; with characteristics of multifunctionality, practicality, comfort and ergonomics. Zero-waste concept and methods are used in the context of clothing design and construction to meet certain standards; production of a garment with zero percent waste where the pieces of a pattern of a design are fitted together in such a way that no fabric is wasted during the cutting [10]. Also, considering lifestyle and attitudes of the users – "Trivan" band, and considering the symbolism of clothes as a tool for non-verbal communication, the design features of clothes for stage performance that can be considered as an indicator or sign of the wearer's identity are emphasized. New technologies - 3D printer and 3D softwares such as CLO3D, Blender and Tinkercad were used together with in order to design the garment for stage performance. Realistic simulation and visualisation of a garment according to the bend's preferences is created in CLO3D fashion design software and the 3D print was designed in Blender and Tinkercad.

2. Materials and methods

2.1. Textile Selection

Eco-Friendly fabrics selection inspired by the findings in [11] regarding the acoustic properties of knitted fabrics made from garment waste, emphasizing sustainability and sound absorption is shown on Fig 1.

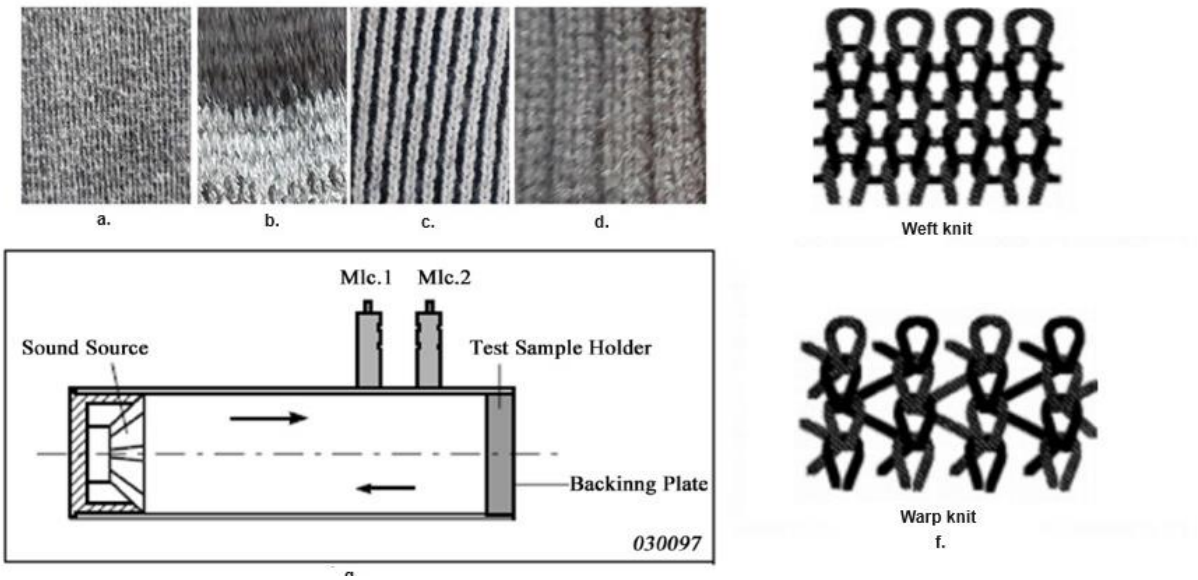


Figure 1: Specimens used for acoustic test, a nature fiber, b & c manmade fibers and blended fibers, e & f type of knitted fabric structure where e. represents weft knit, f represents warp knit, g drawing model of acoustic properties test with impedance tube [11]

Advanced textiles based on [12] weft knitted fabrics with noise absorption properties are chosen for comfort and performance enhancement.

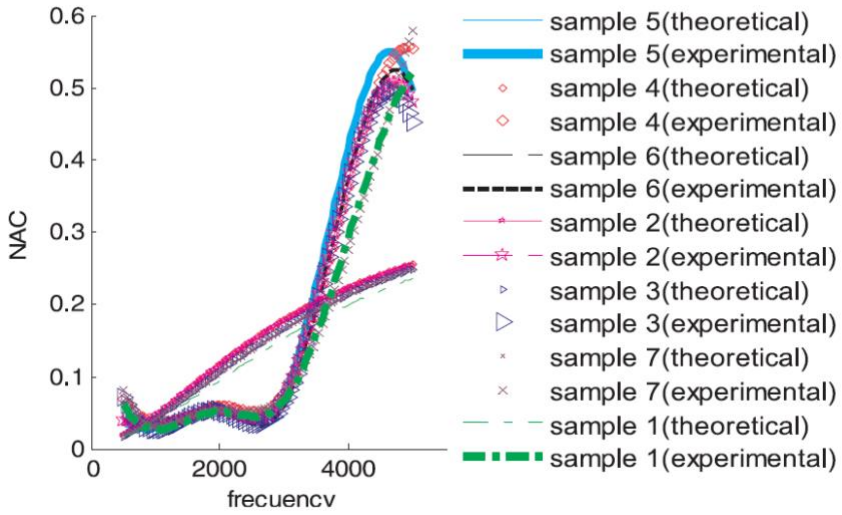
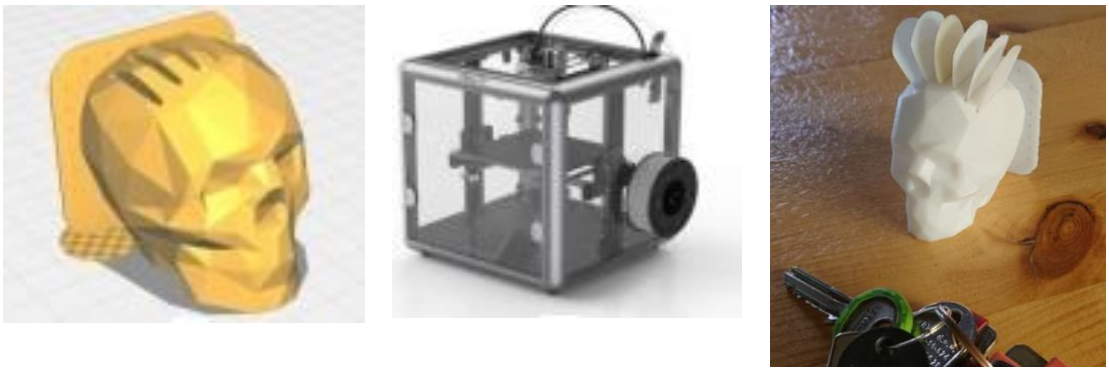


Figure 2: The fluctuations in the Noise Absorption Coefficient (NAC) across various frequencies in samples featuring varying quantities of knit and miss stitches, based on experimental and theoretical data [13]

Reinforcement materials for high-stress areas, informed by [13], emphasizing porous absorbers for sound dampening and durability are chosen for the garment.

2.2. 3D printing materials and method

Based on previous approaches to garment 3D printing and design [14,15] the process began with the conceptualization of a skull-shaped accessory, featuring small, strategically placed holes for storing guitar picks. To enhance its functionality and ease of attachment to clothing, the skull was designed with a flattened back and a plate equipped with stitching holes. This design approach ensured the accessory could be comfortably stitched onto the shoulders of a performer's garment, thereby optimizing comfort and accessibility. For the 3D modeling phase, computer-aided design (CAD) software, specifically Blender and Tinkercad, were utilized. These tools were chosen for their advanced modeling capabilities, allowing for the creation of a detailed and precise design. Following the modeling stage, the design was processed using Cura, a slicing software that prepared the 3D model for printing. This critical step involved converting the model into a printer-compatible format, ensuring the fidelity of the final print. The printing of the accessory was carried out using a Creality Sermoon D1 3D printer. This printer was selected for its enclosed structure and transparent sides, which provide stability and visibility during the printing process. The material chosen for the print was PETG (Polyethylene Terephthalate Glycol), known for its durability and suitability for 3D printing, PETG is a durable and recyclable material, making it a greener choice for clothing applications due to its longevity and reduced environmental impact compared to many non-recyclable plastics. The printing parameters were meticulously set: a nozzle diameter of 0.4 mm, a layer height of 0.2 mm, an infill density of 20%, a printing speed of 40 mm/s, an extrusion temperature of 235°C, and a bed temperature of 90°C. Notably, the print was executed without supports to ensure a clean and efficient production process.



a. b. c.

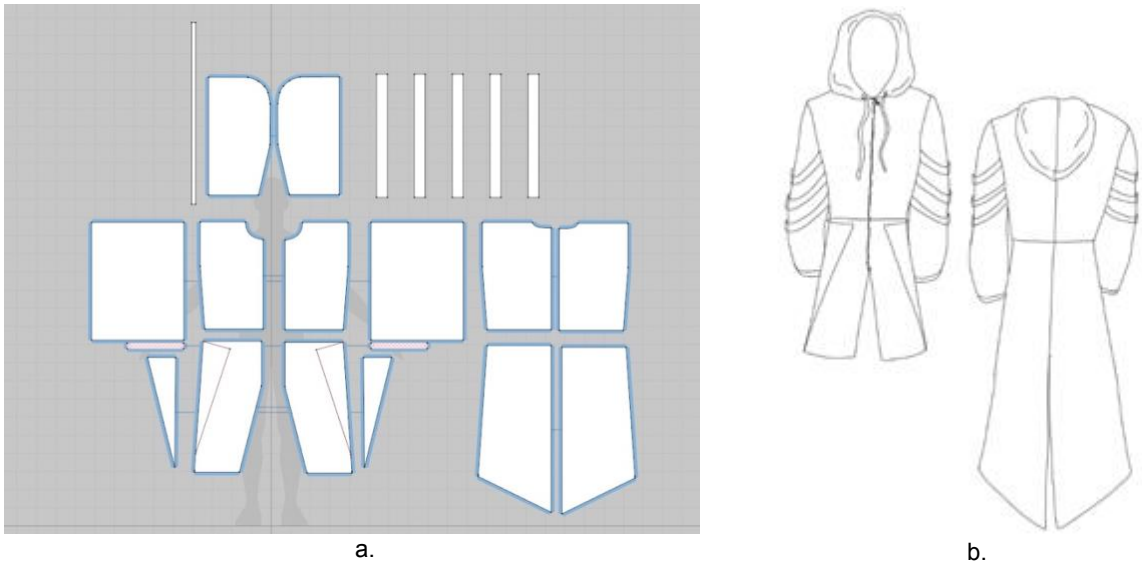
Figure 3: 3D printing: a. model of skull head with plate with holes for stitching made in Cura, b. creality sermon D1 3D printer, c. printed head compared to standard keys

2.3. Design Elements

The material was selected on the basis of features that are important for a stage appearance and a performance that is in accordance with the needs of the band "Trivan". Jersey was chosen because it meets ergonomic principles and ensures comfort and functionality during a dynamic stage performance. The selected material is suitable for stage effects such as lighting and sound absorption, which gives a good visual interaction between the performer and the audience. It improves mobility and comfort on stage by balancing aesthetic appeal with the functional needs of the performer. The durability of the material is also very important, which provides the jersey and thus ensures the longevity of the product and sustainable design, while also meeting the ecological aspects of sustainable development, as re-production is prevented. The goal of this work is the design of a garment for a stage performance inspired by a hoodie, designed and realized according to "zero waste" principles, which is another advantage for which jersey was chosen. It enables the application of the tailoring technique of tailoring parts, whereby the rest of the tailoring is minimized.

3. Experimental part

In the experimental part, a conceptual solution of a garment inspired by a hoodie for the stage performance of the music band "Trivan" was presented. Musicians expressed the need for clothing that would be comfortable and in harmony with their musical expression. Hoodica is an item of clothing that all band members wear every day and feel comfortable in it, which they wanted to transfer to their stage performances, and at the same time create a recognizable style of clothing that will set them apart from the usual outfits on stage. The needs of these musicians led to a design solution with a focus on sustainable design and development. A garment with elements of a hoodie made of cut parts with a geometric shape was designed. The usual method of clothing construction was not used, but the garment was designed on the surface of the material into which the geometric cut parts fit, and thus a large utilization of the fabric was achieved, the width of which is 140 cm and the length is 230 cm. The garment consists of a front top and bottom as it is cut at the waist, a back top and bottom, a hood and long sleeves. The spaces between the main cut parts are used for pockets, a drawstring in the hood and decorative bands on the sleeves.. The fastening is on the front center with a metal fastener, and on the back center there is a gap. A 3D element has been incorporated into the design, adapted to the needs of musicians. The 3D skull has the purpose of a pick holder and has the possibility to be sewn on the garment in any place that is most suitable for each individual musician.



a. b.

Figure 4: Clothing pattern construction in CLO3D software and technical drawing for stage performance

4. Results

A simulation of the chosen garment was created in CLO3D fashion design software program to check the fit and final appearance and to determine whether the design satisfies the musicians and all their requirements. A visualization of the garment is shown on Fig. 6.

Figure 5: The final appearance of the garment for stage performance from CLO3D software

Figure 6: Display of 3D printed elements that are holders for picks on the shoulders of a garment for a stage performance made in Blender 3D software

5. Conclusion

The hoodie is a garment that is very popular among all age groups, due to its simplicity in design. Above all, it provides comfort and satisfies all aspects of functionality. It is the simplicity of the design that opens up numerous possibilities for the redesign of this garment and the development of the design in an unconventional direction, such as clothing for stage performance. The combination of design and advanced materials with modern technology meets aspects of sustainable design and development. The redesigned hoodie presented in this paper is an example of responsible fashion practice and stage clothing that is in sync with the dynamic needs of musicians on stage, as well as visual and acoustic effects. The final 3D printed skull accessory emerged as a testament to the potential of 3D printing in enhancing performance attire. Its design not only provides stage performers with a convenient means to access guitar picks but also adds a unique aesthetic element to their attire. This project underscores the versatility of 3D printing technology in customizing performance wear, paving the way for further innovations in this field.

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THE INFLUENCE OF TEXTILE MATERIALS ON FIT IN THE DEVELOPMENT PROCESS OF DIGITAL MEN'S SOCCER CLOTHING

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Summary: *In addition to aesthetic criteria, soccer clothing must also meet functional requirements, where it is very important to ensure comfort when wearing it. For this reason, the correct selection of textile materials for the production of such clothing, as well as the development of cuts that will ensure unhindered movement during demanding sports activities, are of crucial importance. The regulations for the design of professional football clothing are very demanding and are regulated by FIFA/UEFA. The paper presents research into the possibilities of developing digital football clothing, where the possibilities of development and simulation of a two-layer model of a men's football jersey and additional training clothes were investigated. The impact of different textile materials intended for the production of sportswear on the fit and functionality of the developed models on customized 3D body models was analyzed. The possibilities of rendering the designed and developed 3D models of men's soccer clothing in different variations of colors, details and symbols on the models were investigated.*

Keywords: *textile materials; soccer clothing; digital clothing; CAD system; 3D simulation*

1. Introduction

Football clothing is defined as specific, precisely prescribed clothing (certain textile materials, colors, cut and details) by FIFE/UEFE (Federation Internationale de Football Association/Union of European Football Associations/), which publicly shows affiliation with a football club , where it is necessary that one team of the team is clearly distinguished from the other team, and that it clearly shows the emblem of the club, the sponsor and the brand that made the clothes [1,2]. Basic football clothing consists of a jersey, shorts and socks above the knee, supplemented by sets of training clothes and other accessories. In order to achieve the functionality of football clothing, in addition to the design and construction of the clothing model, it is very important to properly select the textile materials from which the clothing is made [3], considering that during wearing it is necessary to ensure breathability, quick drying and unhindered movement of the player. Clothing for soccer players must be comfortable to wear and easy to maintain [4]. Football clothing as such is generally accepted in society, and all manufacturers of professional football clothing. clothes, design clearly communicate which football club it is.

At the beginning of the development of football, in 1863, the meaning of football jerseys was not great. The players were usually dressed in white short-sleeved T-shirts, and the teams recognized each other by their caps, which were of different colors. It was like that until 1870 and the establishment of the English FA Cup (English Football Association) competition. That competition attracted unprecedented media attention, so the spectators demanded that t-shirts be worn to distinguish the teams from each other. With the further development of football as a professional sport, clubs began to provide the necessary equipment [5]. The jerseys worn by players at the beginning of the twentieth century were made of durable materials, obtained from natural fibers, usually cotton, and were produced in different colors. The jerseys often featured wide vertical and guiding lines, which became a very popular design. In the thirties of the 20th century, in Great Britain, numbers were also printed on the jerseys to indicate the position in which the player plays, which quickly spread to the rest of the world. In the middle of the twentieth century, natural materials began to be replaced by light materials made of artificial fibers. During the following decades, different types of jersey designs alternated, which particularly came to the fore in the 1980s, when large sports companies began to produce jerseys highlighting their brands. With the entry of large sports companies into the jersey production business, the era began when the jersey was no longer just an article of clothing, but also an advertising space. In those years, jerseys were made of durable low-mass polyester [5]. The cooperation of big sports brands and football clubs has recently become inevitable and mandatory, and all sports clothing brands produce football clothing, taking advantage of a large number of potential variations (men, women, youth, children, promo variants and additional kits) that suit an extremely large number combination and have an unsurpassed emphasis on identity. Soccer jerseys for professional men's players are increasingly designed so that models follow the body line, reducing the discomfort of the jersey cuts. Such a design refers to the built male body and the lifestyle that follows and nurtures such a body. In everyday iterations of sports and fashion, the soccer

jersey has become indispensable. Its distinctive heraldic design unites teams, clubs, fans and spaces on and off the pitch. It is known almost everywhere in the world and its symbolism is known to everyone. It serves as an aesthetic and performative way of expressing collective identities and as a visual signifier of the importance of football. The first official jersey of the Croatian national football team was designed by the academic painter Miroslav Šutej in 1990, Fig. 1. Although it has been changed since the Nike brand became the official sponsor, the jersey has mostly retained its national identity [6,7].

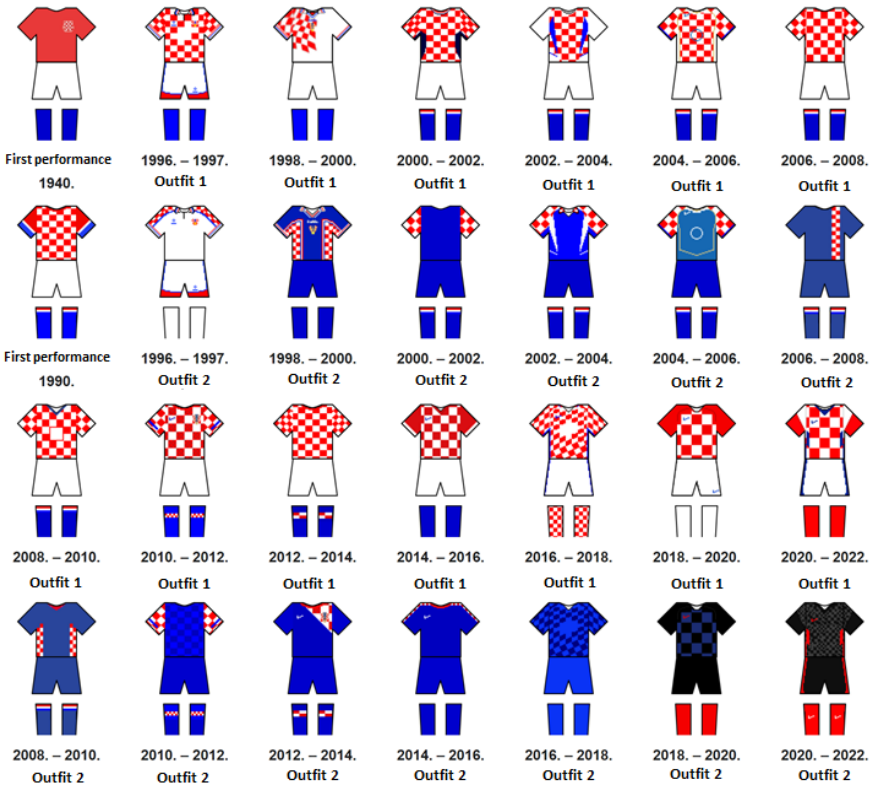
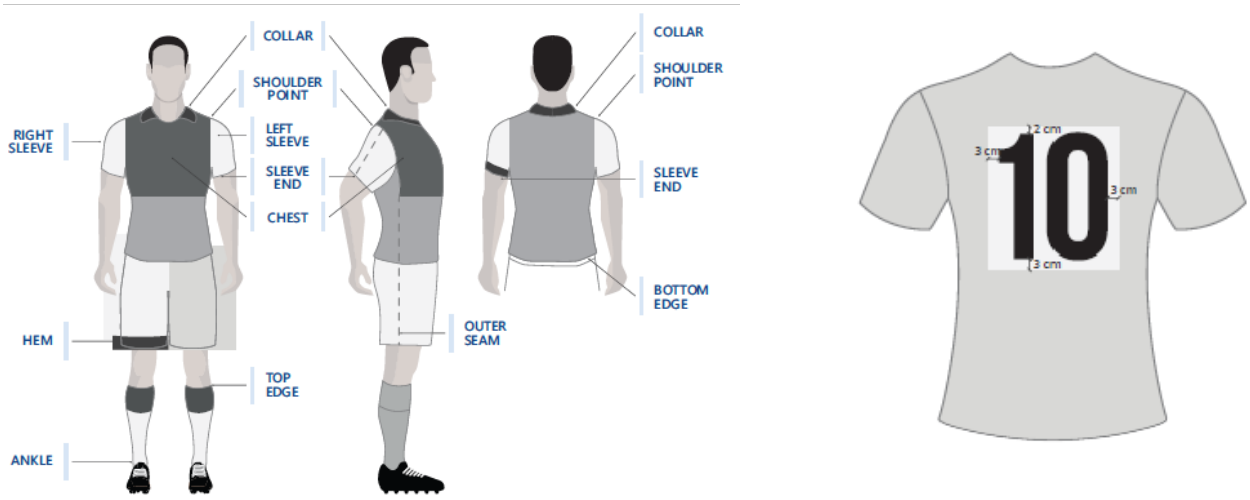


Figure 1. Croatian football jerseys throughout history [7]

2. FIFA/UEFA football kit design requirements

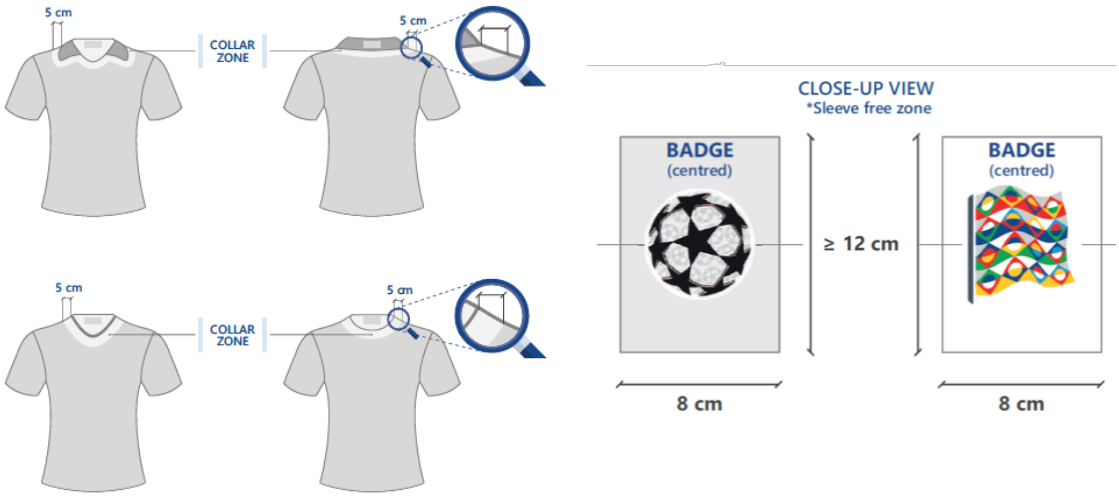
The applicable regulations expressly refer to the specific regulations governing the competition to be played under the auspices of FIFA/UEFA. The regulations apply to the following persons: outfield players, goalkeepers, substitutes, refereeing team, team technical staff (head coach and assistant coaches, equipment manager, etc.), medical team staff (team doctor, physiotherapist, etc.), other team officials with access to the technical area, children with the ball, players' and referees' attendants, center circle bearers and flag bearers. The Rules apply to all equipment that may be worn or used by the aforementioned persons (except football boots and shin guards), all references to teams, sponsors, manufacturers and any third parties appearing on any equipment, any additional items that may be used on the field of play or in a controlled area of the stadium, such as medical equipment, medical bags or match balls. Each team must submit, by the deadline specified in the relevant competition rules, a complete sample set of the following kits to the FIFA/UEFA administration for approval: first-choice outfield kit, second-choice outfield kit, first-choice goalkeeper kit and second-choice goalkeeper kit and any additional alternative play clothes or play garments (shirts, shorts and/or socks) [1,2].

The regulations for the design and production of professional football clothing are very demanding in that, when creating a design solution, it is necessary to comply with a number of rules and laws regulated by FIFA/UEFA, which significantly limits the design process and to the greatest extent directs it to finding a creative graphic solutions based on given elements and model construction in accordance with regulations and properties of selected textile materials. Fig. 2 shows the regulations for the positions of the main points of football clothing and the number zone on the back of the jersey, and Fig. 3 the regulations for the collar zone and the free sleeve zone [1,2].



a. b.

Figure 2. Position regulations: a) main points of football clothing, b) number zone on the back [2]



a. b.

Figure 3. Position regulations: a) collar zone and b) free sleeve zone [2]

3. Design and development of digital men's soccer clothing

In the continuation of the paper, research into the possibilities of computer design, development and analysis of digital prototypes of clothing items that make up men's soccer clothing is presented, with special emphasis on the design and development of a two-layer jersey model, as an innovative functional clothing item. To implement the experimental part of the work, the Clo 3D Fashion design software package and the Fabric Kit measuring system were used to determine the properties of textile materials, applied in the development of digital models [8].

3.1. 3D clothing design and cut construction

For the purposes of industrial clothing production, the design of new clothing models must be presented through technical model drawings, which are also an integral part of the technical documentation. The drawing must unambiguously define the presented model in a clear, simple and comprehensible manner, considering that it is the basis for the constructional elaboration of the cut. A technical drawing is usually created as a 2D drawing, and the possibilities of modern digital tools also enable the creation of 3D drawings, in black and white and in color, Fig. 4. Modeled cut parts for a two-layer jersey and football shorts are shown in Fig. 5. whereby the sleeve cut is connected to the front part of the jersey through modeling, which makes the model

structurally different from standardized models of soccer jerseys. The two-layer jersey was modeled in order to achieve a better fit of the model, but also as an innovative step forward in jersey design, which allows one garment to be designed in such a way that there is one design variation on each side, which refers to the graphic design of the prescribed elements.

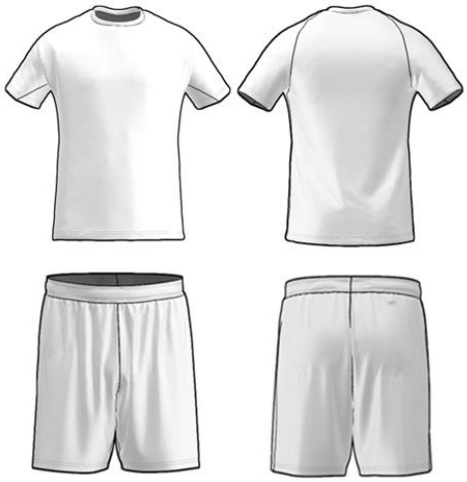


Figure 4: 3D technical drawing of a soccer jersey and shorts

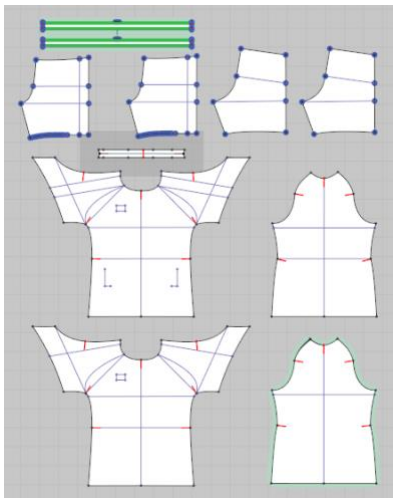


Figure 5: Computer-generated cuts of the garment model - double-layer jersey and shorts

3.2. Development of digital 3D models of soccer clothing prototypes

Using the Fabric Kit measuring system, the properties of selected textile materials, intended for the production of football clothing, were measured, Tab. 1., which are further entered into the Clo 3D program database.

Table 1: Structural, physical and mechanical properties of selected fabrics

Material designation	Material composition	Material type	Surface mass [g/m^2]	Thickness [mm]	Strain [%]		Bending stiffness [cNcm^2 /cm]		Shear stiffness [N/m]
					X (warp)	*Y (weft)*	*X (warp)*	*Y (weft)*	
M1 (Jersey - red layer)	100% Polyester taffeta	Knit	278,15	0,51	13,75	9,64	9,20	13,3	26
M2 (Jersey - gray layer)	100 % Rayon jersey	Knit	269,13	0,20	11,76	10,03	8,10	8,5	29
M3 (Shorts)	100% Poliamid taffeta	Knit	212,67	0,34	8,64	9,67	7,7	6,4	30

In the Clo3D program, the adaptation of the avatar of the male model for clothing size 50, for which the cuts for men's soccer clothing were previously constructed, was performed. All the parameters of the cut parts, Fig. 6, and the parameters of the 3D simulation were defined, and the positioning of the cut parts around the avatar was performed. The properties of the selected textile materials were applied to the tailored parts and computer simulations were carried out with the purpose of transforming the tailored parts into digital 3D models of clothing items, according to the given parameters. The materials selected for the simulation of the two-layer soccer jersey and shorts were selected based on the measured values of the properties, where it is important to emphasize the lower bending stiffness and greater stretchability, which is very important because it contributes to the functionality of the model during wear and enables the player's unhindered movement during performance extreme positions and movements that players perform when playing on the football field. It was found that the materials also have a very good fall and flexibility, which positively affects the fit of the jersey model on the body and also allows greater freedom of movement. By repeatedly performing model simulations and computer analysis of the fit, adjustments of the values of the given parameters and corrections of the cut parts were carried out.

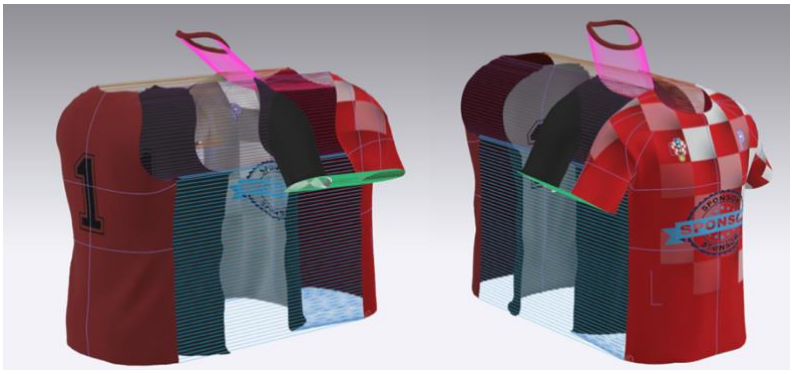


Figure 6: Connection of the joining segments of the cut parts of the two-layer soccer jersey during the preparation for 3D simulation and defining the parameters of the cut parts

3.3. Fit analysis of digital clothing models

Football clothing must have a proper fit that suits every football player for better performance on the football field. Football players are constantly exposed to the action of external forces, so the clothes they wear are subject to stress in the textile material in dynamic conditions. For this reason, each item of clothing should have adequate comfort, which enables unhindered movement and comfort during wear. Computer analysis of the fit of a single digital garment model is performed with the application of digital stress and stretch maps of the simulated textile material by zone on the garment in different body positions. There is a possibility of analysis and application of additional maps that enable pressure measurement at individual points or analysis of contact points between the body and the model.

Figure 7: Material stress analysis on simulated garments

Fig. 7 shows digital models of soccer clothing during stress analysis of the applied properties of selected textile materials. The stress map shows the force per unit area in kPa that acts as an external force on the garment, and is displayed in a range of eight colors, with the blue zone on the garment showing the area where there is no stress, while the red color shows the zone where it is the greatest strain occurred. The materials selected for the football double-layer jersey and shorts show the lowest possible stress value in the groin and arm-trunk areas, which favors the movement and fit of the football kit.

4. Results and discussion

On computer verified digital 3D models of football clothing from the aspect of fit and selection of textile material, using digital tools for pattern design, graphic elements were designed in compliance with all prescribed rules [1,2], in order to fully define the design of the developed football clothing. Fig. 8 shows the digital models of the men's jersey obtained by rendering procedures in two color variations, considering that a two-layer model was developed that allows the jersey to be worn on both sides by turning it around. The shorts have been given a white color to match the two-layer jersey on both sides. Satisfactory fit of the model in dynamic body positions was established. Also, the standards of FIFE/UEFA regarding the position of the coat of arms, sponsor and clothing manufacturer on the jersey and shorts were respected. The requirements of the length of the cut and the silhouette prescribed by the standards of football clubs and associations have been met.

Figure 8: Visualization of the designed digital football clothing

5. Conclusion

The use of modern CAD systems for the development of digital clothing represents a development trend in the industrial conditions of clothing production, however, considering the complexity of the development process, engineering knowledge and skills in the field of computing, clothing engineering and objective evaluation of textiles are required for successful implementation. The development of clothing for special purposes, such as soccer clothing, requires consideration of functional requirements and regulations for its design and production during each segment of work, as well as systematic verification of the design, selected materials, elements of cut and production. The development of digital clothing models allows the development team to check all important parameters on computer model prototypes, to visualize the model in different variations before making actual samples, which significantly facilitates and speeds up the design and development of new models. Raising the level of digital knowledge and skills is extremely important for all stakeholders employed in the fashion industry, in order to improve business models and apply digital technologies in the segment of fashion brand development, but also in other segments of the supply chain.

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DIGITALIZATION IN FASHION MATERIALS FUNCTIONALIZATION

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Abstract: Fashion industry has made a significant gap by utilizing novel materials. Hollow conductive nanofibers with special coatings that enable perfect hydrophobic and repellant surfaces are attractive to designers. Moreover, ideas developed by digitalized fashion dresses can be realized with the help of creative scientific and technological solutions.
This paper describes the model process of digitalization of the surface functionalization process of materials with special hydrophobic and antimicrobial properties that can be used as such in the fashion industry and/ or in medical applications. Special layers containing nanoparticles of metal and metal oxides, in addition to providing special shine and tactile sensations, also have protective properties (against water, UV radiation, viruses and microorganisms). Particularly effective are silver, zinc and titanium oxide nanoparticles, which are therefore increasingly used in the fashion industry within fibers or as a coating on materials to improve surface characteristics such as microbicidal, waterproof, antistatic or UV protection, color ingenuity, dirt resistance, odor-resistant, stain resistant, crease-forming resistance and better thermal performance. In order to apply nanoparticles evenly and homogeneously to the surface of textile materials, several procedures are used, and this paper will describe the procedure of functionalization of the surface with nanoparticles using sol-gel method, i.e. the deep coating procedure. The homogeneity of the coating, as well as its persistence, directly depend on the process parameters that control the functionalization process itself (which includes reagent concentrations, operating temperature, mixing speed, ultrasound frequency and others).
Multiparameter optimization would not be possible without the use of sophisticated mathematical models and algorithms that can be applied for the purpose of conducting and managing processes (such is the statistical methodology of experiment design, neural networks, genetic algorithms, etc.). For the purposes of this paper, the design of experiment methodology was chosen that conducted the optimization of all working parameters of the deep immersion method simultaneously. Using the sophisticated Design Expert State Ease software version 9.1. it was possible to simultaneously optimize all six operating parameters of the process and achieve uniformity of the coating, homogeneity of nanoparticle distribution, durability of the coating while preserving the tactile properties of the material. This coating can be applied to various substrates, which allows the fashion industry to functionalize not only innovative fashion textile materials, clothing and footwear, but also fashion accessories that include handbags and other everyday materials, increasing their innovative usage possibilities and a marketing value.

Keywords: *fashion materials, digitalization, functionalization, coatings, nanoparticles*

1. Introduction

Fashion companies are increasingly exploring the adoption of cutting-edge, newly functionalized and if possible sustainable materials that are eco-friendly and that have special surface properties. These materials, sourced from diverse biological origins, aim to supplant textiles derived from animals or fossil fuels. Their applications span a wide spectrum, encompassing items like sneakers, leggings, and handbags, among others. Furthermore, the integration of smart fabric textiles is gaining momentum within the fashion industry. These textiles, composed of top-tier fibers with specific functionalities, are capable of regulating temperature and controlling muscle vibrations, among other specialized functions. Last but not least, surface with specially modified hydrophobic properties enable huge diversity in possible application.

The pursuit of sustainable fashion products necessitates a comprehensive understanding of new materials and processes, both within academic circles and industrial settings. The fashion industry is progressively transitioning toward a regenerative model that emphasizes the enhanced utilization of sustainable and renewable resources, a reduction in the use of non-renewable inputs, the curbing of pollution and waste generation, while concurrently fostering prolonged product lifespan and facilitating material reuse. Materials can be functionalized through textile industrial processes in order to achieve special functional properties [1]. Functionalization with nanoparticles enables many interesting properties, from water repellency and hydrophobicity [2] to dirt repellency, antimicrobial and UV protection, to name some. Such coatings need to be carefully prepared and characterized prior the usage [3] on different yarns, and woven or non-woven surfaces [4], and after this can be utilized in fashion industry for various purposes (Figure 1).

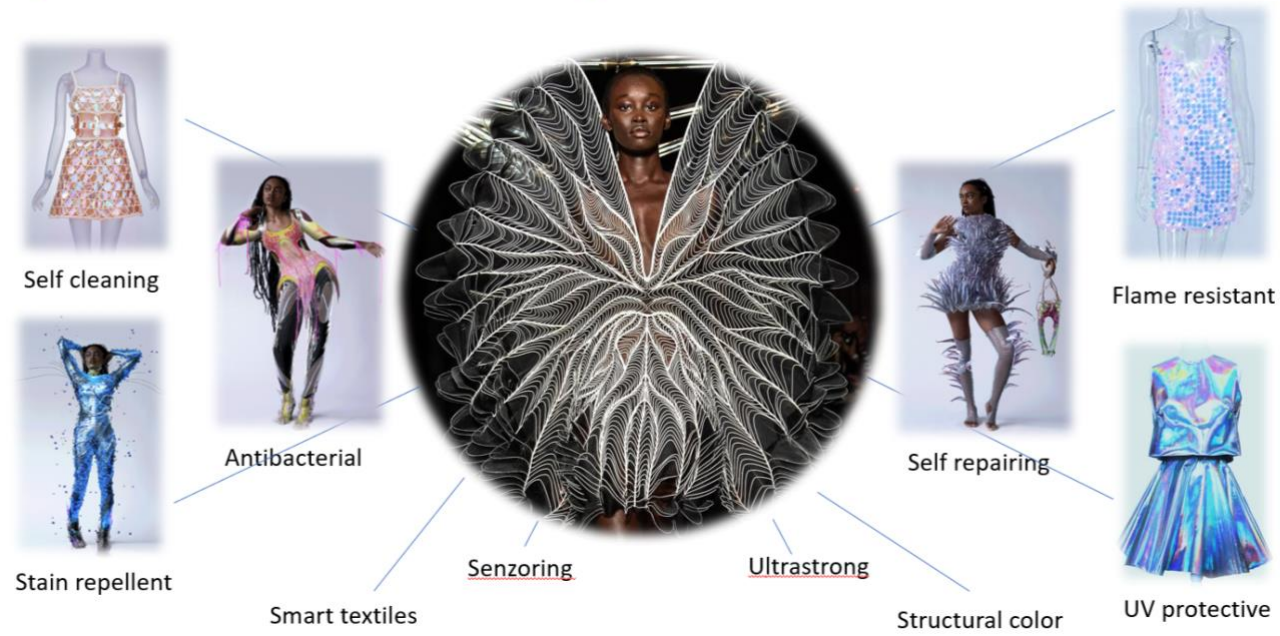


Figure 1: Special application of nanocoatings for fashion and textile industry

1.1. Optimization and Experimental Design

The aims of applying optimization and design methods in materials science and fashion industry can be numerous. Typical factors in fashion materials surface treatment comprise the pH value, reagent concentration, temperature, flow rate, solvent, elution strength, composition, irradiation, or laser sputtering rate. Typical responses are the analytical figure-of-merits as well as objective functions that consist of combinations of different quality criteria. Systematic optimization procedures are carried out in the following sequence:

1.) Choice of an objective function that is composed of several criteria, such as selectivity, sensitivity, and precision. Objective function Z_i is obtained by aggregation of quality criteria z_i by a weighed sum where w_i is weight of criterion i:

$$Z_i = \sum_{i=1}^{n} w_i z_i \tag{1}$$

2.) Selection of the most important factors that affect a given objective function on the basis of a simple experimental design, a screening design, by means of statistical tests

3.) Optimization. To find the most suitable factor combination we can distinguish between simultaneous and sequential optimization approaches. With simultaneous strategies the relationship between responses and factors is studied by running an experimental design, constructing a mathematical model, and investigating the relationship by so-called response surface methods. Very often RSMs are aimed at judging this relationship graphically and the consequences are drawn from those plots. If the optimal point is desired it can be found by calculating the partial derivative with respect to the individual factors or by applying a grid search over the whole response surface. Sequential strategies of optimization are based on an initial design of experiments followed by a sequence of further measurements in the direction of the steepest ascent or descent. That is, no quantitative relationship between factors and responses is evaluated but the response surface is searched along an optimal (invisible) path. The two strategies are exemplified in figure 1. In the case of response surface methods, the response is described by a mathematical model (dotted contour lines of the response surface). By using search methods, the response is measured along a search path, here along a Simplex path.

Figure 2: Water repellent materials functionalized with special hydrophobic coatings

2. Design of Experiment

The term Desing of Experiment is usually used to describe the stages of identifying the factors which may affect the result of an experiment, designing the experiment so that the effects of uncontrolled factors are minimized, and using statistical analysis to separate and evaluate the effects of the various factors involved. Optimization of any process including treatment of materials for fashion industry has to be carried out by studying a limited number of factors. Very often it is easy to select the most important factors, but sometimes the effects of particular one can only be presumed. Its effect has to be assured by suitable screening experiment. Because of the complexity of most of the analytical problems, there can be additional factors that are either unknown or that cannot be controlled. Uncontrolled factors might be the temperature, impurity of reagents, intoxication of an electrode surface, the instability of a plasma or laser source, or the changing quality of an assistant's work. Since the study of all potential factors is usually prohibitive the effect of selected factors will be investigated and the remaining factors should be kept as constant as possible. This general principle is known as the *ceteris-paribus* principle. During optimization procedure several other principles like *replication* of measurements or their *randomization* (running the experiments in a random order) are important. Central composite design consists of a combination of a full or fractional factorial design and an additional design, often a star design. If the center of both designs coincides they are called central composite designs. For the number of runs *r* we obtain: $r = 2^{k-p} + 2k + n_0$ (2)

where *k* is the number of factors, *p* is the number for reduction of the full design, and n_0 is the number of experiments in the center of the design. For example, for a design with three factors the needed number of experiments is 15. To estimate the experimental error, replications of factor combinations are necessary. For this reason, the center point is usually run several times.

The choice of proper design of experiment is crucial since this will dictate the number of experiments needed for optimization process. Differences in experimental design are presented in Tables 1 presents a possible solution to the concept of digital optimization of a system with 5 process parameters. In this work, the CCD design was used for coating of materials with nanoparticles. Silver nano particles were synthesized in a temperature-controlled shaker at 37°C with stirring at 150 rpm, in ultrapure deoxygenated water.

Table 1: Central composite small (not full) design, for 4 parameters in 28 experiments

	GLYMO*, mL	ZnO, g/100mL	Time, min	Ultrasound, Hz
1	45	0.725	45	67.5
2	45	0.725	60	80.0
3	50	1.000	45	67.5
4	45	0.725	30	55.0
5	45	0.450	30	67.5
6	45	0.725	45	67.5
7	40	0.450	45	67.5
8	50	0.725	60	67.5
9	50	0.725	45	55.0
10	40	0.725	45	80.0
11	45	0.725	60	55.0
12	45	1.000	30	67.5
13	45	0.725	45	67.5
14	40	0.725	60	67.5
15	45	0.725	45	67.5
16	45	0.45	45	80.0
17	45	0.725	45	67.5
18	40	0.725	30	67.5
19	45	1.000	45	55.0
20	40	0.725	45	55.0
21	50	0.450	45	67.5
22	45	1.000	45	80.0
23	45	1.000	60	67.5
24	45	0.450	45	55.0
25	50	0.725	45	80.0
26	40	1.000	45	67.5
27	50	0.725	30	67.5
28	45	0.725	30	80.0

*GLYMO is the 3-glycidyloxypropyltrimethoxysilane reagent

3. Results and Discussion

Designed experimental combinations were tested and the obtained data are presented in Table 2.

Table 2: Central composite design, for 6 parameters

1	GLYMO, mL	HCl, mL	Temperature, C	Ultrasound, Hz	Time, min	ZnO, g/100mL
1	40	50	37.0	80.0	60	1.0
2	50	50	37.0	55.0	60	0.4
3	45	44	28.5	67.5	45	0.7
4	40	70	37.0	55.0	60	0.4
5	45	60	28.5	67.5	22	0.7
6	40	70	37.0	80.0	30	1.0
7	40	50	20.0	55.0	60	0.4
8	40	50	20.0	80.0	30	0.4
9	40	50	37.0	80.0	30	0.4
10	37	60	28.5	67.5	45	0.7
11	40	50	20.0	80.0	60	0.4
12	45	60	28.5	67.5	45	0.7
13	50	50	37.0	80.0	30	0.4
14	40	50	20.0	55.0	30	0.4
15	40	50	37.0	55.0	30	1.0
16	45	60	28.5	67.5	68	0.7
17	50	50	37.0	55.0	60	1.0
18	50	70	20.0	80.0	60	0.4
19	40	50	37.0	55.0	60	0.4
20	45	60	28.5	67.5	45	0.2
21	45	76	28.5	67.5	45	0.7
22	40	50	37.0	80.0	30	1.0
23	45	60	28.5	87.0	45	0.7
24	50	50	20.0	55.0	60	1.0
25	50	50	37.0	55.0	30	1.0

26	40	50	20.0	55.0	60	1.0
27	40	70	20.0	80.0	60	0.4
28	40	70	20.0	55.0	60	1.0

As can be seen from data presented in Tables 1 and 2, it is extremely important to select the appropriate Design of experiment, based on required time, money and all other resources. Selection is guided by possibility and available resources od time, money and the number of samples available for functionalization treatments. After the selection, the experiments are run and the data of optimization obtained that are used in mathematical modelling.
The results were used for pre-modeling steps. Based on this, a mathematical model was obtained by DoE State Ease program which can be expressed through working parameters as following:
Recovery angle = A + Bxc(GLYMO(mol/dm-3)) – Cxc(HCl(mol/dm-3)) + D(m/g(ZnO)) + E(Ultrasound power/Hz) – F (time/min) (3)
Validation of the model is performed by the comparison of predicted and experimentally obtained values as is presented in Table 3.

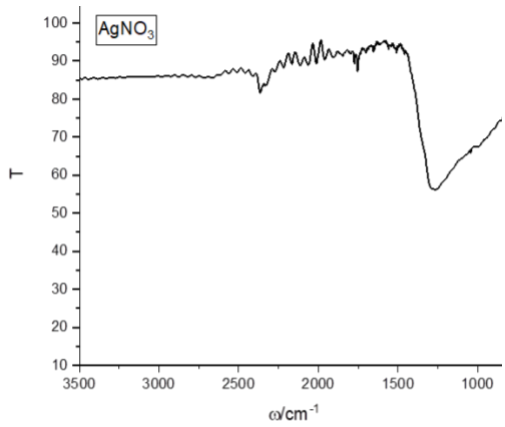
Table 3: Comparison of predicted and actual values of recovery angles

GLYMO*, mL	0.1M HCl, mL	ZnO NPs g/100mL	Ultrasound, Hz	Time, min	Predicted Recovery Angle	Actual Recovery Angle
B*	C*	D*	E*	F*	135.7	135.8

*Where GLYMO is the 3-glycidyloxypropyltrimethoxysilane reagent

As can be seen from the results, the obtained relative error between calculated and predicted values was very low (0.007%). Low values of the coefficient of variation (CV%) of selected model indicate a very good model precision and very good reliability of the experiments. Therefore, only optimal combination of parameters enables simple preparation of special materials with the intended usage in fashion industry.

After optimization and experimental validation of the coating procedure, silver nanoparticles synthesized in the laboratory were coated on the surface of materials, and the results of characterization are shown in Figures 3 to 5. Figure 3 shows the FTIR of the silver nitrate before synthesis of nanoparticles, Figure 4 the SEM microphotograph of the sample surface, and the Figure 5 the size of silver nanoparticles after their preparation.



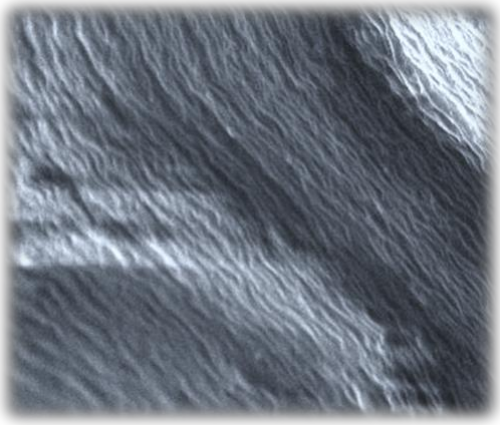


Figure 3: FTIR analysis of the silver nitrate before the preparation Figure 4: SEM microphotograph of sample

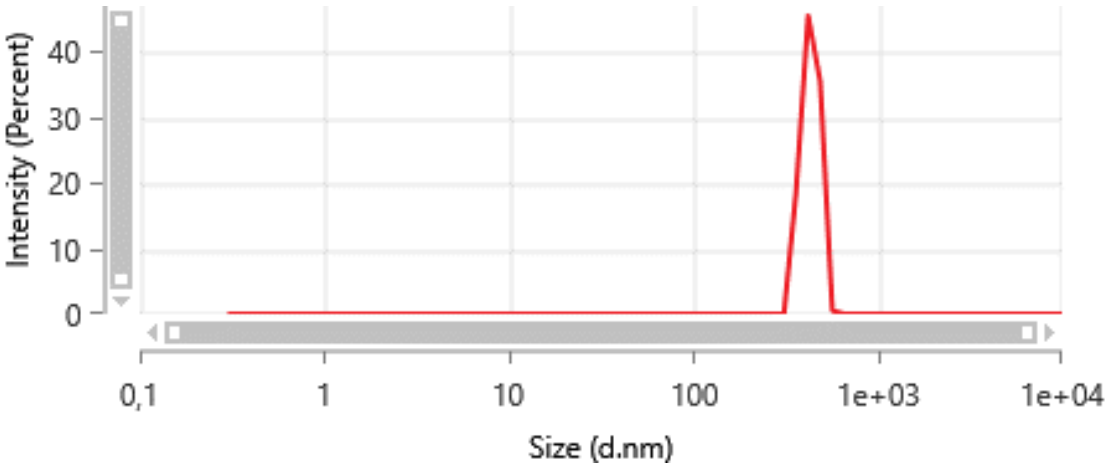


Figure 5: Size and distribution of silver nanoparticles after preparation of samples

Presented results show that digitalization is vital and crucial stage in developing new materials since those processes involve synthesizing, formulating, or preparing novel compounds. Typically, this stage signifies the start of material development, succeeded by proper characterization (and/or purification) and interpretation of the acquired data. However, this methodology holds a significant drawback wherein the outcomes and materials obtained heavily rely on the researcher conducting the experiments and their level of expertise. To address this, early initiatives in digitally transforming material research primarily concentrate on automatization, parallelizing, and downsizing synthesis processes to enable high-throughput procedures.
This work has presented the possibility of optimization of materials surface functionalization, from the perspective of application of novel materials in the fashion industry.

Today we are faced with many challenges – a huge number of data is generated during preparation and characterization of novel materials, and not always the primary data are accessible. In addition, due to restrictions in time and money, there is only one data sat used in optimization. Therefore, the quality of the provided data is vital and crucial. From the statistical point of a view, the question on minimal required number of experiments needed for extensive and reliable measurement uncertainty is raised.
Current advances in computer engineering enable fast and efficient handling of huge amount of data in achieving optimal experimental design.

4. Conclusions

The role of materials and processes in the creation of new fashion products has become increasingly pivotal, exerting a significant influence on product sustainability and durability. These elements, among others, contribute to the complex landscape of sustainability concerns. The fashion industry has a substantial impact on both society and the environment. Sustainable practices have gained paramount importance in the textile and clothing sector, affecting various stages of the product life cycle and their associated implications. The skill set of professionals engaged in fashion product development (FPD) and the requisite training must adapt to a growing understanding of materials and processes. However, the educational sphere is struggling to keep pace with the rapid transformations occurring within the industry. There is an evident need for innovative models of competence acquisition tailored to current demands.

This paper presented a possibility to investigate and validate a series of methodologies that enable fashion scientists' skills geared toward the development of sustainable fashion products for the market by using statistical methodology design of experiment. Additionally, the utilization of software program that is user friendly is a key feature. The study therefore highlights notable progress in understanding usage of design of experiments in functionalization of materials and optimization of such processes, coupled with modeling and further optimization routes.

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IMPACT OF NANO IMPREGNATION ON COTTON FABRIC

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Abstract: *Due to its ability to improve and protect the properties of textile fibers, nanotechnology is becoming increasingly important in the textile industry and can be classified as a scientific discipline. By processing textile fibers, in this case cotton fibers and fabrics, with the method of nano-impregnation, one of the outstanding properties of cotton fibers, hydrophilicity, is not only influenced but completely transformed, making the fiber hydrophobic. Such manipulation of a natural cellulosic fiber such as cotton is a highly inventive method that aims to improve and possibly change the purpose of cotton itself through nanoimpregnation by adding other properties to it besides hydrophobicity, such as an antibacterial effect or antistatic properties and resistance to various stains that can be removed with light water pressure. The paper also contains an experimental part showing the behavior of cotton fabric before and after nano-impregnation. The results before and after nano-impregnation are shown by microscopic analysis.*

Keywords: *nanotechnology, cotton fibre, cotton fabric, nano impregnation, textile industry, textile fabrics.*

1. Introduction

The definition of nanotechnology according to the National Science Engineering and Technology (NSET) is: "Nanotechnology is the understanding and control of matter at the nanoscale, that is, at dimensions between about 1 and 100 nanometers, where unique phenomena enable novel applications. Matter at the nanoscale can exhibit unusual physical, chemical and biological properties that differ significantly from the properties of bulk materials, single atoms and molecules. Some nanostructured materials are stronger or have different magnetic properties than other shapes or sizes of the same material. Others are better able to conduct heat or electricity. They can become more chemically reactive, reflect light better or change color when their size or structure is altered. Nanotechnology is helping to significantly improve and even revolutionize many technological and industrial sectors: Information technology, textile industry, homeland security, medicine, transportation, energy, food safety and environmental science, to name a few" [1].

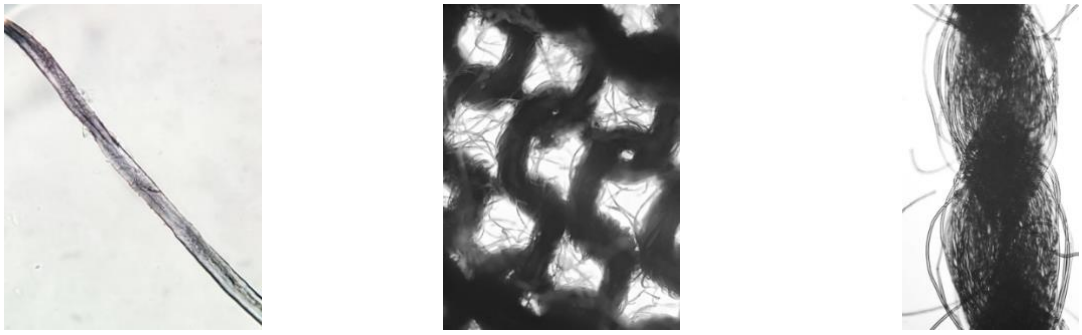
2. Cotton fiber

Cotton fibers are obtained from the cotton plant, especially from the seed coat, the outer layer of the seeds of the cotton plant. It is one of the most important raw materials for textile production and the most commonly used textile fiber worldwide. A total of 19.32 million tons of fibers are produced worldwide every year, with cotton accounting for the largest share of natural fibers at 36% (74.3%). Currently, the share of cotton fibers in global fiber production is declining, which is due to the increasing capacity and consumption of synthetic fibers due to their cost-effective mass production [2].

Figure 1. Cotton [3]

In order to process cotton fibers into items such as bed sheets or T-shirts, the cotton seeds must first be separated from the plant and then the fibers extracted from the seeds. Each cotton fiber is a single cell, and unlike most cells, which are too tiny to see without a powerful microscope, cotton fibers are easily visible to the naked eye, reaching lengths of up to 5 cm. Remarkably, the fibers of domesticated cotton hold the record

as the longest cell among all plant species. The rapid elongation of cotton fibers occurs mainly within a short period of 30 days. They develop as tiny cells in fertilized cotton flowers and quickly fill the ripening bolls so that they almost burst within a month. When producing the threads for the fabric, the individual fibers are laid on top of each other and twisted around each other. Longer fibers are more valuable than shorter ones because they do not have to be laid on top of each other as much and can therefore be woven into finer threads. Thinner and finer threads contribute to fabrics with a higher thread count, i.e. a greater number of threads per square inch. Fabrics with a high thread count, known as fines, are considered to be of higher quality and are therefore more expensive than fabrics with a lower thread count, which are considered to be less fine and airy. Cotton fibers, cotton fabrics and cotton fabrics are shown in Fig. 2 [4].



a. b. c.

Figure 2. Microscopic figures of cotton – a. fiber under enhancemet 100x times; b. knitted fabric under enhancemet 4x times; c. yarn in woven fabric under enhancemet 40x times

The chemical core of cotton fiber mainly consists cellulose. In addition to cellulose, the fiber contains smaller amounts of various substances, including pectins, waxes, organic acids, proteins and minerals. The specific composition of these substances varies depending on the cotton variety and is influenced by genetic and climatic factors, soil composition and similar variables. Pectins consist of polygalacturonic acid and its salts (Ca, Fe or Mg salts). Waxes consist of fatty acids and hydrocarbon esters with 24 to 30 carbon atoms, while minerals include compounds of Ca, Mg, K and Na. In addition, the fiber contains a certain amount of absorbed moisture [2]. The structure of cotton fiber contains pores or capillary spaces of different sizes between the fibrils in each part, resembling a microscopic physical sponge. This intricate internal structure allows liquids and vapors to interact with the cotton fiber, demonstrating its absorbency and unique absorption capacity. Viewed as a whole, the cotton fiber appears as a flat, twisted ribbon with 50 to 100 turns per inch. This structure, which tapers at one end and fibrillates at the other end where it is joined to the cottonseed, gives the fiber a soft feel because it does not have sharply cut ends as found in synthetic staple fibers [5].

3. Nanotechnology in textiles

Textiles are a universal interface and an ideal substrate for the integration of nanomaterials, electronics and optical devices. These integrated materials and technologies provide a versatile platform that responds to various stimuli such as mechanical, chemical, electrical, thermal, optical or magnetic signals. Wearable devices, including sensors, data transmission and processing units, can be seamlessly integrated into garments. A major challenge for the textile industry is that conventional methods of functionalizing textiles do not have a lasting effect; washing, for example, weakens this effect. Textiles can be nanotechnologically designed to exhibit certain properties such as hydrophobicity, antibacterial properties, conductivity, crease resistance, antistatic behavior and light deflection and scattering (see Fig. 3) [6].

Figure 3. Use of nanotechnology in textile [6]

3.1. Nanoengineered textiles

Textiles can be water-repellent by producing nanosheets of hydrocarbons that are three orders of magnitude smaller than a typical cotton fiber. These nanosheets are incorporated into the fabric and create a peach fuzz effect [6]. Similar to the lotus effect, the gaps between the individual whiskers are smaller than a drop of water, but larger than water molecules. This creates a high surface tension, which makes it possible to keep water on the surface [7]. The whiskers provide breathability by allowing the penetration of gasses. Water repellency can also be achieved by forming 3D surface structures on the fabric, either by adding gel-forming additives or by coating the textile with a nanoparticulate film [19]. For example, cotton fibers can be coated with fluorocarbon derivatives by applying a layer of nanoparticles using a low-frequency plasma [9]. The creation of surface roughness on the fabric enables the development of superhydrophobicity without compromising the abrasion resistance and softness of the fabric. Silicon dioxide (SiO_2) nanoparticles can be used in conjunction with water repellents to make textiles hydrophobic [10]. Silicon dioxide nanoparticles (SiO_2 NPs) in the range of 143-378 nm were synthesized using the sol-gel method. Cotton fabrics treated with both SiO_2 NPs and a water repellent exhibited contact angles of over 130°. SiO_2 NPs could be applied to cotton in the presence of a perfluorooctylated quaternary ammonium silane coupling agent (PQASCA) to achieve hydrophobicity [11]. Research in the field of water repellent materials has been inspired by nature and influenced by bio-inspired design [12].

4. Experiment

4.1. Application and impact of nano impregnation on cotton fiber

It is clear from all this that cotton is also used by athletes due to its well-known properties. As a recreational mountain biker, I often wear cotton T-shirts when cycling in summer, but it quickly becomes a problem when the body starts to sweat and the cotton shirt gets soaked. To avoid this, the project uses the German-made MILITARIA Nano System TNW SPRAY, which has superhydrophobic (water-repellent) and oleophobic (all types of oil-repellent) properties. The spray is UV-stable and chemically resistant up to a pH value of 13, breathable and resistant to repeated washing and cleaning. It does not change the texture and color of the material, as a microscopic analysis shows. The equipment used in this experiment (see Fig. 4) included a laboratory microscope of the Faculty of Technology in Bihać (with magnification options of 4x, 10x, 40x and 100x), 100% cotton fabric of T-shirts, MILITARIA Nano System Textile And Wood Spray, a private modern mirrorless camera Nikon Z5 with 24-70 f4/s and 70-200 f.2-8 lenses for recording the entire experimental process, a private smartphone for recording the results of the microscopic examination through the eyepiece of the microscope. In addition to stating the objectives of the experiment in the conclusion, there is also the goal of visually representing the appearance of the fiber and the fabric itself through the microscopic examination of fibers and textiles.

a. b. c. d.

Figure 4. Equipment used in experiment – a. Microscope; b. Nano TNW spray; c.100% cotton fabrics from T-shirt; d. Nikon Z5 with lenses

4.2. Experimental procedure

Cutting material from a 100% cotton T-shirt measuring approximately 10x10 cm. After obtaining the material, the next step is to apply the nanospray to a sample at a 45-degree angle at a rate of approx. 5-10 ml/m2. The nano-impregnated samples were then subjected to microscopic examination, the results of which are shown in Fig. 6.

a. b.

Figure 5. Microscopic examination; a. Cotton fiber; b. Cotton fabric

For the last part of the experiment, the impregnated material was allowed to dry for 24 hours and then the hydrophobicity of the fiber was tested after impregnation. The dripping of water from a glass showed the success of the impregnation and confirmed that the nanospray had fulfilled its intended properties.

5. Results

The results of the microscopic examination of the impregnated fabric showed that the appearance of the fiber has not changed significantly, apart from a slightly darker lumen and fiber walls that have gained some volume (due to the nanospray film) (see Fig. 6).

Figure 6. Nano impregnated cotton fiber

The fabric is still soft to the touch and its most important properties have not changed, with the exception of hydrophilicity. The pictures show samples of cotton fabric with and without nano-impregnation. In the impregnated fabric sample, the water droplets are retained on the surface and some even "slide off" when water is applied, where as in the non-impregnated sample the water is absorbed into the fabric (see Fig. 7).

a. b.

Figure 7. Experiment with water; a. Nano impregnated cotton fabric; b. Non impregnated cotton fabric

After impregnation sample showed hydrophobic behavior, a microscopic examination was carried out with additional water application by spraying. The results of the microscopic examination at 4x magnification are shown in Fig. 8, where small water droplets can be seen on the surface of the fabric as a result of the nano-impregnation of the cotton fabric.

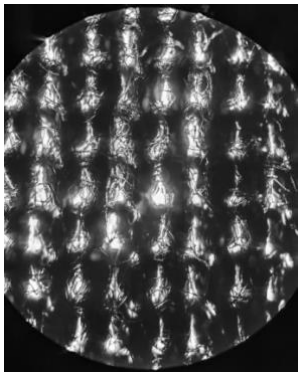


Figure 8. Nano impregnated cotton fabric

6. Conclusion

Throughout the research process, this study has investigated the profound impact of nanotechnology on the advancement of the textile industry, with a focus on textile materials. In the experimental phase, a careful microscopic examination was carried out, which revealed a slight thickening of the primary wall and a slightly darker lumen, indicating the successful application of a nano-film by the precise method of spray coating. The cotton fabric samples treated with the nano-impregnation showed improved hydrophobic properties and increased protection against UV radiation, but retained their basic properties. This breakthrough suggests that cotton garments could be redesigned and take on a new importance in the fashion industry, tailored to the specific requirements of different target groups. Furthermore, the integration of cutting-edge digital fashion technologies into a 3D system allows for a comprehensive exploration of the effects of these advanced materials on models created with specialized digital fashion software. In summary, it is important to emphasize that the fashion industry is a complex ecosystem that encompasses various elements, including textile materials. Therefore, progress in one element requires a holistic approach that takes into account the interconnected aspects in the field of digital fashion.

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DIGITALIZATION OF ELECTROSPINNING PROCESS BY RESPONSE SURFACE METHODOLOGY

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Abstract: *Electrospinning emerges as a valuable and efficient technique for generating continous nanofibers by using electrical forces. Electrospinning and the resulting nanofibers exhibit a diverse array of applications owing to their distinctive properties and nanoscale structure. The realm of its application spans from filtration to various biomedical uses, including tissue engineering, wound dressings, and drug release. In line with the electrospinning process mechanism, a fundamental electrospinning configuration includes a high-voltage system, spinneret, and collector. Aiming to regulate the structure of electrospun fibers and facilitate their practical use, extensive endeavors have been directed towards the adaptation of the electrospinning setup and procedure. Only by appling modern digitalization techniques and algorithms is the multiparameter process guidance possible. Despite the relatively simple components of the electrospinning setup (comprising a high-voltage system, spinneret, and collector), determining the optimal parameters for producing fibers with specific properties remains a challenging task. Consequently, this work introduces a computational approach, leveraging the responce surface methodology (RSM), to simulate process of optimization of the electrospinning process. The primary objective is show that by using the sophisticated algorithms it is possible to simultaneously optimize all operating parameters of the process and achieve the most efficient process and the outcome result (electrospun fibers of desired mechanical, chemical and physical properties). For example, hollow conductive electrospun fibers can be very attractive in fashion industry. Moreover, the same approach can be applied to various other systems, enabling not only the material science but also the fashion industry to apply innovative electrospun fibers in fashion textile materials, clothing and footwear, but also in fashion accessories that include handbags and other everyday materials, increasing their creative potential and marketing value.*

Keywords: *response surface methodology, digitalization, electrospinning, optimization*

1. Introduction

Multiparameter optimization would not be possible without the use of sophisticated mathematical models and algorithms that can be applied for the purpose of conducting and managing processes (such is the statistical methodology of experiment design, neural networks, genetic algorithms, etc.). For the purposes of this paper, the responce surface methodology is discussed as the optimal methodology to be applied in electrospinning [1-5].

The potential for nanotechnology innovation in the textile industry is extensive and promising [1, 2, 3]. Over the last two decades, significant advancements have been made in the realm of novel nano-based materials. The functions encompass a wide range of special materials, including self-cleaning capabilities, electrical conductivity, antibacterial properties, thermal stability and flame retardancy, thermal regulation, and selective permeability/adsorption.

Among the others noteworthy particulate structures include nanoparticles of polymers, carbon nanotubes (CNTs), nanodiamonds, nanoclays, various metal nanoparticles such as silver and titanium or zinc dioxide, as well as a variety of bio-based nanomaterials like cellulose nanocrystals and chitosan. Additionally, the primary methodologies employed in processing nanofibers can be additionaly optimized by digitalization of processing.

Electrospinning is currently regarded as the most versatile technique for producing continuous nanofibers from a diverse range of materials, including plastics, metals, and ceramics. The morphology and properties of these fibers can be customized to meet specific requirements, catering to a wide array of applications such as filtration, membrane technologies, textiles, catalysis, reinforcement, and biomedical fields.

Despite the seemingly straightforward components of the electrospinning setup, which include a high-voltage system, spinneret, and collector, determining the optimal parameters for producing fibers with specific properties remains a challenging task. To address this, the current work proposes a computational approach, employing the response surface methodology (RSM), to simulate and optimize the electrospinning process [4].

The primary objective is to enhance the understanding of the fundamental principles that govern the vital parameters influencing the process, ultimately refining and stabilizing the electrospinning procedure. By utilizing sophisticated algorithms, it becomes feasible to simultaneously optimize all operational parameters of the process, leading to the most efficient process and desired outcomes in the form of electrospun fibers with tailored mechanical, chemical, and physical properties [5].

This approach has the potential for application in various systems, not only within material science but also in the fashion industry, allowing for the integration of innovative electrospun fibers into textile materials, clothing, footwear, and fashion accessories, such as handbags and other everyday materials. This integration could significantly enhance their creative potential and market value.

2. Response Surface Methodology

Response surface optimization is a statistical technique that examines the correlation between multiple explanatory variables and one or more response variables. The fundamental concept behind response surface optimization involves employing a series of designed experiments to achieve an optimal response. This methodology entails utilizing a second-degree polynomial model to estimate the optimal response.

Response surface optimization finds application in maximizing the production of specific substances by fine-tuning operational factors. It has gained extensive use in formulation optimization through the application of appropriate design of experiments (DoE). Statistical techniques like response surface optimization can effectively determine the interplay among various process variables.

Experimental optimization based on response surface optimization can directly make use of methods developed for conventional analytical optimization.
A simplex in one dimension is a line, in two dimensions - a triangle, in three dimensions - a tetrahedron, and in multiple dimensions – a hyper-tetrahedron. To find the steepest path along a response surface an algorithm has to followe the pattern that consists of designing an initial simplex, runns the experiments at the initial vertices and calculates the new vertex point by reflection of the vertex with the worst response.

The simplex method has been the most used experimental optimization algorithm until now because of its main advantages: simplicity, speed and good convergence properties. Problems with the simplex method arise if multimodal response surfaces are investigated (if several local optima exist). In this case the simplex will climb the nearest local maximum or minimum and the global optimum might be missed. Mathematical theory provides more efficient optimization methods, such as the conjugate gradient method or Powell's method. These methods are mainly used in locating optima of mathematical functions and not that often in experimental optimization.

Response surface methods are useful for quantification and interpretation of the relationships between responses and factor effects. Those relationships in analytical chemistry can be based on physical or chemical models, generalized by statisticians as mechanistic models. Another approach would be empirical modeling, in which the parameters have no mechanistic meaning. General empirical models are polynomials of second order, where the response y is related to the variables (factors x) as follows:

$$y = b_0 + \sum_{i=1}^{k} b_i x_i + \sum_{l \le i \le j}^{k} b_{ij} x_i x_j + \sum_{i=1}^{k} b_{ii} x_i^{\,2} \qquad (1)$$

with k the number of factors (variables), b_0 the intercept parameter, and b_i, b_{ij}, b_{ii} regression parameters for linear, interaction and quadratic factor effects. To estimate parameters in equation 1, the experiments have to be carried out at three factor levels, and this estimation is a general problem of least-squares estimation by linear models. The response surfaces based on the mathematical model can be explored graphically, as shown in figure 1.

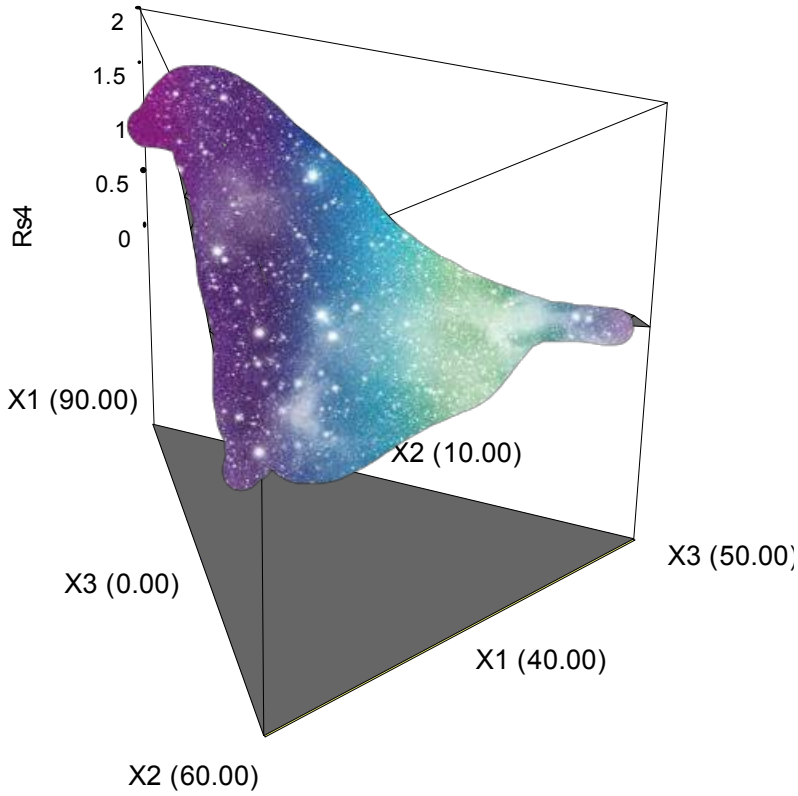

Figure 1: Surface and contour plots - response surfaces example

In the case of a large number of experiments which needs to be carried out, it could be difficult to run the experiments under identical conditions, because strong systematic changes increase the overall experimental error. Their elimination can be accounted for if the changes are taken as a discrete event and the estimation of the time-depended effect are confounded with the estimation of unimportant interactions such as a three-factor interaction.

In recent decades several expert systems have been developed for practical applications in analytical chemistry and applied statistical methodologies. Existing expert systems have been explored for different purposes: the determination of appropriate statistical tests, regression analysis and determination of the “best” experimental design. The State Ease computer program is intended for scientific investigators and statisticians who must design and analyze complex experiments (multi-level experiments with nested factors, repeated measures, and both fixed and random effects). This system is “expert” in the sense that it is able to recognize specific types of complex experimental designs based on the application of inference rules to non-technical information supplied by the user. Secondly, it encodes the obtained and inferred information in a flexible general – purpose internal representation, for use by other program modules. This program also generates analysis of variance tables for the recognized designs and an appropriate computer program runs file for data analysis, using the encoded information.

The State Ease is a prototype expert system for the design of complex statistical experiments which can recognize randomized block designs, including lattice designs within embedded Latin Squares, crossover designs, split plots, nesting, repeated measures and covariates. It is written in an experimental programming language developed specifically for research in Artificial Intelligence.

State Ease software offers a wide variety of designs, possibilities to modify designs, evaluation capabilities, tools for response modeling, graphics for interpretation of result, and multiple response optimization. Among other designs there are two-level fractional and full designs, multilevel factorial designs, Taguchi orthogonal arrays, irregular fractions, Placket-Burman designs, Response surface methods, mixture designs (such as simplex-lattice, simplex-centroid screening and D-optimal), and combined mixture and process designs.

DX6 methods use probability and statistics to define the minimum number of experiments needed to identify significant cause-and-effect relationships between a given number of factors and one or more responses. A

large number of responses would be useful for DX6 application where there are many target analytes but relatively few instrumental conditions to optimize (as it is, for example, in spectroscopy).

Because a large quantity of information on optimization can be produced in a very short time, capabilities to visualize the results are very important. In this program results for each solution can be examined one at the time in a graph. Response surfaces and mixture designs in DX6 often use five or six levels per factor. Assigned values are not just whole integers, but also include one-third and two-third fractions, in or beyond a specified range, to maintain geometric symmetry.

Depending on the design, suggested values in a range from 2 to 4 may be 2, 2.33, 3, 3.33, 3.67, 4 or 1.66, 2, 3, 4, 4.34. These conditions are a clear departure from the common experimental sequences, which vary logarithmically or by orders of magnitude. The most basic decisions are which design to use and how many levels to set for the known factors.

When performing an optimization procedure with State Ease program, first it is necessary to specify the order of polynomial: first order polynomials only model linear behavior, while second order polynomial (called a *quadratic*), reveals two-component interactions. More complex interactions can be modeled by third-order polynomials. After this step, it is important to generate a "candidate set" with more than enough points to fit the specified model. For the mixture side of the problem, the formulators expect complex chemical problems, so they usually choose a third order mixture model called a "special cubic". From the candidate set, selection of the minimum number of points is performed to fit the model.

3. Results and Discussion

Identifying the optimal conditions for a single response using surface response designs is relatively straightforward. However, when a researcher aims to optimize multiple responses simultaneously, the task becomes more complex. In such cases, a simple strategy to adopt is visual inspection. If the number of significant factors permits the graphical representation of adjusted models and the number of responses is manageable, overlaying the surfaces can facilitate the identification of the experimental region that can satisfy the desired criteria.

The actual selection procedure involves computer-intensive matrix calculation designed to produce model coefficients of maximum possible precision. Selection of RSM methodology significantly reduces the amount of required number of samples, as well as time and money needed for the analysis.

The electrospinning process is affected by many variables: solution concentration (A), solvent type (B), viscosity (C), flow rate (D), distance between needle tip to collector (E), surface tension and conductivity (H), voltage (I), ambient parameters (temperature (J), humidity (K)), needle gauge (L) and collector type (M) as well as chemical type (F) and molecular weight (G). In this paper the RSM optimization was applied on the system of 5 (A – E) input and 2 (F, G) output parameters. The goal of the optimization was to keep all input parameters in range, and to achieve the maximal output results. The constraints of the optimization are presented in Table 1.

Table 1: Constraints of the optimization by using Response Surface Methodology

Name	*Goal*	*Limit*	*Limit*	*Weight*	*Weight*	*Importance*
A	is in range	40	50	1	1	3
B	is in range	50	70	1	1	3
C	is in range	0.04	0.1	1	1	3
D	is in range	55	80	1	1	3
E	is in range	30	60	1	1	3
F	maximize	129.7	140.6	1	1	3
G	maximize	112.8	138.8	1	1	3

Based on the proposed conditions, the response surface methodology uses algorithms that search for optimum. The goal of optimization can be the hollow space in electro spun fibers, due to which the conductive properties arise, as is presented in Figure 2. Glowing textiles are interesting materials for fashion industry. Such optimal results, expressed as the optimization goals are presented in Figure 3, and the searching area is presented in Figure 4. The predicted optimal solutions, the first eight possibilities are presented in Table 2.

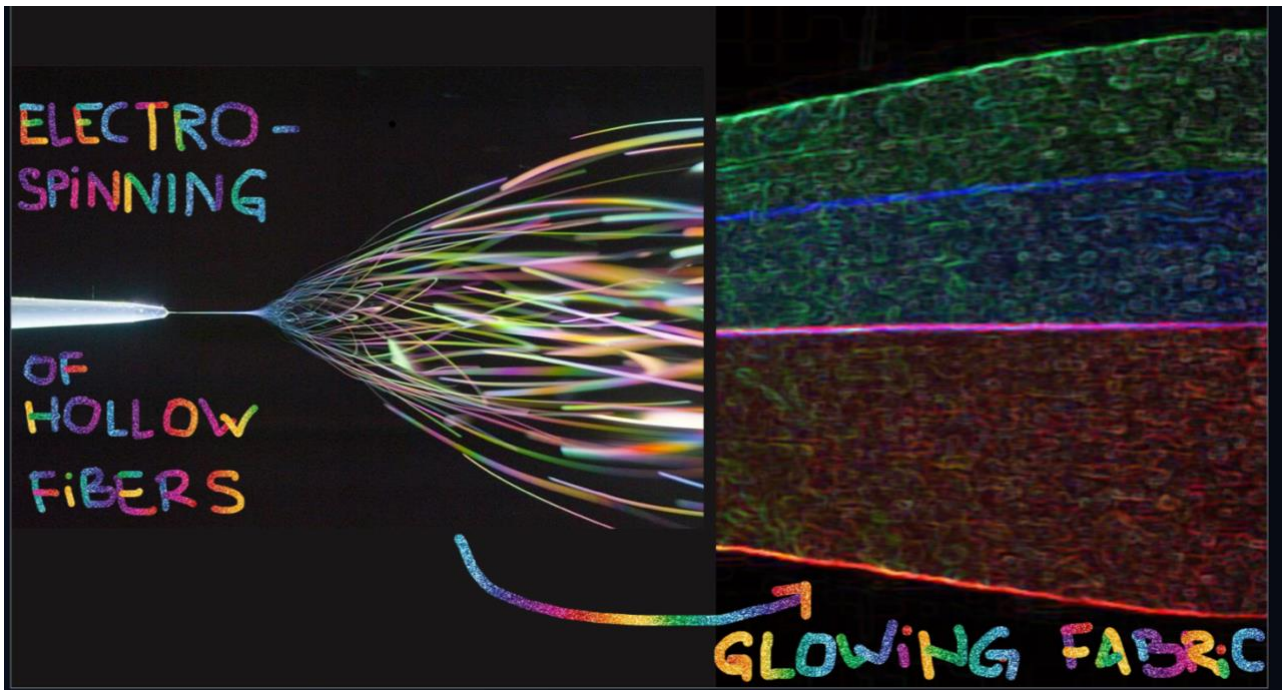

Figure 2: Application of electro spun fibers in fashion as conducting and glowing materials [6]

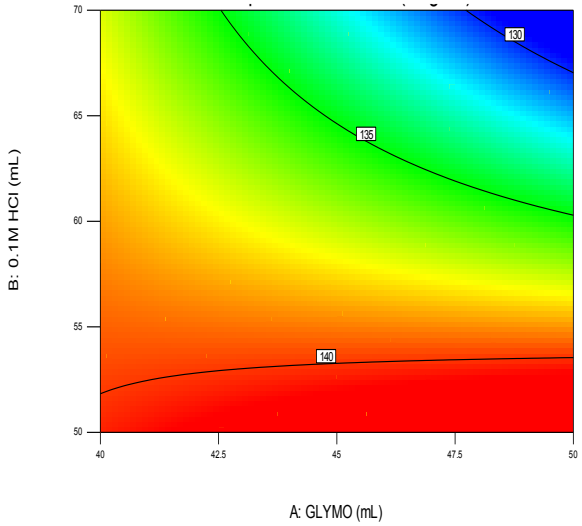

Figure 3: Predicted results presented as the area of the surface with the best (red) and the worst (blue) regions

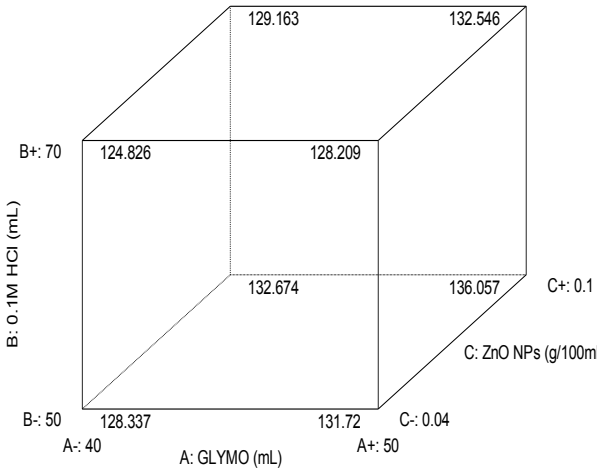

Figure 4: Surface area used as area of optimization in which the mathematical algorithms are searching the predicted optimum

Table 2: Optimized systems with selected process parameters

Number	A	B	c	D	E	F	G
1	50.000	50.000	0.071	79.975	31.340	140.600	136.629
2	50.000	50.297	0.071	80.000	30.572	140.604	136.590
3	49.997	50.588	0.070	79.997	30.302	140.600	136.491
4	50.000	50.007	0.069	79.978	31.822	140.828	136.479
5	48.780	50.000	0.071	80.000	30.004	140.600	136.285
6	49.944	50.101	0.066	80.000	30.004	141.850	136.264
7	49.445	50.000	0.071	78.719	30.000	140.791	136.242
8	50.000	50.003	0.066	79.999	34.086	140.690	136.241

As can be seen from the results, the response surface methodology can be easily applied in fashion materials production. For the purpose of this work, which attended to present the RSM methodology in digitalization of production of fashion materials, the idea of glowing materials was used. However, this property can also be used in medical materials, sports and military usages.

4. Conclusions

Response Surface Methodology (RSM) is a powerful technique employed to identify optimal design factor settings aimed at improving or optimizing the performance or response of a process or product. It integrates design of experiments, regression analysis, and optimization methods into a versatile strategy, ultimately geared toward optimizing the expected value of a stochastic response. The application of response surface methodology in the optimization of analytical procedures has become widespread and well-established. This is largely attributed to its advantages over classical one-variable-at-a-time optimization. These advantages include the generation of significant amounts of information from a limited number of experiments, as well as the ability to assess the interaction effects between variables on the response.

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Additional information:

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GREEN EXHIBITION AND THE GREEN SUMMER SCHOOL OF GREENTEX PROJECT

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Abstract: *As part of the project "Sustainable Design and Process in Textiles for Higher Education" (2021-1-PL01-KA220-HED-000032201; acronym: GreenTEX), from the Erasmus+ program: Partnerships for cooperation in higher education, innovative solutions and opportunities for action for sustainability in the textile and clothing industry are being developed. At the stage of training young people who will enter the labor market in the future, it is necessary to take action to raise awareness of this problem and provide knowledge on how to solve it. Project partners from 5 European universities developed different educational solutions related to sustainable textiles - a textbook, case studies, a multimedia platform and an online exhibition "Green Exhibition", part of which was developed as a pilot educational solution "How to deal with textile waste?" These project results are presented in this paper.*

Keywords: *sustainability of textile, education materials, exhibition, summer school, GreenTEX project*

1. Introduction

The project "Sustainable Design and Process in Textiles for Higher Education" (code: 2021-1-PL01-KA220-HED-000032201; acronym: GreenTEX) is a two-year project from the Erasmus+ program KA220-HED - Partnerships for cooperation in higher education. Five partners from European universities (Lodz University of Technology, Faculty of Material Technologies and Textile Design, Lodz, Poland; Technical University of Liberec, Faculty of Textile Engineering, Liberec, Czech Republic; Kaunas University of Technology, Kaunas, Lithuania; University of Aveiro, Aveiro, Portugal; and University of Zagreb Faculty of Textile Technology, Zagreb, Croatia) are developing innovative solutions and measures for action for sustainability in the textile and clothing industry [1-3].

2. Project Results

The aim of the project is to carry out various types of educational activities in the field of sustainable designs and processes in the textile sector. The situation of the textile and clothing industry and related sectors is not optimistic in terms of environmental concerns and there is a need to raise awareness of their impact on the environment. The GreenTEX project offers a complex idea to improve education considering Circular Economy and Sustainable Development [2-4].

The following results are developed within GreenTEX [2-4]:
- Didactic materials for “Sustainable Design and Process in Textiles” (e-book and handouts),
- Case studies and Open Challenges based on experiences with the industry,
- Multimedia platform Sustainable BOOSTER in Textiles,
- Sustainable Design and Process in Textiles course program to be implemented in bachelors’ studies,
- Scientific and didactic articles based on the project experiences,
- and Green Exhibition based on International Green Summer School.

Didactic materials are created for academic teachers and students. E-book “Sustainable Design and Process in Textiles” brings several aspects of Circular Economy and Sustainable Development that can be applied and considered in textiles (Fig.1) [5]. Additional handouts are available to encourage students to acquire knowledge and skills on the topics described in the textbook. There are 'additional reading' sections in each chapter of the textbook to enable teachers and students to broaden their awareness and understanding.

Figure 1: The GreenTEX diagram – implementation of Sustainable Design and Process in Textiles [5]

The case studies illustrate the current real problems and challenges in companies in Europe. They enable learners to link theoretical knowledge to real-life problems, build confidence in their own skills, and develop decision-making, communication and cooperation skills under competitive conditions.

The digital multimedia platform entitled “Sustainable BOOSTER in Textiles”, available in 6 EU languages, will increase the educational value of the GreenTEX cooperation. It is divided into several modules that can be used individually or as a whole.

Based on the experience gained during the project, GreenTEX researchers and educators have proposed two new programs for the “Sustainable Design and Process in Textiles” course: a short course – 30 h lessons and 3 ECTS; and an extended version with a large student project, 60 h lessons and 6 ECTS.

Scientific and didactic articles based on the project experiences cover two main aspects of the GreenTEX project, educational and scientific.

The last results is Green Exhibition based on International Green Summer School.

2.1. International Green Summer School & Green Exhibition

The International Green Summer School took place from September 4-8, 2023 at the University of Aveiro, Department of Economics, Management, Industrial Engineering and Tourism (DEGEIT), Portugal, (Figs.2-4), coordinated by Elisabeth Pereira and Margarita Robaina. 24 students and 12 mentors from 5 partner universities participated in inspirational lectures given by Monika Malinowska-Olszowy: “Sustainable Development and Circular Economy - intro”, Margarita Robaina: “Economic and financial impacts of CE on textile companies”; Krzysztof Jastrzębski: Design Thinking; Ana Sutlović: “Textile dyes - sustainability and challenges”; Rimvydas Milašius: “Sustainable natural fibres”; Jana Drašarova: “Reusing & Recycling of Textiles”; Katarzyna Zimna: “Visual communication of green products and processes”; visited a local textile company NOSDIL (https://www.nosdil.pt/), and as a main part of the school – faced the challenge [6].

Figure 2: International Green Summer School, Aveiro, Portugal – lectures, team building, and visit to company NOSDIL

The students took part in the pilot study – the challenge of the GreenTEX International Summer School posed in the form of the following question: “How to deal with textile waste?”. The time frame of the project and the results were defined. The students were divided into five groups, with one representative from each of the universities, while the mentors worked with all groups [7].

The groups solved the tasks set and practiced communicating in different ways.

Figure 3: International Green Summer School, Aveiro, Portugal – Design Thinking, idea and realization

The solution proposed by Group I was the concept of an app ("PoinTex") that would help people who want to get rid of unnecessary clothing or textiles to find collection points in their area, but also stores that sell sustainable fashion.

Group II designed and produced shopping bags ("Sustained") from textile waste with the slogan "Zero Waste" and a QR code linking to educational material available online. In "Refabric", Group III implemented the "idea of upcycling textile waste in various design forms – decorative and useful, e.g. bags, badges, table decorations.

Group IV of “ComfyTex” took a systemic approach to solving the waste problem through the proposed collaboration of local government institutions, companies and individuals. Their outcome could be the production of fabric-filled cushions that would improve seating comfort in public places.

Group V "Little scraps Big problem" pointed out the potential of awareness-raising campaigns aimed at representatives of various industries that could cooperate with each other, e.g. the toy industry. The students illustrated their idea by sewing a giant patchwork bag out of fabric scraps to symbolize the scale of the problem and a teddy bear filled with textile scraps that could become the prototype of such a zero-waste toy.

Posters and prototypes based on the textile waste provided as the results become exhibits for Green Exhibition.

Figure 4: Participants of International Green Summer School, Aveiro, Portugal

The Green Exhibition is a virtual presentation of the work and ideas. The "green solutions" presented must find a balance between aesthetic, economic and functional aspects of design, taking into account the ideas of zero waste and circular economy. The main objectives of the exhibition are to disseminate the creative results and to create a repository of ideas that, thanks to the online formula, can be accessed at any time by students and teachers as well as the wider public. The resulting exhibits of the International Green Summer School were presented in University of Aveiro, and as part of Innovatex2023 Conference in Lodz, Poland (Fig.5).

Figure 5: Green Exhibition at Innovatex2023, Lodz, Poland

Currently, the Green Exhibition is in TTF Galerija, Zagreb, Croatia, with additional exhibits *Denim and zero waste pattern design* (TU Liberec), *Only TTF mask* and *Redesign, functionalization and reuse of discarded denim* (TTF). Full Green Exhibition is available at www.greentex.p.lodz.pl/exhibition.

2.2. Other project activities

To monitor project progress, exchange experiences, discuss project issues and solve current problems and challenges; consortium meetings were necessary to achieve the objectives. In 2023 two transnational meetings were held in Liberec, Czech Republic in May, and in Lodz, Poland in November (Fig.6).

a) b)

Figure 6: Transnational meetings – a) Liberec, Czech Republic, b) Lodz, Poland

Meetings with representatives of companies and public institutions were organized at all partner universities to present the project, which helped to gather the necessary information on sustainability (Fig.7). The teaching materials were shown at teachers meetings held in each partner university for their academic staff (Fig.8). Both were a good opportunity to learn about examples of good practice, listen to experts and share experiences.

Figure 7: Multiplier event at University of Zagreb Faculty of Textile Technology

Figure 8: Teachers' training at University of Zagreb Faculty of Textile Technology

3. Conclusion

The prepared teaching materials contain real examples and cases from practice, concrete solutions and offer a whole range of possibilities that can be used in the educational process and in business when planning sustainable development in the textile sector.

The pilot groups of the International Green Summer School solved the problem in different ways. All groups approached the analyzed problem with great insight and creativity. A visit to a company played an important role in the design process and contributed significantly to the prototyping phase. Discarded fabric scraps from

the company became a helpful material for visualizing the proposed solutions. Posters and prototypes based on the textile waste provided became exhibits at the Green Exhibition, which can be expanded upon completion of the project. The students learned about design thinking aspects and tools and will explore them further in the project implementation.

This work contributes to the training of professionals that the current labor market expects and who should be prepared for the new challenges, including the introduction of standards for the circular economy, measuring and reducing the negative impact on the environment, ensuring adequate working conditions and implementing transparent rules for communicating environmental changes and consumers.

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BOOK OF PROCEEDINGS

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