

Digital Prototyping in the Process of Fashion Design

#2D #3D #digital technologies #design #prototyping



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Abstract

Technology has become essential in the fashion industry, driving innovation, efficiency, and sustainability. From design to retail, digital tools like CAD, 3D modeling, and AI are transforming how garments are created and marketed. The rise of digital fashion and “phygital” environments is reshaping traditional roles, merging physical and virtual processes. Investments in fashion tech are increasing, enabling smart textiles, wearable tech, immersive experiences and other technology. While digitalization brings many benefits, such as reduced waste and faster workflows, it also presents challenges like high costs and the need for new technical skills. It is of importance to identify the classification of technological direction in the field of fashion design to understand the opportunities provided.



peer-reviewed
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Introduction

The presence of technology in the modern world is an integral part of any industry, the opportunities and advantages provided by the integration and use of technology ensure growth and development at any level of activity. Technology alongside digitalization ensures operational efficiency, higher quality and better process organization, and provides new opportunities for innovation and creativity.

Fashion designer I. Komarova describes fashion as an industry that lies on the border between design and art. At the same time, it is also a huge, resource-intensive industry that is criticized as a manifestation of consumer society [1].

Scientific research and practice prove that, with the rapid development of the field of technology, it has become a ubiquitous force, determining unprecedented changes in the fashion industry. Technology has become an indispensable partner in cooperation, redefining possibilities and expanding the boundaries of traditional design paradigms [2].

The rapid spread of personal computers and the introduction of the Internet in the late 20th century transformed digital culture. The impact of this phenomenon on fashion was felt as designers such as Jean Paul Gaultier turned to cyberspace for aesthetic inspiration, and Computer Aided Design (CAD) began to transform the garment manufacturing process [3].

A. Deniss describes the presence of digital transformation in fashion, which encompasses almost all stages of development, from design creation to retail. This includes the use of innovations such as process automation, robotics, AI, the Internet of Things (IoT) and others to create new growth opportunities. Digital technologies are fundamentally transforming fashion processes, allowing designers and entrepreneurs to discover new opportunities in the fashion industry [4].

Digital Fashion as the Future of the Industry

The phenomenon of “digital fashion” has recently been seen in the media as the next major step in the fashion industry. The increasing use of 3D software and digital prototyping in the fashion design process is part of the broader “fashion 4.0” digitalization process [5].

According to a 2022 report by McKinsey & Company, fashion companies invested 1.6-1.8 percent of their revenue in technology in 2021. This figure is expected to increase to 3.0-3.5 percent by 2030 (fig. 1) [6].

This highlights the growing importance of digital fashion as a key driver of transformation within the industry. The McKinsey & Company data reinforces this trend, showing a significant projected increase in tech investment by fashion companies, signaling a strong commitment to digital innovation and long-term industry evolution.



Fig. 1 Industry average technology investment.

Source: <https://www.mckinsey.com/industries/retail/our-insights/state-of-fashion-technology-report-2022>



Fig. 2 Classification of Digital Fashion Innovations. Source: https://www.researchgate.net/publication/369845712_Defining_Digital_Fashion_and_Tracking_the_Developments_in_Relevant_Technologies

The latest technologies in modern fashion design

Technology influences the fashion industry in diverse ways, with varying degrees of digitalization integrated throughout every stage of the process. From design and production to marketing and retail, technology has clearly left its mark on the fashion industry. With the advent of online shopping, social media and virtual reality technologies, the way people search for, and purchase clothing has changed exponentially [7], [8]. The symbiotic relationship between technology and fashion design has been widely studied, revealing the transformative impact of technology throughout the entire cycle of the fashion design process [2].

The presence of technology in fashion design can be divided into the following categories:

- the rise of smart textiles,
- digital and 3D fashion design,
- sustainability and technology,
- wearable technology and fashion,
- AI and machine learning in fashion design,
- the impact of immersive technologies [9].

These categories illustrate how technology is not only enhancing creativity and efficiency in fashion design but also reshaping industry's core values and practices.

Building on these technological categories, it becomes essential to explore in what ways digital technologies are applied within the clothing design process.

Digital technologies in clothing design

At the core of this technological evolution is the concept of digital fashion. Digital fashion is a multidisciplinary field that encompasses four main directions:

- digital design and e-prototyping,
- digital business and promotion,
- digital human and metaverse,
- phygital apparel and smart wearable technology (fig. 2).

Digital Design and E-prototyping is one of the most widely used and accessible areas within digital fashion, offering designers the ability to visualize garments, experiment with textures and patterns, and develop virtual prototypes without relying on physical samples. This approach not only speeds up the design process but also supports sustainability by minimizing material waste and allowing for rapid, cost-effective iteration before production.

To fully understand the impact of digital design and e-prototyping, it is important to explore

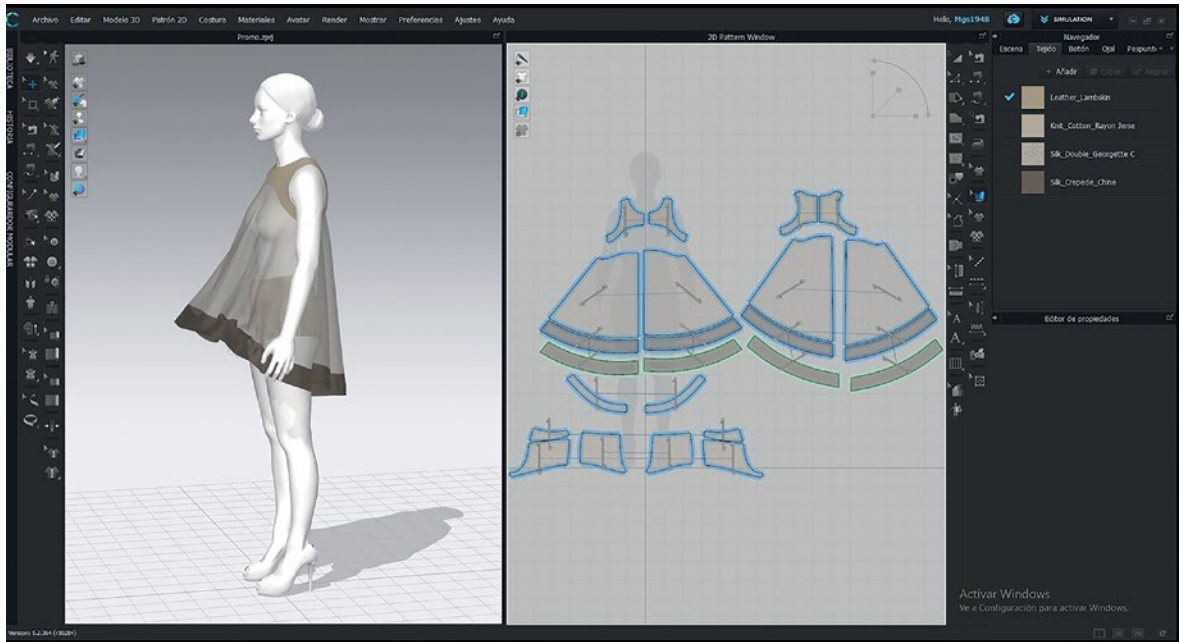


Fig. 3 3D prototyping in CLO3D program.

Source: <https://abcseams.com/clo-3d-virtual-prototyping/>

the specific types and capabilities of 2D and 3D digital technologies that are reshaping the fashion design process.

Types and capabilities of 2D and 3D digital technologies

2D and 3D technologies have become an integral part of clothing design and prototyping, and their capabilities can be divided into:

- **Computer-aided design (CAD):** CAD software is the cornerstone of modern fashion design. It allows designers to create detailed sketches, models and simulate the fit of garments, which not only saves time but also reduces material waste.
- **3D modeling and virtual prototyping:** these tools allow designers to create and visualize garments in three dimensions before production. Virtual prototyping allows adjustments to be made during the design phase, reducing potential errors and saving production costs (fig. 3).
- **Digital textile printing:** this technology has revolutionized fabric design, allowing intricate patterns and vibrant colors to be printed directly onto textiles, opening new customization

options and significantly accelerating the design process [10].

Digital design and virtual prototyping involve 2D illustration, pattern creation, and sizing, as well as 3D simulation and fabric modeling—tools that significantly enhance efficiency and product quality. 2D and 3D digital technologies are among the most common and accessible tools in fashion design, offering relatively low costs while delivering a significant impact on efficiency, creativity, and production quality.

Having explored the capabilities of digital technologies, it is essential to consider that alongside advantages there are also some disadvantages these tools bring to the fashion design industry.

Project results and analyses

To explore current trends and opportunities at the intersection of fashion and technology and to promote research, several scientific grant projects were carried out within the university [11], [12]. One of which explored digital technologies in fashion design. A step-by-step approach was used to implement and evaluate various accessible digital technologies, with the goal of asses-

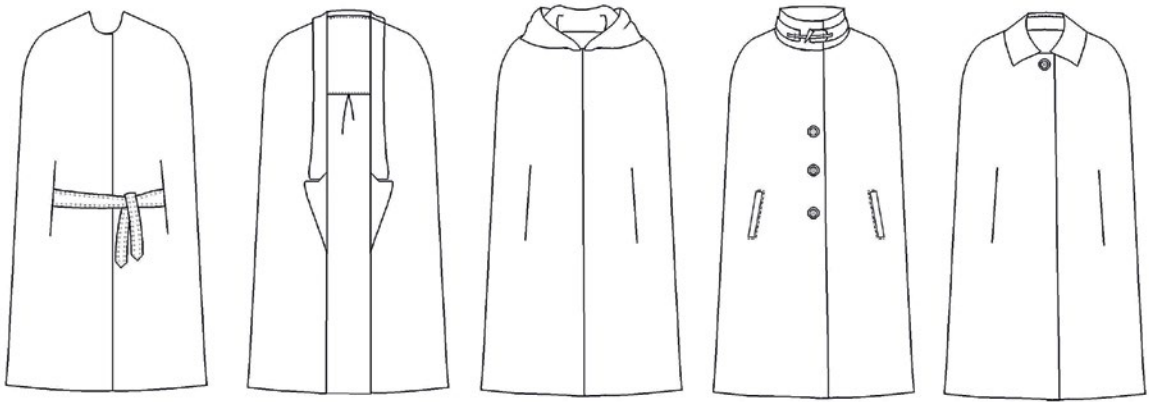


Fig. 4 Idea development in specialized program TexDesign. Source: own study.

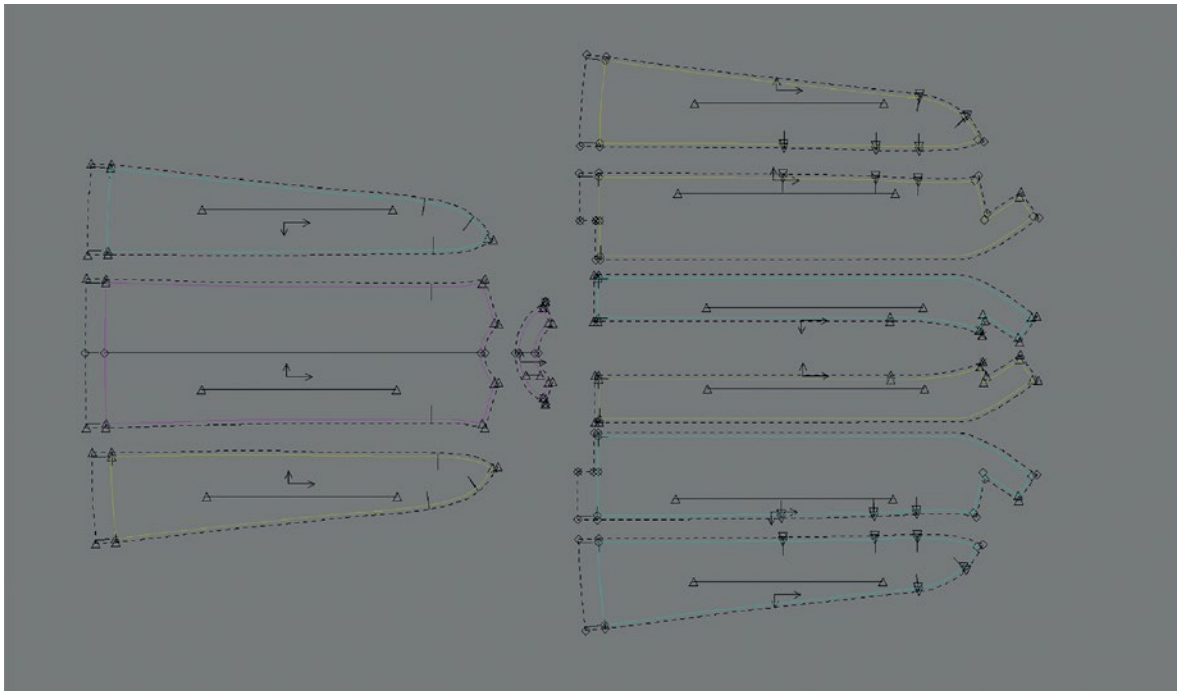


Fig. 5 Pattern layouts in specialized program AccuMark Gerber
Source: own study.

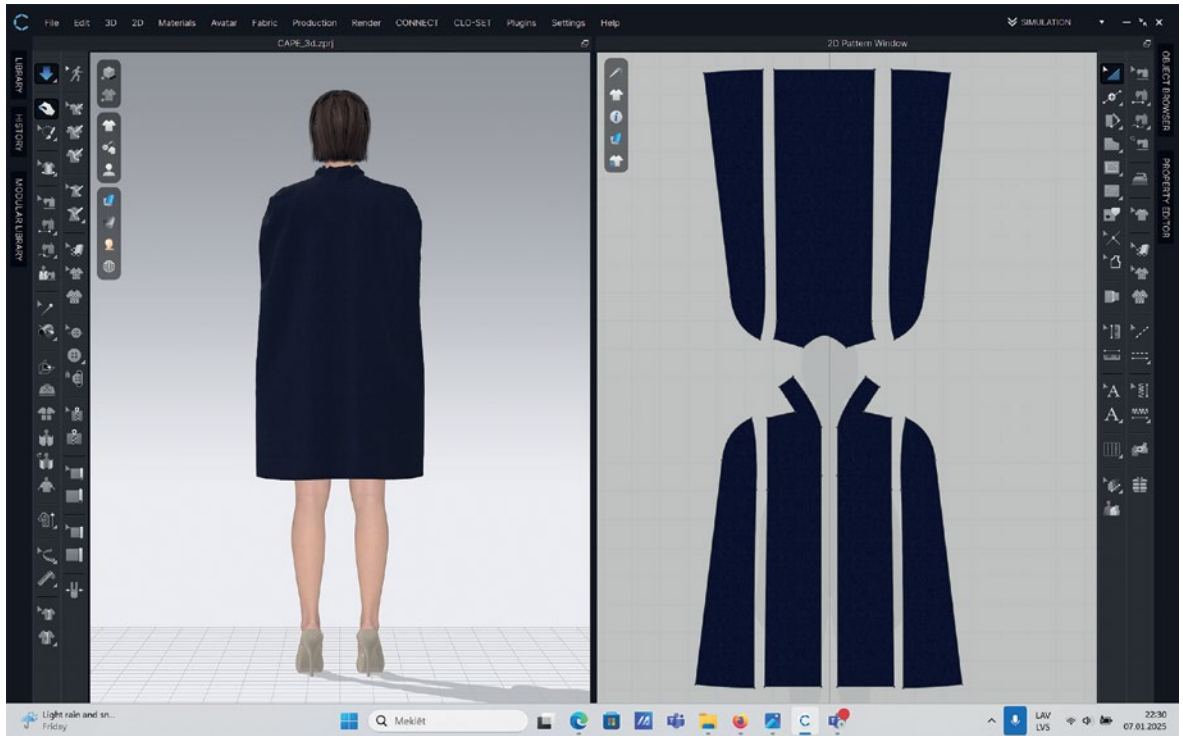


Fig. 6 Developed 3D prototype. Source: own study.

sing their effectiveness in the fashion prototyping process.

It is important to highlight the extensive possibilities offered by 2D computer-aided design (CAD) tools. In the initial phase of prototyping, sketches can be created using any 2D graphic design software and a digital pen, or through specialized programs such as TexDesign, which provide access to a library of pre-made design elements to support idea development and concept visualization (fig. 4).

Following the conceptualization phase, the specialized computer-aided design software AccuMark Gerber is used to develop the garment pattern digitally, eliminating the need for initial hand-drafted paper patterns. The pattern is constructed directly within the software environment, allowing for precise manipulation, refinement, and the generation of all required cutting components and pattern layouts (fig. 5).

Within the software, key features of the pattern are defined and refined. Control points are added to guide construction, measurements are adjusted for accuracy, and the placement of elements such as armholes is specified and additional pattern components — such as facings and lining pieces — are created to complete the garment structure.

3D prototyping allows for the digital development of the model, ensuring that all pattern pieces are accurately aligned and constructed before physical production begins. At this stage, a virtual avatar is selected and customized, appropriate fabric types and physical properties are assigned, and pattern pieces are digitally positioned on the model. A virtual “stitching” process is then carried out to simulate garment assembly, resulting in a realistic 3D prototype (fig. 6).

This enables the designer to assess fit, silhouette, fabric behaviour, and overall design accuracy, making it easier to identify and correct potential issues early in the development process (fig. 7, 8).

The project examines the integration of digital technologies in fashion design, emphasizing their functional application in the design process, their potential to enhance workflow efficiency, and their relevance within educational and research contexts.

The key points of analysis can be divided into three categories:

1. **Technology in Fashion.** 2D and 3D digital tools are transforming fashion design. Software like TexDesign and AccuMark Gerber enables precise pattern making, while 3D simulations help visualize fit and fabric behavior before production.



Fig. 7 Developed 3D prototype. Source: own study.



Fig. 8 Developed 3D prototype. Source: own study.

2. **Efficiency and Workflow.** Digital prototyping improves accuracy and speeds up the design process. It reduces the need for physical samples, allowing designers to iterate rapidly.
3. **Educational Value.** The project highlights the importance of teaching digital skills in fashion. It prepares students for a tech-driven industry and supports innovation through hands-on experimentation.

Advantages and disadvantages of digital technology

Digital technologies in fashion design offer several advantages, including faster design processes, reduced material waste through virtual prototyping, greater creative flexibility, and easier collaboration across teams. Tools like 3D modeling software allow designers to visualize and refine garments without physical samples, promoting both efficiency and sustainability. It is important to choose digital design softwa-

re based on projects specific needs, as programs vary in complexity and purpose.

However, there are also disadvantages, such as high initial costs for software and training, limited tactile feedback compared to working with real materials, digital footprint and the need for technical skills that may not be part of a traditional design background. Also, it is important to clearly determine the needs of the company and to thoroughly research the possibilities amongst the broad field of technologies.

The field of modern fashion production is realized in a Phygital (physical and digital) environment, where the best advantages of physical production are combined with the possibilities of digital technologies. Under the influence of this environment and in synergy with digital fashion, the professional and material boundaries of designers are becoming fluid, thus transforming the traditional image of the fashion designer [5].

Summary

It is important to emphasize the broad nature of this field as it encompasses diversity in application and integrates a wide range of digital technologies — from 2D and 3D design tools to AI, smart textiles, virtual reality, and wearable tech — each contributing uniquely to different stages of the fashion design and production process and giving the opportunity to designers and manufacturers to truly explore how technologies could influence their business.

The close relationship between modern technologies and the diverse aspects of clothing design and manufacturing highlights the interdisciplinary nature of the field. Technological advancements continue to open new avenues for development — ranging from design and sustainability to smart materials, production processes, entrepreneurship, immersive technologies, and artificial intelligence. As these innovations evolve, they continuously offer fresh solutions and possibilities for the fashion industry.

Innovations in digital fashion are not limited to computer-aided design (CAD) and manufacturing (CAM) but encompass the entire clothing production chain. Successful process development requires a consistent, mutually synchronized system that combines the best advantages of physical production with the capabilities of digital technologies, embracing a Phygital environment.

Each of the technological directions requires extensive research to understand the nuances, advantages, and applications of direction, which, in turn, depends on the capabilities and priorities of the designer/company. ■

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