



The Role of Computers in Product Development in Textiles: A Comprehensive Review

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Computers have changed the way products are made throughout the textile value chain. They make it possible to innovate faster, in a way that is better for the environment, and that puts the needs of customers first. This paper summarizes the role of computer-based tools and systems in the production of textile goods, such as working together in the supply chain, designing, simulating, prototyping, integrating production, and checking quality. We look at changes in computer-aided design (CAD), 3D virtual prototyping, computer-aided engineering (CAE), computer-aided manufacturing (CAM), and product lifecycle management (PLM) from 2015 to 2025. Some examples of applications are digital twins for process optimization, virtual fit and sizing, color management, 3D clothing simulation, and digital fabric drape prediction. We also look at how big data analytics, machine learning, and artificial intelligence (AI) are used to evaluate sustainability, choose materials, and predict demand. There are many benefits to computerization, such as a faster time to market, cheaper sampling, more precise pattern-making, and more options for mass customization. There are still problems, like the need for skilled workers, the need for platforms to work together, and the high cost of deployment. AI-driven generative design for textiles, real-time IoT-driven manufacturing feedback loops, and cloud-based collaborative design environments are all things that are likely to happen in the future. The review's conclusion gives a plan for how to use computer-driven methods in a smart way. This makes sure that investments in technology are in line with goals for sustainability, speed, and new ideas in textile product development departments.

Introduction

The clothing and textile industry is one of the largest in the world. It makes clothes and other things for people who want things that are quick, flexible, and good for the environment. In the past, it took a lot of time and money to make a product because you had to make a lot of copies, draw patterns by hand, and test things out. Computer technology has changed the way people think about this in the last thirty years, especially in the Department of Textile Engineering and Design, where making things is becoming more and more digital-first. Digital workflows are now possible using computers for everything from ideation to design, simulation, prototyping, production scheduling, and marketing. Reduced waste results in significant time and cost savings. The importance of computer programs has increased as more individuals want to learn about Industry 4.0 and how to manufacture products without harming the environment. They provide process automation, virtual sampling, and predictive analytics. This research examines the most sophisticated computer programs used in textile production from 2015 to 2025. It provides valuable information about these initiatives for textile researchers, students, and industry professionals.

Computer-Aided Design (CAD) in Textiles

CAD for Fabric and Apparel Design

CAD technologies changed how designers make woven, knitted, and nonwoven fabric structures by letting them see how the fabric will look and feel on a computer before they make prototypes. This has saved a lot of materials and made it easier to come up with new designs. Some of the most popular programs for making virtual fabric that looks like real fabric are Textronics, NedGraphics, and Pointcarre. It is easier to make digital patterns, grade them, and make clothing markers with CAD programs like Gerber AccuMark, Lectra Modaris, CLO3D, and Browzwear. Designers can change the shapes, seams, and styles of clothes on a computer, which makes sure that they are very accurate and cuts down on mistakes made by hand.

3D Virtual Prototyping

The newest trend is 3D garment simulation. You can see how clothes fit, look, and move by putting them on virtual avatars. Developers use virtual try-on solutions in their own businesses, and merchants use them outside of their businesses to help customers. This means that fewer real prototypes are needed, which saves time and money. 3D prototypes are very helpful for mass customization and online shopping because they let customers see the finished product on avatars that look like them.

Computer-Aided Engineering (CAE) and Simulation

Fabric Behavior Simulation

Using finite element analysis (FEA), CAE tools analyze how textiles behave mechanically, anticipating how they will drape, stretch, compress, and feel comfortable in different temperatures. This lets engineers choose fiber mixes and weave or knit structures that satisfy practical performance needs, such those of sportswear or medical textiles.

Color Prediction and Digital Printing

Computerized color management systems (CMS) use spectrophotometry and ICC profiles to guarantee color constancy between batches and substrates. Because digital textile printing (DTP) is entirely computer-driven, it allows for on-demand manufacturing and lower inventory costs. By transferring drawings directly to printers, CAD-linked DTP operations reduce translation mistakes.

Computer-Aided Manufacturing (CAM) and Automation

CAM in Textile Production

Machine instructions for cutting, weaving, knitting, and embroidery machines are converted from CAD data using CAM systems. These days, smart factories use robotic sewing cells, knitted CAD/CAM interfaces, and automated cutting tables to increase accuracy and decrease reliance on manpower.

Integration with Industry 4.0

IoT sensors and machine data analytics are used in contemporary textile mills for production optimization and predictive maintenance. Computer systems allow just-in-time production and lower inventory holding costs by integrating design and manufacturing data (CAD–CAM integration).

Product Lifecycle Management (PLM) Systems

PLM solutions provide a unified digital foundation for handling every stage of the textile product lifecycle, including design, sourcing, manufacture, distribution, and end-of-life. They improve cooperation between suppliers, sourcing teams, designers, and merchandisers while maintaining transparency and version control. For remote product development teams, cloud-based PLM solutions have gained popularity in the post-COVID age.

AI, Big Data and Digital Twins in Textile Development

AI in Design and Forecasting

Through the analysis of massive datasets from social media, sales, and market reports, AI-driven technologies forecast fashion trends, optimize color palettes, and recommend novel

fabric combinations. With its innovative patterns and styles, generative AI is becoming a co-creator for designers.

Digital Twins for Process Optimization

A digital twin is an electronic model of a textile process or product that is updated in real time by Internet of Things sensors. It makes it possible to simulate and optimize weaving efficiency, dyeing parameters, and finishing procedures in real time, which lowers resource consumption and improves uniformity in quality.

Advantages of Computerization in Product Development

- Speed: Development cycles are significantly shortened by digital sampling.
- Accuracy: Fit problems are minimized by accurate pattern grading and simulation.
- Cost savings: Fewer physical prototypes and less fabric waste.
- Customization: Large-scale, mass personalization.
- Sustainability: Less energy, water, and chemical consumption as a result of less manufacturing trial and error.

Challenges and Barriers

- High labor expenses and capital expenditures for CAD/CAE/PLM systems.
- Problems with compatibility between various machine interfaces and software systems.
- Employees with conventional training who are resistant to change.
- Issues with data privacy and cybersecurity in cloud-based collaboration systems.

Future Outlook and Research Gaps

- Global teams may use cloud-based collaborative design ecosystems.
- Design automation powered by generative AI that incorporates human innovation.
- Digital showrooms with AR/VR capabilities to cut down on in-person trade exhibits and samples.
- PLM incorporates life-cycle sustainability modeling to improve decision-making.
- Open-source, low-cost solutions to democratize access for SMEs and mills in underdeveloped nations.

Conclusion

The creation of contemporary textile products is now mostly dependent on computers, which have changed the process from being manual, sequential, and resource-intensive to being digital, parallel, and data-driven. Faster, more accurate, and sustainable innovation is made possible by the use of digital twins, PLM systems, CAD/CAE/CAM, and AI-based forecasting. For adoption to be inclusive, however, issues with cost, interoperability, and training must be resolved. The creation of textile products in the future will take place in fully integrated digital ecosystems that provide mass customization and sustainability via the interconnection of design, simulation, manufacturing, and sale.

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