Tech-Driven Fashion Navigating the Opportunities and Challenges of Digitalization

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Abstract

Background: The fashion industry, which includes the creation, making, and sale of clothing and other items, makes around $3 trillion each year by United Nations Sustainable Development Goals. In order for the industry to meet these goals it will need to embrace digital technology that facilitates sustainability and innovation. Methods: This work of research outlines an effort to evaluate the existing body of scholarship regarding the implementation of modern technologies like the Internet of Things (IoT), Artificial Intelligence (AI), Augmented Reality (AR), and Virtual Reality (VR) in the fashion world. It appraises their present use, assesses their value, and examines the degree of change that they may make in the context of the industry's future. Results: The integration of these technologies has advanced smart clothing, circular economy, trend forecasting, personalized recommendations, health prediction, and immersive shopping. However, challenges include energy storage in wearables, limited AI adoption, and technical integration issues. The immersion that AR and VR provide has made it possible for customers to virtually fit into clothes. The study hopes that through the discussion of these technologies, useful solutions can be found. Conclusion: The study recommends expanding AI in fashion logistics, advancing energy-efficient smart textiles, and leveraging IoT-AI-edge computing systems, along with developing smart clothing frameworks, to promote a sustainable, digitally-driven fashion industry.

Keywords: Fashion industry, digital technologies, AI (Artificial Intelligence), Technical integration, Sustainability

Significance | The research Seeks how the new technologies are innovatively changing apparels through improvement in design, production, marketing, and customer services globally.

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1. Introduction

The fashion industry, which includes the design, production, and sales of garments and accessories, has become one of the biggest sectors of the global economy (Şen, 2008). It is important in the development of cultural phenomena, economic growth, and shaping the global brand of consumerism (Rachwal-Mueller & Fedotova, 2024). It has a direct influence on millions of employment opportunities within the textiles, manufacturing, retail, logistics, and many other industries (Repp et al., 2021). In the meantime, growing environmental and social concerns placed additional burdens on the fashion industry to adopt more sustainable approaches (Todeschini et al., 2017). As one of the top industries in pollution, waste, and overconsumption, it is imperative for the industry to align itself with the United Nations Sustainable Development Goals (SDGs)specifically, the goals that aim for the reduction of consumption and production processes that are deemed unsustainable by the year 2030 (Glavič, 2021). Change is needed in the fashion industry most urgently. The fast fashion paradigm, which involves the production of cheap and stylish clothing at an industrial scale, is detrimental to the environment (Niinimäki et al., 2020). Associated problems include overconsumption, resource exhaustion, waste generation, and child labor. The fashion industry is responsible for around 10% of the world's carbon emissions, 20% of the world's wastewater, and

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enormous amounts of textile waste, which adds to the already critical environmental situation (Filho et al., 2024). Such actions are detrimental to the world, and at the same time, endanger the perpetuity of the industry. Therefore, the need of the hour for the fashion industry is sustainable and responsible production and consumption (Lee, 2021).

Every year, the fashion industry generates nearly $3 trillion - essentially being 2-3% of the global GDP. Aside from that, it serves is one of the world's key employers, creating millions of opportunities in agriculture (for textile production), design, manufacturing, and retail (Peters et al., 2021; Flood, 2017). Nonetheless, the industry has to adopt new sustainable strategies to maintain their relevance and growth (Ghobakhloo et al., 2021). With changing consumer preferences for eco-friendly goods, fashion brands need to incorporate technologies that ensure transparency, efficiency, and environmental responsibility (Ikram, 2022). Achieving the SDGs, especially in respect to fostering sustainable consumption and production, requires expansive efforts and transformational actions within the entire fashion supply chain (Choi & R, 2021). The incorporation of emerging digital technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Augmented Reality (AR), and Virtual Reality (VR) can facilitate this change. These technologies stand to advance the sustainability and operational efficiency of the fashion industry while also enhancing customer and user experience (Zhang et al., 2022; Gomes et al., 2020). Furthermore, these technologies may allow for lower resource consumption, streamlined supply chains, reduced waste, and improved product identification and tracking (Rejeb et al., 2019).

As an illustration, features like IoT technology enable the live monitoring of raw materials, products, and goods within the supply chain, enhancing visibility and lowering inefficiencies (Sallam et al., 2023). AI has the ability to enhance the productivity and efficiency of a manufacturing facility's production planning by reducing demand forecasting, trend forecasting, and improving wasteful inventory management. Also, AI systems can optimize customer engagement by personally addressing each customer's unique needs, thereby increasing satisfaction. The immersion that AR and VR provide has made it possible for customers to virtually fit into clothes. This decreases the necessity for samples and returns, thereby minimizing wastage and energy consumption (Nweje & Taiwo, 2025). There remain unaddressed issues pertaining to the technology's remarkable promise. These digital technologies have great merits, but their application is constrained by high implementation costs, substantial investment needed for the infrastructure, and considerable research and development expenditure (L. Chen et al., 2011).

Smaller fashion firms, in particular, may have a difficult time accessing these technologies (Aakko & Niinimaki, 2018). Also, the absence of a uniform set of guidelines and system interoperability greatly increases the chances of underutilized technological advancements (Dave & Mittapally, 2024). Additionally, there are some issues related to the privacy and security of data, especially with the use of AI, IoT, and other technologies that capture and store enormous amounts of data about consumers (Alhitmi et al., 2024). These critical concerns must be solved in advance to guarantee responsible deployment of technologies (Burr & Leslie, 2022). This research intends to study IoT, AI, AR, and VR technologies and their impact towards achieving sustainability goals in the fashion industry. The study will survey relevant literature on the application of these technologies, evaluate their effectiveness in resolving the challenges the industry faces, determine existing gaps, and examine how these technologies can contribute to the goals of a sustainable and digitized fashion industry. The goal of this study is to answer how the fashion industry can reach its sustainability targets and decrease its environmental impact while satisfying the needs of consumers who are more aware of environmental issues. The study hopes that through the discussion of these technologies, useful solutions can be found.

2. Materials and Methods

This study seeks to examine the impact the IoT, AI, AR, and VR have on the emerging digital technologies within the fashion industry (Rane et al., 2023). The aim of this review is to evaluate the effects of these technologies on sustainability, innovation, operational efficiency, and, subsequently, on the future of the fashion industry. As the research tries to understand the impact of digital technologies on the fashion industry, it takes a qualitative approach for the study design. The methodology leverages secondary data, which is an established approach for integrating research from various sources, using systematic reviews, and meta-analyses. This approach will enable the study to comprehensively analyze and evaluate current research literature around the phenomena, showcasing digital technology's trends, gaps, and insights within the fashion industry.

2.1 Data Collection

The literature review comes from data collected from the following academic databases: Web of Science (WoS), Scopus, IEEE, Xplore. These databases were selected because of their extensive coverage of peer-reviewed publications on technology, sustainability and industrial innovations. They also give access to veritable, scientifically sound documents that are very useful in constructing an assessment concerning digital technologies and fashion. The articles were chosen based on their relevance to the topic, with publication dates from 2018 to 2023 in order to incorporate the most recent advancements and insights in the field.

2.2 Data Analysis Process

The analysis of data for the current research study was based on thematic analysis, which is a qualitative method used to identify, analyze, and interpret patterns (themes) within collected data. This method allowed them to better understand how profoundly digital technologies impacted the fashion industry.

2.2.1. Article Review and Coding

After applying the inclusion and exclusion criteria, a total of 105 peer-reviewed articles published between 2015 and 2024 were picked. Each article was critically analyzed, and relevant portions were highlighted and indexed through coding relevant to the themes. Using open coding, keywords and ideas were collected from the documents, which formed the basis of an initial codebook. These were later consolidated into larger thematic categories. Articles were permitted to be located in various themes to ensure all aspects of digital transformation in fashion were comprehensively captured optimized.

2.2.2. Emergent Themes and Insights

The examination gave rise to the following themes: sustainability, enhanced consumer experience, and innovation. Each theme included several technologies and practices that were shifting various aspects of the fashion industry (Casciani et al., 2022; Alexander & Rutter, 2022).

A. Sustainable Production and Circular Economy

The combination of IoT and AI technologies has brought forth new, sustainable possibilities in integrating the "Internet of Things" (Rathore, 2019). These advanced technologies aid in efficient energy management by not only remotely monitoring but also giving real-time feedback on energy consumption, fabric utilization, and machine wear, which helps in the reduction of unnecessary energy use in factories (Soori et al., 2023). On the consumer end, sensors in smart garments can track how often clothes are worn and how often they are washed, which helps in assessing both garment's durability and recyclability (Y. Zhou & Zhao, 2024). Demand forecasting and trend prediction with unprecedented accuracy are made possible with AI, and this is done by applying the collected data, which drastically eliminates overproduction. Overproduction is one of the most detrimental issues of sustainability the industry has faced in the past (Celi et al., 2025). Sustainable manufacturing technologies enable 3D printing on-demand.

This form of additive manufacturing creates garments by employing processes that generate very little waste material. The method encourages small-scale local production, which diminishes the carbon footprint linked to mass production as well as international shipping (Glogar et al., 2025). Together with strategies employed in circular fashions, like turn-in programs and upcycling, these technologies lay the groundwork for a more responsible and progressive fashion ecosystem (Cowa).

B. Enhancing Consumer Experience

The interaction of consumers with fashion products is changing due to the integration and adoption of immersion technologies, for example: augmented reality (AR) and virtual reality (VR). AR features permit individuals to simulate wearing clothing via their smartphones or mirrors, and this has a great impact on reducing product returns (Fernandes & Morais, 2021). Such features not only increase the ease and trust in online shopping but also assist with sustainability by decreasing wasteful packaging as well as reversing logistics. In contrast, virtual reality is used for sophisticated fashion shows or digital showrooms where consumers can view entire collections as 3D models from the comfort of their houses. This allows for a further reduction in the need for supporting infrastructure and transportation, thus minimizing environmental footprint. For example, AI-based recommendation systems tailored for ecommerce leverage client intelligence database records like browsing activity, purchase history, and even weather data to provide extremely tailored suggestions for garments (Rubio-Tamayo et al., 2017). Such systems enhance customer satisfaction which in turn reduces the chances of unused purchases thus driving consumption on these items. Moreover, smart garments have further transformed the fashion experience of consumers by integrating style with utility, in such devices, biometric and thermoregulation (environmental interaction) and fitness monitoring can be provided.

C. Innovation and Digital Transformation

Innovation plays a central role in every business, including the fashion industry. With the growing use of technology in fashion, the metaverse gives rise to new possibilities for smart clothes, such as telemedicine health check, Virtual Reality (VR) Surgery, and clothing capable of tracking a wearer's posture or movement and providing feedback for self-improvement. Emergent Themes and Insights in Digital Fashion Transformation data shown in Table 01, extracted data by (Casciani et al.2022; Burr, & Leslie, 2022; Akhtar et al., 2022). Another advancement example is garment prototyping in the metaverse; designers can use virtual prototyping and digital twins to design, simulate, and test garments without needing to create physical samples (Kalantari et al., 2022). Designers at this stage can complete the prototyping phase in the metaverse, powered by Artificial Intelligence (AI) algorithms, which can identify the most marketable themes from social media, fashion-oriented blogs, and online shops. The automation tools provided by AI open even more possibilities for conceptual frameworks (Cantamessa et al., 2020). Automation further enhances digital tools. Combining global cloud systems accessible in various time zones allows for better collaboration between designers, suppliers, and manufacturers, paving the path for innovative ideas. With these changes, the approach towards developing the fashion and apparel industry progresses from traditional single-handed fashion

manufacturing systems to an interconnected agile network (Wu et al., 2014).

2.2.3. Visual Representation

A radial diagram was suggested (Figure 4) and aims to capture the scope of digital fashion innovation that includes its themes. In the center of the diagram, the focus is placed on the three foundational themes which are: sustainability, consumer experience, and innovation. The Internet of Things (IoT), Artificial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR), and 3D Printing contribute as peripheral technologies (Rane et al., 2023). From each of the technologies, there are branches that represent practical embodiments such as supply chain enhancement, virtual fitting rooms, personalized AI recommendations, and on-demand manufacturing. This figure addresses the extent of digital evolution within the fashion industry and demonstrates how various technologies and results are interconnected, simultaneously (Rathore, 2023).

3. Role of Digitalization in Advancing Sustainable Fashion

As the fashion industry adapts to emerging technologies, digital tools for designing, producing, advertising and selling clothing have started to appear. Bertola and his colleagues have shown that innovation is not the only impetus in using technology. There is also a greater need for sustainability, efficiency, transparency, and accountability throughout the fashion value chain. The use of digital technologies makes it possible to incorporate intelligent and self-driving systems that allow for responsible consumption, waste reduction, customization, and enhanced customer engagement. The Internet of Things (IoT) is one of the technologies that is fostering this development **Figure 1.** IoT is defined as the integration of computing and communication technologies into everyday things like clothes, where they can be supervised and controlled remotely, thereby capturing and relaying information in real-time (Rahman et al., 2024). With regards to fashion, IoT is used to develop smart clothes that monitor, register physical activity, track health parameters, and change temperature with varying surroundings (Samie et al., 2016). These clothing items are especially beneficial for sportspeople, senior citizens, and medical patients because they provide constant biometric monitoring. In the context of production, IoT increases visibility within the supply chain by tracking the movement of raw materials, monitoring factory parameters, and confirming ethical procurement. Fashion brands are also aided by accurate real-time data collection, which facilitates effective inventory control and mitigates the risk of overproduction in fashion items, thus achieving sustainable objectives (Anozie et al., 2024).

3.1 Artificial Intelligence (AI)

Digital fashion transformation cannot occur without the integration of Artificial Intelligence (AI). Systems driven by AI can review expansive datasets and analyze trends to provide expert suggestions (Rahman et al., 2024). In retail, personalization powered by AI creates tailored shopping experiences by suggesting complete looks to customers depending on their previous purchases, favorite styles, and current weather conditions (Elena, 2020). AI plays an integral role in design and product development by style automation, fashion forecasting, and fit optimization (Rahman et al., 2025). AI is also aiding fashion brands in automating quality control, defect detection in production processes, and enhancing the accuracy in manufacturing precision (Rahman et al., 2024). Such advancements help minimize operational waste, reduce product returns, and improve demand forecasting (Babu et al., 2022).

3.2 Augmented Reality (AR) and Virtual Reality (VR)

Both online and in-person shopping now feature the expanded usage of Augmented Reality (AR) and Virtual Reality (VR). Using a smartphone or a smart mirror, AR permits the customer to interactively try on clothing. This technological approach minimizes wasted resources because it alleviates the reliance on fitting rooms. In turn, this helps minimize return rates, which are a significant wastage resource of e-commerce (Bonetti et al., 2017). VR develops 3D immersive environments in which customers or designers can interact with virtual showrooms, attend digital fashion shows, and collaborate on garment design development. These modern techniques not only mitigate time and financial expenditure but also lessen the carbon footprint generated by travel, physical sampling, and the maintenance of brick-and-mortar stores (Murugesan et al., 2024).

3.3 Printing 3D

The capability of creating garments and accessories on demand is made possible by 3D printing and digital fabrication, which change the traditional processes of manufacturing **(Table 02).**

This technology is based on additive manufacturing techniques, which build complex structures by depositing materials layer by layer. It has numerous sustainability advantages, such as minimal fabric waste, lower emission of gasses from transportation due to production at the point of consumption, and using recyclable or biodegradable materials (Sun & Zhao, 2017). Custom-made items designed to suit individual body measurements also promote inclusivity and diminish surplus stock. More and more, 3D printing is used to make avant-garde shoes and other accessories as well as garments that test the limits of contemporary fashion design (Hudson & Hwang, 2020).

Apart from these technologies, the operation of fashion businesses is impacted by digital platforms and tools for data analytic and virtual collaboration, in a customer relationship management manner. Digital mood boards, AI-based design software, and cloud logistics systems exemplify how diverse the fashion industry's technological ecosystem is and will continue to grow. These tools

Table 1. Emergent Themes and Insights in Digital Fashion Transformation.

Theme	Key Technologies	Insights
Sustainable Production & Circular Economy	IoT, AI, 3D Printing	- IoT sensors monitor energy, waste, and garment u sage. - AI forecasts demand and reduces overproduction. - 3D printing enables low-waste, local production.
Enhancing Consumer Experience	AR, VR, AI, Smart Wearables	- AR/VR enable virtual try-ons and immersive shopping. - AI offers personalized recommendations. - Wearables combine style with biometric and fitness tracking.
Innovation & Digital Transformation	Smart Clothing, Digital Twins, AI	- Smart garments used in healthcare, sports, and work wear. - Virtual prototyping reduces time and cost. - AI-driven trend forecasting aligns design with market needs.

Table 2. Role of Digitalization in Advancing Sustainable Fashion

Technology	Key Features	Sustainability Impact
Internet of Things (IoT)	- Smart garments with sensors (track health, activity, adjust temperature)	- Enhances supply chain transparency - Reduces waste and overproduction - Supports ethical sourcing
Artificial Intelligence (AI)	- Data analysis to identify trends, optimize design, and personalize shopping experiences	- Reduces waste through demand forecasting - Improves manufacturing precision - Reduces returns
Augmented Reality (AR)	- Virtual try-ons via smartphones or smart mirrors	- Reduces reliance on physical fitting rooms - Lowers return rates, reducing waste
Virtual Reality (VR)	- Immersive environments for virtual showrooms, digital fashion shows, and 3D garment collaboration	- Reduces travel, sampling, and physical store emissions
3D Printing	- On-demand production of garments and accessories using additive manufacturing techniques	- Minimal fabric waste - Localized production reduces transportation emissions - Customizable items promote inclusivity
Digital Platforms & Tools	- AI-based design software, cloud logistics systems, and digital mood boards for collaboration	- Streamlines workflows - Reduces production timelines - Minimizes environmental impacts

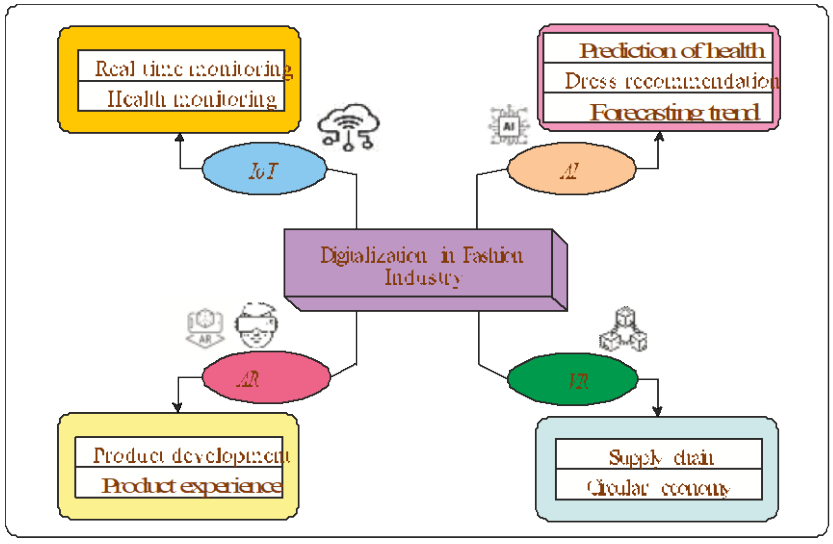

Figure 1. Digitalization in the fashion industry.

enable designers, manufacturers, marketers, and retailers to work across greater distances with ease, shorten the time of production, and improve responsiveness to market opportunities all while minimizing environmental impacts (Akhtar, 2023). All in all, digitalization and the incorporation of technology into business processes is making the fashion industry more responsive, customer-oriented, and green. With IoT, AI, AR/VR, and 3D printing technologies, brands are able to sustainably optimize innovation, strengthen consumer-relations, and make those interactions more transparent. This ongoing change marks a crucial turn towards the day fashion will be not only modern and creative but also socially and environmentally resilient and responsible (Popkova et al,.2024).

4.Discussion and Working strategies

The effects are revolutionary and multifaceted as the fashion sector merges with contemporary technologies. The Akram et al. (2022) study tells us how modern production techniques and individual consumption experiences highlight the advantages of digitization in the fashion industry. Achieving these benefits is overly complex to the fashion industry's use of technology with eco-friendly policies, which means that the advantages could only be achieved through harnessing the proper methods and strategic frameworks. This section discusses the emerging methods of encouraging shifts towards digitization and outlines how their implementation in concrete cases could lead to anticipated results.

4.1 Internet of Things (IoT) and Artificial Intelligence (AI)

The Internet of Things (IoT) and Artificial Intelligence (AI) are now being applied in the fashion industry, and this is augmenting the efficiency and productivity of the industry. Babu et al. (2022) asserts that IoT sensors, which are already embedded in smart garments and IoT systems, monitor data such as products usage, resource utilization in production, and production efficiency in real time **Figure 2**. AI algorithms then utilize this information to optimize manufacturing processes, minimize waste, and improve demand forecasting accuracy. In addition, consumers interact with smart garments through mobile applications that provide essential information regarding garment caring, wearing history, and sustainability tips. Such a feedback loop allows for improving designs, advanced and more sustainable production methods, and changing consumer behaviors towards more sustainable practices throughout the product's life cycle (Akram et al., 2022).

The **Figure 2**, attached in the citation of Trakadas et al. (2020) describes the application of AI and IoT in the fashion supply chain, spanning from the initial designing to the consumption stages. In the initiating designing stage, IoT sensors select material, while AI optimizes eco-friendly designs. During production, IoT monitoring tracks energy and material expenditure, while AI efficiency improvements and waste reduction are implemented. Thereafter, smart garments collect real-time usage data that aids care recommendations and enhances garment longevity. Engagement occurs through mobile applications, where users gain tailored advice on how to practice sustainability. Lastly, user data integrates into the system, thus providing feedback for innovative improvement for advanced garments down the line in design and production.

4.2 Printing 3D and Digital Fabrication in Sustainable Fashion

In the fashion world, 3D printing stands out as an innovative and environmentally friendly solution compared to other manufacturing procedures (Figure 3). Unlike traditional clothing production that tends to deal with bulk fabrics and creates a lot of waste, 3D printing allows for on-demand, precise manufacturing. This drastically reduces excess inventory, aligns production and consumer demand, and decreases the chances of overproduction (Murugesan et al., 2024). With 3D printers, unlike bulk models of garments, custom-designed garments can be created digitally, with materials only being applied on the model where it is needed leading to lower material waste. It abolishes scraps of fabric, promotes the creation of waste-free designs, and greatly enhances the sustainability of fashion designs. The ability to customize garments according to individual body shapes helps mitigate the number of returns and discarded items—another form of waste in the fashion world—due to poor fit. This technology profoundly aids the circular fashion economy because it allows the adoption of eco-friendly and innovative materials like biodegradable polymers or recycled filaments. Moreover, the desktop 3D printers facilitate localization of production which decreases the carbon emissions associated with the lengthy supply chains (McKinney et al., 2020).

4.3 Augmented Reality (AR) and Virtual Reality (VR

The shopping experience is being augmented with features like virtual try-ons, high-tech immersion displays, and product showcases with the learning of Augmented Reality (AR) and Virtual Reality (VR) systems **Figure 4.** These technologies enhance convenience while reducing the need for sampling and showroom visits, making it more sustainable (Ikeata, 2024). Customers can now try on clothes from the comfort of their smartphones or smart mirrors located in stores. This advancement not only saves time but also minimizes the carbon emissions related to return shipping (Mangiaracina, 2021).

5. Conclusion

As a major global sector, the fashion industry contributes approximately 2% to the world's GDP and plays a vital role in the global economy, yet it faces criticism for its environmental impact and social neglect, including excessive CO_2 emissions and material waste. This study explores how digital technologies like IoT, AI, AR, and VR can help the industry align with the UN Sustainable Development Goals (SDGs). It highlights advancements in smart

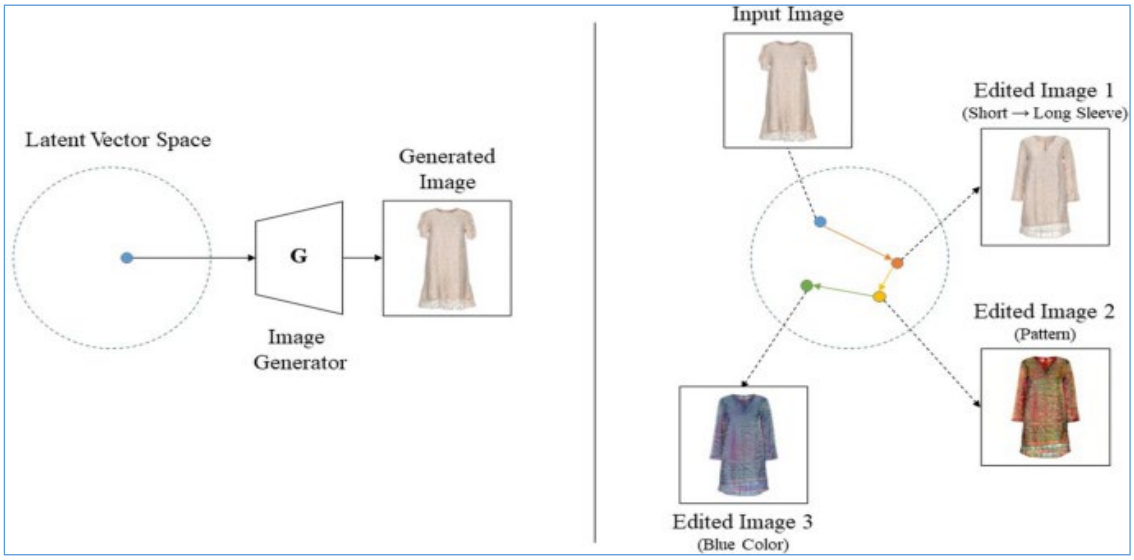

Figure 2. Flowchart of IoT and AI Integration in Smart Manufacturing

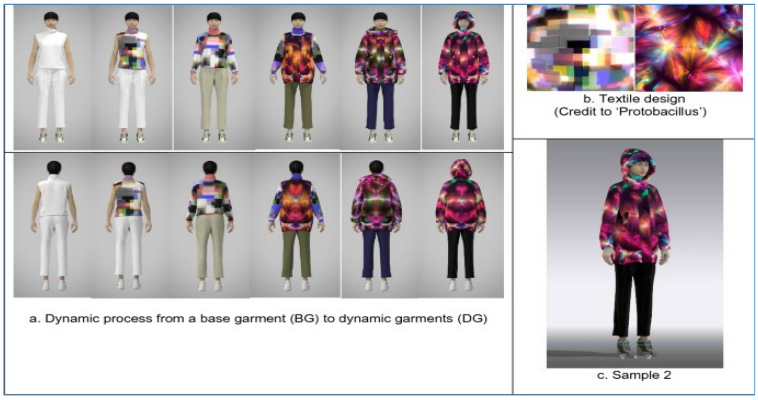

Figure 3. AI-Driven Transformation of Base Garments into Dynamic Fashion Designs Using Digital Textile Patterns

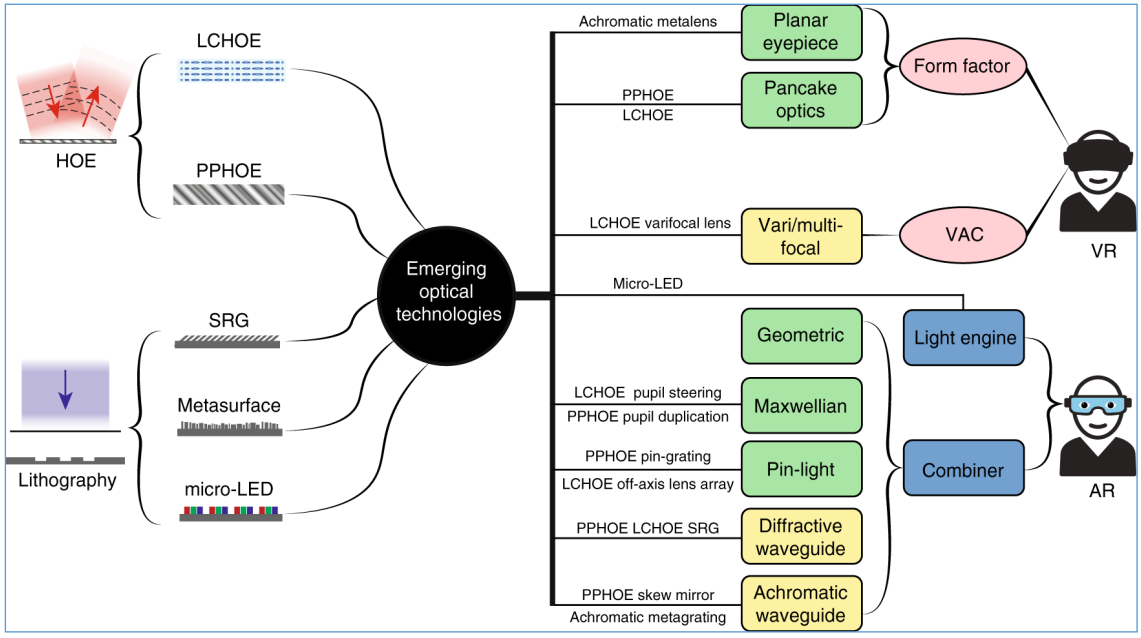

Figure 4. Schematic of some emerging optical technologies applied in AR/VR.

clothing, trend forecasting, environmentally responsive dress recommendations, health monitoring, supply chain optimization, and immersive shopping experiences. The study also identifies current limitations and recommends broader technological adoption, improved energy storage for smart textiles, integration of IoT and AI with edge computing, and the development of smart clothing for rescue operations.

Author contributions

A.R. was responsible for the conceptualization, methodology, investigation, data analysis, and writing of the original draft. A.R. also reviewed and edited the manuscript and approved the final version for submission.

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Competing financial interests

The authors have no conflict of interest.

References

Aakko, M., & Niinimäki, K. (2018). Fashion Designers as entrepreneurs: Challenges and Advantages of micro-size companies. Fashion Practice, 10(3), 354–380. https://doi.org/10.1080/17569370.2018.1507148

Akhtar, W. (2023, November 12). Digital Innovations in fashion: mapping the co-evolution of technological advancements and fashion industry. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4913915

Akhtar, W. H., Watanabe, C., Tou, Y., & Neittaanmäki, P. (2022). A new perspective on the textile and apparel industry in the digital transformation era. Textiles, 2(4), 633–656. https://doi.org/10.3390/textiles2040037

Akram, S. V., Malik, P. K., Singh, R., Gehlot, A., Juyal, A., Ghafoor, K. Z., & Shrestha, S. (2022). Implementation of Digitalized Technologies for fashion Industry 4.0: Opportunities and challenges. Scientific Programming, 2022, 1–17. https://doi.org/10.1155/2022/7523246

Alexander, B., & Rutter, C. (2022). Towards transformation: digitalization, sustainability and customer experience. Fashion Practice, 14(3), 319–328. https://doi.org/10.1080/17569370.2022.2129468

Alhitmi, H. K., Mardiah, A., Al-Sulaiti, K. I., & Abbas, J. (2024). Data security and privacy concerns of AI-driven marketing in the context of economics and business field: an exploration into possible solutions. Cogent Business & Management, 11(1). https://doi.org/10.1080/23311975.2024.2393743

Anozie, U. C., Pieterson, K., Onyenahazi, O. B., Chukwuebuka, U. O., & Ekeocha, P. C. (2024). Integration of IoT technology in lean manufacturing for real-time supply chain optimization. International Journal of Science and Research Archive, 12(2), 1948-1957.

Babu, M. M., Akter, S., Rahman, M., Billah, M. M., & Hack-Polay, D. (2022). The role of artificial intelligence in shaping the future of Agile fashion industry. Production Planning & Control, 35(15), 2084–2098. https://doi.org/10.1080/09537287.2022.2060858

Bertola, P., & Teunissen, J. (2018). Fashion 4.0. Innovating fashion industry through digital transformation. Research journal of textile and apparel, 22(4), 352-369.

Bonetti, F., Warnaby, G., & Quinn, L. (2017). Augmented reality and virtual reality in physical and online Retailing: A review, Synthesis and research agenda. In Progress in IS (pp. 119–132). https://doi.org/10.1007/978-3-319-64027-3_9

Burr, C., & Leslie, D. (2022). Ethical assurance: a practical approach to the responsible design, development, and deployment of data-driven technologies. AI And Ethics, 3(1), 73–98. https://doi.org/10.1007/s43681-022-00178-0

Cantamessa, M., Montagna, F., Altavilla, S., & Casagrande-Seretti, A. (2020). Data-driven design: the new challenges of digitalization on product design and development. Design Science, 6. https://doi.org/10.1017/dsj.2020.25

Casciani, D., Chkanikova, O., & Pal, R. (2022). Exploring the nature of digital transformation in the fashion industry: opportunities for supply chains, business models, and sustainability-oriented innovations. Sustainability: Science, Practice and Policy, 18(1), 773-795.

Celi, M., Victoria, R. S., & Colombi, C. (2025, March 21). Redeployment of trend forecasting : managing the overproduction challenge in the fashion industry. https://www.politesi.polimi.it/handle/10589/230048

Chen, C., Palma, F., & Reyes, L. (2019). Reducing global supply chains' waste of overproduction by using lean principles. International Journal of Quality and Service Sciences, 11(4), 441–454. https://doi.org/10.1108/ijqss-03-2018-0024

Chen, L., Xu, S., & Li, J. (2011). Recent advances in molecular imprinting technology: current status, challenges and highlighted applications. Chemical Society Reviews, 40(5), 2922. https://doi.org/10.1039/c0cs00084a

Choi, T., & R. (2021). Achieving sustainable development goals (SDGs) : sustainable supply chain management in the fashion industry. https://theses.lib.polyu.edu.hk/handle/200/11431

Cowart, A., & Maione, D. (2022). Transitioning toward the Slow and long: Developing Experiential Futures approach toward system change in fashion. Dialnet. https://dialnet.unirioja.es/servlet/articulo?codigo=8669686

Dave, D. M. K., & Mittapally, B. K. (2024). Data Integration and Interoperability in IoT: Challenges, Strategies and Future Direction. Int. J. Comput. Eng. Technol.(IJCET), 15, 45-60.

Elena, M. (2020, December 9). Artificial intelligence in fashion : how consumers and the fashion system are being impacted by AI-powered technologies. https://www.politesi.polimi.it/handle/10589/167521

Fernandes, C. E., & Morais, R. (2021). A review on potential technological advances for fashion retail. dObra[S] – Revista Da Associação Brasileira De Estudos De Pesquisas Em Moda, 32, 168–186. https://doi.org/10.26563/dobras.i32.1372

Filho, W. L., Dinis, M. a. P., Liakh, O., Paço, A., Dennis, K., Shollo, F., & Sidsaph, H. (2024). Reducing the carbon footprint of the textile sector: an overview of impacts and solutions. Textile Research Journal, 94(15–16), 1798–1814. https://doi.org/10.1177/00405175241236971

Flood, C. (2017). Ethical implications of the fashion industry. DigitalCommons@SHU. https://digitalcommons.sacredheart.edu/acadfest/2023/all/153/

Ghobakhloo, M., Iranmanesh, M., Grybauskas, A., Vilkas, M., & Petraitė, M. (2021). Industry 4.0, innovation, and sustainable development: A systematic review and a

roadmap to sustainable innovation. Business Strategy and the Environment, 30(8), 4237–4257. https://doi.org/10.1002/bse.2867

Glavič, P. (2021). Evolution and current challenges of sustainable consumption and production. Sustainability, 13(16), 9379. https://doi.org/10.3390/su13169379

Glogar, M., Petrak, S., & Naglić, M. M. (2025). Digital Technologies in the Sustainable Design and Development of Textiles and Clothing—A Literature Review. Sustainability, 17(4), 1371. https://doi.org/10.3390/su17041371

Gomes, P., Magaia, N., & Neves, N. (2020). Industrial and Artificial Internet of Things with Augmented Reality. In Internet of things (pp. 323–346). https://doi.org/10.1007/978-3-030-44907-0_13

https://doi.org/10.25163/microbbioacts.7110036

Hudson, K., & Hwang, C. (2020). Application of 3D Prototyping to promote Size-Inclusive design Practices for Plus-Size Apparel. Fashion Practice, 14(1), 5–25. https://doi.org/10.1080/17569370.2020.1804152

Ikeata, A. (2024). Improving shopping experience in apparell setting in Turku. Theseus. https://www.theseus.fi/handle/10024/875197

Ikram, M. (2022). Transition toward green economy: Technological Innovation's role in the fashion industry. Current Opinion in Green and Sustainable Chemistry, 37, 100657. https://doi.org/10.1016/j.cogsc.2022.100657

Kalantari, S., Pourjabar, S., Xu, T. B., & Kan, J. (2022). Developing and user-testing a "Digital Twins" prototyping tool for architectural design. Automation in Construction, 135, 104140. https://doi.org/10.1016/j.autcon.2022.104140

Lee, Y. K. (2021). Transformation of the Innovative and Sustainable Supply Chain with Upcoming Real-Time Fashion Systems. Sustainability, 13(3), 1081. https://doi.org/10.3390/su13031081

Mangiaracina, R. (2021, October 20). Innovative tools for the prevention of product returns in e-commerce. https://www.politesi.polimi.it/handle/10589/179010

McKinney, E., Cho, S., Zhang, L., Eike, R., & Sanders, E. (2020). Analysis of zero waste patternmaking approaches for application to apparel. In Sustainable textiles (pp. 31–51). https://doi.org/10.1007/978-3-030-37929-2_2

Md Habibur Rahman, Tanjila Islam, Mohammad Hamid Hasan Amjad, Md Shihab Sadik Shovon, Md. Estehad Chowdhury, Md Rahatul Ashakin, Bayazid Hossain, Proshanta Kumar Bhowmik, Md Nurullah, Atiqur Rahman Sunny (2024). "Impact of Internet of Things (IoT) on Healthcare in Transforming Patient Care and Overcoming Operational Challenges", Journal of Angiotherapy, 8(11),1-8,10041.https://doi.org/10.25163/angiotherapy.81110041

Murugesan, B., Jayanthi, K. B., & Karthikeyan, G. (2024). Integrating Digital Twins and 3D Technologies in Fashion: Advancing Sustainability and Consumer Engagement. In Illustrating Digital Innovations Towards Intelligent Fashion: Leveraging Information System Engineering and Digital Twins for Efficient Design of Next-Generation Fashion (pp. 1-88). Cham: Springer Nature Switzerland.

Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T., & Gwilt, A. (2020). The environmental price of fast fashion. Nature Reviews Earth & Environment, 1(4), 189–200. https://doi.org/10.1038/s43017-020-0039-9

Nweje, U., & Taiwo, M. (2025). Leveraging Artificial Intelligence for predictive supply chain management, focus on how AI-driven tools are revolutionizing demand forecasting and inventory optimization. International Journal of Science and Research Archive, 14(1), 230-250.

Pathak, J., Kumar, A., Tripathi, S. L., & Raj, B. (Eds.). (2025). Smart Textiles and Wearables for Health and Fitness. John Wiley & Sons.

Peters, G., Li, M., & Lenzen, M. (2021b). The need to decelerate fast fashion in a hot climate - A global sustainability perspective on the garment industry. Journal of Cleaner Production, 295, 126390. https://doi.org/10.1016/j.jclepro.2021.126390

Popkova, E. G. (Ed.). (2024). Smart Technologies and Innovations in E-business. IGI Global.

Rachwal-Mueller, A., & Fedotova, I. (2024). THE IMPACT OF CULTURAL FACTORS ON CONSUMER BEHAVIOR: A HOLISTIC MODEL FOR ADAPTIVE MARKETING APPROACHES. Economics of the Transport Complex, 44, 165. https://doi.org/10.30977/etk.2225-2304.2024.44.165

Rahman, M. H., Aunni, S. A. A., Ahmed, B., Rahman, M. M., Shabuj, M. M. H., Das, D. C., Akter, M. S., Numan, A. A. (2024). "Artificial intelligence for Improved Diagnosis and Treatment of Bacterial Infections", Microbial Bioactives, 7(1),1-18,10036

Rahman, M. H., Biswash, M. A. R., Debnath, A., Siddique, M. A. B., Rahman, M. M., Rabbi, M. M. H., Mou, M. A. (2025). "The Future of AI in Laboratory Medicine: Advancing Diagnostics, Personalization, and Healthcare Innovation", Journal of Primeasia, 6(1),1-6,10151. https://doi.org/10.25163/primeasia.6110151

Rahman, M. H., Biswash, M. A. R., Siddique, M. A. B., Rahman, M. M., Mou, M. A., Debnath, A., Fatin, M. (2025). "Significance of Artificial intelligence in clinical and genomic diagnostics", Journal of Precision Biosciences, 7(1),1-14,10149. https://doi.org/10.25163/biosciences.7110149

Rahman, M. H., Islam, T., Hossen, M. E., Chowdhury, M. E., Hayat, R., Shovon, &. M. S. S., Shabbir, H. -. A. -., Alamgir, M., Akter, S., Chowdhury, R., Sunny, A. R. (2024). "Machine Learning in Healthcare: From Diagnostics to Personalized Medicine and Predictive Analytics", Journal of Angiotherapy, 8(12),1-8,10160. https://doi.org/10.25163/angiotherapy.81210160

Rane, N., Choudhary, S., & Rane, J. (2023). Enhanced product design and development using Artificial Intelligence (AI), Virtual Reality (VR), Augmented Reality (AR), 4D/5D/6D Printing, Internet of Things (IoT), and blockchain: A review. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4644059

Rathore, B. (2019). Artificial intelligence in sustainable fashion marketing: Transforming the supply chain landscape. Artificial Intelligence, 8(2).

Rathore, B. (2023). Integration of Artificial Intelligence& It's Practices in Apparel Industry. International Journal of New Media Studies (IJNMS): Vol. ISSN.

Rejeb, A., Keogh, J. G., & Treiblmaier, H. (2019). Leveraging the internet of things and blockchain technology in supply chain management. Future Internet, 11(7), 161. https://doi.org/10.3390/fi11070161

Repp, L., Hekkert, M., & Kirchherr, J. (2021). Circular economy-induced global employment shifts in apparel value chains: Job reduction in apparel production activities, job growth in reuse and recycling activities. Resources Conservation and Recycling, 171, 105621. https://doi.org/10.1016/j.resconrec.2021.105621

Rubio-Tamayo, J., Barrio, M. G., & García, F. G. (2017). Immersive Environments and Virtual Reality: Systematic review and advances in communication, interaction and simulation. Multimodal Technologies and Interaction, 1(4), 21. https://doi.org/10.3390/mti1040021

Sallam, K., Mohamed, M., & Mohamed, A. W. (2023). Internet of Things (IoT) in supply chain management: challenges, opportunities, and best practices. Sustainable machine intelligence journal, 2, 3-1.

Samie, F., Bauer, L., & Henkel, J. (2016, October). IoT technologies for embedded computing: A survey. In Proceedings of the Eleventh IEEE/ACM/IFIP International Conference on Hardware/Software Codesign and System Synthesis (pp. 1-10).

Şen, A. (2008). The US fashion industry: A supply chain review. International Journal of Production Economics, 114(2), 571–593. https://doi.org/10.1016/j.ijpe.2007.05.022

Soori, M., Arezoo, B., & Dastres, R. (2023). Internet of things for smart factories in industry 4.0, a review. Internet of Things and Cyber-Physical Systems, 3, 192–204. https://doi.org/10.1016/j.iotcps.2023.04.006

Sun, L., & Zhao, L. (2017). Envisioning the era of 3D printing: a conceptual model for the fashion industry. Fashion and Textiles, 4(1). https://doi.org/10.1186/s40691-017-0110-4

Todeschini, B. V., Cortimiglia, M. N., Callegaro-De-Menezes, D., & Ghezzi, A. (2017). Innovative and sustainable business models in the fashion industry: Entrepreneurial drivers, opportunities, and challenges. Business Horizons, 60(6), 759–770. https://doi.org/10.1016/j.bushor.2017.07.003

Trakadas, P., Simoens, P., Gkonis, P., Sarakis, L., Angelopoulos, A., Ramallo-González, A. P., Skarmeta, A., Trochoutsos, C., Calvo, D., Pariente, T., Chintamani, K., Fernandez, I., Irigaray, A. A., Parreira, J. X., Petrali, P., Leligou, N., & Karkazis, P. (2020). An Artificial Intelligence-Based Collaboration Approach in Industrial IoT manufacturing: key concepts, architectural extensions and potential applications. Sensors, 20(19), 5480. https://doi.org/10.3390/s20195480

Wu, D., Rosen, D. W., Wang, L., & Schaefer, D. (2014). Cloud-based design and manufacturing: A new paradigm in digital manufacturing and design innovation. Computer-Aided Design, 59, 1–14. https://doi.org/10.1016/j.cad.2014.07.006

Zhang, Z., Wen, F., Sun, Z., Guo, X., He, T., & Lee, C. (2022). Artificial Intelligence-Enabled Sensing technologies in the 5G/Internet of Things era: From Virtual Reality/Augmented Reality to the Digital Twin. Advanced Intelligent Systems, 4(7). https://doi.org/10.1002/aisy.202100228

Zhou, Y., & Zhao, J. (2024). Leveraging computational systems for lifecycle management and enhancement of circular economy in fashion: A study on tracking, recycling, and reuse technologies. Applied and Computational Engineering, 87(1), 148–153. https://doi.org/10.54254/2755-2721/87/20241531