

THE IMPACT OF ARTIFICIAL INTELLIGENCE TECHNOLOGY IN TEXTILE DESIGN

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Abstract

Artificial Intelligence (AI) has become an indispensable tool across various industries, including textile design. Its ability to enhance creativity, streamline production processes, and enable personalized design experiences has revolutionized the textile industry. This study explores the impact of AI technology on textile designing, with a focus on how AI transforms traditional design practices, accelerates production, promotes sustainability, and enhances creativity. The study reviews the impact of Artificial intelligence (AI) technology in textile design, with emphasis on its advantages and challenges. Through machine learning with Artificial neural networks (ANN) and Generative Adversarial networks (GANs), artificial intelligence can be used to create unique patterns and designs through a combination of several motifs of

designers. AI-tools also assists and improve the textile industry through trend forecasting by understanding trends and customer choices which intentionally helps with customer experience. Databases such as ResearchGate and Emerald Insights provided journals that proved the role of AI in waste reduction and enhancing sustainability through eco-conscious processes. The article also highlights a few challenges such as implementation costs, data dependency and job displacement. Recommendations such as upskilling, collaborative data sharing, cloud computing and government and industry association support were suggested to allow the proper implementation of AI technology in the textile industry.

Keywords: Artificial Intelligence, Textile Design, Generative Design, Smart Textiles, Sustainability.

Introduction

The textile industry has always been a field where creativity meets functionality. Traditionally, textile designers relied on manual skills for creating patterns, selecting materials, and producing fabrics. However, with the rapid advancements in digital technologies, the design landscape has changed dramatically. The introduction of Artificial Intelligence (AI) into the textile design process marks a significant shift, allowing designers to automate repetitive tasks, experiment with innovative patterns, and optimize the production process (Kotsiantis, 2017). This transformation offers several benefits, such as reducing the time required for prototyping, promoting sustainability by minimizing waste, and enabling the creation of intricate, data-driven designs that would otherwise be impossible to achieve manually. The impact of AI on textile design can be categorized into several areas: design automation, personalized consumer experiences, smart textiles, and sustainable production (Kotsiantis, 2017).

Artificial intelligence (AI) technologies have been implemented in the textile design sector to increase production, cost, quality, information, just-in-time manufacturing, and computer-integrated manufacturing. One of the most significant and ancient industries in the world of manufacturing, the textile sector has seen significant change recently, primarily due to

artificial intelligence (AI). Artificial intelligence (AI) processes massive amounts of data to generate unique patterns, streamlines manufacturing with precision and waste reduction, and optimizes supply networks. Despite problems such as employment displacement and ethical data use, AI integration promises unprecedented creativity and environmentally sustainable behaviors, balancing growth and responsibility (Kotsiantis, 2017).

AI in textile design is transforming the design process by enhancing designers' talents with machine learning algorithms that examine patterns, colors, and trends to develop fresh designs and innovations. AI's impact extends beyond design and into the sphere of production. AI-powered machinery improves textile manufacturing operations like weaving, knitting, and dyeing. These clever robots monitor production in real time, making quick modifications to ensure accuracy and reduce waste (Fibre2Fashion, 2024). Textile manufacturers will use artificial intelligence (AI) to improve productivity and workforce capacity as industrial automation spreads (Kotsiantis, 2017). AI can also help with fabric simulation, allowing designers to see how their patterns would look on different materials, textures, and lighting situations without the need for physical samples. These AI tools provide designers more creative flexibility, allowing them to test out multiple concepts quickly, resulting in faster iterations and advancements in textile design. The incorporation of AI into design not only improves productivity, but also pushes the frontiers of what is achievable in textile aesthetics and practicality.

Methodology

This article examines the impact of artificial intelligence technology on textile design utilizing a detailed literature review and secondary research methods. This entails meticulously studying peer-reviewed journal articles and other relevant publications to obtain further information. The book-searching and selection procedure was divided into two sections. First, some scholarly databases, journals and articles from reliable sources were selected:

- ResearchGate
- ScienceDirect
- The AATCC Journal of Research
- Emerald Insights

These articles, journals and databases were selected for the second phase after keywords, key phrases and sentences found in them fit the research purpose and objectives. The following search phrases were frequently used: “artificial intelligence “textile design,” “impact of AI in textile design,” and “application of AI in textile design,” as well as “application of AI in fashion design”. Artificial intelligence, machine learning, and deep learning were all included. The search was restricted to English-language journal papers published during the previous ten years to ensure currency and relevance. Publications that promised a broader range of understanding on the subject, such as infrastructure requirements, training needs, and ethical considerations, were given priority alongside articles that provided actual data, case studies, or comprehensive reviews on the impact and application of AI in textile design.

Table 1: Flow Chart of the search screening

S/ N	Phase	Descripti on	Records Identified	Records Screene d	Texts Assessed	Studies Exclude d	Studie s Includ ed
1	Identif ication	Records identified through research	100				
2	Screen ing	Records after removin g duplicate s		80			
3	Eligibi lity	Articles assessed for eligibility			50		

4	Exclusion	Texts articles excluded				30	
5	Inclusion	Texts articles included					10

Table 2: Exclusion Reasons

Reasons For Exclusion	Number of Records
Not Relevant in AI	15
Not focused on textile design	10
In other languages	2
Published more than 10 years ago	2

Discussion of Findings

Artificial Intelligence

The term artificial intelligence (AI), coined in the 1950s, refers to a wide range of emerging technologies, including machine learning and deep learning, that aim to imitate human intelligence Lawkowski, Tucci & Craig, (2022). It is a field of research in computer science that creates and examines methods and software that allow machines to observe their surroundings and use learning and intelligence to choose actions that maximize their chances of attaining set goals (Russell & Norvig, 2021). In general, AI systems operate by consuming huge volumes of labeled training data, analyzing it for correlations and patterns, and using these patterns to forecast future states Lawkowski, Tucci & Craig, (2022). Artificial intelligence (AI) is the technology that makes it possible for computers and other devices to mimic human autonomy, creativity, problem-solving, learning, and comprehension Stryker and Kavlakoglu, (2024).

Artificial Intelligence in Textile Industries

In the textile and fashion industries, artificial intelligence (AI) and related sectors are powerful instruments for raising output and performance. There are many uses for AI tools, ranging from design concepts to trend predicting in the future Anwer *et al.*, (2024). In the textile industry, expert systems and artificial neural networks (ANN) are utilized Sikka *et al.*, (2022). The ANN methodology involves backpropagation, variable learning rate, and multiple linear regressions. It can assist with fiber grading, yarn quality prediction, fabric problem diagnosis, and dye recipe prediction. The use of neural networks in textile coloring and printing has also decreased the need for human intervention by predicting dye formulations, matching colors, and detecting dyeing errors (Sikka *et al.*, 2022).

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The hair area index, hair longitude index, mean absolute hair-length deviation index, normal hair-length index deviation, and hair-length index coefficient are currently examined by AI in the yarn production process Sikka *et al.*, (2022). AI is able to identify flaws, evaluate failure rates using science, and modify control parameters to maximize spinning. AI has primarily been utilized to examine yarn's programmable qualitative aspects. The impact of AI on textile design, covering areas such as trend forecasting, design automation, sustainability, and customization.

Fusion of Creativity and Technology

AI can create original textile patterns that satisfy customer tastes and current market demands by analyzing trends, color palettes, and consumer inclinations. AI is used by designers to create complicated designs that would be too difficult or time-consuming to create by hand. This merging of technology and creativity speeds up the design process and encourages quick innovation in the sector. Because AI can learn from data, it can also produce designs that are innovative and defy the conventions of traditional textile design. For example, by combining historical design data with current trends, IBM's Watson AI system has been utilized to develop novel textile patterns. According to Kim *et al.* (2018), this kind of AI-driven innovation may result in the creation of completely new textiles and patterns that are suited to certain consumer tastes. The use of Generative Adversarial Networks (GANs) in textile design is one prominent example

of AI in action. GANs may create complex and unique designs by learning from large datasets of textile patterns that already exist. The result is a combination of several motifs and styles that gives designers a wide range of creative possibilities Fibre2Fashion, (2024).

Integration of AI in Smart Textiles

AI is also shaping the development of smart textiles, which integrate electronic components or sensors into fabrics to offer additional functionalities, such as monitoring vital signs, changing colour based on environmental factors, or generating energy. AI algorithms help in processing data collected by these sensors, enabling real-time adjustments to the fabric's properties (Tao, 2019). Smart textiles are especially useful in fields such as healthcare, sports, and defence, where monitoring and adaptive responses are crucial.

AI and Sustainable Smart Textiles

With sustainability being a key focus in textile production, AI is also employed to design eco-friendly smart textiles. By optimizing the production process and reducing the need for hazardous chemicals, AI technologies help manufacturers develop fabrics that are both functional and sustainable. For example, AI can assist in choosing the most sustainable materials and design patterns that minimize waste, thus supporting the development of eco-friendly textiles Lee & Kim, (2021).

Trend Forecasting

One of the most important contributions of AI to textile design is its capacity to forecast fashion trends. Traditionally, designers used intuition, experience, and trend reports to predict new styles. With AI algorithms can analyze large volumes of data to identify patterns and trends, helping designers understand market preferences and create relevant products Audaces, (2024). AI algorithms can use historical data, social media activity, and customer behavior to forecast future color, pattern, and fabric trends McKinsey & Company, (2020). Furthermore, AI trend forecasting minimizes the likelihood of overproduction, which is a prevalent concern in the fashion business. Textile companies can reduce waste and surplus inventory by effectively anticipating demand and producing clothing in numbers that meet market needs Pellegrini *et al.*, (2020).

Enhancing Sustainability through Eco-conscious Practices

The textile sector has a significant environmental imprint, marked by excessive water use, chemical pollution, and textile waste Fibre2Fashion, (2024). AI algorithms may assess fabric cutting patterns to reduce waste and ensure that every piece of material is used efficiently Feng et al., (2021). This minimizes the amount of textile waste produced throughout the production process, which contributes significantly to environmental pollution. AI enables accurate forecasting of fabric requirements, reducing offcuts and overproduction. Furthermore, AI helps to produce environmentally friendly materials such as bioengineered fibers and textiles made from recycled materials. This optimisation not only lowers prices and waste, but it also improves delivery times. By using AI into textile production, firms increase productivity while also promoting sustainable practices (Strategic Consortium of Intelligence Professionals (SCIP), (2024).

Reducing Waste with AI

One of the key challenges in the textile industry is waste reduction, and AI is proving to be a powerful tool in addressing this issue. AI systems can optimize material use, minimizing waste during the cutting and sewing processes. Machine learning models are being developed to analyse production data and suggest efficient cutting layouts that reduce fabric waste. AI also allows for virtual prototyping, where textile designers can simulate their designs in a digital environment, reducing the need for physical samples and the associated material waste Wilson & Gupta, (2021).

AI for Sustainable Material Selection

AI-driven tools can analyse the environmental impact of different textile materials and help designers choose the most sustainable options. By considering factors such as carbon footprint, water usage, and biodegradability, AI can support the creation of eco-friendly textile designs. This not only promotes sustainability but also helps manufacturers comply with increasingly stringent environmental regulations Chang & Li ,(2022).

Colour Matching and Dye Formation

Another area where artificial intelligence is being used in the textile industry is in color matching AATCC, (2022). Traditionally, establishing a dye solution to match a given color was done visually, with a few color correction phases in between. Artificial Intelligence technology, such as DataColor's SmartMatch, stores and leverages past experiences to provide a color match with a lower Delta E CMC, reducing the need for color correction.

Virtual Try-On Technology

AI also plays a role in the growing trend of virtual try-ons, where customers can see how a textile design or clothing item would look on them without having to physically try it on. Augmented reality (AR) combined with AI-driven fashion platforms allows customers to visualize different fabrics, styles, and patterns in real-time. This technology enhances the shopping experience and minimizes the need for physical samples, reducing waste and time Wang & Xu, (2020). The application of artificial intelligence in the fashion and garment industries has seen a groundbreaking innovation known as virtual try-on technology. This groundbreaking technology allows clients to virtually try on apparel and accessories in a digital context, providing a realistic and interactive shopping experience without the need for physical fitting rooms (Buyukaslan *et al.*, 2020). By utilizing augmented reality (AR) and virtual reality (VR) technologies, virtual try-on has garnered substantial acclaim, completely transforming the online fashion shopping process Brubacher *et al.*, (2023). Virtual try-ons also save money and time for fashion firms. Because it lowers the need for physical inventory and costly sample production, firms may present a greater selection of products electronically, hence lowering manufacturing and logistics expenses Singh, (2024). Virtual try-on technology enhances the buying experience by allowing real-time depiction of items on customers. Online retailers can benefit from less uncertainty, normalized return rates, and higher conversion rates. The integration of AI-driven recommendations provides personalization based on style and body type, boosting pleasure and loyalty through tailored suggestions drawn from client data.

Machine Learning and Pattern Recognition

One of the core applications of AI in textile design is the use of machine learning algorithms for pattern recognition and design generation. Through supervised learning, AI models can analyse vast datasets of textile patterns and styles, enabling designers to generate new and unique patterns based on historical data. This not only saves time but also allows for the discovery of novel design elements that may not have been considered otherwise Zhang & Taylor, (2020). AI models like convolutional neural networks (CNNs) are particularly effective in detecting patterns, textures, and colours, allowing designers to generate innovative textile designs autonomously.

Generative Design and AI-Assisted Creativity

Generative design systems, powered by AI, enable textile designers to create complex, intricate patterns based on a set of design rules or objectives. These algorithms can generate thousands of variations of a design within seconds, allowing designers to experiment with a wide array of possibilities before selecting the final design. Generative adversarial networks (GANs) are particularly useful in textile design as they can generate entirely new patterns by learning from a database of existing designs LeCun, Bengio, & Hinton, (2021). This ability to explore a large design space empowers designers to push the boundaries of creativity and innovation.

Customization through AI

In today's market, consumers increasingly demand personalized products tailored to their individual tastes and preferences. AI allows for mass customization in the textile industry by analysing consumer data, such as browsing behaviour and purchase history, to generate personalized design recommendations. AI algorithms can also allow customers to co-create their own designs by providing input on colours, patterns, and styles, with real-time AI assistance guiding the design process Lu & Liu, (2022). This level of customization enhances consumer satisfaction and builds stronger relationships between brands and their customers.

Future Prospects

Looking ahead, the integration of AI and human creativity will continue to shape the future of textile design. As AI technologies become more

accessible and user-friendly, more designers will be able to harness their power to create innovative, sustainable, and personalized textiles. Furthermore, AI's role in smart textiles will expand, opening new possibilities in healthcare, fashion, and beyond. As AI continues to play a growing role in the textile industry, businesses are expected to start exploiting the data their machinery sensors collect inside rather than just making it available to customers AATCC, (2022). Furthermore, the ethical use of consumer data is a legitimate concern. The use of consumer data for design and production must be done with caution to protect privacy and comply with regulatory norms. Looking forward, the future of AI-generated textiles is bright. As AI technologies advance, their applications in textile design and manufacturing will grow more advanced. The synergistic relationship between AI and human creativity has the potential to catalyze unprecedented advances in textile design, manufacturing efficiency, and sustainability Fibre2Fashion, (2024).

Challenges with The Impact of Artificial Intelligence Technology in Textile Designing

Despite the numerous benefits of AI in textile design, several challenges remain. One major challenge is the steep learning curve associated with mastering AI tools. Designers accustomed to traditional methods may find it difficult to adapt to AI-driven systems. Additionally, the cost of implementing AI technologies can be prohibitive for smaller textile companies. Ethical concerns also arise regarding the over-reliance on automation and the potential displacement of human jobs.

Data Dependency

One of the key obstacles of incorporating AI into textile design is its dependency on data. AI systems are data-driven, which means that the accuracy, inventiveness, and success of AI-generated designs are determined on the amount and quality of data input into the algorithms. However, acquiring and curating vast statistics relevant to textile design can be difficult, particularly when it comes to data on customer preferences, fashion trends, and material performance McKinsey & Company, (2020).

Job Displacement

Concerns about job displacement due to automation are widespread; nevertheless, AI also creates new opportunities for skilled labor in fields

such as maintenance, programming, and data analysis Fibre2Fashion, (2024). AI systems may currently undertake tasks such as cutting, stitching, and quality monitoring, potentially causing employment losses in these sectors Nayak & Padhye, (2018).

Implementation Costs

The high initial costs of AI software, hardware, and integration processes pose a barrier to entry for smaller players in the textile industry. Many places, particularly developing ones, lack the requisite technology infrastructure to support AI-driven design and manufacturing processes and this creates a digital divide leaving the less developed companies or countries out. Furthermore, integrating AI into current systems can be challenging and time-consuming. Companies may encounter technological issues when attempting to integrate traditional operations with AI-powered products.

Conclusion

Artificial Intelligence is transforming textile design by automating repetitive tasks, enabling personalized designs, and promoting sustainability. From generative design to smart textiles, AI offers numerous benefits that allow designers to push the boundaries of creativity while addressing the environmental and ethical challenges facing the textile industry. As AI continues to evolve, its impact on textile design will undoubtedly grow, offering new opportunities for innovation and efficiency. AI-generated textiles represent a paradigm shift in the textile sector, opening up new frontiers of creativity, efficiency, and sustainability. By using the potential of AI, the sector can satisfy the changing demands of a fast-paced, environmentally sensitive market. However, the successful integration of AI in textiles depends on a careful balance of scientific innovation and ethical considerations. AI has transformed trend forecasting by giving data-driven insights that help designers remain ahead of customer desires. Design automation has accelerated the creative process, enabling greater experimentation and creativity. AI has also aided sustainability initiatives by optimizing material use and eliminating waste.

Nonetheless, incorporating AI into textile design has numerous benefits, but it also raises several obstacles that must be addressed before the technology can be properly used. Data dependency, job displacement,

implementation costs, and ethical concerns all represent substantial barriers to the mainstream adoption of AI in the textile business. To address these difficulties, stakeholders in the textile and fashion industries must work together to ensure that AI technologies are adopted in a way that promotes innovation, protects jobs, and is consistent with ethical and sustainability goals. Addressing these problems will allow AI to become a significant tool for driving innovation and revolution in textile design.

Recommendations

In order to tackle the associated challenges of the impact of artificial intelligence in the industry, the following strategies are recommended:

Improved Data Quality

This can be helpful through collaborative data sharing between textile brands, fashion designers and other stakeholders. Adoption of data validation tools and real-time data updates can help to improve the application of AI in the industry. The validation tools help check relevance of any data before they are passed to AI systems which would improve its reliability.

Skill-up and Workforce Educational Programs

A deliberate investment in training and education is essential to provide the workforce with the necessary skills for these expanding positions. Fashion and textile companies should engage in employee reskilling programs, with a focus on developing digital literacy, AI understanding, and data analytic abilities. Fashion businesses can build up in-house AI training programs to teach designers and production workers how to collaborate with AI tools. These projects should focus on incorporating AI into creative processes while maintaining the human touch.

Cost-friendly Implementation of Artificial Intelligence

AI-driven tools can be expensive for small and medium enterprises (SMEs) but can be made affordable. One way to do this is through the help of the governmental support or industrial associations to assist smaller brands. Implementing cloud-based AI computing can make artificial intelligence easily accessible and affordable for SMEs.

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