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# Synergy of Real and Digital Worlds - Promising Insights for the Future Generations of Fashion

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***Abstract:*** ***Digital transformation (DT) is reshaping the fashion industry, revolutionizing the way brands, retailers, and consumers interact. It is not a fad but a necessary step towards innovation and survival in today's business context. Implementing digital transformation requires a bespoke approach that addresses specific challenges and goals within the existing framework of each brand or retailer. Fashion brands are leveraging digital technologies throughout their value chain, from product design and production to marketing and distribution. Computer-aided design (CAD) software, predictive analytics, and 3D printing are streamlining the design and prototyping phases, reducing time-to-market and improving product quality. Technologies like 3D body scanning, seamless garments and digitized looms are also being adopted. Brands like Hugo Boss are using smart factories that incorporate robotics, artificial intelligence (AI), analytics, and the Internet of Things (IoT) to increase efficiency. Moreover, digital-integrated supply chain platforms, such as blockchain, are enabling faster and more efficient production by connecting brands with manufacturers and suppliers globally. The adoption of digital solutions extends to the production of futuristic textiles, digital clothing and virtual model / digital show stoppers. Retailers are also embracing DT to enhance the customer experience and expand their reach. E-commerce has become a crucial channel, allowing retailers to sell products online and reach a wider customer base. Many retailers are investing in robust online platforms and incorporating augmented reality (AR) and virtual reality (VR) technologies to offer immersive in-store shopping experiences. Data analytics and AI are being used to personalize recommendations and offers, enhancing customer engagement and loyalty. In-store virtual assistants or kiosks are worth mentioning in light of digital clientele. Social media platforms play a vital role in the fashion industry's digital transformation. Fashion brands are partnering with social media influencers to promote their products and reach a larger audience. Additionally, collaborative consumption models are emerging through digital apps, supporting sustainability efforts such as zero waste, recycling, and sharing goods or services. Consumers are benefiting from greater convenience, choice, and personalized experiences in the digital fashion landscape. They have access to a wide array of products from around the world and can find inspiration and style ideas on social media platforms. User-generated content and reviews facilitate informed purchase decisions. Mobile technology advancements have blurred the lines between online and offline retail experiences, enabling consumers to shop anytime and anywhere.***

***Adaptability, inclusivity, diversity, authenticity and traceability of product life cycle (Blockchain) have become driving instincts of Gen Zers and Millennials at purchase points. However, traditional industry players and small independent retailers face increased competition from e-commerce giants, necessitating their adaptation to digital technologies to remain relevant. The COVID-19 pandemic has accelerated this shift and normalized the idea of going digital. This paper presents an in-depth review of how digital transformations have various players within the fashion Industry with special reference to the brands, designers and enterprises implementing these for their evolution and progression to thrive in this rapidly evolving landscape.***

***Keywords: Digital, Data Analytics, Mobile, Blockchain, COVID-19***

## I. INTRODUCTION

Digital transformation involves the utilization of digital methods to overhaul systems and strategies within a business. Although the fashion industry embarked on this journey years ago, the past year has significantly intensified this shift, leading to the emergence of innovative solutions for longstanding challenges. The rapid advancement of technology, coupled with its swift adoption by consumers, necessitates a heightened priority for many fashion brands. Faced with the demands for growth and cost efficiency, numerous brands have initiated a series of endeavours to enhance their speed in bringing products to market and incorporate sustainable innovation into their fundamental processes of product design, manufacturing, and supply chain management [1][2].

The graphical representation of the recent technologies applied in fashion business is as given in the figure 1 below.

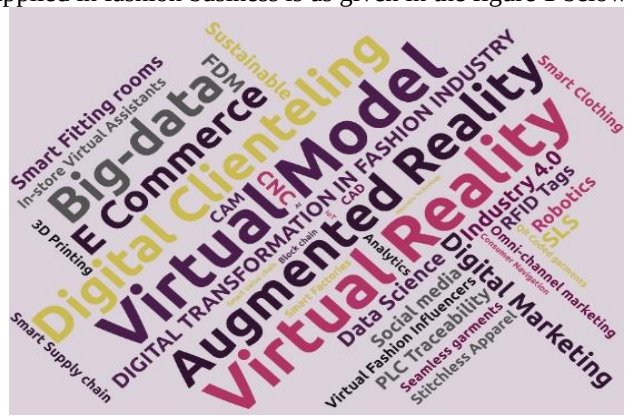


**Figure: 1 Graphical Representation of Recent Technologies Applied in Fashion**

The role of consumers has evolved from passive observers to empowered individuals who seek more than just purchasing fashion items.

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The widespread use of digital technologies has enabled them to interact, feel a sense of belonging, exert influence, and essentially become advocates for the brands they choose. Informed, discerning, and in control, consumers now prioritize their appearance in both public and social media, as well as the perception associated with the products they purchase and own [3]. The impact of digital transformation on retail customers is particularly pronounced in the realm of fast-fashion brands, compelling them to transition from a multi-channel paradigm to an Omni-channel approach [4]. This study, characterized by its exploratory nature, focuses on reviewing the scope and opportunities through secondary data or a literature survey to formulate theoretical propositions for further research.

## II. BRAND PLAYERS OF DIGITAL TRANSFORMATION

Eternea's proficient team is increasingly focusing on AR and VR technologies to provide consumers with a virtual trial room experience at their fingertips. Against the backdrop of the COVID-19 pandemic, the fashion industry is gearing up for a future dominated by digital platforms for shows and events. Inega, an artist and talent management agency based in Mumbai, has introduced a digital showstopper named Nila on Instagram, marking India's first non-human "Virtual Model." Nila, perpetually portrayed as 20 years old, is designed for photo shoots and runway walks [5-9]. In the realm of production, Hugo Boss utilizes smart factories to create a digital twin of the traditional manufacturing facility. This digital twin can replicate every aspect of the original, significantly reducing the margin of errors during production. Smart factories enhance efficiency by minimizing the need for human intervention, reducing time-to-market, cutting down on raw material waste, and ultimately lowering production costs.

## III. ROLE OF SOCIAL MEDIA IN DIGITAL TRANSFORMATION

In the past decade, social media has played a profoundly influential role in the fashion industry, and its power has only intensified in the last year. Consumer preferences are evolving, compelling brands to adjust their strategies accordingly. Traditional websites are losing relevance as social media platforms—such as TikTok, Instagram, Twitter, and YouTube—emerge as powerful tools for directly driving sales to dedicated sites. The global lockdowns prompted consumers to spend more time online, creating a void in physical interactions that virtual alternatives began to fill [10].

Brands like Musier, Rouje, and Eliou have adeptly transformed their Instagram pages into virtual fashion magazines, engaging followers in collections, posts, and stories. Their fresh and youthful brand identities resonate with Instagram's predominant customer base of Gen Zers and Millennials. Influencer marketing has seen a surge in recent years, extending beyond human influencers to include digital figures like Noonoouri, a virtual model crafted by Munich-based designer Joerg Zuber. With nearly 400K Instagram followers, Noonoouri collaborates with prestigious brands such as Dior, Versace, and Swarovski, endorsing their products to a substantial audience [3].

While mobile apps experience a significant boom, brick-and-mortar stores are undergoing their digital transformation. In-store digital technologies, such as mobile payment options, free Wi-Fi, personal shoppers, digital signage, interactive windows, and virtual mannequins, are becoming integral to the retail experience. According to Rey-García et al., these disruptive innovations don't necessarily signal the demise of physical stores but rather have the potential to enhance their value contribution to consumers [4].

## IV. DIGITAL TRANSFORMATION IN RETAIL ENVIRONMENTS

The fashion industry, encompassing a wide spectrum from global discount retailers to exclusive luxury brands, plays a significant role in the global economy. It faces constant challenges, influenced by global economic uncertainties, evolving trends, and industrial transformations. To cope with the pressure for growth and cost efficiency, many brands are initiating initiatives to enhance their speed to market and incorporate sustainable innovation into their core product design, manufacturing, and supply chain processes [11].

Consumers now expect their reality to align with their virtual experiences, making personalization a crucial aspect of the customer journey. Retailers are bridging online and offline experiences by utilizing QR codes on items and providing access to pricing, product information, reviews, and more. In-store virtual shopping assistants, located in fitting rooms or kiosks, act as liaisons between customers and real-life staff members. These virtual assistants can facilitate requests for different sizes, check garment availability, connect with staff, and offer product recommendations [12]. Smart fitting rooms use RFID tags in each garment, enabling mirrors to recognize items, search for variations, access the store's catalogue, add items to the cart, and allow customers to virtually try on clothing [13].

Digital clienteling is revolutionizing the customer experience across multiple channels, leveraging technological advancements in digital marketing, commerce, analytics, sales, and service platforms. Predicting consumer preferences upon entry to a store and activating interactions at the right moment was once considered an impossible dream, but advances in clienteling are bringing this dream closer to reality. While clienteling has been a practice for sales associates in recognizing key customers, the challenge has increased with global customers operating across various geographies and channels [14].

E-commerce has become an indispensable tool, with an increasing number of brands operating solely online, reflecting the profound shift in shopping habits since the start of the pandemic. A 2021 report indicates that 43% of consumers who had never purchased clothing online began doing so in the past year. This surge in e-commerce has prompted fashion brands to explore new ways of collecting and utilizing data, such as consumer navigation on websites for personalized product recommendations [15].

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The integration of IoT functionality into retail packaging is anticipated to drive innovation in consumer packaged goods. Before advanced technologies like Printed Electronics (PE), Augmented Reality (AR), or the Internet of Things (IoT) emerged, packaging primarily served to contain, protect, preserve, and inform [16]. Recent innovations in conductive nanomaterials, such as silver nanowires, carbon nanotubes, and graphene, enable their use in interactive packaging, allowing for wireless communication systems. For instance, graphene-based wireless communication devices not only engage with users but also protect products against counterfeiting. Conductive inks like silver-graphene [17], fluorine, and silicon-based inks are employed for smart packaging by companies such as Novalia, Saralon GmbH, and Thinfilm, respectively. Screen-printed sensors offer two-way communication based on IoT, monitoring, informing, and interacting. Lightweight and flexible printed electronics are utilized as innovative smart labels, while near-field communication tags enhance the integration of electronic intelligence into everyday products, ensuring efficient, reliable, and secure data exchange [18, 19].

## V. DESIGN IN THE FASHION VALUE CHAIN AND DIGITAL TRANSFORMATION TOOLS

Design is a pivotal initial step in the product life cycle, followed by production, marketing, and distribution. In today's landscape, virtual design tools are enhancing traditional design processes, making them more streamlined, time-efficient, and resource-conserving.

Virtual design tools, such as design software, 3D modelling, and augmented reality, are transforming the design practices of an increasing number of brands. Augmented Reality (AR) overlays computer-generated images onto the user's real-world view, offering benefits like digital measurements for customized clothing, precise resource measurement to reduce waste, and time-saving for inclusive sizing. Remote fittings with an avatar of the customer further enhance the design process. 3D modelling, a computer graphics technique, creates digital representations of objects or surfaces, enabling custom designs and prints. Tools like Browzwear and Optitex exemplify 3D modelling, allowing designers to visualize fabric movement during motion [20].

Computer-aided Design (CAD) software is another essential tool, that enables designers to create 2D and 3D digital sketches. Platforms like AutoDesk and Eva Engines synchronize data along the value chain, with Eva Engines transforming sketches into 2D product images. After design, the production phase in the fashion value chain involves product development, production management, material production, and assembly [21].

Automation plays a crucial role in various production stages, such as fabric inspection, CAD & CAM, fabric spreading and cutting (utilizing technologies like Bullmer cut, Eastman CNC (Raptor), and Tukatech's CNC Automatic Cutting Machine - Tukacut), sewing, pressing, and material handling. Sewing robots, like Sewbo and LOWRY Sewbot, contribute significantly to fabric gripping, handling, and sewing, with the ability to analyze and manipulate fabric like humans. These robots, built using Industry 4.0 technology, can be programmed for specific sizes or styles, reducing the need for human labour and increasing production efficiency. Robotic 3D sewing technology, employing 3D robotic arms, is versatile in producing various garments and products, from shirts and trousers to jackets, upholstery, and even airbags. This technology not only ensures high-quality products but also reduces labour costs and enhances overall productivity [22].

## VI. DIGITAL APPS AND APPLICATIONS IN FASHION

VAULT, a virtual wardrobe stylist app, is tailored to meet the unique needs of clients through a digital platform, facilitating the organization and management of wardrobes while offering personalized outfit suggestions [23]. Users upload images of their wardrobe ensembles and accessories, and the app provides a range of customization options, ensuring a streamlined experience. The potential features of virtual wardrobe and styling apps are highly appealing. They include AI-driven ensemble suggestions for daily wear and specific events and digital wardrobe organization based on style, mood, and colour [24]. These apps can go beyond by incorporating customization, noting the user's personal preferences and style over time. They are designed to understand and adapt to the user's evolving style, offering buying recommendations from online retail platforms based on individual preferences. Additionally, these apps provide trend forecasts, and some even offer live styling workshops conducted by influencers for subscribers.

The primary motivations for using these apps include time-saving, wardrobe organization, and styling tips. Social media influencers or celebrities often launch these apps to promote and inspire the public to learn and use them. The introduction of a virtual wardrobe assistant can include incentives such as a free one-month trial of premium plans, complimentary influencer/stylist workshops, and access to coupons for purchasing garments on online retail platforms. This service taps into the trend for luggage-free travel, appealing not only to globe-trotting professionals but also to fashion-forward clients. Digital transformation significantly improves enterprise performance by reducing costs, increasing revenue, improving efficiency, and fostering innovation. This transformation plays a crucial role in supply-side structural reform, enabling high-quality development of enterprises, and stimulating innovation momentum [25].

## VII. CONCLUSION

The fashion industry is renowned for its challenges, significantly influenced by global economic uncertainties, evolving trends, and industrial shifts. Faced with the pressures of growth and cost efficiency, many brands are undertaking initiatives to enhance their speed to market and incorporate sustainable innovation across product design, manufacturing, and supply chain processes. Digital channels play a pivotal role in consumer journeys, with the vast majority utilizing them before, during, or after making purchases.

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The drivers for digital transformation in the fashion industry often stem from either significant opportunities or existential threats. The convergence of Big Data, the Internet of Things (IoT), and data science empowers fashion brands to better understand their customers, respond to market trends and personalize sales information and products. Sustainability efforts are gaining momentum, with innovative technologies impacting everything from the design stage to resale. Values such as inclusivity and diversity are now in the spotlight, supported by solutions like virtual fashion and adaptive clothing.

Consumers today demand Omni-channel streamlining, seeking easy access to what they desire with just a click or two. Digital transformation goes beyond simply adding technology; it entails a shift in mentality and work approaches. It's about embracing new ways of thinking and working to stay relevant and responsive in a dynamic and rapidly evolving industry.

## FUTURE PERSPECTIVES

Predictive analytics utilizes statistical algorithms and machine learning methodologies to extrapolate future outcomes based on historical data, serving as a key solution for mitigating disorganization and guesswork within the supply chain. Artificial Intelligence-driven trend forecasting, a subset of predictive analytics, predicts future trends, encompassing geographical considerations and market potential. This aids fashion brands in refining their collection planning processes. Leveraging data analytics enables fashion entities to enhance inventory management, optimize profitability, and refine consumer targeting, resulting in a more efficient and precise collection planning approach compared to previous methods.

The sustainable fashion movement has witnessed substantial growth in the last two years, with reselling emerging as a significant facet driven by e-commerce and the pandemic. The collaborative consumption model, encompassing trading, renting, gifting, sharing, bartering, lending, and swapping of goods or services through digital platforms such as apps, has gained prominence. Platforms like Real Real and Vestiaire are reshaping the landscape of fashion and luxury resale. Depop stands out as a prominent social resale platform catering to younger generations seeking affordable and sustainable second-hand apparel. Style Lend operates as a peer-to-peer fashion rental marketplace, while Reflaunt simplifies resale for major retailers by allowing consumers to resell their previous purchases directly on the brand's e-commerce sites. Noteworthy sustainability initiatives include Madwell recycling jeans into housing insulation, Wawwa utilizing recycled cotton for ethically made apparel, and MycoWorks developing faux leather from agricultural waste.

Regardless of the platform, the overarching focus for the future remains on circularity in the fashion industry, emphasizing environmentally friendly practices. These areas hold promising prospects for insights that can shape future generations of fashion.

## DECLARATION STATEMENT


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