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Integrating Artificial Intelligence, Big Data, and IoT for Smart Manufacturing in the Textile and Ready-Made Garments Sector

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Abstract

Textile and Ready-Made Garments (RMG) have for a long time been the foundation stone of world manufacturing especially in the developing economies. With the advent of Industry 4.0 which has brought the smart manufacturing age, a new era of smart manufacturing with the integration of Artificial intelligence, big data and the Internet of Things (IoT) has been introduced. This article explains the way these technologies transform the production of textiles and RMG by improving automation and quality control and improving the efficacy of production. Based on case studies of industries and technological advances, the research gives a broad picture of the digital revolution that is taking the industry by storm and suggests strategic recommendations for implementation.

Keywords: Artificial intelligence, Big data, IoT, Smart manufacturing, Textile, RMG

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1. Introduction

The textile and RMG industry is at the threshold of change. Such pressures as dynamically evolving trends of fashion, complexities of global supply chains, the increasing cost of labour, and sustainability issues prompt manufacturers to look for more forward-looking technological solutions (Sahoo and Lo, 2022). Smart manufacturing that is powered by AI, big data, and IoT is in a position to address these pitfalls by optimizing operations, reducing waste, and enhancing general productivity.

This paper explores the role of AI, Big Data and IoT to bring a smart manufacturing ecosystem in the textile and RMG sectors. The following aspects provide the focus for the discussion: automation, quality control as well as production effectiveness, which are the areas where these technologies are most effective (Del et al., 2022).

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AI and big data analytics are revolutionizing the textile and apparel industry, as they enable higher levels of automation and quality control, as well as greater efficiency of production. AI technologies such as deep learning, neural networks, and image processing are being used in textile testing, design, as well as manufacturing processes (Sikka *et al.*, 2022). These technologies allow for the creation of smart garments, better defect detection, and streamlined supply chain management. The amalgamation of AI, IoT, and big data analytics is very important for smart manufacturing in Industry 4.0, through which process parameters can be optimized & predictive maintenance would be possible. There are however issues on the management, security, and interpretability of data. Once the textile industry adopts these technologies, it is in for immense gains of productivity, quality and innovation (Choi *et al.*, 2023).

The value of the textile and ready-made garments industry increased to \$1.84 trillion in 2023 and is forecast to hit \$3.77 trillion by 2033 due to changes brought by smart manufacturing. With the use of novel technologies like AI, Big Data and IoT in smart manufacturing, companies can handle their work efficiently and sustainably. This report examines how these technologies support the textile industry, their positive effects together and what obstacles exist to their wider use.

2. Methods

This exploratory research looked at how the use of AI, big data, and the IoT is changing the manufacturing process in the textile and RMG industry. The study used existing information from journal articles, industry reports, and case studies to gather information from well-known textile companies. A thematic content analysis was carried out to find the main patterns and trends in automation, quality control, and how much work can be done more efficiently (Kaur, 2025). Case examples like Arvind Mills, Adidas' Speedfactory, Jaya Shree and Beximco were studied to show how these companies are using these new ways of thinking and working in their businesses. The research also looked at popular articles and studies that were found by doing a search on Google Scholar and other databases like IEEE Xplore and Emerald Insight. This method helped us learn a lot about how people use technology in the textile industry today, what progress has been made, and what things could be different in the future.

3. Findings

3.1. Smart Manufacturing: Concept and Context

Smart manufacturing is a term used to describe the involvement of sophisticated digital technologies in enhancing manufacturing processes and the quality of products. In the context of textile and RMG industries, smart manufacturing means that intelligent systems support the traditional workflow and make it adaptive, efficient, and generated by data (Wijayono and Putra, 2018). The key technology making this transformation possible includes:

Artificial Intelligence (AI): Capable of decision-making, pattern recognition and predictive analytics; machine learning algorithms and neural networks.

Big Data Analytics: The capability to gather, store and analyze gigantic data sets in real-time to yield insights and well-informed decisions.

Internet of Things (IoT): A network of interconnected devices and sensors which communicate and automate processes across the value chain in manufacturing.

3.2. AI in Textile and RMG Manufacturing

3.2.1. Automation through AI

AI plays an important role in automating those tasks that are complex and repetitive. In textiles, AI-propelled robots can effectively cut fabric, stitch and dye, with high levels of accuracy. Computer vision systems enable machines to be flexible with regard to the changes in the texture and material of a given object, which was previously a human task. AI automates the supply chain as well using smart inventory management and demand prediction. For instance, forecast models built on historical sales data and external predictors (weather, trends, economy indicators) enable factories to optimize purchases and production more precisely, avoiding

overproduction and stockouts. AI is changing the way textiles are made by replacing manual tasks and helping companies use data to guide their choices. It plays a role in different parts of production, starting from quality control and moving through supply chain management (Nath and Dutta, 2023).

3.2.2. AI for Quality Control

Stains, loose threads or any other weaving irregularities can largely decrease the product value. Classical manual inspections are labour-intensive and error-prone. Visual inspection systems that run on artificial intelligence can process high-resolution images of fabrics in real time to spot even the slightest of defects with an accuracy of over 95%. Machine learning algorithms keep enhancing their defect classification models with fewer false positives and higher precision. This means better product quality and fewer returns or reworks, thus saving time and money (Figure 1).

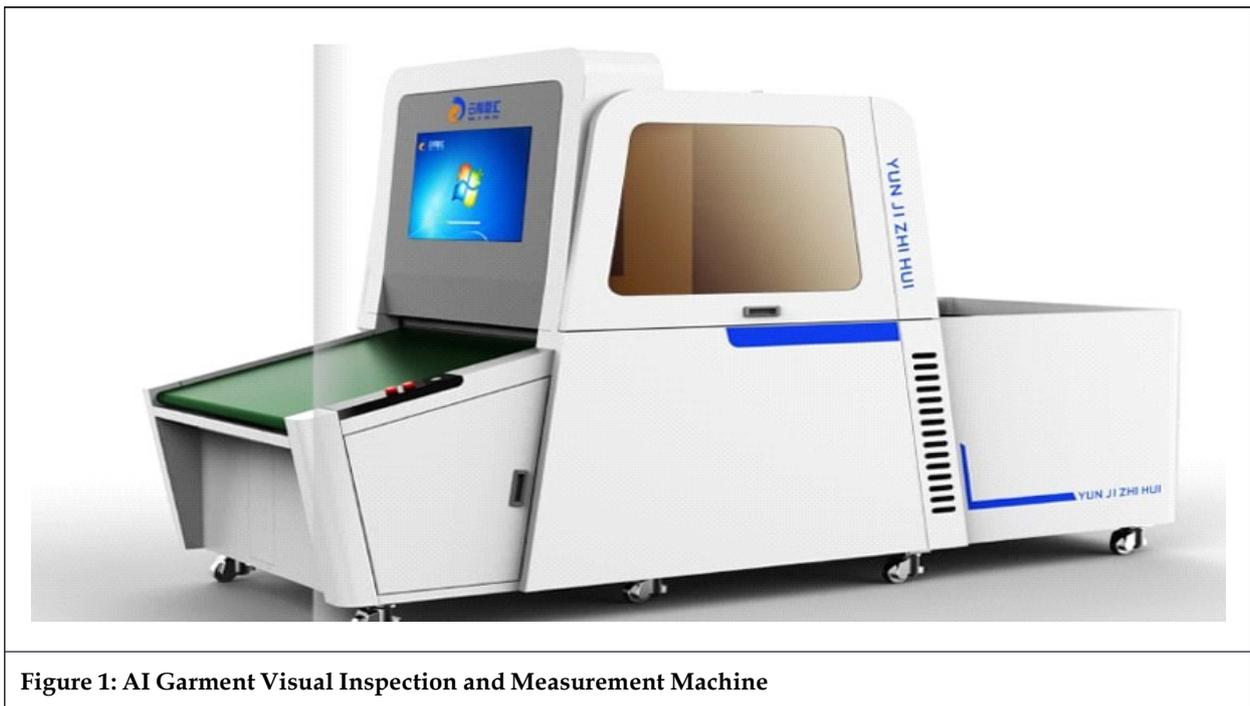


Figure 1: AI Garment Visual Inspection and Measurement Machine

3.2.3. Predictive Maintenance

AI can predict machine failures that are yet to be seized by accessing patterns of sensor data from machines that include looms, and units of dyeing or sewing machines (Liu et al., 2022). Predictive maintenance reduces downtime, increases the machinery's lifespan, and maximises production scheduling.

3.2.4. Important Uses of AI

Such systems use AI to identify weaving problems, staining and colour variances with very high accuracy. It guarantees that the products stay of high quality and that less waste is produced during mass production (Kistamah, 2024). AI uses information from sensors to anticipate when things will fail, lessening the time devices are offline and the costs involved. Algorithms may spot changes in the performance of machines which are then quickly dealt with so repairs can be scheduled. Predictive analytics enabled by AI help companies predict demand, manage stock levels and organise logistics. Doing this helps control excess inventory and allows the business to adapt more easily to changes in the fashion industry which is very fast-moving.

Stylists and programmers use AI to design, colour and produce products that fit the preferences of their customers (Hu et al., 2018). Levi Strauss finishes its jeans using AI-based lasers that keep accuracy high and help decrease chemical and water use and Adidas uses AI-driven robots in its Speedfactory for making custom shoes at record speed. Thanks to AI and IoT, the industry is developing smart textiles that can measure heart rate and body temperature, giving it a role in health and sports areas. ANNs are being used for tasks involving cotton grading, predicting the strength of yarn and evaluating how comfortable a fabric is. To

illustrate, in the yarn winding process, ANNs predict unevenness better than standard statistics AI Applications in Textiles.

3.3. Role of Big Data in Smart Manufacturing

3.3.1. Enhancing Decision-Making

The textile industry creates an ocean of data from the procurement, production and distribution to retail. Big Data analytics transforms this data into actionable insights (Kumar et al., 2022). For example: Sales and trend data advise designers in the organization of collections as per consumer needs. Real-time production data aids managers in optimizing workflow and the distribution of resources. Energy consumption data allows energy-efficient production planning. Data lakes and cloud platforms enable effortless data integration across different business units, providing a source of truth to guide strategic decisions. By using Big Data analytics, companies look at large production, chain and customer interaction data to improve efficiency and protect the environment.

3.3.2. Real-time Monitoring and Feedback Loops

Managers are able to monitor the production in real-time with the use of dashboards, and analytics with Big Data platforms (Hossain et al., 2024). Any variation in the rate of production, quality indices, or performance of machines raises alerts, and corrective action can be taken promptly. Feedback loops driven by data analytics guarantee that all stages of production are constantly improved, helping to make lean production and waste minimization realities.

3.3.3. Customer Behavior Analysis

Big Data from e-commerce outlets and social media allows RMG manufacturers to know what the consumers' preferences and purchasing habits are. Such revelations enable the brands to embrace demand-driven manufacturing, decrease unsold inventory, and provide personalized products.

3.3.4. Important Uses for Big Data

Analysing production data is one way for Big Data to see where the process is slowing down and make improvements. With tools such as Hadoop and cloud analytics, organisations can quickly handle information, save money and enhance their decision-making practises in textile industries (Figure 2). By examining online conversations, sales data and comments from customers, Big Data can foresee trends in the market and help manufacturers make products that customers prefer (Habib et al., 2014).

For mass customization, Big Data allows for making many items personalised at once by using both types of filtering. Sustainability: Using insights from data helps conserve resources, reduces waste and brings down the environmental effect of a business. For example, Big Data assists in checking water and energy use, tackling the industry's problems that affect the environment IoT Impact. Information covering the fabric's

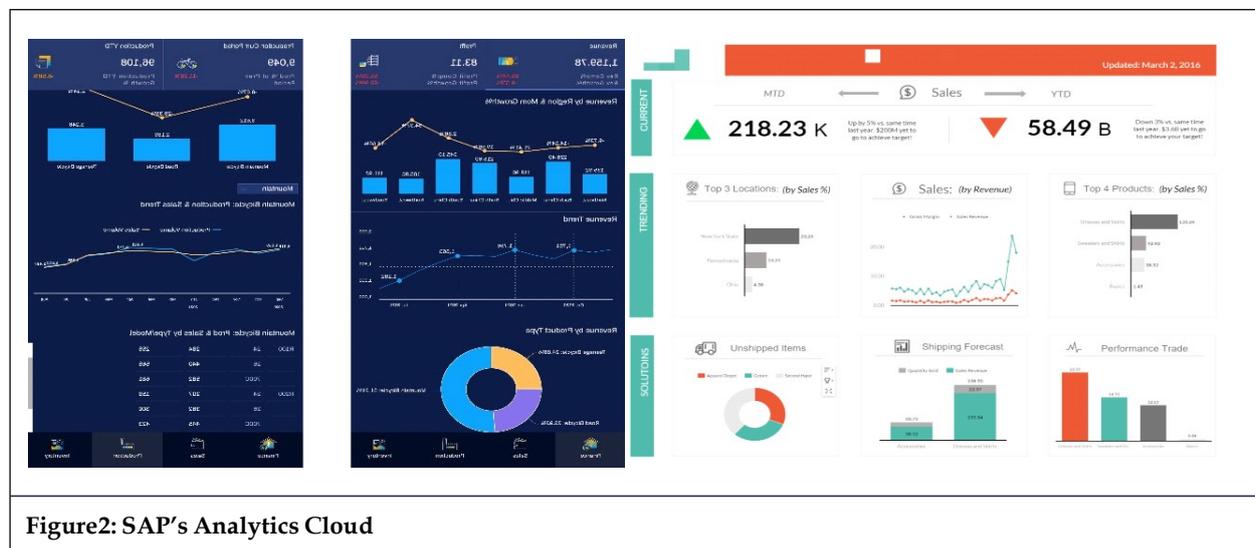


Figure2: SAP's Analytics Cloud

structure, the design layout used and customer body details are packaged as textile data. Because of SAP's fast analytics and in-memory processing tools, it is possible to analyse data quickly, helping make instant decisions in Big Data for the textile industry.

4. IoT in the Textile and RMG Sector

4.1. Smart Factories and Connected Machines

IoT facilitates the establishment of smart factories, as machines, systems, and people are connected. Smart sensors on looms, dyeing tanks, or embroidery machines measure temperature, pressure, humidity, etc. which are vital to the quality of products (Chaudhari, 2025). When these sensors are tied to cloud-based systems, the manufacturers get a full view of the shop floor activities. This connectivity enables automatic control of equipment, better synchronization of workflows, and better usage of resources. Collecting and sending data in real-time becomes possible with IoT and is essential in bringing Industry 4.0 to life.

4.2. Inventory and Supply Chain Management

RFID tags and IoT-enabled trackers create an end-to-end view of raw materials and finished products throughout the supply chain (Figure 3). Real-time tracking eliminates delays, eliminates theft or loss and maximizes warehousing. IoT devices also allow automatic balancing of stock. For example, once the fabric rolls drop below a certain level, the system activates a procurement request – thus enhancing the minimization of material shortage downtime (Saravanan et al., 2022).

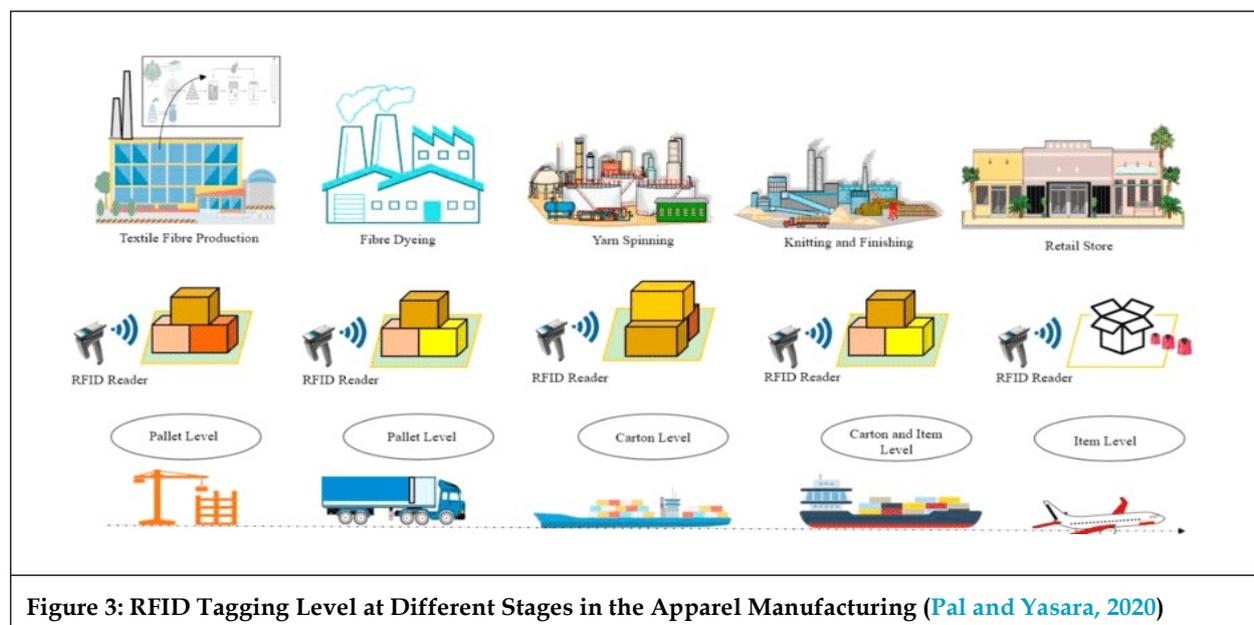


Figure 3: RFID Tagging Level at Different Stages in the Apparel Manufacturing (Pal and Yasara, 2020)

4.3. Worker Safety and Productivity

Wearables and IoT-enabled safety tools are used for the monitoring of the health of workers, movement tracking, and dangerous exposure in factories. Smart helmets, gloves and vests give data on fatigue, posture and heart rate so that one can intervene early before he gets involved in an accident. Furthermore, smart wearables can guide workers on complicated tasks, thus increasing efficiency and reducing training time.

4.4. Important Uses of the Internet of Things

Real-time sensors on equipment send data on temperature and vibration which lets manufacturers adjust their actions to keep both quality and efficiency high. With AI and IoT together, companies can forecast unlikely failures in their machines. The example from Jaya Shree Textiles proves that monitoring 42,000 spindles using AI and IoT sensors improved reliability by about 19%. It is possible to track inventory and optimise logistics instantly with IoT using new technologies including Welspun's Wel-Trak 2.0 for monitoring products. With IoT technology in textiles, sensors monitor certain conditions and widen the market (Prakash et al., 2023).

With ESG Compass and live quality control, products become more sustainable and waste is minimised. With IoT, controlling energy and automating tasks are made simpler, making dependence on humans less necessary. By joining AI, Big Data and IoT, manufacturing becomes connected and smarter. Information from IoT devices is analysed by Big Data analytics to gain useful insights. After learning, the system uses what it discovered to enhance operations, anticipate results and handle tasks without human assistance. For instance, data from IoT sensors tells us what is happening on machines, Big Data analyses the info and spots patterns and AI modifies the system’s parameters to prevent issues.

5. Synergistic Impact on Production Efficiency

The combination of AI, Big Data and IoT has synergetic effects on the value chain of textile and RMG.

5.1. Optimized Resource Utilization

AI algorithms apply real-time data from IoT sensors and Big Data analytics to dynamically assign resources such as machines, labour, and materials in accordance with production needs. This JIT approach eliminates idle time, and wastes, and enhances throughput.

5.2. Energy Efficiency

Smart meters and IoT devices monitor the consumption of energy during processes. AI systems evaluate the data to suggest an operational change to decrease consumption of energy during peak hours or switch to renewables if available.

5.3. Agile and Responsive Manufacturing

With integrated systems, manufacturers can keep up with prompt requirements for their products on the market. Rising sharply to the need for a product design, production lines are automatically redesigned, fabric purchasing changes dynamically, and the workforce is intelligently scheduled (Hack-Polay et al., 2020).

6. Industry Case Studies

6.1. Arvind Mills (India)

Arvind Mills deploys an AI vision system to examine the fabrics for flaws. This has thereby slashed quality control by 70% and increased defect detection rates drastically.

6.2. Adidas’ Speedfactory

Smart production was adopted by Adidas in its retired Speedfactory, where IoT-networked machines and AI were applied to manufacture personalized shoes quickly. Even though the Speedfactory was moved to Asia, its leading technologies still influence Adidas’ production processes today (Yosephine et al., 2023).

6.3. Jaya Shree Textiles (India)

Grasim Industries’ Jaya Shree Textiles has begun using AI and IoT technology to carry out predictive maintenance. Keeping an eye on vibration, ultrasound and temperature for all 42,000 spindles allowed the company to improve reliability by 19%, minimize outages and transition to anticipating required maintenance with help from Integrated Technology AI Predictive Maintenance (Chakraborty et al., 2021).

Technology	Application	Impact
AI	Defect Detection, Predictive Maintenance	Improved quality, reduced downtime
Big Data	Trend Forecasting, Mass Customization	Enhanced market responsiveness, reduced waste
IoT	Real-Time Monitoring, Smart Textiles	Increased efficiency, new product opportunities

6.4. Beximco (Bangladesh)

Among the companies leading the RMG manufacture in Bangladesh is Beximco, a company which came to invest in inventory and quality control systems for its operations which were based on the use of IoT, with the result of enhanced traceability and compliance with the requirements of the global buyers.

7. Challenges and Limitations

There are challenges to using these technologies, including the high price, the requirement for workers with special skills and issues related to protecting data privacy. However, with more technology becoming available, these barriers should disappear in the future. There will also be AI-enhanced textiles that change according to stimuli and textiles that use blockchain for extra supply chain transparency, both helping to create change in the industry (Textile Focus, 2024). Regardless of the advantages, some barriers hindering the widespread implementation of AI, Big Data, and IoT for textile manufacturing exist:

High Initial Investment: Prepayments on equipment, software and professional staff may be too high for Small and Medium Enterprises (SMEs).

Data Security: The more data collected and the greater connectivity the more the cyber security threats.

Skill Gaps: The workforce needs retraining to work with the new digital tools.

Interoperability Issues: The combination of old and new technologies may be technically complicated.

8. Conclusion

The combination or integration of AI, Big data and IoT in textile and RGM is no longer a futuristic concept, but an ongoing reality. These technologies boost automation, quality control, and production efficiency, thus allowing producers to keep up with the ever-changing dynamics of a global market. Despite the challenges, strategic investment, workforce development, and collaborative innovation can enable smart manufacturing to meet its full potential and achieve a sustainable, agile, and intelligent textile industry.

Textile and ready-made garments are changing for the better thanks to AI, Big Data and IoT. Manufacturers are better able to fulfil worldwide needs and protect the environment thanks to automation, optimising resources and the introduction of innovative products. More funding will improve performance, ensuring the industry performs better in Industry 4.0.

9. Future Outlook and Recommendations

In order to achieve a complete smart manufacturing potential, the following steps should be taken:

Public-Private Partnerships: Governments should provide incentives and facilities support for textile clusters' digital transformation (Sapra, 2024).

Upskilling and Training: Colleges and Corporations should work together in developing training programs to produce a digitally literate labour force.

Standardization: Standardization of industry data and communication will improve interoperability of systems.

Gradual Implementation: Manufacturers need to take a step-wise approach beginning with quality control, and then rolling out to other departments.

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