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Artificial Intelligence and Image Processing for Semi-finished Goods Inventory Management in Textile Industry

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Abstract

This study investigates the application of artificial intelligence (AI) and image processing technologies within the textile industry, specifically focusing on optimizing production processes. The primary aim was to assess the impact of AI and image processing systems on inventory management of semi-finished products, production efficiency, and labor optimization. Findings indicate substantial improvements, including a decrease in stock discrepancies, higher on-time tracking rates, significant time savings in production, and reduced labor costs. Further analysis highlights the financial advantages of technological integration, particularly in lowering production expenses. This research contributes to the literature by demonstrating the practical benefits of these technologies in production management, offering insights that could be applicable across other manufacturing sectors. Future research should explore the wider adoption of AI and image processing technologies across various industries and investigate their potential environmental impacts within production processes.

Keywords

Digital Transformation, Production Management, Artificial Intelligence, Image Processing, Textile Industry

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Tekstil Sektöründe Yarı Mamul Stok Yönetimi İçin Yapay Zekâ ve Görüntü İşleme Uygulaması

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Öz

Bu çalışmada, yapay zekâ (AI) ve görüntü işleme teknolojilerinin tekstil endüstrisine entegrasyonunu ve üretim süreçlerinin optimizasyonuna odaklanılmıştır. Bu araştırmanın temel amacı, yapay zekâ ve görüntü işleme sistemlerinin uygulanmasını takiben yarı mamul envanter yönetimi, üretim verimliliği ve işgücü optimizasyonundaki gelişmeleri incelemektir. Sonuçlar, stok hatalarında önemli azalmalar, zamanında takip oranlarının arttığını, çeşitli üretim süreçlerinde önemli zaman tasarrufu sağladığını ve işçilik maliyetlerinde kayda değer bir azalma olduğunu ortaya koymuştur. Ayrıca üretim maliyetleri düşmüştür ve bu da teknolojik entegrasyonun olumlu finansal etkisini göstermiştir. Bu araştırma, üretim yönetiminde yapay zekâ ve görüntü işlemenin pratik bir uygulamasını sağlayarak, bu teknolojilerin operasyonel verimliliği nasıl artırabileceğini ve maliyetleri nasıl azaltabileceğini göstererek mevcut literatüre katkıda bulunmaktadır. Bulgular, diğer imalat sektörlerinin de benzer teknolojik gelişmelerden yararlanabileceğini ve hem araştırmacılar hem de endüstri uygulayıcıları için değerli bilgiler sağlayabileceğini göstermektedir. Gelecekteki araştırmalar, bu teknolojilerin farklı endüstrilerde daha geniş uygulamalarına odaklanmanın yanı sıra, üretim süreçlerinde yapay zekâ ve görüntü işlemenin çevresel etkilerini keşfetmeye odaklanabilir.

Anahtar Kelimeler

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Introduction

The textile industry is a critical economic sector on a global scale. It is therefore imperative that it undergoes significant transformation, especially about sustainability, given its substantial environmental impact (Rathore, 2022, p. 234). This transformation encompasses objectives such as enhancing resource efficiency and minimizing waste, particularly in production processes. Technological advancements are increasingly pivotal in achieving sustainable development goals, including economic growth, environmental protection, and social equity, by enhancing production efficiency and reducing environmental harm (Stock et al., 2018, p. 255; Akhtar et al., 2022, p. 650).

The management of semi-finished goods stocks in the textile sector is widely regarded as being quite challenging. Conventional monitoring techniques frequently result in an oversight of errors and inefficiencies. This oversight can lead to initial time losses and increased costs over time. Indeed, the utilization of conventional methodologies frequently engenders delays in production, thereby impeding businesses' capacity to align with contemporary production methodologies. (Kaur, 2017, p. 40).

Conversely, contemporary production technologies, particularly those augmented by artificial intelligence, have the capacity to address the intricacies inherent in all production processes with greater efficiency and ease. The integration of artificial intelligence within production processes has been shown to enhance efficiency by facilitating the processing of substantial data sets (Kaur, 2017, p. 40). Furthermore, advancements in image processing technology, in conjunction with the development of artificial intelligence, have led to significant progress in the field of error detection (Mohiuddin Babu et al., 2024, p. 2095). This technological breakthrough has been shown to provide significant industrial benefits, increase production workflow, and reduce operational losses and damage.

In this study, artificial intelligence and image processing technologies are utilized to overcome the difficulties in the management of semi-finished stocks in a textile factory. On the other hand, the effective role of the improvements brought by these technologies to production processes in sustainable development goals is also emphasized. In the application phase, the data obtained from the integration of artificial intelligence and image processing technology are analyzed and the effect of these technologies on optimizing production workflows is emphasized. The findings made us realize the importance of the integration of technological integration in the textile industry, especially in promoting sustainable development. The study also provides insights on how the application of these technologies can improve production efficiency and greatly reduce environmental impacts.

1. Literature

The main objective of sustainable development is the long-term balanced operation of social, environmental and economic paradigms. By minimizing environmental degradation and making the best use of natural resources, we can leave a cleaner world for future generations. To achieve this, businesses aim to contribute to the process by renewing their production processes with modern technologies while being environmentally friendly. Especially in industrial production, technologies such as automation systems, data analytics and artificial intelligence come to the fore in this context. In addition, while reducing waste, errors and inefficiencies, it also develops technical solutions in terms of sustainability as it ensures efficient use of energy resources (Syafrudin et al., 2024, p. 1).

The textile industry generally has a production structure that progresses with semi-finished stock. The overall production processes for semi-finished products, which are considered unfinished, must be managed effectively. The use of traditional manual tracking systems for this leads to problems such as human errors, inefficiencies and unwanted waste of time. At the same time, these manual methods lead to delays in production and complexity in inventory management. Therefore, there are difficulties in managing and tracking production processes (Kaur, 2017, p. 40).

In response, the incorporation of modern technologies, in particular artificial intelligence (AI) and image processing, offers great opportunities for textile production improvement. AI enables the processing of large datasets, which results in improved production methods and better efficiency of resource allocation. Simultaneously, image processing technologies that make use of visual data recorded by sensors and cameras are essential to accurate monitoring of inventories, efficient quality control, and timely identification of errors on

production lines (Mohiuddin Babu et al., 2024, p. 2095). When combined, all these technologies are likely to notably improve the administration of half-completed inventories, optimize production processes, and minimize delays in operations.

This article explores the challenges associated with the management of semi-finished product inventories within textile manufacturing facilities and examines the potential contributions of artificial intelligence and image processing technologies in addressing these challenges. Furthermore, it highlights the improvements these technologies provide to production methodologies and their significance in advancing sustainable development. Through a comprehensive analysis of data derived from the implementation of AI and image processing, this paper aims to demonstrate how these technologies can enhance the efficiency of production workflows. The results demonstrate the great potential of the application of technology in the textile sector, especially in promoting sustainable development. The research also delivers key messages about how the application of these technologies can enhance the efficiency of production while substantially reducing environmental effects. The key objective of sustainable development is the attainment of long-term equilibrium among social, environmental, and economic factors. With the reduction of environmental degradation and maximum utilization of natural resources, the objective is to make the world cleaner for future generations. To do this, companies are adopting innovative technologies that enhance manufacturing processes with ecological sustainability preserved. Notably, in the industrial production sector, technologies like automation systems, data analysis, and artificial intelligence (AI) emerge as major tools to attain sustainable development goals. Moreover, advancements in technology play a critical role in reducing waste, limiting errors, and eliminating inefficiencies, as well as promoting the utilization of renewable energy sources where feasible (Syafrudin et al., 2024, p. 1).

The textile industry, while globally significant (Haber, 2014, pp. 128-140), faces considerable environmental challenges. Textile production contributes to excessive natural resource consumption, water pollution, chemical waste, and substantial energy use (Naqvi et al., p. 426). Therefore, developing a sustainable management approach is crucial. Recent strategies to mitigate the environmental impact include using recyclable materials, enhancing energy efficiency, reducing water consumption, and implementing effective waste management systems (Hasanbeigi & Price, 2015, p. 30-33). These efforts require optimizing energy usage and minimizing carbon emissions while maintaining efficient processes. Technological integration plays a pivotal role in this transformation (Hassan et al., 2024, pp. 5-7).

In the context of production systems, semi-finished products – defined as items that have not yet reached their final state (Stendahl & Eliasson, 2014, p. 14) – assume a pivotal role. However, the management of these intermediate goods presents numerous challenges. The precise monitoring of semi-finished inventories is imperative for ensuring efficiency and effective planning (Najlae et al., 2020, p. 1255). Conventional methods, which frequently depend on manual tracking techniques, are susceptible to human error and inefficiencies that can result in production delays (Sanders et al., 2016, p. 823). Inaccurate tracking hinders the identification of bottlenecks in processes and the optimization of production processes, leading to resource wastage and extended waiting times (Colledani et al., 2014, p. 777). This underscores the imperative for the adoption of more sophisticated inventory management techniques.

The use of artificial intelligence (AI) and image processing technologies in business activities presents attractive opportunities for improving the efficiency of operations. AI assists in managing big data, which means more precise forecasting, better process optimization, and faster decision-making. Meanwhile, image processing plays a role in quality control and inventory management by creating comprehensive conclusions from visual information (Peres et al., 2020, pp. 122–123).

In the context of the textile industry, the integration of artificial intelligence with image processing technologies has led to significant advances in the field of inventory management for semi-finished products. By using cameras and sensors to capture real-time visual data, manufacturers can inspect every stage of the production process with exceptional precision. Subsequently, AI algorithms interpret these data streams to provide real-time assessments of the condition of semi-finished products, enabling immediate detection of disruptions or overstocking, and facilitating timely interventions (Sarkar et al., 2023, pp. 200–230). These technologies improve inventory tracking and control, preventing overproduction and optimizing production processes. Additionally, they ensure that bottlenecks in production lines are detected in a timely manner, reducing delays. This level of technological application is crucial for the transition to more efficient, sustainable and environmentally friendly production processes. The integration of artificial intelligence and image processing in the textile industry is central to

improving production processes as well as achieving sustainable development goals (Pawlicka and Bal, 2022, pp. 20-21). In addition, the current digitalization of the textile industry is important for aligning production processes with sustainability goals. Digitalization plays a dual role of reducing production costs, mitigating environmental impacts, increasing competitiveness, and consequently reducing environmental footprints, as well as increasing labor productivity. In conclusion, the application of artificial intelligence and image processing technologies in the management of semi-finished inventories is crucial to compensate for production inefficiencies and improve the trend towards sustainability (Merli et al., 2024, pp. 2–3).

The forward-looking effects of these technological innovations on the industry are significant. Likewise, Waqar et al. (2024) investigated the applications of AI-powered image analysis and pattern recognition algorithms (IAPRA) to drive digital transformation in the concrete industry. While the investigation unlocked IAPRA's potential in terms of concrete detection, power assessment, and lifespan prediction, it also revealed obstacles such as complexities in implementation, economic and regulatory issues, and technology integration issues. The SEM analysis implied that removing these barriers would greatly improve quality control, allow for predictive maintenance, and increase overall productivity.

Kim et al. (2022) presents a comprehensive work that explores the use of artificial intelligence in manufacturing. In this work, the authors shed light on how artificial intelligence has the potential to revolutionize conventional manufacturing processes in the framework of Industry 4.0. Given the limitations of artificial intelligence at present, it is stated that research remains focused on enhancing its convergence with various engineering fields, precision engineering, and manufacturing. The research seeks to encapsulate the astounding success of artificial intelligence in the most productive and lucrative manufacturing industries. Here, the potential of artificial intelligence to revolutionize the manufacturing industries is emphasized.

Amza and Cicic (2015) presented an artificial intelligence-based approach for defect detection in radiographic images of industrial products. In the study, a novel two-stage algorithm based on feature analysis of X-ray images is presented. In the first stage, an automatic decision whether an object is a defect or not is made based on geometric criteria. In the second stage, a final decision is made using 'logical' criteria based on the quality requirements of the product. The study has shown that fuzzy logic techniques can be used effectively in this process. This approach contributes to improving the accuracy of defect detection in the field of industrial image processing.

Zhang and Dong (2021) addressed the challenges of effective use of information technology and customized label management in the manufacturing sector. The study identified hidden rules through artificial intelligence models using approval form data on customized labels of an electronics manufacturer. The authors applied the iterative testing method to address imbalances in time characteristics and data distribution and improved the effectiveness of AI models by optimizing model parameters. The research aimed to speed up the decision-making process and reduce the error rate by creating a warning system when the user's settings do not match the predicted results. As a result, the accuracy rate of the AI model increased from 80% to 95%, line downtime was reduced from 4 to 1 per month, and the cost of downtime at full capacity was reduced.

Tarachkov, Tolstel and Kalabin (2023) dealt with the development and evaluation of the effectiveness of an algorithm used in the process of preparing semi-finished products for packaging. The aim of the study was to ensure the correct placement of frozen nugget products transported in open cartons on a high-speed conveyor line. Product orientation was performed using the DR-1 robotic manipulator from Intelligent Robotics LLC. The system also includes a carton detector and conveyor speed sensor. The application of the algorithm enabled the totes to be aligned automatically, increasing productivity and reducing the number of faulty products. This approach makes an important contribution to the automation of production processes.

2. Method

This research aims to examine the effects of artificial intelligence and image processing technologies on the monitoring and management of semi-finished product stocks in the textile industry. The methods, data collection processes, analysis techniques and application areas used for the purpose of the research will be explained in detail.

2.1. Research Model and Design

The main purpose of this study is to understand how the integration of artificial intelligence and image processing technologies into production processes in the textile industry affects the management of semi-finished product stocks. In this context, quantitative data includes indicators that measure costs, changes in inventory management, production speed and efficiency.

The research consisted of three main phases:

- Data Collection Phase: Literature review related to the sector will be conducted and application-based data will be collected.
- Technological Integration Phase: Integration of artificial intelligence and image processing technologies into production processes will be ensured and data collection systems will be commissioned.
- Data Analysis Stage: The collected data will be evaluated by statistical analysis and the results will be interpreted.

2.1.1. Data Collection Techniques

In textile mills, on-site observations will be made to evaluate the use of technology in production processes, focusing on semi-finished product tracking and its impact on production efficiency. Cameras and image processing modules will monitor the location, size, and condition of semi-finished products, with artificial intelligence algorithms analyzing the collected data to identify bottlenecks, shortages, and optimize inventory management. This data collection and analysis will offer insights into improvements in efficiency, inventory management, and cost savings, and provide tangible evidence of the effects of technological integration on production processes.

2.1.2. Data Analysis Methods

In this research, data will be used to improve production processes in textile mills by focusing on condition assessment, optimization and decision-making. The goal is to improve production efficiency and optimize inventory management by using insights gained throughout these processes to guide decisions.

Condition Assessment: The first step involves a thorough assessment of the current production processes. Key data points such as stock levels, production times, machine status, and semi-finished product tracking will be analyzed to identify inefficiencies, bottlenecks, and disruptions. This stage is crucial for identifying areas for improvement and identifying where technological solutions can be implemented.

Optimization: In the second stage, the collected data will be analyzed to optimize various production parameters. This will include improving inventory management and reducing production times. Strategies will be developed for better production planning, and the most effective solutions will be determined for each step of the process, considering factors such as machine efficiency and stock management.

Decision Making: The final stage will use data to inform decision-making processes. The goal is to eliminate inefficiencies, speed up production, and optimize stock levels while reducing costs. Decisions will be supported by technological interventions such as artificial intelligence and image processing that will enable timely, data-driven choices that improve overall production efficiency

2.1.3. Application Area and Sample Selection

This research focuses on the integration of artificial intelligence and image processing technologies in a textile production facility in Turkey. The study examines the effects of these technologies on increasing the efficiency of production processes, especially in the textile industry. As a pilot application, the technological integration process was carried out in the sewing workshop and the improvements in the production processes were analyzed.

This study focuses on the application in a particular textile mill and the improvements it provides. In this factory, which was selected to evaluate the effects of technological integration on production processes, artificial intelligence and image processing technologies were discussed and the developments in this process were included in the research. The main difficulties in the production processes of the factory were evaluated under headings such as semi-finished stock management, production line arrangements, labor productivity, and production time.

The study examines how these technologies are implemented in the factory and their impact on costs, labor utilization, production time, and inventory management. In addition, issues such as the arrangement of the production line, the optimization of transport processes and improvements in the handling of semi-finished products are among the focus of the research. The data obtained during the implementation process are evaluated comparatively in terms of both the efficiency of the production processes and the costs, and conclusions are drawn on the success of the improvements made.

3. Improvement & Comparative Results

In this section, the improvements and gains achieved after the integration of artificial intelligence and image processing technologies into the production processes in the textile factory will be discussed. As the first step of technological integration, thanks to the pilot application carried out in the sewing workshop, the improvements achieved in terms of management of semi-finished product stocks, optimization of production processes and labor productivity were examined in detail.

3.1. Management and Follow-Up of Semi-Finished Product Stocks

Previously, the factory had to manually track semi-finished product stocks, and significant challenges were encountered in these processes. Determining the location of semi-finished products, determining their stage, and regularly checking stock levels were done in a time-consuming and error-prone method. This situation caused disruptions in the production process and overstock. However, with the integration of artificial intelligence and image processing technologies, it has become possible to monitor each semi-finished product in the production process and stock levels have started to be monitored in real time. Cameras and image processing software detect the instantaneous position, size and condition of each semi-finished product, and this data is transferred directly to the production management system. Thus, the traceability of the production process has been increased, and accurate and timely control of stock levels has been ensured.

Table 1. Inventory management and tracking of semi-finished products - before and after comparison

Semi-Finished Product Type	Stock Error (Before)	Stock Error (After)	On-Time Follow-Up Rate (Before)	On-Time Follow-Up Rate (After)
Fabric	18%	6%	55%	92%
Sewing Needle	22%	8%	50%	88%
Pant Cut	14%	5%	60%	95%

According to Table 1, stock errors in semi-finished products have decreased significantly and there has been a significant increase in timely follow-up rates. For example, the inventory error of the fabric decreased from 18% to 6%, while the on-time tracking rate increased from 55% to 92%. The stock error of the sewing needle increased from 22% to 8%, and the timely follow-up rate increased from 50% to 88%. The stock error of trouser cutting has decreased from 14% to 5%, while the on-time tracking rate has increased from 60% to 95%. These data show that stock management and tracking processes have improved considerably, production processes have become more efficient, and the capacity to respond to customer demands in a timely manner has increased.

3.2. Time Saving in Production Processes

The time savings in production processes reveal the positive effect of technological integration on productivity increase.

Table 2. Comparison of production time savings - before and after technological integration

Production Process	Before (Hours)	After (Hours)	Time Savings (%)
Semi-Finished Product Tracking	8	2	75%
Production Line Inspection	5	2.5	50%
Total Production Time	12	8	33%

Table 2 demonstrates significant reductions in production time across various processes. Semi-finished product tracking time has decreased from 8 hours to 2 hours, reflecting a remarkable 75%-time savings. Similarly, the production line inspection time has been halved, from 5 hours to 2.5 hours, leading to a 50%-time reduction. Overall, the total production time has been reduced from 12 hours to 8 hours, resulting in a 33%-time savings. These reductions indicate improvements in process efficiency and optimization, helping the company to operate more effectively and potentially increase production capacity.

3.3. Labor Productivity and Human Resource Savings

Thanks to the integration of artificial intelligence and image processing technologies, an increase in labor productivity has been achieved and labor savings have been achieved.

Table 3. Workforce efficiency and labor savings through technological integration

Workforce Count	Before (People)	After (People)	Workforce Savings (%)
Semi-Finished Product Tracking	15	7	53%
Production Control	10	5	50%
Total Workforce	600	570	5%

Table 3 highlights significant workforce reductions across various processes, demonstrating improved efficiency. Semi-finished product tracking saw a reduction from 15 to 7 people, resulting in 53% of workforce savings. Similarly, the production control workforce was reduced from 10 to 5, yielding 50% savings. On a broader scale, the total workforce decreased from 600 to 570, reflecting a 5% overall reduction. These reductions in workforce numbers suggest that the company has managed to optimize its human resources, likely through automation, process improvements, or better task management, thereby enhancing operational efficiency while maintaining productivity.

3.4. Saving on Production Costs

The impact of technological integration on costs is clearly demonstrated by the reduction in the operating budget.

Table 4. Reduction in production costs - before and after technological integration

Cost Item	Before (USD)	After (USD)	Cost Reduction (%)
Stock Management Cost	50,000	20,000	60%
Labor Cost	514,286	385,714	25%
Total Production Cost	542,857	461,428	15%

Table 4 demonstrates substantial cost reductions across key production areas. Stock management costs have decreased by 60%, from 50,000 USD (1,750,000 TL) to 20,000 USD (700,000 TL), indicating a significant

improvement in inventory handling efficiency. Labor costs have been reduced by 25%, from 514,286 USD (18,000,000 TL) to 385,714 USD (13,500,000 TL), which could suggest more efficient workforce utilization or the introduction of automation. Overall, total production costs have decreased by 15%, from 542,857 USD (19,000,000 TL) to 461,428 USD (16,142,000 TL). These reductions highlight the success of the company's technological integration and process optimizations in enhancing operational efficiency and profitability while maintaining production effectiveness. All calculations are based on the exchange rate of 1 USD = 35 TL as of December 2024.

The results of the data show how challenging the manual, time-consuming and error-prone techniques previously used were. Old processes had low efficiency and high error rates, especially in critical areas such as the management and tracking of semi-finished stocks. This was due to systems that required constant manual intervention, as well as old methods that made accurate and timely data tracking difficult. With the introduction of new technology and automation systems, errors have been significantly reduced, and processes have accelerated. Inventory errors, production control and labor utilization have become efficient, enabling previously time-consuming processes to be performed more quickly and accurately. For example, previously, to correct stock errors and supervise the production process, employees were making great efforts and manual operations that could take days. With the new system, these processes can be quickly managed in a digital environment, minimizing human errors, reducing production costs and increasing labor productivity. The reduction in the number of labor forces and the decrease in production costs with the effect of technology reveal the inadequacy of the old systems and clearly demonstrate how effective the improvement provided by the data is.

Discussion

The findings of this study show that the integration of artificial intelligence and image processing technologies into production processes in textile factories leads to significant productivity gains and provides operational improvements. Improvements in critical areas such as the management of semi-finished stocks, monitoring of production processes and labor productivity have eliminated the shortcomings of traditional production methods and clearly demonstrated the benefits of technological integration.

First of all, the improvements made in the management and tracking of semi-finished stocks are quite remarkable. In the old system, manual monitoring and mismanagement of stocks led to high error rates and time losses. However, thanks to the new system, data such as the instantaneous location, status and size of each semi-finished product can be automatically monitored through image processing software and these data are instantly transferred to the production management system. This has resulted in a significant reduction in stock errors, while a significant increase in on-time tracking rates has been achieved. For example, the inventory error of the fabric increased from 18% to 6%, and the on-time tracking rate increased from 55% to 92%. These improvements increase the traceability of production processes, while at the same time allowing for faster and more accurate responses to customer demands.

Saving time is one of the most obvious consequences of technological integration. Reducing time losses in production processes allows the company to work more efficiently and flexibly. Semi-product follow-up time was reduced by 75% from 8 hours to 2 hours. In addition, the time spent on production line inspection was cut in half, and the total production time was reduced by 33%. This data shows that the company's production capacity can increase, and operational efficiency is greatly improved thanks to the fact that processes are becoming faster and more efficient.

The increase in labor productivity is also an important finding to be considered. The integration of artificial intelligence and image processing technologies has led to a significant reduction in the number of workforces. There has been a 53% decrease in the number of employees in the semi-finished product tracking process and a 50% decrease in production control. While this data shows the effective savings that technology provides on the workforce, it also makes it possible to direct employees to more strategic and creative jobs. The ability to do more work with fewer employees contributes to the company's both reducing costs and increasing its efficiency.

Finally, the reductions in production costs are also noteworthy. Inventory management costs were reduced by 60% and labor costs by 25%. This shows that technological integration also provides significant benefits in financial terms and increases the profitability of the company. There was a 15% reduction in total production

cost. This suggests that improving cost-effectiveness strengthens the company's competitive advantage and will help it gain a stronger position in market conditions.

The findings of this study show that the integration of artificial intelligence and image processing technologies in the textile industry not only increases production efficiency but also provides significant improvements in critical areas such as inventory management, labor efficiency and cost control. However, for technological integration to be successfully implemented, companies need to invest in their infrastructure and provide the necessary training to adapt employees to these new technologies. Future research may examine the wider applications of these technologies and their potential benefits in other manufacturing sectors.

Conclusion

This study revealed that artificial intelligence and image processing technologies play a key role in improving production processes in the textile industry, and this integration helps to reduce costs by increasing efficiency. The results highlight the effectiveness of technological solutions, especially in key areas such as semi-finished stock management, production line control, labor productivity and optimization of total production costs. The improvements have contributed to a broader understanding of the potential benefits of such technologies in manufacturing sectors and have filled existing gaps in literature.

From a scientific point of view, this study makes an important contribution in the fields of production management and digital transformation. Research on the integration of artificial intelligence and image processing technologies is often only at the theoretical level, not supported by practical examples. The applied data provided by this study concretely illustrates how these technologies operate in real-world scenarios and transform the operational performance of businesses. In this respect, a unique contribution has been made to literature, and it is one of the first in-depth analysis made specifically for the textile industry.

The results of the research offer several recommendations for future research. First, this study includes an applied analysis conducted on only one textile factory. Future studies may examine the integration of similar technologies in different industries and larger-scale production facilities. In addition, research on the sustainability and environmental impacts of such technologies will further deepen the knowledge in this field. Secondly, since the focus of this study is operational efficiency and cost optimization, research can be done that focuses more on human factors such as employee satisfaction and organizational culture. The long-term effects of technological transformation on the workforce need to be examined in more depth for both employees and managers.

There are also limitations to this study. First, the analysis was limited to only a specific textile mill, so the generalizability of the findings is limited. It is important to conduct similar research in companies with different business structures or in textile sectors in different countries to test the accuracy of these findings in a broader framework. In addition, practical difficulties such as the high installation and maintenance costs of artificial intelligence and image processing technologies used in the study were not considered. Future studies investigating the feasibility of such technologies should also consider the implications of these costs and technological infrastructure requirements.

Finally, this research provides important insights into the digital transformation process in the textile industry and provides data supported by practical examples, creating a valuable resource for both academics and professionals in the industry. This study aims to be a reference point for researchers who want to learn more about how artificial intelligence and image processing technologies can be used efficiently in their production processes. Technological innovations and digital transformation are expected to inspire further research across cross-industry boundaries.

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