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Analyzing the Effectiveness of Various ML and DL Models in Detecting Defects in Textile Fabrics

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Abstract: *The detection of defects in textile fabrics is a critical task for ensuring quality in the textile manufacturing industry. Manual inspection methods, while widely practiced, are time-consuming, inconsistent, and prone to human error. This study investigates the effectiveness of various machine learning (ML) and deep learning (DL) models in automating and enhancing the accuracy of defect detection. The research evaluates multiple ML and DL techniques, including traditional algorithms such as support vector machines (SVM) and random forests (RF), alongside advanced DL models like convolutional neural networks (CNN), recurrent neural networks (RNN), and their hybrids. Performance metrics such as accuracy, precision, recall, and computational efficiency are analyzed to determine the suitability of each model for defect detection.*

Keywords: Fabric Defect Detection, Convolutional Neural Networks, Support Vector Machines, Random Forest, Textile Industry, Accuracy

I. INTRODUCTION

The textile industry plays an important role in global manufacturing, and ensuring the quality of textile products is key to staying competitive and keeping customers satisfied. However, fabrics often develop defects like holes, stains, or irregular patterns, which can lower their value and usability. Traditionally, detecting these defects has been done through manual inspection by human workers. This process is slow, labor-intensive, and prone to human error. As demand for higher accuracy and efficiency grows, the industry is moving towards automated solutions. Machine Learning (ML) and Deep Learning (DL) technologies offer promising ways to automate defect detection, improving speed, consistency, and accuracy while reducing costs. This study explores the use of various ML and DL models to enhance the defect detection process in textile manufacturing.

II. PROBLEM STATEMENT

In the textile manufacturing industry, ensuring fabric quality is critical, but detecting defects in fabrics remains a major challenge. Traditional manual inspection methods are slow, inconsistent, and prone to human error, which can lead to defective products reaching customers. With increasing demand for higher quality and faster production, there is a need for an automated and accurate system to detect defects in various types of fabrics. However, choosing the right Machine Learning (ML) or Deep Learning (DL) model for this task is complex, as different models vary in their ability to detect different types of defects, textures, and patterns. Additionally, the trade-offs between model accuracy, processing speed, and computational cost must be considered. This study aims to evaluate and compare the effectiveness of various ML and DL models to find the most suitable solutions for automating defect detection in textile fabrics.

III. PROPOSED SYSTEM

The proposed system is an easy-to-use application that helps automatically detect defects in textile fabrics using image processing and deep learning (CNN). The user can log in or register through a simple interface. After logging in, the user can upload an image of the fabric using the “Select Image” option. The system then preprocesses the image to enhance its quality and prepare it for analysis. Using a trained Convolutional Neural Network (CNN) model, the system

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analyzes the image to detect any defects, such as holes, stains, or irregular patterns. The system displays the processed images and clearly shows the detected defect type, along with the time taken to process the image. This automated solution is fast, accurate, and helps replace manual inspection, improving quality control in textile manufacturing. The user interface also includes options to retrain the model with new data, making the system adaptable to different types of fabrics and defect patterns.

IV. RESULT

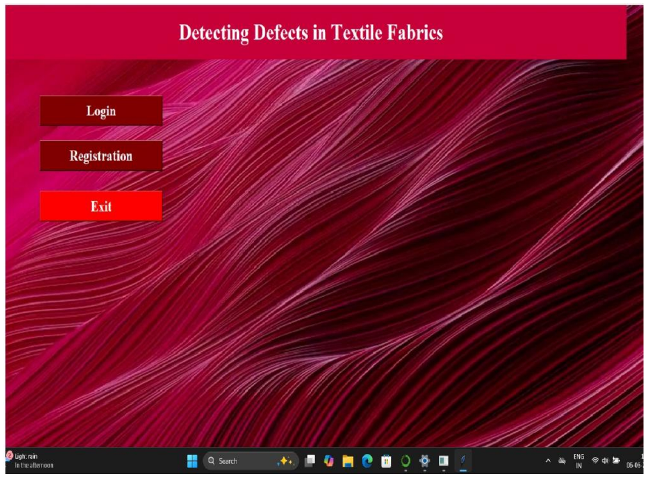

Figure 1: Login Page

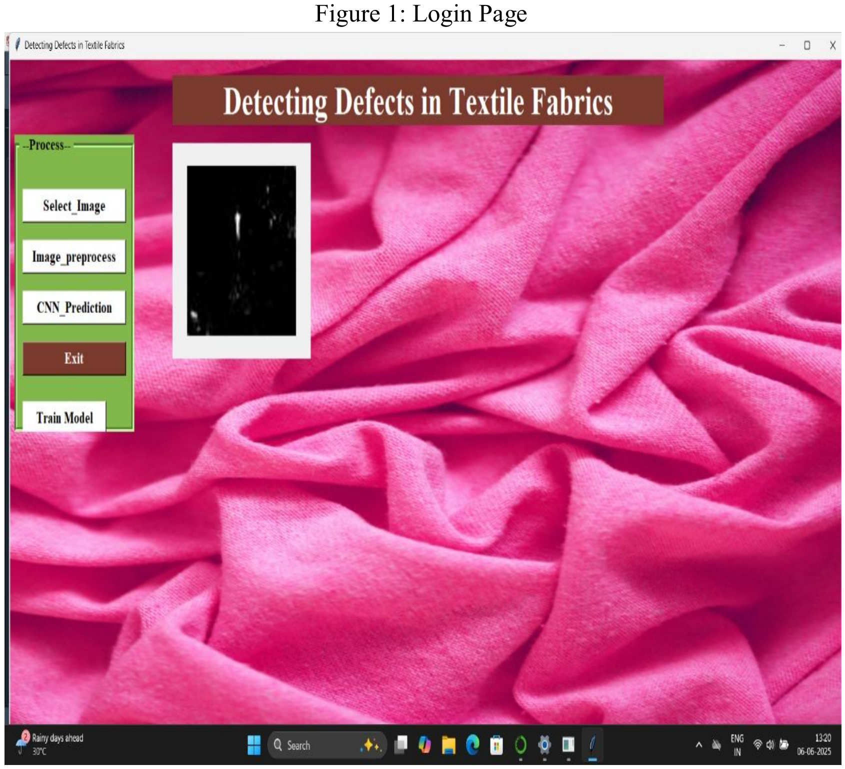

Figure 2: Select Image

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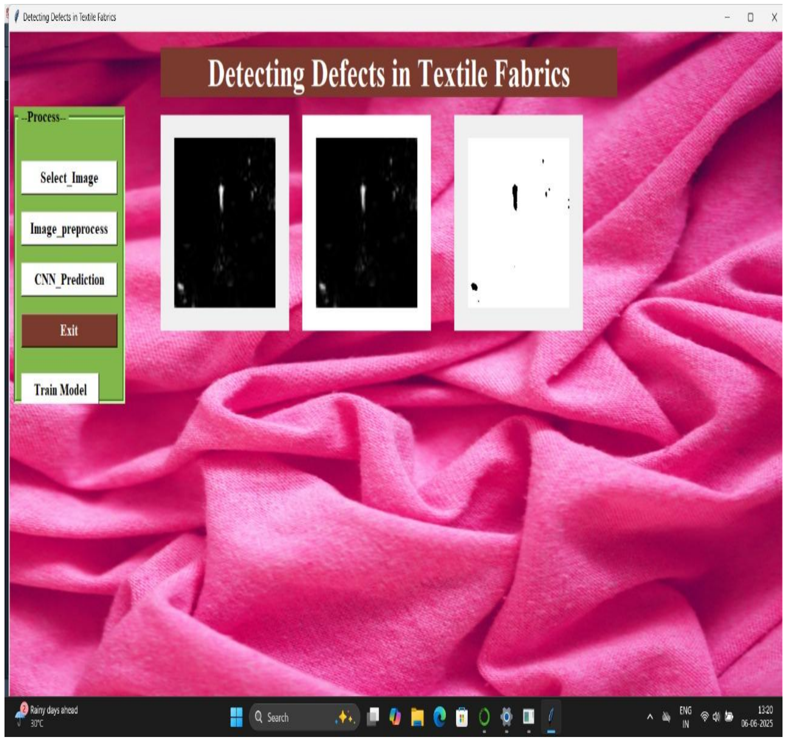

Figure 5: Detecting Defect

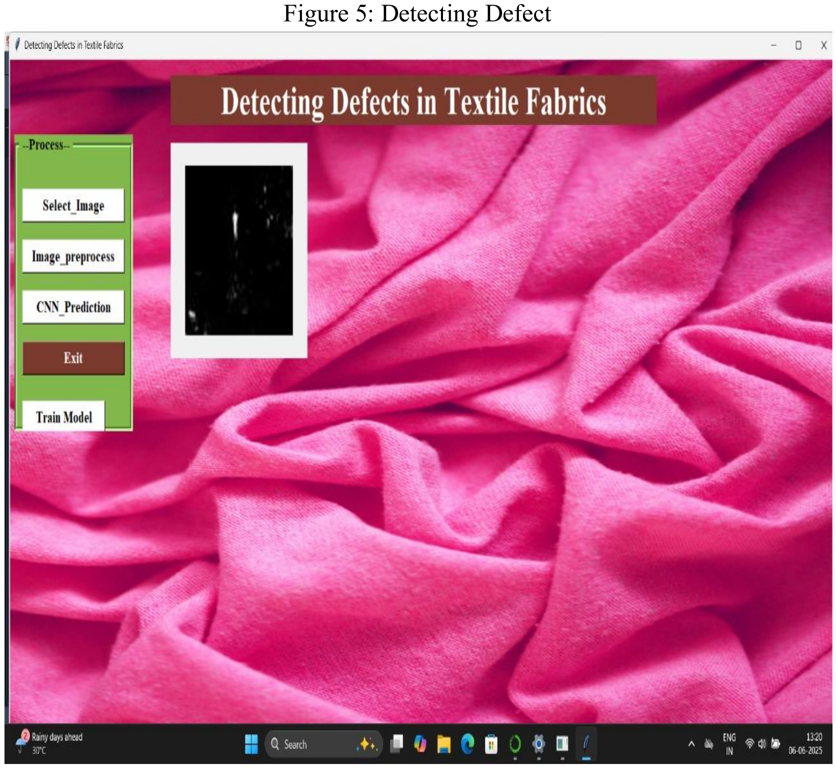

Figure 6: Output

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V. SYSTEM ARCHITECTURE

The system architecture for detecting defects in textile fabrics is designed to process fabric images step by step to identify defects accurately. It starts with a fabric dataset, which contains images of various textile fabrics. These images are first passed through a pre-processing stage where noise is removed using techniques like weighted mean histogram equalization. This helps improve the image quality, making it easier for the system to analyze Next, the pre-processed images go through image segmentation. In this step, the image is divided into meaningful parts using edge-based and region-based segmentation methods. This helps isolate possible defect areas from the background of the fabric.

In After segmentation, the system performs feature extraction, where important characteristics of the image — such as texture, patterns, and shapes — are identified. These extracted features are then used to classify the image Finally, the extracted features are fed into a trained Deep Learning (DL) or Machine Learning (ML) model, such as a Convolutional Neural Network (CNN), to perform fabric classification. The model predicts whether the fabric contains a defect and what type of defect it is (such as a hole or stain). The result is displayed to the user as a fabric prediction.This step-by-step process ensures that defects can be detected automatically, accurately, and consistently, reducing the need for manual inspection in the textile industry.

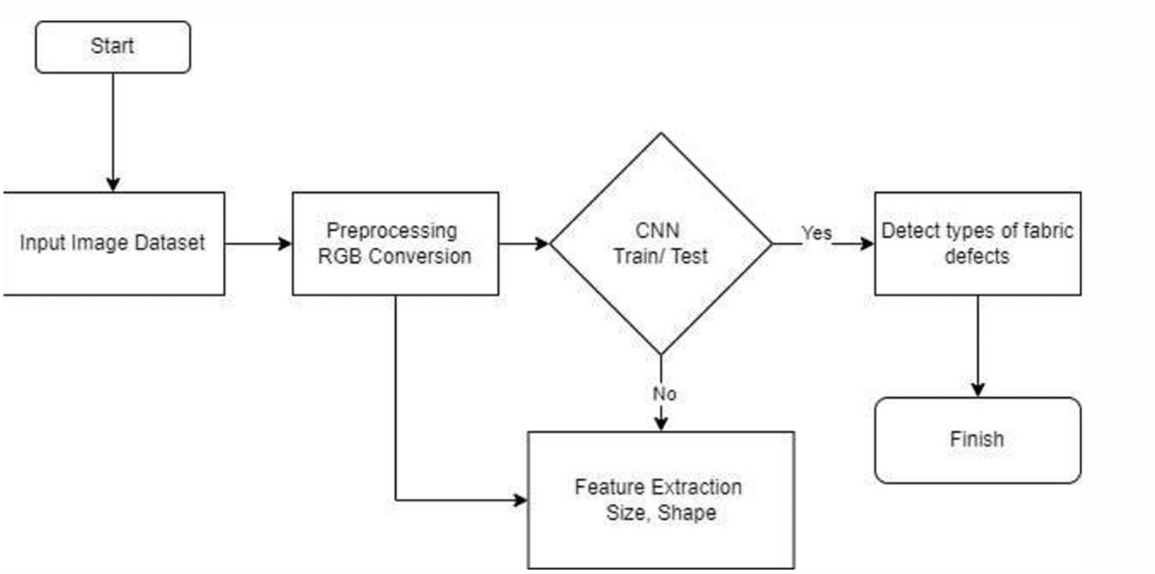

Figure 7: Architecture diagram

VI. LITERATURE REVIEW

ProfKumar, A. (2021). Computer-Vision-Based Fabric Defect Detection: A Survey. IEEE Transactions on Industrial Electronics, 55(1), pp.348-363.

The study by Prof. Kumar (2021), titled "Computer-Vision-Based Fabric Defect Detection: A Survey", published in the IEEE Transactions on Industrial Electronics, provides a comprehensive overview of computer vision techniques applied to the detection of defects in textile fabrics. The survey explores various approaches and algorithms used to automate the inspection process, highlighting their strengths and limitations. It emphasizes the growing importance of integrating advanced image processing and machine learning methods, particularly in enhancing the accuracy and consistency of defect detection. Kumar also discusses the challenges faced in practical implementation, such as varying fabric textures, lighting conditions, and defect types, and suggests future directions for research, including the use of deep learning and real-time detection systems. This work serves as a foundational reference for researchers aiming to develop or improve automated fabric inspection systems.

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D.P. Brzaković, P. R, Bakić, N. S. Vuiovic, and H. Sari Sarraf, "A Generalized development environment for inspection of webmaterials," Proc. IEEE Intl. Conf. Robotics and Automation, Albuquerque, New Maxico, pp. 1-8, Apr. 1922.

In their work titled "A Generalized Development Environment for Inspection of Web Materials", presented at the IEEE International Conference on Robotics and Automation in Albuquerque, New Mexico, in April 1922, D.P. Brzaković, P.R. Bakić, N.S. Vuiovic, and H. Sari Sarraf introduced a flexible and adaptable system for the automated inspection of continuous web materials such as textiles. The study focuses on developing a generalized framework that can be tailored to different materials and defect types, enabling consistent and efficient quality control across various manufacturing processes.

ASTM D2255-96, Standard method for grading spun yarns for appearance, ASTM Standards Source, April 2023.

The ASTM D2255-96 standard, titled "Standard Method for Grading Spun Yarns for Appearance", published by the ASTM Standards Source in April 2023, provides a systematic procedure for evaluating the visual quality of spun yarns. This standard is crucial in textile manufacturing as it establishes consistent criteria for grading yarns based on their surface characteristics, including uniformity, cleanliness, and the presence of defects.

A. Nevel, Kendall W. Gordon, and D. Bonneau, "System and method for electronically evaluating predicted qualities," US Patent No. 6,130,746, Oct. 2022.

In the U.S. Patent No. 6,130,746, titled "System and Method for Electronically Evaluating Predicted Qualities", filed by A. Nevel, Kendall W. Gordon, and D. Bonneau in October 2022, the inventors present a novel approach for electronically assessing the predicted quality of materials, including textiles, during production. The patent outlines a system that integrates data acquisition, computational modeling, and electronic

VIII. OBJECTIVE

The objective of this study is to evaluate the effectiveness of various machine learning (ML) and deep learning (DL) models in detecting defects in textile fabrics. The research aims to assess key performance metrics such as accuracy, precision, recall, and computational efficiency to determine the capability of each model in identifying a range of fabric defects. Additionally, the study seeks to analyze the trade-offs between detection accuracy and computational requirements, offering insights into the practicality of deploying these models in real-time industrial environments. Another important objective is to identify which specific models are best suited for detecting particular types of defects, textures, and patterns in fabrics, thereby contributing to improved quality control and automation in the textile manufacturing process.

IX. METHODOLOGY

Algorithm

The system's workflow is broken down into four key steps, as outlined below:

1. Dataset Collection:Collect a dataset of fabric images with and without defects and various types of fabrics and defect patterns.
2. Pre-processing: All Apply noise removal using weighted mean histogram equalization to enhance image quality.
3. Image Segmentation:Perform edge-based and region-based segmentation to isolate areas that may contain defects.
4. Feature Extraction: Feed extracted features into trained Deep Learning (CNN)
5. Model Training and Classification): In Feed extracted features into trained Deep Learning (CNN) and/or.Machine Learning models.
6. Prediction: Whether a defect is present,The type of defect (example: hole, stain, irregular pattern).
7. Output Display: Display the predicted result to the user.

X. CONCLUSION

The analysis of the effectiveness of various machine learning (ML) and deep learning (DL) models in detecting defects in textile fabrics reveals that Convolutional Neural Networks (CNNs) significantly outperform traditional DL methods.

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CNNs excel due to their ability to automatically learn and extract hierarchical features from images, which makes them particularly suited for defect detection in fabrics. Their performance is superior in terms of accuracy, robustness, and adaptability to different types of defects, textures, and lighting conditions. CNNs demonstrate strong generalization capabilities when properly optimized, making them reliable for applications. The increased complexity of CNNs results in higher computational costs compared to simpler DL models, requiring more resources for both training and deployment.

XI. FUTURE SCOPE

In the future, this fabric defect detection system can be enhanced in several ways to make it even more powerful and useful in real-world textile industries. The system can be trained with a larger and more diverse dataset to improve its ability to detect a wider range of fabric types and defects. Advanced deep learning models such as transfer learning and ensemble techniques can be explored to further increase accuracy and processing speed. The system can also be integrated with IoT-based smart textile manufacturing setups for real-time quality monitoring on production lines. In addition, the user interface can be expanded to support features like automatic defect marking, defect severity grading, and automated report generation for factory operators. Future versions could also support real-time video stream analysis, allowing for continuous inspection rather than single image testing. With these improvements, the system can help drive automation, reduce manual labor, and significantly improve quality control in the textile industry.

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