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Analyzing The Effectiveness Of Various ML And DL Models In Detecting Defects In Textile Fabrics

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Abstract: Ensuring high-quality textile production is critical for maintaining industry standards, and defect detection plays a crucial role in quality control. Traditional inspection methods are labor-intensive and prone to human error. This study evaluates the effectiveness of various Machine Learning (ML) and Deep Learning (DL) models in detecting defects in textile fabrics. A dataset of fabric images with annotated defects was used to analyze the performance of these models. The findings indicate that while conventional ML models provide reasonable accuracy for simple defects, Deep Learning approaches, particularly Convolutional Neural Networks (CNNs), excel in identifying intricate and subtle imperfections. The study highlights the potential of integrating intelligent fabric inspection systems in manufacturing to enhance quality control, reduce production costs, and minimize manual intervention. Future work aims to expand the dataset, refine detection algorithms, and explore applications in related domains such as apparel manufacturing and textile recycling.

Index Terms: Machine Learning, Deep Learning, Textile Defect Detection, Convolutional Neural Networks, Image Processing, Quality Control

I. INTRODUCTION

Quality control in the textile industry is essential for ensuring defect-free fabrics. Traditional manual inspection methods are time-consuming and prone to errors. This study explores the effectiveness of Machine Learning (ML) and Deep Learning (DL) models in detecting textile defects. While ML models provide basic classification, Deep Learning, especially Convolutional Neural Networks (CNNs), offers superior accuracy in identifying complex defects. By integrating AI-driven defect detection, manufacturers can enhance efficiency, reduce costs, and improve fabric quality. This research evaluates various models to determine the most effective approach for real-time defect detection in textile production.

II. Problem Statement

Manual fabric defect detection is slow, error-prone, and inefficient for large-scale production. Variations in fabric texture, lighting, and image quality further impact accuracy. This study evaluates Machine Learning (ML) and Deep Learning

(DL) models to automate defect detection, aiming to enhance accuracy, reduce waste, and improve production efficiency

III. OBJECTIVES

This study aims to develop an AI-driven fabric defect detection system using Machine Learning (ML) and Deep Learning (DL). The goal is to enhance accuracy, minimize errors, reduce manual labor, and lower production costs. By comparing different models, the research seeks to identify the most effective approach for real-time defect detection, ensuring seamless integration into textile manufacturing for improved quality control and efficiency.

IV. METHODOLOGY

The study follows a systematic approach to analyze the effectiveness of Machine Learning (ML) and Deep Learning (DL) models in fabric defect detection. A labeled dataset of textile images is collected and preprocessed using techniques like noise reduction and normalization. Various ML and DL models, including Convolutional Neural Networks (CNNs), are trained and fine-tuned for defect classification. Performance is evaluated using metrics such as accuracy, precision, recall, and F1-score. The best-performing model is then optimized for real-time defect detection and seamless integration into textile production lines.

Approaches used for building System:

[1] Data Collection & Preprocessing – Gather a labeled dataset of textile images and apply preprocessing techniques like noise reduction, normalization, and augmentation.

[2] Feature Extraction – Utilize image processing techniques and deep learning architectures to extract key features for defect classification.

[3] Model Selection – Compare various Machine Learning (ML) and Deep Learning (DL) models, including CNNs, for optimal performance.

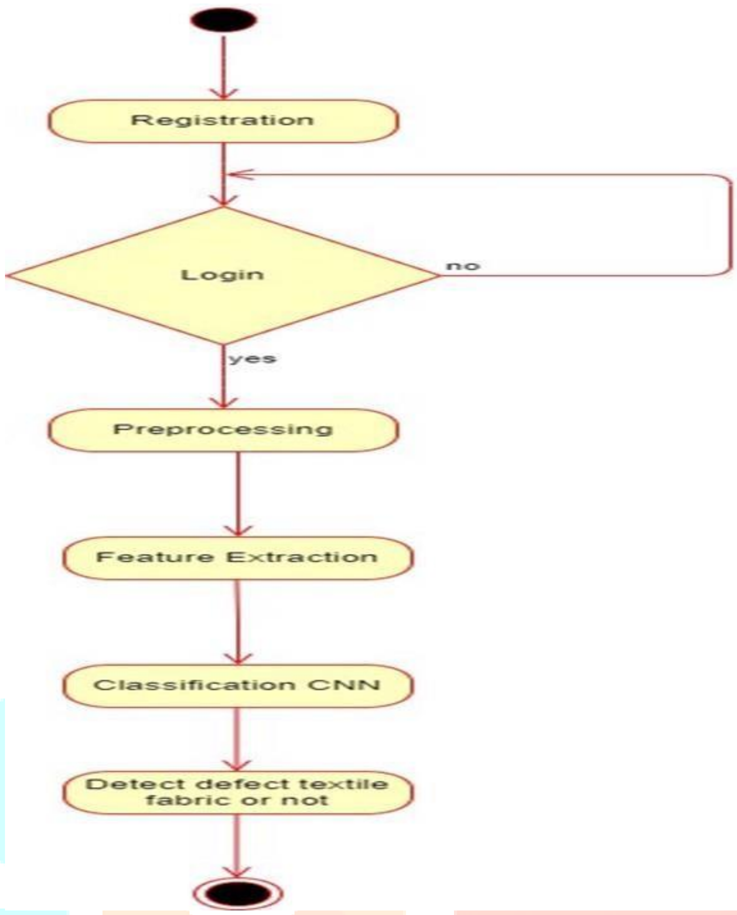
[4] Training & Optimization – Train models using labeled data and fine-tune hyperparameters to improve accuracy and efficiency.

[5] Performance Evaluation – Assess models using metrics such as accuracy, precision, recall, and F1-score to determine effectiveness.

[6] Real-time Implementation – Optimize the best-performing model for real-time defect detection and seamless integration into production lines.

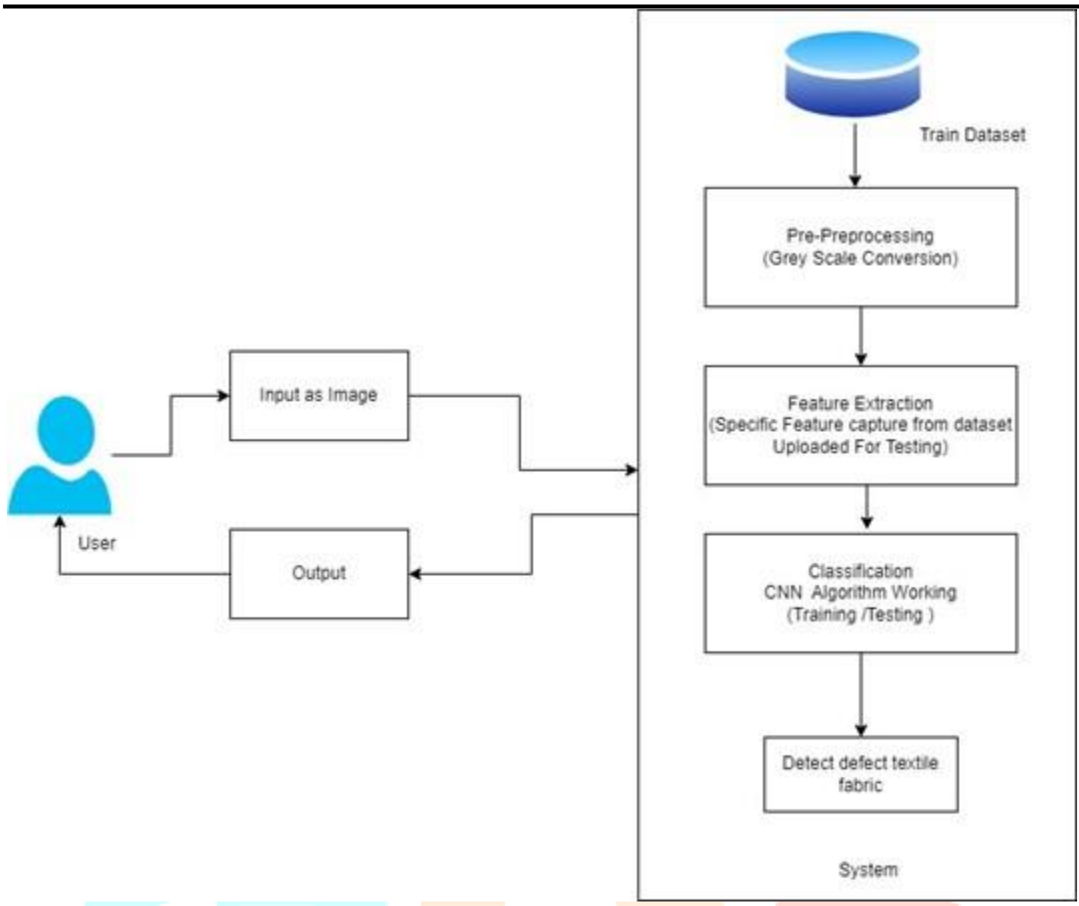
[7] Testing & Validation – Conduct rigorous testing on unseen data to ensure reliability, scalability, and adaptability to different fabric types.

V. Workflow



VI. SYSTEM ARCHITECTURE

1. **User Input** – The system receives an image of the textile fabric uploaded by the user for defect detection.
2. **Pre-Processing** – The input image undergoes grayscale conversion to enhance feature extraction and improve model accuracy.
3. **Feature Extraction** – The system captures key features from the fabric image, focusing on textures and patterns to identify potential defects.
4. **Dataset Utilization** – A pre-trained dataset containing labeled fabric defect images is used for training and testing the model.
5. **Classification Model (CNN)** – A Convolutional Neural Network (CNN) processes the extracted features and classifies the fabric as defective or non-defective.
6. **Training & Testing** – The model is trained on a labeled dataset and then tested with real-world fabric images to ensure accuracy and robustness.
7. **Defect Detection Output** – The system provides the final output, indicating whether the fabric contains defects, which is then displayed to the user.
8. **Real-time Processing** – The model is optimized for quick and efficient defect detection, making it suitable for real-time implementation in textile manufacturing.



VII. CONCLUSION

This study demonstrates the effectiveness of Machine Learning (ML) and Deep Learning (DL) models, particularly Convolutional Neural Networks (CNNs), in detecting defects in textile fabrics. By automating the defect detection process, the system enhances accuracy, reduces human errors, and improves quality control in textile manufacturing. The proposed approach minimizes manual labor and production costs while ensuring real-time defect identification. Future work will focus on expanding the dataset, optimizing model performance, and integrating the system into industrial production lines for large-scale deploymen

VIII. FUTURE SCOPE

Future improvements will focus on enhancing model accuracy, expanding datasets for better adaptability, and integrating real-time defect detection into industrial production lines. Deploying the system on edge devices and IoT platforms will enable on-the-spot inspection. The system can also classify multiple defect types and suggest corrective actions. Further advancements may include AI-powered robotic inspection and applications in apparel manufacturing, medical textiles, and other industries.

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