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Efficient Detection of Fabric Defect using ML Techniques

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ABSTRACT: The textile industry, as the third-largest industry globally and the second-most polluting, faces a pressing need for automation. The surplus of rejected clothes underscores the importance of proper pre-production quality inspection, specifically through automation, to achieve higher quality, improved efficiency, and reduced human errors. This inspection encompasses both neural networks and traditional methods. Traditional methods involved the manual placement of fabric under a frame for inspection, relying on human observation. In contrast, neural networks have harnessed the capabilities of artificial intelligence and machine learning algorithms to automate the fabric inspection process. In this project, we adopt a statistical-based approach called the grey level co-occurrence matrix (GLCM) combined with classification techniques for defect detection. To evaluate the performance of our models, we utilize a publicly available dataset supplemented with additional data collected by our team. The comprehensive dataset enables us to conduct an efficient performance analysis. Our findings indicate that the Random Forest classifier outperforms the Support Vector Machine (SVC) classifier

KEYWORDS: Automation, Segmentation, Neural Networks, Textural Analysis, Artificial Intelligence, Machine Learning.

I. INTRODUCTION

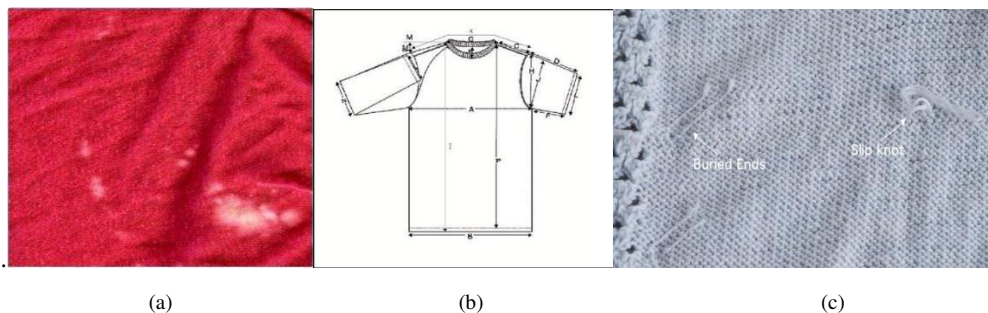
The garment industry is reportedly the world's third biggest manufacturing industry after automotive and technology industries. With the technology escalating vastly, the increase of the bulk production in the industry has also multiplied. Speed is the key to this mass production. It also leaves them with the bulk of the environmental and social costs. It is also known that the fashion industry is the second-most polluting industry after oil.

Mass produced garments, which are processed to get them to market as quickly as possible, have an enormous impact on the environment. Chemicals used to make synthetic fabrics such as sodium hydroxide and carbon disulfide, are derived from coal, oil, or natural gas. Fashion is also one of the worst when it comes to human rights abuses and exploiting workers, especially women and children. According to the International Labour Organization, there are ~40 million garment workers worldwide, and 80% of them are women between the ages of 18 and 35. Many of them make less than minimum wage and work insanely long hours. With all that going on, if the final product does not reach to customer's satisfaction there will be a loss of both capital and labor. Therefore, to minimize the revenue loss it is important to take some active measures out of which one is the examining of the textile before production called the quality check i.e., before the conversion of the fabric to a wearable cloth piece, proper inspection of that fabric is necessary.

Eighty-seven percent of the total fibre input used for clothing is ultimately incinerated or sent to a landfill. Only a fraction of what's manufactured gets recycled. Less than 1% of the fiber is reused to make new clothes, representing the loss of the billions of dollars' worth of clothes, which are not reused and thrown as waste, adversely affecting the environment, according to the foundation. These are the certain quality related problems in garment manufacturing that should not be over looked: Sewing defects - Like open seams, wrong stitching techniques used, same colour garment, but usage of different colour threads on the garment, miss out of stitches in between, creasing of the garment, erroneous thread tension and raw edges are some sewing defects that could occur so should be taken care of. Some of the defects that are common in the industry: -

- Colour defects - That could occur are difference of the colour of final produced garment to the sample shown, accessories used are of wrong color combination and mismatching of dye amongst the pieces.
- Sizing defects - Wrong gradation of sizes, difference in measurement of a garment part from other, for example- sleeves of XL size but body of L size. Such defects do not occur has to be seen too.
- Garment defects - During manufacturing process defects could occur like faulty zippers, irregular hemming, loose buttons, raw edges, improper button holes, uneven parts, inappropriate trimming, and difference in fabric colours

Fig 1. Defects that are common in the industry (a) Image of Colour Defects (b) Image of Sizing defects (c) Garment defect



Defect in the garments industry is a common phenomenon that hampers the smooth production rate and focus on poor quality products having an impact on overall factory economy. Minimization of defects is a must in quality and economical management pre-production. Which if not taken care of would require rework that neither customers want to pay for and nor the companies. Therefore, fabric defect detection is considered as a challenging task to do as the quality and the price of a fabric are totally dependent on the efficiency of the automation of the process. Earlier, manual efforts were used for the process but lack of concentration, human fatigue and time consumption were the major drawbacks of the scenario.

To overcome the aforementioned challenges, the automation of processes using computer vision and digital image processing is crucial. This project aims to conduct a comprehensive investigation into different computer vision-based techniques employed in the textile industry for early detection of fabric defects before the production phase. Our focus is on a particular approach for fabric defect detection, which will undergo thorough examination and evaluation. Specifically, we have opted for a statistical texture analysis method combined with machine learning techniques to detect and identify defects in the fabric. This chosen approach will be rigorously analyzed and compared with other methods to determine its reliability and effectiveness.

II. RELATED WORK

[1] Extraction of oil painting features is the fundamental and important step in image classification. Due to issues including dimension and angle change, a single feature extraction approach cannot accurately recognize an oil painting region. So, based on SVM and KNN classifiers, this research proposes a unique multi-feature fusion method for feature extraction and recognition from oil paintings. The brand-new technique combines the shape features, local binary pattern, SIFT, and semantic elements of images of oil paintings. Three data sets, comprising accuracy object area and inaccuracy object area, are used in the experiment. The experiment's findings indicate that by integrating numerous features, oil painting feature extraction can greatly increase average classification accuracy while also having superior adaptability.[2] In this paper we defined a new feature called trace extracted from the GLCM and its implications in texture analysis are discussed in the context of Content Based Image Retrieval (CBIR). The theoretical extension of GLCM to n dimensional Gray scale images are also discussed. The results indicate that trace features outperform Hara lick features when applied to CBIR. [3] In this paper various combinations of distance and directional angles used for GLCM calculation are analyzed in order to recognize certain patterned images based on their textural features. Patterns considered in this paper are horizontally striped, vertically striped, right diagonally striped, left diagonally striped, check red and irregular.[4] The authors first define the problem of fabric defect detection and discuss the importance of automated quality control in the textile industry. They then categorize fabric defect detection methods into traditional algorithms and learning-based algorithms. They then discuss the strengths and weakness of each approach. They also discuss the challenges of fabric defect detection, such as the variability of fabric defects and the complexity of textile manufacturing

processes. Finally, they present a number of recommendations for future research in fabric defect detection. [5] The authors first discuss the challenges of crop classification in early phenological stages, and then review the use of texture features for crop classification in general. They then present a case study on the use of GLCM to extract texture features from images of crops taken from low altitude remote sensing platforms. The results showed that the accuracy of the classification was improved by using GLCM to extract texture features. [6] Fabric defect detection has been a topic of significant research in the textile industry. Developing a robust automatic fabric defect detection system (FDDS) is crucial for ensuring high-quality products and maximizing revenue. Two main approaches have been widely explored: statistical methods such as gray level co-occurrence matrix (GLCM) and transform-based methods like the Gabor filter approach. GLCM involves extracting texture statistics and plotting them against inter-pixel distance, while the Gabor filter approach utilizes a bank of filters to decompose images and compare magnitude responses for defect decision. This paper proposes a new GLCM-based FDDS and compares it with the Gabor filter approach. The GLCM approach demonstrates higher defect detection accuracies and computational efficiency, making it a promising solution for fabric defect detection in industrial settings. By employing automated visual inspection systems, the textile industry can enhance productivity, minimize financial losses, and maintain high-quality standards. [7] The paper proposes a fabric defect detection technique with a combination of feature extraction and classification techniques. The proposed approach incorporates the following methods such as data acquisition, pre-processing, feature extraction and classification. Here, the input fabric images is classified as defect-free or defective by utilizing the combined feature with efficient machine learning approach named as RDF classifier. Initially, the image acquisition process is done with the help of line scan cameras. Here, the texture is the most important feature in the fabric defect detection and these features are extracted by with the two fusion methods namely, GLCM and the Gabor wavelet filter after pre-processing. After extracting the valuable features, the classification is performed by the RDF classifier.[8]In this paper hybrid fabric defect classification method that combines Local Binary Patterns (LBP) and Gray-level Co-occurrence Matrix (GLCM) for efficient and accurate classification of fabric defects. The experiments are conducted on a dataset of 600 fabric images containing six different types of defects. The results demonstrate that as the dimension of the feature values increases, the classification accuracy improves. The combination of LBP_{2,3} feature and GLCM achieves a significant advantage with an accuracy of 97.6%, outperforming existing classification methods. However, it is noted that the computational time increases due to the larger data size. Previous research in fabric defect classification has shown varying levels of accuracy. Methods based on geometrical characteristics achieved 86.2% accuracy, while wavelet transformation and GLSM correlation yielded accuracies of 93.1% and 94% respectively. [9] The authors first discuss the challenges of wood texture classification, and then review the use of texture features for wood texture classification in general. They then present a case study on the use of GLCM and LBP to extract texture features from images of wood. The results showed that the accuracy of the classification was improved by using GLCM and LBP to extract texture features.[10] The research paper introduces a texture classification system that is robust to changes in illumination. It utilizes a combination of Gray Level Co-occurrence Matrix (GLCM) and binary patterns (LBP, LLBP, SLBP) for feature extraction. Additionally, a rotation-invariant, scale-invariant steerable decomposition filter is applied to enhance the image. The system employs classifiers (PNN, K-NN, SVM) for texture classification and achieves higher accuracy compared to other methods. The paper highlights the significance of texture classification in various applications and discusses the importance of intensity normalization using histogram equalization. Overall, the proposed method demonstrates improved performance in texture classification.

III. METHODOLOGY

Fabric defect detection is a critical task in the textile industry. The Gray-Level Co-occurrence Matrix (GLCM) technique is an effective method for detecting fabric defects by analyzing the spatial relationship between pixel intensities in an image.

Data Collection and Generation: The research study compiled a diverse dataset of fabric images, including self-generated data, publicly available datasets from Kaggle, and fabric images obtained through targeted searches on Google. This ensured a comprehensive range of fabric samples for analysis, with approximately 30% of the images specifically created and collected for controlled and consistent data.

Feature Extraction: The focus was on extracting texture features from the fabric images using the Gray-Level Co-occurrence Matrix (GLCM) technique. To ensure consistency, all images were converted to grayscale, and the GLCM was computed for each image using specified distance and angle parameters. Five specific texture features (contrast, dissimilarity, homogeneity, energy, and correlation) were then extracted from the GLCM for each fabric image.

Dataset Preparation: The collected and generated fabric images were utilized to create the training dataset. Each fabric image contributed a feature vector containing the extracted texture features, and a corresponding label was assigned to indicate whether the fabric was faulty or non-faulty. The feature vectors and labels were stored separately for further processing.

Training and Evaluation: The training dataset was divided into a training set and a test set using a specified ratio. The research study employed a Random Forest classifier as the classification model. The Random Forest classifier was trained on the training set to learn the patterns and relationships between the extracted texture features and the fabric categories. Subsequently, the trained classifier was evaluated on the test set to assess its performance and measure its accuracy.

Fault Detection: To validate the efficacy of the developed methodology, new fabric images were obtained for fault detection. Pre-processing techniques were applied to ensure the suitability of these images for analysis. The same feature extraction process was then applied to extract the texture features from the new fabric images. Finally, the trained Random Forest classifier was employed to predict whether a fabric image contained a fault based on the extracted texture features. The resulting prediction indicated the presence or absence of a fault in the fabric image.

IV. EXPERIMENTAL RESULTS

As we applied GLCM pre-processing to extract texture features from the fabric images. This step involved calculating various statistical measures, such as contrast, dissimilarity, homogeneity, energy, and correlation, from the GLCM matrices.

Once we obtained the feature vectors, we divided the dataset into training and testing sets. We then trained two popular classification algorithms, namely Random Forest and SVM (Support Vector Machine), on the training set.

To evaluate the performance of the system, we tested both the Random Forest and SVM models on the testing set. The Random Forest algorithm achieved an impressive accuracy of 85% in accurately detecting fabric defects. On the other hand, the SVM algorithm achieved an accuracy of approximately 76%.

•Confusion matrix: -

In the context of fabric defect detection using the Random Forest classifier, the confusion matrix visually summarizes the classification results. It consists of four quadrants representing different scenarios:

- True Positives (TP): The model correctly predicts a faulty fabric image as faulty.
- True Negatives (TN): The model correctly predicts a non-faulty fabric image as non-faulty.
- False Positives (FP): The model incorrectly predicts a non-faulty fabric image as faulty.
- False Negatives (FN): The model incorrectly predicts a faulty fabric image as non-faulty.

By analysing the confusion matrix, we can evaluate the model's performance in terms of accurately detecting faulty and non-faulty fabric images. The values in the matrix indicate the number of instances falling into each category.

•Random forest: -

The fabric defect detection system in this study used GLCM pre-processing and the Random Forest algorithm. The results showed that the Random Forest algorithm achieved a high accuracy of 85% in detecting fabric defects. This means it was successful in accurately identifying and distinguishing between defective and non-defective regions in fabric images. These findings are promising for practical use in the textile industry, where accurate defect detection is important for ensuring product quality and productivity. Future research can focus on optimizing parameters and exploring additional techniques to further improve the system's performance.

•Support Vector Machine (SVM):-

In addition to the Random Forest classifier, the SVM classifier was also employed to detect fabric defects. The SVM classifier achieved an accuracy of approximately 76% in identifying fabric defects. Although the SVM classifier demonstrated a moderate level of accuracy, it was slightly outperformed by the Random Forest classifier, which achieved an accuracy of 85%. This suggests that the Random Forest classifier is a more effective approach for fabric



defect detection. Further analysis and experimentation may be required to investigate the specific factors contributing to the performance difference between the two classifiers.

Fig 2 (a)Confusion matrix of random forest (b) Confusion matrix of SVM

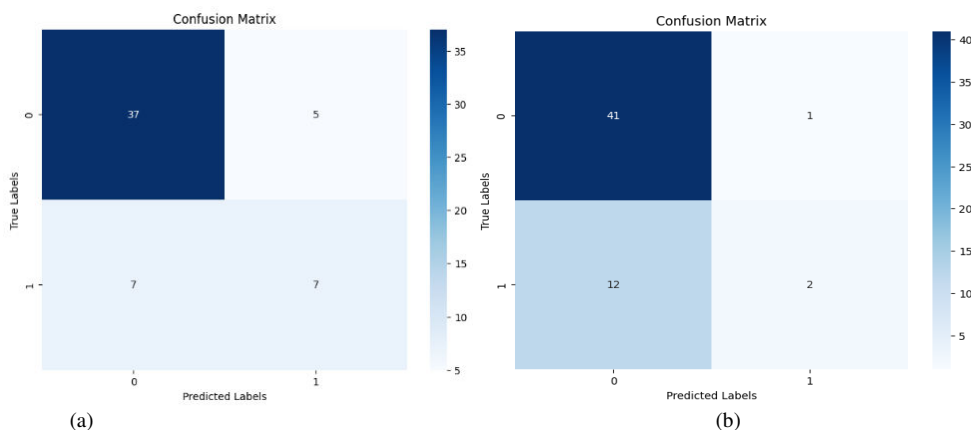
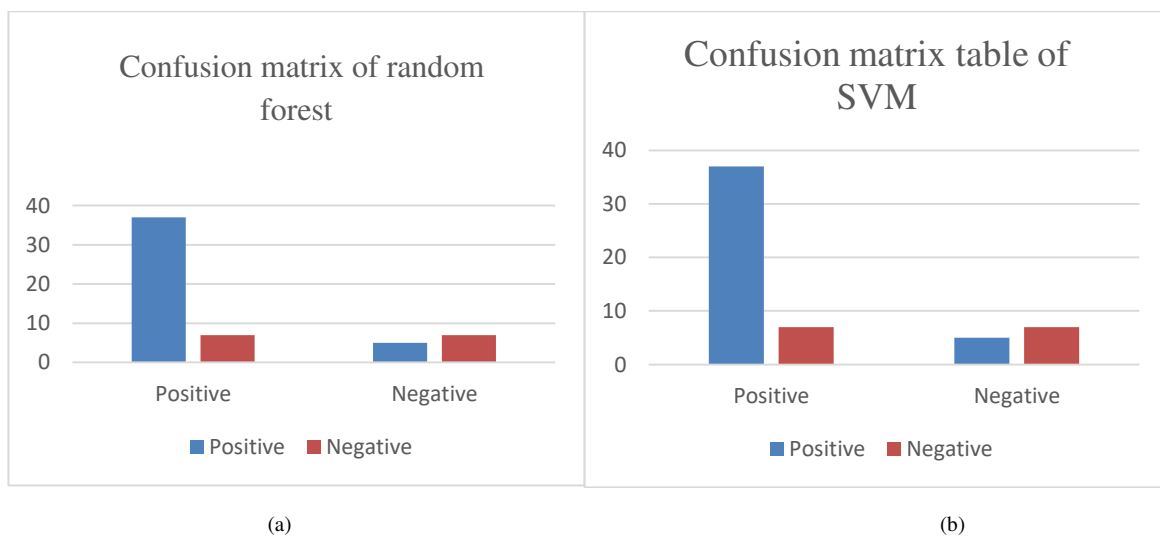


Fig. 3 (a) Graph of Confusion matrix of Random Forest (b) Graph of Confusion matrix of SVM



V. CONCLUSION

In conclusion, this fabric defect detection project utilized the Gray-Level Co-occurrence Matrix (GLCM) for pre-processing fabric images and applied the Random Forest and SVM algorithms for defect classification. The research aimed to accurately identify and classify various fabric defects, including holes, thread pulls, horizontal lines, drop stitches, knots, splicing, thick places, and needle lines.

The project involved data collection from multiple sources, including self-generated fabric images, publicly available datasets, and images obtained from online sources. Texture features were extracted from the fabric images using GLCM, focusing on contrast, dissimilarity, homogeneity, energy, and correlation. These features provided valuable insights into the unique characteristics of each fabric defect type.



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