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Tanjim Mahmud
Rangamati Science and Technology University , Bangladesh

Juel Sikder
Rangamati Science and Technology University, Rangamati

Rana Joyti Chakma
Rangamati Science and Technology University

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Tanjim Mahmud[1(✉)], Juel Sikder[1], Rana Jyoti Chakma[1], and Jannat Fardoush[2]

[1] Department of Computer Science and Engineering, Rangamati Science and Technology University, Rangamati, Bangladesh
{tanjim.cse,rchakma}@rmstu.edu.bd, sikder_juel@yahoo.com

[2] Department of Computer Science and Engineering, University of Chittagong, Chittagong, Bangladesh
jannat.soma@gmail.com

Abstract. Fabric inspection is very significant in textile manufacturing. Quality of fabric defends on vital activities of fabric inspection to detect the defects of fabric. Profits of industrialists have been decreased due to fabric defects and cause disagreeable loses. Traditional defect detection methods are conducted in many industries by professional human inspectors who manually draw defect patterns. However, such detection methods have some shortcomings such as exhaustion, tediousness, negligence, inaccuracy, complication as well as time-consuming which cause to reduce the finding of faults. In order to solve these issues, a framework based on image processing has been implemented to automatically and efficiently detect and identify fabric defects. In three steps, the proposed system works. In the first step, image segmentation has been employed on more than a few fabric images in order to enhance the fabric images and to find the valuable information and eliminate the unusable information of the image by using edge detection techniques. After the first step of the paper, morphological operations have been employed on the fabric image. In the third step, feature extraction has been done through FAST (Features from Accelerated Segment Test) extractor. After feature extraction, If PCA (Principal Component Analysis) is applied as it reduces the dimensions and preserves the useful information and classifies the various fabric defects through a neural network and used to find the classification accuracy. The proposed system provides high accuracy as compared to the other system. The investigation has been done in a MATLAB environment on real images of the TILDA database. AQ1 AQ2

Keywords: Defect detection · FAST (Features from Accelerated Segment Test) · Neural network · PCA (Principal Component Analysis)

1 Introduction

The textile industry is a rising sector. Development and advancement of the sector normally bring to build the going through huge investment. Be that as it may, the textile, like any other sector, industry experienced various issues. These include some insurance to diminish the effect of misfortunes that are budgetary, client disappointment, time squandering, and so on. Fabric defects are probably the greatest test

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confronting the textile business. Fabric is made in a day by day life utilizing fibers and a usually utilized material. Most fabrics are delivered after passing through a series of making stages. Various machines and methods are utilized during the making stages. Fabrics are subjected to pressures and stresses along these lines that cause defects. As indicated by their structures and directions, defects take various names. The textile business has distinguished in more than 70 types of defects [1] such as laddering, end-out, hole, and oil spot as shown in Fig. 1. Unexpected tasks might be the reason for various defects on the fabric surface during the manufacturing of fabric [2]. The lack of defects can diminish the cost of fabric by 50–60% [1]. The decrease in the impacts in the production process is typical for the industrialist.

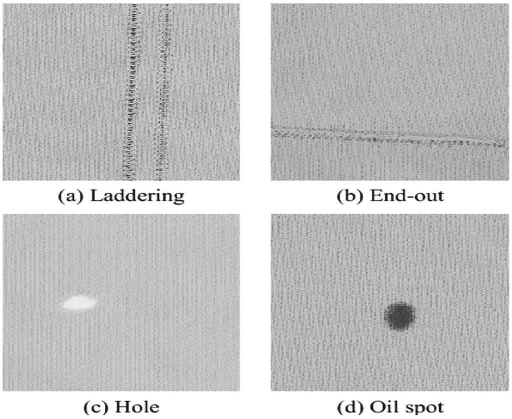

Fig. 1. Different defects in a fabric

Thus, fabric manufacturing is one of the largest traditional businesses where fabric inspection systems can play a vital role in growing the manufacturing rate. These days, the significance of an inspection process nearly rises to with manufacturing process in the current industrialist viewpoint. The idea of inspection process is to recognize the happened errors or defects, on the off chance that any exist, at that point to change argument or give alert of inspector for checking the manufacturing procedure [3]. For the most part, fabric defects recognition utilizes two kinds of investigation models [4]. The essential one is that the human-based inspection systems as shown in Fig. 2.The second framework is automated based inspection systems as shown in Fig. 3. Accordingly, human-based defect detection done by specialists' turns out to be rapidly a mind-boggling and fussy task [5, 6]. In this manner, having proficient and automated based frameworks nearby is a significant necessity for improving unwavering quality and accelerating quality control, which may expand the profitability [7–10]. The subject of automated based defect detection has been examined in a few works in the most recent decades. In spite of the fact that there is no widespread methodology for handling this issue, a few strategies dependent on image processing procedures have been proposed in recent years [11–13]. These strategies were utilized to recognize defects at the image level, so the precision rate is little and additionally, it is hard to find the defects precisely. In this way, they can't be stretched out to various fabrics. As of late, some different techniques dependent on local image-level have been proposed, which utilize the base unit as the fundamental activity object to extract image features.

These methodologies can be ordered into four principle gatherings: Statistical, Signal processing-based, Structural methodology, and Model-based methodology.

Fig. 2. Human-based inspection system

Fig. 3. Machine automated inspection system

In the statistical approach, gray-level properties are utilized to describe the textural property of texture image or a measure of gray-level reliance, which are called 1st-order statistics and higher-order statistics, separately [14]. The 1st-order statistics, for example, mean and standard deviation [15, 16], rank function [17], local integration, can gauge the variance of gray-level intensity among different features between defective areas and background. The higher-order statistics depends on the joint probability distribution of pixel sets, for example, gray-level co-occurrence matrix [18] gray-level difference strategy [15] and autocorrelation method. In any case, the inconvenience of this strategy is that defects size is sufficiently enormous to empower a compelling estimation of the texture property. So this methodology is feeble in handling local little defects. Additionally, the calculation of higher-order statistics is tedious [17].

In the subsequent class model-based methodology, the generally utilized strategies are Markov random field Gaussian Markov random field [16]. The texture features of a contemplated texture and can signify to all the more exactly spatial interrelationships between the gray-levels in the texture. However, like the methodologies based on second-order statistics, additionally it is tough for model-based methodology to deal with identifying small-sized defects in light of the fact that the methodologies as a rule require an adequately large region of the texture to assess the parameters of the models.

The structural approach generally utilized on properties of the primitives of the defect-free fabric texture for the nearness of the flawed region, and their related placement rules. Apparently, the practicability of this methodology is to congestion to those textures with regular macro texture.

Not at all like the above methodologies which separate the defects as far as the visual properties of the fabric texture, the signal processing based methodology extract features by applying different signal processing procedures on the fabric image. It is projected that the distinguishable between the defect and the non-defect can be improved in the handled fabric image. This methodology further comprises of the accompanying techniques: Spatial filtering, Karhunen-Loeve transform, Fourier transform, Gabor transform, and Wavelets transform.

As a weakness of this methodology, its performance is effortlessly influenced by the noise in the fabric image. These coefficients exemplify to optimal the defect-free fabric image, be that as it may, not the optimal separation between the defect and the non-defect.

They are progressively proficient in the separation of fabric defects than different techniques that depend on the texture investigation at a single scale [19]. Contrasted with the Gabor transform; the wavelet transform has the benefit of greater adaptability in the decomposition of the fabric image [20]. Consequently, the wavelet transform is seen as the most suitable way to deal with the feature extraction for fabric defect detection.

Table 1. Taxonomy of some most recent related works

Article	Classifier	Machine learning technique	Accuracy rate
[21]	Artificial Neural Network	Counterpropagation	82.97%
[22]	Artificial Neural Network	Backpropagation	78.4%
[23]	Artificial Neural Network	Resilient backpropagation	85.57%
[24]	Support Vector Machine	NA	77%
[25]	Artificial Neural Network	Backpropagation	84%
[26]	Artificial Neural Network	Backpropagation	81%
	Artificial Neural Network	Least mean square error (LMS)	87.21%
[27]	Artificial Neural Network	Backpropagation	85.9%
[28]	Artificial Neural Network	Backpropagation	76.5%
[29]	Artificial Neural Network	Learning vector quantization (LVQ)	67.11%
[30]	Model-based clustering	NA	65.2%
[31]	Artificial Neural Network	Backpropagation	71.34%
[32]	Artificial Neural Network	Resilient backpropagation	69.1%

Table 1 Illustrates the taxonomy of most recent fabric defects detection methods, in light of their classifier, machine learning technique, and accuracy rate.

In this paper, we propose an innovative defect detection algorithm which has the capability to cope with different types of defects. Our algorithm is based on four phases. In the initial phase, image segmentation has been utilized on an excess of a couple of fabric images so as to enhance the fabric image and to locate the important data and wipe out the unusable data of the image by utilizing different edge detection strategies. After the initial phase, morphological operations have been utilized on the fabric image. In the third step, feature extraction has been done through FAST (Features from Accelerated Segment Test) extractor. After feature extraction, If PCA is applied as it lessens the dimensions and preserves the helpful data, and characterizes the different fabric defects through a neural network; additionally classifier has been utilized to find the accuracy rate. The proposed framework gives high precision when contrasted with the other framework. The investigation has been done in MATLAB environment on real images of the TILDA database [33].

The remaining of the paper is arranged as follows: In Sect. 2, the various types of fabric defects are presented. In Sect. 3 explains our proposed approach for defect detection. In Sect. 4 presents the application of our system and analysis. Finally, Sect. 5 accomplishes the paper and presents our future research plans.

2 Defects in Fabric

In order to prepare various categories and forms of fabric items in the industry, fabric materials are used. Consequently, yarn quality and/or loom defects affect the fabric quality. Fabric defect has been estimated [34] that the price of fabrics is reduced by 45%-65% due to the presence of defects such as dye mark/dye Spot, slack warp, faulty pattern card, holes, spirality, grease oil/ dirty stains, mispick, slub, wrong end, slack end, and so on [1]. In a fabric, defects can occur due to: machine faults, color bleeding, yarn problems, excessive stretching, hole, dirt spot, scratch, poor finishing, crack point, material defects, processing defects, and so on [35, 36].

3 Proposed Methodology for Defect Detection

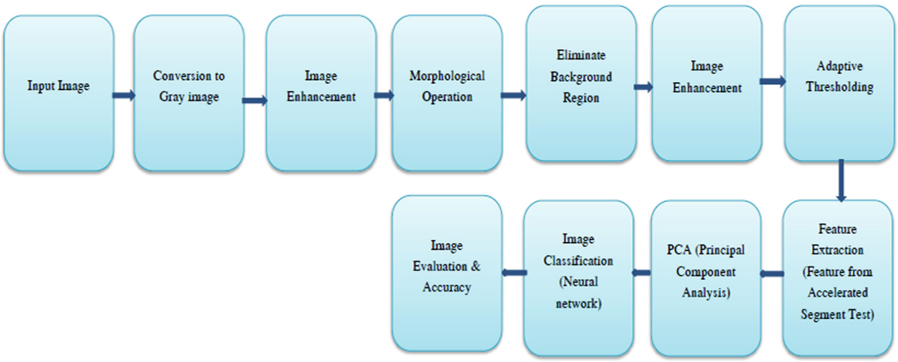

Fig. 4. Block diagram of the developed system

Figure 4 shows the steps of methodology, to sum up; the following steps are image segmentation, feature extraction, PCA (Principal Component Analysis), and image classification.

3.1 Image Segmentation

Image segmentation is a fundamental advance in image analysis. Segmentation isolates an image into its objects or segment parts. Edge detection is a mechanism in image processing to make the image segmentation procedure and pattern recognition more precise [37, 38]. It fundamentally diminishes the measure of information and filters out pointless data, while protecting the helpful properties in an image. The adequacy of many image processing relies upon the flawlessness of identifying significant edges. It is one of the procedures for detecting strength discontinuities in a digital image. Essentially we can say, the way toward arranging and setting sharp discontinuities in an image is known as edge detection. There are many edge detection strategies available, every procedure intended to be keen on particular types of edges. Factors that are concerned about the choice of an operator for edge detection include edge direction, edge structure, and noise condition. The paper applied the histogram equalization strategy on fabric image as shown in Fig. 6. After that edge detection strategy has been applied as shown in Fig. 6. There are numerous operators in edge detection methods model Roberts, Sobel, and Prewitt [39, 40] and the result shows that the Canny's edge detection method performs superior to every other strategy.

3.2 Feature Extraction

The feature extractor applied on the dataset of images as shown in Fig. 6 which relies on the extractor of the local feature. The point of local feature portrayal is to express to the image which depends on some notable regions. The image relies upon its local structures with a lot of local feature extractors and which is get from a lot of image regions called interest regions [41]. FAST (Features from Accelerated Segment Test) has been applied to the fabric picture to extract the features as shown in Fig. 6. Rosten and Drummond proposed initially that FAST is a strategy for recognizing interest regions in an image [42]. An interest region in an image is a pixel that has a very much characterized position and can be vigorously identified. An interest region has high local data substance and they ought to be in a perfect world repeatable between various images [43].

3.3 PCA (Principal Component Analysis)

It is a straight forward method used in dimensionality reduction to decrease the features that are not helpful. It protects the valuable features of the information or image [44, 45]. If applied after feature extraction through feature extractor FAST, it gives a great performance or accuracy via classifier.

3.4 Image Classification

Neural network [26, 45] is a machine learning technique that has been applied to classify the Images of fabric defects as shown in Fig. 6 and applied the pattern recognition framework and to get the great outcomes after train the framework by dataset [46, 47]. It can partition the dataset into a testing stage and training stage to locate the hidden neurons in the pattern recognition framework as shown in Fig. 5. The classifier will apply for the classification accuracy when feature extraction from the extractor. The classifier has been applied to the real image of fabric [33].

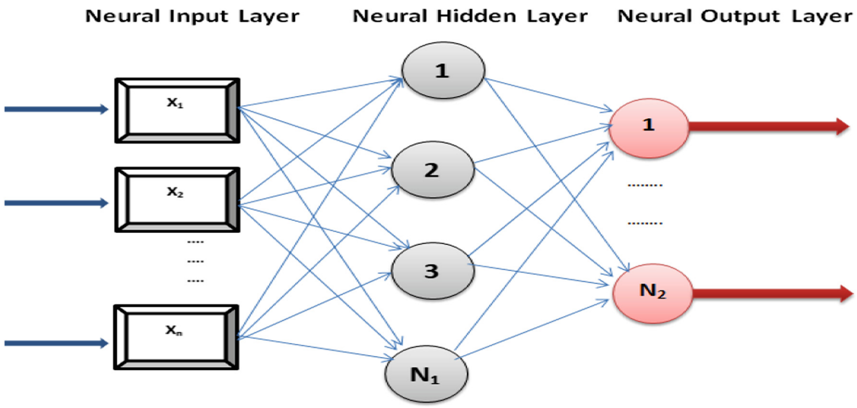

Fig. 5. Neural network

4 Application of the System and Analysis

4.1 Proposed Methodology

Phase 1	For enhancing the fabric images to apply edge detection method
Phase 2	For the application of FAST (Features from Accelerated Segment Test) extract the features and discover the interest regions
Phase 3	Consequently, applied the PCA (Principal Component Analysis) to decrease the dimensions and reserve the beneficial data
Phase 4	Applied machine learning algorithms neural network to get better accuracy as it provides better outcomes

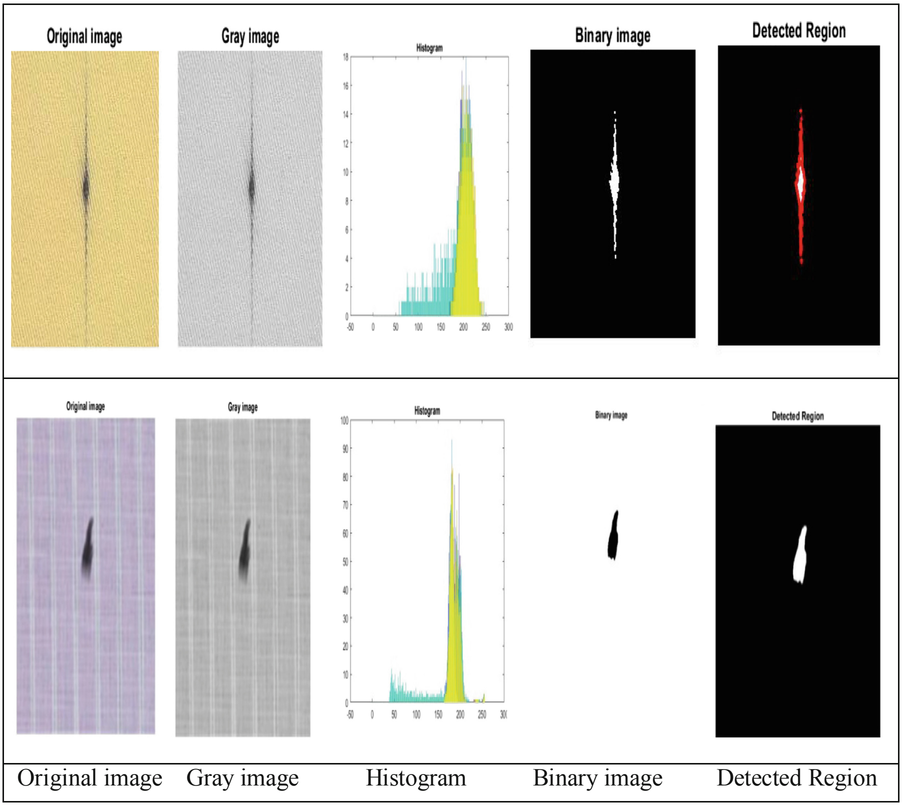

Fig. 6. Application of the system

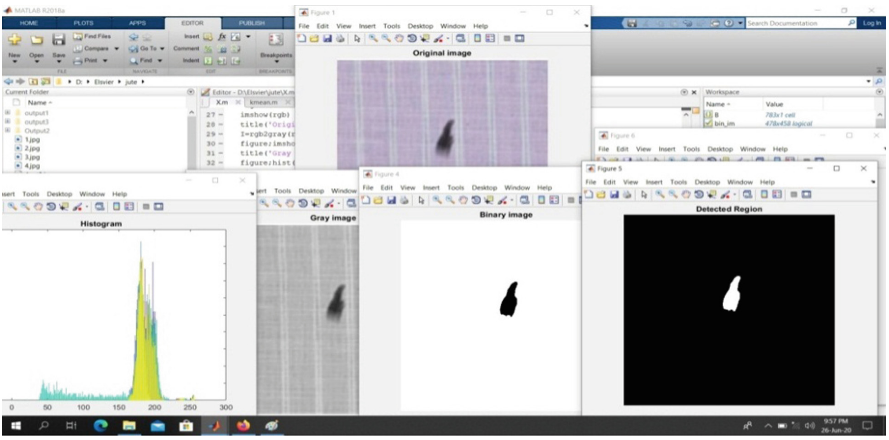

Fig. 7. MATLAB environment for defect detection

Table 2. Comparison of neural network-based classification models

Article	Accuracy	Comment
[21]	82.97%	
[22]	78.4%	
[23]	85.57%	
[24]	77%	
[25]	84%	
[26]	85.9%	
[27]	76.5%	
[28]	67.11%	
[29]	65.2%	
[30]	71.34%	
[31]	69.1%	
Developed system	97.21%	Greatest accuracy among all developed systems

As compared to the other techniques our methodology provides better accuracy as shown in Table 2.

Experiments are worked on TILDA database [33] and give better result in terms of 100% detection rate for the training set and 97.21% accuracy for the test set.

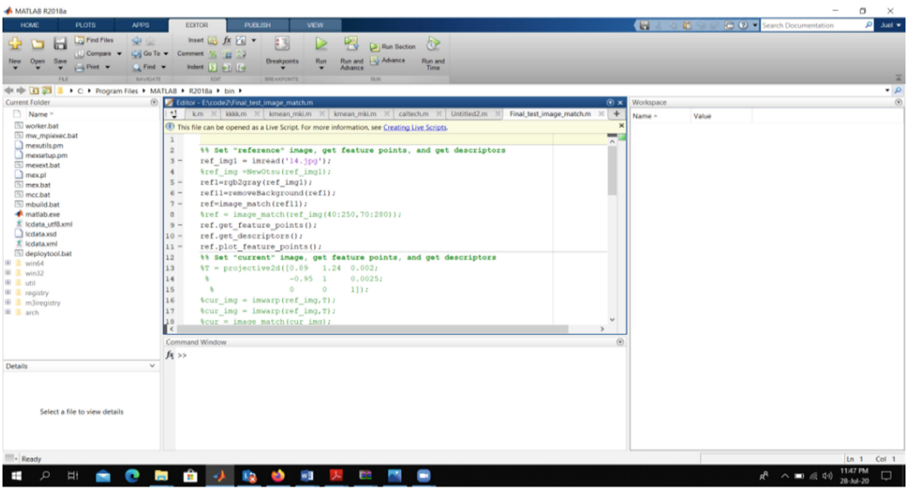

Fig. 8. System snapshot

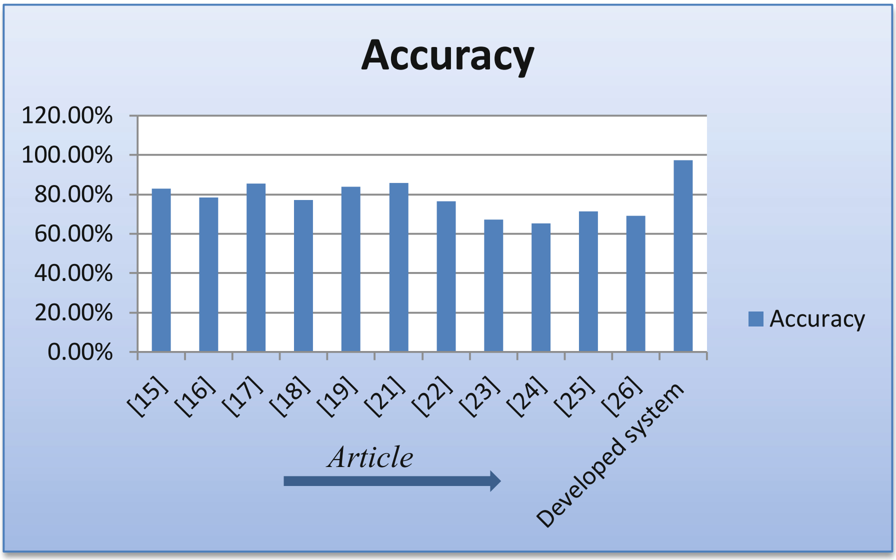

Fig. 9. Performance comparison of different studies

The proposed methodology feature extraction technique as compared to the other discussed methodology feature extraction techniques using machine learning algorithms gives better accuracy as shown in Fig. 9.

5 Conclusion and Future Work

The detection of faulty fabrics plays an important role in the success of any fabric industry. The fabric industry needs a real-time quality control to find defects quickly and efficiently. Manual control is inefficient and time-consuming that leads to heavy loss. On the other hand, automatic quality control is considerably more proficient, in light of the fact that it is a real-time and autonomous compared to manual productivity. Till now all the fabric detection systems suggested by all the researchers, the accuracy rate for detecting defective fabric is very low. However, this paper analyzed the shortcomings of the traditional approach for fabric defect detection, and proposed an innovative fabric defect detection technique based on a FAST (Features from Accelerated Segment Test) extractors and PCA (Principal Component Analysis) combined with a neural network classification, to enhance the recognition accuracy rate that texture fabrics cannot be effectively detected by present existing techniques. The paper concludes that the proposed fabric defect detection technique gave better accuracy after applied the machine learning algorithm and PCA in comparison to the other referenced approaches. Additionally, our method notably showed its efficiency in separating defect-free from defective areas of the fabric. Moreover, after a series of improvements, our method exhibited better recognition performance for the fabric images. Having successfully trained the neural network, 30 samples of each type of defect were used to assess the accuracy of the network classification. The defective images were then graded with a 97.21% overall accuracy score. With a 100% accuracy score, the dye spot defect was identified. The experimentation has been applied to the real images of the TILDA database dataset. The implementation has been done in MATLAB software as shown in Fig. 7 and Fig. 8. It automatically detects the fabric defect.

In the future, we will focus on sensor data-oriented systems and developing an optimal system to match more accurately with a real system for fabric defect detection as well as applying our machine learning algorithms for other different feature extractors.

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