FABRIC DEFECT DETECTION USING VARIANCE AND INTENSITY ANALYSIS

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ABSTRACT: *The purpose of this paper is to design a fabric defect detection system using image processing techniques. Fabric defect inspection is one of the most important processes to discard the inferior quality fabrics during the manufacture of fabric and garment in textile industry. Currently, in Sri Lankan textile industries the inspection process is carried out manually by humans and therefore subjective and prone to human error. Also, there are many other drawbacks such as tiredness, boredom and inattentiveness which cause to reduce the efficiency of industrial process. Because of this, the process has been automated with new computer technologies as an effective alternative to increase the quality of fabric.*

In this paper, variance analysis and intensity analysis has been used as the preceding step to identify the defects in the fabric. Because the defect-free fabric has uniformity in the structure, the occurrence of a defect in the fabric alters the regular structure. Therefore, the fabric defects can be predetermined by analyzing the parameters such as variance and intensity. To improve the efficiency of the technique and to overcome the problem of detection errors, further thresholding, noise removal, morphological operations and connected components analysis were carried out. To verify the success of the technique, it is implemented on plain fabric samples with different colors containing five common defect types such as hole, missed yarn, pin hole, knitting fault, oil mark. Eventually, based on the methodologies employed in this paper, it provides a promising stage for the development of an automated fabric defect detection system. This fabric fault detection system was designed and implemented using high level programming language MATLAB.

Keywords: Regular structure, Thresholding, Morphological operation

1. INTRODUCTION:

The textile industry is a most important and rapidly growing sector that makes a considerable impact to the economical state of Sri Lanka. Quality is a major parameter in textile, thus good quality products increase the profit of the industry as well as the customer satisfaction. If the defects in the fabric are not detected properly significant financial loses can be occurred. Hence, the fabric inspection process should carry out vigilantly. The key issue, therefore, is how and under what circumstances fabric inspection will lead to quality improvement. As a result, the automated fabric inspection systems have been designed to improve the efficiency of the inspection process. Until, recently, the fabric inspection is still undertaken manually by skilled staff with a maximum accuracy of only 60%-75% [2, 19]. The modern fabric manufacturing industry faces a lot of challenges due to high productivity as well as high quality manufacturing environment. Because the production speeds are faster than ever and because of the increase in roll sizes, manufacturers must be capable of identifying defects, locating the sources of defects, and making the necessary corrections in less time so as to lessen the amount of low-quality fabric [2]. This in turn places a greater strain on the inspection departments of the manufacturers. Due to the factors such as tiredness, boredom and carelessness, the staff performance is

often unreliable. Therefore, the best reliable evaluation is through the application of an automated inspection system.

From the early beginning, the target is to achieve optimum potential benefits such as high quality, low cost, comfort, accuracy and speed in the manufacturing process. As the technology is revolutionized the fabric inspection process has been developed from manual to automated machinery to help achieve all those benefits in the manufacturing process. The application of automated fabric inspection would seem to offer a number of advantages, such as improved quality, reduced labor costs, the elimination of human errors and increase the profit of the industry. Therefore, the automated visual inspection is gaining progressive importance in fabric manufacturing industry. An automated inspection system usually consists of a computer-based vision system. Because they are computer-based, these systems do not undergo the drawbacks of human visual inspection. The application of digital image processing is useful in textile manufacturing and inspection. In recent years, it has proven to be the most promising, rapid and reliable solution for the development of automated fabric inspection systems. Considerable efforts have been taken to develop and/or improve the task of automated fabric inspection systems. As all fabric has the periodic regular structure, analyzing the parameters such as variance, intensity of the fabric presents a possible way to predetermine the occurrence of defects in the fabric.

The described method in this paper represents an effective and accurate approach to automatic defect detection. It is capable of identifying various types of defects by monitoring the fabric structure. Presence of a defect over the periodical structure of a fabric causes changes in the variance and intensity parameters of the fabric. By thresholding the defected area to create a binary image, it is possible to identify the exact location of the defect. Further, for accurate detection of the defects the noise removal, morphological erosion and dilation, connected component analysis are carried out.

The fabric defect could be simply defined as a change in or on the fabric construction. Fabric defects can occur due to machine faults, color bleeding, yarn problems, scratch, poor finishing, dirt spots, excessive stretching, and crack points [1]. Because of the wide variety of defects, it will be useful to apply the study on the most major fabric defects. The chosen major fabric defects are: hole, missed-yarn, oil mark, knitting fault and pin holes.

A fabric fault detection system designed with MATLAB is used for this procedure. It is implemented on the above-mentioned chosen fabric defects as well as the defect-free samples to identify as defect or non-defect. To verify the success of the defects it is implemented on one hundred and fifty samples.

Fabric inspection or defect detection is a process of identifying and locating defects in fabric. A fabric defect is a result of the manufacturing process. The textile industry is very concerned with quality. It is desirable to produce the highest quality goods in the shortest period of time possible. Fabric quality inspection process is very important for manufacturing industry.

Figure 3.1 Manual fabric inspection system

Mainly, fabric defect detection uses two type of inspection model. The first one is the Human based Inspection Systems (HIS). The second system is Automated based Inspection Systems (AIS).

In modern textile industry, fabrics are manufactured in complex forms with high quality and high production line. Thus, the inspection process becomes more difficult and complicated. Therefore, industrial fabric inspection process has extremely high requirements.

Traditionally, Human based inspection systems are based on human. This process is performed by well-trained human inspectors. Usually, after the produced fabric is doffed from the weaving machine, it is batched into large rolls and sent to the inspection department. Most industries have power driven fabric inspection machines where the manufactured fabric rolls are unrolled on an inspection table (under adequate light) at a relatively higher speed of 8-20 meters per minute [3]. When a defect is found on the moving fabric, the inspector stops the machine to record the defect and its location, and starts the motor again. For each inspected fabric roll, the number of defects per meter length is calculated and the fabric is classified. Extra ordinary defect rate or repeating defects are informed to the production department so that appropriate actions can be taken to reduce the defect rate.

While, modern fabric industries demonstrate a high productivity and high-quality manufacturing environment, human based inspection systems have no ability to satisfy today's requirements due to limitations based on the physiological nature of human. Therefore, Human based inspection systems (HIS) suffers from many drawbacks described as follows:

1) Training phase takes much long time to be a skilled inspector.
2) The continue inspection becomes difficult and inefficient due to limitations in human behavior such as boredom and tiresomeness.
3) Human perceiving speed is slower when compared to machines hence the process takes longer time.

4) The human based inspection system could never reach 100% of defect detection accuracy.
5) The inspector sometimes not capable of identifying the level of defects that is acceptable.
6) The low fabric inspection is not compatible with high speed production line.
7) Human inspectors have to deal with extensive variety of defects.
8) Human based inspection systems are limited in finding defects and hence cause to reduce the profit of the fabrics.

As a result of these drawbacks several attempts are made to replace the manual inspection systems by automated systems to increase the accuracy and efficiency of the process by increasing the quality level of fabrics.

The shortcomings such as low profit, low accuracy and very slow performance of manual fabric inspection process have led to the necessity of automated inspection systems. Many researches are carried out in recent years to develop automated inspection systems with high accuracy, stability and speed with respect to manual inspection systems. Beside this, automated inspection systems are provided high defect detection rates, reduce labor costs, improve product quality and increase manufacturing efficiency.

The automated inspection systems are generally consisting of four phases: image acquisition, image pre-processing, feature extraction and decision making. All the phases in the system need to work in the best way to achieve the accurate and effective inspection software.

The main detriments of existing inspection systems are the high cost for hardware and software development, vast computational efforts are required, and the defect detection ranges are limited. So, the researchers aim to design systems with minimal cost. The developments in fabric inspection system software facilitate for better extraction of defects and patterns.

This research aims to design useful and high detection rate automated fabric inspection system software using digital image processing techniques. The use of advanced image processing techniques is proposed, including image segmentation and feature extraction, which would effectively detect a variety of defects in textile fabrics. The improvement of this study is to analyze the parameters such as variance and intensity in the fabric for better extraction of features. Although similar methods have been proposed in recent years to detect defects, many problems remain to be solved for practical implementation. Hence, the study involves the following principle objectives:

1) Improving the fabric quality level by detecting several types of defects as well as the non-defect patterns.

2) To design a high detection rate system with high detection speed to reduce the cost and meet's the manufacturer's needs.
3) Elimination of human drawbacks in manual inspection process.
4) Increasing the manufacturers' credibility.
5) Identifying and optimizing the main parameters which effect on defect detection process.

The economic benefit of this research is to minimize the total cost in fabric and garment manufacturing by reducing dismissals due to defects in fabrics. Indeed, the knowledge gained from this project can also be applied to solve similar kind of quality control problems for other industries as well.
The rest of the paper is organized as follows. Next section the theory and the methodology used for the research was discussed. Section three briefly presents the results including new algorithmic results and the paper ends up with the conclusion.

2. METHODOLOGY

Most defects in fabric occur while it is woven on the loom. The few defects are shown in, figures (2.1), illustrate the defects described.

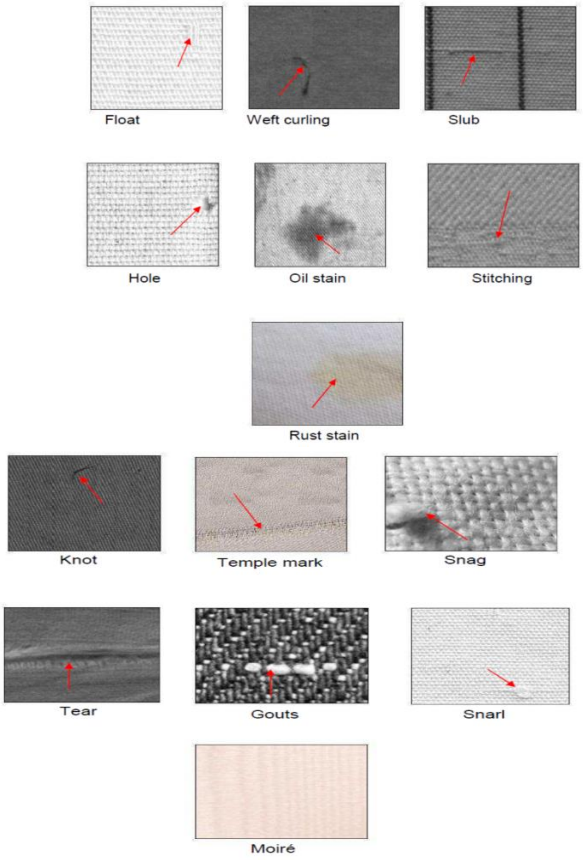

Figure 2.1 Common types of fabric defects

Currently, there are a number of defect detection approaches are used for defect identification. Due to the sophisticated and unpredictable variations in the fabric

patterns, it is harder to find a global method for fabric defect detection. And it is harder to find out most efficient classification method for fabric defect detection. Hence, it is desirable to have a generalized system for automated fabric defection. In this research, the task of fabric inspection is texture segmentation and identification problem and therefore, fabric defects can be detected by monitoring its structure. By considering the periodic regular structure of the fabric the parameters such as variance and intensity are analyzed to detect the defects in which the defected area shows a high variance and low intensity values than the non-defected areas. The proposed system is simple, fast and has an optimized computational complexity.

To achieve the objectives of this research, the following tasks are carried out:

1. Acquisition of images with and without defects at different resolution levels.
2. Development of a suitable procedure using a software package (Matlab) to implement the proposed technique

3. Test and verify the success of the technique using real plain fabric samples containing the same simulated defects.

Intensity Value

```
function output= intensity_value(matrix)
[R,C]=size(matrix);
for m = 1:R
for n = 1:C
P(m,n) = double(matrix(m,n));
end
end
output=P;
```

Variance Analysis

```
function output= variance_analysis(matrix,P,Q,L)
% PxQ=window size
% overlap of L
I=matrix;
[R,C]=size(I) ;
V = zeros(length(0:L:(R - 1 - P)),length(0:L:(C - 1 - Q))) ;
M = 0 ;
for m = 0:L:(R - 1 - P)
M = M + 1 ;
N = 0 ;
for n = 0:L:(C - 1 - Q)
N = N + 1 ;
B = double(I(m+(1:P),n+(1:Q))) ;
V(M,N) = std(B(:))^2;
end
end
output=V;
output=P;
```

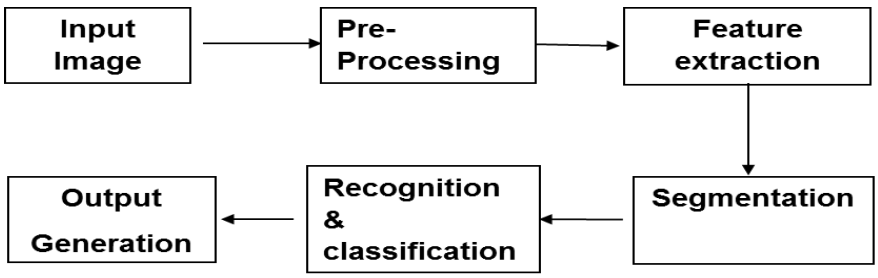

Figure 2.2 Architecture of the proposed system

In order to accomplish this task, it is required a specific software was implemented for this task using MATLAB programming language. Image processing toolbox is used to image preprocessing, segmentation, noise removal, morphological operations and connected components analysis. The design of the classification procedure of the defects was based on the ranges of values obtained from variance and intensity analysis. Initially, five types of common fabric defects and non-defect fabrics were selected for this system. Fabric samples are be satin, terrain and poplin. The proposed system identifies and classifies the selected five types of common defects as well as non-defected fabrics.

The main interface provides facility to load the image into the system and run the system. After running the system, the output is generated as non-defected or defected with defect type.

Based on the analysis carried out in the Analysis phase, the final design of the system was worked out.

3. RESULT AND DISCUSSION

The fabric defect detection method is evaluated through the developed prototype which is described in the chapter of theory and methodology. The selected samples with JPEG format were uploaded to the system for further processing of identifying defects. In this research work, five types of common defect types and defect-free samples were selected. As pre-processing step, the color images were converted into gray scale images and further processing of identifying defects was done on that gray scale images.

It is found that the proposed automated fabric inspection prototype is capable of identifying the existing fabric defects such as hole, missed yarn, pin hole, knitting fault and oil mark.

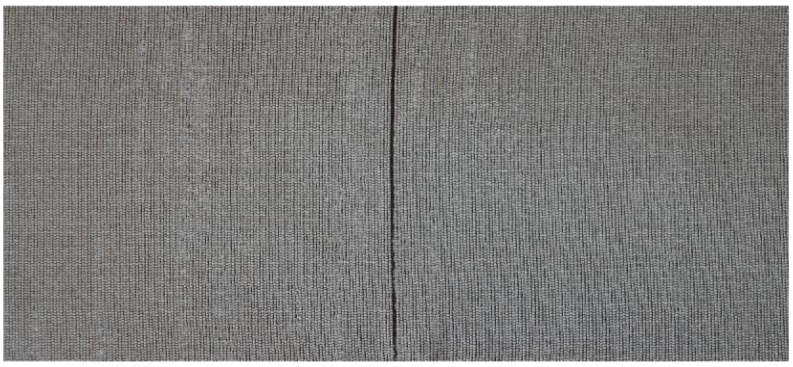

Figure 3.1 Sample RGB image (defect type : missed yarn)

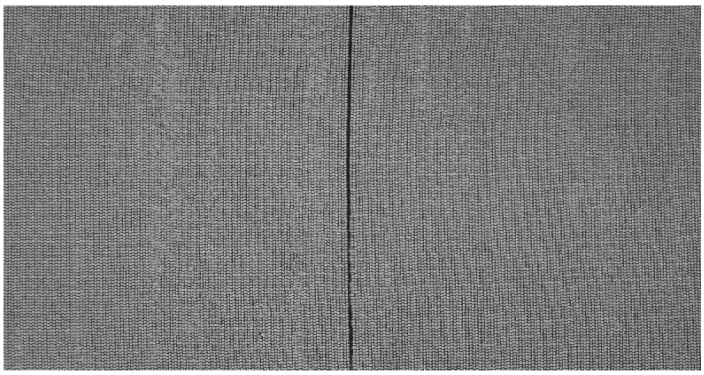

Figure 3.2 Gray scale image

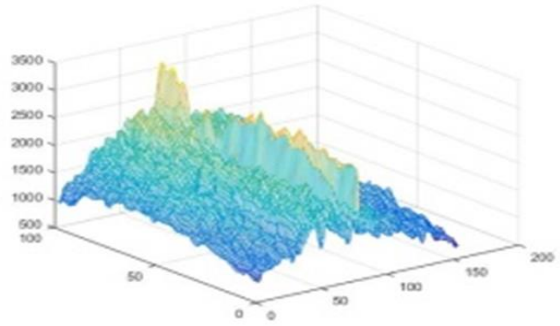

Figure 3.3 Surface plot of variance

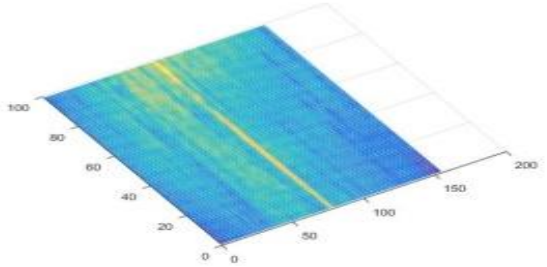

Figure 3.4 Top view of the surface plot

Figure 3.5 Output obtained from thresholding step

Figure 3.6 Output obtained from noise removal step

Figure 3.7 Output obtained from morphological erosion

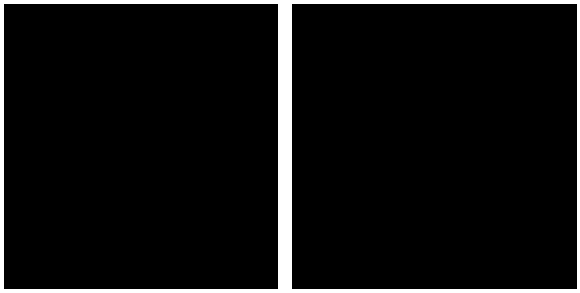

Figure 3.8 Output obtained from morphological dilation

All over the proposed method was used to test 150 samples including above mentioned five defect types and non-defect samples. The accuracy obtained is 81.33%. In this study, an automated fabric defect detection system using digital image processing has been proposed. In experimental work five types of common fabric defects such as hole, missed yarn, knitting fault, oil mark and pin hole were identified and classified. One hundred and fifty defected and non-defected fabric samples were tested and obtained 81.33% accuracy of the system. When examining the samples that are not accurately diagnosed it was realized that the lighting of the images are non-uniform. The proposed system is successful in identifying the exact location of defects. When variance and intensity analysis is carried out it shows an alteration in the defected area over the uniform regular structure and by defining threshold values separately for each defect type the binary image is created isolating the exact location of the fabric defect. Then the steps such as noise removal, morphological operations were implemented for better extraction of the defected area. The connected component analysis step counts the number of objects in the sample image and accurately identifies the fabric as defected or non-defected. For classification process, the ranges of values obtained from variance and intensity analysis are perfectly suitable and provides an accurate detection of defect types.

4. CONCLUSION AND FUTURE WORK

As the modern textile industries faces lot of challenges due to high productivity and high-quality fabric manufacturing environment the manual inspection process has become inefficient and the necessity for automated fabric inspection systems are growing day by day. Therefore, various researches are going on to develop a system that will increase the fabric quality level. Fabrics are formed by thread groups that periodically woven. But the easily affected structure of fabrics is the reason of distortions that occur on fabric patterns. The designed method used variance and intensity analysis along with digital image processing techniques to implementing and detecting these distortions. As the fabric patterns are complex and have changeable structure,

analyzing variance and intensity parameters aid to identify the exact location of the defect in the fabric. In final step of the methodology, the detected defects were classified into groups. This part was implemented so as to help the inspector to define the type of defects easily. In general, it can be said that the proposed system is successful with showing the accuracy of 81.33%. This study explained an effective automated fabric inspection technique which was applied on plain fabric using digital image processing techniques. Meanwhile, there are some essential aspects where the method's performance can be enhanced. Therefore, the following points are proposed.

1. Develop the system to identify and classify more number of common types of defects.
2. Improve the classification method using artificial neural network.
3. Improve the efficiency and accuracy of the overall system by optimizing the factors such as image resolution that affect the defect detection process.

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