Fault Identification and Classification in Textile Web Materials using Particle Analyzer

U.S. Ragupathy, B. Venkatesan and P.T. Sasikkannan

Abstract—Quality is the watchword of any type of business. A product without quality leads to loss and lack of customer satisfaction. This is true in case of textile industries also. Textile manufacturing is a process of converting various types of fibers into yarn, which in turn woven into fabric. Weaving process is used to produce the fabric or cloth by interlacing two distinct set of yarn threads namely warp yarn and weft yarn. In textile industries, quality inspection is one of the major problems for fabric manufacturers. Currently in textile industries manual inspection is carried out. The fabric obtained from the production machine are batched into larger rolls and subjected to the inspection frame. The nature of the work is very dull and repetitive. Due to manual inspection of the manufactured fabric, there is a possibility of human errors with high inspection time. This paper proposed a PC-based inspection system with benefits of high detection rate and low cost. Both normal and faulty images captured through the Charge Coupled Device (CCD) cameras, and considered as a samples to the Particle Analyzer. Proposed method is performing with the accuracy of 93.33% for the set of 40 images.

Keywords—Image Acquisition, Morphological Operations, Particle Analyzer, Pre-processing.

I. INTRODUCTION

The Indian textile production has a major impact on the world economy through millennia. At present fabric inspection depends on human sight, the result of inspection influenced by the physical and mental condition of inspector. Now, all the textile industries aim to produce good quality fabrics with high production rate. In the textile sector, there are huge losses due to faulty fabrics. The fabric is obtained by interweaving of warp and weft yarn. The faults found in the fabrics are around 80 - 85% of the defects in the garments industry. These faults are obtained in the fabrics due to irregular weaving of warp and weft yarn in the weaving process. Some of these fabric defects are visible, while others are not.

Again some fabric defects may be identified during weaving and some after weaving process. The manual inspection of fabric material is not economical and work is very dull. Hence, the investment in automated fabric defect detection is economic when reduction in labor cost and other benefits are considered.

The various fault detection approaches for textile web material is given in [1]. An automated defect detection and classification system enhances the product quality and results in increased productivity [2] and [3]. Improved gabor filters for textile detection results in less computational complexity as well as possibility of online implementation. Auto-correlation is used as a robust algorithm for patterned and un-patterned fabric defect detections [4]. In the fabric fault detection methodology, particle analyzer gives better results compared to other traditional methods. Particle analyzer constrains the analysis to a defined region using an Region of Interest (RoI) and defines a particle to consist of a minimum number of pixels. All the classifiers require training from the known classes of fabric defects. A large number of classes with large intra-class diversity remain as major problem in using Feed-Forward Neural Network (FFN) and Support Vector Machines (SVM) based inspection techniques [5] and [6]. By using PIC microcontroller, detection of fault is done by using Neural Network. The overall accuracy of the microcontroller based system is 76.33% [7].

On detail review of the above literatures, existing method is performing with lower accuracy and an idea about PC based fabric inspection method is proposed. The rest of the paper is organized as follows. The proposed methodology with its block diagram is given in section II. Section III deals with the Particle Analyzer. Results and discussion are presented in section IV. Conclusion is drawn in section V.

II. PROPOSED METHODOLOGY

The images of fabric material with different faults are captured and then processed. Images with No fault, Hole and Slub are considered for inspection. The proposed scheme tries to strengthen the fault detection rate. It consists of four major steps: Image Acquisition, Preprocessing, Morphological Operations and Particle Analyzer.

First web material images are captured using the CCD cameras through Embedded Vision System (EVS). The second step involves the conversion of RGB images in to gray scale images. The third step involves the Particle Analyzing.


**A. Image Acquisition**

There are two common types of scanning techniques employed for the fabric inspection cameras: line scanning and area scanning. The disadvantage with the line scan cameras is that they do not generate complete image at once and requires external hardware to build up images from multiple line scans [8]. For area scan cameras, the usage of transport encoders is optional and the inspection resolution in both directions is independent of web speed. In this paper, the camera having high resolution of 659×498 (H×V Pixels) with CCD sensor technology, which is capable of capturing the video with 71 frames/second is used. The pixel data from the camera is converted into a digitized image by the frame grabber. All web inspection systems used for fabric inspection, have to cope with the multiple camera inputs. Some systems does this by using some kind of video multiplexer unit between the camera and the frame grabber. A rather expensive way to cope with multiple cameras is to use one frame grabber unit per camera. IEEE 1394 FireWire cable is used for communication between camera and Vision system, and Ethernet cable is used for communication between the EVS and working station (PC).

**B. Preprocessing**

In the proposed scheme, the image obtained from CCD cameras are preprocessed and analyzed for fault detection and classification. During preprocessing, the fabric color images are converted into gray scale images. The converted gray scale images are subjected to thresholding. The thresholded images are the binary images, which are characterized by the particle analyser.

**C. Morphological Operations**

Mathematical morphology operations are based on the mathematical concepts of set theory. Mathematical morphology contributes a wide range of applications like edge detection, noise removal, image enhancement and image segmentation. In this work, morphological operations are carried out to eliminate the poor lighting.

![Fig.2 Morphological operated Images: (a) Original Image (b) Gray Scale Image (c) Gray Level Thresholded Image (d) Eroded Image](image)

Mathematical morphology is used to extract the RoI. Based on the experimental lighting setup, the gray converted web material images are thresholded with the value of 175. As the defects are greater in it sizes, small objects are eliminated with the help of morphological operations [9]. The circular structuring elements are more similar to the defects structure, hence 3x3 circular structure element is used for erosion to eliminate the poor lighting. Fig. 2 shows the different processing images with the dark object methodology.

The erosion of A by B is given in the equation 1.

\[ A \ominus B = \cap_{b \in B} A_{-b} \]  

(1)

**D. Particle Classifier**

Particle classifier is a method for characterizing the particles in a binary or gray-level image. It used the results of this analysis to identify specific objects in the image. The parameters used for particle classifier includes: number of pixels, number of holes, perimeter length, height, breadth, moment of inertia, rotation and translation, and shape equivalence. The parameters chosen will analyze and identifies an object even if it is scaled, translated, or rotated with respect to the samples [10].
III. PARTICLE ANALYZER

Particle Analyzer is used for the inspection of web materials by defining feature descriptor to represent the different classes in specifics. Particle Analyzer operates on binary image using the Image Analyze Particles. A particle in the binary image consists of one or more pixels with the values marked as zero.

![Block Diagram of Textile Web Material Classification using LabVIEW](image)

Fig.3 Block Diagram of Textile Web Material Classification using LabVIEW

![Front Panel of Textile Web Material Classification using LabVIEW](image)

Fig.4 Front Panel of Textile Web Material Classification using LabVIEW

Based on RoI, the particle is subjected to have maximum number of pixels. In this paper, erosion is done to fit the particles by filling the small objects with reference to the sample faults center, major and minor axes. Particle Analyzer is used to define the total number of particles as well as area, perimeters and so. The Statistics of the different gray scale distribution in an image is considered for the particle classifier. Fig.3 and Fig.4 shows the block diagram and the front panel of the textile web material classification using LabVIEW respectively.

Classification score and Identification score are the two parameters which are considered for the classification of different classes. For all the classes, scoring range is fixed as 0 – 1000 units. Classes are defined by considering the values of Classification score and Identification score. Classification score is the degree of certainty that a sample is assigned to one class compared with another classes. Classification score indicates how much better the assigned class can represent the input sample than the other classes represent the input. Identification score indicates the degree of similarity between the sample and samples in the class to which the sample is assigned. Identification score comes in to act only when the classification score is unable to categorize the class of the sample.

IV. RESULTS AND DISCUSSION

In this work, 40 images are considered: 10 fault free and 30 faulty images. Results are compared with the existing systems for the validation. The experiment is conducted in two phases: Training and Testing.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Classification Score</th>
<th>Identification Score</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
<td>1000</td>
<td>Normal</td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
<td>1000</td>
<td>Normal</td>
</tr>
<tr>
<td>3</td>
<td>1000</td>
<td>1000</td>
<td>Normal</td>
</tr>
<tr>
<td>4</td>
<td>1000</td>
<td>1000</td>
<td>Normal</td>
</tr>
<tr>
<td>5</td>
<td>1000</td>
<td>1000</td>
<td>Normal</td>
</tr>
<tr>
<td>6</td>
<td>810.72</td>
<td>885.58</td>
<td>Hole</td>
</tr>
<tr>
<td>7</td>
<td>378.55</td>
<td>659.33</td>
<td>Hole</td>
</tr>
<tr>
<td>8</td>
<td>278.83</td>
<td>634.72</td>
<td>Hole</td>
</tr>
<tr>
<td>9</td>
<td>815.66</td>
<td>901.83</td>
<td>Hole</td>
</tr>
<tr>
<td>10</td>
<td>787.48</td>
<td>891.52</td>
<td>Hole</td>
</tr>
<tr>
<td>11</td>
<td>724.05</td>
<td>649.13</td>
<td>Slub</td>
</tr>
<tr>
<td>12</td>
<td>575.56</td>
<td>570.4</td>
<td>Slub</td>
</tr>
<tr>
<td>13</td>
<td>669.39</td>
<td>549.41</td>
<td>Slub</td>
</tr>
<tr>
<td>14</td>
<td>612.83</td>
<td>459.49</td>
<td>Slub</td>
</tr>
<tr>
<td>15</td>
<td>625.79</td>
<td>490.28</td>
<td>Slub</td>
</tr>
</tbody>
</table>

Table I shows the resultant values of the Classification score and Identification score for 15 samples. While considering the sample 8, Classification score is 278.83 which is not more sufficient to find the class of the sample. So Identification score also considered and class is defined.

<table>
<thead>
<tr>
<th>Inspection Method</th>
<th>No. of Fabric Images</th>
<th>No. of Faulty Image</th>
<th>No. of Images Identified as Faulty</th>
<th>No. of Fault Classified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Inspection</td>
<td>40</td>
<td>30</td>
<td>29</td>
<td>28</td>
</tr>
<tr>
<td>Microcontroller based automatic Inspection</td>
<td>40</td>
<td>30</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>Proposed Inspection Methodology</td>
<td>40</td>
<td>30</td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>

TABLE II

Fault Identification and Classification Results for Textile Web Material Images
The existing microcontroller based fabric inspection and manual inspection are compared with the Particle Analyzer. Results are shown in the Table II. It is observed that the proposed method performing like the manual inspection as well as performed 33.33% better than the existing micro controller based fabric fault inspection system for the set of 40 images with 30 faulty images and 10 fault free images.

![Graph showing comparison between manual and proposed methods](image)

**Fig.5 Comparison of Fault Identification and Classification between the Existing and Proposed Method**

The comparison of Existing and Proposed method for Fault Identification and Fault Classification is shown in Fig. 5. From the figure, it is observed that the proposed inspection method is performing better than the existing micro controller based automatic inspection system with neural network classifier and the manual inspection method.

V. CONCLUSION

In this paper computer aided fabric fault detection is implemented. Particle Analyzer is performing like the manual Inspection. PC-based approach is time consuming and efficient while compare with the manual inspection and micro controller based inspection methods. As a future scope, more number of samples can be examined and the processing can be done by simultaneous capturing of the image.

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REFERENCES


