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Fabric defect inspection system using neural network

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Abstract
In a Least Developed Country (LDC) like Bangladesh where the textile is the main core of the economy, there is a major drawback in this sector which is the defect detection of the fabric. In the manual fault detection system with highly trained inspectors, very less percentage of the defects is being detected in upon fabrics in the textile industries. But a real time automatic system can increase this percentage in a maximum number. This research implements a textile defect detector which uses computer vision methodology with the help of neural networks to identify the classification of textile defects.

Keywords: Fabric Fault Processing, MATLAB, Image Processing, Neural Network

1. Introduction

Fabric defect detection is an important part of quality control in the textile industry. Usual methods of fabric inspection on the production line is done essentially by the worker on the circular knitting machine by introducing a light source in the middle of the circular product which enables the worker to detect the produced defects, and then stop the machine immediately. Stress and fatigue happens to the worker due to inspection in case of higher and quicker productivity. However, the method has been both time consuming and has lower accuracy of detection. Defect detection or inspection is a process identifying and locating defects. 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 [1].

Quality inspection is an important aspect of industrial manufacturing. In textile industry, fabric defect detection plays an important role in the quality control. The quality of the fabric can be improved by decreasing defects in the fabrics [2].

Automated visual inspection systems are much needed in the textile industry, especially when the quality control of products in textile industry is a significant problem [3, 4]. In the manual fault detection systems with trained inspectors, very less percentage of the defects are being detected while a real time automatic system can increase this to a maximum number [5]. Thus, automated visual inspection systems play a great role in assessing the quality of textile fabrics. Texture analysis refers to the characterization of regions in an image by their texture content [6]. Texture analysis attempts to quantify intuitive qualities described by terms such as rough, smooth, silky, or bumpy as a function of the spatial variation in pixel intensities [7, 8]. In this sense, the roughness or bumpiness refers to variations in the intensity values, or gray levels.

2. Fabric Defects

Fabric texture refers to the feel of the fabric. It is rough, velvety, smooth, soft, silky, lustrous etc. The different textures of the fabric depend upon the types of weaves used. Textures are given to all types of fabrics, cotton, silk, wool, leather, and also to linen. Textile Fabric materials are used to prepare different categories and types of Fabric products in the textile industry. Natural fabric and synthetic fabric are the two different classifications of textile fabric. Synthetic fabrics are fairly new and have evolved with the continuous growth in textile industry [1, 9].

In a fabric, defects can occur due to:

- Machine faults
- Hole
- Color bleeding
- Yarn problems
- Scratch
- Poor finishing

- Dirt spot
- Excessive stretching
- Crack point

3. Brief Literature Survey

In general, fabric analysis is performed on the basis of digital images of the fabric. Alternatively, there are some works (Ciamberlini *et al*. [1]) based on the optical Fourier transform directly obtained from the fabric with optical devices and a laser beam. Digital image processing techniques have been increasingly applied to textured samples analysis over the last ten years. Several authors have considered defect detection on textile materials. Kang *et al*. [5, 6] analyzed fabric samples from the images obtained from transmission and reflection of light to determine its interlacing pattern. Tsai and Hu [3] used Fourier transforms of solid plane fabric images as the inputs to an artificial neural network for fabric defect detection. They trained the neural network to identify four types of defects: missing pick, missing end, oil fabric stains and broken fabric. In a recent paper, Hu and Tsai [9] have also used wavelet packet bases and an artificial neural network for the stated goals. Wavelets had been previously applied to fabric analysis by Jasper *et al*. [1, 5]. Escofet *et al*. [3, 4] have applied Gabor filters (wavelets) to the automatic segmentation of defects on non solid fabric images for a wide variety of interlacing patterns. In the following sections we revise part of this work. Defects can be classified as local or global. Global defects because an overall distortion of the basic structure of the fabric and can be detected by means of Fourier analysis. Local defects only affect a small area of the image of the fabric under inspection. The performance of the Fourier transform based techniques for defect detection is illustrated by two examples, one corresponding to a global defect, the second representing a local defect.

4. Image Processing

An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. When x, y, and the amplitude values of f are all finite, discrete quantities, we call the image a digital image. The field of digital image processing refers to processing digital images by means of a digital computer. Note that a digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as picture elements, image elements, pels, or pixels. Pixel is the term most widely used to denote the elements of a digital image [5].

5. Artificial Neural Network

The Artificial Neural Networks (ANN) is inspired by the way biological nervous system works, such as brain processes an information. ANN mimics models of biological system, which uses numeric and associative processing. In two aspects, it resembles the human brain. It acquired knowledge from its environment through a learning process. Synaptic weights, used to store the acquired knowledge, which is interneuron connection strength. There are three classes of neural networks, namely single layer, multilayer feed forward networks and recurrent networks.

In this paper, multilayer feed forward network used in which the processing elements are arranged in three layers called input layer, hidden layer and output layer. During the training phase, the training data fed into to the input layer. The data is propagated to the hidden layer and then to the output layer. This is called as the forward pass of the back propagation algorithm. In forward pass**,** each node in hidden layer gets input from all the nodes from input layer, which multiplied with appropriate weights and then summed. The output of the hidden node is the nonlinear transformation of the resulting sum. Similarly, each node in output layer gets input from all the nodes from hidden layer, which multiplied with appropriate weights and then summed. The output of this node is the non-linear transformation of the resulting sum.

The output values of the output layer compared with the target output values. The target output values are those that we attempt to teach our network. The error between actual output values and target output values is calculated and propagated back toward hidden layer. This is called as the backward pass of the back propagation algorithm. The error used to update the connection strengths between nodes, i.e. weight matrices between input-hidden layers and hidden-output layers updated. During the testing phase, no learning takes place i.e., weight matrices are not changed. Each test vector fed into the input layer. The feed forward of the testing data is similar to the feed forward of the training data. The back propagation algorithm used to calculate the gradient error function using chain rule of differentiation.

After the initial computation, the error propagated backward from the output units, so it is called as back propagation.

The algorithm for back propagation is as follows.

1. Apply feature vector x_n to artificial neural network and forward propagate through network using
   $a_j = \Sigma\, w_{ij}\, z_i$ and $z_i = h(a_i)$
2. Evaluate ∂_k for all output using
   $\partial_k = y_k\, t_k$
3. Back propagate the ∂s using
   $\partial_j = h'(a_j)\Sigma\, w_{kj}\, \partial_k$

to evaluate required derivative. The back propagation algorithm has higher learning accuracy and faster. Its aim is adapting the weights to minimize the mean square error.

6. Methodology

The system of digital image processing may be presented schematically as shown in below Figure 1. The following operations are carried out during image quality improvement:

1. Image Acquisition
2. RGB to Gray Color Conversion
3. Image Enhancement (Thresholding)
4. Defect Identification

Block Diagram of the Proposed System:

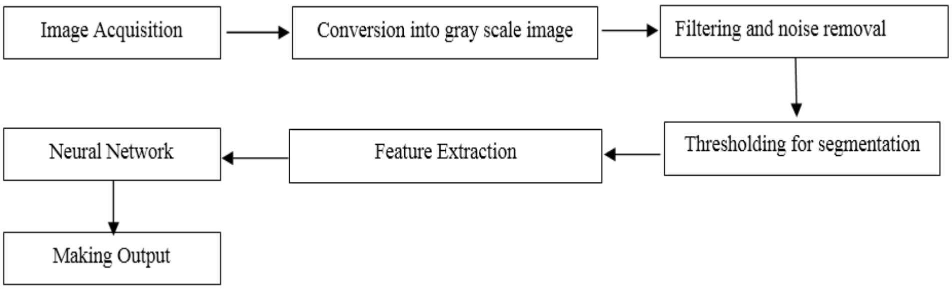

Fig 1: Block diagram of the textile defect inspection method

7. Algorithm

The algorithm has been implemented using MATLAB and is found to be reasonably fast and accurate than the existing computationally intensive methods. The results are promising even when it is applied to localize defects on images with varying lighting or exposure levels.

The proposed algorithm is divided into no. of steps discussed below:

1. **Image Acquisition:** Textile/fabric surface image is acquired by using the CCD camera from top of the surface from a distance adjusted so as to get the best possible view of the surface. Figures 2 show the quality of the acquired fabric images. The textile images under test are of size 256x256 (64KB). For proper imaging, uniform lighting system is to be maintained to avoid any illusive defect by virtue of light reflection properties falling on surface. Different Fabric/Textile Images Originally, the images are acquired at RGB color scale. The images then are converted to gray scale using rgb2gray function in MATLAB.

2. **Gray Scale Image**: The acquired RGB image is converted to gray scale image by using the rgb2gray command in MATLAB. A gray scale image (0 – 255gray shades) is obtained.

3. **Filtering and Noise Removal**: In this process image is filter and remove the noise before subjected to ANN.

4. **Image Thresholding:** The image after noise removal is brought under image into two colors i.e. we get a binary image with white as back ground and black as the object of interest. Segmentation algorithm is applied over the binary image to get the segmented patterns. Bwlabel command is used to segment the fabric image.

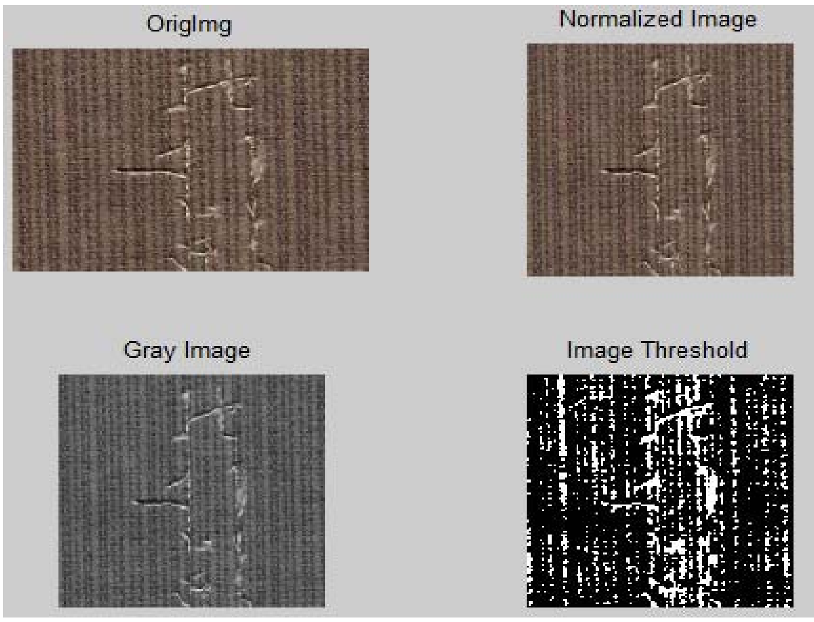

Fig 2: Preprocessing Showing Plots

5. **Feature Extraction:** The defective fabric images are classified automatically according to their texture features by using neural network. The texture features are assessed as the network input values and the defect classification is obtained as the output. A feature extraction algorithm is performed by using the discrete wavelet transform (DWT) method. The paper uses single-level two-dimensional wavelet decomposition with respect to particular wavelet called Symlet '*sym4*'. The method computes approximation coefficients and detailed coefficients of images. It extracts 6 geometrical features like mean, median, standard deviation, minimum, maximum, and variance for these approximation and detailed coefficients.

1) *Low Pass Approximation:* - Is a one or two dimensional wavelet analysis function.
2) *Horizontal Detail Image*: - For an Input Image the Horizontal Points of image are displayed in this portion.
3) *Vertical Detail Image*: - For an Input Image the Vertical Points of image are displayed in this portion.
4) *Diagonal Detail Image:* - For an Input Image the Diagonal Points of image are displayed in this portion.

6. **Training and Classification:** Before the recognition to be done, the Artificial Neural Network must be trained'so that the network gets a potential of mapping various inputs to their corresponding output, so that the system classify various characters. For training the Neural Networks, we have different feature vectors obtained from the database using the above feature extraction technique. The technique uses 6 different geometrical features to extract 48 parameters are fed into ANN.

Experimental Results

The inspection system captures fabric images by acquisition device (digital camera) and passes the image to the computer. Initially the inspection systems normalize the image.

The output layer is to produce target outputs as 1 for defect images and 0 for defect free images. From a set of 80 samples 52 samples of different characters are chosen to train the Neural Networks and the rest of the untrained samples are taken to test the Network. It shows a recognition rate of 87.5% for 2 class problem.

The figure below shows the performance of the system in Training, Testing, and Validation phases.

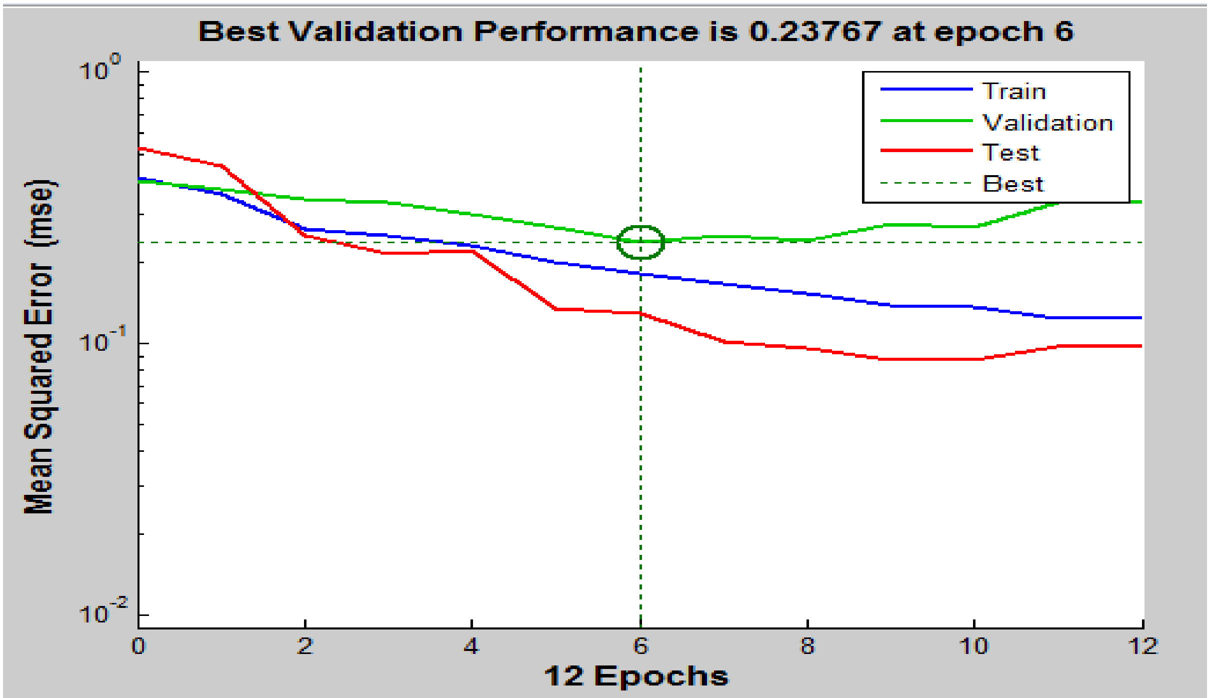

Fig 3: Performance Plot for System.

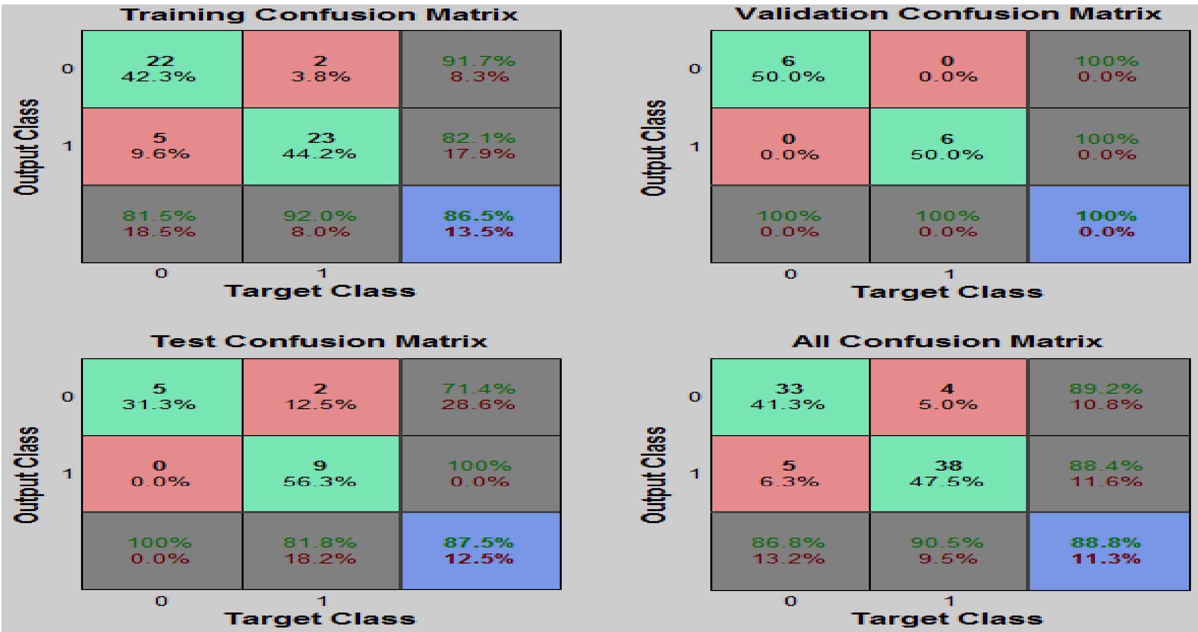

Fig 4: Confusion Matrix obtained for 2 Class Problem, recognition rate obtained 87.5%.

Conclusion

In this paper, we propose artificial neural network for patterned fabric inspection.

In this paper, a fabric defect identification system based on statistical features and back propagation was presented. Firstly images acquired, preprocessed and statistical features are extracted. The extracted features are input to BPN classifier for further matching process. We achieved total success rate of fabric identification is 87.5%. The results obtained by our proposed system indicate that a reliable computer based fabric inspection system for textile industries can be created and it can produce high accuracy than manual inspection system.

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