Plain Woven Fabric Defect Detection Based on Image Processing and Artificial Neural Networks

Dr.G.M.Nasira[1], P.Banumathi[2]

[1]Department of Computer Science, Chikkanna Govt. Arts College, Tirupur – 2, India

[2] Department of Computer Science and Engineering, Kathir College of Engineering, Coimbatore – 62, India

ABSTRACT : *Textile industry is one of the revenues generating industry to TamilNadu. The detection of defect in fabric is a major threat to textile industry. Woven fabrics are produced by weaving. Weaving is a process of interlacing two distinct yarns namely warps and weft. A fabric fault is any abnormality in the fabric that hinders its acceptability by the user. The price of the fabric is affected by the defects in fabric.At present, the fault detection is done manually after production of a sufficient amount of fabric. The nature of work is very dull and repetitive. There is a possibility of human errors with high inspection time in manual inspection, hence it is uneconomical. This paper proposed a computer based inspection system for identification of defects in the woven fabrics using image processing and Artificial Neural Network (ANN) with benefits of low cost and high detection rate. The inspection system first acquires high quality vibration free images of the fabric. Then the acquired images are first preprocessed and normalized using image processing techniques then the preprocessed image is converted into binary images. From the binary image first order statistical features are extracted and these extracted features are given to the input to the Artificial Neural Network (ANN) which uses back propagation algorithm to calculate the weighted factors and generates the output. The ANN is trained by using 115 defect free and defected images.*

Keywords: *Artificial Neural Network (ANN), Back Propagation Algorithm Fault Detection,, Feature Extraction. Image processing.*

I. INTRODUCTION

Quality control means conducting observations, tests and inspections so that making decisions which improve its performance. A fabric is a flat structure. Woven fabrics are produced by weaving, which is the textile art in which two distinct sets of yarns or threads – called the warp and weft – are interlaced with each other at right angles to form a fabric or cloth. The warp represents the threads placed in the fabric longitudinal direction, while the weft represents the threads placed in the width-wise direction. The weave pattern is periodically repeated throughout the whole fabric area with the exception of edges. The plain weave is the most made weave in the world, it is relatively inexpensive, easy to weave and easy to finish [1]. First quality fabric plays the main role to insure survival in a competitive marketplace in a weaving plant. This introduces stress on the weaving industry to work towards low cost first quality products as well as just in time delivery. Second quality fabric may contain a few major defects and/or minor several structural or surface defects [2]. Online system provides images from current production and is located directly on or in the production line, while offline system is located after the production line. Till now the fabric inspection is still undertaken offline and manually by skilled staff with a minimum accuracy. The dream of textile manufacturers is to achieve optimum potential benefits such as quality, cost, comfort, accuracy, precision and speed. Online inspection system requires very high resolution imaging to enable defects as small as a single missed thread, a fine hole or stain to be detected[3]. Plain fabric inspection systems still a challenge due to the variable nature of the weave.

The fabric defect is a change in or on the fabric construction. The weaving process may create a huge number of defects named as weaving defects. These defects appear in the longitudinal direction of the fabric (warp direction) or in the width direction (weft direction). Presence or absence of the yarn causes defects such as miss-ends or picks, end outs, and broken end or picks. Some defects are due to yarn defects and additional defects are due to machine related and appeared as structural failures[4].

Automatic fabric inspection systems are designed to increase the accuracy, consistency and speed of defect detection in fabric manufacturing process to reduce labor costs, improve product quality and increase manufacturing efficiency[6][7]. The operation of an automated fabric inspection system can be broken down into a sequence of processing stages. The stages are image acquisition and Preprocessing, feature extraction, training and decision.

II. IMAGE PREPROCESSING

The most important parameter used in the image acquisition is the resolution. The resolution of an image can be referred either by the size of one pixel or the number of pixels per inch. The lower the image resolution, the less information is saved and higher resolution means more information is saved but larger memory size is required to store[2]. The scanning of fabric images begins from 300 dpi resolution because human vision is approximately 300 dpi at maximum contrast. The scanned image is stored in 'tif' format and grayscale image. A flat scanner is used to capture various plain fabric samples containing different types of defects. Initially the resolution level is set to 300 dpi and then gradually increased by step of 100 dpi till 1200 dpi as a maximum resolution[3]. The image acquisition is performed by different types of camera like CCD (Charged Coupled Device), CMOS (Complementary Metal Oxide Semiconductor), digital camera etc., The images are stored in matrices of size 500x500 pixels.

After acquiring the image, the image is normalized using interpolation method. The normalized image is converted into binary image, and then from the binary image the features are extracted.

III. FEATURE EXTRACTION

The texture of an image region is described by the way the gray levels are distributed over the pixels in that region. The features are described the properties of an image region by exploiting space relations underlying the gray level distribution of a given image. Statistical approaches compute different properties. Based on the number of pixels defining the local features the statistical approach can be classifying as first-order (one pixel), second-order (two pixels) and higher-order (three or more pixels) statistics [3]. The difference between first-order and higher-order statistics is that first-order statistics estimate properties of individual pixels, and do not consider pixel neighborhood relationships, whereas second and higher-order statistics estimate properties of two or more pixel values occurring at specific locations relative to each other. Higher order statistics not considered for implementation due to interpretation difficulty and calculation time. The following first and second order statistics are consider among the available statistics as texture features in representing images.

2.1 First Order Statistics

First order statistics texture measures are calculated from the original image intensity values. They do not consider the relationship with neighborhood pixel. Features derived from this approach include moments such as mean, standard deviation, energy, entropy, skewness and kurtosis [8].

$$mean\ (\mu_1) = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} I(i,j)}{M\ x\ N} \qquad ---(1)$$

$$standard\ deviation\ (\sigma_1) = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N} (I(i,j)-\mu)^2}{M\ x\ N}} \qquad ---(2)$$

$$energy(e_1) = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} I^2(i,j) \qquad ---(3)$$

$$entropy = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} I(i,j) - \ln(I(i,j)) \qquad ---(4)$$

$$skewness = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} (I(i,j)-\mu)^3}{M\ x\ N\ x\ \sigma^3} \qquad ---(5)$$

$$kurtosis = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} I(i,j)-\mu)^4}{M\ x\ N\ x\ \sigma^4} \qquad ---(6)$$

IV. ARTIFICIAL NEURAL NETWORKS

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. 1. It acquired knowledge from its environment through a learning process. 2. 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 is 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 is fed into to the input layer. The data is propagated to the hidden layer and then to the output layer. This is called 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 are 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 are 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 are 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 the backward pass of the back propagation algorithm. The error is used to update the connection strengths between nodes, i.e. weight matrices between input-hidden layers and hidden-output layers are updated. During the testing phase, no learning takes place i.e., weight matrices are not changed. Each test vector is 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 is used to calculate the gradient error function using chain rule of differentiation. After the initial computation, the error is 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

$$a_j = \sum w_{ij} z_i \quad and \quad z_j = h(a_j) \qquad ---(11)$$

2. Evaluate ∂_k for all output using

$$\delta_k = y_k t_k \qquad ---(12)$$

3. Back propagate the ∂s using

$$\delta_j = h'(a_j) \sum w_{kj} \delta_k \qquad ---(13)$$

$$use \quad \frac{\partial E_n}{\partial w_{ji}} = \delta_j z_i \qquad ---(14)$$

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.

V. RESULTS AND DISCUSSIONS

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 using interpolation methods. The normalized image is filtered with adaptive median filtering. The number of connected components and their region property area with bounding box is calculated. Taking the value of area as threshold the image is converted into binary image. The first and second order statistics values are calculated from the binary image. These calculated statistics values are used as feature vector to the multilayer feed forward network. The input layer consists of 10 neurons, hidden layer consists of 20 neurons and output layer consists of 5 neurons. The fist neuron of output layer is for no defect, second neuron is for stain type fault, third neuron is for hole type fault, fourth neuron is for weft float type fault and fifth neuron is for warp float type fault. The neural network uses Log sigmoid algorithm as transfer function. Mean of sum of squares of the network weights and biases is used for performance function. The fabric has hole type fault, the target output of fault pattern is 1 and remaining patterns are 0. The output layer is to produce target outputs as [{1 0 0 0 0}, {0 1 0 0 0},{0 0 1 0 0},{0 0 0 1 0}, {0 0 0 0 1}].

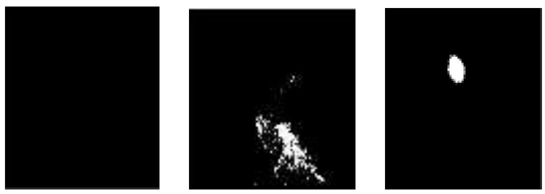
The performance of the system is evaluated by using 115 different fabric images. There are 25 defect free images and 40 images of each type of defect. The network is trained by more than 180 defect and defect free images. To identify the defect we consider 10 statistical properties given above. In each defect type 25 non defective and 40 defective samples are used for training and 12 images for testing.

(a) (b) (c)

Fig(1)-Plain Woven (a) Defect free image (b) Stain defect image (c) Hole defect image

(a) (b) (c)

Fig(1)-Plain Woven Normalized (a) Defect free image (b) Stain defect image (c) Hole defect image



(a) (b) (c)

Fig(1)-Plain Woven binary (a) Defect free image (b) Stain defect image (c) Hole defect image

Our system is successful 95% in identifying stain fault accurately, 98% in identifying hole fault accurately, 90% in identifying weft float fault accurately and 92% in identifying warp float fault accurately. The total performance of the system is 94.6% accurately in identifying all four types of faults. Artificial Neural network simulates the input set after calculating input set and identify defect of image as an actual output. Therefore, this system is simple and successfully minimizes inspection time, produces high accuracy than manual inspection system.

VI. CONCLUSION

In this paper, a new intelligent and a fabric defect inspection system based on texture feature and back propagation was presented. Firstly images acquired, preprocessed then GLCM is formed and texture features are extracted. The extracted features are input to BPN classifier for further matching process. Four types of fabric defects were identified. We achieved total success rate of fabric identification is 94.6%. The results obtained by our proposed system indicate that a reliable fabric inspection system for textile industries can be created.

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Biography

Dr. G. M. Nasira received M.C.A. and M.Phil degree in the year 1995 and 2002 respectively and the Doctorate degree from Mother Teresa Women's University, Kodaikanal in the year 2008. She is having around 15 years of teaching experience in College. Her area of interest includes Artificial Neural Networks, Fuzzy Logic, Genetic Algorithm, Simulation and Modelling. She has presented 38 technical papers in various Seminars / Conferences. She has presented 5 technical papers in International Conference. She has published 15 articles in International Journal. She is a member of Indian Society for Technical Education (ISTE).

P.Banumathi received BE, MCA, M.Phil and MBA in the year 1994, 2004, 2007 and 2008. She is having 13 Years of teaching experience and 5 years of Industrial experience. Her area of interest is Artificial Neural Networks and Image Processing. She has presented 15 technical papers in various Seminars / National Conferences. She has presented 3 technical papers in International Conference. She has published 5 articles in International Journal. She is a member of Indian Society for Technical Education (ISTE) and Computer Society of India (CSI).