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Image Processing and Artificial Neural Network techniques in Identifying Defects of Textile Products

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Abstract - This paper proposes an Artificial Neural Network based defect identifier for identifying defects in woven fabric images of the textile industry. Image processing is the upcoming technique to enhance raw images into meaningful information. Image processing is used in various applications where in textile industry is one of the main application area of it. Defects in fabric is a major threat to textile industry. A fabric defect is any abnormality in the fabric that hinders its acceptability by the user and hence the price of the fabric is affected. The defect detection which is done manually is cumbersome, not very accurate and time consuming. Hence automated defect identification system becomes essential in textile industries. A detailed literature survey reveals that a liitle attention has been paid to automatic defect identification in woven fabric images. Hence an attempt has been made using image processing and ANN techniques for defect identification in woven fabric images. A total of 200 woven fabric images are taken as samples, out of which 150 are used for training and 50 used for testing the network. These images are preprocessed and normalized using image processing techniques and converted into binary image by taking intensity value as threshold. Six statistical values namely mean, standard deviation, smoothness, energy, entropy and skewness are calculated from the binary image. An ANN structure which consists of (i) input layer having 6 neurons, (ii) one hidden layer having 5 neurons and(iii). Output layer having one neuron have been used. The training of the net is done using MATLAB 2012. The error percentage in identifying the defect images was less than 1%, which is well accepted.

Keywords - Artificial Neural Network (ANN), Defect Identification, Feature Extraction. Image processing, Levenberg-Marquardt algorithm, Statistical features.

I. INTRODUCTION

This paper describes the development of ANN based identifier for woven fabric images based on Image processing and ANN techniques. Image processing is one of the most important techniques in identifying defects out of which image acquisition and image preprocessing are used in our proposed system to enhance image features for further processing and analysis. Statistical features measures the spatial distribution of pixels, it is assumed that the defect free regions are stationary and these regions extend over a significant portion of defected images. Therefore, the statistical feature method is chosen to calculate statistical values in woven fabric images.

Artificial neural networks (ANNs) are networks of simple processing elements operating on their local data and communication with other elements. The design of ANNs was motivated by the structure of a real brain, but the processing elements and the architectures used in ANN have gone far from their biological inspiration. Each neuron in the network is able to receive input signals, to process them and to send an output signal. Each neuron is connected at least with one neuron, and each connection is evaluated by a real number, called the weight coefficient, that reflects the degree of importance of the given connection in the neural network.

A fabric is a flat structure, among the available fabrics woven fabrics 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. 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 periodically repeated throughout the whole fabric area with the exception of edges. The quality of the fabric is determined based on the non-defects. The fabrics with defects are identified as second or third quality fabrics. Presently defect identification carried out as visual identification, which leads to minimum accuracy with more time consumption. Plain woven fabric defect identification is been a challenging one to the textile industry, hence our investigation focuses on plain woven fabric defect identification. In this paper an ANN based fabric identification system is designed to increase the accuracy, consistency and speed of defect identification in the plain woven fabric manufacturing process to reduce labor costs, improve product quality and increase manufacturing efficiency. The operation of an ANN based identifier system can be broken down into a sequence of processing stages. The stages are image acquisition and Preprocessing, feature extraction, training and testing.

II. PROPOSED SYSTEM

In this paper, we focus only on plain woven fabric images with defect and defect free. Since human vision is approximately 300 dpi at maximum contrast The images were captures using digital camera ranges from 300 dpi to 1200 dpi resolution. We have identified that images of 512x512 size with 1000 dpi resolution are most suitable for our identifier which is evident from figure 1.

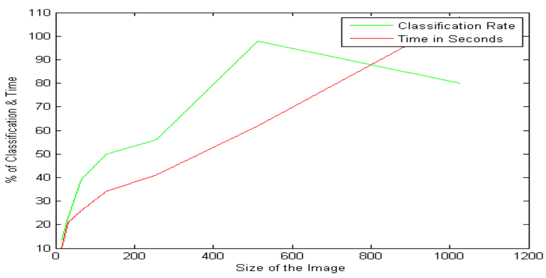

Figure 1 Detection rate and CPU time of 512x512 image

III. MPLEMENTATION OF IMAGE PROCESSING TECHNIQUES FOR THE PROPOSED SYSTEM

The image processing techniques which were used for our proposed system includes interpolation techniques, adaptive median filtering and feature extraction. These techniques are frequently used for plain woven fabrics which is evident from the various literature survey conducted by us.

3.1 Interpolation Technique

Interpolation technique is the process of estimating an image value at a location in between image pixels. Interpolation methods determine the value for an interpolated pixel by finding the point in the input image that corresponds to a pixel in the output image and then calculating the value of the output pixel by computing a weighted average of some set of pixels at that point. In our investigation the captured image resized into 512x512 image, by using bicubic interpolation technique which produces better results compared with the linear and cosine interpolation techniques,

3.2 Adaptive Median Filtering

A large number of methods have been proposed to remove impulse noise from digital images. The best-known order-statistics filter is the median filter, which replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel. In the present system we have used adaptive median filtering technique to remove noise because, it preserves edges and fine pixels when compared with the mean, min and max filtering techniques. The standard algorithm used for adaptive median filtering is as follows.

1. For each pixel location (i,j), initialize w = 3.
2. Compute $I_{i,j}^{min,w}$, $I_{i,j}^{med,w}$, $I_{i,j}^{max,w}$ which are the minimum, median and maximum of the pixel values in $I_{i,j}^{w}$ respectively.
3. If $I_{i,j}^{min,w} < I_{i,j}^{med,w} < I_{i,j}^{max,w}$, then go to step 5. Otherwise set w = w + 2
4. If $w \leq w_{max}$ go to step 2. Otherwise we replace $P_{i,j}$ by $I_{i,j}^{med,w}{}_{max}$
5. If $I_{i,j}^{min,w}{}_{max} < P_{i,j} < I_{i,j}^{max,w}{}_{max}$, then $P_{i,j}$ is not a noise pixel, we rep[lace by $I_{i,j}^{med,w}$

3.3 Feature Extraction

A statistical feature of an image represents different properties, which are classified based on the number of pixels. In our research, we have used first order statistics, which estimates the properties of individual pixels. In our system six statistical values such as mean, standard deviation, energy, entropy, skewness and kurtosis are calculated to train our ANN that produces high detection rate with minimum time, which is listed in the table 1. The formulas for the above mentioned statistical values are

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

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

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

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

$$skewness = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(I(i,j)-\mu)^3}{M\ x\ N\ x\ \sigma^2} \qquad ---(5)$$

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

Sr.No.	No. of features	% of Detection	CPU time
1	5	98.7	642.0625
2	6	99.0	620.0938
3	7	98.6	625.4063
4	8	98.6	636.7031
5	9	96	615.2813

Table 1 : No. of Features with detection rate and CPU time

IV. ARTIFICIAL NEURAL NETWORKS

In this paper, a 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. The Levenberg-Marquardt(LM) algorithm has emerged as the most widely used and successful for designing multi layer feed forward supervised learning.

An approximated Hessian matrix J^TJ is invertible, Levenberg–Marquardt algorithm introduces another approximation to Hessian matrix: $H \approx J^TJ + \mu I$ --- (7) where μ is always positive, called combination coefficient and **I** is the identity matrix.

From the equation (7), we noticed that the elements on the main diagonal of the approximated Hessian matrix will be larger than zero. Therefore, with this approximation it can be sure that matrix ***H*** is always invertible. So, the update rule of LM algorithm can be presented as

$$W_{k\_1} = W_k - (Jk^{T} J_k + \mu I)^{-1} J_k e_k \quad \text{---(8)}$$

When the combination coefficient μ is very small (nearly zero), the LM uses Gauss–Newton algorithm and μ is very large the LM uses the steepest descent algorithm. Fig 2 shows the ANN architecture for our identifier.

V. RESULTS AND DISCUSSIONS

The problem of human defect inspection system has been described. It is evident from the previous sections that the ANN based identification system solved the disadvantages in human visual inspection system. Hence, an attempt has been made to rectify the lacking of human visual inspection. Our identifier system captures fabric images by acquisition device (digital camera) and passes the image to the computer. Initially the identifier normalizes the image using interpolation methods, filtered with adaptive median filtering techniques and taking the intensity value as threshold the image is converted into binary image. ANN ake a different approach to solve the problem than that of conventional methods. ANN process the information in a way similar to the human brain. The six first order statistics values are calculated from the binary image. These calculated statistics values are used as feature vector to the multilayer feed forward network, which uses LM algorithm to train the network. The input layer consists of 6 neurons, hidden layer consists of 20 neurons and output layer consists of 1 neuron. The output layer produces target output as 1 for defect images and 0 for defect free images. The neural network is trained with 200 images and tested with 50 images. The following figures 2 to 5 illustrate the defect and non defect, filtered, normalized and resultant images of plain woven fabric.

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Figure.2 (a) Defect free image


(b) Defected image

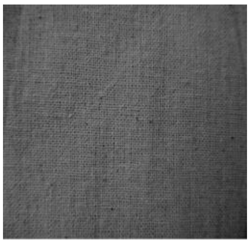
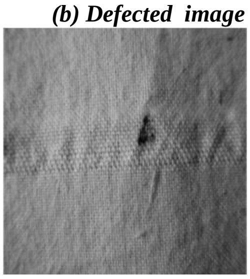


Figure.3 (a) Normalized defect free image


(b) Normalized defected image

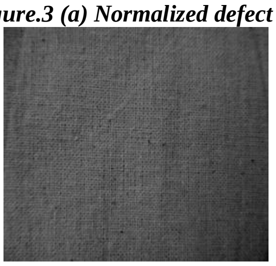
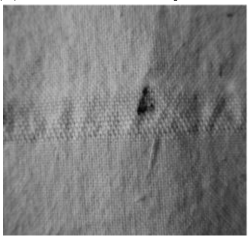


Figure. 4(a) Filtered Defect free image


(b) Filtered defected image

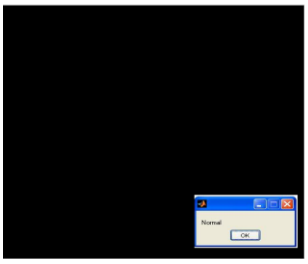
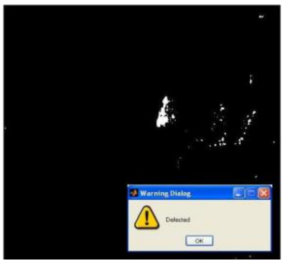


Figure. 5 (a) Resultant defect free image



(b) Resultant defected image

The training algorithm used to train the net as shown in figure 2 using MATLAB 12. We have used $1x10^{-5}$ as the acceptable error level and 0.05 as the learning rate for the training.The training was carried out by 1000 epoachs. And also depicts the gradient , mu and validation check during 1000 epoachs. Our system produces 99% accurate results in identifying defects. Our network simulates the input set after calculating input set and identify defect of image as an actual output. As discussed on the literature survey the various existing detection system produces a maximum of 93.4% of accuracy with 650 seconds of cpu time. The accuracy produced by this new network produces 99.1% of accuracy with 625 seconds of cpu time which is 5.7% higher and 25 seconds lesser than the existing systems which is shown in the Table 2. Hence the result proves that this network was success in minimizing detection time, produces high accuracy than visual inspection system.

Sl. No	Parameters	Existing System	Proposed System
1	CPU time(Sec)	650	625
2	% of detection	93.4 %	99.1 %

Table 2 Comparison with existing methods

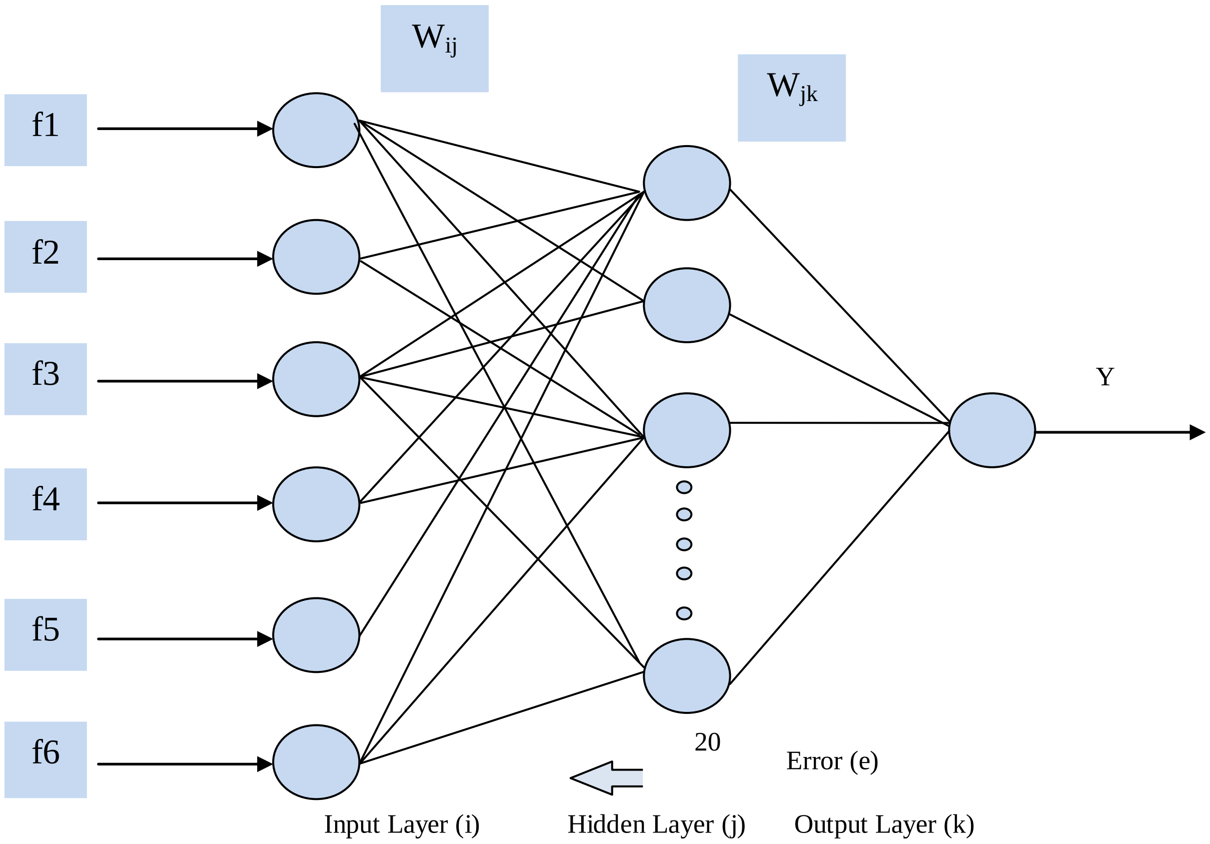


Figure 6 Artificial Neural Network Architecture

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BIOGRAPHY

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