Identification of Woven Fabrics Defects using Image Processing

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Abstract: -This paper reports identification of the defects in the woven fabrics, using image processing. These faults consist of end-break, mispick, double-end, double pick, oil stain and knots in the fabric. The faulty samples are scanned and processed using image processing. After eliminating the noises from the pictures, carried out by filtration, the pictures are introduced to neural network. In this research a 3-layer perceptron neural network has been utilized. The transform function is based on the function of Sigmoid. To train the network, 85 samples were used. Due to the increase of weights and the layers of neurons resulted from the increment in input, the process time will be added. This will result in a decrease in the calculation error.

Key-Words: - Image Processing, Neural Network, Perceptron, Back-Propagation, Co-occurrence, Woven Fabrics Defects

1 Introduction

In the majority of textile factories, the quality fabrics are controlled and monitored by human vision. Due to the high importance of this job, this should be done with high accuracy and confidence. The vision control causes the tiredness of the operator and error in detecting the faults, which is led to decrease of the fabric quality. Raising these problems has made the manufacturers to find a solution. For the first time image processing was applied by Wool Research Organisation of New Zealand(WRONZ) to evaluate the change in the appearance of the carpet after use[1].

As it is known the defects of the woven fabrics are resulted from the quality of the yarn or weaving operation. There are very common faults in the woven fabrics which should be identified and removed from the fabrics. These faults include end-break, mispick, double-end, double-pick, oil stain and big knot. However, these problems should be avoided as much as possible during spinning and weaving. Nowadays the on-line control systems are employed on the machines to prevent creating such problems[2].

Some of these faults, such as double-end and double-pick which are repeated during the interlacing the warp and weft yarns, can be identified using the texture method.

Of vital point in identification of the faults in the fabric is the conditions of taking picture which should be always kept even. The dust and flying fibres can misled the monitoring system[3].

To improve the performance of the processing and analysis, it is necessity to develop the hardware and software involved in the operation. The hardware comprises powerful microprocessors and microchips[4].

In this work we used the neural network, a 3-layer perceptron. To determine the input vector, the method of co-occurrence, which is simple, has been utilized.

2 The Conventional Methods of Faults Identification of Fabric

As it is obvious, the principles of all fault detectors are based on the comparison. I.e. the faulty and faultless fabrics are compared in this procedure. Therefore, a faultless fabric is scanned its picture is filtered. Then some characteristics of this picture is extracted and stored. The same thins is done for the faulty fabric. The comparison between the characteristics of these demonstrates the differences between them which indicate the nature of the defect of the fabric.

The techniques of Sobel edge operator, gray level statistical morphological, gabour filter, wavelet transform and Fast Fourier Transform(FFT) has been used in identification of the fabrics defects. However, the results indicate that each above methods have its own advantages and disadvantages. For instance in Sobel edge operator a 3×3 matrix has been used which one of matrix is relevant to horizontal edge and the second matrix is related to vertical edge. This method is to marking the faults such as misend which is identified by vertical edge. The defected place on the fabric is specified by a vertical bright line. Of disadvantages of this method is the presence of some false edges, resulted from noises. The noises may be created during taking picture from the sample fabrics. If the edges appears as weave pattern, identification of the fault would be difficult[5].

The statistical method and pattern recognition were used to identify the knot and slub in the fabrics. The results obtained from these methods were the same, although sometimes these methods identified a perfect fabric as a faulty one. Also, pattern recognition method is complicated and its calculation is time taking[6, 7].

Using neural network could improve the results obtained from other methods.

3 Apparatus and Materials

To prepare suitable pictures from the faulty fabrics, provided earlier, a Canon scanner(Model LIDE25) and a PC with processor 1.7 Centrino, were used.

The surfaces of the faulty samples were scanned and they were saved as digital pictures with jpg extension. A CCD camera, also, can be utilised to develop the investigation. The camera can be installed on the weaving machine. Taking into consideration this fact that weaving rate is about 18 inches/min., therefore the camera is able to take picture from the whole surface of the fabric and identify the defected points on the fabric using powerful microchips processors. In this research work, due to some restrictions, the samples were scanned and used to identify the faults using neural network.

4 The Method

Two types of plain and twill fabrics with different warp and weft densities were used in this research. The fabrics having the faults of misend, mispick, double end, double pick, knot and slub were scanned. To identify these faults in the fabric the neural network of a 3-layer perceptron was utilized. Each network consists of training and trial procedure, during which the error level of the network was determined.

In the neural network, the neural knot is the smallest structural unit. In fact the neural knot is a transform function, which takes a definite input value, gives a value in the output. The definite input value is obtained by multiplying the weight matrix of neural knot in input vector which is added to residual neural knot. In other word the weight matrixes and the back-propagation vectors are the memory of neural network. The learning capability of the neural network is based on these elements[8].

If n is the output of neural network we can write:

$$n = f(wp + b) \qquad (1)$$

Where f is the transform function, p is input vector and b and w are residual vector and the weight matrix of neural knot. The layer is obtained from integrating a number of these neurons.

4.1 Training Neural Network

The most important capability of the neural network is its learning potential. i.e. if a number of input values along with corresponding responses are applied to neural network, it can learn the relationship between input and output values. Once if some new input values, which are different from initial input values, is applied to the neural network, the output value would be most likely the desired response. The training procedure includes following steps:

i- Feeding training inputs into neural network
ii- Comparison of the data with correct values
iii- Determining the amount of error
iv- Changing the weigh and residual matrixes so as if the same input is applied to network, the error decreases compared with previous value. e.g. the output of network closes to desired value. This cycle is repeated several times, so that the output becomes the desired response. In this research work, number of repeat in the procedure was 10000 and its error was considered 0.001.

4.2 Testing Network

To test the network, some number of inputs, which are different from training inputs, applied to the network. Then the output of network is compared with desired responses relevant to training inputs. If the network can be extended, its output should be similar to desired responses. Otherwise the procedure of training should be repeated. The training input or network architect can also be changed. After this step and verifying the network, it is ready for use. The user can change the number of layers, number of knot in the layer and also transform function. These are parameters in hands of user to obtain the best results from the network.

4.3 Determining Input Vector for Neural Network

To determine the input vector to apply into neural network, there are different methods. Using fast

Fourier transform(FFT), due to the nature of repeatability in the textiles, can be utilized. Fourier spectrum can describe the frequency of changes in the digital image of the fabric, particularly in the thick parts[9].

4.3.1 The Optical Method

In this method to investigate the surface of the fabric, the refraction ray is used. i.e. a Fourier lens is put in the path of parallel light rays passing through the fabric[10]. This has been demonstrated in Fig. 1.

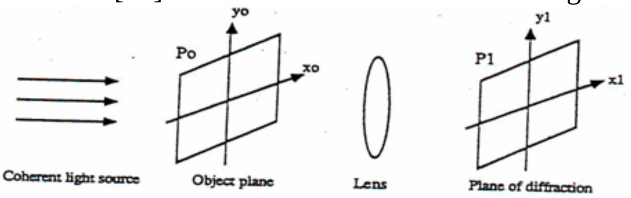

Fig. 1- The optical method

4.3.2 The Unidirectional Diffraction Method

If a unidirectional transform is used instead of a two directional Fourier transform, its spectrum would be unidirectional, too. In the relevant spectrum, the axis of x indicates number of pixels from picture taken and the axis of y shows the intensity of each pixel. Then these graphs have been normalized as shown in Fig. 2. From the spectrum obtained for each sample, one input vector with 93 elements has been created to apply into network.

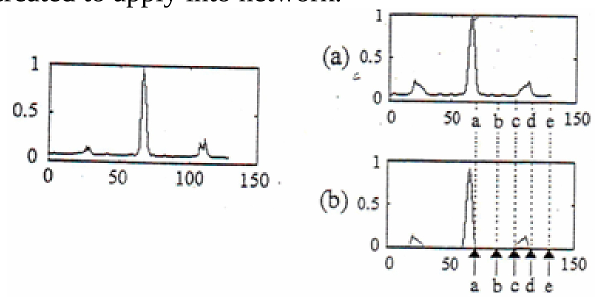

Fig. 2- The unidirectional spectrum of diffraction for perfect sample and after being normalised(a) and thresholding(b)

4.3.3 The Co-Occurrence Method

At first the matrix of image is read by function of *imread* which is a library function in MATLAB software. Then the maximum and minimum values of this matrix are specified. This is carried out to prevent comparison of the values are not in the matrix which saves the time required for the matrix of *P*. The matrix of *P* is determined from comparing between the intensity values of two points in the image matrix. In fact the elements of the matrix *P* are the number of points with definite intensities. For each value, Θ and d of a matrix are determined. After determining the matrix *P* using following formulas, one of input vector is formed:

$$Con = \sum_{i,j=0}^{N-1} p_{i,j}(i-j)^2 \tag{2}$$

$$Dis = \sum_{i,j=0}^{N-1} p_{i,j}|i-j| \tag{3}$$

$$Hom = \sum_{i,j=0}^{N-1} \frac{p_{i,j}}{1+(i-j)^2} \tag{4}$$

$$\sum_{i,j=0}^{N-1} p_{i,j}^2 \tag{5}$$

Where $p_{i,j}$ are the elements of matrix *P* and *N* the number of different intensities in the image matrix, which is assumed:

$$\begin{cases} \theta = 0\ ,90 & R = 2\times D_Y \times (D_X - 1) \\ \theta = 45,135 & R = 2\times (D_X - 1)\times (D_Y - 1) \end{cases} \tag{6}$$

In this formula, D_x and D_y are the dimensions of the image matrix in two main directions.

In Co-Occurrence method, the input parameters, i.e. image intensity, direction and angle(*dir*), distance(*dis*) and symmetry was applied. The range of each parameters are as follows:
$1 \le dis \le 2$ and $0 \le dir \le 3$

Using this method, 8 states of co-occurrence for the image is calculated. In each state for each picture, 4 characteristics of contrast(Con), dissimilarity(Dis), homogeneity(Hom) and diffraction(Asm) is calculated. Therefore in each image 32 characteristics is calculated and applied to neural network. In this stage the network, with respect to the training, is able to identify the fault in the image.

5 The Structure of Applied Neural Network

The number of neurons in first layer is equal to number of inputs(equal to characteristics vector) which is 32 and the number of neurons in last layer is equal to number of defects types of the fabrics, which is classified to 6 in this work, as mentioned earlier. The number of neuron in second layer is equal to the average of the number of neurons of first and third layers, which is 16.

The function considered for each layer is *Sigmoid* and in last layer of neuron the maximum value indicates the class of characteristics vector, given in Table 1.

Table 1- The functions of Sigmoid in neural networks

Log-Sigmoid	$a = \frac{1}{1+e^{-n}}$		logsig
Hyperbolic Tangent Sigmoid	$a = \frac{e^{n}-e^{-n}}{e^{n}+e^{-n}}$		tansig

After determining 32 characteristics for the image, the value of corresponding error of the neuron is assumed 95% and other value of neuron is considered 5%. The structure of the neural network has been illustrated in Fig.3.

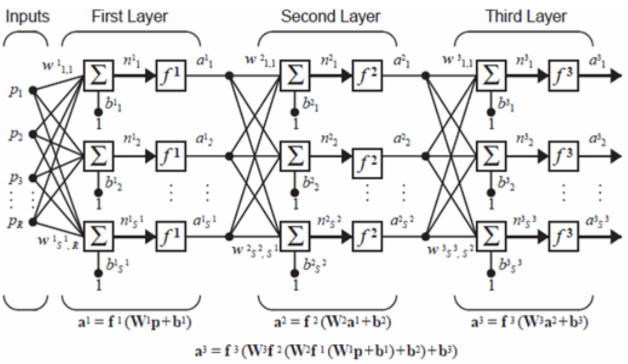

Fig. 3- The structure of the neural network(a 3-layer perceptron)

As can be observed from Fig. 4, the input vector(32 characteristics extracted from fabric image) is applied to first input layer. The output of first layer is considered as input for second layer(hid layer) and virtually the output of second layer is considered as input for third layer which determines the fault of fabric.

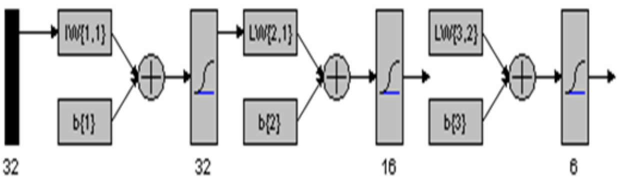

Fig. 4- The schematic neural network designed for identification of fabric defects

6 Results and Discussion

After the above mentioned steps, the system was employed to identify the defects of the fabric. 200 faulty samples classified in 6 groups were applied to the neural network, which can be seen from Table 2. Regarding the obtained results, it can conclude that the capability of the system will improve if the extent of training is increased and enhance the capability of hardware used. The results showing the ability of neural network to identify the defects of the fabrics have been given in Table 2, too.

Table 2- The faulty fabrics, identified by neural network

Type of Fault	Number of Faulty Samples	Number of Correct Identification	Number of Incorrect Identification	The Percentage of Correct Identification
misend	45	43	2	95.5%
mispick	36	33	3	91.6%
Knot	20	18	2	90%
Oil stain	13	13	0	100%
Double end	43	40	3	90%
Double pick	43	43	0	100%

As can be observed from Table 2, 190 faults out of 200 faults, 95%, were identified correctly and only 10 samples, 5%, were identified incorrectly. Considering the results, indicates the capability of the system will improve, if the hardware and software facilities are available. Fig. 5 also illustrates the performance of the neural network.

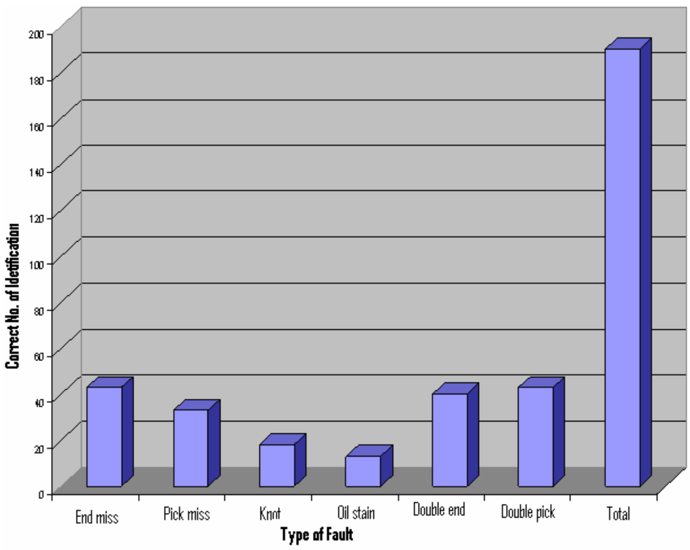

Fig. 5- Identified faulty fabrics by neural network

Figures 6, 7, 8, 9, 10 and 11 show the pictures of faulty fabrics.

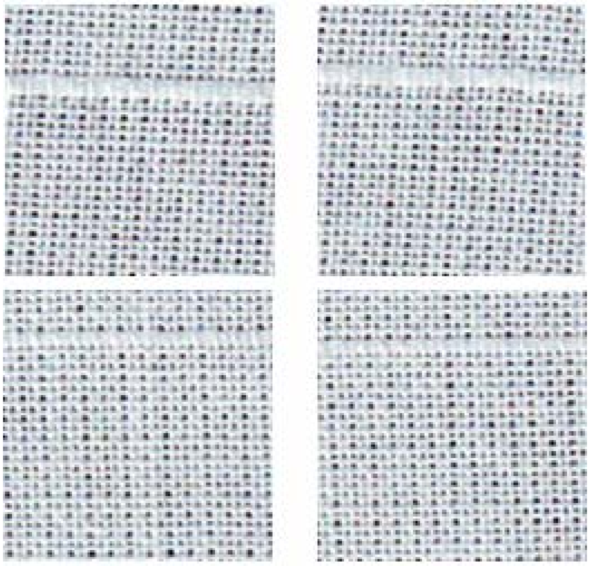

Fig.6- The faulty fabrics with double picks

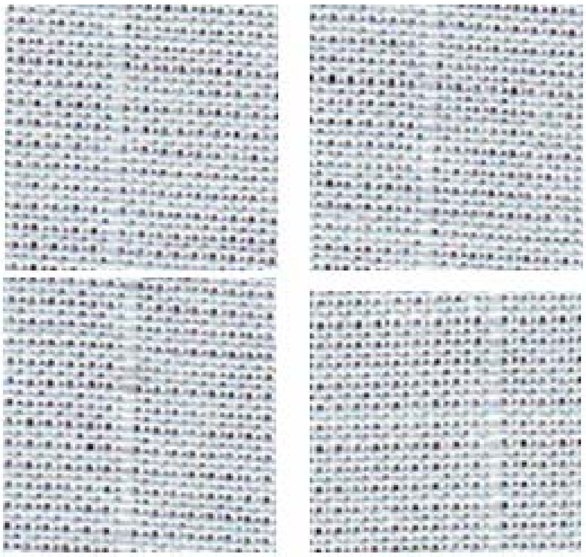

Fig.7- The faulty fabrics with double ends

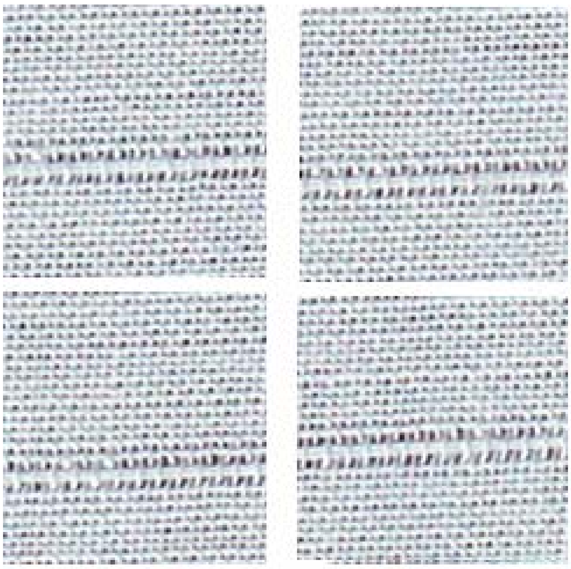

Fig.8- The faulty fabrics with mispick

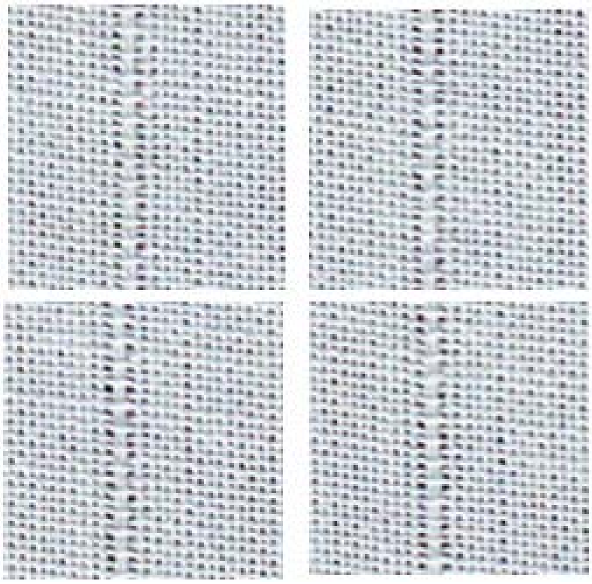

Fig.9- The faulty fabrics with misend

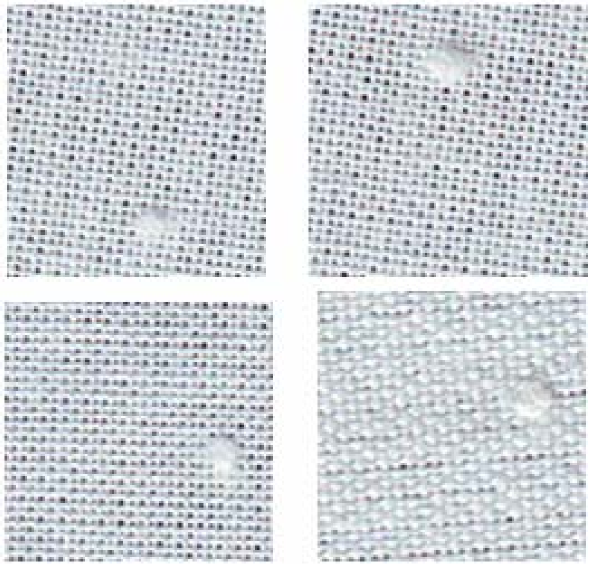

Fig.10- The faulty fabrics with knot

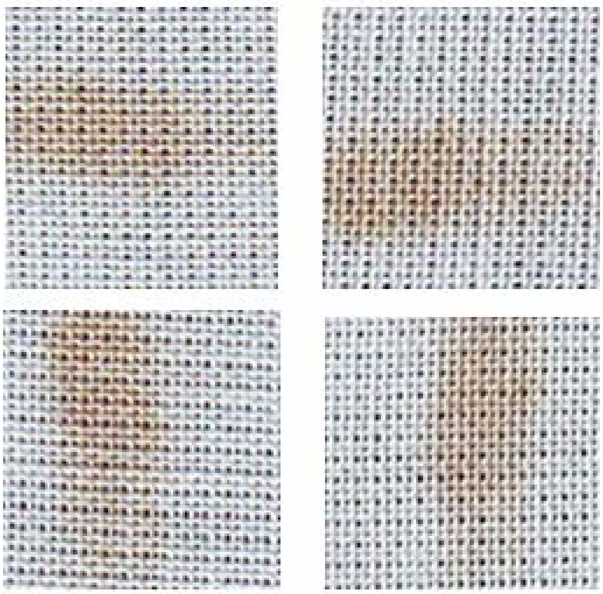

Fig.11- The faulty fabrics with oil stain

7 Conclusion and Suggestions

In this research work used 85 samples of woven fabrics including plain and twill patterns, to train the neural network. The results show the cycle number of training will be increased when the density of the fabric is added. To decrease the amount of error, it is suggested that higher number of samples with higher variety of types of the fabrics to be used. The system also can be designed to identify more types of defects instead of 6 faults. If the number of the hid layers and the number of knots in the neural network is increased, the error of the system will decrease.

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