Defect Detection of Patterned Fabric Using Regular Band And Distance Matching Function

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Abstract-*In traditional fabric defect detection System, Visual inspection of by human being is time consuming, inefficient and costly method. So in order to overcome this drawback, the fast and cost efficient automatic pattern fabric inspection method is introduced. In this paper, patterned fabric defect detection method using distance matching function and Regular band is proposed. The distance matching function is used to find horizontal and vertical period of repetitive unit of a patterned fabric. The regular band method is used for the regularity analysis of the patterned texture.. This method gives better accuracy than the existing methods for the defects detection such as hole, broken end, thick bar, thin bar, multiple threading and knots.*

Keywords-Regular band, distance matching functionGray level co-occurrence matrix, Atifical neural network.

I. INTRODUCTION

The fabric defect detection is very important for the quality control in the textile manufacturing process. Previously visual inspection by human being was carried out, which yields error due to human fatigue and hence accuracy and efficiency was less in traditional inspection methods. To overcome above problem automatic fabric defect detection is necessary to improve quality and as well as production rate[13], which increases the efficiency of the product. There are many kinds of fabric defects like hole, broken end, multiple knitting, thin bar and thick bar caused due to malfunctioning of the machines or machine spoils. These defects reduce the quality of the product and hence losses in the revenues[1][12]. Textures can be classified into patterned and non-patterned textures. Various techniques have been developed for patterned texture inspection[5].Statistical texture analysis measures the spatial distribution of pixel values. Ngan and Pang [13] explained regularity analysis for patterned texture using various methods[9][10]. The Regularity of a patterned texture means the spatial relationship between pixel intensities and repeat distance of repetitive units. The Spatial relationship is that one pixel in an image should have dependencies and steady changes with its surrounding neighborhood. Chan & Pang [6] explained Fourier transform for detecting fabric defects, but due to lack of spatial information it is not well suited for fabric defect detection. Ajay Kumar [1][14][11] explained Gabor filter method contains both frequency and spatial information but it has computational complexity. This paper is focused on regularity analysis for patterned texture.

II. RELATED WORK

Patterned fabric has repetitive units of texture means the spatial relationship between pixel intensities and the repeat distance of repetitive units[5][8]. The spatial relationship between pixel intensities means that one pixel in an image should have dependencies and steady changes with its neighboring pixel . Many methods have been developed for the inspection of patterned fabric such as Direct Thresholding [5] which is easy to implement but having coarse in detection result, Wavelet Golden Image Subtraction [5] method in which golden image can contain several repetitive units taken from a defect free image. It is a shift-invariant method able to outline the defective region with shortest time complexity but fails to detect defect near the border. Bollinger Band [6] implemented on the concept of moving average and standard deviation. Bollinger bands constitutes of three bands. The upper and lower Bollinger bands can highlight the defective information after calculation and also highlights background information. This method has achieved clarity and can be implemented on loom but unable to detect border line defects[4].

The paper is organized as follows. First, a review of previous work is given in section II. The new principle of regularity analysis of patterned texture using regular band and the repetitive pattern extraction using Distance matching function are introduce in section III. An evaluation of patterned texture using regular band and distance matching function is given in section IV. Finally conclusion is delivered in section V.

III. PROPOSED METHODILOGY

In the proposed work, we have extracted repetitive pattern by using distance matching function and this period n used for fabric defect detection. The Regular bands are used to detect defects using regularity approach.. The RB consists of two subbands, the light regular band(LRB) and dark regular

band(DRB) [5]. The moving average and standard deviation are the tools used in this method. Standard deviation indicates any irregularity of the signal. The maximum and minimum values of standard deviation will become tolerance level for normal variations of the regular Signal. The method RB consists of two stages: training stage and testing stage.

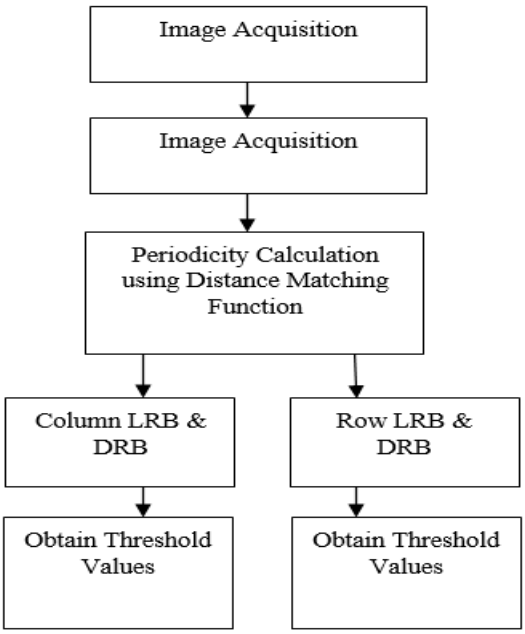

Fig 1. The training process of proposed algorithm

A] Training Stage

Step 1: Image preprocessing

Image preprocessing consists of color to gray image conversion followed by histogram equalization. Equalization processing changes the grayscale histogram concentrated of original image into a uniform distribution within the scope of all gray and make the number of pixels of gray level consistent and removes the blurring in the image as shown in Fig. 2.

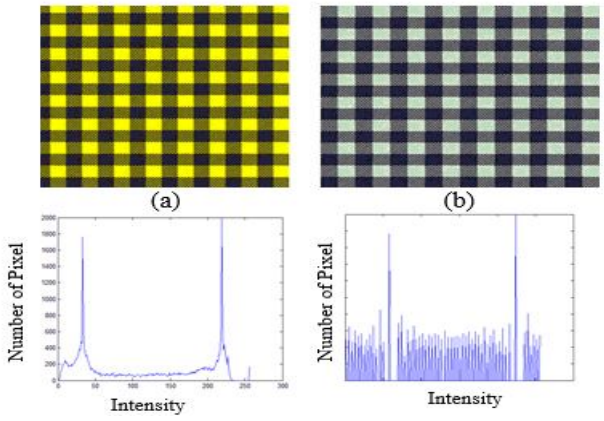

Fig 2. Image preprocessing a) Gray image b) histogram equalized image c) Histogram of gray images d) Histogram of equalized image

Step 2: Modified Distance Matching Function

Oh G [15] proposed the distance matching function to calculate the periodic distance of patterned units in fabrics by considering the similarity between neighbouring patterned units of fabrics. [7][16]. For the image f(x, y) the row and column sum is calculated for the different value of period p where p varies from (1 to M/2 for M rows or 1 to N/2 for N columns) using equation (1) and (2).

$$sum_{\lambda x}(p) = \sum_{x=1}^{M} \sum_{y=1}^{N-p} [f(x,y) - f(x,y+p]^2 \quad (1)$$

$$sum_{\lambda y}(p) = \sum_{y=1}^{N} \sum_{x=1}^{M-p} [f(x,y) - f(x+p,y)]^2 \quad (2)$$

Maximum value of P is considered as half of total numbers of rows and columns by considering minimum 1 fold repetition of patterned unit. The first forward distance and backward distances are calculated using equations (3-6).

$$D_1(p) = Sum_{\lambda x}(p+1) - Sum_{\lambda x}(p) \quad (3)$$
$$D_2(p) = Sum_{\lambda y}(p+1) - Sum_{\lambda y}(p) \quad (4)$$
$$D_1(p-1) = Sum_{\lambda x}(p) - Sum_{\lambda x}(p-1) \quad (5)$$
$$D_2(p-1) = Sum_{\lambda y}(p) - Sum_{\lambda y}(p-1) \quad (6)$$

The second forward difference is the difference between first forward difference and first backward difference of rows/columns which is calculated using equations (7) and (8)

$$\Delta D_{1_{\max}}(p) = D_1(p) - D_1(p-1) \quad (7)$$
$$\Delta D_{2_{\max}}(p) = D_2(p) - D_2(p-1) \quad (8)$$

Final periodic distance p is equal to average of difference between the peaks of second forward difference as shown in Fig 2.

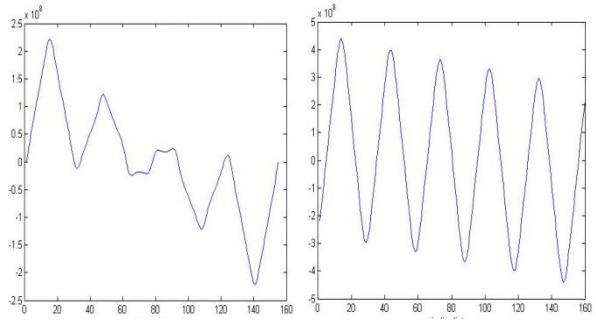

Fig 2. a) Rowwise second forward distance b) Columnwise second forward distance

Step 3:Regular band Calculation

Regular bands are used to detect defects using regularity approach[2][3] that is to study or represent signal generation for each vertical and horizontal line of the defect free region. Any defect in a defective region corresponds to an irregularity in the signal.The moving average and standard deviation methods are used for this.

$$\mu_{r_n} = \left(\frac{\sum_{j=1}^{r_n} x_{ij}}{n} \right) \quad (9)$$

Where μ_(r_n)=Moving average
n= period and x_ij is the sum of pixel intensities.

Standard deviation is a good measuring method indicating any irregularity of a signal. The maximum and minimum value of standard deviation of a signal indicates the range within which the tolerance level for variation of regular signal.

$$\delta_{r_n} = \sqrt{\frac{\left[\sum_{j=r_1}^{r_n} (x_{ij} - \mu_{r_n})^2\right]}{n}} \quad (10)$$

Where δ_(r_n) is standard deviation.

Calculation of Regular Bands: For every image LRB and DRB is calculated on rows as well as on columns.

$$L_{r_n} = (\mu_{r_n} - \delta_{r_n}) + \mu_{r_n} \quad (11)$$

$$D_{r_n} = (\mu_{r_n} + \delta_{r_n}) - \mu_{r_n} \quad (12)$$

Step 4: Obtain threshold Values

Four threshold values LRBmax , LRBmin, DRBmax, and DRBmin are calculated from LRB and DRB of regular band which represents the limits of regularity of non defected patterened fabric image.

LRBmax=max(L_(r_n)) (13)
LRBmin=min(L_(r_n)) (14)
DRBmax=max(L_(r_n)) (15)
DRBmin=min(L_(r_n)) (16)

B] Testing Stage

Testing stage is similar to training stage as shown in Fig. 4, only difference is that we apply threshold obtained in training stage to the LRB and DRB band of testing image for the defect detection.

Step 1: Image preprocessing
Step 2: Modified Distance Matching Function
Step 3:Regular band Calculation
Step 4: Thresholding for defect detection

In this step, thresholding is applied to the LRB and DRB of defected sample using the threshold values LRBmax, LRBmin, DRBmax, DRBmin. Whenever the defect occurs in patterned fabric it affects the regularity or similarity of patterned fabrics and thus LRB & DRB values gets changed. The thresholding operation results in defect detection which is further enhanced by morphological filtering.

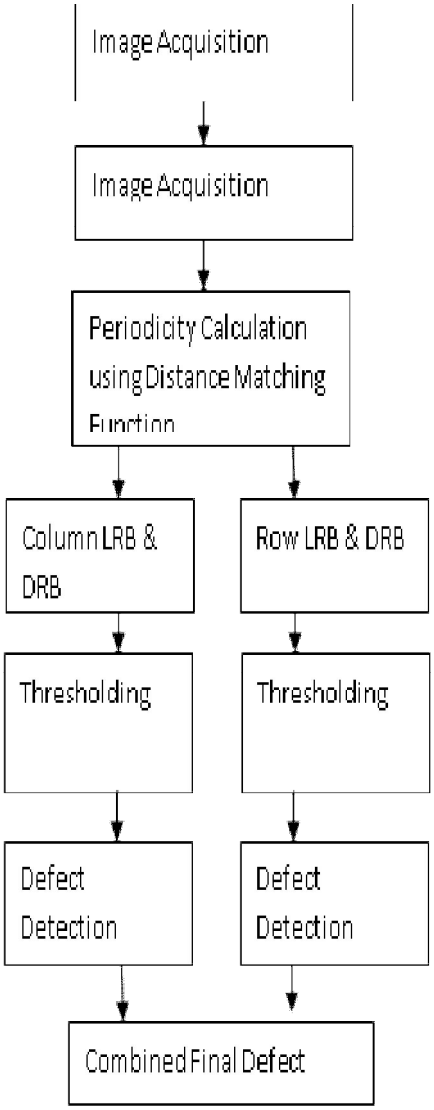

Fig 4. The testing process of proposed algorithm

IV. EXPERIMENTAL RESULTS

This method is implemented using MATLAB R2015b on windows environment having 2.27 Ghz core i3 processor with 8 GB RAM. Extensive experiments are carried out on the TILDA textures database[17] to detect the hole, thick bar, knot, thin bar and oil strain as shown in fig 5. The performance of algorithm is measured on the basis of percentage cross validation accuracy as shown in Table 1.

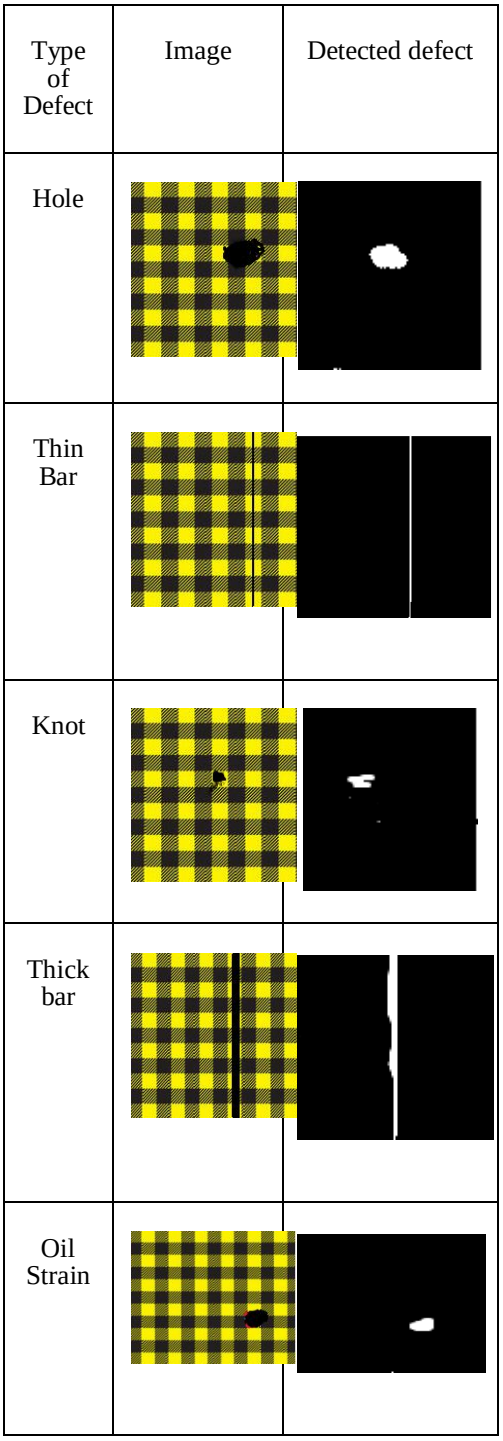

Fig 5. Defects on patterned fabric detected using proposed method

% Cross Validation Accuracy = (Number of correctly detected samples / Total number of samples) * 100

Table 1. % Cross Validation Accuracy

Type of Defect	Total samples	Defect Detected	% Cross Validation Accuracy
Hole Defect	150	146	97.33
Thin bar	150	148	98.66
Thick bar	150	147	98.00
Oil stain	150	140	93.33
Multiple netting	150	144	96.00

V. CONCLUSION

In this paper we have proposed the supervised pattern fabric defect detection method using regularity analysis using distance matching function. For the moving average, LRB & DRB calculation, period obtained from distance matching function is used.Regular Band method is unable todetect the defects in complex patterened fabrics and time consuming method as it is supervized learning method.

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