Automatic Fabric Defect Detection using Spatial and Spectral Features

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Abstract— **Fabric inspection plays a significant role in quality control of textile materials. Traditionally human operators perform the task of fabric inspection in industries. The identification rate is about 70%. Manual inspection suffers from many drawbacks. Inorder to increase the speed and efficiency of fabric inspection and to reduce the labour cost, we need reliable automated defect detection systems There exists many algorithms that utilize digital image processing and pattern recognition techniques to perform defect detection on fabric. An image processing based machine vision system for visual inspection of fabric quality is proposed here. This paper introduces a new approach to the detection of fabric defects from the images of textile fabric, based on analysis of the GLCM and DCT features of textile images. To obtain more representative fabric features, features from space and DCT transformation domain are extracted.**

Keywords— Quality control; Fabric inspection;, Textile inspection; Automatic Fabric Inspection using GLCM; Automated defect detection using DCT; Fabric quality assurance

I. INTRODUCTION

Quality is one of the main goals of almost all companies. Success of a company depends upon their ability to deliver first quality products in time. Likewise, success of a weaving mill depends upon their ability to detect and avoid fabric defects. Automated defect detection systems are evolved to overcome the drawbacks of traditional inspection method. We need reliable automated defect detection systems ,to increase the speed and efficiency of fabric inspection and to reduce the labour cost . A reliable defect detection system is a key factor for achieving improved product quality and increase in efficiency of product lines. It has proven that fabric inspection is one of the most difficult of all textile processes to automate. There exist many algorithms that utilize digital image processing techniques to perform defect detection on fabric. In this paper, we are introducing a new method for fabric inspection using a combination of GLCM and DCT features. The combination of GLCM and DCT makes the fabric features more distinct.

II. FABRIC DEFECT DETECTION

A. *Fabric Defects*

Any change that occurred to the regular fabric structure can be termed as fabric defects. There are two types of fabric defects: weaving defects and machine related defects. Weaving defects will occur in the horizontal direction (weft direction) or in the vertical direction (warp direction). Some examples of weaving defects are slubs, broken ends, warp float etc. Machine related defects appear as structural failures and machine residues. For example: holes, oil spots etc. The population of fabric defects may vary dynamically as small changes in the weaving process can result in variety of defects. Similarity between different classes of defects and diversity within the same classes makes the fabric defect detection problem more complex and challenging

B. *Fabric Inspection*

Traditionally defect detection is carried out by human beings. They have to detect defects on the fabric material moving through their field of view. Most mills use power driven machines to unroll the fabric on an inspection table at a relatively higher speed. When the inspector detects a defect, he will mark it as a minor or major defect. Results of manual inspection will depend upon the operator's work experience, mental and physical health, working environment etc. So we need an efficient automated defect detection system to increase the speed and effectiveness of fabric inspection, and thereby to reduce labour cost, improve product quality and increase manufacturing efficiency. Some weaving defects are shown in Fig.1

Automatic defect detection methods can be classified into 3: Statistical, Spectral and Model Based methods. There exist low cost statistical methods such as thresholding, edge detection, fractal dimension method etc for defect detection. But these methods do not perform well for fabric images which contains defects that appear without altering the mean grey level of defect free area. Spectral approaches are based on the features in spatial-frequency domain which are less sensitive to noise and intensity variations. Fourier method performs well in detection of global defects, but it can't be

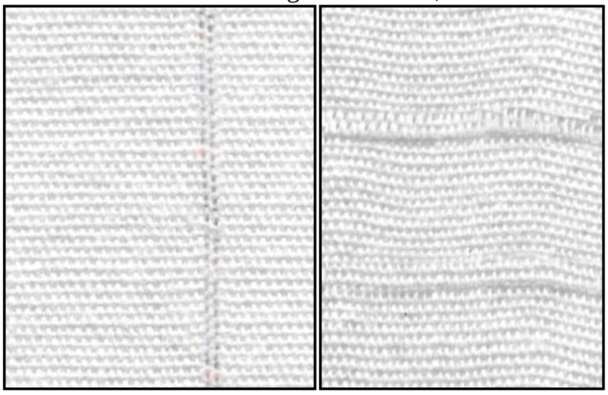

Fig 1. Weaving Defects

used to detect local defects effectively. Wavelet method can't be used to solve all types of problems. It can be used to detect certain types of defects only. Model based approaches give good results for certain types of random textured fabrics. It is not suitable for all types of fabric. Statistical, Spectral, and Model Based methods give different results and they have their own advantages and disadvantages. Hence, two or more methods can be combined to get good results than either one individually.

III. PROPOSED METHOD

A new algorithm for fabric defect detection using a combination of gray-level co-occurrence matrix(GLCM) and Discrete Cosine transform(DCT) is proposed in this paper. To obtain more representative fabric features, features from space and DCT transformation domain are extracted.

Gray Level Cooccurrence Matrix (GLCM) method is used to extract the second order statistical texture features from the fabric image. It gives us information about the spatial distribution of gray levels. It is highly accurate when compared to other spatial domain techniques.

DCT method is used to extract features from frequency domain. Since DCT has better energy compaction property, more details of the image are concentrated on a few coefficients. Hence defect detection can be performed on the basis of analysis of these coefficients. In online fabric inspection, the local transforms such as DCT could be preferable, because DCT can be directly obtained from imaging device hardware using commercially available chips that perform fast and efficient DCT transforms and there exists fast algorithms to compute DCT. The new fabric defect detection method consists of the stages shown in Fig 2.

A. *Image Preprocessing*

Pre-processing stage improves the quality of the image and thus increases the interpretability of data present in the image. Noise removal and contrast enhancement are the two major steps involved in pre-processing. Originally, the images are acquired at RGB color scale The images then are converted to gray scale. As a result we get an image consists of 256 gray levels with 0 represents black and 255 represents white color.

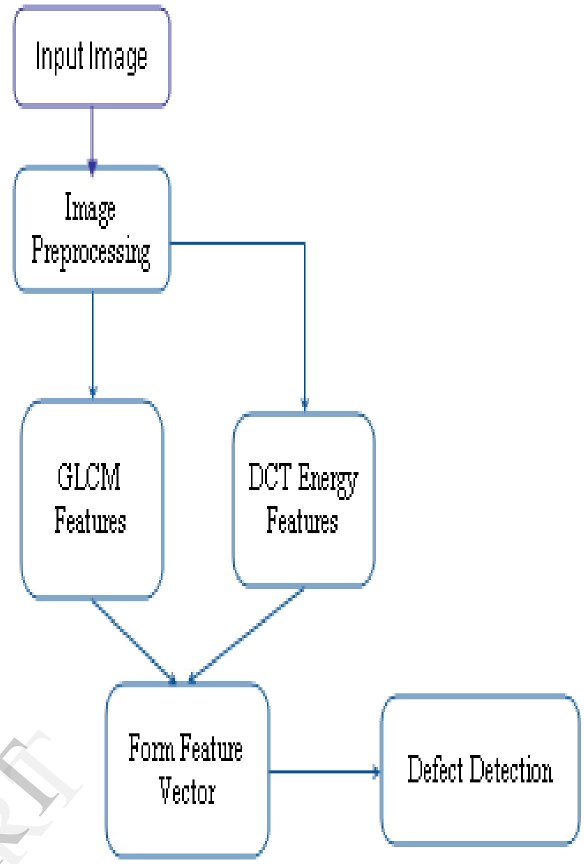

Fig 2. Proposed Method

Images may be contaminated with noise during acquisition stage or during transmission stage. Hence, an effective noise removal technique should be applied on the input image.

Adaptive Median filter is used to remove the noise from the fabric image. It is a decision based filter that adapts its behavior based on the characteristics of the image. It is good at removing noise from images, even if the noise density is high. The adaptive median filter checks whether the current pixel is noisy or noise free. If it is noise free, it remains as unchanged. If it is noisy, the pixel is replaced with a non-noisy median value. Adaptive median filter method preserves the details of input image, while removing noise. So it reduces the error between the original image and the filtered image.

Histogram equalization method is adopted to enhance the contrast of the fabric surface. Histogram equalization widens the dynamic range of the gray levels present in the image, and thus highlights the defective region. This method is fully automatic i.e. no need of any parameter specification. It involves simple calculations and thus computationally less complex.

B. *Feature Extraction*

Defect detection techniques, generally classified into the spatial domain and the frequency domain, compute a set of textural features from defect free reference image and search for significant local deviations among the feature values of the test image. To obtain more representative fabric features, features from space and frequency domain are extracted. Both GLCM and DCT are applied on the fabric image to form the feature sequence. Gray Level Cooccurence method is used to extract features from spatial domain and DCT approach is used to extract features from frequency domain.

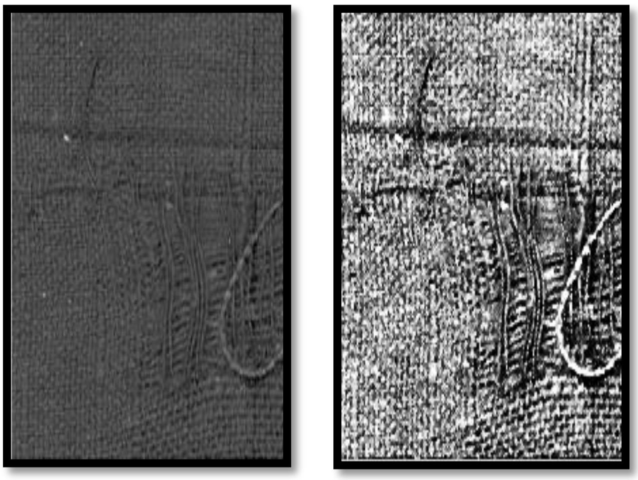

Fig.3.Fabric image before and after preprocessing

The Gray Level Co-occurrence Matrix (GLCM) and associated texture feature calculations are popular and accurate image analysis techniques. We can extract various statistical features of the fabric image from the Gray Level Cooccurence matrix. This approach is based on the assumption that, statistical behaviour of defective area will be different from the statistical behaviour of defect free area. GLCM features can be calculated for different orientations (horizontal, vertical and diagonal) and an average of feature values for different orientations can be used to form the feature vector.

GLCM is a tabulation of how often different grey levels co occur in an image at a particular orientation and distance. If our image consists of 0 to G-1 gray levels, then the GLCM will consists of G rows and G columns .The elements of the GLCM at (i ,j) th position i.e. p(i,j) gives the probability of cooccuring gary levels i and j ,at a given distance and orientation, in the image. General form of gray-tone spatial-dependence matrix for images is shown in Fig 4. Six GLCM features are extracted for defect detection. Those features are

- Energy: Energy measures textural uniformity (i.e. pixel pair repetitions).

$$Energy = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}[p(i,j)]^2 \qquad (1)$$

- Contrast: Measures the amount of local intensity variations

$$Contrast = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}p(i,j)[i-j]^2 \qquad (2)$$

- Entropy: Measure of complexity of the image

	0	1	2
0	# (0, 0)	# (0, 1)	# (0,2)
1	# (1, 0)	# (1, 1)	# (1, 2)
2	# (2, 0)	# (2, 1)	#(2, 2)
3	# (3, 0)	# (3, 1)	# (3, 2)

Fig. 4. GLCM matrix representation

$$Entropy = -\sum_{i=1}^{G-1}\sum_{j=1}^{G-1}p(i,j)\ln P(i,j) \qquad (3)$$

- Correlation: Statistic representing how closely two variables co-vary

$$Correlation = \frac{\sum_{i=0}^{G-1}\sum_{j=0}^{G-1} ijp\,(i,j)-\mu_x\mu_y}{\sigma_x\sigma_y} \qquad (4)$$

- Cluster Prominence: Measure of the skewness (lack of symmetry) of the matrix

$$Prom = \sum_{i}^{G-1}\sum_{j}^{G-1}p(i,j)\,(i+j-\mu_x-\mu_y)^4 \qquad (5)$$

- Homogeneity: Measure of homogeneity of the image

$$Homogeneity = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}p(i,j)\frac{1}{1+(i-j)^2} \qquad (6)$$

In the DCT domain most of the image information is packed into a few coefficients i.e. much of the signal energy lies at low frequencies; these appear in the upper left corner of the DCT. Thus by analyzing these coefficients we can extract useful information from the actual image. The energy distribution in the 2D-DCT domain reveals information about the edge pattern in the spatial block. The energy concentrated in top horizontal region reveals information about vertical edges in the block; the energy concentrated in left vertical region indicates horizontal edges in the block, and the energy concentrated in diagonal region implies diagonal edges in the block. Three energy features of a BDCT are:

- E1-Horizontal energy value

$$E_H = \left[\sum_{u=0}^{P-1}\sum_{v=0}^{Q-1}(v+1)^2 \times D^2_{u,v}\right]^{1/2} \qquad (7)$$

- E2-Vertical energy Value

$$E_V = \left[\sum_{u=0}^{P-1} \sum_{v=0}^{Q-1} (u+1)^2 \times D^2_{u,v} \right]^{1/2} \quad (8)$$

- E3-Diagonal Energy value

$$E_D = \left[\sum_{u=0}^{P-1} \sum_{v=0}^{Q-1} (u+1)(v+1) \times D^2_{u,v} \right]^{1/2} \quad (9)$$

In the above equations D u,v are DCT coefficients where u + v not equal to zero.

In many cases, fabrics have regular patterns of design. Any discontinuity in regular pattern can be identified by analysing DCT energy features. For the purpose of feature extraction, the image is splitted into 8x8 blocks and energy features of each block are calculated. Form the feature vector by taking mean value of energy features of individual blocks. The energy features calculated from the DCT domain permits us to find the direction of weaving defect accurately i.e. whether it is in weft direction or in warp direction. Because, if a defect occurs in a particular direction, the new edge information will cause a change in the corresponding energy feature calculated from the DCT domain .The final feature vector consists of features extracted using GLCM and the features extracted from the DCT domain.

C. *Classification*

The feature vector consisting of GLCM features and DCT energy features, is fed to Neural Network classifier for defect detection. Neural Networks are machine learning systems that mimic the human nervous system. Artificial neural-networks are the fastest and most flexible classifiers that can be used for fault detection. It consists of a number of similar elementary processing units (neurons) connected together into a network. .Neural Network based classification consists of two phases –a training phase and a testing phase. In the training phase, the neural network makes the proper adjustment for its weights (W) to produce the correct response. When the actual output is the same as the target output, the network has completed the training phase. In the testing phase the neural network is asked to classify a new set of images and its success is evaluated. In this paper, Backpropogation learning method is used to train the Neural Network Classifier. This learning method enable us to train the network using limited no: of samples and it is simple to implement.

IV. RESULTS AND DISCUSSIONS

The proposed algorithm decides whether the fabric image is defective or normal. In the proposed algorithm 36 images were tested, 30 out of 36 images were found to be defected and 6 images were normal, which what we get in the manual test. To verify the classification ability, four different classes of fabric images were used. Those four types are:

1. No defect
2. Weaving defect in weft direction.
3. Weaving defect in warp direction
4. Other defects (e.g. Holes, Oil spots etc)

TABLE 1. DEFECT DETECTION PERFORMANCE(1)

Type	Detection Rate
No Defect	100%
Weaving defect in weft direction	95%
Weaving defect in warp direction	98%
Other defects	95%
Average detection rate	97%

This algorithm can also be used to classify the fabric image into 3 categories based on the amount of defect present in the fabric .The categories are

1. No defect
2. Minor defect
3. Major defect.

Defect Detection Performance rate of the proposed method is shown in TABLE 1 and TABLE 2.

TABLE 2. DEFECT DETECTION PERFORMANCE(2)

Type	Detection rate
No defect	100%
Minor defect	98%
Major defect	100%
Average detection rate	98%

V. CONCLUSIONS

An efficient Fabric defect detection method based on analysis of GLCM and DCT energy features is proposed in this paper. To obtain more representative fabric features, features from space and frequency domain are extracted. GLCM is an accurate method for extracting information about the spatial distribution of grey levels in an image. The edge pattern in fabric imges can be fully captured from its DCT coefficients in frequency domain. Classification is carried out with the help of Neural Networks, which provides fast and efficient classification.

The proposed method can be used for the inspection of plain fabrics as well as patterned fabrics. It is simple to understand and fast enough to be implemented online. The method gives good defect detection performance. Further research can be conducted to localize the defect present in the fabric, based on the features extracted in the proposed algorithm. If more images are available, we can also try to detect variety of defects from fabric images

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REFERENCES

[1] K.V.Naveen Kumar, U.S.Ragupathy "An Intelligent Scheme for Fault Detection in Textile Web Materials **"**International Journal of Computer Applications (0975 – 8887) Volume 46– No.10, May 2012

[2] R. Thilepa, K. Sathiyasekar "Automated Fabric Defect Recognition System using Image Processing and Artificial Neural Networks with the Support of Microcontroller" European Journal of Scientific Research ISSN 1450-216X Vol.67 No.4 (2012), pp. 595-601

[3] Rishav Dewan, Monika Aggarwal "Identification of Defects in Textiles Based on Statistical Analysis of DCT coefficients of Textile Images" Aarhat Multidisciplinary International Education Research Journal (AMIERJ)Peer-Reviewed Journal Volume No 1 Issues II 2012

[4] B K Behera and M P Mani "Characterization and Classification of Fabric Defects using discrete cosine transform and artificial neural networks" Indian journal of fibre and textile research vol 32 ,December 2007, pp.421-426

[5] Edmund Y. Lam and Joseph W. Goodman "A Mathematical Analysis of the DCT Coefficient Distributions for Images" IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 9, NO. 10, OCTOBER 2000

[6] P. Banumathi and Dr. G. M. Nasira "Fabric Inspection System using Artificial Neural Networks" International Journal of Computer Engineering Science (IJCES) Volume 2 Issue 5 (May 2012) ISSN: 2250:3439

[7] Atiqul Islam, Shamim Akhter, and Tumnun E. Mursalin, "Automated Textile Defect Recognition System Using Computer Vision and Artificial Neural Networks" World Academy of Science, Engineering and Technology 13 2008

[8] Swati F. Bhope, S. P. Patil **"**Defects dentification in Textile Industries**",** International Journal of Chemical Sciences and Applications. Vol 1, Issue 1, June, 2010

[9] Lin, H.D. and Ho, D.C. (2007), "Detection of pinhole defects on chips and wafers using DCT enhancement in computer vision system", International Journal of Advanced Manufacturing Technology, Vol.34, No.5-6, pp.567-583.

[10] Cho, C.S., Chung, B.M. and Park, M.J. (2005), "Development of real-time vision-based fabric inspection system", IEEE Transactions on Industrial Electronics, Vol.52,pp.1073-1079.

[11] Chan, C. H. and Pang, G.K.H. (2000)," Fabric defect detection by Fourier analysis", IEEE Transactions on Industry Applications, Vol.36, pp.1267-1276.

[12] S.Anitha, Dr.V.Radha," Comparison of Image Preprocessing Techniques for Textile Texture Images", International Journal of Engineering Science and Technology Vol. 2(12), 2010

[13] Michael UNSER, Frank ADE, "Feature extraction and decision procedure for automated inspection of textured materials**" ,** Pattern Recognition Letters 2 (1984) Elsevier Science Publishers

[14] Priyanka M. Shanbhag , Manish P. Deshmukh2 & Shekhar R. Suralkar, "Overview: Methods of Automatic Fabric Defect Detection", G.J. E.D.T., Vol. 1(2) 2012:42-46