Fabric Defect Detection using Discrete Wavelet Transform

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Abstract – *The main objective of our project is to detect the fabric faults of various types. The hardware platform and software is developed for solving this problem. In our project vertical yarn missing, horizontal yarn missing, oil stain and hole, such defects are detected using Discrete Wavelet Transform and KNN classifier. This system is introducing texture defect detection using decomposition of defective and defect free images. The system acquires the image by using image acquisition device. This system based on MATLAB R2017b(9.3.0.713579) software.*

Key Words: **Fabric inspection, Fabric defects, Discrete Wavelet Transform (DWT), Decomposition, KNN classifier, classification**

1. INTRODUCTION

Nowadays there are advances in machine visions and hardware, monitoring and classification process of industrial product can be performed automatically using intelligent software and high speed hardware. Product inspection is an important aspect in modern industry manufacturing. Any abnormality in the product surface is called the Defect. The problem of web inspection particularly, is very important and complex and the research in this field is widely open [1]. In the best manual case, a human can detect not more than 60% of the present defects and he cannot deal with the fabric wider than 2 meter and moving faster than30m/min [2]. Fabric automated visual inspection is becoming an attractive solution to the manual inspection in modern textile industry. An automated system can provide an objective and reliable evaluation on the texture production quality. Many methods have been developed which performs real-time fabric defect detection with significant accuracy. These methods can recognize around 95% of defects on the fabric. Figure 1 shows the hardware schematic for laboratory unit.

Zhang and Wong [3] have used Gabor filter wih the Modified Elman Neural Network and the recognition rate was too good. Bastruk, Yugnak [4] showed result about 99.8% using Gabor wavelets and Principle Component Analysis. Shuyue Chen and Jun Feng [5] introduced Singular Value Decomposition which has an excellent anti-noise property and no influence by the surrounding factors. XU Guo-Sheng [6] used Curve Fitting Techniques for fabric defect detection. Zhang et al. [7] have introduced Morphological technique for defect detection. Conci and Proenca [8] have used Fractal Dimension approach to detect the fabric defects. Using Co-occurrence matrix method 14 features were derived by Haralick [9]. Cumulative Histogram [10], Local Binary Pattern [11], Fourier Transform [12],[13],[14], such many methods have used to detect fabric defects.

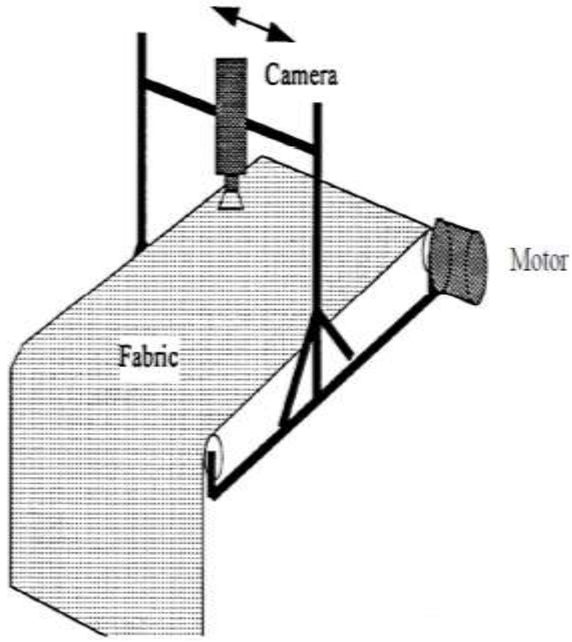


Fig -1: A schematic design of the laboratory test unit

2. WAVELET TRANSFORM

Wavelet Transform is defined as a multiresolution analysis of a finite energy function [15]. Wavelets convert the image into a series of wavelets (set of basis functions) that can be stored more efficiently than pixel blocks. The image is decomposes using high pass and low pass filters. The decomposition of an image is performed by decomposing their rows and columns as unidimensional signals [15]. Wavelet transform is capable of providing the time and frequency information simultaneously, hence giving a time-frequency representation of the signal. A wavelet series is a representation of a square-integrable function by a certain orthonormal series generated by a wavelet. Wavelet analysis provides more precise information about signal data than other signal analysis techniques. Wavelet transform is represented by,

$$X(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} \overline{\varphi\left(\frac{t-b}{a}\right)} x(t) dt$$

Where, a is scaling parameter and t is time.

Wavelet analysis can be performed in MATLAB and wavelet toolbox, by which wavelet transform coefficients can be computed. The toolbox include many wavelet transforms that use wavelet frame representations such as discrete, continuous, non-decimated and stationary wavelet transforms.

3. DISCRETE WAVELET TRANSFORM

Discrete wavelet transform, which transforms a discrete time signal into discrete wavelet representation. It has inherent multi-resolution nature and can be used in applications where scalability and tolerable degradation are important. The discrete wavelet transform uses the periodized extension mode, each of the two dimensions of the image must be a power of 2. DWT decomposes a signal into a set of mutually orthogonal wavelet basis functions. These functions differ from sinusoidal basis functions in that they are spatially localized i.e., nonzero over only part of the total signal length. Also these functions can be stored more efficiently than pixel box [16]. The DWT of signal x is calculated by passing it through a series of filters,

$$y[n] = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]\, g[n-k]$$

where g is impulse response of low pass filter

Properties [16] of DWT:

1. Wavelet functions are spatially localized.
2. Wavelet functions are dilated, translated and scaled versions of a common mother wavelet.
3. Each set of wavelet functions forms an orthogonal set of basis functions.
4. DWT is invertible, so that the original signal can be completely recovered from its DWT representation.

4. DWT ARCHITECTURE

In DWT architecture, the input image is decomposed [20] into high pass and low pass components using High Pass Filters and Low Pass Filters giving rise to first level of hierarchy. The process is continued until multiple hierarchies are obtained.

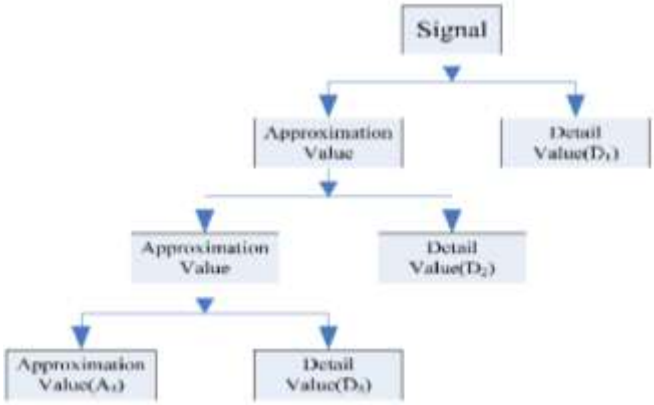


Fig -2: DWT Decomposition Architecture

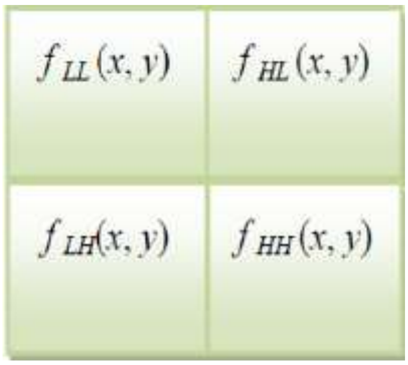


Fig -3: First level of Decomposition

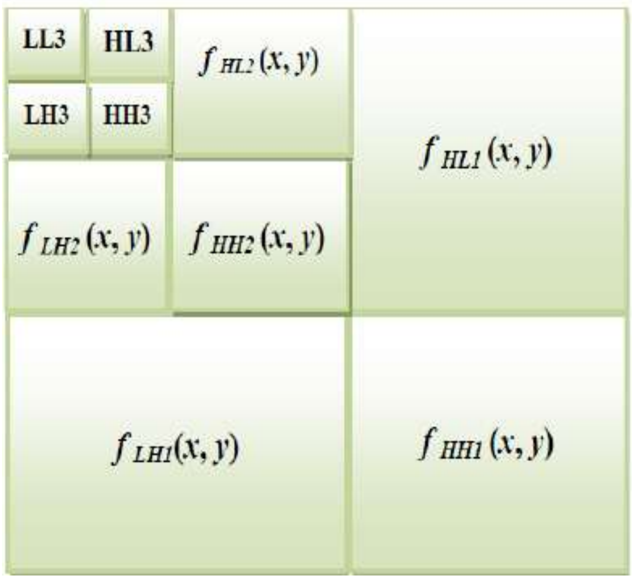


Fig -4: Third level of Decomposition

The 2D-DWT operates in a straight forward manner by inserting array transposition between two 1D-DWT. The rows of the arrays processed first with only one level of decomposition. This divides the array into two vertical halves in which the first half storing the average coefficient and the second vertical half stores the detail coefficients [19, 21]. This process is repeated with the columns resulting four sub-bands within the array defined by filter output. Approximation coefficient and detail coefficient is a one dimensional wavelet analysis function.

When the fabric image is decomposed it should choose the wavelet that has a good compact support, high vanishing moment and good symmetry, therefore DB wavelets family is selected as a better wavelet family for the fabric image decomposition [17, 18]. The Daubechies wavelets are a family of orthogonal wavelets defining a discrete wavelet transform and characterized by a maximal number of vanishing moments for some given support. With each wavelet type of this class, there is a scaling function (called the father wavelet) which generates an orthogonal multiresolution analysis.

5. K- NEAREST NEIGHBOUR CLASSIFIER

The k-nearest neighbor algorithm (k-NN) is a method for classifying objects based on closest training examples in the feature space. KNN is a simplest classification method than others. KNN is a method for classifying objects based on closest training examples in the feature vector. An object is classified by a majority vote of its neighbors [23]. K is always a positive integer and typically small. Training process of this algorithm is only consists of the storing features vectors and labels of the training images. KNN is a nonparametric algorithm [24] i.e. it does not make any assumptions on the underlying data distribution. J.Gao et.al. [22] Suggests the nearest neighbor is the best classification method. LiLi, Zhang YanXia et.al. [23] proves that the kNN is easier and simpler to build an automatic classifier.

6. PROPOSED ALGORITHM

1. Load the Test Texture image in JPG Format.
2. Reduce the noises in Test Texture image.
3. Convert the Test Texture image to Gray scale image.
4. Transform the gray scale image (spatial domain) into frequency domain using DWT. Extract the approximation coefficient matrix image using decomposition.
5. Classification of the image using KNN classifier.
6. Get the output whether the image is defect-free or defective.

7. FLOWCHART

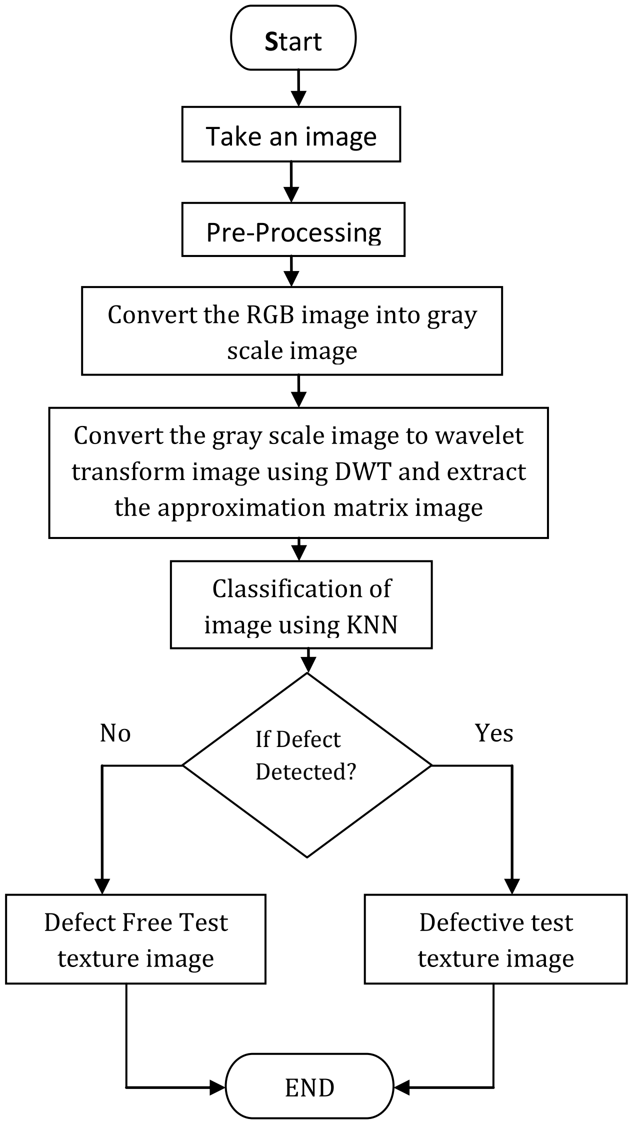


Fig -5: Flow Chart

8. SYSTEM HARDWARE AND SOFTWARE

8.1 Hardware

- Logitech Web-camera
- 5 rpm motor
- Roller system
- Lighting system uses normal 2 lamps

8.2 Software

- MATLAB software(9.3.0.713579), 64 bit
- Image processing tool

Fig -6: System Hardware

9. PERFORMANCE ANALYSIS IMGES AND TABLE

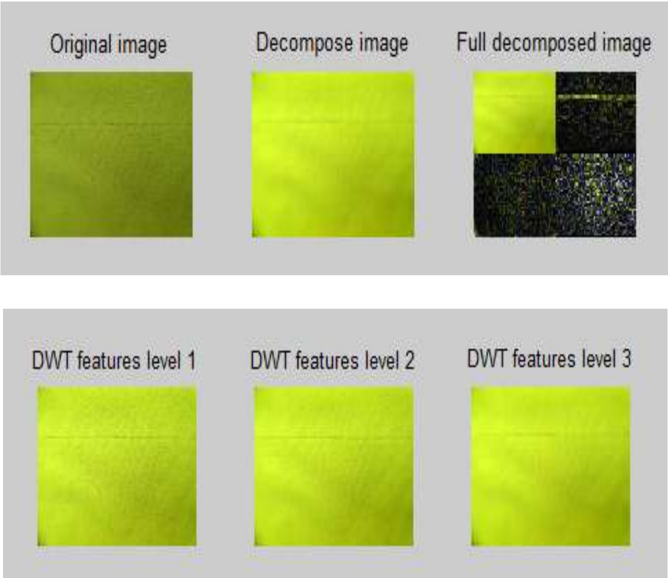
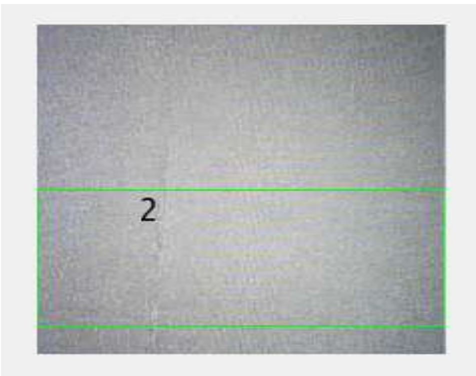
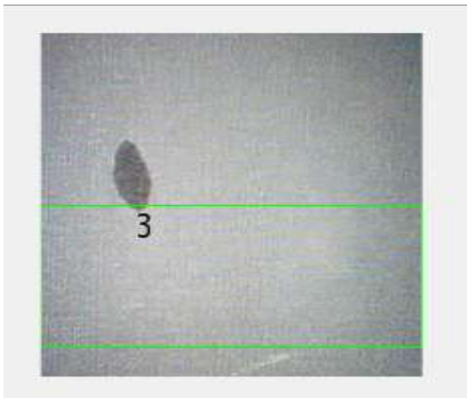


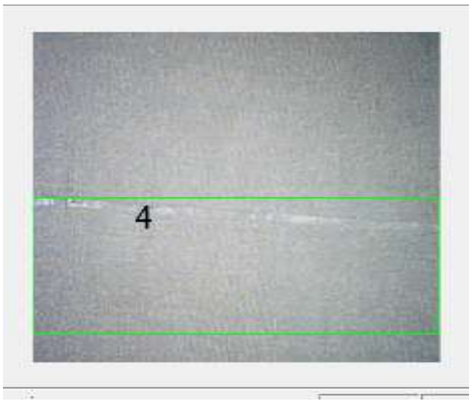
Fig -7 Third level decomposition of test image(Synthetic Fabric material)



(a)



(b)



(c)

Fig -9: Online Real Time Fabric faults images; (a) Vertical yarn missing; (b) Ink stain; (c) Horizontal yarn missing

Table-1: Result of various faults detection in %

Train Images in %	DWT and KNN Result in %				
	Good Fabric	Horizontal yarn missing	Vertical yarn missing	Hole	Stain
100	100	100	100	100	90
90	100	100	100	100	80
80	100	100	100	100	70
70	100	100	70	100	70
60	90	90	70	100	70
50	80	60	70	100	60

10. CONCLUSION

In this paper, we proposed a computational efficient method to identify the fabric faults. Discrete wavelet transform is a faster method than others. We have focused on the four types of fabric faults such as horizontal yarn missing, vertical yarn missing, oil/ink stain and hole, which occur frequently. The method can detect 95% of defects.

REFERENCES

[1] D. Brzakovic and N. Vujovic, "Designing a defect classification systems: a case study", *Pattern Recognition,* Vol. 29, NO. 8, pp. 1401-1419, 1996.

[2] Stojanovic and Mitropoulos, "Defect Detection and Classification on Web Textile Fabric using multiresolution decomposition and neural networks".

[3] Y.H. Zhang and W.K.Wong, "A new intelligent fabric defect detection and classificaton system based on Gabor filter and modified Elman Neural Network", 2010.

[4] Basturk and Yugnak, "Inspection of defects in fabrics using Gabor Wavlelet and Priciple Componets Analysis", 2007.

[5] Shuyue Chen and Jun Feng, "Research on Detection of Fabric Defects Based on Singular Value Decomsition", 2010.

[6] XU Guo-sheng, "The application of Curve Fitting Techniques in Fabric defect Detection", 2010.

[7] ZhangYF, Bresee RR, "Fabric defect detection and classification using image analysis." Journal of Textile research,1995, 65(1):1-9.

[8] A. Conci and C. B. Proenca, "A fractal image analysis system for fabric inspection based on box-counting method," Comput. Netw. IsDN syst., vol. 30, no. 20, pp. 1887-1895, Nov.1998.

[9] R. M. Harlick, K. Shanmugam and I. Dinstein, "Textural features for image calssification," IEEE Trans Syst., Man, Cybern., vol.3, no. 6, pp. 610-621

[10] H. Kauppinen, "A two stage defect recognition methd for parquet slab grading," in Proc. IEEE conf. pattern Recog., Barcelona, Spain,2000, vol-4, pp.803-806

[11] T. Ojala, M. Pietikainen, and D. Harwood, "A comparitive study of texture measures with classification based on featured distribution," Pattern recognition, 29(1):51-59, 1996.

[12]D. M. Tsai and C. Y. Heish, "Automated surface inspection for directional textures," Image Vis. Comput., vol. 18, no. 1, pp. 49-62, Dec 1999.

[13]L. M. Hoffer, F. Francini, B. Tiribilli, G. Longobardi, "Neural network for the optical recognition of defects in cloth," Optical Engineering 35 (11) (Nov 1996) 3183-3190.

[14]S. H. Chiu, S. Chou, J. J. Liaw, "Textural defect segmentation using a Fourier-domain maximum likelihood estimation method," Textile Resarch Journal 72 (3) (2002) 253-258.

[15]S. G. Mallat., "A theory for multiresolution signal decomposition: The wavelet representation", IEEE Transaction on Pattern Analysis ang Machine Intelligence, 11:674–693, 1989.

[16]Introduction to Discrete Wavelet Transform, 2004.

[17]Shengqi Guan, Jianchang Yuan, Ke Ma, "Fabric Defect Detection based on Wavelet Reconstructoin", 978-1-61284-774-0, IEEE, 2011.

[18]Shengqi Guan, Xiuhua, Shi, Haiying Cui, Yuqin Song, "Fabric Defect Detection Based on Wavelet Characteristics", 978-0-7695-3490-9, IEEE, 2008.

[19]Z. Ibrahim, S. Al-Attas, Z. Aspar, "Model-based PCB Inspection Technique Using Wavelet Transform", Proceedings of the 4th Asian Control Conference (ASCC), 2002.

[20]T.D.Venkateswaran, G.Arumugam, " Defect Detection In Fabric Images Using Two Dimensional Discrete Wavelet Transformation Technique", IJCSCN

[21]P.-C. Wu and L.-G. Chen, "An efficient architecture fortwo-dimensional discrete wavelet transform",IEEE Trans. Circuits and Syst. Video Tech., vol. 11, no. 4, pp. 536-545, April 2001.

[22]J. Gao, Z. Xie, and X. Wu, "Generic object recognition with regional statistical models and layer joint boosting," Pattern Recognition Letters, vol. 28, no. 16, pp. 2227-2237, 2007.

[23]LiLi, ZHANG YanXia and ZHAO YongHeng, "K-Nearest Neighbors for automated classification of celestial objects," Science in China Series G-Phys Mech Astron, Vol.51, no.7, pp. 916-922, 2008.

[24]Saravanan Thirumuruganathan, "A Detailed Introduction to K-Nearest Neighbor (KNN) Algorithm"