A Review of Automatic Fabric Defect Detection for Patterened Fabric

Sarojini Ganapati Naik[1], Prof. M.S.Biradar[2], Mr. K.B.Bhangale[3]
[1, 2, 3] Department of Electronics and Communication
[1, 2] Siddhant College of Engg., Talegaon – Chakan Road, Sudumbare
[3] Vishwakarma Institute of Technology, Kamshet, Pune

Abstract- *— This paper provides a review of automated fabric defect detection for patterned fabric. Fabric defect detection is necessary and essential in automation, as well as in quality control in the textile manufacturing industry. Human inspection is not an efficient method because errors may occur due to human fatigue and fine defects cannot be detected .So we require automatic fabric defect detection in industry to improve quality as well as to reduce labour and production cost. Patterned texture-like fabric is built on a repetitive unit of a pattern. Regularity is one of the most important features in many patterned textures. Many traditional approaches such as gray level co-occurrence matrices, autocorrelation, traditional image subtraction and hash function are based on periodicity concept. These approach includes image retrieval, image synthesis, and defect detection of patterned textures.*

Keywords— Fabric defect detection, patterned textures, periodicity,regularity.

I. INTRODUCTION

In textile industry fabric is made up of cotton or wool or nylon or polyester or combination of any of these. Defect is nothing but flaws on the fabric resulted during manufacturing process. Defects may be because of machine faults, yarn problems, poor finishing excessive stretching and among others. Textures can be classified into patterned regular textures and irregular textures. Nagan et.al. [3] introduced a regular band method for patterned textures. Regularity analysis very important feature because it is highly invariant but perceptually motivated feature. This paper focuses on the inspection of patterned fabric and produces a survey of various traditional techniques available. The researchers are finding difficulty in defect detection of patterned fabric compare to non-patterned fabric.

The patterned fabric gives an information about spatial relationship among the pixels than un patterned fabric.

II. TYPES OF FABRIC DEFECTS

There are many kinds of fabric defects. These defects are caused due to malfunctioning of the machines or machine spoils and etc. These defects in fabric reduces the quality of the product and hence loss in revenues[41].To avoid such problems automatic fabric inspection is essential and hence automatic fabric defect detection increases the efficiency of the product. Automatic inspection is done by finding faults in fabric using many of the image processing techniques.

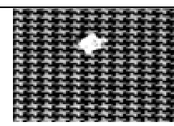
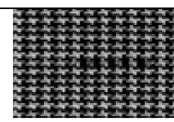
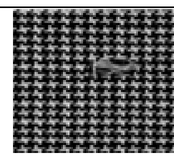
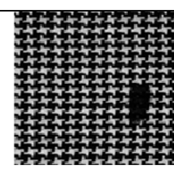
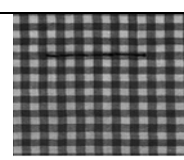
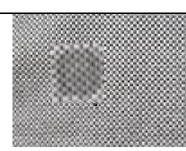
Type of Defect	Images
Hole	
Broken end	
Knitting multiple	
Thick bar	
Thin bar	
Oil Strain	

Fig. Defective samples in black star-patterned ,small box and box patterned fabric.

III. TEXTURE ANALYSIS TECHNIQUES OF FABRIC DEFECT INSPECTION METHODS

Regularity of patterned texture is spatial relationship between pixel intensities and the repeated distance of repetitive units. Spatial relationship is one pixel in an image should have dependencies and steady changes with its neighborhood on patterned structures. Repeated distance of repetitive unit is measurement that can monitor the pattern distorts and overlaps within its placement for the construction of whole image. The regularity is related to periodicity.

3.1 Co-occurrence Matrices:

The co-occurrence matrix method is also known as the spatial gray-level dependence method and is mainly designed by Harlick and Sharpio[42]. They have elaborated the different properties of co-occurrence matrix like entropy, energy, contrast, inertia, correlation, local homogeneity, dissimilarity and so on. It is based on repeated occurrences of different grey level in a texture. Gray level co-occurrence estimates the properties related to statistics i.e GLCM feature used for texture characterization. Co-occurrence matrix is basically a square matrix with elements corresponding to the relative frequency of occurrence of pairs of gray level values of pixels separated by certain distance in a given direction.

Conners et al. [21] have used some features of co-occurrence matrix to identify different kinds of defects in wood. Rosler [26] has also developed a system using co occurrence matrix features, which can maintain 95% of the defects as small as 1mm in size. To derive maximum texture information using co-occurrence matrix, the parameter values should be equal in orientation of the fabric pattern and distance should be equal to the pattern period [28]. The number of gray levels is usually reduced to minimize the size of the co occurrence matrix.

3.2 Auto Correlation:

Auto-correlation is a correlation between an image and its translated image. It gives information about repeated distance of repetitive unit in patterned texture.In defect free Fabric, no difference between gray values of the pixels and gray level in texture primitive[43]. In defective fabric difference in both intensity and geometrical defects. There is strike change in gray values of the pixels compare to defect free fabric. Cheterikov et.al. [9][10] defined contrast function between a polar representation of autocorrelation for an input image. Auto correlation merasures regularity, fitness, coarseness of texture along with dimension of a repetitive unit.

3.3 Traditional Image Subtraction(TIS):

One of the previous method for patterned fabric inspection is traditional image subtraction (TIS) method. In this method entire image of the test circuit board is subtracted from the perfect master image of the same type of circuit board. Chin and Harlow [11] used an exclusive-OR (XOR) operation for image subtraction in printed circuit boards (PCBs). It involves the subtraction of an entire image of the test circuit board from a reference image of the same type of circuit board. This method is based on repeat distance of a repetitive unit as well as the periodicity in patterned textures. Later, Tao et al. [33] and Sandy et al.[12] used same technique [34] on lace, which is kind of patterned fabric with fine and complex thread patterns. In TIS method First partitioning the input test image is done, then converting the gray level image to a binary image. Finally, XOR operation between the reference image (also called the golden image) and the test image is done. In TIS method Easy to choose the size of Golden Image with shortest time complexity as well as able to outline defective region after detection.

3.4 Hash Function:

Hash functions are one way functions, often used in cryptography to ensure the integrity of files by creating a binary signature specific to that file [13][14]. Hash function generates one dimensional signatures of an image. The resultant signature is compared with image having golden template or the image with repeating definite patterns, and with the texture itself. Baykal et al. [13], [14] used specially designed hash functions to generate signature values for each horizontal line of the image, resulting one dimensional signature waveforms for textures. Signatures have been used to preprocess image and approximate the location of the defects. Koshimizu [43] first used horizontal and vertical pixel sum values to extract approximate locations of regions containing defects. Hash function is time-saving due to 1D approach though it is sensitive to noise.

3.5 Near Infrared (NIR) Imagining Method:

The NIR method [15] is a hardware approach to utilizing near-infrared (NIR) illumination instead of the traditional visible (VIS) light source for patterned fabric defect detection. The defects are usually undistinguishable in the usual VIS image. Millan and Escofet [15] defines the basic patterned fabric structure as low energy structure signal where a different design like squares, circles are high energy signal. The high energy signal usually contains noises, so difficult to detect the defect. NIR illumination transforms the input image into a new NIR image that reduces the high energy signal.

Then, by thresholding, the defects like holes and broken ends can be detected. In NIR image contrast reduction of the superstructure signal(bands, square) helps in fabric inspection and defect segmentation in basic structure.

3.6 Image decomposition

In image decomposition [45] decomposed fabric image into cartoon structure as defective object and texture structure as repeated patterns. The image decomposition is optimized by finding the correlation between a given defect free fabric image and the texture structure of a testing image. A defective fabric image is the superposition of defective objects (cartoon structure) and patterned fabric (texture structure). The total variation and semi-norm in negative Sobolev space to regularize cartoon and texture structures, respectively.

IV. REVIEW OF APPROACHES WITH PERIODICITY

4.1 Golden Image Subtraction (GIS) method

The golden image subtraction (GIS) method [16] is designed for detecting defects of patterned fabrics and the WGIS is an improved version of GIS. A golden image can contain several repetitive units taken from a defect-free image. The golden image used in GIS, performing like a convolution filter on the test image, and it is not a static comparison between the golden template and the test image. The GIS method can highlight the defective region after thresholding on the image of energies of GIS for every input image. The GIS method is shift-invariant method and it is easy to choose the size of Golden Image with Shortest time complexity. GIS method can able to outline defective region after detection

4.2 Bollinger Bands (BB) Method:

Bollinger bands are calculated on the basis of standard deviation and originally used financial technical analysis to indicate oversold or overbought for stock. BB method is an efficient, fast and shift-invariant approach which can segment out the defective region in patterned texture. The patterned rows or columns generate periodic upper and lower band. For any defect, there is a break in periodicity in the pattern. For any change in the pattern there is a remarkable change in the upper and lower band. Ngan and Pang[18] extended Bollinger bands from one dimensional to two dimensional. Good results are obtained use of an appropriate bandwidth and period length. The upper and lower Bollinger bands can accentuate the defective information after calculation and attenuates the background information of patterned fabric. BB is built on the concept of moving average and standard deviation in which defects can be shown clearly in the final image and it is also applicable in on-loom machine.

4.3 Regular Band(RB) Method

The Regular Bands method is based on the idea of periodicity. A repetitive unit is the fundamental component of a patterned texture, which can be broadly viewed as either one-dimensional (e.g., periodic signal) or two-dimensional (e.g., patterned image). For example, in an one-dimensional view, applying an appropriate transformation to the defect-free region of a periodic signal can result in its explicit expression as an intuitive periodicity, which is defined as a new kind of regularity of the patterned texture. This transformation is constructed by using the structural characteristics of the repetitive unit of any patterned texture. The structural characteristic is obtained by using the repetitive unit as a convolution filter sliding on the test signal. The numerical values of an defective region would exceed the normal range of the signal. Therefore, by designing a suitable transformation, any numerical values of the abnormal part is significant enough to be segmented out using thresholding and the shape of any defective region can be outlined.In this method, defect is detected on the basis of regularity approach. In method signal generation for each vertical and horizontal line of the defect free region. If any defect is there then there is an irregularity of the signal. In this method moving average and standard deviation method is used.

V. CONCLUSION

The review of fabric defect detection methods is useful in defect detection of patterned fabric. The core ideas along with strengths are mentioned. Due to lack of uniformity in the image database, performance evaluation and nature of the intended application is not prudent to explicitly declare the best available method for fabric defect detection. Therefore the effective performance evaluation requires careful selection of data sets along with its clear definition of scope.

REFERENCES

[1] Chin R.T. (1987) Computer Vision, Graphics, and Image Processing, 41(3),346-381.

[2] Yang X. Pang G., and Yung N (2005) IEEE Proceedings Vision, Image Processing,152(6) 715-723.

[3] Ngan H.Y.T. and Pang G.K.H. (2009) IEEE Trans. on Automation Science and Engineering, 6(1).

[4] Sengottuvelan P., Wahi A. and Shanmugam A. (2008) Research Journal of Applied Sciences, 3(1) pp 26-31.

[5] Srinivasan K., Dastor P. H.,Radhakrishnaihan P., and Jayaraman S.(1992) J. text. Inst., vol. 83, no. 3, pp.431-447.

[6] R. M. Haralick and L. G. Shapiro, Computer and Robot Vision.Reading, MA: Addison-Wesley, 1991, vol. 1

[7] H. C. Lin, L. L.Wang, and S. N. Yang, "Regular-texture image retrieval based on texture-primitive extraction," Image Vis. Comput., vol. 17, pp.51–63, 1999.

[8] C. F. J. Kuo and T. L. Su, "Gray relational analysis for recognizing fabric defects," Textile Res. J., vol. 73, no. 5, pp. 461–465.

[9] D. Chetverikov, "Pattern regularity as a visual key," Image Vis.Comput., vol. 18, pp. 975–985, 2000.

[10] D. Chetverikov and A. Hanbury, "Finding defects in texture using regularity and local orientation," Pattern Recognit., vol. 35, pp. 2165–2180,2002.

[11] R. T. Chin and C. A. Harlow, "Automated visual Inspection: A survey,"IEEE Trans. Pattern Anal. Machine Intell., vol. PAMI-4, no. 6, pp.557–573, Nov. 1982.

[12] L. Tao, P. Witty, and T. King, "Machine vision in the inspection on patterned textile webs," IEE Colloq., pp. 9/1–9/5, Ind. Inspect. (Digest No: 1997/041).

[13] I. C. Baykal, R. Muscedere, and G. A. Jullien, "On the use of hash functions for defect detection in textures for in-camera web inspectionsystems," in Proc. IEEE Int. Symp. Circuits Systems, ISCAS, 2002, vol.5, pp. 665–668.

[14] I. C. Baykal and G. A. Jullien, "Detection of defects in textures withalignment error for real-time line-scan web inspection systems," inProc. IEEE MWSCAS The 2002 45th Midwest Symp. Circuits Systems,Aug. 4–7, 2002, vol. 3, pp. 292–295.

[15] M. S. Millan and J. Escofet, "NIR imaging of non-uniform colored webs: Application to fabric inspection," Proc. SPIE, vol. 5622, pp.188–193, 2004.

[16] H. Y. T. Ngan, G. K. H. Pang, S. P. Yung, and M. K. Ng, "Defect detection on patterned Jacquard fabric," in Proc. IEEE Int. Workshop on 32nd Applied Imagery Pattern Recognition, Oct. 2003, pp. 163–168.

[17] H. Y. T. Ngan and G. K. H. Pang, "Novel method for patterned fabric inspection using Bollinger bands," Opt. Eng., vol. 45, no. 8, Aug. 2006.

[18] Henry Y. T. Ngan, Student Member, IEEE, and Grantham K. H. Pang "Regularity Analysis for Patterned Texture Inspection" IEEE TRANSACTIONS ON AUTOMATION SCIENCE AND ENGINEERING, VOL. 6, NO. 1, JANUARY 2009 131

[19] M. Tuceryan and A. K. Jain, "Texture analysis," in Handbook of Pattern Recognition&Computer Vision, 2nd ed. Hackensack, NJ:World Scientific, 1999, pp. 207–248.

[20] Siew L. H., Hodgson R. M., and Wood E. J.(1988) IEEE Trans. Patt. Anal .Machine Intell., 10(6), 92-105.

[21] Conners R. W., McMillan C. W., Lin K., and Vasquez-Espinosa R. E. (May 1980) IEEE Trans .Patt. Anal. Machine Intell.,3(6),204-222.

[22] Iivarinen J. (2000) Proceedings of SPIE 4197, 140-145.

[23] Tsai I., Lin C., and Lin J. (Mar 1995) Text.Res. J., 65, 123-130.

[24] Harlick R. M., Shanmugam K. and Dinstein I. (1973) IEEE trans. Sys. Man Cybern.,3, 610-621

[25] Iivarinen J., Rauhamaa J., and Visa A.,(1996) In International Conference on Pattern Recognition, 4, 356–360.

[26] Rosler R. N. U. (1992) Mellind Texilberichte, 73, 292.

[27] Amet A. L., Ertüzün A., and Erçil A. (1998) Proc. IEEE Southwest Symposium on Image Analysis and Interpretation, 205-210.

[28] Zucker S. W., and Terzopoulos D. (1990) Image Modelling, A. Rosenfield (Ed.), 423-445.

[29] Bodnarova A., Williams J. A., Bennamoun M., and Kubik K. K. (1997) Proc. IEEE TENCON'97 Conf., Brisbane (Aus.), 307-310.

[30] Monadjemi A. (2004) PhD thesis,University of Bristol, UK.

[31] R.M. Haralick, “Statistical and Structural Approaches to Texture,” Proc. IEEE, vol. 67, no.5, pp. 786-804,1979.

[32] Y.F. Zhang and R.R. Bresee, “Fabric Defect Detection and Classification Using Image Analysis,” TextileResearch Journal, vol. 6, pp. 1-9, Jan 1995.

[33] L. Tao, P. Witty, and T. King, “Machine vision in the inspection on patterned textile webs,” IEE Colloq., pp. 9/1–9/5, Ind. Inspect. (Digest No: 1997/041).

[34] R. T. Chin and C. A. Harlow, “Automated visual inspection: A survey,” IEEE Trans. Pattern Anal. Machine Intell., vol. PAMI-4, no. 6, pp.557–573, Nov. 1982.

[35] H. Y. T. Ngan, G. K. H. Pang, S. P.Yung, and M. K. Ng,“Wavelet based methods on patterned fabric defect detection,” Pattern Recognit., vol. 38, no. 4, pp. 559–576, 2005.

[36] R. T. Chin and C. A. Harlow, “Automated visual inspection: A survey,” IEEE Trans. Pattern Anal. Machine Intell., vol. PAMI-4, no. 6, pp. 557–573, Nov. 1982.

[37] L. G. Shapiro and G. C. Stockman, Computer Vision. Englewood Cliffs, NJ: Prentice-Hall, 2001.

[38] R. Jain, R. Kasturi, and B. G. Schunck, Machine Vision. New York:McGraw-Hill, 1995.

[39] K. I. Laws, “Texture Image Segmentation,” Ph.D. dissertation, Univ.Southern California, Los Angeles, 1980.

[40] L. G. C. Hamey and T. Kanade, “Computer analysis of regular repetitive textures,” in Proc. DARPA Image Understanding Workshop, 1989,pp. 1076–1088.

[41] AUTOMATED FABRIC DEFECT DETECTION—A review Henry Y.T. Ngan & Grantham Kwok Hung Pang.

[42] R. M. Haralick and L. G. Shapiro, Computer and Robot Vision. Reading, MA: Addison-Wesley, 1991, vol. 1.

[43] L. M. Hoffer, F. Francini, B. Tiribilli, and G. Longobardi, “Neural network for the optical recognition of defects in cloth,” Opt. Eng., vol. 35,no. 11, pp. 3183–3190, Nov. 1996.

[44] Fabric Defect Detection Using Auto-Correlation Function - by E Hoseini

[45] Koshimizu, H.: Fundemental study on automatic fabric inspection by computer image processing. SPIE Imag. Appl. Aut. Ind. Ins. Ass. 182, 30–37 (1979)

[46] Patterned Fabric Inspection and Visualization by the Method of Image Decomposition Michael K. Ng, Henry Y. T. Ngan, Senior member, IEEE, Xiaoming Yuan, and Wenxing Zhang