International Journal of Scientific Research Engineering & Technology (IJSRET)
Volume 2 Issue 8 pp 472-478 November 2013 www.ijsret.org ISSN 2278 – 0882

Locating Fabric Defects Using Gabor Filters

Padmavathi S, Prem P, Praveenn D
Department of Information Technology, Amrita School of Engineering, Tamil Nadu, India

Abstract-
Quality inspection is the key aspect in a fabric industry. Developing an automatic visual inspection system requires a robust and efficient algorithm for finding defective area. Locating the defective area is required to cut the cloth at appropriate locations. In this paper Gabor filters are used to find the appropriate location of defects in a fabric image. The parameters of the filter bank are tuned before using it for the location identification. This method is tested for 16 different defects that commonly occur in fabric industry and the results are summarized.

Keywords- *Fabric defect detection, Defect location identification, Texture analysis, Gabor filter.*

1. INTRODUCTION

In textile industry, inspection of fabric defects plays an important role in the quality control. The current inspection task is primarily performed by human inspectors. This intensive labour results in human fatigue and hence cannot always give consistent evaluation of products. This signifies the need of automatic defect detection. The primary requirements of such a system will be greater accuracy, minimum time and minimum cost. The fabric image could be captured through a camera and from the image obtained the defect could be identified. The fabric image could be considered as a regular textured image. Any defect in the fabric results in image with different texture and hence texture analysis methods will be suitable in identifying the defects. Once the fabric is identified as defective, the location and the area of the defect needs to be identified. Depending on the location of the defects suitable algorithms could be framed for cutting the fabric at appropriate location and hence reduce the wastage of the cloth. Gabor filters are used to identify different textures. In the process of filtering, the texture with high intensity will get smoothened and also the texture with low intensity will get isolated[4].

The parameters of the Gabor filter needs to be chosen appropriately to isolate the defective region in the fabric image. After tuning the parameters a simple thresholding method is applied to segregate the defective area in the image. This paper discusses the choice of parameters and their performance in identifying 16 common defects that occur in the fabric industry.

2. Fabric Defects

In Textile industry, defects that are addressed at the point of fabric inspection or cutting are known as Fabric defects. The latest point where fabric defects should be addressed is at assortment procedure. Fabric defects should not appear in final garments. Based on the cause, fabric defects can be classified into colour defects, construction defects and defects caused by non-cleanliness. Based on the level of acceptance the defects are classified into Critical, Major and Minor. Critical defects are defects that are not allowed to be shipped, (ie) their presence should be 0%. Major defects are serious defects that are not allowed over 3%. Minor defects are defects that are not allowed over 5%. The percentage varies for major and minor defects based on the buyer's requirement. Some of the major fabric defects which occur very frequently are broken pick, ends out, float, holes, stitches, knots, loose threads, starting mark, oil stains and marks, bad selvedge, double pick, snarls, cracks and smash. The names of the defect and the corresponding images are shown in first two columns of Table 4.1.

Among these oil stains and oil marks look alike visually; however oil stains occurs in a group whereas if the stain occurs only on a single thread then it is said to be oil marks. Oil weft is the stain that occurs on the width wise thread and Oil warp is the stain that occurs in lengthwise thread. If the weft or warp threads are not stitched properly and floats around, then it is called as float defect. If the threads are not stitched properly and float around it is termed as stitch defect. Hole defect is the defect in which we can see through the fabric material because of the presence of a hole. These holes may vary in size. Bad selvedge is the defect if any kind of fault is found with respect to the selvedge of the fabric. In textile industry selvedge is the part that holds the fabric at one end. Knots and loose warp occur because of the threads being loosely stitched. In the former the knots are predominantly visible. In crack defect, the weft thread will be cut in between and will be missing for 4 or 5 lines. In Broken pick, the weft thread will be missing (i.e.) half cut in a single line. In Double pick defects, two weft threads will be present in place of a single weft thread. In loop defects, the weft threads will be missing at the edges of the fabric. In snarls, the weft threads will be twisted throughout its length. In starting mark defects, the weft thread will be missing from the beginning till the end. If some amount of thread is missing lengthwise then the defect is termed as ends out (like broken pick).

2.1 Texture Analysis

A Texture is defined as a feature that provides information in the spatial arrangement of colours or intensities in an image. It is characterized by the spatial distribution of intensity levels in a neighbourhood. It can also be defined as a repeating pattern of local variations in image intensity which cannot be defined for a point. There are four approaches to describe a texture; they are Structural, Statistical, Spectral and Modeling. In Structural approach, texture is described as a set of primitive texels in some regular or repeated relationship. In Statistical approach, texture is a quantitative measure of the arrangement of intensities in a region. In Spectral approach, texture is characterised in the frequency domain. In modeling approach, techniques involve constructing models to specify textures. Statistical methods are particularly useful when the texture primitives are small, resulting in micro textures. Identifying the defective area using statistical methods is difficult.

Spectral method is generally used because of its robustness and efficiency. In this approach, texture is characterised by texture primitives or texture elements, and the spatial arrangement of these primitives [9]. The high degree of periodicity of basic texture primitives, such as yarns in the case of textile fabric, permits the usage of spectral features for the detection of defects. However, random textured images cannot be described in terms of primitives and displacement rules as the distribution of gray levels in such images is rather stochastic. Therefore, spectral approaches are not suitable for the detection of defects in random texture materials. In spectral methods, the texture features are generally derived from the Fourier transform [10,11], Gabor transform [12, 13] or Wavelet transform [14]. The Fourier transform is an analysis of the global frequency content in the signal. Short Time Fourier Transform (STFT) does Fourier analysis through the windowed Fourier transform. It is not able to localise the defective regions in the spatial dependency. If the window function is Gaussian, the windowed Fourier transform becomes the well-known Gabor transform, which achieves optimal localisation in the spatial and frequency domain [15].

3. LOCATING FABRIC DEFECTS

Gabor filters are widely used for many texture related applications. The fabric image containing any one of the defect as discussed in section 2.1 is given as input to the system. A set of Gabor filters with different parameters, called the filter bank, are applied to the image. The average response of theentire filter bank is taken and converted to binary image by thresholding at T. Each filter in the filter bank has specific parameters. Since infinite number of filters are possible in the filter bank a choice of the appropriate filters is needed for the lesser computation cost and better accuracy. Tuning these parameters is necessary for identifying the location of defective area and is done using the un- defective fabric image.

3.1 GABOR FILTER

In Spatial domain, 2D Gabor fiter is a Gaussian kernel function modulated by a sinusoidal plane wave. Two-dimensional Gabor functions were proposed by Daugman [1] to model the spatial summation properties (of the receptive fields) of simple cells in the visual cortex. Gabor kernel function as shown in Equation 1, is a complex sinusoidal function which works on the specific frequency and orientation. It is the most suitable tool for boundary detection, texture image segmentation and texture classification[5,6,7],target detection, fractal dimension management, document analysis, edge detection, retina identification, image coding and image representation[2,3].

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma)=\exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\cos\left(2\pi\frac{x'}{\lambda}+\psi\right)$$

Where $x'=x\cos\theta+y\sin\theta$ and $y'=-x\sin\theta+y\cos\theta$

Eq (1)

The wavelength , orientation , phase offset , aspect ratio , and bandwidth / is called the parameters of Gabor kernel function [8].

3.2 GABOR FILTER PARAMETERS

3.2.1 Wavelength (λ)

This parameter represents the cosine factor of the Gabor filter kernel. Its values are specified in pixels which hold the real number value greater than or equal to 2. The value =2 should not be used in combination with phase offset =-90 or =90 because in these cases the Gabor function is sampled in its zero crossings. Then in order to avoid the undesired effects at the image borders and to get the better result, the wavelength value should be smaller than or equal to one fifth of the input image size.The images shown in Figure 3.1a,b,c, shows the Gabor filter kernels with values of the wavelength parameter of 5, 10 and 15 respectively. The values of the other parameters are orientation 0, phase offset 0, aspect ratio 0.5, and bandwidth 1.

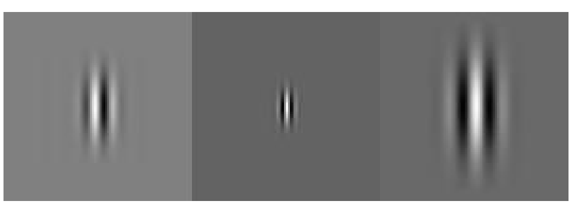


Figure 3.1 (a) (b) (c)

3.2.2 Orientation (θ)

This parameter specifies the orientation of the normal to the parallel stripes of a Gabor function. Its value is specified in degrees and it can fall between 0 and 360. This orientation value depends upon the orientation of the edges in the image. Only for that particular theta value, the results will hold perfect. The images in Figure 3.2 shows the Gabor filter kernels with orientation 90, 45 and 0 respectively. The values of the other parameters are: wavelength 10, phase offset 0, aspect ratio 0.5, and bandwidth 1.

Figure 3.2 (a) (b) (c)

3.2.3 Phase offset (ψ)

It is the argument of the cosine factor of the Gabor function with which its degree values are real numbers which varies between -180 and 180. The values 0 and 180 correspond to canter-symmetric functions, while -90 and 90 correspond to anti-symmetric functions and all other cases correspond to asymmetric functions. In this paper, the phase offset value is kept as = [0 pi/2] because =0 returns the real part of the image and =90 returns the imaginary part of the image. The images in Figure3.3 shows Gabor filter kernels with values of the phase offset parameter of 0, 180, -90 and 90 degrees, from left to right, respectively. The values of the other parameters are: wavelength 10, orientation 0, aspect ratio 0.5, and bandwidth 1.

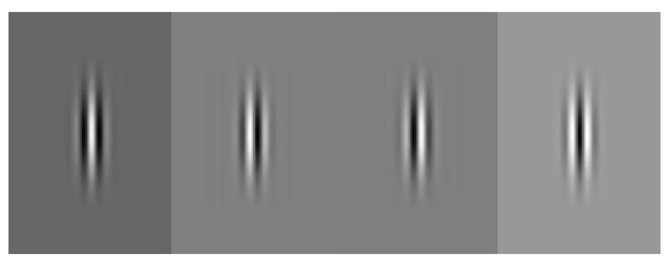


Figure 3.3 (a) (b) (c) (d)

3.2.4 Aspect ratio (y)

The spatial aspect of the kernel function is dependent on this parameter. For = 1, it is circular and for < 1 the support is elongated in orientation of the parallel stripes of the function and its default value is = 0.5.The images in

Figure 3.4 shows Gabor filter kernels with values of the aspect ratio parameter of 0.5 and 1, from left to right, respectively. The values of the other parameters are wavelength 10, orientation 0, phase offset 0, and bandwidth 1.

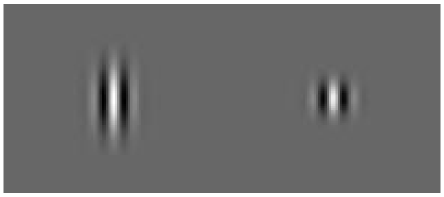


Figure 3.4 (a) (b)

3.2.5 Bandwidth (b)

The parameter, b depends on the ratio, where is the standard deviation of the Gaussian factor of the Gabor function and is the preferred wavelength. It is calculated as given in Equation2

$$b = \log_2 \frac{\frac{\sigma}{\lambda}\pi + \sqrt{\frac{\ln 2}{2}}}{\frac{\sigma}{\lambda}\pi - \sqrt{\frac{\ln 2}{2}}}, \quad \frac{\sigma}{\lambda} = \frac{1}{\pi}\sqrt{\frac{\ln 2}{2}} \cdot \frac{2^b + 1}{2^b - 1} \qquad (2)$$

The value of cannot be specified directly. It can only be changed through the bandwidth *b*. The bandwidth value must be specified as a real positive number. Default is 1, in which case and are connected as: = 0.56 . The smaller bandwidth results in larger , larger support of the Gabor function and larger number of visible parallel excitatory and inhibitory stripe zones. The images in Figure 3.5 shows Gabor filter kernels with bandwidth parameter 0.5, 1, and 2, from left to right, respectively. The values of the other parameters are wavelength 10, orientation 0, phase offset 0, and aspect ratio 0.5.

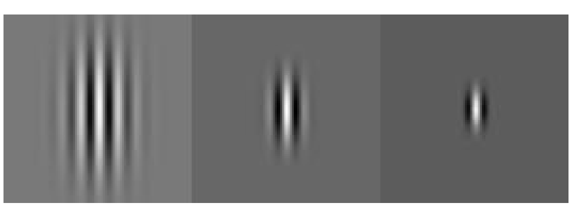


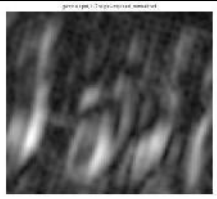
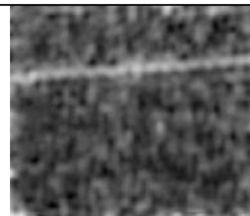
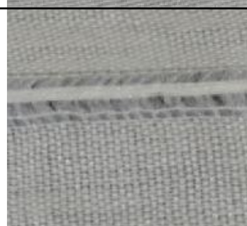
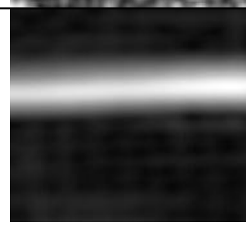
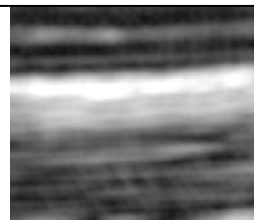
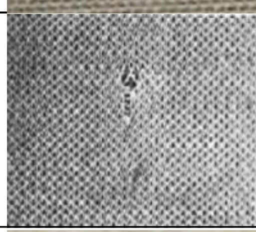
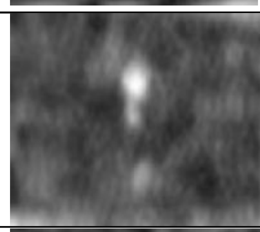
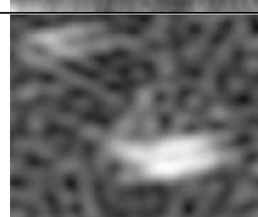
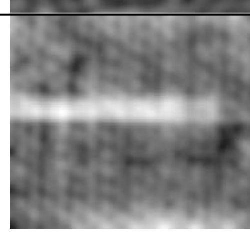
Figure 3.5 (a) (b) (c)

3.3 THRESHOLDING

In the process the filtered image will have the texture regions as low energy points and the defected region as high energy points. A hard threshold is applied on the response of the filter bank, to identify the defective area. This process results in a binary image where black pixels correspond to defect free area and white pixels correspond to defective area.

The algorithm is experimented on fabric images with 16 different defects that occur in the fabric industry. The defective images are taken from different fabric materials. The defect free portion is used for identifying the parameters. Among the parameters wavelength and bandwidth affect the response of the filter depending on the scale of the image (ie) when the thread is small and the defective area is restricted to few threads, the larger values of and smaller values of is required to identify the defective area. Aspect ratio and phase offset has minimal effect in identifying the defective area. Hence these parameters are kept constant. The orientation parameter affects the response of the filter depending on the orientation of the threads and the defective thread orientation. Hence the parameters and are identified from the un-defective image. These parameters are then used for the filter bank to identify the defective area. The average response is taken and thresholded, which result in a binary image showing the defective area in white color. The defective image, the filtered response and the binary image are shown in Table 1. To calculate the accuracy of the algorithm the defective area is manually selected by the user. The difference between the location selected by the user and the location given by algorithm is calculated.

International Journal of Scientific Research Engineering & Technology (IJSRET)
Volume 2 Issue 8 pp 472-478 November 2013 www.ijsret.org ISSN 2278 – 0882

Defect name	Input Image	Filtered image	Thresholded Image
Bad Shedding			
Double Pick			
Ends Out			
Float			
Holes			
Knots			
Loose Warp			

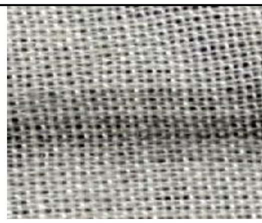
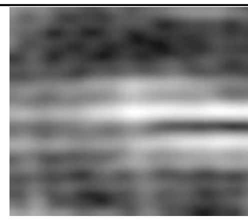
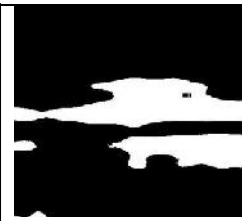
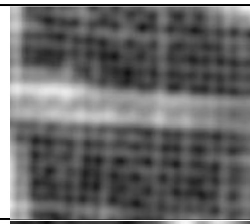
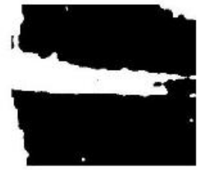
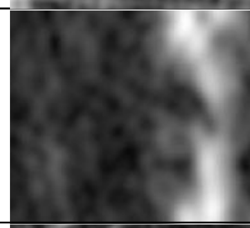
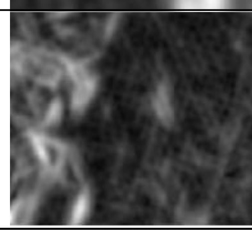
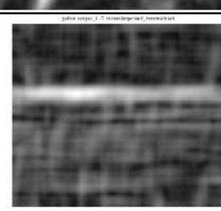
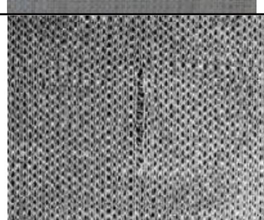
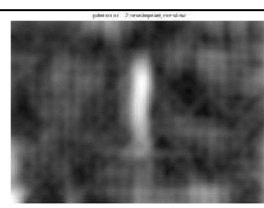
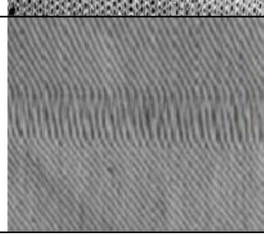
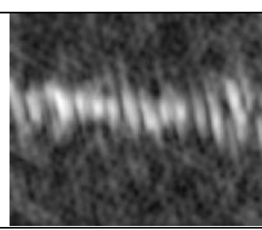
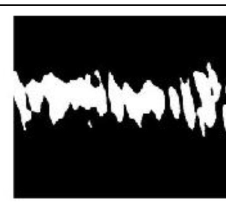
Oil Mark			
Oil Stain			
Selvedge Float			
Smash			
Starting Mark			
Stitches			
Weft Crack			

Table 1. Locating Fabric Defects

5. CONCLUSION

The experimental results conducted on various defective images shows that locating the defects in a fabric image can be achieved with proper tuning of the parameters of Gabor filter. When the defective area is small the wave length parameter should be large. The orientation parameter tuned to the orientation of the thread. The Gabor Filter followed by thresholding helps to find the location of the defect with very small false alarms. This algorithm gives 83.5% overall accuracy in locating the defects.

ACKNOWLEDGMENT

We wish to express our profound gratitude to Prof. K.Gangadharan, HOD of Information Technology of Amrita University. We also wish to express our sincere gratitude to all the staff members who has given us their valuable input.

REFERENCES

[1] J.G. Daugman:*"Uncertainty relations for resolution in space, spatial frequency, and orientation optimized by two-dimensional visual cortical filters", Journal of the Optical Society of America A*, 1985, vol. 2, pp. 1160-1169.

[2.]N. Petkov and P. Kruizinga, "*Computational models of visual neurons specialised in the detection of periodic and aperiodic oriented visual stimuli: bar and grating cells", Biological Cybernetics,* **76** (2), 1997, 83-96.

[3] P. Kruizinga and N. Petkov, " *Non-linear operator for oriented texture", IEEE Trans. on ImageProcessing,* **8** (10), 1999, 1395-1407.

[4]K.N.Sivabalan and Dr.D.Gnanadurai / *International Journal of Engineering Science and Technology (IJEST), "Efficient defect detection algorithm for gray level digital images using gabor wavelet filter and Gaussian filter"*,ISSN : 0975-5462 Vol. 3 No. 4 Apr 2011 3195 .

[5] A. Bovik, M. Clark, and W.Geisler., "*Multichannel texture analysis using localised spatial filters", IEEE Truns. on PAMI*,12(1):55-72, January 1990.

[6] D. Dunn and E. Higgins., "*Optimal Gabor filters for texture segmenation",. In IEEE Transactions on Image Processing*,volume 4, pages 947-964, July 1995.

[7] I. Fogel and D. Sagi.,"*Gabor filters as texture discriminator",Biological Cybernetics,* 61:103-113, 1989.

[8] D.M. Tsaia, S.K. Wua, and M.C. Chen,"*Optimal Gabor filter design for texture segmentation using stochastic optimization," Image and Vision Computing*, vol. 19, pp. 299-316, 2001.

[9] F. Vilnrotter, R. Nevatia, and K. Price, (1986) *IEEE Transactions on Pattern Analysis and Machine intelligence*, 8:76–89.

[10] Wechsler H., *"Texture Analysis-a survey",Signal Processing*, 2,271-282, 1980.

[11] Azencott R., Wang J. –P., and Younes L., *"Texture classification using Windowed Fourier Filters",IEEE Trans. Pattern Anal. Mach. Intell.*19,148-153, 1997.

[12] Daugman J. G., *"2-D Gabor function - interactive visualization", Journal of the Optical Society of America*2, 1160-1169, 1985.

[13] Clark M. and Bovik A. C., *Texture segmentation using Gabor modulation/demodulation ",PatternRecognition Letters6, 261-267, 1987.*

[14]Mallat S. G., , "*A theory for multiresolution signal decomposition: The wavelet representation ",IEEE Trans. Pattern Anal. Mach. Intell.*, 11, 674-693., 1989.

[15] Daugman J., *"Two-dimensional analysis of cortical receptive field profiles",Vision Research*, 20,847–856.

Author

S. Padmavathi, B.Tech, Information Technology, Amrita University, Coimbatore, Tamil Nadu, India

P. Prem, B.Tech, Information Technology, Amrita University, Coimbatore, Tamil Nadu, India

D. Praveenn, B.Tech, Information Technology, Amrita University, Coimbatore, Tamil Nadu, India