Fabric Defect Detection Using Image Fusion in Log Gabor Filter

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Abstract: Background: Defect detection of textiles is a necessary requirement for quality control and customer satisfaction. Quality inspection process for textile fabrics is mainly performed manually by inspectors; however, manual detection may be particularly challenging due to the large number of fabric defect classes, which are characterized by their vagueness and ambiguity. Thus, manual defect detection in fabric is insufficient and costly, so the automated fabric inspection is required. **Material and Methods:** In this paper, a new defect detection algorithm based on log Gabor filter is proposed to deal with the problem of automated defect detection for textile fabrics. This algorithm was based on the idea of image fusion using the log Gabor filters resulted. **Results:** The performance of the proposed algorithm is experimentally tested and evaluated by using a wide variety of homogeneous textile images with different types of common fabric defects. The test results obtained accurate, effectiveness and better performance for defect detection. **Discussions:** Experimental results demonstrate the efficiency and performance achieved by performing image fusion in log Gabor.
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1. Introduction

Defect detection is defined as an important problem in localization of abnormal surface areas in industrial products such as paper, textile, aluminum plates, etc.

It has been estimated that the price of fabrics is reduced by 45%–65% due to the presence of defects [1]. Therefore, in order to ensure the quality control in fabric industry, all products must be tested against deficiencies, and thus any defect must be detected, repaired or replaced. However, this task is currently performed by human labor which may not always give consistent results [10]. Human labor can be replaced by Fabric Automatic Visual Inspection (FAVI) system to perform the task of defect detection [2]. Image processing techniques like recognition provide more reliable results than human inspection, which also give more objective and stable performance.

The texture materials can be divided into uniform, random or patterned textures. While texture defects may be caused by many reasons, much of them are caused by machine malfunctions. Other defects are caused by faulty yarns or machine spoils [2].

In this paper we focus on fabric textiles. In the literature automated defect detection techniques for fabric textiles have three main approaches: statistical approaches, spectral approaches and model based approaches as in [1]. In this paper we proposed a spectral approach using log Gabor filter.

There are various fabric defect detection techniques based on the Gabor filters. In [3,9] a method of detecting the fabric defects automatically was proposed based on Gabor filters. It was based on the energy response from the convolution of Gabor filter banks in different frequency and orientation domains. They used the image fusion (geometric mean) and thresholding and resulted with a binary image that gives an indication whether it is defected or not.

Authors in [4] proposed a Gabor filter strategy based on scale transformation, the Gabor filter banks were convolved with normal fabric image to extract normal texture features. Then the convolution of Gabor filter banks and defected image is carried out to obtain the deviation images, and then they are fused. Lastly the fabric defects are detected by threshold processing.

However the Gabor filter has some limitations which are discussed in the next section, so in this paper a new algorithm based on log Gabor filter is presented for uniform fabric textiles.

2. Material and Methods

2.1 Log Gabor filter based feature extraction

Gabor filters are a traditional choice for localization of spatial and frequency information. But the Gabor filters have some limitations in bandwidth where the maximum bandwidth is limited to one octave and Gabor filters are not optimal if one is seeking broad spectral information with maximal spatial localization[5]. In [6] Field proposed an alternate method to perform both the DC compensation and to overcome the bandwidth limitation of a traditional Gabor filter. Field suggests that natural images are better coded by filters that have Gaussian transfer functions when viewed on the logarithmic frequency scale instead of a linear one. It lets more information to be captured in the high frequency areas and also has desirable high pass characteristics.

The Log-Gabor filters are defined in log-polar coordinates of the Fourier domain as Gaussians shifted from the origin.

The log Gabor filter bank is given by the formula [7]:

$$G(\rho,\theta,s,t) = exp\left(-\frac{1}{2}\left(\frac{\rho-\rho_s}{\sigma_\rho^2}\right)^2\right) exp\left(-\frac{1}{2}\left(\frac{\theta-\theta_{st}}{\sigma_\theta^2}\right)^2\right) \quad (1)$$

Where $\boldsymbol{\rho}$, $\boldsymbol{\theta}$ is the log-polar coordinates -octave scales. $\boldsymbol{s}$ indicates the scale, $\boldsymbol{t}$ indicates the orientation. $\boldsymbol{\rho_s}$, $\boldsymbol{\theta_s}$ are frequency centers of filter and $\boldsymbol{\sigma_\rho}$, $\boldsymbol{\sigma_\theta}$ is the angular and radial bandwidths.

The log Gabor filter bank are constructed in terms of two Components: the Radial and angular component [8].

Also some parameters are required to design Log-Gabor filter such as the following:

- The minimum frequencies wish to cover, and is set by the wavelength of the smallest scale filter
- The number of filter scales.
- The number of filter orientations to use.
- The angular overlap of the filter transfer functions which is controlled by the ratio of the angular interval between filter orientations and the standard deviations of the angular Gaussian spreading function.

2.2 Image Fusion

Image fusion is a process of combining images, obtained by sensors of different wavelengths simultaneously viewing of the same scene, to form a composite image. [11] Consequently, the resulting image will be more informative than input images.

Image fusion can be applied in either spatial or frequency domain. There are many fusion techniques and rules, in [12], author categorized image fusion rules into two parts, Pixel based fusion rule, and Window based fusion rule.

In the first rule, manipulation occurs at respective pixel values among two input images. But in the second rule, the fused pixel depends on the neighborhood pixels of the respective one.

2.3 The Proposed Algorithm

In the proposed technique, uniform fabric textile images are tested against defects that may not be revealed by the critical eye. Our technique makes use of energy response from the convolution of Log Gabor filter banks in different frequency and orientation domains.

The proposed defect detection algorithm applies fast Fourier transform to the image, then uses the log Gabor filter to localize frequency information and get the set of log Gabor filter images. Then Image fusion is performed by direct multiplication of the set of log Gabor filtered images in different scales and orientation to get a single fused image, followed by applying filtering techniques to remove the noise. The connected components in the resulting image labeled to decide whether the image is defected or not. The detailed steps for the proposed algorithms are listed below:

Step 1: input the defected colored image d(x,y) to the detection system.

Step 2: Convert image d(x,y) to grayscale to get the grayscale image f(x,y).

Step3: Apply Fast Fourier transform to get the image in the frequency Domain F(u,v).

Step4: Apply Log Gabor filter on F(u,v) ,with scale=5, orientation=7 to get the convolved images set G(s,r).

Step5: Apply image fusion(direct multiplication) on the filtered images set G(s,r) in the spatial domain get the image g(x,y).

Step 6: Apply median filter on g(x,y) to get the filtered image s(x,y).

***Step** 7*: label the connected components in s(x,y), and decide whether the image is defected or not.

The previous steps are shown in the block diagram in figure 1.

3. Results

To measure the performance for the proposed algorithm we used a set of uniform fabric textile images (twenty images), nineteen images are defected with different common fabric defects, and one is normal image.

The log Gabor is applied on each image in the image set. The bandwidth of Log-gabor is set by the ratio of standard deviation of a Gaussian function in log-frequency domain to the filter center frequency which is assumed to be 0.55 in our experiments, resulting in bandwidth of approximately 2 octaves. The set of images was constructed with a total of 7 orientations and 5 scales. The minimum overlap that is used to get the even spectral coverage is set to the value 1.9.

The proposed algorithm decides whether the image is defected or normal. In the proposed algorithm twenty images were tested, 19 out of 20 images were found to be defected and one image was normal, which what we get in the manual test by critical eye.

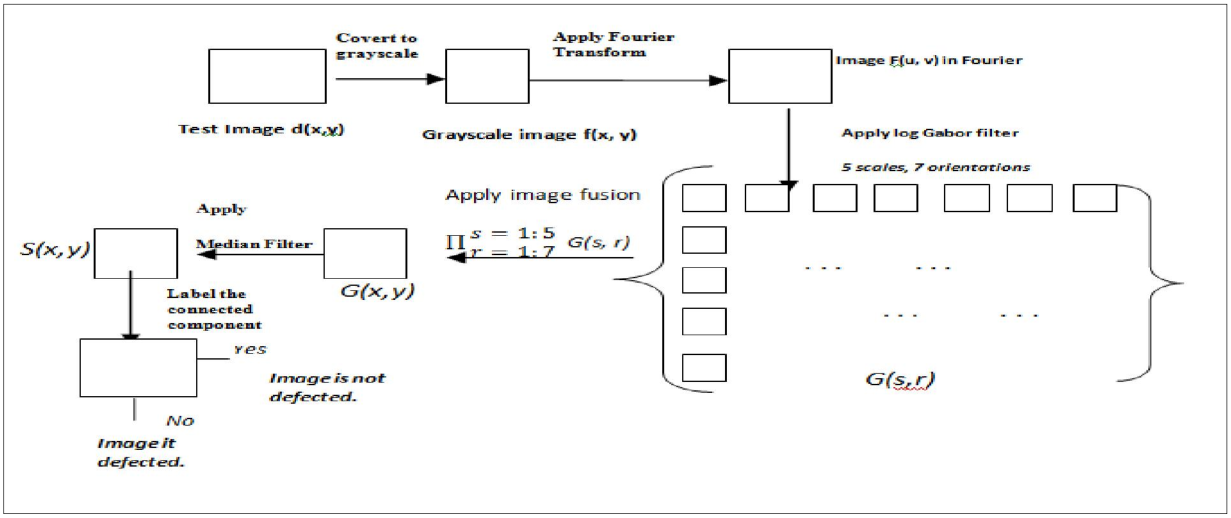

Figure 1. Block Diagram for the proposed algorithm

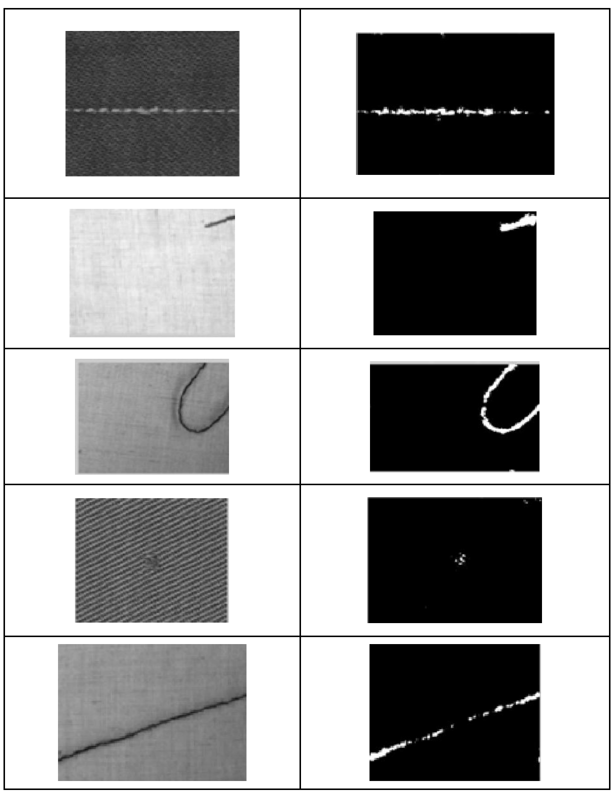

Figure 2: defected fabrics in the left, along with the defect detection resultant images in the right.

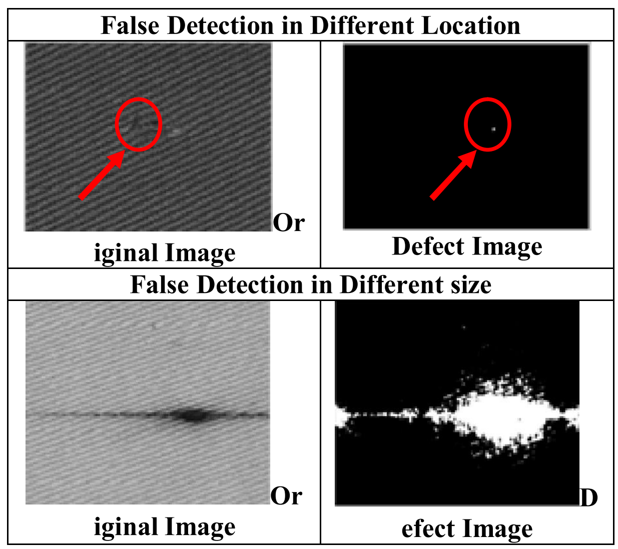

Figure 3: False detection in different location or size.

In the case of the defected images we classified the results into two categories: (1) **True detection** which means that the defect is detected in the correct (expected) Location and with the same size, (2) **False detection** which means that the defect is detected in the image but in different place or in different size.

According to what was discussed previously, 14 out of 19 images were found truly defected.

Figure 2 shows a set from them where the defected fabric images in the left side and the defect detection images in the right side.

On the other hand, five images out of 19 were found with false detection. One image had a false detection in the location of the defect and three images with hole defects had growth in defect than the original one, false detection in different location or size is shown in figure 3.

3. Conclusion

This paper has presents a new algorithm for defect detection of gray level of textile image using convolution of log Gabor filter in different scales and orientations. After the image fusion applied by direct multiplication to combine all set of images into a single image then the filtering technique applied to reduce the noise.

The performance of the proposed defect detection scheme has been evaluated by using fabric defects images in different types, sizes, and shapes of defects. The results obtained have shown that the scheme presents a simple and effective defect detection method and this method has accurate location of defects in the fabric.

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