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Automatic Defect Detection of Patterned Fabric via Combining the Optimal Gabor Filter and Golden Image Subtraction ⋆

Junfeng Jing*, Shan Chen, Pengfei Li

School of Electronic and Information, Xi'an Polytechnic University, Xi'an 710048, China

Abstract

A new algorithm based on optimal Gabor filter and the basic Golden Image Subtraction (GIS) is presented for patterned fabric defect detection. Firstly, the defect-free patterned fabric images are processed to search optimal real Gabor filter parameters using traditional Genetic Algorithm (GA). Then test patterned fabric images are filtered according to the obtained optimal real Gabor filter. Furthermore, the basic GIS are adopted to perform subtractions between golden images from referenced fabric images and test images to get resultant images. Finally, thresholding is obtained by training a large amount of defect-free patterned fabric samples to segment defects from fabric background. Experiment results indicate that the average detection success rate is up to 96.31% with ninety defective patterned images and ninety defect-free patterned images. It demonstrates that the proposed method is more efficient.

Keywords: Defect Detection; Gabor Filter; GIS; Genetic Algorithm; Patterned Fabrics

1 Introduction

The market value of patterned fabric is much higher than other fabrics in commercial world. Thus patterned fabric defect detection is an important procedure for fabric quality assurance, and automatic fabric defect detection research has a far-reaching significance, which is an inevitable trend of textile industry development.

Nowadays, existed approaches for fabric defect detection are mainly for non-patterned fabric, which have achieved over 95% recognition success rate [1,2] and have been broadly characterized as statistical, spectral, model-based [3,4]. But it has a few methods for patterned fabrics. One of the reasons is repetitive design that provides more underlying information; the other is complicated and varied fabric texture transform.

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*Corresponding author.
Email address: jingjunfeng0718@sina.com (Junfeng Jing).

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The main theories are presented in patterned fabric detection. Baykal et al. have adopted hash functions [5,6] for the sake of inspecting patterned fabric defect. The method is time-saving, while it is sensitive to noise and cannot outline defect shape. Bollinger Band (BB) method [7] has been basically used in the stock market for overbought and oversold shares, which can segment fabric defect with clean and clear images, but it cannot properly align input images and reference images. Sandy et al. [8], Li et al. [9] have used Traditional Image Subtraction (TIS) method which is based on Exclusive-OR operation on lace patterned fabric. However, TIS cannot do perfectly pixel-by-pixel comparison between golden template and test area. Then, Direct Thresholding (DT) [1] method adopts the fourth level of vertical and horizontal extraction of detailed sub-images with Haar Wavelet decomposition. Although the DT method is immediate and fast, output images are coarse in resolution. Afterwards, the basic GIS method [1, 2] is applied in golden image and test image in order to get resultant image. The GIS method has better performance than TIS but the result is not perfect due to excessive white noises in acquired images. To address this problem, the Wavelet preprocessed Golden Image Subtraction (WGIS) [1, 2] is proposed. Though overall success detection rate is 96.7%, only the common dot-patterned fabric is tested. In the following, the basic Regular Bands (RB) method [10, 11] utilizes distance matching function to determine the periodic distance of length and width of regular band in regular patterned fabrics, the fabric defects are extracted from fabric background by comparing two features of regular band to thresholdbut the method only is appropriate for periodic and regular patterned fabrics.

Kumar et al. [12–16] have summarized that Gabor filter is especially effective for fabric defect detection due to the property of optimal localization in both space domain and frequency domain with multiple dimensions and orientations. In our work, a new method based on Gabor filter and GIS method was presented. The proposed method involves three stages as shown in Fig. 1: training stage, obtaining threshold stage and defect detection stage. In the training stage, a set of fault-free patterned fabric samples are used in obtaining the optimal Gabor filter parameters that match special fabric texture via GA [17]. In the obtaining threshold stage, thresholding for discerning defect-free and defective patterns can be determined by Direct Threshold (DT) [1, 2] method. In the defect detection stage, by means of GIS, resultant images of the test images can be gained. Then, the fabric defect is extracted from the fabric background by comparing thresholding with the energy value of test image.

The paper is organized as follows: Section 2 mainly describes the theories involved, which includes basic Gabor filter, optimal Gabor filter via GA, basic GIS method and Direct Threshold (DT) method. Section 3 presents the proposed method for detecting the presence or absence of defects in an inspection image. Section 4 provides experimental results in fabric defect detection and evaluates the performance of the proposed method. The detail conclusion is described in Section 5.

2 The Theories Involved

2.1 Gabor Filter

Real and imaginary part of a typical Gabor filter are called as real and imaginary Gabor filter, respectively. The real part is even function, which is usually used to derive excellent blob detections in the field of image processing [18]. The imaginary part is odd function, which is an effective edge detection operator and usually utilized to derive excellent edge detectors [19].