Journal of Fiber Bioengineering and Informatics 8:2 (2015) 259–266
doi:10.3993/jfbim00122

Automatic Inspection of Woven Fabric Density Based on Digital Image Analysis ⋆

Junfeng Jing*, Qiying Deng, Pengfei Li

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

Abstract

In order to inspect woven fabric density automatically, a method combining image processing and multi-scale wavelet transform is proposed in this paper. Firstly, fabric images are pre-processed by Bimodal Gaussian function histogram equalization to obtain more structure information. Secondly, fabric images are decomposed into horizontal and vertical sub-images by using wavelet filter. Thirdly, texture features are extracted from the sub-images through binarization and smooth processing. Finally, density of yarns is acquired accurately after analyzing features of warps and wefts of the fabric. The experiment results prove that the proposed algorithm is perfectly suitable for three principle weaves and the relative error of automatic inspection compared with manual inspection is less than 0.86%.

Keywords: Fabric Density; Woven Fabric; Wavelet Transform; Smooth Processing; Binarization

1 Introduction

Fabric density is an important index in inspection of the fabric quality. However nowadays fabric density inspection relies on traditional manual operation with the aid of a magnifying glass, microscope and so on [1]. Manual analysis is time-consuming, and results are greatly influenced by subjective factors of checkers, which might lead to different results among different checkers. Therefore, textile industries have a demand of an objective and accurate recognition system, which can obtain the woven fabric density with high speed, to satisfy the need of flexible production. With development of computer vision, pattern recognition, image processing and analysis, some relevant algorithms are presented to detect woven fabric density and many achievements have been obtained. T. J. Kang [2, 3] extracts reflected light image and transmitted light image of fabric style with the illumination system. However, this method can only be applied in few fabrics. Gray level co-occurrence matrix is proposed by J. J. Lin in [4] for density inspection, which is just suitable for plain weaves. B. Xu [5] uses the inspection method based on Fast Fourier

⋆Project supported by the the Scientific Research Program Funded by Natural Science Foundation of China (No. 61301276), Xi'an Polytechnic University Young Scholar Backbone Supporting Plan, Discipline Construction Funds of Xi'an Polytechnic University (No. 107090811), and the Xi'an Polytechnic University Scientific Research Foundation for Doctors (No. BS1416).

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

Transform (FFT) which is applied to acquire energy spectrum diagram. M. Tunák et al. [6] use Fourier transform to obtain frequency spectrum image of fabric. By selecting the horizontal and vertical center region of frequency spectrum to reconstruct fabric image, the reconstructed image only consists of warp or weft and then the density of the fabric is calculated. But the method based on Fourier transform is only applicable to monochrome fabrics. Comparing with the Fourier transform, wavelet transform could select a particular frequency band or scale in transformation [7]. Therefore, it is conducive to choose more effective texture information and give up some unrelated texture information making it possible to improve the speed and accuracy of texture analysis.

In this paper, an automatic assessment of woven fabric density based on image processing technology is proposed. Woven fabric image is preprocessed by median filter and Bimodal Gaussian function histogram equalization algorithm in order to filter noise and improve contrast. Then wavelet transformation is applied to decompose the pre-processed image into horizontal and vertical sub-images. After extracting and analyzing features of sub-images, woven fabric density is achieved accurately. The main process of woven fabric density is indicated in Fig. 1.

Fig. 1: Flow diagram of automatic inspection of fabric density

2 Wavelet Transform

Wavelet transform is inherited and developed from traditional Fourier transform. With good localization properties both in the time domain and frequency domain analysis and focusing on the details of any local information, wavelet transform is widely used in signal processing, pattern recognition and many other fields [8, 9]. The definition of wavelet transform is shown as follows.

$$W_f(a,b) = \int_{-\infty}^{+\infty} f(t)\psi_{a,b}(t)dt = \int_{-\infty}^{+\infty} f(t)a^{-\frac{1}{2}}\psi\Big(\frac{t-b}{a}\Big)dt \tag{1}$$

where, a is the dilation factor, b is the translation vector and ψ is Fourier transform.

Continuous Wavelet Transform (CWT) and Discrete Wavelet Transform (DWT) are two types of wavelet transform including. The reason of applying DWT is that only the discrete signals could be processed by computer [10]. Discrete wavelet transform coefficient is shown in Eq. (2):

$$C_{a,b} = \int_{-\infty}^{+\infty} f(t)\psi_{a,b}(t)dt \tag{2}$$

where, the reconstruction function is given in Eq. (3).

$$f(t) = C\sum_{-\infty}^{+\infty}\sum_{-\infty}^{+\infty} C_{a,b}\psi_{a,b}(t) \tag{3}$$

where, C is a constant independent signal.