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Automatic Measurement Method of Yarn Dyed Woven Fabric Density via Wavelet Transform Fusion Technique ⋆

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Abstract

The yarn density is always considered as the fundamental structural parameter used for the quality evaluation of woven fabrics. Conventional yarn density is measured by one-side image analysis. In this paper, a novel density measurement method is developed for yarn dyed woven fabrics based on dual-side fusion technique. Firstly, both face-side and back-side image of woven fabric are acquired via a lab-used dual-side imaging system. Secondly, the affine transform is used for dual-side image alignment. Then, the color images of woven fabrics are transferred from RGB to CIE-Lab color space, the intensity information of image extracted from L component is used for the texture fusion and analysis. Subsequently, the dual-side image is merged by the self-developed Wavelet transform fusion method. Finally, the fast Fourier transform is utilized to measure yarn density of the fused image, the yarn alignment image could be reconstructed using inverse fast Fourier transform. Our experimental results show that the accuracy of density measurement by using proposed method is close to 99.44% compared with traditional method and the robustness of this new proposed method is better than that of conventional analysis methods.

Keywords: Density Measurement; Yarn Dyed Woven Fabric; Image Fusion; Image Processing; Dual-side Scanning

1 Introduction

The yarn density is an important parameter of woven fabric and plays a decisive role for the fabric appearance evaluation and the determination of its physical properties, so fabric density measurement is an indispensable part in textile quality testing. The traditional method of yarn density is manually operated in the textile laboratory based on human eyes with the aid of pins. Although it has the advantages of easy and practical, this method suffers the time consuming and inefficient, and it is also subjectively affected by the knowledge and experience of inspectors. With the rapid development of image processing and artificial intelligence, textile researchers have already presented many digital methods to measure density of woven fabrics automatically. Generally, the proposed method based on image processing can be classified into two categories: frequency domain analysis and spatial domain analysis.

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It was reported that the methods based on frequency domain analysis are usually transferring the acquired fabric image from spatial domain to frequency domain. The yarn density can be determined through feature extraction among the frequency spectrum. In 1990, Wood employed the Fourier transform and autocorrelation function to model the spatial periodicity of yarn structure and fabric pattern [1]. Later on, in 1992, Ravandi S. A. Hosseini used Fourier transform to analyze appearance of plain weave fabric [2]. In Xin's researches, The peak filtering was utilized to remove random frequency points in power spectrum after Fast Fourier Transform (FFT), the selected peak points represent periodicity information of woven fabric [3]. In 2001, one set of fabric structure analysis system was developed based on the Fourier spectrum by Jaume Escofet and his colleagues. The minimum structural unit of fabric texture was extracted through convolution and template matching. The frequency points corresponding to yarn arrangement were identified and located to determine the density of warp and weft yarns [4]. Similar methods have been reported in many references [5-9]. In addition to Fourier transform, the wavelet transform is another effective method to measure yarn density. In 2001, Feng and Li employed to perform a multi-scale decomposition and measure the woven fabric density [10]. In 2007, Shen recommended a novel approach based on Wavelet and Radon transform for fabric weave pattern and structural pattern detection. It was reported that fabric texture directions, weave pattern and yarn density could be determined through proposed method [11]. In 2015, Jing proposed a method combining the multi-scale wavelet transform and morphology processing, via successive operations of dilation and erosion, to detect the density of the warp and weft of woven fabric automatically [12]. In same year, Kang utilized Gabor wavelet and Graylevel Co-occurrence Matrix (GLCM) to extract the texture features of fabric images. Then Probabilistic Neural Network (PNN) was applied to classify the three basic woven fabrics [13].

Although the methods based on spectrum analysis were effective for those fabrics with regular textures, it seems that irregular texture has effects on the performance of the spectrum based methods. The methods based on spatial domain analysis usually could be defined as those methods using statistical or geometrical analysis to characterize the fabric image in spatial domain, extracting the geometrical or statistical parameter of fabric structure. In 1991, Nishimatsu utilized a Charge Coupled Device (CCD) camera and a frame grabber board to digitalize the image of fabric at 50x magnification. It was reported that the recognition accuracy of this method for plain fabrics was as high as 92.5%, while the accuracy for twill fabrics was only 79.1% [14]. In 2002, Gao and his colleagues proposed a correlation function-based approach to calculate the weft and warp repeats [15]. Lin J.J. attempted to use the Gray-level Co-occurrence Matrix to measure yarn density, and the author reported that this method was effective for the density measurement of twill fabrics [16], however, no related works reported for those fabrics with complex textures.

From the previous works described above, it is obvious that both spectrum based methods and space domain based methods have its advantages and disadvantages for the density measurement and texture analysis due to the diversity of woven fabrics. It was found that one-side imaging system and the corresponding algorithms was used in most of previous references. However, the yarn information acquired only from one side is not complete and insufficient for the texture analysis, because there are some interlaced yarns can not be observed from the face-side surface or the back-side surface, it means only parts of one single yarn is visible from one side. In this case, it is reasonable to merge all the image information to improve the accuracy of image analysis.

In this paper, a new dual-side modeling and measurement method for the yarn density based on the dual-side scanning and fusion technique is proposed to digitize more complete information about the yarn structure or fabric textures, the related algorithms for the image alignment and