Defect Detection in Fabric Materials

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Abstract: ***This paper investigates various approaches for automated inspection of textured materials using Gabor filters. A new supervised defect detection approach is used to detect defect in textile web. Unsupervised web inspection is used with multichannel filtering scheme. This scheme establishes high computational savings and results in high quality of defect detection. The experimental results conducted on real fabric defects for both approaches proposed in this paper.***

Keywords: Computer vision, defect detection, Gabor filters, Gabor wavelets, industrial automation, multichannel filtering, quality assurance, textile industry.

1. Introduction

Inspection of industrial products offers low-cost, high speed, and high-quality detection of defects. Some industrial inspection problems deal with the textured materials is most challenging. This inspection problem occurred in textured materials become texture analysis problems at microscopic levels. Textured materials take many forms, having similarity in overall automation requirements for visual inspection.

In general, an image of fabric sample can be considered as a typical textured image. The detection of local fabric defects have problems in computer vision. In textile looms, the fabric produced is typically 8–10 ft wide and rolls out at the speed of 5–6 ft/s. The fabric produced is packed into rolls and later unrolled for inspection on the inspection table. Because of, offline inspection has slow speed of production, it is insufficient in relative environment.

Typically I-TEX inspection system available in market because, majority of automated inspection systems currently available in the market are offline which can detect fabric defects up to a speed of 100 m/min. Many other web inspection systems available from commercial vendors are used to detect and locate defects accurately, maximizing the throughput. Defect detection is limited to a certain range of defects. Fabric defect detection have proposed different algorithm to reduce the cost, improve throughput and range of defects that can be detected

2. Literature Survey

Fourier-domain analysis has been used for the detection of fabric defects [1], because fabric texture exhibits a high degree of periodicity. Fourier analysis is not suitable for detection of local defects, because the Fourier bases are of infinite length, and contribution from each of the spectral components is difficult to quantify. Instead, detection of local fabric defects requires multire solution decomposition of fabric images across several scales. A feature vector composed of significant features at each scales is used for the identification of defects. Such a multi resolution analysis of fabric sample using Discrete wavelet transform (DWT) has been detailed in [2]–[3]. Texture adapted wavelet bases whose response is close to zero for normal fabric texture and significantly different for fabric defect, thereby enabling detection. This paper demonstrated fabric defect detection using only real Gabor functions.

3. Proposed Work

In this paper, fabric defect detection is investigated using Gabor filters. One common technique of implementation of multi resolution analysis is to use wavelet transforms. It is difficult to characterize a texture pattern from the wavelet coefficients because of wavelet bases are shift invariant, since the wavelet descriptors depend on pattern location. Gabor filters can also decompose the image into components corresponding to different scales and orientations. Gabor filters used extensively for texture analysis (5), document analysis, and object detection.

Many textures can be modeled as a collection of similar, not necessarily identical, primitive objects called textels. In uniform textures, the textels are identical and arranged in repeating pattern with a constant displacement along X and Y axis. When a texture contains textels not arranged in square lattice, asymmetric Gabor filters are useful. The fabric defect detection is done using asymmetric Gabor filters in this paper. For supervised defect detection, no effective systematic method for automatically selecting the desired Gabor filter. The organization of this paper is as follows.

1) A review of Gabor filters is presented, the bank of Gabor filters used for power spectrum sampling of the image.
2) Supervised defect detection to detect a class of fabric defects.
3) Unsupervised defect detection includes multichannel.

3.1 Supervised Defect Detection

Supervised defect segmentation is segmentation of a similar class of local fabric defects with knowledge about the orientation and size of a sample defect can be regarded as [4], [6]. When the approximate orientation and size of defects are known, the power spectrum sampling of the respatial frequency plane is not necessary. In such cases, segmentation has been achieved with only one Gabor filter from the Gabor filter bank. A heuristic algorithm is used to automatically select a Gabor filter to detect a class of fabric defects. In order to choose the best Gabor filter, a cost function that can represent an appropriate measure of discrimination of texture features against that of defects has to be selected. The cost function used in the proposed algorithm. A Gabor filter is said to represent a defect if, it produces higher outputs for regions corresponding to defect as compared with other defect free regions of the image. The following section describes a heuristic algorithm to select the best representative Gabor filter from the bank of Gabor filters to detect a class of fabric defects.

a) Filter Selection Algorithm

A bank of S X L Gabor filters with S scales (p = 1,....,S) and L orientations (q = 1,...L) is investigated for supervised defect detection. To represent the class of fabric defects to be detected consider a real fabric image sample with a defect. This image is divided into non-overlapping square regions. Each of the Gabor filters in the filter bank is applied to each of these regions and a filtered output is obtained.

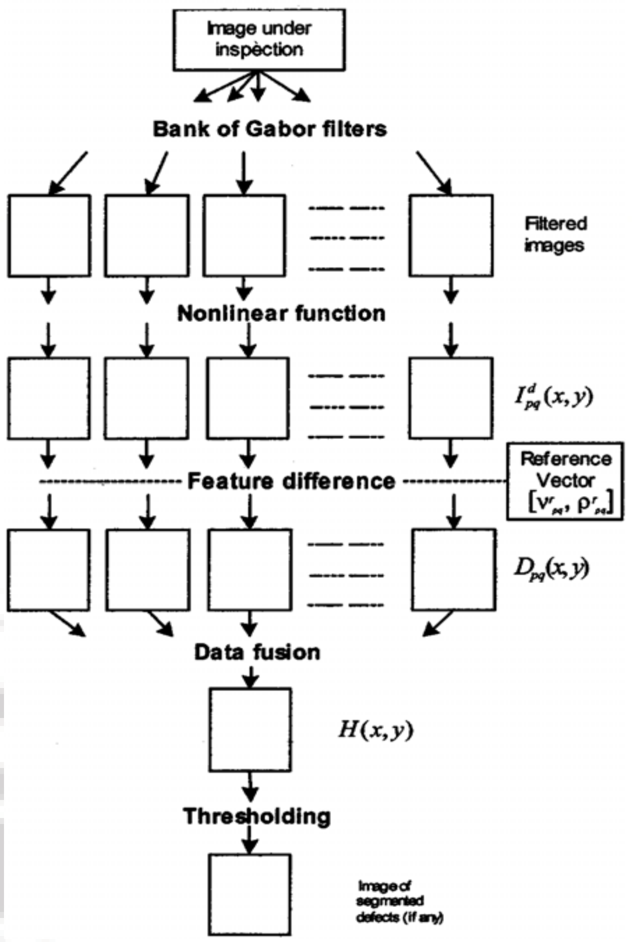
b) Thresholding

The thresholding limit is determined from a reference or defect-free fabric image. This reference image is filtered with Gabor filter and the magnitude of filtered image is obtained. A window centered at the image. Thus, threshold value is the maximum value of gray levels. The window size is chosen to avoid any possible distortion effects from the image due to discontinuities at the border. In this paper, the window size is obtained by removing ten pixels from each side of the image.

3.2 Unsupervised Web Inspection

The dimension and orientation of local defects generated in textile webs vary randomly. Therefore, a complete automation of visual inspection process requires unsupervised defect detection that can be used for the online web inspection. The term "unsupervised defect detection" refers to the detection of unknown class of defects. Multichannel filtering theory for the processing of visual information in the biological model of human visual system used for various texture segmentation algorithms. A variation of this algorithm, which can be used for the detection of local fabric defects. This section investigates another variation of this algorithm using asymmetric Gabor filters. Any modification of multichannel filtering algorithm for defect detection should lead to a reduction in computational complexity and offer high rate of detection.

Proposed Architecture of Unsupervised defect segmentation in textured materials.



a) Multichannel Filtering

Multichannel filtering approach allows multi resolution analysis of fabric texture. Every acquired image from the imaging system is filtered with a bank of self-similar Gabor filters. Each of these Gabor filters is selectively tuned to a narrow range of frequency and orientation. The octave (dyadic) band decomposition is commonly used for wavelet decomposition. This is used for the selection of frequency bands for the frequency-domain sampling of acquired images.

b) Nonlinearity

A local nonlinear function is used to rectify multi-channel filter response. This nonlinear function transforms both negative and positive amplitudes to positive amplitudes. The magnitude nonlinearity requires minimum computations, therefore, preferred in this work.

c) Feature Difference

An image of defect-free fabric (reference image) is also used to compute 18 reference feature images. These reference feature images are computed at the beginning of inspection. Therefore, the mean and standard deviation from each of these 18 images is used to locate defects in the image under inspection.

d) Data Fusion

Information gathered by different sources (channels) from the same image is often uncertain, fuzzy, or incomplete. We have performed qualitative and quantitative analyses of several binary and analog fusion algorithms used for fabric defect detection. The fusion scheme first generates six images from the addition of pixels at the same scale. Then geometric mean of resultant pixels at the adjacent orientations generates five images; pixels from these five images are averaged to produce a unique fused image.

e) **Thresholding**
The fused image output is subjected to thresholding. The fused image output in order to suppress the pixels not belonging to defect. This operation further reduces the probability of false alarm.

4. Specifications

a) *Input:* Input Image of fabric sample.
b) Software Configuration: Software Specification:
c) Front End : Matlab
d) Tools Used : Matlab 2010
e) Operating System : Windows XP

5. Conclusion and Future Work

In this paper, a supervised defect detection approach used to detect a class of fabric defects. The multichannel filtering scheme used for texture segmentation, has been extended and tailored for unsupervised inspection of textile webs. The role of mask size, and the number and frequency range of Gabor filters in the filter bank, on performance and computational load has been discussed. This paper has shown that this scheme is ready to used for online web inspection.

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