Fabric Defect Detection Using Image Analysis

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ABSTRACT: Quality inspection is an important aspect of modern industrial manufacturing. In textile industry production, automate fabric inspection is important for maintain the fabric quality. For a long time the fabric defects inspection process is still carried out with human visual inspection, and thus, insufficient and costly. Therefore, automatic fabric defect inspection is required to reduce the cost and time waste caused by defects. The investment in automated fabric defect detection is more than economical when reduction in labor cost and associated benefits are considered. The development of fully automated web inspection system requires robust and efficient fabric defect detection algorithms. Image analysis has great potential to provide reliable measurements for detecting defects in fabrics. In this paper, we are using the principles of image analysis, an automatic fabric evaluation system, which enables automatic computerized defect detection - (analysis of fabrics) was developed. On-line fabric defect detection was tested automatically by analyzing fabric images captured by a digital camera.

I INTRODUCTION

Fabric defect detection has been a long-felt need in the textile and apparel industry. Surveys carried out as early as 1975 [1] show that inadequate or inaccurate inspection of fabrics has led to fabric defects being missed, which in turn has had great effects on the quality and subsequent costs of the fabric finishing and garment manufacturing processes.

Fabric faults, or defects, are responsible for nearly 85% of the defects found by the garment industry. An automated defect detection and identification system enhances the product quality and results in improved productivity to meet both customer demands and to reduce the costs associated with off-quality. Higher production speeds make the timely detection of fabric defects more important than ever. Presently, inspection is done manually when a significant amount of fabric is produced; the fabric roll is removed from the circular knitting machine, and then sent to an inspection frame. An optimal solution would be to automatically inspect fabric as it is being produced, and to encourage maintenance personnel to prevent the production of defects or to change the process parameters automatically, consequently improving product quality[2].

The study of this problem has led to the identification of two main categories of defects in fabrics: horizontal and vertical variations. While the first category is mainly linked to the yarn (quality and management), the second category : needles, sinkers, feeders, and so on. The solutions to these problems are, for the first category, a careful selection and management of the yarn, and for the second, the correction or substitution of the defective elements.

In a previous work, neural network methods were applied to images of simple fabrics for classifying faults. The result showed the successfulness of the methods, but this approach is not useful in industry because the process is time-consuming and there are no ways to determine the fault's location and area.

In this paper, we presents a method for the automatic detection and identification of defects on fabrics. The work was intended to develop a monitoring system for random processes based on video images during the production phase. The developed system consists of hardware equipment [3], data evaluation implemented in software and determination of acceptable tolerances related to final product quality.

II RELATED WORK

Bollinger Bands (BB) method is an efficient, fast and shift-invariant approach. It can segment the defects of the fabric with clear and clean images. This method is basically used in the stock market for oversold and over bought shares. Bollinger Bands method is based on moving average and standard deviation measures. The method is one-dimensional approach. BB method cannot properly align reference image and input image.

Chin and Harlow used Traditional Image Subtraction (TIS) method on lace which is a kind of patterned fabric. TIS method is based on Exclusive-OR operation. This method is one of the traditional subtraction methods. However, TIS is very sensitive to noise and cannot do pixel-by-pixel comparison because of complex thread patterns.

Hash function is also one of the patterned fabric defect detection techniques that is used in cryptography for generating binary signature documents for security purpose. Hash function is one dimensional approach. Four basic properties of this function are checksum hash function, plain hash function, XOR hash function and multiplication has function. It is very sensitive to small changes, defects in textures and shifting of the image directions.

Direct Thresholding (DT) method utilizes the fourth level of horizontal and vertical extraction of detailed sub-images of Haar Wavelet transform. The method thresholding can be achieved directly on these sub-images as the defect can be substantially enhanced. The DT method is computationally fast and output images are coarse in resolution.

Many researchers in the field of image analysis have used neural networks as a classifier. In these approaches, the data of the images is reduced, in one form or another, to accelerate the processing time. Techniques used to extract image features include statistical procedures [4,5], time-frequency domain transforms such as the discrete cosine transform[5], the Fourier transform[6] and the wavelet transform.

All these systems are very specialized and usually do not give further information related to the process and the cause of a given defect. The objective of this paper is the development of a computerized system capable of detecting defects in fabrics during the knitting process.

Further, this system should be able to identify the type and potential source of the defect, providing the operator with information on how to correct the problem. The developed systems are capable of identifying defects with greater accuracy than experts in industry, which promises significant improvements in quality.

III REGULAR BANDS AND INDEPENDENT COMPONENTNALYSIS

Regular Bands (RB) method is one of the efficient, fast and shift-invariant methods that are used for patterned fabric defect detection. Existing RB method is based on periodicity which means repeat distance of a repetitive unit of patterned texture. RB method makes use of regularity approach. Any irregularity signal in the image is considered to be defective. The basic idea of the RB method is to generate a signal for each vertical and horizontal line of the defect-free region.

Existing RB method can handle defects with dark color means at low pixel intensities and light color which means high pixel intensities. But RB is less sensitive to noise distortion and cannot detect the defects at the border of the input images.

ICA is one of the novel proposed techniques for revealing the hidden factors in the patterned fabric. ICA model is noise free. It is used for indicating and locating the defects on patterned fabric images. ICA deals with filter for natural images and based on the ICA decomposition, removes noise from the images that are corrupted with additive Gaussian noise. The process of ICA is depicted in the flowchart form along with algorithmic modules for defect detection shown in fig.1.

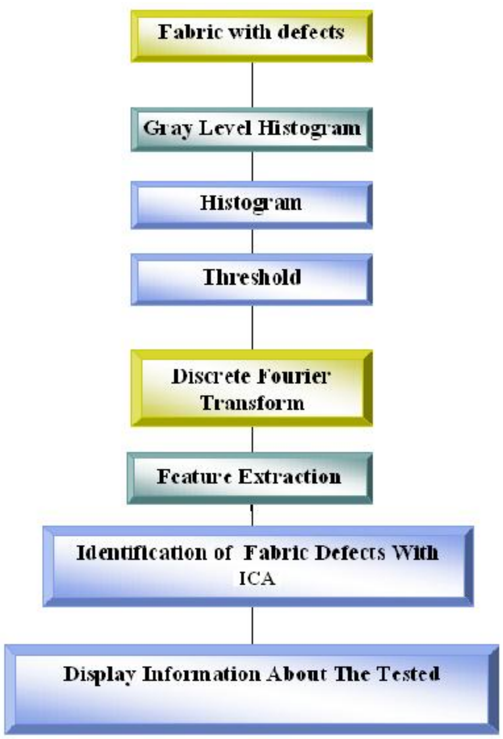

Fig 1: Flow chart with algorithmic modules

ICAs very different application is on feature extraction. Application of ICA can be found in many different areas such as audio processing, biomedical signal processing, image processing, telecommunications and econometrics. So, here we are using ICA in proposed system for improving the efficiency while detecting defects in the system because it is noise free.

IV PROPOSED METHOD

Obtaining high-quality, a high-resolution image from the fabric of a machine presents several challenges. One of these is isolating the mounting components from the considerable vibration that is produced during the operation of a machine. Each of these challenges has been addressed and met in developing our (on-circular knitting machine) image acquisition subsystem.

For each kind of defects, a large number of samples were acquired by image-capture equipment. Each type of defect is imaged many times from random different locations. The images of these defected samples were analyzed by a computer program. The samples for each kind of fabric defect were divided into two groups. The first group had any samples and was used for training, and the other group was used for testing.

A) *Hardware description*

The image acquisition subsystem is implemented with standard components on a low-cost personal computer. These components consist of a digital camera, a source of illumination for front-lighting the fabric, a personal computer (PC) and a display monitor.

These components are used to acquire high-resolution, vibration-free images of the fabric under construction and to store them on the personal computer's memory. The software running on the interface board controls the image acquisition process, and accumulates a two-dimensional (2-D) image suitable for the ensuing analysis (i.e., defect segmentation).

B) Image acquisition operation

During image acquisition, the camera exposure time is designed to be fixed. The fixed exposure time is realized by the exposure time control of the camera-encoder interface. The acquired image frame serves as an input to the image analysis or, more specifically, to the defect segmentation algorithm, which is also executed on the interface board. To maintain full coverage of the fabric, the acquisition subsystem begins capturing the next frame while the current frame is being analyzed for defects.

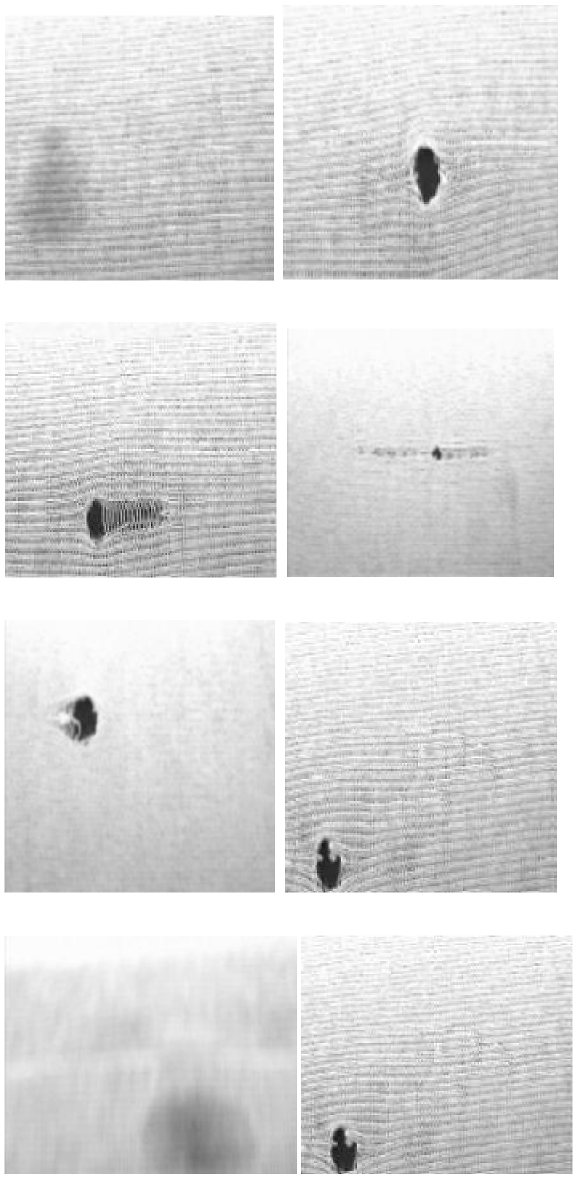

Fig: An image of a fabric with different defects

C) *Defect segmentation algorithm*

In designing the defect segmentation algorithm for our inspection system, we observed that the images of fabrics constitute ordered textures that are globally homogenous, that is, statistics measured from different patches in an image are correlated. It was further noted that images containing defects as shown in above fig are less homogenous than those that are defect free. Therefore, the essence of the presented segmentation algorithm is to localize those events (i.e. the defects) in the image that disrupt the global homogeneity of the background texture. To find defects, following conditions are considered:

1) Defects exhibit low-intensity variation within their boundary, and
2) Relative to the textured background, they constitute a small portion of field of the field of view.
The acquired images are transferred to the host computer and processed by the procedures

D) *Feature extraction system*

Having pre-processed the digitized mammograms and isolated the knitting defects from their background, the next step is to extract some features which can be used to discriminate between normal (standard) and defective fabrics. These features will be used as the input to the classifier. Two sets of features are introduced; statistical features and texture features.

i) Statistical features

The main aim of feature extraction is to find some characteristics that distinguish between normal (standard) and defective fabrics. Statistical features are numerically descriptive measures of the histogram. Statistical features such as mean, standard deviation, variance, coefficient of variation, moment, skewness and kurtosis are used to characterize the histograms and to distinguish between normal and defective fabrics.

ii) Texture features

We can use boundary information to describe a region, and shape can be described from the region itself. A large group of shape description techniques is represented by heuristic approaches which yield acceptable results in describing simple shapes. Region area, rectangularity, elongation, direction, compactness, etc. are examples of these methods. Unfortunately, they cannot be used for region reconstruction, and do not work for more complex shapes.

V PERFORMANCE

The performance of the described inspection system was evaluated as: Initially, the camera-carrier was moved in a reciprocating motion along the height of the simulated machine with a slow speed. Next, testing involved isolating the mounting components from the considerable vibration produced during the machine's operation. Later, defect acquisition is done and defects are identified by the camera then remedial method on the monitor of the computer is specified to help the operator.

Let consider the image acquisition subsystem consistently produced high-quality images of the fabric. During the analysis of the captured images, the acquisition subsystem was directed to capture the next 320×240 image frame, so that 100 % coverage of the knitted fabric was maintained. When analyzing more than 2000 images for both fabric types, the overall defection rate of the presented approach was found to be 92%, with a localization accuracy of 3 mm and a false alarm rate of 2.5%. The false alarm rate was computed as the total number of false detections divided by the total number of processed images. Note that the detection rate of 92% represents the average over all defect types.

In general, because we are dealing with an edge-based segmentation approach, defects that produce very subtle intensity transitions (e.g. mixed yarns and barre) were detected at a lower rate (i.e. 50-60%). On the other hand, for the most commonly occurring and most serious defects, such as needle line, dropped stitch, holes and oil spots, the defection rate was 92%. Because the camera sometimes captures part of the defect but not all, the defect can therefore be classified with another type; for example a dropped stitch defect can be shown as a hole.

VI CONCLUSION

We have described a computer vision-aided fabric inspection system to detect and classify circular fabric defects using common different texture recognition methods, including thresholding analysis. In this paper, we have described a vision-based fabric inspection system that accomplishes on-circular machine inspection of the knitted fabric with 100% coverage. The concepts of Regular Bands and ICA for patterned fabric defect detection are used for efficient defect detection in fabrics because ICA is noise free and Regulars bands are fast. The inspection system is scalable, and can be manufactured at relatively low cost using off-the-shelf components. The fabric inspection system texture was described in terms of its image acquisition subsystem and its defect segmentation algorithm. The image acquisition subsystem is used to capture high-resolution, vibration-free images of the fabric under construction. The essence of the presented segmentation algorithm is the localization of those defects in the input images that disrupt the global homogeneity of the background texture. Novel texture features are utilized to measure the global homogeneity of the output images.

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