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Research Article

Surface Defect Detection for Some Ghanaian Textile Fabrics using Moire Interferometry

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Abstract: This analysis focused on using Moiré Interferometry method to measure surface defects in woven fabrics. A laser imaging system based on moiré Interferometry has been used as a tool for surface defect inspection of static textile fabric. Test textile fabrics samples with five different types of defects (hole, oil stains, warp-lacking, weft-lacking and dirt) were used. With the sample sand witched between two Ronchi rulings and illuminated by an expanded HeNe laser beam to form Moiré configuration. The images from the fabric were acquired with a high resolution CCD camera. The recorded images were transferred to a computer for analysis by the image pro plus 5.0 software. By making use of image processing and FFT techniques, the surface defects such as lack of yarns and oil stains were analysed and detected. During the process of inspection and defect identification, it was observed that the three parameters, textual structure, the shape and size of the defect varied. In this paper, moiré based technique for defect detection is presented. The result of the inspection of the textile fabric on the textile images revealed that FFT analysis serves as a filter in identifying such defects. Also, the fabric texture densities limited the intensity of the laser beam transmission through some fabrics. However, the variation of such intensities helped to deduce that the area covered with stain scatter most of the incident light and the more localised the defect the more the spread out of its transform. It explained the behaviour of the frequency spectrum of each sample and the smaller the width of the yarn spacing, the broader the entire diffraction pattern.

Keywords: Defect detection, fast fourier transform, moiré, quality assurance, textile industry, textured defect

INTRODUCTION

Defect detection from images plays a significant role in the quality of manufactured product, and its application areas continue to increase. Today, the advent of low cost digital computers and increased computing power significantly encouraged further development in the field, especially in the area of fabric detection to reduce the dependence of human inspectors in this subjective, tedious and time consuming process. According to some studies, human visual inspection can only estimate about 60-70% of the significant defects (Schictanz, 1978).

Recent advances in image technology and image processing have also resulted in inexpensive, high quality image acquisition, and pattern recognition. This situation made automated imaged-based inspection an attractive alternative to human inspection (Castellini *et al*., 1996). The problem of defect detection is very complex and the research in this field is widely open (Bradshaw, 1995; Castellini *et al*., 1996). Many systems for defect detection have been proposed, but generally they, have not a satisfactory performances.

The main problems such as the extremely high data flow, noise influence, inter-class similarity and inter-class diversity, large number of defect classes, dynamic defect populations and flexibility with standard production lines are not solved yet.

In this study, Moiré based technique is used as an alternative and better approach to detect defects in fabrics. Moiré was used because of its high levels of magnification and non-contact technique. This method compared to more traditional methods, utilises the interference between gratings to produce fringes that clearly stands out creates a pattern which indicates the amount of defect experience by the specimen. Before introducing this method, the characteristics of fabric structure in the frequency spectrum will be examined and some defect examples will be described. After that, the procedures of the method and experimental results will be discussed.

According to Zhang and Bresee (1995), he introduced two approaches to detect defects: gray-level statistical and morphological methods. A simple system based on adaptive thresholding and binary filtering is described (Northon *et al*., 1992). Although the influence of noise is observed, the noise distribution is normal and the noise amplitude is small compared to the signal amplitude. The system is bases on the light scattering technique and it uses electro-optic equipment

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for real-time defect detection. This approach gives good results for some type of defects, but requires complex and expensive equipments (Harris, 1996).

Lanes and Moure (1998), he has defined a number of convolution masks to detect the defect. This method, which depends on intensity change on the fabric image, can only capture the significant defects such as knots, web and slob. However faultless fabric has a periodic regular global structure. The occurrence of a defect in a fabric means that the regular structure has been destroyed. Therefore, the fabric defect can be defect by monitoring fabric structure. Ciamberlini and his colleagues have used the optical Fourier transform to monitor the fabric structure. Their methods can be classified as follows: fixed masks or structured detects adaptable filters Escofet *et al*. (1998) electronic elaboration of the image (Harris, 1996), and binary histogram (Lanes and Moure, 1998). Fixed masks, structured detectors and adaptive filters and the fixed optical filters placed over the photo detector active area. They are composed of periodic array transparent and opaque zones and their location depends on the peak of the fabric diffraction image. When a defect occurs, some localised peaks, in the diffraction image will be passed to the sensor. However, this type of operation requires careful alignment and different fabric type requires different filters.

The method of electronic elaboration is based on the subtraction of the reference image of the faultless fabrics from that of the fabric under inspection. The binary histogram method as based on the summation of the graylevel pixels, which have gray-level greater than a threshold. The threshold is defined according to the fabric type and system sensitivity.

Optical processing is very expensive and requires careful calibration. Also, this method could not recognised fabric with higher fabric density. Another class of method is dependent on digital image processing. Fourier and associated transform to characterized carpet patterns (wood, 1990). Fourier transform analysis is used to measure fabric appearance in their paper (Ravandis and Tariumi, 1995). Fabric surface characteristics fill and warp yarns for plain-weave cotton fabric were also discussed. Angular correlation of the Fourier spectra was used to evaluate fabric web resistance to abrasion (Escofet *et al*., 1998).

Furthermore, sari-saraf and his colleagues (Sari-Saraf and Goddard, 1996) have used Fourier transform to detect fabric defects their approach examines and perform a one dimensional signature diagram in the two dimensional spectrum. The signature diagram is obtained by integrating the points within each ring in the two dimensional spectrum. The rings are concentric ring filter in optical processing (Castellini *et al*., 1996). The main advantage of the approach is that it is less sensitive to the background noise (intensity source variation). Also, it is more effective for revealing a defect due to dimensional Fig. 1: System flow of fabric defect detection change in the structure of the fabric. The study's main purpose was to find out how Moiré technique was being used in the area of surface defect analysis on woven fabrics. This method can only recognized the high fabric densities by using the zoomed camera, but long computational time is required.

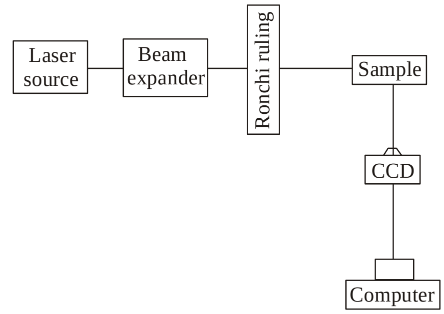

Fig. 1: System flow of fabric defect detection

MATERIALS AND METHODS

Fabric image acquisition: The research project was conducted from September, 2002 to December, 2002 at the Laser and Fibre Optic Centre (LAFOC) at the Department of Physics, University of Cape Coast, Cape Coast, Ghana. On line fabric image acquisition presents several challenges to obtaining high-resolution image. One of these challenges is the isolation of the mounting components from the considerable vibration that is produced during loom operation. Another is the irregular forward motion of the fabric among the loom rollers after it is woven.

In this study, five cotton fabrics were used. Defects with double yarn missing yarn, hole, oil stains, warplacking, weft-lacking and dirt were inspected and compared with faultless fabric. The image acquisition system includes a personal computer, frame grabber, CCD camera, a system monitor Ronchi rulings beam expander and a He-Ne gas laser emitting at a length of 632.8 nm with an output power of 15 mw. The fabric image is captured by a CCD camera (iAC800) and the frame grabber digitizes the video signed into a 768*576 pixel with 8-bit gray-level resolution image and stores it into computer memory as shown in Fig. 1. This image data is then processed by the image pro plus 5.0 software. The beam was expanded and collimated into a parallel beam of diameter about 2 cm to cover the entire sample material. Such power output was used to achieve the high contrast fabric images.

RESULTS

Experimental results are used to verify the proposed approach. In this experiment, five defective samples were used to examine this approach.

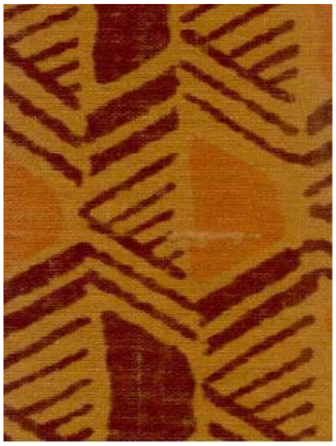

Fig. 2: Double yarn

Fig. 3: Double yarn

Fig. 4: Double warp (missing yarn)

A real sample of double fill and its central spatial frequency spectrum diagrams are shown Fig. 2 and 3. By observing these two diagrams. However, the high spatial frequency peaks in Fig. 6 and 7. Are loosely

Fig. 5: Double warp (missing yarn)

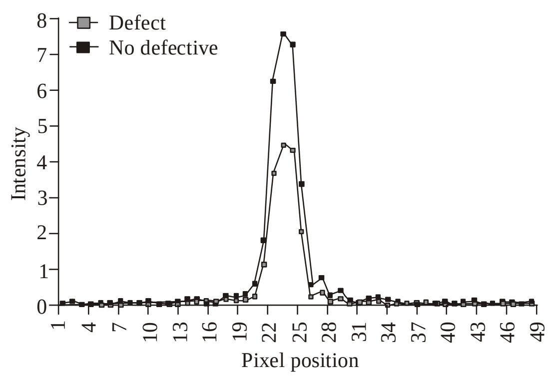

Fig. 6: Double yarn direction combined spectrum showing the variation of intensity with pixel position

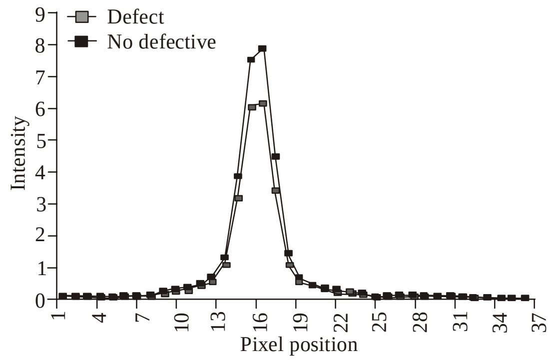

Fig. 7: Double yarn direction combined spectrum showing the variation of intensity with pixel position

localized and embedded with some noise. A number of reasons can explain this result. For example, the surface tufts give a random textured component in the fabric images that distort the periodic structure. In addition, the illumination fluctuation gives high frequency noise background. Because of these effects, only parameters around the central peaks and the first peaks can be extracted for defect characteristics.

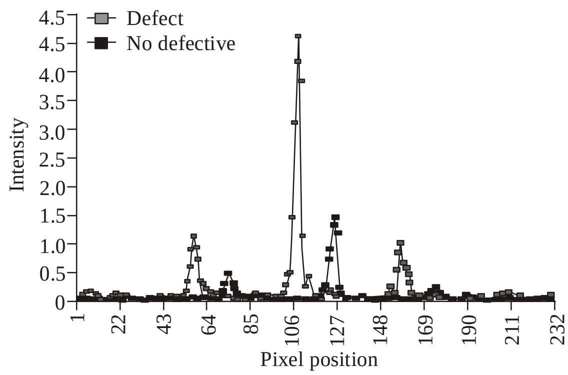

Fig. 8: Missing yarn (double warp) direction combined spectrum showing the variation of intensity with pixel position

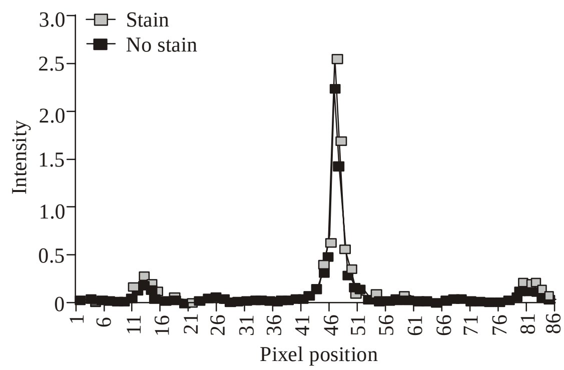

Fig. 9: The intensity variation with pixel position for stain and without stain direction spectrum

Another example of defect detection is given in Fig. 4 and 5 shows a real defect sample of missing (warp) yarn. The brighter spots that form a vertical line are caused by the missing yarn. Since the fabric thread count is lower than the faultless fabric, the average light intensity of the defect is higher; the reason is that the fabric is broken and leads to increase of light intensity as shown in Fig. 8.

For the low fabric density are lower because the number of thread are decreased. The thread width may be changed in this defect. In addition, due to the irregular texture in the warp direction, the first peak value is decreased and ripples occurs which will cause it to be lower and higher intensity.- Textile fabrics with stain were observed to scatter most of the incident fluxes making transmission impossible resulting in low intensity as shown in Fig. 9. The fabrics with stain have a lower peak due to reflection and scattering as a result of dirt which combine with the oil. When there was no stain on the fabric, most of the incident fluxes were not scattered but transmitted; resulting in high peak value. The field distribution in the diffraction pattern is the Fourier transform of the field distribution across the aperture. The more localised the defect, the more spread out was its transform-the same is true in two dimension. Also, the smaller the diffraction aperture, the larger the angular spread of the diffracted beam or the larger the spatial frequency bandwidth. One of the important conclusions of this work is that, this model was used to understand the behaviour of frequency spectrum of the Fast Fourier Transformed image of the fabric.

CONCLUSION

An approach based on Moiré Interferometry has been described to detect the surface defect in some Ghanaian textile fabrics. The system was found to be very fast and versatile in detecting defects on textile fabric surface. Also, this method can be used to recognise the high fabric densities by using zoomed CCD camera, since the Moiré method utilizes gratings of pitch between 0.01 to 1 mm which most textile fabrics are interlaced. This prototype system is manually operated by focusing the image onto the CCD camera, however, further improvement on the system can be made automatic in order to have on-line monitoring. Through this research it has become possible to use the Moiré Interferometry technique and FFT analysis. From the analysis, the missing yarn has a smaller FWHM than the double yarn. Also, missing yarn fabrics have higher intensities values than that of the double yarn fabrics.

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