(REFEREED RESEARCH)

YAPAY GÖRME TABANLI KUMAŞ HATA TESPİT SİSTEMİ

ARTIFICIAL VISION BASED FABRIC DEFECT DETECTION SET-UP

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ABSTRACT

Due to the cost and complexity of existing defect detection systems, a fabric defect detection device based on an artificial vision system has been developed in this study. Using knitted pile fabric, six types of defects were studied: loop drop, fly defect, grease spot, cross- striped defect, hole defect and pilling defect. Obtained fabric images were converted into histograms by a computer program developed within the scope of this study and defect types were characterized.

Keywords: Artificial vision, defect detection, textile, fabric

ÖZET

Mevcut hata tespit sistemlerinin pahalı ve komplike olmalarından yola çıkılarak bu çalışmada, yapay görme sistemi tabanlı bir kumaş hata tespit cihazı geliştirilmiştir. Örme havlı kumaş kullanılarak ilmek düşmesi, uçuntu hatası, yağ lekesi, enine yönde çizgi hatası, patlak ve boncuklanma olmak üzere altı tip hata üzerinde çalışılmıştır. Elde edilen kumaş görüntüleri yine bu çalışma kapsamında geliştirilen bir bilgisayar programı ile histogramlara dönüştürülmüş ve hata tipleri karakterize edilmiştir.

Anahtar Kelimeler: Yapay görme, hata tespit, tekstil, kumaş

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1. INTRODUCTION

Defect detection in textile fabrics are still made mostly by human inspectors using a fabric control machine. The fabric on the control machine, moves through the inspectors' visual field and the inspector have to detect these small defects. In general, the identification rate is 70% for controls performed with this method and this ratio decreases with fatigue (1). So, human inspectors fail on detection defects in terms of accuracy, consistency and efficiency (2, 3). The first industrial studies related to computer vision are based on 70s (4). At that time, the cost of computing power was very high, and this was an obstacle in the development of image analysis techniques. But with the recent advances in computer and imaging technology, low-cost software and programs have emerged and these have enabled effective image analysis techniques to evolve. This has made automated image analysis detection systems an attractive alternative to human inspection (5, 6).

The first considerations in textile about image analysis were textile quality control, evaluation of trash content in cotton and evaluation of blend irregularity in blend yarns (7-9). Studies about detecting and classifying fabric defects with image analysis have been began to carry out in 1980s and these studies were firstly on woven fabrics (4, 10-19). A few research about detecting the fabric defects has been studied on knitted fabrics (20-23).

Existing defect detection methods are collected in three categories: statistical, spectral and model-based. Each category has its own specific use area (3, 24). Example, statistical methods are not useful for the detection of textured defects, such as woven and knitted fabrics. Therefore, spectral methods such as Fourier transform (25-27) are used to detect these kind of fabric defects. Nearby another approaches using wavelet or Gabor functions (28-32) have also been used for fabric detections.

All these literature have given important datas about defect detection systems but none of them was studied on the relation between the defects and histograms. However the histograms are very clear and easy graphics for inspectors to understand and notice the defect while the fabric is flowing through the 'fabric control machine'.

In this study, knitted fabric defects are tried to define with histograms using a very simple and cheap artificial vision based fabric defect detection set up.

2. MATERIAL AND METHOD

2.1. Material

In the study, the knit pile fabric made from 100% cotton that has7 loop/cm course density, 12 loop/cm wale density and 150 gram/m^2 fabric weight was used.

Arduino nano circuit board was used to transfer the data obtained from fabric by way of TSL201R optical line sensor to Java software, to process it with the help of Java programming language, and then to compose histograms. TSL201R optical line sensor is exerted with the purpose to acquire data over fabric. The charge accumulation amount of each pixel is directly proportional to the light density and the integration time. The gap between two sequential outputs is identified as integration pitch.

2.2. Method

The user interface is made up as a desktop application in C# programming language at the Microsoft Visual Studio 2015 platform. Within the program, there is an integrated java library. Histogram graphics were edited by way of the software encoded in java programming language at processing 3.0.1 program. Operating Arduino nano and TSL201R optical line sensor, the defect detection device designed and advanced in this study.

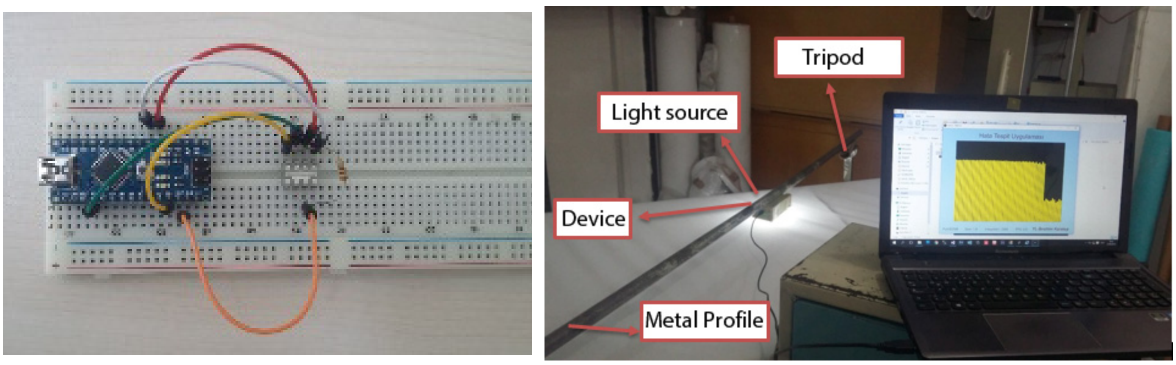
A single optical line sensor can scan a length of 11.55 cm. The data interval increases as much as the usage angle of optical line sensor scales up. Yet, as moving away from the surface of which its image would be taken, the measurement would not be carried out in the expected quality and accuracy since the data inspected by optical sensor would be affected negatively by environmental factors such as light. For this reason, in this study, the defect detection device was fixed at optimum 10 cm height which is proposed by TSL201R optical line sensor producer TAOS firm and then measurement was done.

As observed on Figure 1, the defect detection device transformed into a closed box was mounted over a metal profile with fixed stays to enhance the accuracy of optical sensor and to shorten the integration time. Thereby, the defect detection device could be isolated from external effects such as noise and light. The device was connected with a laptop computer via 5V usb cable with intent to process the detected data. The fabric flow was enabled between two cloth take up machines which were installed in opposing sides. White fluorescent light source with 302.5 mm length was placed just below the defect detection device in the midst of two cloth take up machines. In this study six types of defect, namely loop drop, fly defect, grease spot, cross-striped, hole, piling were sought to uncover. The 30 meter roll of knit pile fabric was transferred wrapping from one machine to another between two cloth take up machines with a speed of 17.7 meter per minute. The defect detection is performed with only one sensor so the sensor has scan only the length of 11.55 cm on the fabric.

The fabric was passed three times through the same scanning. The histogram graphs of each defect type obtained from the three scan results were compared and it was discovered that the three histogram graphics of each defect type were similar to each other. The number of frame per second taken by the defect detection device is accounted as 10.6 fps in the best achieved integration time (536 milliseconds). In the similar studies using the artificial vision system, the fps values were measured in range of 2 and 25 fps (33-35).

According to the autocorrelation based approach which is among the statistical approaches, the defect detection can be procured examining regular structures. In case any data is discerned out of the regular structures, the riffles and fluctuations come into existence on histograms.

The system's operation principle relies on capturing a wavelength over the light reflected on sensor from the light source located at the back of fabric. This wavelength remains stable throughout the fabric surface. Yet, as the sensor faces any defect, the light amount reflected on sensor shifts hence, the riffles and fluctuations occur on histograms. The flow diagram of the procedure is drawn and showed in Figure 2. In the diagram the WL abbreviation describes the wavelength of the light.



The integration of Arduino Nano and TSL201R optical line sensor on board

Figure 1. Application of Defect Detection Device

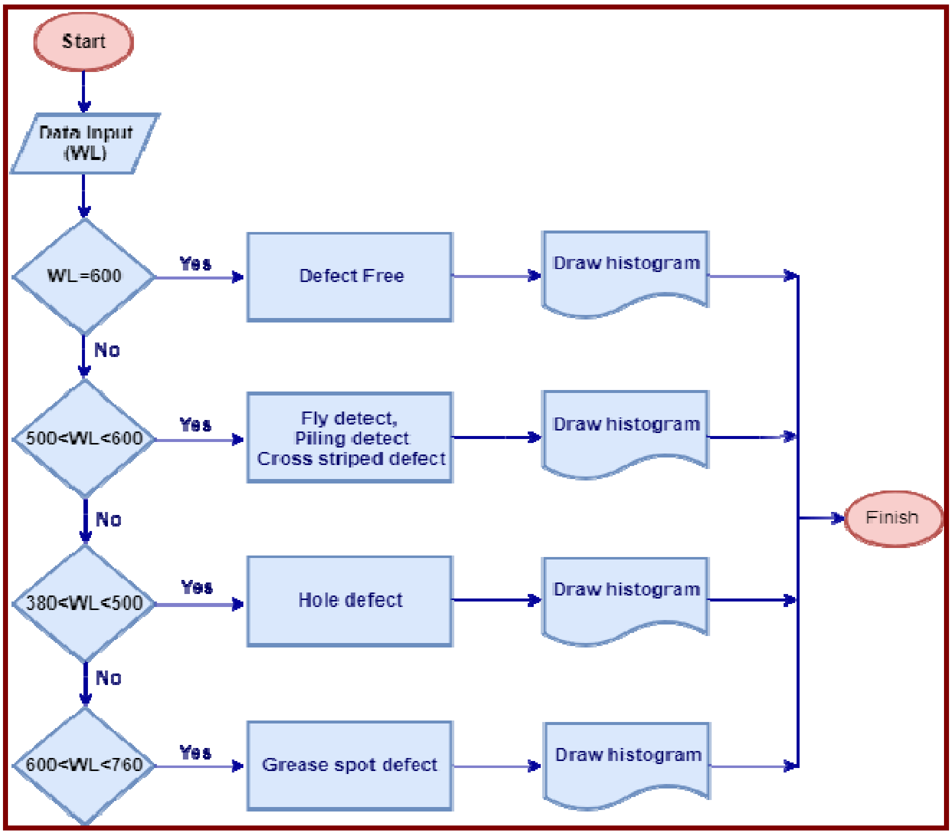


Figure 2. The flow diagram of the procedure

3. RESULTS AND DISCUSSION

The data obtained from the advanced defect detection device was evaluated by the autocorrelation based approach and the results explained in detail below were gotten. As aforementioned in previous sections, the reason to choose the autocorrelation approach is the quite conserved structure of autocorrelation method against enlightening and noise variations and this structure's superiority over other statistical approaches. In addition, the classification accuracy rate of autocorrelation method on certain fabric types is higher than those of morphological approaches.

In this study, the prototype of defect detection device at minimum cost was advanced operating Arduino Nano and TSL201R optical line sensor and the defect detection was carried out basing upon the autocorrelation approach. Owing to the autocorrelation method, the images taken from the defect detection device were transformed into histograms in accordance with defect types (riffle, valley, concave).

The image of defect free fabric and its histogram are shown at Figure 3. As can be understood from the figure; the histogram of the defect free fabric gave a perfect graph. Any riffle or concave form were not occured in the graph because the amount of light passing through all the surface of the fabric is the same as there is no faulty region in the fabric. So defect free fabric histogram is exactly different from the other defective fabric histograms.

The image of hole defect on fabric and its histogram are indicated at Figure 4. As shown in the figure, the hole zone emerges in riffle form due to the maximum light penetration at this yard.

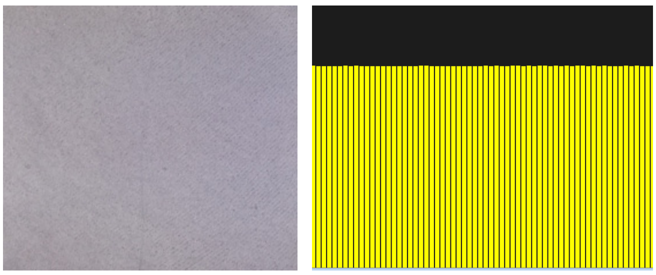


Figure 3. The image of defect free fabric and its histogram

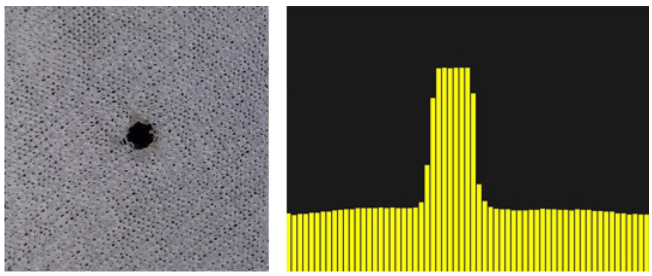


Figure 4. The image of hole defect on fabric and its histogram

The image of grease spot defect on fabric and its histogram are shown at Figure 5. The grease spot obturates fabric pores and to prevent majorly the light to traverse as it can be assumed from the fabric image. Therefore the fabric area where the grease spot is intense creates a concave shape on histogram since this zone is impenetrable to light.

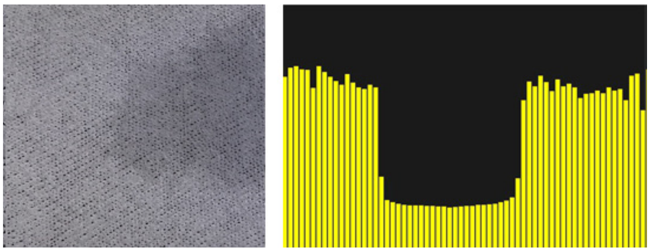


Figure 5. The image of grease spot defect on fabric and its histogram

The image of loop drop defect on fabric and this defect's histogram is shown at Figure 6. Comparing to the histogram of defect free fabric, the emergence of slight riffle is observed. It is deemed that this riffle forms as the feet, leg and head parts of sporadically dropping loops fill the gap of fabric.

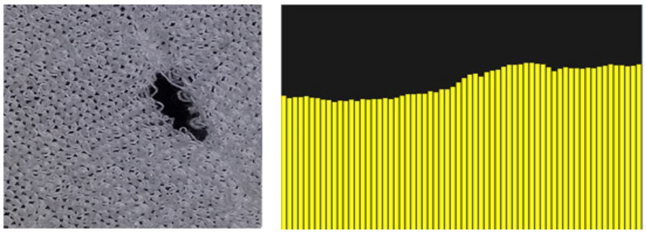


Figure 6. The image of loop drop defect on fabric and its histogram

The image of fly defect on fabric and the histogram resulting from this defect are brought forth at Figure 7. The concaves are composed intermittently whereabouts fly defects appear because light amount reaching optical sensor is lower there.

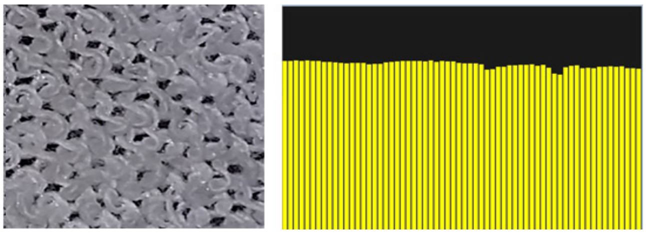


Figure 7. The image of fly defect on fabric and its histogram

The image of cross-striped defect on fabric and its histogram are displayed at Figure 8. This defect's histogram looks like that of fly defect (Figure 7) as it is apparent on the figure. This is why the white light under the fabric attained the optical sensor in some areas while reaching the sensor at a low level or none at all in other areas at the cross-striped defect.

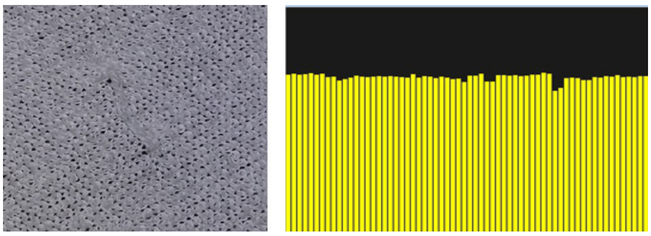


Figure 8. The image of cross-striped defect on fabric and its histogram

The image of pilling defect on fabric and its histogram are shown in Figure 9. The pilling defect is similar to the fly defect in terms of apparition on fabric. The fibers get lumpy at pilling defect and these lumps remain tied to the fabric. During the process of defect detection, the white light transmits less light where these lumps locate and it composes the concave at histogram.

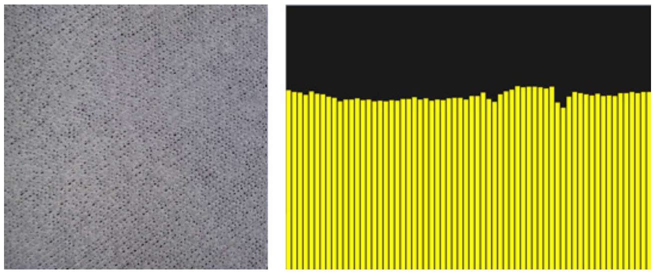


Figure 9. The image of pilling defect on fabric and its histogram

Within the extent of study, the defect detection device advanced to identify certain defect types on knit pile fabric carried out requested measurements at the expected accuracy value. In consequence of the literature review, it was observed that the histograms acquired from the defect detection device developed within this study are similar to those in the related studies (9, 19, 33-35).

4. CONCLUSION

The cost of artificial vision systems in industrial domains is quite high. The installation and disposal of these systems require high amount of budget for producers. The human-oriented defect detection systems are still in use to identify defects at small enterprises. This study goes into the design and active operation of an artificial vision-based defect detection device alternative to existent expensive devices thanks to its low-budget. Six types of defects on knit pile fabric, namely fly defect, loop drop, grease spot, hole, pilling, and cross-striped defect were examined using the artificial vision based defect detection device which was advanced within the scope of this study. The fly defect, pilling, and cross-striped defect form alike histogram graphics (creating in places riffles and valleys). Its reason is assumed as that pilling and fly defects generate similar views on fabric, yet almost identical histogram graphic of cross-striped defect to those of pilling and fly defect is evaluated as an unexpected situation.

It is found that the defect detection device has decent accuracy to fly, pilling, and cross-striped defects, however it has not the expected discernibility capacity. Based on this fact, it is deduced that the discovery of fly, pilling, and cross-striped defects needs the micro-scale examination.

In the future, for the second part of this study; defect detection will be performed with multiple sensors to scan the entire width of the fabric. In addition, statistical analyzes of datas will be added to the study.

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