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Image Processing Applications on Yarn Characteristics and Fault Inspection

İplik Karakteristiği ve Hata Tespiti Üzerine Görüntü İşleme Uygulamaları

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IMAGE PROCESSING APPLICATIONS ON YARN CHARACTERISTICS AND FAULT INSPECTION

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***ABSTRACT*:** New developments in machine vision and automation technologies provide more sensitive process control and quality inspection in each stage of the production line. Industry 4.0 and Image Processing techniques have been used in many areas in textile industry in last decade. Image processing techniques have been also used in textile industry on automatic detection of fiber, yarn and fabric characteristics with improved accuracy and quicker results. In this study, a machine vision system for automatic inspection of yarn bobbin and fabric abrage defect is presented. The prototype system is presented with its components. An image processing algorithm is developed and it is applied on different bobbin and fabric samples including abrage fault. The success of the given machine vision system is discussed herein.

Key Words: Image processing, machine vision system, yarn fault, yarn bobbin, yarn abrage

İPLİK KARAKTERİSTİĞİ VE HATA TESPİTİ ÜZERİNE GÖRÜNTÜ İŞLEME UYGULAMALARI

***ÖZET*:** Makine görüşü ve otomasyon teknolojilerindeki yeni gelişmeler, üretim hattının her aşamasında daha hassas bir süreç kontrolü ve kalite denetimi sağlamaktadır. Endüstri 4.0 ve Görüntü İşleme teknikleri, son on yılda tekstil endüstrisindeki birçok alanda kullanılmıştır. Görüntü işleme teknikleri, tekstil endüstrisinde, elyaf, iplik ve kumaş özelliklerinin gelişmiş doğruluk ve daha hızlı sonuçlarla otomatik olarak algılanmasında da kullanılmıştır. Bu çalışmada, iplik bobini ve kumaş abraj kusurunun otomatik belirlenmesi için bir makine görme sistemi sunulmuştur. Prototip sistem bileşenleri açıklanmıştır. Geliştirilen görüntü işleme algoritması abraj hatası içeren farklı bobin ve kumaş örneklerine uygulanır. Oluşturulan yapay görme sisteminin başarısı burada tartışılmaktadır.

Anahtar Kelimeler: Görüntü işleme, iplik hatası, bobin abrajı, yapay görme sistemi

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1. INTRODUCTION

Abrage fault is detected on the bobbin after the yarn production and on the fabric before the read-made process. Nowadays, this fault control is currently performed by the human eye both on the yarn package and the fabric. In the control of the bobbin, the yarn bobbins are placed in a creel prior to packing and transported to a room illuminated by UV light, where the bobbins are individually controlled. In an enterprise with an average daily production capacity of 15 tons of yarn, approximately 7500/day bobbins are controlled. Four workers are to be employed at least. This process is time consuming and tiring. When the number of bobbins to be checked daily is considered, the risk of overlooked bobbin is high. On the other hand, the automated process flow in fully automated spinning mills is interrupted by visual evaluation. If the abrage faults cannot be detected either on the yarn package or on the fabric surface, it will be eventuated as defective (second quality) end-use textile product. This situation is being reflected as a serious problem for the manufacturers and cause very high reclamation costs. In order to perform this operation automatically, a machine vision system based on the inspection of different fiber contents in yarn bobbin from their different reflectance values under the same lightening conditions is proposed.

Studies on fiber characteristics generally focused on the determination of the geometric properties of the fibers diameter, length, fineness and crimp [1-10]. When the studies on the yarn characteristic are investigated, it was stated that they were generally on determination of yarn hairiness, yarn twist, yarn unevenness, and yarn defects (thick, thin, and neps) by using image processing methods [11-21]. In order to detect the foreign fiber or material content in staple fiber lint, some studies have been conducted. In these studies, different machine vision systems were proposed for automatic detection of foreign fibers [22-27]. J.Silvestre et al. conducted a study in order to determine the abrage faults caused by the mixing of the different types of fibers on the yarn spool (cops). Two types of yarn samples were used in the study; raw yarn and dyed yarn. It was concluded that the faulty parts of the bobbin can be detected by using the different reflectance properties of the fibers the under the UV light [28]. In another study by Çelik [29], a simple prototype of vision inspection system was described for abrage fault detection and an algorithm was built. A simple prototype system was manufactured and the abrage regions of the bobbin samples were detected successfully. When a yarn bobbin including foreign material is used for fabric production, it will cause different appearance after finishing or dyeing processes. It is also a critical fabric fault. The fabric abrage is also detected on industrial fabric quality inspection machines. The fabric surface is scanned by human eyes under UV lightening. This detection process is achieved manually by the workers. Success of manual inspection process completely depends on worker concentration and experience. The studies on the determination of fabric characteristics are mostly focused on objective quality and performance evaluation such as fabric defect detection, fabric defect classification, pilling and wrinkle resistance evaluation [31-41].

In this study, a machine vision system for automatic inspection of yarn bobbin and fabric abrage defect is presented. The prototype system and properties of its components are investigated. An image processing algorithm is developed and it is applied on different bobbin and fabric samples including abrage fault.

2. DESIGN OF ABRAGE INSPECTION SYSTEM

A prototype vision inspection system is developed to acquire image frame of the yarn bobbin and fabric samples for analyzing (Fig. 1). The system consists of a lightening unit, a camera system (BASLER ace acA1920-40uc) a cabin and a PC. A top-lightening cabin design is made. The lightening unit consists of 12 LED UV fluorescent lamps designed to position the camera system in the middle of the lightening unit. The cabin is painted in matt black color to provide a homogeneous illumination and to eliminate reflection in the cabin. A suitable apparatus is designed for positioning the bobbin and fabric sample at the bottom of the system. The distance of the bobbin or fabric sample to camera is designed to be adjustable so that the camera field of view can be adjusted according to the bobbin size. A simple screw system is used for sample distance adjustment.

High quality images are needed for image-processing algorithm. The noise or ghosting of the received image directly affects the success of the algorithm. Therefore, the prerequisite for creating a powerful algorithm is to obtain images with high quality and minimal noise factor. The hardware, lightening and other equipment details of the machine vision system are determined according to requirements of yarn and fabric manufacturing firms.

According to the lighting conditions, the related camera parameters; Light Source Pre-set, Gain, Gamma and Exposure time have been adjusted via the camera software interface (Pylon). Different camera parameters are tried for abrage inspection tests, it is seen that these parameters are very effective on determining the abrage fault. Later they will be optimized to get their best set values.

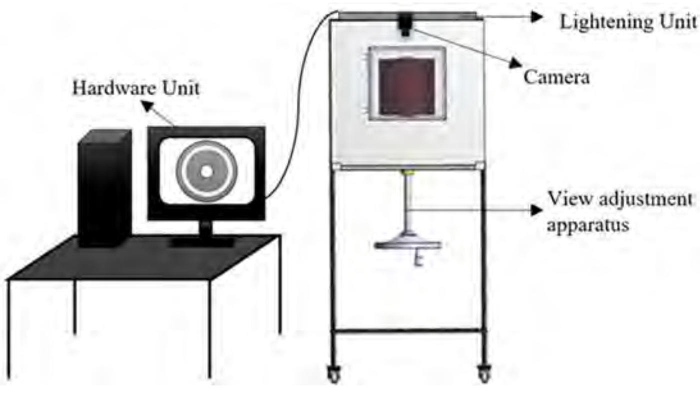

Figure 1. Prototype Cabin Design for Machine Vision Inspection System

3. DEVELOPMENT OF IMAGE PROCESSING ALGORITHM

Image processing algorithm that determines the abrage area has been created in MATLAB – Image Processing Toolbox environment. Image processing is based on different methods. Initially, the digital image frames size (1208x1928) were acquired and saved. Then the image is converted into digital form. Some operations are performed for image enhancement and extracting some useful data to be utilized. It is a type of signal dispensation in which input is an image like video frame or photograph and output may be image or characteristics associated with that image [30]. By using image enhancement filters and morphological processes, the image processing stages are given in (Fig.2), an image processing algorithm is developed. The images taken from the sample (bobbin or fabric) to be detected are first converted to gray level image. The gray image quality is enhanced by applying some noise filtering and image smoothing filters.

The intensity levels in the lower and higher quarter of the range are not prominent in gray images so the intensity transform is used to sharpen the image. For this purpose, the function "*imadjust*" is used for intensity transformation of gray-scale images [32].

$$g = imadjust\ (f, [low_{in}\ \ high_{in}], [low_{out}\ \ high_{out}], gamma) \qquad (1)$$

Where the values below low_in and above high_in are clipped; that is, values below low_in map to low_out, and those above high_in map to high_out. Using the empty matrix ([ ]) for [low_in high_in] or for [low_out high_out] results in the default values [0 1]. If high_out is less than low_out, *the output intensity* is reversed. Parameter (ɣ) gamma indicate the shape of the curve that maps the intensity values in f to create g. If gamma is less than 1, the mapping is weighted toward higher (brighter) output vales. If gamma is greater than 1, the mapping is weighted toward lower (darker) output values. If it is omitted from the function argument, gamma defaults to 1 (linear mapping). Fig. 3 illustrates, the various mapping available in function *"imadjust"*. Fig. 4 shows the effect of gamma parameters on bobbin image frame. In this study, ɣ = 2 was chosen to determine the abrage error.

Figure 2. Steps of the image processing

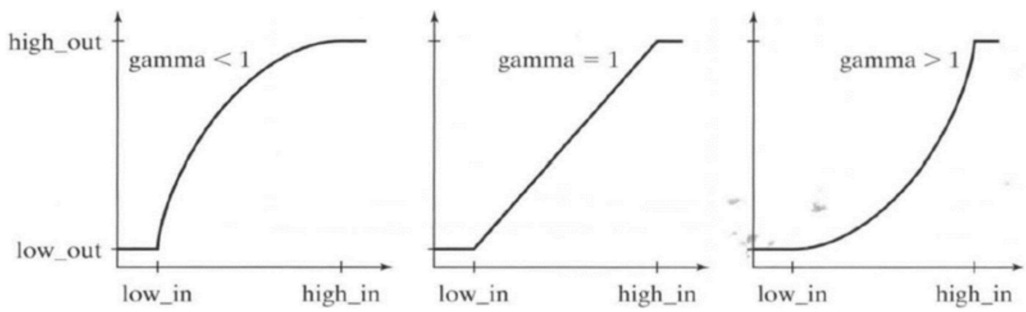

Figure 3. The various mapping available in function *imadjust.* [30]

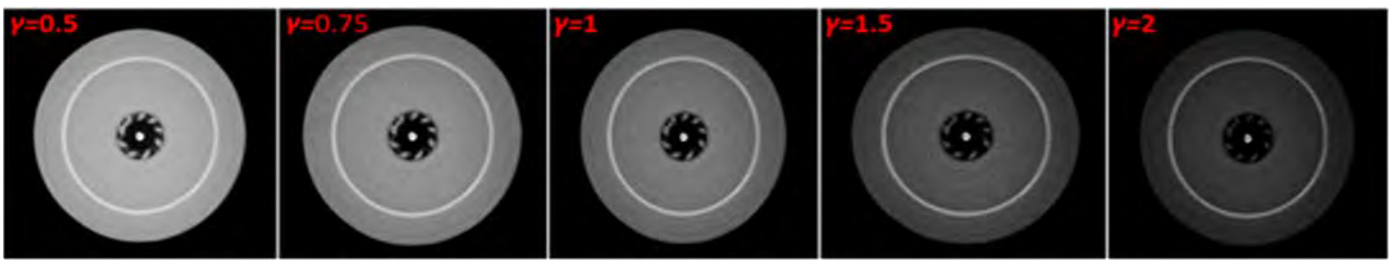

Figure 4. Effect of gamma parameter on image

After the finishing pre-processing stage, in order to obtain binary image, Otsu's thresholding was applied to the enhanced image. Otsu's thresholding method is used to distinguish the object from the background and insulate only object (foreground) from the image. The image frames is converted into the binary form of black 0) and white(1). For labeled boundary of the spreading area, mathematical morphology is used to extract image detail based on enhancement processes such as skeletonizing, thinning, thickening, and convex hull and object marking properties of form or shape within the image. The opening and closing operations; the morphological processes were applied to be able to trace the abrage boundaries on binary image. When opening is used to turn off the excess parts of the image. The closing operation helps to fill empty parts in the image. Then the abrage fault part was labeled. Finally, fabric or bobbin sample is evaluated for the abrage fault presence and so the faultless part were determined in black color and the faulty parts were labeled in white color.

For fabric abrage fault inspection, the single jersey type knitted fabric samples were produced via a sample circular knitting machine with 3 different abrage size (thin, medium and thick) and 2 different fabric densities (16 wales/cm and 14 wales/cm). Fabric faults were made manually in thin, medium and thick sizes for each fabric density. The algorithm given in Fig.2 was used but the applied morphological operation step was adapted according to fabric samples due to different surface properties of the fabrics than bobbins. In order to eliminate the high brightness caused by the fabric structure, the opening and closing values were applied together.

The main purpose of this study was to perform fault detection on the yarn package. The prepared cabin system was designed for this purpose. However, fabric abrage fault detection was also tested on small pieces of samples for a start study. Since the fabric width is generally about 1.5-2 meters and the texture characteristics of its surface is very different from yarn bobbin, a specific machine vision system should be designed for fabric abrage detection. In this preliminary study, the success of developed algorithm on fabric abrage detection was observed. According to the fabric inspection findings, knowledge about design of a new machine vision system for fabric abrage inspection was obtained that will be useful for further study.

4. RESULT AND DISCUSSION

The machine vision system and developed image processing algorithm is applied on bobbin and fabric samples including abrage fault. A total of ten bobbin and ten fabric samples with different sizes and abrage positions are produced. All of the abrage regions are detected successful on both bobbin and fabric samples. In the case of the bobbin, boundaries of the faulty part were drawn in full. A sufficient amount of bobbin was examined for each fault type and the accuracy of the algorithm was visualized. The presented study is start-up phase for next study that will be designed to determine the area percentage of the defective part. Some example applications of the bobbin abrage inspection is given in the Fig. 5. Because the tension of the fabric placed on the plate used for fabric tightness was not equal on all sides, so detection was affected by this situation. As the fabric tension deteriorates the image quality, the abrage has not been found in the desired manner. It was seem that taken the surface smoothness was distorted in the image frames due to excessive stretching of the fabric edges. Although the image quality was not sufficient, a successful result was obtained for fabric inspection. Fig. 6 shows the detection of abrage fault in a fabric structure.

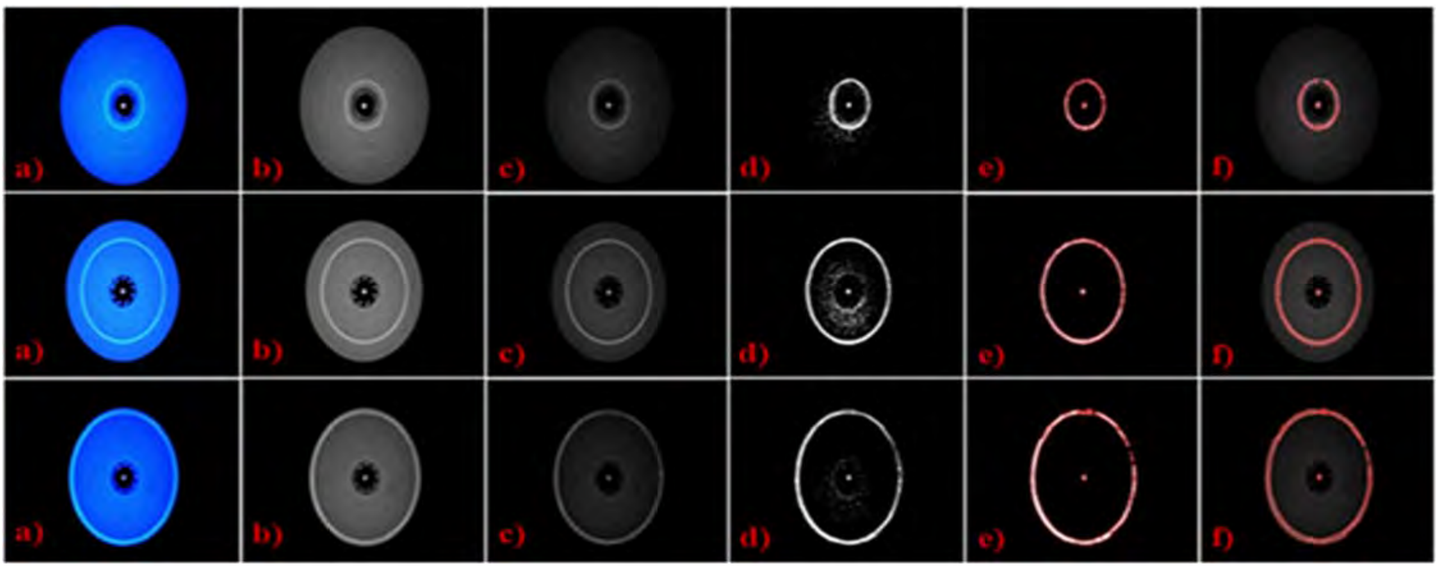

Figure 5. Inspection of yarn bobbins fault **(a)** RGB image **(b)** gray image **(c)** gamma correction applied image **(d)** binary image **(e)** Morphologic operation opening-closing **(f)** labeled image

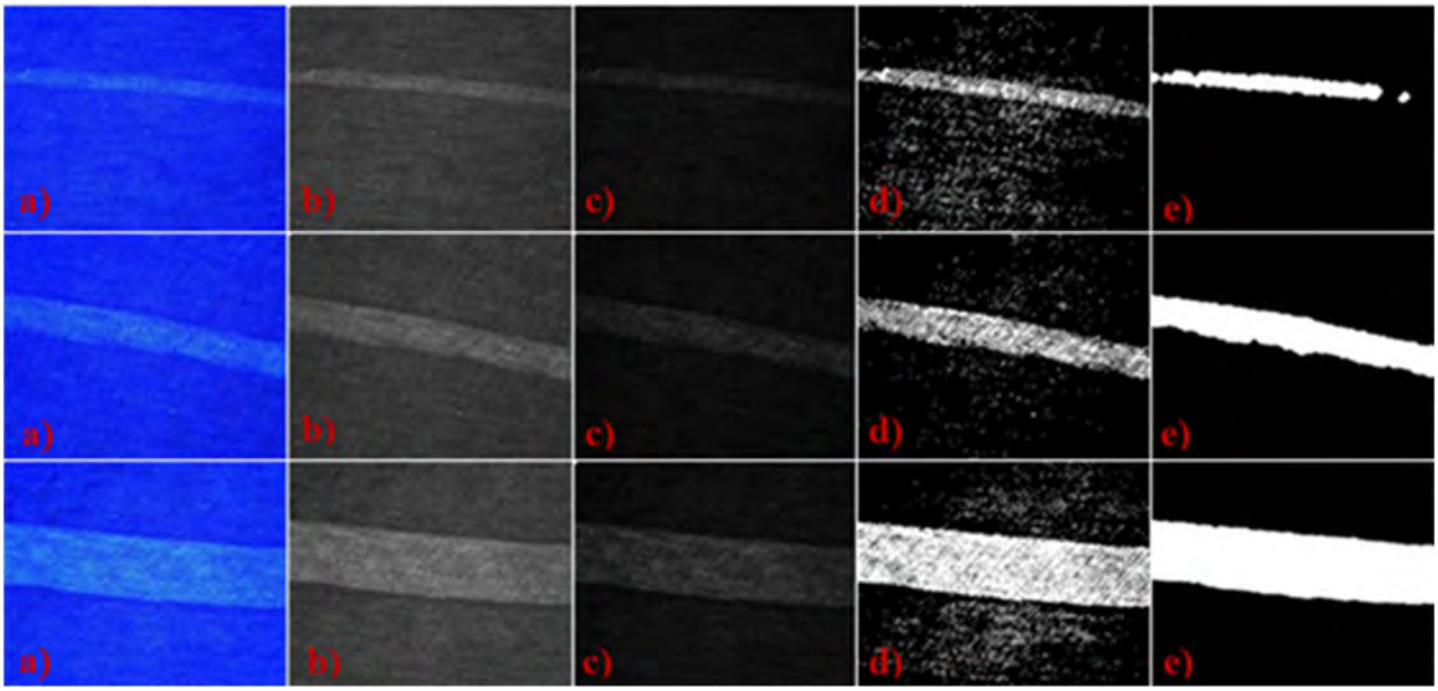

Figure 6. Inspection of fabric detection **(a)** RGB image **(b)** gray image **(c)** gamma correction applied image **(d)** binary image **(e)** morphologic operation opening-closing

5. CONCLUSION

In accordance with the studies on image processing applications to yarn characteristics and fabric inspection, it was revealed that many subjective and manual inspection operations can be automatically and sensitively achieved by using different image processing methods. Most of these proposed methods can be adapted to industrial systems and run in real-time. By this way, the yarn manufacturing efficiency and yarn quality can definitely be improved.

In this study, 10 bobbin samples and 10 fabric samples including abrage fault were used for inspection. The purpose of this study is to check the presence of the abrage in the bobbin or fabric sample. Only the abrage existence of the samples were tested. Finally, all of the abrage faults were successfully detected on both bobbin and fabric samples. The details of the faults such as area percentage in the bobbin cross-section will be analyzed in further study. The image processing algorithm is in progress.

In the next study, a statistical analyzed will also be performed to evaluate the accuracy and precision of the true detection. It is also planned that the upgraded algorithm will determine the location of the abrage and classify it according to its size. The proposed system will be adapted to the automation system of the yarn spinning mill replacing with the manual inspection process. The image processing technique can be used to determine the time-consuming quality control process much shorter and faster. In addition, due to the high ratio of accuracy, it is possible to detect even the fault that are too sensitive to be seen by the image processing method. So the next project aims to use the prototype system for real time detection.

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