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Faults Detection with Image Processing Methods in Textile Sector

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Abstract – The quality control process for determining fabric faults causes high cost and time loss when performed with human eyes. Adding a real-time system to the fabric production mechanisms is very difficult to detect mistakes. In this study, 5 MP Raspberry Pi camera module is used to detect the image of the fabric moving through the conveyor band and a Raspberry Pi 3 minicomputer to process the received image and display it on the touch screen. In addition, studies on the inspection of the faults in the woven fabrics, which are the most applied areas of image processing methods, have been investigated and thresholding method, HSV color space transformation and morphological processes have been used in order to detect the fault in any fabric accurately and correctly. The most suitable threshold values for these methods have been determined by testing in the images obtained as a result of the investigations.

Keywords – Fabric Faults, Faults Detection, Image Processing, Segmentation, Morphological Operation

I. INTRODUCTION

The quality and smoothness of fabric surfaces is of great importance in the textile industry. The demand for fabrics, which are very common in use, has increased rapidly, especially with the continuous growth in fashion sector. Parallel to the increase in demand, fabric production also increases at the same rate. Only the quality of the fabrics produced should not fall. If the production of defective products due to faults found in fabrics is realized, the producers may suffer serious material damage. For this reason, the fabrics to be produced must be checked before they are offered to consumers. Inspection of fabric surfaces in the production is very beneficial in terms of production cost because the fastest and most accurate job is done. If this observation is done based on the human eye, production slows down and it is insufficient to examine the types of errors that are difficult to detect. Since the evaluation of the faults on the fabric will vary from person to person, a certain fault tolerance will not be obtained and a certain standard of production quality will not be achieved.

When it comes to national fabric manufacturing industry, methods used in the quality control process are conventional methods and quality control systems imported from abroad. Conventional control is carried out with the human eye. This process increases production cost and causes slower operation failure to detect errors beyond faults tolerance due to elongation of demanded product's elapsed time and fatigue of the human eye.

It has been observed that a number of international studies have been conducted within framework of literature works. Thanks to our proposed system, camera usage and image processing algorithms are independent of human supervision and they are more important than other works. In addition, although stereo image acquisition techniques are used within the scope of the examined articles, a single camera is used for image acquisition and transmission in the proposed method. In this study, it is aimed to find fault types on the fabric surface independently of human control.

Chronologically, Wood et al. used Fourier power spectrum to determine the content of the spectral frequency of the source images to determine faults on the carpet [1]. It shows that the Fourier spectrum is repeated periodically for accurate texture images. For this reason, tissue thickness and pattern regularity are measured by autocorrelation. Cross-correlation is used for pattern recognition. Campell et al. used discrete Fourier transform in error detection on denim fabric with a multi-layer artificial neural network [2]. Faults are detected with obtained features by Fourier transform in maximum probability classifier. Tsai et al. Used the Fourier transform-based spherical image refinement scheme to detect faults on fabric [3]. With a one-dimensional Hough transform, any contour lines on the image were removed using inverse Fourier transform. The difference between new image and the actual image obtained at this point is predicted as an error. Sari-Sarraf et al. [4] used edge fusion and wavelet transform in pre-processing of images. 3700 subjects with 26 different types of imperfections from vibration-free and high-resolution cameras have detected errors with 89% accuracy rate using 2-D Dauechies wavelets over their images.

Kumar et al. performed Gabor wavelet feature selection with a guided error approach in detecting fabric faults [5]. In addition, Gabor function with low computational cost has only proposed error detection through virtual part. Tsai et al. [6] has implemented a Gabor filter design with one dimension to transform fabric images into a two-dimensional, gray-level picture, and to reduce computational load of fabric faults detection. Chiu et al. developed a Fourier domain maximum probability estimator based on a proportional Brownian model for detection of fabric faults [7]. This method has succeeded on four wrong fabric pictures. Tsai et al. uses Fourier transform-based spherical image scheme [8]. They tried to remove repetitive patterns in fabric texture by inverse Fourier

transformation by performing the optimum radius adjustment in the refresh process in the images. In the figure, regions with homogeneous transition have the same gray level and the regions with defective are more apparent. Shu et al. [9] developed a Gabor filtering method based on multiple threads and scales for automatic error detection. The method in different frequencies operate depending on the energy of the convolution of the filter bank. Many studies have demonstrated the feasibility of this method. Ogata et al. [10] used two-dimensional discrete Fourier transforms to detect spherical errors on embossed fabric, and Gabor filters for local errors. Hou et al. [11] designed multiple adaptive wavelets for detection of each fabric faults. 98% detection rate was achieved by using multiple adaptive wavelet transform on 56 images with 8 kinds of errors and 64 images without errors. Sengottuvelan et al. [12] proposed a method based on Fourier transformation by examining relationship between images and structures in frequency space in fabric images. They obtained 7 important features from the central frequency spectrum and classify them according to 3 kinds of error types.

The study included in four sections. In Section I, introduction section, the aim of the research and literature research is stated. Materials and methods are in Section II. In Section III, obtained results with proposed method were evaluated. In the conclusion and discussion, it is envisaged that proposed algorithm applied real-time prototype and fabric faults are detected.

II. Materials and Method

A. Thresholding Method

Thresholding is one of the most important approaches for visual segmentation purposes. Segmentation is used to separate meaningful regions. The purpose of segmentation is distinguished objects from background. Gray level is symbolized as L and gray level ranges from 0 to L-1. In Otsu method, C_0 and C_1 must be defined in terms of single level threshold. As T is thresholding value in the range of $[C_1, L\text{-}1]$, it is assigned to pixel class C_0 otherwise C_1. Pixels in the range $[0, t\text{-}1]$ representing threshold value T are assigned to pixel class C_0 in the pixel order In images, probability of repeating all gray values must be calculated. The formula for this condition expressed as P_i;

$$P_i = h(i) / N \tag{1}$$

Where $h(i)$ is recurrence of Gray levels and N is total pixels. The gray level probabilities are calculated within their own weights:

$$W_0 = \sum_{t=0}^{t=1} P_i \qquad W_1 = \sum_{t=t}^{L-1} P_i \tag{2}$$

The mean value is:

$$\mu_0 = \sum_{i=0}^{t-1} \left(\frac{i \times P_i}{W_0}\right) \qquad \mu_1 = \sum_{i=t}^{L-1} \left(\frac{i \times P_i}{W_0}\right) \tag{3}$$

The average intensity expression of image:

$$\mu_t = \mu_0 W_0 + \mu_1 W_1 \tag{4}$$

The following formulas are used to classify classes:

$$\sigma_0 = W_0(\mu_0 - \mu_t)^2 \qquad \sigma_1 = W_1(\mu_1 - \mu_t)^2 \tag{5}$$

Objective function with these calculated values is found as follows:

$$f(t) = \sigma_0 + \sigma_1 \tag{6}$$

Finally, threshold value must be found by making experiments on all gray levels that will maximize the objective function. For this, threshold value (t') is calculated as:

$$t' = \arg\max\{f(t)\} \tag{7}$$

The real image of a fabric at Fig. 1, there is a fabric image with a thresholding process in Fig. 2.

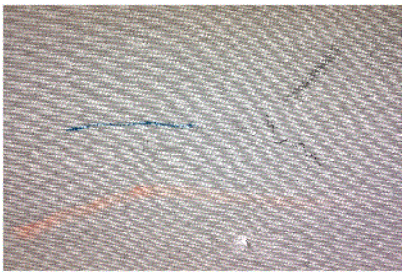


Fig 1. Real fabric image

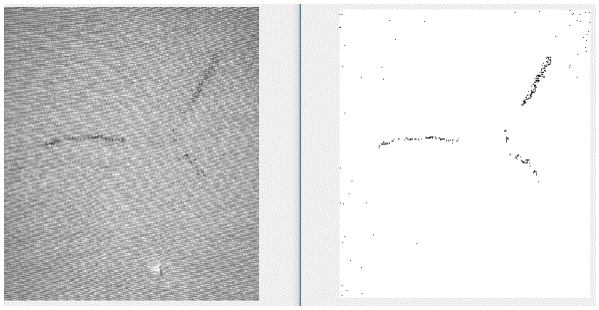


Fig. 2. Thresholding image

B. HSV Space Transformation

The areas of application of HSV are high-quality computer applications, space change in case colors cannot be selected. In its simplest form, it is used to select the various colors required for a particular picture. That is, users can select desired color from color channel.

Hue is represented by colour circle. A triangle is used to represent saturation and value. The triangle represents horizontal axis value and vertical axis represents saturation. When a specific colour is needed, a colour is chosen from circular region and saturation is chosen from the vertical angle of the triangle. Brightness value can be selected from horizontal angle of the triangle.

In this work, color space transformation is applied from RGB color space to HSV color space. The point to note here is that the RGB values must be reduced to between 0 and 1.

After each pixel has been normalized by dividing by 255, HSV values can be found with the following formulas:

$$R^{'} = R/255 \quad G^{'} = G/255 \quad B^{'} = B/255 \tag{8}$$

Calculation for Hue value:

$$H = \begin{cases} 0^{o} & ,\Delta=0 \\ 60^{0} \times (\frac{G^{'} - B^{'}}{\Delta} \bmod 6) & ,C_{max} = R^{'} \\ 60^{0} \times (\frac{B^{'} - R^{'}}{\Delta} + 2) & ,C_{max} = G^{'} \\ 60^{0} \times (\frac{R^{'} - G^{'}}{\Delta} + 4) & ,C_{max} = B^{'} \end{cases} \tag{9}$$

Calculation for Saturation value:

$$S = \begin{cases} 0 & ,C_{max} = 0 \\ \dfrac{\Delta}{C_{max}} & ,C_{max} \neq 0 \end{cases} \tag{10}$$

Calculation for Value:

$$V = C_{max} \tag{11}$$

The areas of application of HSV are high-quality computer applications, space change in case colors cannot be selected. In its simplest form, it is used to select the various colors required for a particular picture. That is, users can select desired color from color channel.

The advantages of HSV's color space is very similar to human's color perception. Other than HSL, methods define colors in relation to primary colors. The colors used in HSV can be easily detected by the human brain. However, this does not always apply to RGB and CMYK. Fig. 3 shows application of various channels of HSV to fabric surface.

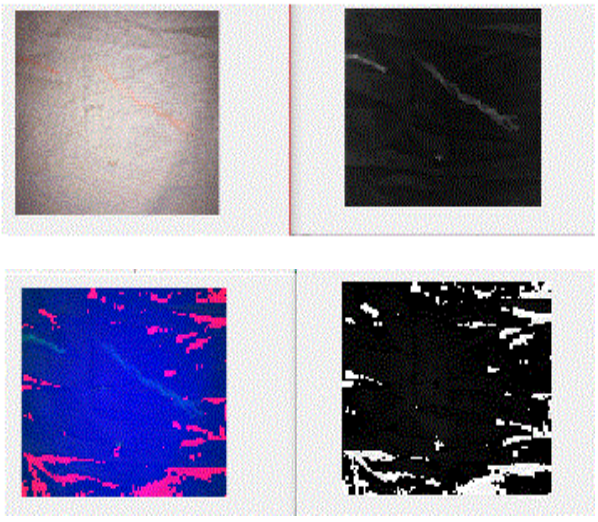


Fig. 3. Four HSV channels of Fabic image

C. Morphological Operations

Mathematical morphological operation is a powerful image processing analysis in nonlinear neighbourhood processes required for applications such as identification and extraction of structures such as borders, skeletons, noise reduction and segmentation. There are two basic operations used in morphological image processing: expansion and erosion. Other processes are obtained using these two processes. For example; opening and closing operations.

Opening morphological operation that is used to enlarge or thicken an object in a binary image. Expanding a numeric image means enlarging it as much as the intersection of image with the structural element.

Closing morphological process that helps to reduce an object in a binary image. The closing process is the inverse of an opening process. With closing process, numerical image is etched. In other words, the objects in the picture are small, if they are wide, the bound objects tend to separate.

Opening and Closing Process: Opening and closing, spreading and grinding operations are performed by sequential application of binary image. Opening is achieved by sequential application of expansion and etching. With this operation, two objects close to each other are separated without causing too much change. Closing is achieved by sequential application of the grinding and expansion process. So two objects close to each other are connected without much change in the image.

In this study, the noises in the image were eliminated using morphological opening and closing operations and the existing faults were clarified.

D. Proposed method and System structure

As a basic principle in the proposed study, it is aimed to perform on-line error detection by appropriately processing image taken from an external environment in a proper manner. The methods to be applied for this reason can be classified under two main headings. These headings are processed on the computer and detected errors in light to the obtained attributes. As can be seen in Fig. 4 and Fig. 5, illuminated fabric image is captured by the camera and processed on an embedded system.

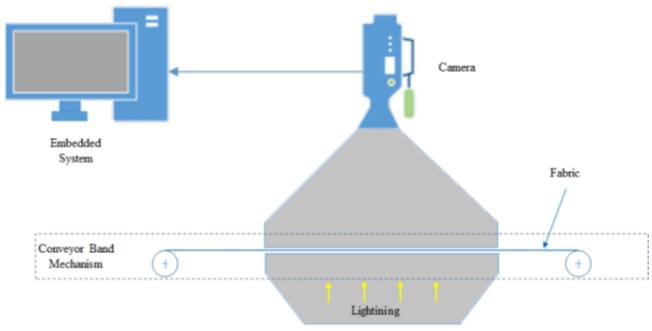


Fig. 4. Working principle of System

The fabric moving through the conveyor belt is transferred from rollers to other rollers by means of the DC motor while video frame is taken for the detection and processing of fabric image by camera. In this video image processing unit, individual thresholding, HSV space conversion and morphological opening / closing methods are applied and then faults on fabric are determined. Here, if there is an error above tolerance, instantly processed image on fabric of fault is reflected on interface and presented to user's evaluation.

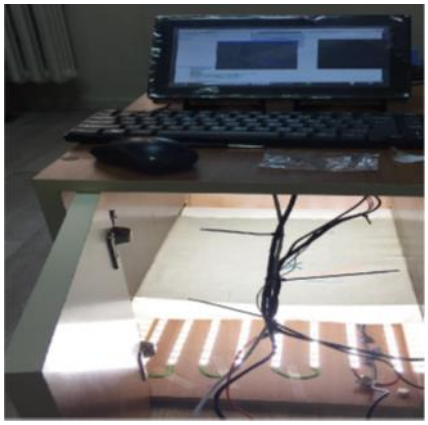


Fig. 5. System Structure

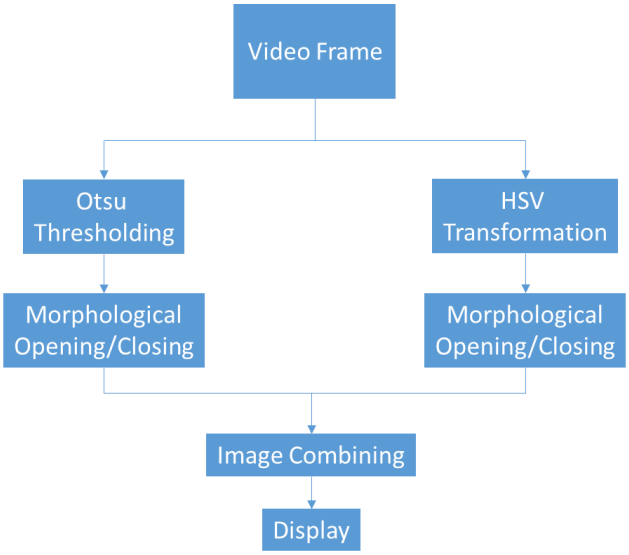


Fig. 6. Block Diagram of Proposed System

III. RESULTS

In this study, rips, stains, etc. on fabrics produced for different purposes in textile. The detection of faults is provided using image processing methods. Obtained faults are grouped into various forms and image processing methods are used according to these group faults.

HSV space was used to find oil and other stains on the fabric. This is to indicate texture difference of oil spot which is close to texture of fabric. Thus, grease and similar stains, dirts have been observed more comfortably.

Thresholding has been done to find scratches such as ballpoint pens and pencils. Because these tones, which are in a different colour than the texture of the fabric, give a darker image by pulling down the light value. Thus, ballpoint pen and similar spots were observed more easily on the image by the thresholding. In addition, the thresholding is ripped and is also effective in detecting tears.

Morphological opening and closing operation has been applied to clear the noise from view and to clarify the detected faults. Thus, it is possible to observe faults obtained more clearly.

These separately used spaces and filters were collected at the end to obtain a single image. All faults that may occur on this display are shown on a single image. Errors that may occur or are likely to be missed are reduced to the lowest level, converted to a level that the quality control element can easily perceive, and faults that can be avoided by saving time with speed increase in quality control process have been removed in Fig. 7. and Fig. 8.

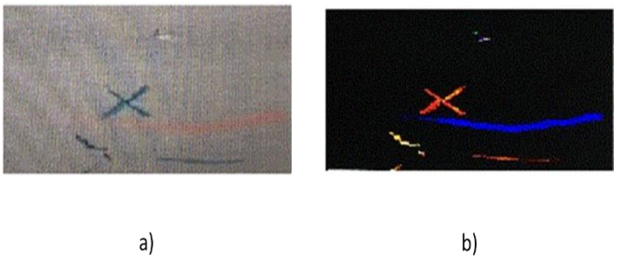


Fig. 7. a) Original image b) Processed image

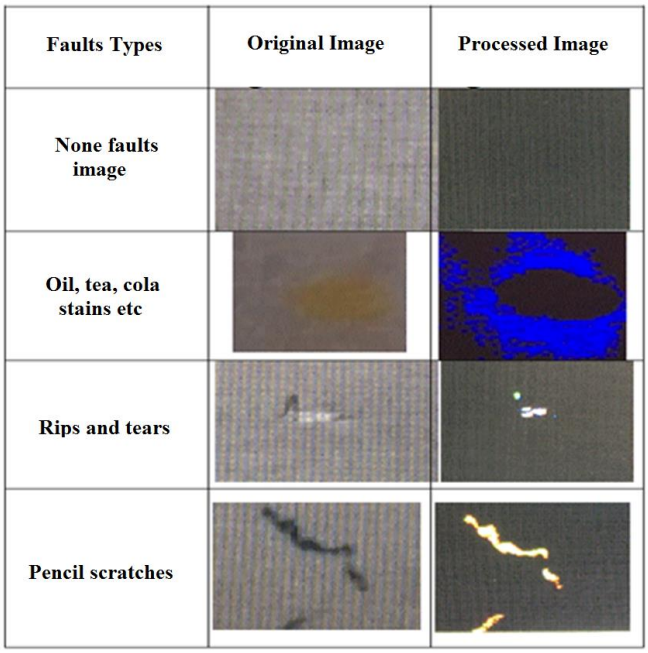


Fig. 8. Original and Processed image with different faults type

IV. CONCLUSION AND DISCUSSION

There are no methods similar to proposed method in literature. In this study, light is distributed homogeneously on fabric and examined with help of a single camera. This makes it easier to detect the faults by the camera and conveyor band speed can be increased. In the literature studies, camera angle was changed or multiple cameras were used and speed of conveyor slowed down because installed systems were affected by dust, no image was obtained with single camera, no homogenous illumination was provided. In addition, it has been determined that damage images obtained in some studies are distorted in their shapes. In our work, a single camera was used and it will be possible to find correct fault without any influence from undesirable materials such as dust on the fabric. In our proposed method, there will be no limitation in the size of controlled fabrics due to the homogeneous distribution of light on surface of fabric. At the same time, an embedded system independent of the computer was designed. In the literature, there is no real system capable of analysing the conveyor with high speed and accuracy with embedded systems. Thanks to the embedded system used, energy and space will be saved. With this method, the quality control

process in the glass production sector will be made more reliable and faster.

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