Automatic Detection and Classification of Weaving Fabric Defects Based on Digital Image Processing

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***Abstract* — this paper describes the detection and classification of fabric defects based on digital image processing. The work is intended to provide the higher speed and accuracy of defect detection than human vision and to find the source of the defects. At first, we find the size and position of wefts or warps from an image. Then calculate the pattern of weft and warp positions and figure out whether there is a defect or not. The patterns of weft and warp may differ based on the type of fabrics. Sample pattern of good fabric is used to detect and classify the defect of the fabric with same pattern. OpenCV library and python programming language is used for the experiment. Seven kinds of defects on the fabrics model images are detected and five real fabric images are used for the experiment. The experiment shows the result of successful defect detection with 95% rate, and it is 50% faster than human vision in fabrics density calculation.**

Keywords — digital image processing; defects; edge detection; OpenCV

I. INTRODUCTION

The clothing is the second most important thing for a human being. A cloth is fabricated from fabric and the fabric can be made by weaving, knitting, crocheting, felting, or braiding of fibers. In the textile industry, there are two major steps to making fabric. They are the conversion of fiber to yarn and yarn to fabric. Textiles can be made using various ways such as weaving, knitting, crocheting, or braiding [1,2]. There are three basic types of weaves: plain weave, satin weave and twill. The plain weave is the most fundamental types of others. It is produced by making a simple crisscross pattern using aligned warp and weft. The weft thread crosses over the warp threads and then under the next warp. The next weft crosses the warp threads by the opposite form of the previous one crossing. In satin weaves the warp yarns are running top to bottom when weft running sideways folding at each side. A twill wave has the same form of warp and weft crossing pattern as plain weave with little differences. Warps cross the wefts diagonally and number of warps for crossing is based on the twill design. It is the pattern of plain weave in Fig.1.

In weaving loom industry, defects are the considerable problem of controlling the quality of the fabric. Defects may appear during the production stage. Fabric with defects may reduce its price and even can cause the rejection from customer. There are various kinds of defects for different type of weave. The common defects in woven fabrics are shown in Fig.2.

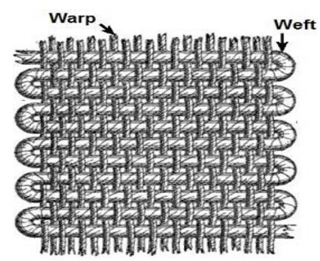

Fig.1. Warp and weft pattern of a plain weave

The hole defects are caused by defective machine elements. The float defect is formed when a filling yarn is slack and thick or thin weft defect is by a bad quality yarn. Double pick defect is caused when the loom being stopped and weft is still passing. Insufficient and excessive weft density defects are caused when weft is threaded over or under amount of time. These are the common types of defect and brief reason of why they are caused. Now, we can find the correct way to stop continuing having defects in production. There are various kinds of defect detection techniques in image processing technology.

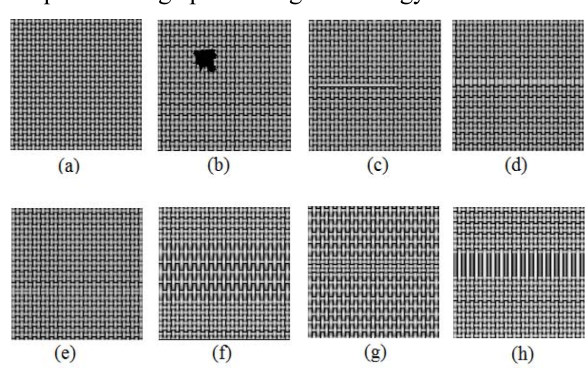

Fig.2. Fabrics and defects (a) good fabric (b) fabric with hole (c) float (d) thick weft defect (e) double pick (f) insufficient weft density (g) excessive weft density (h) broken weft

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We have already implemented two kinds of fabric defect detection methods using image processing: the comparison method that uses the correlation of fabric image [3] and defect detection using Hough Line Transform [4]. These two methods show the efficient results in detecting defect from fabric image. The correlation method has higher speed of defection and the Hough line transform has the more detailed result. The only limitation is they can't identify what kind of defect is detected. So there is weakness to fix the source of defect. The system may confuse that it is yarn defect or wrong pick defect. If it is yarn defect we can't fix it easily because the yarn needs to be removed or replaced with normal yarn. If other type of defects we can change the density of weft or fix the pattern of weft.

II. PROCESS OF EXPERIMENTING THE SAMPLES

Open CV, imutils, numpy libraries and python programming language are used to experiment the defect detection. All test fabric images are from the paper "Simulation and recognition of common fabric" by Maroš Tunák and Aleš Linka from Technical University in Liberec, Department of Textile Materials; Hálkova 6, Liberec 46117, Czech Republic[5].

We used the combination of morphological operations and contour detection techniques to detect and classify the defect. The process of detecting has some stages:

- Reading image data from file (or) camera.
- Filtering or noise removing.
- Thresholding to get better segmentation
- Using morphology operation
- Finding contours of wefts and warps.
- Classifying shape of contours.
- Classifying wefts and warps
- Detecting defects by defining position and size of contours.
- Defining type of defects.

The fabric image data is read using *cv2.imread()* function. The image is converted from color image to gray scale and cv2.medianblur() function is used to filter unnecessary noises. Then we made threshold to the smoothed image for segmentation process [6]. Thereshold Binary function is used for thresholding. The function is written down below.

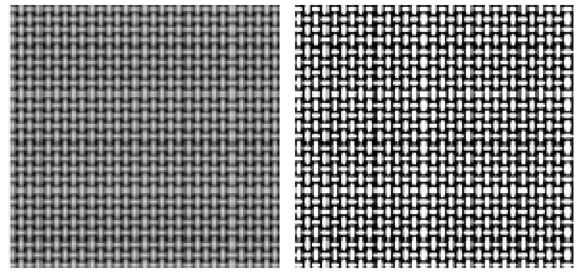

Fig.3. Gray scaled and threshold image

$$dst(x,y)=\begin{cases}\max Val & if \quad src(x,y)>thresh \\ 0 & otherwise\end{cases} \tag{1}$$

Where:

dst (x,y) – the intensity of destination

src(x,y)- the intensity of source image

thresh – threshold point

We set the maximum value to the destination if defined threshold is less than the source intensity. If not it set 0 to the destination. The maximum intensity and the minimum intensity are set to 255 and 0. The next step is using morphology operations. We used morphology opening operation to remove remaining noises in the background image. The interlacing points of wefts and warps are the background image and the parts of wefts and wefts are foreground image. Then we used the morphological closing technique to remove noises from foreground image. It provides not to mistake in finding the contours of wefts and warps with defects or noises. After using morphology operations, *cv2.findcontours()* function is used to define contour of wefts and warps. We set the interlacing points between wefts and warps as background. So *cv2.findcontours()* function finds all contours of wefts and warps. In this step, we get the contours of wefts and warps and the central point and area of these contours by using *cv2.moments()*function and *cv2.contourarea()* function . Then we classified the type of defect if it is presented based on the pattern of centroid contours and size and shape of contours. Figure 4 shows the basic pattern of plain weave fabric.

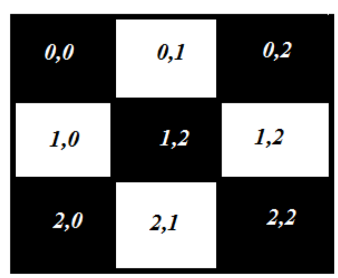

Fig.4. the basic pattern of plain weave fabric

The pattern of warps is calculated by the equation(2).

$$d_{i,j} = \begin{cases} d_{i,j+a} & if \quad j < c \\ d_{i+b,j} & if \quad i < r \end{cases} \tag{2}$$

where:

d – the destination of warp contour

i ,j– the index of the destination

r – the row of the matrix

c – the column of the matrix

a – the horizontal distance between two destination

b – the vertical distance between two destination

In table.1, the indexes of all first five warp contours are listed. All row indexes (the second values) are same number. So the vertical positions of warps are in the good pattern. The column indexes (the first values) in the same row of the table have the same difference values from neighbor. And odd table rows numbers have each of the same column indexes. The even table row numbers are also the same. So the fabric has the same pattern with plain weave. No defects were found.

TABLE I THE INDEXES OF WARP CONTOURS

	1	2	3	4	5
1	30,13	74,13	119,13	163,13	207,13
2	8,38	52,38	97,38	141,38	185,38
3	30,66	74,66	119,66	163,66	207,66
4	8,93	52,93	97,93	141,93	185,93
5	30,121	74,121	119,121	163.121	207,121
6	8,149	52,149	97,149	141,149	185,149
7	30,176	74,176	119,176	163,176	207,176
8	8,204	52,204	97,204	141,204	185,204

The detected defects of sample fabrics are shown in figure(5). The defect areas are drawn with red color.

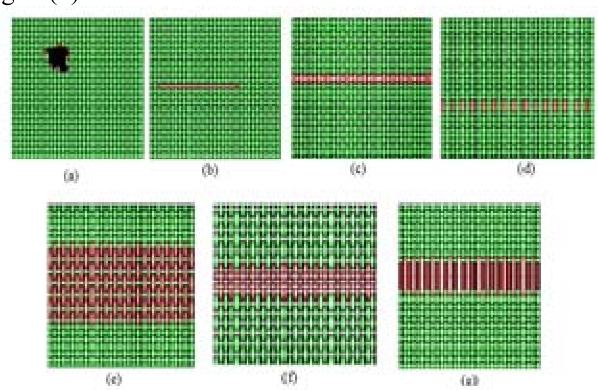

Fig.5. Detected defects: (a) fabric with a hole (b) float (c) thick weft defect (d) double pick (e) insufficient weft density (f) excessive weft density (g) broken weft

The numerical results of detected defects are given in the table II.

TABLE II THE RESULT OF DEFECT DETECTION

size	defects	type	places	area	avg_area	Standard avg_area
690x692	1	float	253,343	6687	390.8	320.5
688x699	31	thick yarn	23,15	650	392.5	320.5
694x693	15	double pick	24,15	736	329.8	319.2
696x688	4	insufficient	15,85	1276	511.4	320.5
691x689	42	exceed	20,15	33	310.1	320.5
688x686	27	broken pick	15,171	2686	715.8	325.3

The average contour area of fabrics with defects is different from the average area of stand sample. It is one of the common facts for detecting the defects. The experimental result shows the position of wefts and warps are in good pattern. The images used in the experiment are simulated and it provides defining

warps and wefts. For detecting defects on real fabrics it may have some different results. We used the plain fabric which is woven with 1.5 cm diameter yarn without any defect.

The size of our input image was 273 x 537 Fig.6. The image was converted to gray scale and smoothed by removing noises. Then we used *cv2.threshold()* function to perform

#segmentation Fig.7. After segmenting the image we find the contours of visible wefts or warps using *cv2.findContours()* function. Contours are drawn on the original image so we can check the detection is going well or not Fig.8.

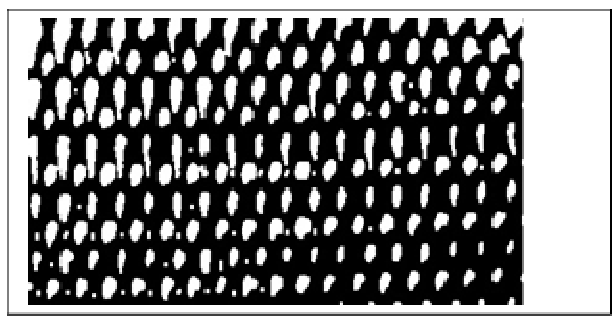

Fig.6. Image after morphology transform

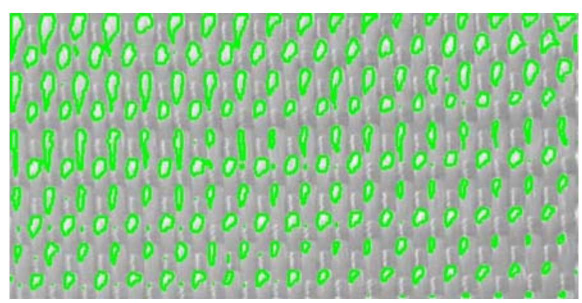

Fig.8. Fabric with warps contours

In figure (8), contours have various shape and size even though the fabric is good quality. That may be formed because of having bad quality of the image or having bad lighting angle when it was captured. Then the centers of all contours are marked with red dots on the image to classify the form of pattern.

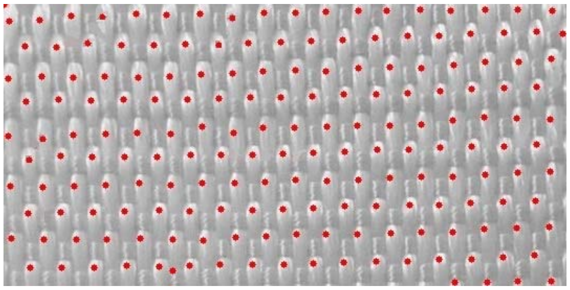

Fig.8. Fabric with centers of all warp positions

According the form of contours the warps are not seemed in a good position. The effect of bad lighting and angle of image capturing may cause the differences shapes and size of warps. If the camera captured the image, not from the frontal and center of that image, the shape, size and pixel value may be different from the original. But the pattern of red dots indicates that the method works well with real fabric defect detecting. There are no weft's contours in the fabric because the color of wefts is different. We can classify that warps are in the right pattern without weft's contours and say that there is no defect in the fabric. If the fabric has another type of pattern we can't use this method for classifying types of defects but we can still use detecting defects.

III. Conclusion

Quality control of weaving loom industry is important for reducing cost of products and improving quality of the products. Using digital image processing technology can provide less cost of labor, fast and accurate processing. Detecting defects and classifying the reason of causing defects based on the image processing gives the advantage in quality control and rapid production. Using the combination of various methods of defects detecting can provide more effective defect detecting technique and higher rate of identification.

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