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Automatic Density Detection and Recognition of Fabric Structure Using Image Processing

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Abstract:

This paper presents a new approach for processing images of woven fabrics to determine the warp-weft densities. This approach includes three main steps, namely; image pre-processing, wavelet transform, morphological processing and density calculation. In the experimental process, different woven fabric images were scanned at a high resolution, then these images were transferred to the MATLAB program. By using the wavelet transform and morphological processing density of warp and weft is obtained. . This method is based on widely used digital image analysis techniques. It allows automatic warp yarn and weft yarn cross area segmentation through a spatial domain integral projection approach consequently with 97 % accuracy, the densities were predicted only by using the images instead of counting them by hand.

In Today's work, woven fabric structure classification is based on manual work in textile industry by using Pick glass. This paper proposes an automatic approach to classify the three woven fabrics: plain, twill and satin weave. Firstlyto detect the interlacing area where weft yarn and warp yarn crossed over each other we apply horizontal and vertical projection in order to reduce the analysis of fabric images. Then gray level co-occurrence matrix (GLCM) is adopted to extract the texture features of pre-processing fabric images. Finally Neural Network is applied to classify the three basic woven fabrics. The experimental results demonstrate that the proposed method can automatically, efficiently classify woven fabrics and obtain accurate classification results.

***Keywords* — Woven Fabric, Wavelet Transform, Morphological Processing, Principal Component Analysis, Fuzzy Clustering, Integral Projection, Gray Level Co-Occurrence Matrix, Texture Analysis.**

I. INTRODUCTION

Woven fabrics are highly structured materials which mainly include plain weave, twill weave and satin weave. The structures are affected by the weave pattern and density of yarns. In today's work, density detection is often done artificially in textile industry. fabric win construction or weave pattern of fabric can be identified by using microscope or magnifying glass which a manual operation. The density that is number of warps and wefts present in fabric can be measured by using pick glass which takes more time to complete the work. This manual work is very difficult and harmful to the human(inspector) eyes and also the judgement of inspector may not be accurate because it may vary from one inspector to other. Because of all such kind of reasons we constructed such a system which gives accurate judgment of weave pattern and density of fabric. Our system gives us automatic classification of fabric and also counts of warp and weft of fabric. This system can be very important and useful to reduce labour cost. By using this system, textile industries can improve their efficiency. For density detection we used Image processing and wavelet transform. wavelet transform can be used so that we decomposed our image into 4 parts, horizontal image, vertical image, diagonal image and approximation image. Then we used morphological processing for further processing. Now in second part of this system we used Principal component analysis and fuzzy c means clustering and Neural Network for identification of fabric weave structure from the three basic structures:-Plain, Twill and Satin weave.

II. PROPOSED SYSTEM

A. Density Detection:-

The Process for density detection by measuring warp and weft of woven fabrics can be shown in the following figure**:-**

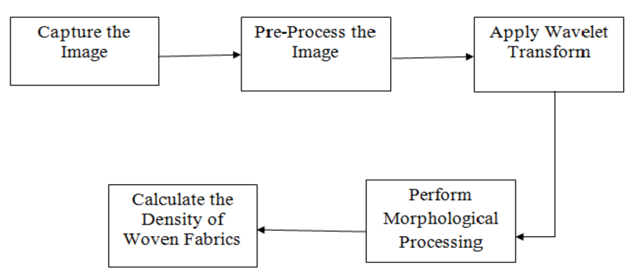

Fig 1. Processing steps for woven fabric density detection

1) ***Images captured:-***Firstly, fabric image can be captured using high resolution camera.

2) ***Image pre-processing***:- For improving the visual effect and facilitate human as well as machines to analyze and understand the images, image enhancement and filtering are used to reduce noise and make fabric structure more clear and also we converted color image into gray level image.

3) ***Wavelet transform***:- Wavelet transform can be used to decompose the fabric image into four parts which gives us a fabric image having horizontal, vertical, diagonal and approximate image. Here, A fabric image at level s can be decomposed into four components. The approximate image is at level s+1 and the other details in three orientations (horizontal, vertical and diagonal) via two dimension(2D)DWT [1]. In the processing, the input fabric images should be processed via low-pass and high-pass filtering, and down sampling in a horizontal direction, so is the vertical direction. Then high frequency horizontal, decomposition approximate number, diagonal and vertical detail component are obtain. Further, The same decomposition could be done for the low frequency image(Approximate image) and same results are obtain. This decomposition steps of 2D DWT can be expressed in fig shown below:- while the wavelet reconstruction is the inverse transform of wavelet decomposition .i.e. reverse of the figure below.

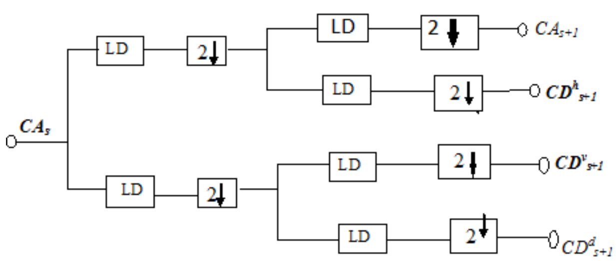

Fig 2:-The decomposition step of 2D DWT

4) ***Morphological Processing*:-** Morphological processing can be used to warp and warp, weft and weft completely. Here we used Binarization Process . Binarization is that the images are shown in form of white and black pixels. For this Process we used Bernsen algorithm as a typical binarization algorithm and an adaptive method of dynamic selection threshold is apply to realize binarization processing [1]. Bersen algorithm could be described as follows: w(x,y)=0.5*(maxf(x+m,y+n)+minf(x+m,y+n))w≤m≤w,—w≤n≤w
Where f(x,y)is the gray value of the pixel(x,y)
w(x,y)is the threshold of each pixel.

So,In such a way, To distinguish the information between warp and warp, weft and weft morphological processing is required.

5) ***Density evaluation:-***
Calculate density that is no. of warp and weft in that image.

$$D = \frac{sum*P*10}{2.54M(N)}$$

Where, P= is the resolution of CCD
D=the density of weft and warp yarn of woven fabrics
M(N)=is the size of processed images.

B. Weave Pattern Classification

The second part of this system is recognition of fabric weave pattern. In textile industry, Weaving is a kind of technique in which two distinct sets of yarns are interlaced at right angles to form a fabric. The way in which the threads are interlace with each other is called the weave. There are basic three types of weave pattern:- Plain weave, Satin weave, or Twill.

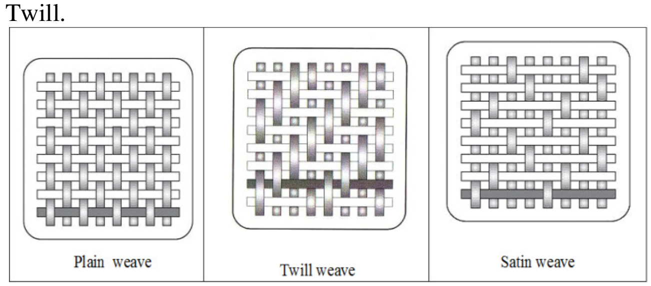

Fig 3.These are the basic weave types of woven fabrics.

1) ***Plain Weave*:-** Plain weave is also called Tabby Weave. It is simplest and most common of the three basic textile weaves. It can be formed by passing each filling thread over and under each warp yarn, with each row alternating, producing a high number of intersections.
2) ***Twill Weave*:- Twill** is a type of textile weave with a pattern forms a diagonal parallel ribs (in contrast with a satin and plain weave).
3) ***Satin Weave*:- Satin** is a type of weave that typically has a glossy surface and a dull back. This weave is characterized by four or more weft yarns floating over a warp yarn or vice versa, four warp yarns floating over a single weft yarn.

The exact process for weave pattern classification of fabric is as shown in figure below:-

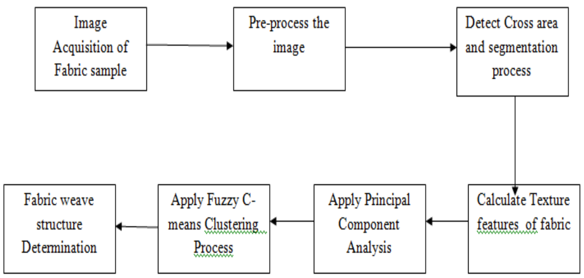

Fig 4. Processing steps for weave pattern classification.

4) ***Fabric image acquisition*:-** Firstly, the Fabric image is captured using high resolution camera. Then the captured colour image are resized into M*N pixels and converted into gray scale image for improving processing speed.

5) ***Image pre-processing*:-** For improving the visual effect and facilitate human as well as machines to analyze and understand the images, image enhancement and filtering are used to reduce noise and make fabric structure more clear and also we converted clour image into gray level image.

6) ***Yarn cross area detection and segmentation*:-** Here we apply a spatial domain integral approcach, to detect the interlacing area where weft yarn and warp yarn are crossed over each other. Because of the Interstices between yarns display darkness, the pixels around them have relative lower grey levels. [5]For the local minima of the vertical and horizontal integral projections, we can locate the positions of interstices among yarns. Suppose I(x, y) be an gray scale image having MxN pixels. The horizontal and vertical projection of the entire image is defined respectively as H(y) and V(x), thus, we have:

$$H(y)=\sum_{x=1}^{N} I(x,y) \qquad (2)$$

$$V(x)=\sum_{y=1}^{N} I(x,y) \qquad (3)$$

The local lowest values of H(y) and V(x) indicate the interstices between yarns. By finding the local minima of horizontal and vertical integral projections, the warp-yarn separation lines and weft-yarn separation lines are found respectively. The cross area of weft and warp yarns are identified by intersecting the warp-yarn separation lines with weft-yarn separation lines.

7) ***Texture feature calculation*:-** For texture feature calculation we used GLCM(Gray Level Co-occurrence Matrix).The change of image gray levels indicates the texture of image. The grey level co-occurrence matrix of an image shows the statistic characteristics of grey level or grey level gradient under the condition of a certain spatial position.[5] The features which are extracted from GLCM are related to the density of fiber and the orientation of yarn on a cross area. In this system, we use GLCM based texture features to discriminate the different cross area states of warp and weft. GLCM is calculated based on two parameters, which are the distance between the pixel pair d and their angular relation *. * the angular relation is quantized in four directions (0°, 45°, 90° and 135°). For rectangular M×N image segment I(x, y), gray levels i and j, the non-normalized GLCM Pij are defined by:

$$p_{ij,\theta} = \sum_{x=1}^{N}\sum_{y=1}^{N} C\{(I(x,y)=i)\wedge(I(x \pm d\theta_0, y \mp d\theta_1) = j)\} \qquad (4)$$

8) ***Principal component analysis*:-** It is a useful technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension.

Here, As a standard tool in modern data analysis, principal component analysis (PCA) applies to large areas from image processing to bioscience. PCA is used to extract relevant information from data sets consisting of a large number of interrelated variables [14]. Therefore, PCA is the method to solve our above problems. It states that our basic idea for using PCA are (i) to minimize redundancy in our feature vector sets and (ii) maximize the signal which expressed by our feature vectors. The goal of PCA is to identify the most meaningful basis to re-express the data set. In this work, we assume that each fabric image has m detected image cells and each cell is expressed by a feature vector with 192 elements[5]. The feature data set for a captured fabric image is a 192×m matrix X. By using Principal Component Analysis, we aim at finding a new basis P which will reveal an optimal representation Y of the original data set X. P's row vectors will become the principal components of X. Geometrically, P is a linear transform which stretches and rotates X into Y:

PX=Y

9) ***Fuzzy c-means clustering*:-** fuzzy c-means clustering is used to analyzed these optimized texture features for classifying the different cross area states by using algorithm shown below:-

10) Algorithm for weave pattern classification:-

***Step 1*:-** Firstly Initialization(iteration 0) is done:-
Randomly choose the centers of clusters *vi.*

***Step 2*:- :-**compute the membership function *ui,k.*using:-

If $\|x_k - v_i\| = 0$ then set $u_{i,k} = 0$ (for i$\neq k$)

If $\|x_k - v_i\| \neq 0$ then

$$u_{i,k} = \left(\sum_{j=1}^{c}\left(\frac{\| x_k - v_i \|}{\| x_k - v_j \|}\right)^{2/m-1}\right)^{-1} \qquad (5)$$

Where v_i = is the center of the i^{th} cluster.

The norm $\|x_k - v_i\|$ is the distance between the sample x_k and the centers of classes v_i.

***Step 3*:-** :- Upadated the positions of the centers *vi* .

$$v_i = \frac{\sum_{k=1}^{n} u_{i,k}^{m} x_k}{\sum_{k=1}^{n} u_{i,k}^{m}} \qquad (6)$$

Step 4:- If $\| U^{(t+1)} - U^{(t)} \| > \varepsilon$, then increment the iteration t and back to the step 2.otherwise stop the algorithm.ε is the termination criterion.

III. RESULT AND DISCUSSION

The experimental results for the two techniques(Density Detection and pattern classification) are shown below. For the codes of these algorithms we used matlab software. For this matlab version 2014a is used. Matlab provides hundreds of built-in functions for technical computation, graphics, etc.

1) Image captured using camera for both processing:-

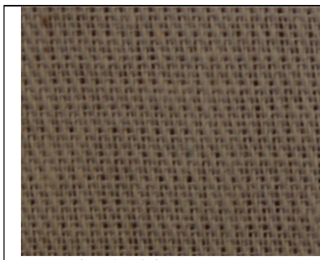

Fig.(5) Plain weave

Fig. (6) Twill weave

2) Output of wavelet transform:-

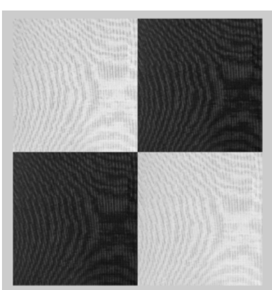

Fig.(7)o/p of wavelet transform for plain weave

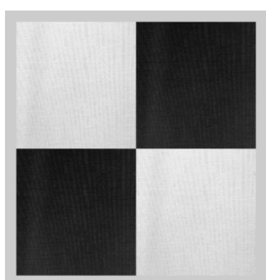

Fig.(8)o/p of wavelet transform for twill weave

3) Reconstructed image:-

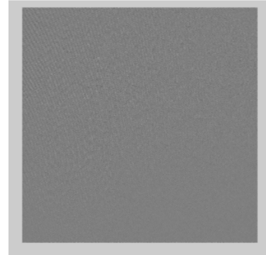

Fig.(9) Reconstructed image of plain weave

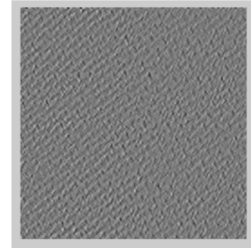

Fig.(10) Reconstructed image of twill weave

4) Results for contrasted with manual:-

Fabric Samples	**Computer(yarns/10cm)**		**Manual(yarns/10cm)**	
	Warp	Weft	Warp	Weft
P1	53	**90**	53	90
P2	162.9	52.7	163	53
P3	204.2	38.6	204	39
P4	136.1	61.8	136	62
P5	164.7	52.1	165	52
P6	43.1	93.4	43	94
S1	225.6	31.4	226	32
T1	198.0	40.7	198	41
T2	217.6	34.1	218	34
T3	53.0	90.0	53	90

Table 1:- Results for density calculation for some samples

5) Result for Horizontal and Vertical Projection for Plain Weave pattern:-

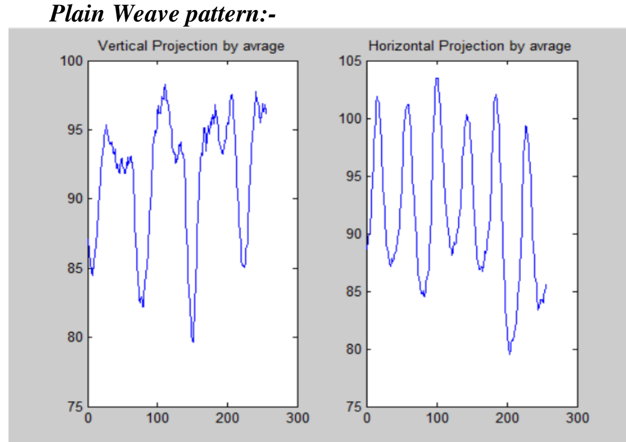

Fig 11. Integral projection curves

6) Cross area Detection of fabric sample:-

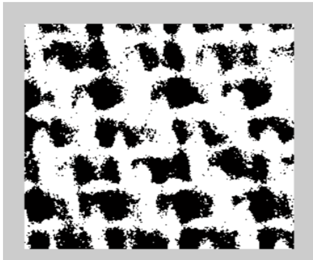

Fig 12.cross area detection

7) *Output of neural network:-*

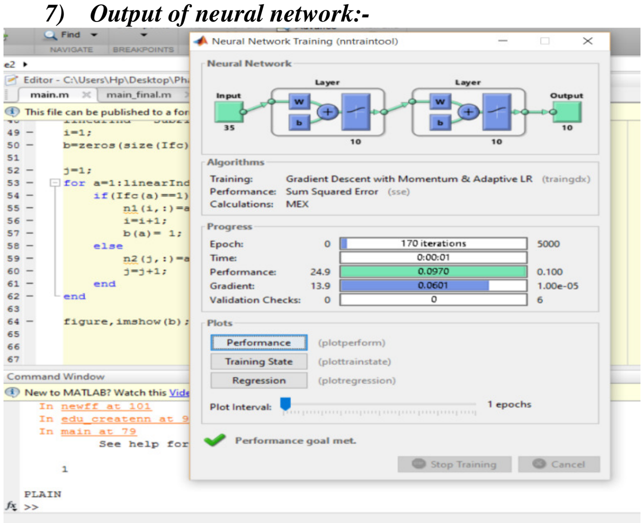

Fig 13. Neural network training and o/p of weave pattern recognition

IV. CONCLUSION

The wavelet transform can be used to analysis the structure of woven fabrics could detect the density of woven fabric perfectly, which requires woven fabrics with high quality. The algorithm is processed under the condition of weft being completely horizontal and warp being vertical. Nevertheless, It is being hard to avoid the affect by external interference in the process of actual image captured, the images of fabric weaves will be skew to a certain degree at various angles. Under the circumstances, the density detection of fabric would not be precise. Hence, the next target is that skewing detection and rectification should be disposed for woven fabrics images to make the fabric density more accuracy.

In this paper, we have developed a novel automatic method for Density detection and woven fabric structure identification. This method is based on digital image analysis techniques as we used fabric image which is captured by using camera. It allows automatic weft yarn and warp yarn cross area detection and segmentation through a spatial domain integral projection approach. Secondly, by applying fuzzy c-means clustering to extracted texture features based on grey level co-occurrence matrix and also by using principal component analysis, we can classify detected segments into two clusters. hence in such a way, by using a fuzzy rule based analysis on texture orientation features, the cross area states are automatically determined. To verify the validity of this method, a number of fabric images of different types are used. The samples have, different fiber appearances, yarn counts and weave types. The recognition results matches the actual structure of tested samples.

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