Effective Segmentation in Plain woven Fabric Defect Detection by using Digital Image Processing

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Abstract— *Quality control is an important issue in the garments industry. In the past two decades during which computer vision based inspection has become one of the most important application areas. Fabric industry is one of the most important field in identifying defects or flaws. But these days lot of work can be done on to remove defects in images of fabric in fabric industry and calculate defective areas in fabric images more precisely. This paper proposes, a user friendly MATLAB based graphical user interface (GUI) that segments the defected area of a fabric image using Entropy filter method. From the segmented image, features of defected area such as area, entropy, standard deviation, smoothness, skewness, GLCM, max intensity, min intensity, mean, standard deviation and energy are calculated, for classification of images as defected or not. Also accuracy, specificity and sensitivity are calculated with respective to ground truth, for the performance evaluation. The GUI is implemented satisfactorily using MATLAB.*

Keywords — *Fabric defect, Entropy filtering, Standard deviation filtering, Range filtering, Segmentation, True positive, True Negative, Sensitivity*

I. INTRODUCTION

A reliable defect detection system is a key factor for achieving improved product quality and increase in efficiency of product lines. It has proven that fabric inspection is one of the most difficult of all textile processes to automate. There exist many algorithms that utilize digital image processing techniques in various stages to perform defect detection on fabric[1]. In this paper, we are introducing an efficient method for segmenting fabric images to identify defected area. This paper proposes, a user friendly MATLAB based graphical user interface (GUI) that segments the defected area of a fabric image using entropy filter method. From the segmented image, features of defected area such as area, entropy, standard deviation, smoothness, skewness, GLCM, max intensity, min intensity, mean, standard deviation and energy are calculated, for classification of image as defected or not, which is considered as future scope of this paper. The GUI is implemented satisfactorily using MATLAB and the feature parameters are calculated. Also accuracy, specificity and sensitivity are calculated, for the performance evaluation.

Recently, S. Sahaya Tamil Selvi et al. [9] has assessed that median filtering produces better results for fabric images after making comparisons on the performances of Low pass filtering, Wiener filtering, Median filtering and Guassian filtering. It has been found that median filtering and Gaussian filtering outperform than others. Several automated techniques are designed for diabetic retinopathy screening, accurate detection of DR is still challenging. The paper referred in [3] segments the blood vessels using adaptive median thresholding. And from the segmented image, features parameters are calculated, for classification of image as normal or abnormal. In the paper referred in [2], a new approach has been used for automated fabric defect detection using the thresholding and morphological operations based segmentation method and classification. It has been found that the performance of proposed approach is showing better performance as compared to the existing methods. Referred paper [5] presents promising results for a novel system for multi-class defect detection and classification in fabrics using both geometric and texture features to capture the visual properties. Fabric defect detection using PSO has been done effectively in [6][7][8].

This paper presents a detailed version of performing segmentation on defected fabric images by employing various filtering techniques in an automatic fabric defect inspection system. The following sections of this paper are as follows. In Section 2, an overview of the basic concepts of morphology which are dealt in this paper is presented. In Section 3, the methodology of the proposed technique has been discussed. In section 4, the result of the implementation of proposed segmentation methods on fabric digital images are presented. Finally, a conclusion is drawn in Section 6.

II. BASIC CONCEPT

A. *Fabric Images*

The different textures of the fabric depend upon the types of weaves used. Textile Fabric materials are used to prepare different categories and types of fabric products in the textile industry viz. cotton, silk, wool, leather, and linen. There are a large number of types of fabric defects available out of which color yarn, missing yarn, hole, slub, crease mark and spot are the frequently occurred defects, which are shown in Fig.2.

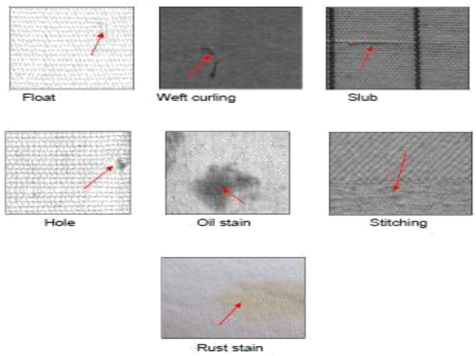


Fig 1: Various defects in Fabrics

B. *Morphology*

Morphological image processing techniques are widely used for image analysis. Morphological image processing techniques are used in many successful machine vision algorithms [2]. The morphological operations for fabric defect detection are inherently sensitive to the size and shape of the defect. In morphology four main operations are separately applied on images as shown below.

1) ***Erosion*:** The effect of the Erosion operator on a binary image is to erode away the boundaries of regions of foreground pixels making the areas of foreground pixels shrink in size, and holes. Every object pixel that is adjacent to a background pixel is changed into background pixel. Formula for erosion is,

$$A \Theta B \qquad \text{----- (1)}$$

2) ***Dilation:*** Dilation is one of the operators which enlarge the boundaries of regions of foreground pixels. The foreground pixel area grows in size while holes in the regions become smaller [20]. Every background pixel that is adjacent to a foreground pixel is changed into a foreground pixel. Formula for dilation is,

$$A \oplus B \qquad \text{----- (2)}$$

3) ***Opening:*** In morphology, opening is the dilation of the erosion of set A by structuring element B is,

$$A \circ B = (A \Theta B) \oplus B \qquad \text{----- (3)}$$

Where Θ and $\oplus$ denote erosion and dilation, respectively in equation (7). Opening has the effect of removing small objects from the foreground of an image, placing them in the background.

4) ***Closing:*** The operation Closing is erosion of the dilation of that set of a set A by a structuring element B is,

$$A \bullet B = (A \Theta B) \oplus B \qquad \text{----- (4)}$$

Where Θ and $\oplus$ denote erosion and dilation, respectively in equation (8). Closing removes small holes effecting in removing the extra black pixels from the images [20].

C. *Entropy Filtering*

Entropy Filter returns an array J, where each output pixel represents the entropy value of the 9-by-9 neighborhood around the corresponding pixel in the input image I. I can have any dimension. If I to be in more than two dimensional, entropy filter will treat it as a multidimensional grayscale image and not as a truecolor (RGB) image. The output image J will be the same size as the input image I . In MATLAB the function entropyfilt represents the entropy filter.

Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image.

Entropy=-sum (p.*log2(p)) ----- (5)

where p contains the histogram counts returned from imhist.

III.METHODOLOGY

The digital analysis of two-dimensional images of fabric is based on processing the image acquirement, with the use of a computer. The image is described by a two-dimensional matrix of real or imaginary numbers presented by a definite number of bytes. The system of digital image processing in Fabric defect detection may be presented schematically as shown in the Fig 2.

A. *Image Acquisition*

The first stage of any vision system is the image acquisition stage. After the image has been obtained, various methods of processing can be applied to the image to perform the many different vision tasks required today [6]. However, if the image has not been acquired satisfactorily then the intended tasks may not be achievable, even with the aid of some form of image enhancement. Textile fabric surface image is acquired by using a CCD camera from top of the surface from a distance adjusted so as to get the best possible view of Fabric surface.

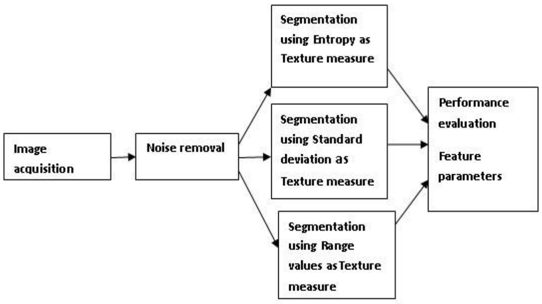


Fig 2: Block diagram of Segmentation process

B. Filtering

The removal of noise is essential task of image filtering. Most often during image acquisition or transmission, there is always chance for the digital image to get corrupted because of noise. The variation in intensity value is called *noise* due to non-perfect camera acquisition or environmental conditions [5]. In the proposed method, the total variation filtering technique combined with the optimization technique PSO has been implemented which performs well than the other traditional methods like median filteing, mean filtering and Gaussian filtering techniques, which has been published as a paper referred in[10] [12]. The resultant images after removal of noise are stored in a drive for further processing. The fabric images are shown in the fig. 2 .

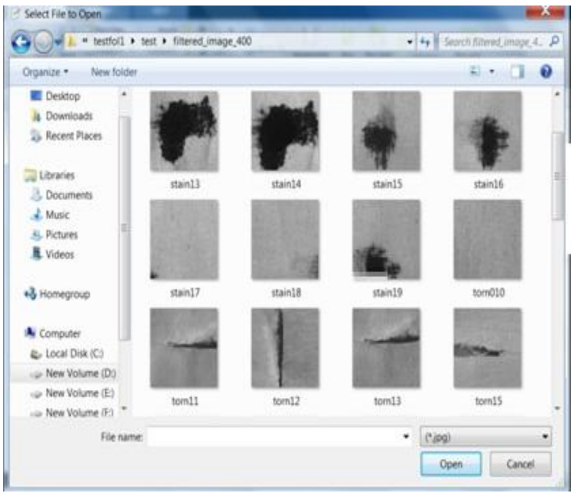


Fig 3: Dataset containing various defects of fabric images

C. Image Segmentation

Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. The segmentation process assigns a label to every pixel in an image such that certain visual characteristics are shared by pixels with the same label. Several methods can be used to segment the defect, i.e., detect the defect on the image, ranging from simple segmentation methods (e.g., thresholding) to more advanced methods.

Here, in this proposed method, Entropy filter combined with morphological operations are used to segment the fabric images. The algorithm for the proposed segmentation is as follows:

Step 1: Create texture image by using the entropy Filter. The entropy filter will return an array where the output pixel will contain the entropy value of the 9- by-9 neighbourhood around the corresponding pixel in the input image I. The Entropy array represents statistical measure of randomness.

Step 2: Create rough mask for the bottom texture by following the steps below.

a. Set a threshold value of 0.8 for the rescaled image I to segment the textures. as it is considered as a rough intensity value of pixels along the boundary between the textures.
b. Convert the image into a binary image
c. The segmented objects in this binary image will be in white. If this binary image is compared to the original image I, the top texture is lying as overly segmented which means they are appearing multiple white objects and the bottom texture is segmented now. So, the bottom texture will be extracted using morphological operation now.
d. Use of imclose which is one of the morphological operation will smooth the edges and will close any open holes in the object in the binary image.

Step 3: Use Rough Mask to Segment out the top texture image texture by following the steps below.

a. Compare the binary image of roughMask which was created in the step 2.a to the original image I.
b. Get raw image of the top texture using roughMask.

D. Feature Extraction

Feature Extraction is a stage where various methods are employed for capturing visual content of images for indexing & retrieval purpose. There can be number of features defined from an image ***and*** there are methods for calculating each of these features. The features which are better suited for a particular application are selected for further analysis [11]. From the segmented image, features of defected area such as area, entropy, standard deviation, smoothness, skewness, GLCM, max intensity, min intensity, mean, standard deviation and energy are calculated, for classification of image as defected or not.

E. Performance Evaluation

Performance evaluation of the proposed method is done through statistical analysis by calculating Sensitivity, Specificity and Accuracy. Calculation of these metrics depends on calculating values of parameters called True Positive, False Positive, False Negative and True Negative. In the proposed methodology, the segmented images are displayed in a way that, the defected area is in white and the background area is in black.

1) True Positive(TP)

A true positive is a count of white pixels in both segmented image and Ground truth image. This is a metric showing that the no. of pixels which are in actual defective portion of the fabric image and, which have been correctly identified as defective area pixels in the segmented image also.

2) False Positive(FP)

A false positive is a metric showing that the no. of pixels which are in background portion (non – defective) of the fabric image and , which have been identified as pixels in the defective area in the segmented image.

3) True Negative(TN)

A true negative is a count of black pixels in both segmented image and Ground truth image. This is a metric showing that the no. of pixels which are in original background portion of the fabric image and, which have been correctly identified as pixels in the background area in the segmented image also.

4) False Negative(FN)

A false negative is a metric showing that the no. of pixels which are in defective portion of the fabric image and , which have been identified as pixels in the background area in the segmented image.

5) Algorithm

The following is the Algorithm for computing True positive.

Step 1: Load the segmented image I.
Step 2: Assign the size of the image, m as row and n as column.
Step 3: Load ground truth of the image G.
Step 4: Calculate the true positive by comparing each pixel of image I with that of Ground truth image G as follows:
Assign TP=0
Step 5: for i=1 to m step of 1
    for j=1 to n step of 1
    Check if I(i, j)=1 and G(i, j)=1 then
        TP = TP + 1
Step 5: Print the calculated value of True positive (TP).

The above algorithm with few modification on comparison of pixels in the images I and G, can be used to calculate True negative, False positive and false negative.

6) Sensitivity

Sensitivity is a statistical measure that indicates the ratio of true positive with overall true defective area pixels.

Sensitivity=(TP/TP+FN) -----(6).

7) Specificity

Specificity is a measure complementary to sensitivity, which is defined as the ratio of true negative with overall true non -defective area pixels.

Specificity=(TN/TN+FP) -----(7).

8) Accuracy

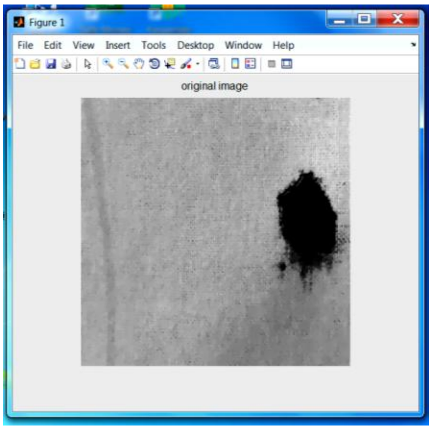
Accuracy is a measure which defines the correctness of the above two measures.

Accuracy = (TP + TN) / (TP+FN + TN + FP) ----(8).

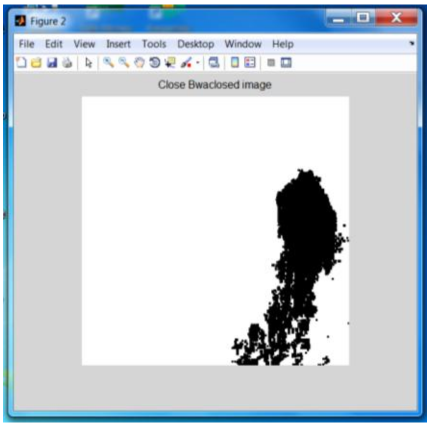
IV. RESULTS AND DISCUSSIONS

The performance of the proposed method is evaluated based on the Average Sensitivity, Specificity, and Accuracy rate according to the formula given in the equation (6), (7) and (8). The evaluation has been done for various defected fabric images of type Ink stains, Oil stains, Tear, Missed thread, and Dirty fabrics. The segmentation process was performed using three different Filtering techniques namely Entropy filter, Standard deviation filter and Range filter. Testing of images was done over a set of 100 images and only few sample of the resultant images are tabulated in Fig 9.

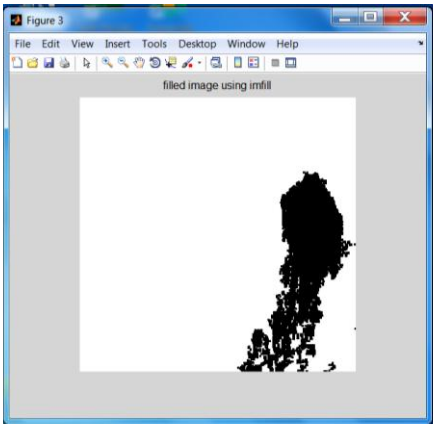
The average values of Sensitivity, Specificity and percentage of Accuracy rate of the three filtering based Segmentation for the five different defected fabrics is shown in the Table-1, Table- 2 and Table-3. The respective graphs are represented in Fig 6, Fig 7 and in Fig 8.



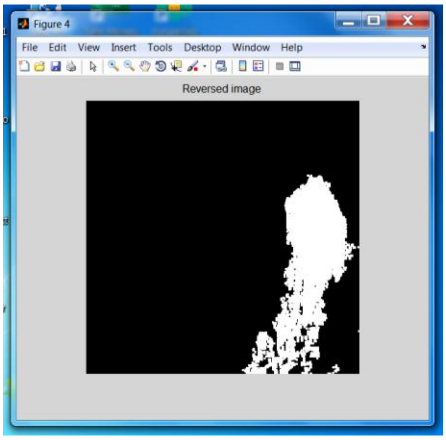
(a)



(b)

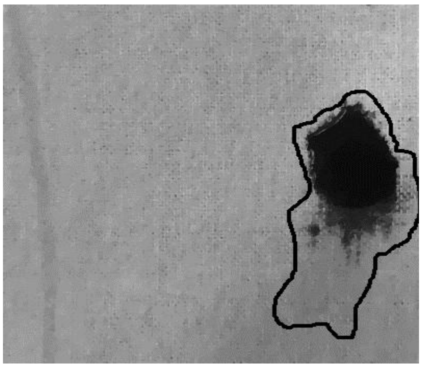


(c)

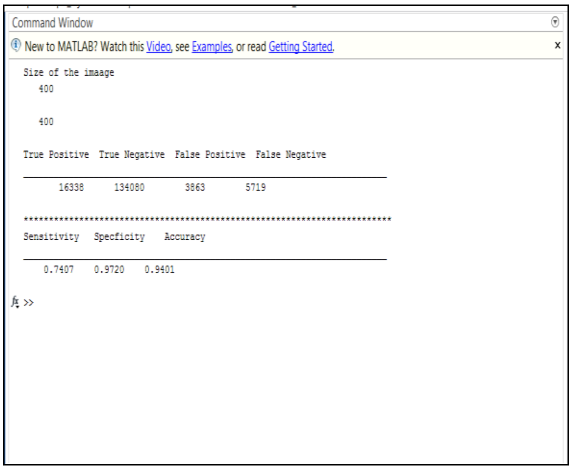


(d)

Fig 4: (a), (b), (c) and (d) shows the step by step stages in the proposed Segmentation process.



(e)



(f)

Fig 5: (e) Ground Truth image and (f) Model of the performance evaluation calculation.

TABLE I CALCULATED AVERAGE SENSITIVITY OF THE IMAGES

Average Sensitivity					
Model	**Ink_stain**	**Tear**	**Oil stains**	**Missed Thread**	**Dirty fabric**
Entropy Filter	**0.5025**	**0.3956**	**0.544**	**0.3484**	**0.5214**
Standard deviation Filter	**0.0225**	**0.0201**	**0.0097**	**0.0007**	**0.0049**
Range Filter	**0.0271**	**0.0201**	**0.0097**	**0.0007**	**0.0049**

TABLE II CALCULATED AVERAGE SPECIFICITY OF THE IMAGES

Average Specificity					
Model	**Ink_stain**	**Tear**	**Oil stains**	**Missed Thread**	**Dirty fabric**
Entropy Filter	**0.9603**	**0.9456**	**0.9995**	**0.8437**	**0.9625**
Standard deviation Filter	**0.9806**	**0.9841**	**0.9937**	**0.9678**	**0.9763**
Range Filter	**0.9806**	**0.9841**	**0.9937**	**0.9678**	**0.9763**

TABLE III CALCULATED ACCURACY OF THE IMAGES

Average Accuracy					
Model	Ink_stain	Tear	Oil stains	Missed Thread	Dirty fabric
Entropy Filter	0.8061	0.8671	0.9671	0.6855	0.7899
Standard deviation Filter	0.6579	0.8466	0.9236	0.6589	0.5962
Range Filter	0.6594	0.8466	0.9236	0.6589	0.5962

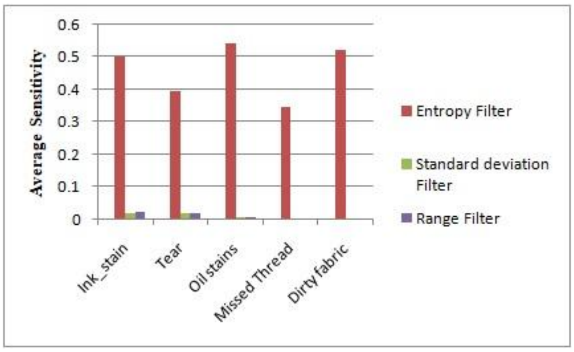


Fig 6: Graph representation of Table I.

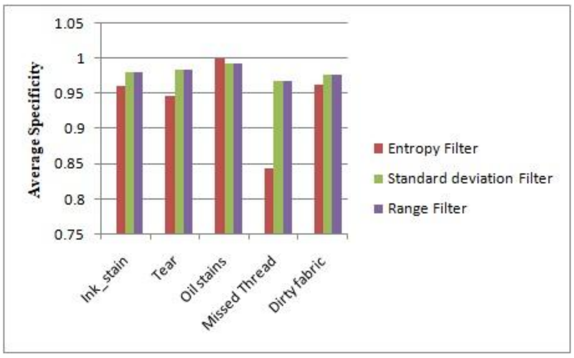


Fig 7: Graph representation of Table II.

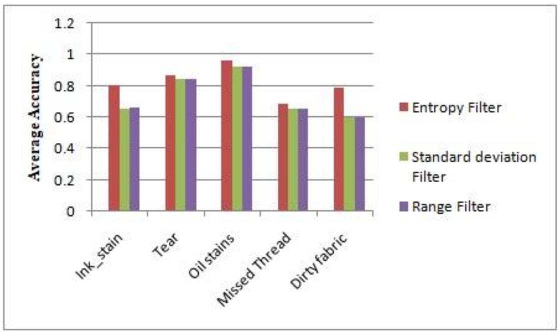


Fig 8: Graph representation of Table III.

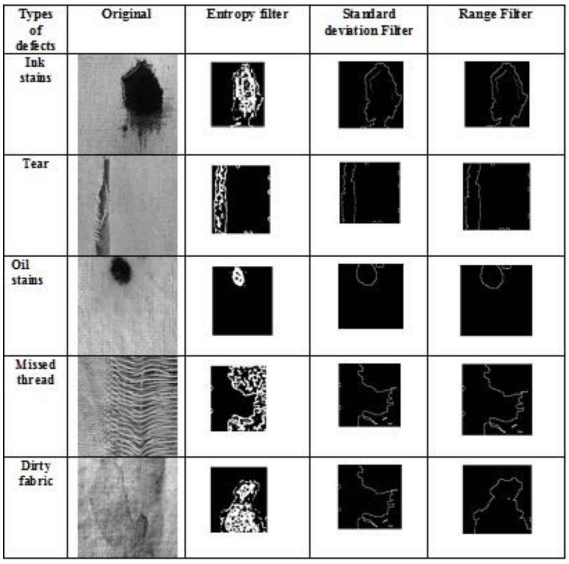


Fig 9: Resultant output images of the proposed Segmentation process by applying three different filtering methods.

V. CONCLUSIONS

A In this paper segmentation has been applied on fabric images to identify the defected area. The functionality is evaluated based on the evaluation metric applied on resultant images. Comparisons have been made on three various Segmentation methods based on evaluation metrics Sensitivity, Specificity and Accuracy rate. Among the three models viz. Entropy filtering segmentation, Standard deviation filtering segmentation, Range filtering segmentation, it is evident that Entropy model proves better. Moreover the performance of Standard deviation filtering and Range filtering segmentation models seem to have the same performance. Analyzing the performance on various types of defected fabric images, the Entropy based segmentation model is identified to be more suitable for identifying defective area of fabric images.

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Mrs. S. Sahaya Tamil Selvi received M.Sc., M.Phil., MBA,SET in the year 1996, 2005,2008 and 2017. She is having 16 Years of teaching experience. Her area of interest is Data structures and Algorithms, Artificial Intelligence, Neural Networks and Digital Image Processing. She has presented 9 technical papers in various Seminars / National Conferences.

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