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Contrast Stretching and Non Linear Median Filters for Fabric Inspection

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***Abstract*— In automatic fabric inspection, fabric image acquires impulse noise due to malfunctioning in camera sensors, faulty memory locations in hardware, or transmission via a noisy channel. Eliminating such noise is an important preprocessing task. The fabric image should be enhanced to achieve a high interpretability of perception to detect defects. In this paper contrast stretching, grey level thresholding and median filters are used to enhance the fabric image. The performances of these methods are evaluated using Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). The contrast stretching with spatial median filter gives suitable results to enhance the perception of defects.**

Keywords— **Defect Detection, Pre-processing, Contrast Stretching, Median Filter, Thresholding**

I. INTRODUCTION

Textile industry plays an important role in the economy of developing countries. In textile manufacturing quality inspection as an important phase that ensures the quality of the end products. It is carried out by human inspectors and they require more time for training and it increases the operational cost. Only 80% [1] of the defects can be identified. Fabric defects are responsible for nearly 85% of the defects found in the garment industry [2]. Manufactures recover only 45-65% of their profit from second or off quality goods [3].

Automatic fabric inspection is performed by a specially design software able to compare the real time fabric image with the desired pattern of the textile material. Image acquisition is a important step for the automatic quality control because it provides the input data for the whole process. The acquisition is performed by an optical sensor which is almost always a video camera (with one line or a matrix of CCD). Local illumination is directly associated with the quality of image acquisition because it is straight forward to demonstrate that its variations can heavily affect the patterns visibility in the fabrics image [4].It's influence should be carefully eliminated without degrading the original image. A robust image enhancement technique has to suppress the noise while preserving natural information in the fabric image.

A. *Need for Noise Removal*

Images are often contaminated with noise during image acquisition or transmission. With each digital image a signal is transmitted from a sensor to a memory chip embedded inside a camera. Transmission technology is prone to a degree of error, and noise is added to each image. This type of transmission error is referred as salt and pepper or impulsive noise. The ratio of incorrectly transmitted points to the total number of points is referred to as the noise composition of the image. In particular, by introducing bit errors and impulsive noise into an image not only lowers its perceptual quality, but also makes subsequent tasks such as edge detection and segmentation more difficult. Therefore, the removal of such noise is often a necessary preprocessing step in image processing applications.

Thus noise removal filters takes a corrupted image as input and produce an estimation of the original image without any noise. A large number of linear and non linear filtering algorithms [5] have been proposed to remove impulse noise from corrupted image to enhance image quality. Most of the linear filters generally have a neighbourhood averaging mechanism to remove impulse noise and tend to destroy all high frequency details like edges, lines and other fine image details.

Image enhancement techniques are necessary to improve an image, where "improve" is sometimes defined objectively (e.g., increase the signal-to-noise ratio), and sometimes subjectively (e.g., make certain features easier to visualize by modifying the intensity).Thus it is necessary to develop a robust preprocessing technique to provide an accurate and noiseless image.

The paper is organized as follows: Section II discusses the image preprocessing techniques. Section III presents the enhanced image preprocessing algorithm for textile images. The performance of the algorithms are evaluated and presented in section IV. Finally, conclusion and references are given in section V.

II. PREPROCESSING TECHNIQUES

Preprocessing improves the quality of image while conserving the original image information. It includes removal of blurring and noise, increases the contrast range to enhance the image information. A robust image enhancement technique is needed to suppress the noise while preserving natural information in the images. The aim of image preprocessing is to increase both the accuracy and the interpretability of the digital data during the image processing phase.

A. Contrast Stretching

Contrast stretching or normalization is a simple image enhancement technique that attempts to improve the contrast in an image by `stretching' the range of intensity values it contains to span a desired range of values. It differs from the histogram equalization where it can only apply a linear scaling function to the image pixel values. The goal of contrast enhancement is to improve the intensity contrast in the input image, highlighting the defect regions whilst leaving the unimportant background regions intact. Thus it improves the interpretability of human perception and provides better input for automated image processing techniques [6].

B. Non Linear Filter

Generally the data sets collected by image sensors are contaminated by noise. Denoising is often a necessary and the first step to be taken before the image analysis. A large number of linear and non linear filtering algorithms [5] have been proposed to remove impulse noise from corrupted image to enhance image quality. Most of the linear filters generally have a neighborhood averaging mechanism to remove impulse noise and tend to destroy all high frequency details like edges, lines and other fine image details. This led to the development of nonlinear median-type filters to be used for noise removal. A median filter is an example of a non-linear filter and, if properly designed, is very good at preserving image detail. Median filters are good at removing salt and pepper noise from an image, and also cause relatively little blurring of edges, and hence are often used in computer vision applications.

C. Thresholding

When converting a pixel from grayscale to black and white, the threshold is the gray value above which it will be considered white, and below or equal to it will be considered as black. In many vision applications, it is useful to be able to separate out the region of interested object from the regions of the image that correspond to background. Thresholding often provides an easy and convenient way to perform segmentation on the basis of the different intensities in the foreground and background regions of an image.

III. PREPROCESSING TECHNIQUES FOR TEXTILE IMAGES

Preprocessing is the important method to enhance images for texture analysis. The contrast of an image is the distribution of its dark and light pixels. A low-contrast image exhibits small differences between its light and dark pixel values. The histogram of a low-contrast image is narrow. Since the human eye is sensitive to contrast rather than absolute pixel intensities, a perceptually better image could be obtained by stretching the histogram of an image so that the full dynamic range of the image is filled.

Gray level thresholding divides an image into two classes. The enhanced preprocessing involves fusion of contrast stretching, thresholding and non linear median filter such as median, vector median, spatial median filter are discussed and is as follows.

A. Contrast Stretching with Thresholding and Median filter (CSTMF)

Median filter is well known nonlinear process useful in reducing impulsive or salt-and-pepper noise which can occur due to a random bit error in communication channel. It is a more robust method than the traditional linear filtering, because it preserves the sharp edges.

The Mean Filter is a linear filter which uses a mask over each pixel in the signal. Each of the components of the pixels which fall under the mask are averaged together to form a single pixel using Eqn(1). This new pixel is then used to replace the pixel in the input signal.

$$\text{Medianfilter}\,(x_1 \ldots . x_N) = \text{Median}\,(\|x_1\|^2 \ldots\ldots \|x_N\|^2) \qquad (1)$$

where $x_1, x_2 \ldots\ldots x_N$ are image pixel range.

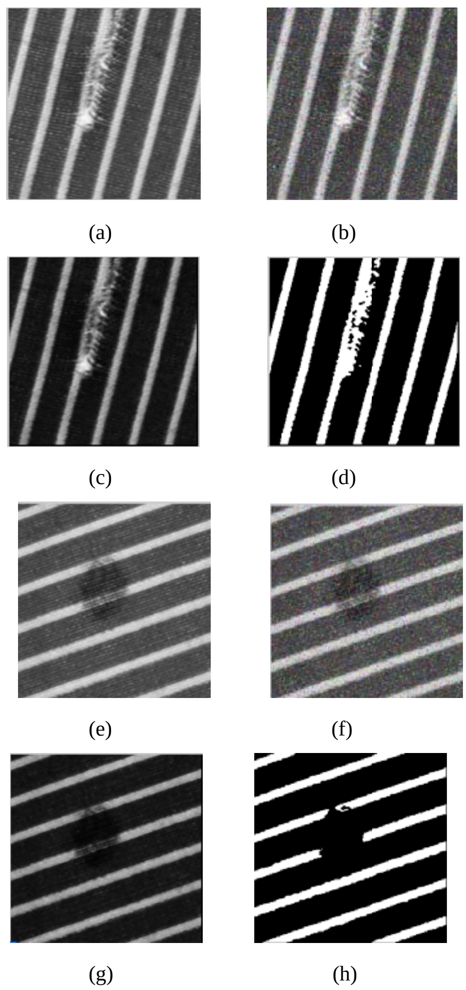

Fig. 1 (a)&(e)-Input Image,(b)&(f)-Image with Noise,(c)&(g)-Contrast Stretched Image,(d)&(h)-Image with Median Filter

Fig. 1 shows the result for median filter with contrast stretching and thresholding applied images for thread defect and oil stain.

B. Contrast Stretching with Thresholding and Vector median filter (CSTVMF)

The Vector Median Filter (VMF) was developed by Astola, Haavisto, and Neuvo in 1990. In the Vector Median Filter a point in the signal is compared with the points surrounding it as defined by a filter mask. Among these points, the summed vector distance from each point to every other point within the filter is computed. The point in the signal with the smallest vector distance amongst those points in the filter is the minimum vector median. The point in space that has the smallest distance to every other point is considered to be the best representative among the set. In basic implementation of the Vector Median Filter, the vector median replaces the point in the signal currently studied using Eqn(2).

$$VMF(x_1,\ldots x_N) = MIN\left(\sum_{i=1}^{N} \| x_N - x_i \|, \ldots, \sum_{i=1}^{N} \| x_N - x_i \|\right) \quad (2)$$

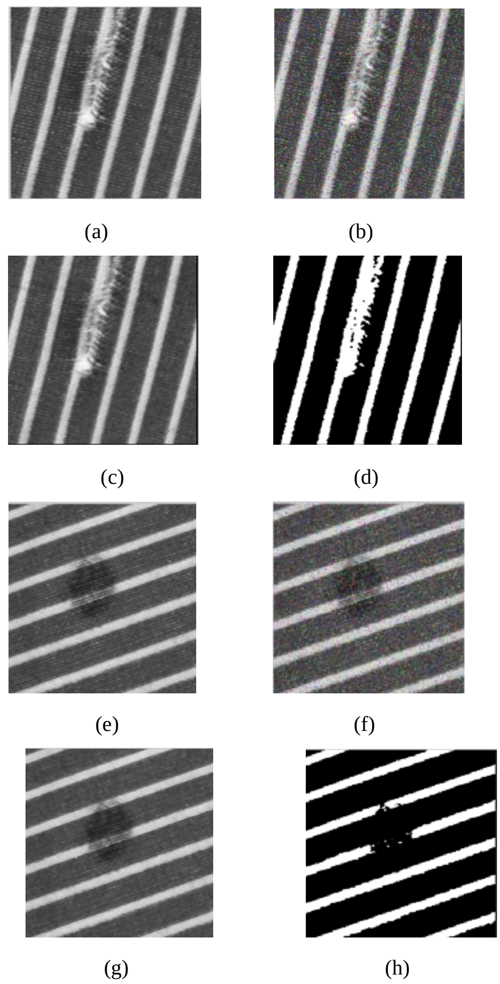

Fig. 2 (a)&(e)-Input Image,(b)&(f)-Image with Noise,(c)&(g)-Contrast Stretched Image,(d)&(h)-Image with Vector Median Filter

Fig. 2 shows the result for vector median filter with contrast stretching and thresholding applied images for thread defect and oil stain images.

C. Contrast Stretching with Thresholding and non linear Spatial Median Filter (CSTSMF)

The spatial median filter (SMF) [7] is a uniform smoothing algorithm with the purpose of removing noise and fine points of image data while maintaining edges around larger shapes. The SMF is based on the spatial median quantile function which is a L1 norm metric that measures the difference between two vectors. The spatial depth between a point and a set of points is defined by Eqn(3).

$$S_{depth}(X, x_1, \cdots, x_N) = 1 - \frac{1}{N-1}\left\| \sum_{i=1}^{N} \frac{X - x_i}{\|X - x_i\|} \right\| \quad (3)$$

where X is any pixel in the sliding window, $x_{1,} x_2, \cdots x_N$ are pixel values in the sliding window of size N.

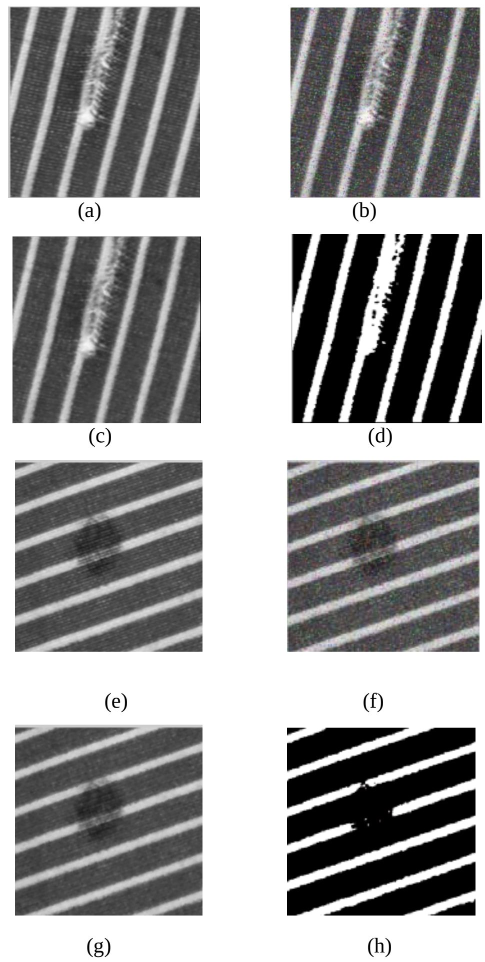

Fig. 3 (a)&(e)-Input Image,(b)&(f)-Image with Noise,(c)&(g)-Contrast Stretched Image,(d)&(h)-Image with Spatial Median Filter

The SMF is an unbiased smoothing algorithm and will replace every point that is not the maximum spatial depth among its set of mask neighbours. Figure 3 shows the result for spatial median filter with contrast stretching and thresholding applied images for thread defect and oil stain.

IV. EXPERIMENTAL SETUP AND EVALUATION

To test the accuracy of the preprocessing algorithms, three steps are followed.

- A textile texture image is taken as input.
- Enhanced preprocessing algorithm is applied to the image.
- The MSE and PSNR value is calculated for different algorithm.

The reconstruction of an image has the dimensions of 256 pixel intensity. The textile images contain defects that vary from small to large size. It is necessary to have an image enhancement technique to assist easier identification of defects. The following two measures were used to evaluate the performance of the algorithm.

1) Mean Square Error (MSE)
2) Peak signal to Noise Ratio (PSNR)

1) Mean Square Error (MSE)

The metric MSE is defined as:

$$\boldsymbol{MSE} = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\|I(i,j)-K(i,j)\|^2 \qquad (4)$$

For two $m\times n$ monochrome images I and K, one of the images is considered a noisy approximation of the other. Other metrics like Root Mean Square Deviation RMSE, Mean Absolute Error MAE and PSNR are defined using MSE.

2) Peak Signal to Noise Ratio (PSNR)

The PSNR is defined in logarithmic scale, in dB. It is the ratio of peak signal power to noise power. Since the MSE represents the noise power and the peak signal power, it is unity in case of normalized image signal. The image metric PSNR is defined as:

$$\boldsymbol{PSNR} = 10.\log_{10}\left(\frac{MAX_I^2}{MSE}\right) \qquad (5)$$

Here, MAX_i is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255.The following Figure 4 & 5 gives the results using MSE and PSNR.

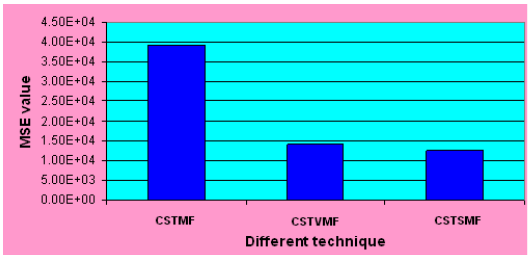

Fig. 4 Results of Preprocessing algorithms using MSE value

The fig. 4 gives the MSE ratio for different enhanced image preprocessing algorithm and Fig. 5 gives the PSNR value for different enhanced image preprocessing algorithm. From the fig. 4 & 5 it is observed that contrast stretching technique with thresholding and spatial median filtering (CSTSMF) algorithm gives high PSNR value and low mean square error. So the CSTSMF method gives desirable results compared with other preprocessing techniques.

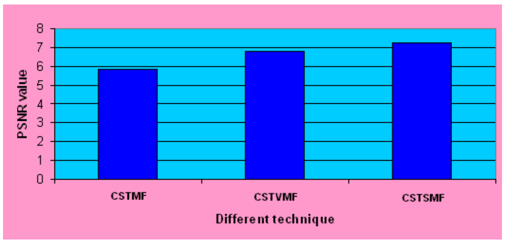

Fig. 5 Results of Preprocessing algorithms using PSNR value

CONCLUSION

Textile industry needs automation of fabric defect detection to improve the quality of the end product. Manual inspection requires more time and inefficient, even a small unnoticed defect could affect the quality of the product. The software based system will analyse the raw fabric and searches for defect. The fabric image is captured by cameras with an adequate artificial illumination and noise may be introduced from a variety of sources that degrades the image quality. It is necessary to employ an image enhancement technique to suppress the noise while preserving natural information in the images. In this paper an enhanced image preprocessing technique is introduced using contrast stretching, gray level thresholding and three non linear median filters are studied. The proposed texture enhanced image preprocessing techniques CSTMF, CSTVMF and CSTSMF were evaluated using Peak Signal to Noise Ratio (PSNR) and Mean Square Error. The contrast stretching, gray level thresholding with non linear spatial median filtering CSTSMF performs better than CSTMF and CSTVMF techniques with high PSNR and low MSE values.

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