DOI: 10.21917/ijivp.2011.0032

FAST AND EFFICIENT DETECTION OF CRACK LIKE DEFECTS IN DIGITAL IMAGES

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Abstract

This paper focus on detect detection in digital images using the various feature extraction parameters and segmentation. The operation of feature extraction is done on every row of the image to make the accurate results about the properties of pixels. The Algorithm is compared with existing methods such as independent component analysis method and Optimal Gabor filter method. This algorithm is fast and simple in detecting the defects in digital images.

Keywords:
Median, Segmentation, Gabor Filter

1. INTRODUCTION

The use of visual inspection systems are used in many industrial and commercial applications. There are various visual inspection systems such as defect detection of tiles, metal, fabric inspection and etc. Keeping this things in mind we propose a new algorithm which uses feature extraction and segmentation in order to identify the defects in gray level digital images. The base knowledge for research work has been collected from various resource materials. [1] M.Ghazvini, A.Monadjemi, K.Jamshidi said defects can be identified using detail matrices which consist of median, max and min points. [2] J.L.Sobral emphasized wavelet sub band and optimized gabor filters can be used for texture defect detection. [3] Hamid Alimohamadi highlighted the use of filter banks and optimized filter for defect detection and extraction of feature image. [4] Ajay Kumar and Grantham Pang revealed gabor filters can be deployed for fabric defect detection using bernoulli's rule of combination. [5] Kaicheng Yin and Weidong Yu used segmentation for defect detection in garments production system. [6] Henry Y.T.Ngan, Grantham K.H.Pang, S.P.Yung, Michael K.Ng highlighted the use of golden image subtraction method in the area of patterned fabric defect detection. [7] Jun Xie,Yifeng Jiang,Hung-tat Tsui highlighted the use segmentation technique in medical imaging. [8] Yi-leng chen,Tse-Wei Chen,Shao-Yi Chien revealed how wavelet transform can be used for fast texture feature extraction. [9] A.Serdaroglu, A.Ertuzun, A.Ercil revealed the use the wavelet transforms for identifying defects in texture fabric images. In this research work the minimum, maximum and median values are calculated for each row of the image to frame the feature vector. The high frequency components are eliminated using the median value of each row and at last the low frequency component image along with the median value of each row is used to detect the defected points with sudden intensity variation from the former picture element or sudden variation from the median value. The proposed research work is divided in this paper as the second section consists of feature extraction and the next section contains elimination of high frequency components and the subsequent sections consist of identifying defects, experimental results and analysis and references. Apart from the proposed algorithm we have also implemented two existing algorithms named Independent component Analysis method and defect detection using gabor filters. At last we have compared this methods with the proposed algorithm. The following sections will clearly explain in detail about the proposed research work

2. FEATURE EXTRACTION

After initial preprocessing the given image is subjected to feature extraction strategy. At first the given image is converted to a gray level image. Then the image is row wise bifurcated. The various parameters such as minimum, maximum and median value is calculated for each row of the image. The minimum is represented with the equation.

$$\begin{matrix} \text{Minimum} = \text{Min}\left(f\left(x, y\right)\right) \mid y = 1,2....N \\ \text{where } x = \text{integer constant} \end{matrix}, \tag{1}$$

where f(x, y) is the image and y varies from 1 to N and x remains stationary for a row. The same process is repeated for all rows. The collected minimum values are kept in a data structure which holds multiple values. The other step in feature extraction is to identify the maximum value of each row. The maximum value is identified by the following equation.

$$\begin{matrix} \text{Maximum} = \text{Max}\left(f\left(x, y\right)\right) \mid y = 1,2....N \\ \text{where } x = \text{integer constant} \end{matrix}. \tag{2}$$

In the above equation f(x, y) is the image where x is kept constant for a row and y varies within the stipulated range as mentioned in the equation. The third most feature is extraction of the median value for each row. The median value is represented using the following equation,

$$\begin{matrix} \text{Median} = x_m \mid \left(x_1, x_2, ...x_m, x_{m+1}, ...x_n\right) \\ \text{where n is odd} \end{matrix}. \tag{3}$$

The above equation states x_m is the middle value of the particular row of the image when arranged in ascending order .The above case can be only be applied if the number of pixels in each row is odd. The median value is found for even number of pixels using the following equation,

$$\begin{matrix} \text{Median} = \left(x_m + x_{m+1}\right)/2 \mid \left(x_1, x_2, ...x_m, x_{m+1}, ...x_n\right) \\ \text{where n is even} \end{matrix}. \tag{4}$$

The above mentioned equation states in case the number of pixels in the row is even the middle value x_m of the ascending order wise arranged row and the next value to middle value x_{m+1} is averaged to find the median value. The features Minimum, Maximum and Median are put together to frame the feature vector. The instead of collecting features for the whole image the features are collected row wise to obtain accuracy in detection of defects in digital image.

3. ELIMINATION OF HIGH FREQUENCY COMPONENTS

After the extraction of feature vector the median value is used to eliminate the high frequency components in the digital image. Traditionally the texture components in the image have high frequency spectrum. So a defect is assumed to be in low frequency spectrum. The median values which are gathered from the feature vector row wise are used to form a new image which has only low frequency components which also includes the defected area. The image H is formed using the following equation,

$$H = \begin{cases} 1 & \text{if } f(x,y) \le \text{Median} \mid y = 1,2,\ldots N \\ 0 & \text{otherwise} \end{cases} . \quad (5)$$

The above eq. states that f(x, y) is the original image and H is the output image which is obtained. The H is a binary image which is set to positive value when the intensity of the image f(x, y) is less than or equal to Median value of that particular row and H will result in zero value when the median value is less than f(x, y).The extracted image K is formed by using the following equation,

$$K = \begin{cases} f(x,y) & \text{if } H(x,y) = 1 \\ 0 & \text{otherwise} \end{cases} . \quad (6)$$

The extracted image K is formed by having the binary image H. When the value of the binary image H is 1 then the corresponding intensity value of f(x, y) is applied for K otherwise the zero value is applied for K. The K extracted image consists of low frequency components including the defected area and eliminates the high frequency components. The idea behind generating an extracted image K is the search operation for the defected area can only be done in low frequency areas where all the high frequency elements are made as zero. This technique in turn increases the speed of the search algorithm which is deployed for identifying the defected areas in the digital image.

4. IDENTIFICATION OF DEFECTED AREA

The extracted image K and the median value of each row of the original image f(x, y) is used for identifying the defected area. The defected area is identified sudden variation from the former pixel or from the median value. Every pixel in the row is checked individually with the former pixel and with the median value of that particular row. The pixel which has abrupt variation from the median value of about 60% or from the former pixel of about the same value is considered as a pixel in defected area. The comparison process excludes the pixels which have zero value in order to expedite defect detection algorithm. The defect detection algorithm is explained clearly with the help of the following equation,

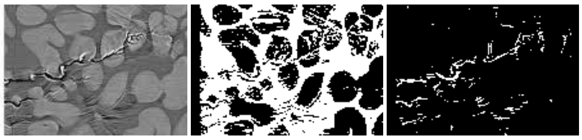
$$DIM = \begin{cases} 1 & \text{if } K(x,y) < \text{Median}(i)^{*}.6 \\ 1 & \text{if } K(x,y+1) < K(x,y)^{*}.6 \end{cases} . \quad (7)$$

$$y = 1 \text{ to } n$$

DIM is the resultant image which precisely highlights the defected area.

5. RESULTS OF THE PROPOSED ALGORITHM

Various images with varied sizes have been used to identify the defected area in the image. Around 100 samples of image have been tested with the help of the proposed algorithm. We have given four samples hereby



(a) (b) (c)

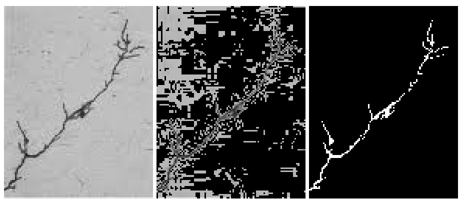
Fig.1. (a) Original image (b) High frequency eliminated image (c) Segmented image

The sample 1 image which of size 102 x 150 consists of defect in a flower design oriented fabric. Fig.1(a) shows the original image Fig.1(b) shows the high frequency components removed image and Fig.1(c) shows the image in which defects have been identified.

(a) (b) (c)

Fig.2. (a) Original image (b) High frequency eliminated image (c) Segmented image

The Second Sample is a Bitmap image which shows a crack on a wall with some specific designs. The Fig.2(a) shows the original image. Fig.2(b) shows the image where high frequency components are removed and Fig.2(c) shows the defects in the original image with the help of white marked areas. The size of sample 2 is 124 x 96.



(a) (b) (c)

Fig.3. (a) Original image (b) High frequency eliminated image (c) Segmented image

Sample 3 is image with a crack in a wall Fig.3(a) shows the original image Fig.3(b) consists of only low frequency components including the defected area and Fig.3(c) shows the defected area in sample 3 images.

(a) (b) (c)

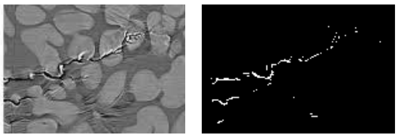
Fig.4. (a) Original image (b) High frequency eliminated image (c) Segmented image

Sample 4 images shows a wall made up of bricks where it consists of a crack Fig.4(a) shows the original image. Fig.4(b) shows the image with low frequency components. Fig.4(c) shows the crack identified by the algorithm with white marks.

We used around 100 samples for testing the efficiency of the algorithm. We have obtained around 90% to 95% of accuracy in all the samples.

6. INDEPENDENT COMPONENT ANALYSIS METHOD

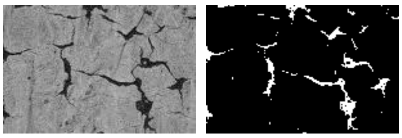
This Method was proposed by A. Serdaroglu In his research work [9] revealed the use of Independent component analysis method along with wavelet transforms for identifying defects in textile fabric images. The idea behind this ICA method is to find the mean value and standard variance for the whole image. These two features are extracted to identify the defects. The original image pixel values are subtracted from the mean value and then will be divided by the standard variance. The intensities which are below certain value will be classified as a defected area. The following sections show the defected original image and the identified defected area.



(a) (b)

Fig.5. (a) Original image (b) Segmented image

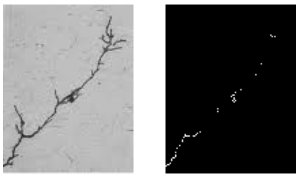
Fig.5(a) shows the original image and Fig.5(b) shows defected region identified image



(a) (b)

Fig 6. (a) Original image (b) Segmented image

Fig.6 shows the result of second sample



(a) (b)

Fig.7. (a) Original image (b) Segmented image

Fig.7 is the result of the Third sample using ICA method

(a) (b)

Fig.8. (a) Original image (b) Segmented image

7. OPTIMAL GABOR FILTER METHOD

The optimal Gabor filter method was proposed by Hamid Alimohamdi in his research work [4] detecting skin defects in fruits. The 2D Gabor filter is applied on the image which has different scales and frequencies. The real and the imaginary parts are convoluted to form the filtered image. The Gabor wavelet function is given as,

$$\Psi(x,y) = \frac{1}{2\Pi\,\partial x \partial y}\exp\left[-\frac{1}{2}\left(\frac{x^2}{\partial_x{}^2}+\frac{y^2}{\partial_y{}^2}\right)\right].\exp(j2\Pi Wx) \quad (8)$$

The Gabor filter gives two types of output one the convoluted image and identified defected region image. The optimized filter is chosen by results based on convolution

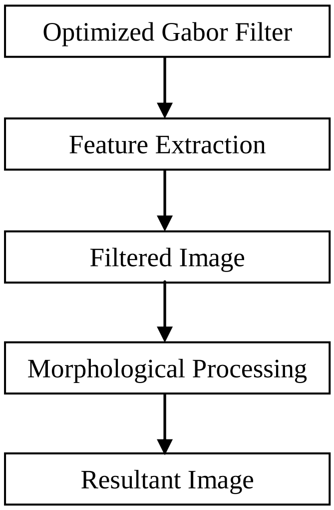
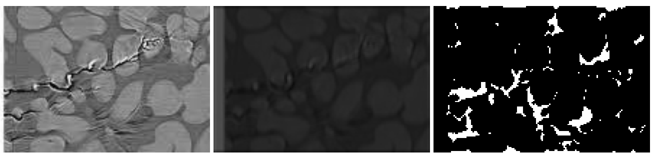


Fig.9. Flow Diagram of Gabor filter Method

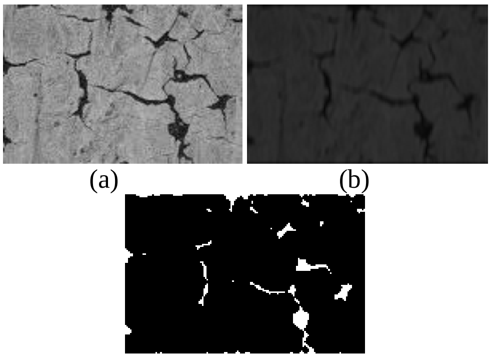
The Optimized filter is chosen from varied scales and rotations. The Feature is extracted such as mean and standard variation. The optimum value is chosen by mean divided by square of standard deviation. The threshold value is chosen from the mean value with appropriate intensity variation to obtain the filtered image. The Filtered image is subjected to morphological operations such as dilation and erosion with the help of structural element to obtain the resultant image.



(a) (b) (c)

Fig.10. (a) Original image (b) Convoluted image (c) Segmented image

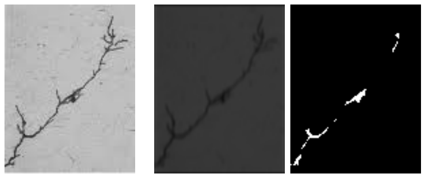
The above samples Fig 10(a) is the original image, Fig 10(b) is the convoluted image and Fig 10(c) is the identified defected region image. The third image results in false positives and also said as error rate.



(c)

Fig.11. (a) Original image (b) Convoluted image (c) Segmented image

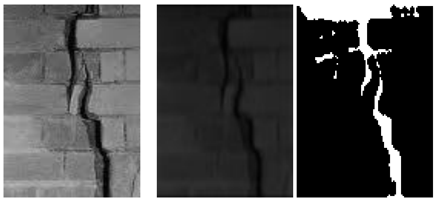
The Sample 2 images such as Fig.11(a), Fig 11(b), Fig 11(c) are original, convoluted and resultant image respectively



(a) (b) (c)

Fig.12. (a) Original image (b) Convoluted image (c) Segmented image

The above is the sample 3 image result



(a) (b) (c)

Fig.13. (a) Original image (b) Convoluted image (c) Segmented image

Sample 4 resultant images shown above with Error rate.

8. COMPARATIVE RESULT ANALYSIS

Table.1. Comparative Result Analysis

Sl. No.	Name	Pixels In Defected Area	Proposed Algorithm		Independent Component Analysis Method		Optimal Gabor Filter Method	
			Defect detection Accuracy%	Elapsed Time (seconds)	Defect Detection Accuracy%	Elapsed Time (Seconds)	Defect Detection Accuracy%	Elapsed Time (Seconds)
1	Sample 1	650	89.38	0.1598	27.07	0.1611	41.84	0.5843
2	Sample 2	1087	94.84	0.1458	78.19	0.1604	44.43	0.5722
3	Sample 3	277	98.19	0.1574	15.52	0.2004	85.55	0.5014
4	Sample 4	941	95.11	0.1581	84.80	0.1987	94.47	0.5234

The above statistics show the proposed algorithm is better than the other algorithms used above. Apart from the accuracy there is no Error rate detected in the algorithm. The Independent component analysis method uses defect free samples for more accuracy which is not the case for proposed algorithm.

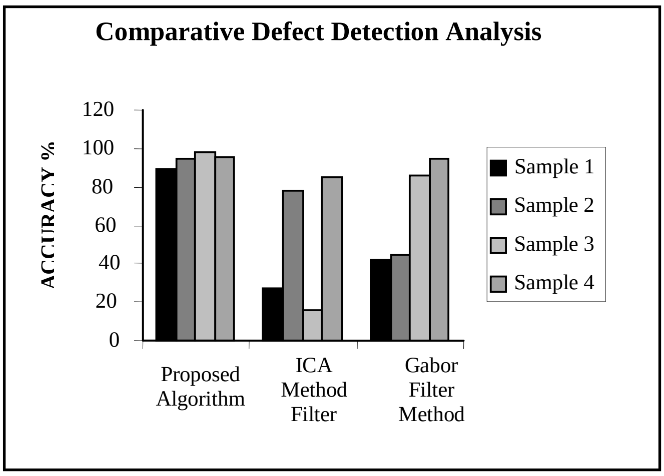


Fig.14. Comparative Defect Detection

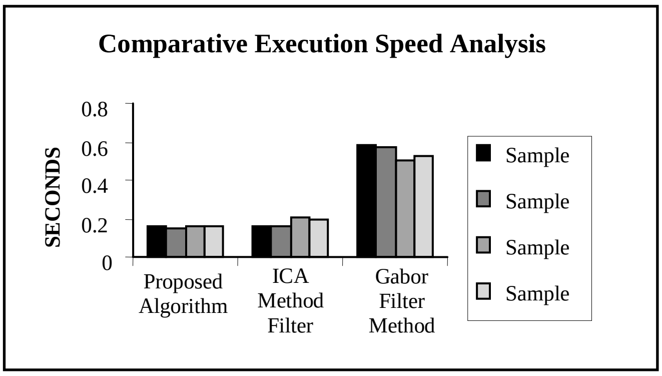


Fig.15. Comparative Execution Speed Analysis

The Pictorial representation reveals the proposed algorithm has some better aspects than the other algorithms used above.

9. CONCLUSION

The Algorithm has the capacity to be used in various types of images. This Algorithm is most suitable for the defects which have low frequency. This algorithm can be deployed in Automated Visual inspection Systems. However to increase the efficiency of the algorithm to be suited for all forms of defects some future work has to be done.

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