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Metallographic Image Fusion

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Abstract—Image processing plays important role in manufacturing, aerospace, biomedical fields. To determine the classification of metallic sample, edge structure and images without blur are required. Instead of finding the noise kernel blur section of images can be removed by using multiple images fusion. There are different methods used for image fusions like average method, maxima, wavelet transform. For image fusion discrete wavelet transform is used. Image fusion improves the quality of image, data content. In this paper three images are used to fuse together. This images having standard size of 640x480 pixels. Image fusion improves the quality so that edge structure can be determined. According to edge structure the classification is done using ASTME standards.

Keywords— *Haar wavelet transform, PSNR, wavelet coefficients*

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I. INTRODUCTION

In industries metal particle structure plays important role while in designing machines, gears, and mechanical parts. For study of atom particle microscope is used. These microscope have different resolution. Some microscope focal length adjustment is done by human. It is observed that focused image consist of some shadow part. In advance microscope, shadow part is get removed and it is implemented histogram plotting and thresholding. But this microscope are too costly. This project will provide new approach.The purpose of image processing is to extract information from image. But for image processing clear images are required. Blur is the noise in images that ruin the edge detection that leads to false classification.There are different technique such as blind decovolution but in this methods noise kernel needed to determine first.Image fusion is best method than blind deconvolution which is proved in one of the research paper.Image took by the microscope have some blur section and some without blur due to error in adjusting focal length because the microscope is handling manually. So, this blur section removal is important to avoid error while calculating grain size and grain number. Image fusion leads to increase in the data of images**.**Due to defocusing the pixel intensities are scattered in its surrounding space. There are different methods used for images fusion such as averaging, selecting maxima, laplacian pyramid, discrete wavelet transform, short wavelet transform. Here discrete wavelet transform method is used for image fusion.Wavelets are obtained from single prototype wavelet called as mother wavelet by dilation and shifting [1].

Wavelet have been first found in the literature in works of Grosmann and Morlet[1].Wavelet mean 'small wave'. So wavelet analysis is about analyzing signal with short duration - finite energy functions. They transform the signal under investigation into another representation which presents the signal in a more useful form. This transformation of the signal is called wavelet transform There are different mother wavelets. Haar is simple type of wavelets.Wavelet transform divides any images into four components.These components are horizontal, vertical , digonal and approximation component. Approximation component represents the approximate image. Horizontal details are represented in horizontal component. Similarly vertical and horizontal details are represented in respective components. There are different mother wavelet such as haar, daubechies.Haar transform were introduced by Alfred haar[7].Haar wavelet is simplest wavelet. Here three images are of same size and same resolution. The size of image is 640X480.These I1,I2,I3 are three images with different sections of blur. After applying the wavelet transform using wavelet coefficients image fusion is performed.

The principle followed for image fusion is given below:

Suppose I1, I2, I3 are three images took by microscope.

The image fusion principle :

$$R(i,j) = W1(i,j) \text{ If } W1(i,j) > W2(i,j) \text{ AND } W1(i,j) > W3(i,j)$$
$$= W2(i,j) \text{ If } W2(i,j) > W1(i,j) \text{ AND } W2(i,j) > W3(i,j)$$
$$\text{Else}$$
$$= W3(i,j) \quad (1)$$

Where W1, W2, W3 are the wavelet coefficients values of image I1, I2, I3 respectively. i stands for rows and j stands for column.

Where R be the resultant fused image coefficients.

Using the image coefficients resultant image is formed. wavelet transform is method for multi resolution analysis, in which image decomposed into lowest approximation[2].In multi focus images some part is clear in one image and other part is clear in another image[2].Using discrete wavelet transform wavelet coefficients are calculated. Wavelet coefficients have higher value for clear part of image and lower value for blur part of image. The coding is done by using MATLAB. The version of MATLAB used is 7.9. Using the one level of discrete wavelet transform image fusion is done. Wavelet transform is transform domain. Wavelet transform is nothing but applying low pass filter and high pass filter to image and down sampling the image. The inverse process is applied while inverse discrete wavelet transform. This code is implemented without any MATLAB inbuilt function. This code is generalized so it can be applied to any images which satisfies the specification criteria. The images used are of bit map format (.bmp). The sample image and blur section of images are shown at the bottom of the table. Image I1,I2,I3 are three images with different section are blur. These images along with blur section and respective fused section image are shown at the bottom of image. DWT is mostly used in the image compression. This is newer approach to use DWT to achieve image fusion.

Edge detection improves image readability and it is a modification of approximation coefficients by simple edge detectors like sobel, prewitt, canny, compass etc. [5] Prewitt is 3x3 mask. Compass is the rotation of prewitt mask. Compass having good ability to detect edges in all directions. Images processing is done in MATLAB without using any math works functions.

II. RELATED WORK

In biomedical field wavelet transform was used for image fusion. Advance microscope is used for calculation of grain size and grain number. But these microscope are more costly and also consisting shadow part at high resolution. Previously some industries are using the manually operating microscope. Histogram plotting method is used to identify is whether blur part present in image or not. But shadow part present in focused image is still one of the troubles which is causing error in grain number calculation and classification.

III. SPECIFICATION OF THE SYSTEM

The specification of the system along with different parameter are given in the table below:

SPECIFICATION TABLE

TABLE.1

Parameters	Values
Number of images per sample	3
Format	BMP,TIFF
Resolution	20x,100x.
Size	640x480
Software	MATLAB
Wavelet type	HAAR

IV. ALGORITHM

1. Image Fusion: To reconstruct focused image without blur under focused image, over focused image and focused image of the samples are used. Steps performed to get fusion of images are as follows

i) DWT: DWT stands for discrete wavelet transform. Using haar as a mother wavelet discrete wavelet transform is performed. Haar wavelet transform takes the average of the sum and average of difference. This is arranged in particular manner. This transform is applies over under focused and over focused images. Due to wavelet transform image is get divides into four components. These components are approximation, horizontal, vertical and diagonal components.

ii) Image fusion: First calculate the wavelet coefficients and compare these wavelet coefficients of the three images. Higher value wavelet coefficients are taken as wavelet coefficients for respective fused image.

iii) IDWT: Take the inverse discrete wavelet transform of fused image.

2. Edge Detection: For edge detection compass operator is used. Compass operator is like high pass filter. Edges are high frequency components.

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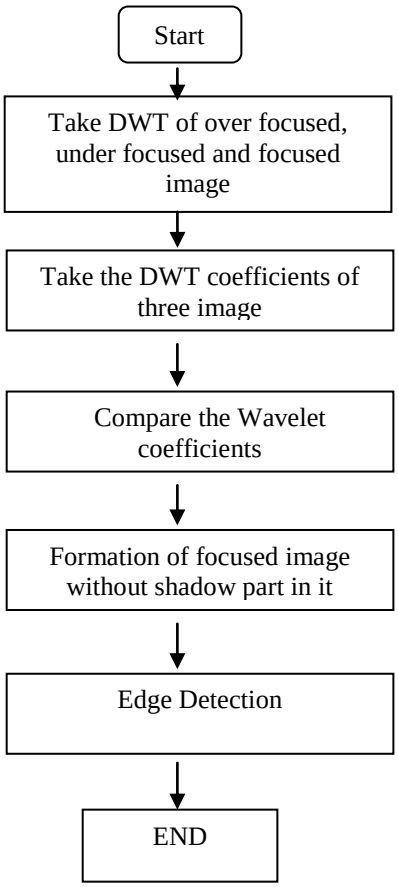
V. FLOWCHART



VI. BLOCK DIAGRAM :

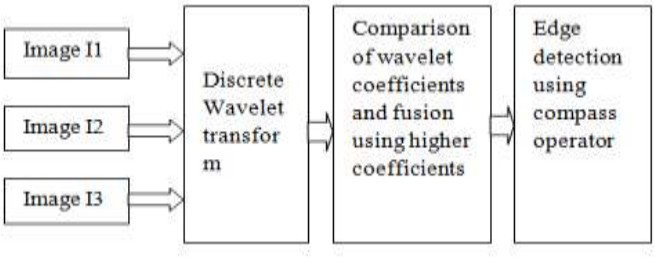


Figure.1 Block diagram of the system

ImageI1: Under focused image

ImageI2: Over focused image

ImageI3: Focused images

These three images are input to DWT.

Image I1 : Image I1 is first sample image which is taken below focal point. This image is having certain blur section. Image I1 is given below:

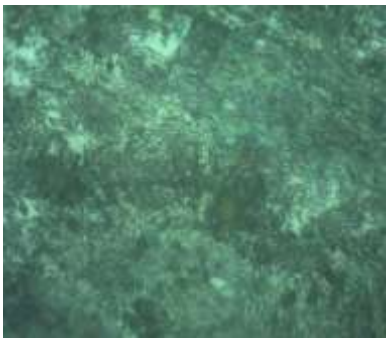


FIGURE.2 Sample Image I1

The blur section in image I1 is given below:

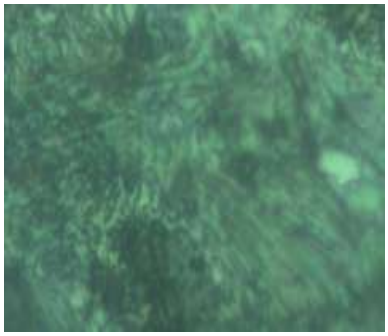


FIGURE.3 Blur section in image I1

Similarly image I2,I3 along with blur section and focused image part is given at the end of the paper.

Discrete Wavelet Transform: There are different wavelet transform. In that Haar is simple wavelet transform.The respective HAAR wavelet transform are :Haar wavelet function is given by

$$x(t) = 1/\sqrt{2} \qquad 0 \le t \le 1/2$$

$$= -1/\sqrt{2} \qquad \tfrac{1}{2} \le t \le 1$$

$$= 0 \text{ elsewhere}$$

It was discovered by ALFRED HAAR. Haar transform takes average of sum and average of the difference and arrange it in particular manner. Haar applied over the array is shown below:

The input array:10 20 30 40 50 60 70 80

The output of array: 15 35 55 75 -5 -5 -5 -5

Image fusion: Using the proposed principle image fusion is done. The wavelet coefficients are compared and using higher coefficients image fusion is done.

Edge Detection: Edge structure is required for classification. There are different algorithm for edge detection. Compass uses prewitt mask by rotating it. Due to this good edges are detected.

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VII. WORKING OF THE SYSTEM

Image fusion is most important part of the project. Here discrete wavelet transform is using for image fusion. we focused on implementing the wavelet transform with MATLAB without using math work functions. We performed discrete wavelet transform over under focused and over focused images. The result of discrete wavelet transform is as shown below on under focused image:

FIGURE.4 DWT of Image I1

Similarly the DWT operation is performed over three images I1, I2, I3. The fusion of three is image is given below

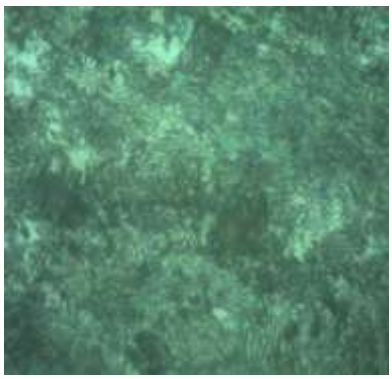

FIGURE.5 Fusion of three images

Edge detected image using compass operator is given below:

FIGURE.6 Edge Detection result

Comparisons Of different image fusion methods

TABLE.2

S. N.	Fusion methods	Domain	Advantage	Disadvantage
1.	Simple average	Spatial	Simple and easy to implement	Not accurate and not assure of getting clear images after fusion
2.	Discrete wavelet transform	Transform	The DWT fusion method may outperform the slandered fusion method in terms of minimizing the spectral distortion. It also provide better SNR than pixel based approach.	In this method final fusion image has less spatial resolution. [10]

Measuring Parameter used :
PSNR: PSNR is peak signal to noise Ratio. It is ratio between the maximum possible power of signal and power of corrupting noise that affect the fidelity of its representation [10].

VIII. RESULTS

Using images fusion technique blur part present in image is removed using discrete wavelet transform method. The quality of image has been improved. Images fusion is performed in MATLAB without any inbuilt functions. Resultant image has been used for edge detection and further for classification. PSNR values of fused image was improved. Compass operator have good tracing of edges in all directions. It is better than sobel and prewitt.
Total 50 samples were tested with proposed algorithms.
Few sample results are shown in table 2.
The results are much improved with other compared method.
The table of comparisons of different methods of image fusion with parameter of PSNR values are given below:

Comparison of PSNR values of different methods

TABLE. 3

Sample	Images	PSNR values of two reference images with respect to focused image	PSNR Values of resultant image by average method	PSNR values of resultant image by discrete wavelet transform
Feritepearlight	Image 1	37.14	37.8368	43.8217
	Image 2	35.984		
Stainless Steel 1	Image 1	34.6518	31.6914	45.7436
	Image 2	33.4918		
Stainless Steel 2	Image 1	29.2652	29.9319	44.655
	Image 2	29.7347		
Ferrite Pearlite	Image1	30.726	39.92	45.873
	Image 2	30.00		
Brass 1	Image1	27.8122	34.8408	39.1127
	Image 2	32.7138		
Brass 2	Image 1	33.2840	36.7742	43.8915
	Image 2	32.5947		
Cast Iron1	Image 1	32.9919	33.1759	39.4435
	Image 2	27.6809		
Cast Iron 2	Image 1	36.3566	36.3221	44.0790
	Image 2	37.1365		
Gun Metal	Image 1	25.7161	27.9257	32.1792
	Image 2	23.3416		
Bronze	Image 1	29.2654	32.5965	36.3571
	Image 2	29.4852		
Copper 1	Image 1	34.9234	37.5560	43.5245
	Image 2	35.0617		
Copper 2	Image 1	29.4111	32.3169	36.7258
	Image 2	29.7832		
Stainless Steel 3	Image 1	26.5756	27.5283	38.5203
	Image 2	23.2230		
Stainless Steel 4	Image 1	33.6940	31.8019	44.73
	Image 2	34.8090		
Stainless Steel 5	Image 1	34.8328	31.3109	44.007
	Image 2	30.7325		

IX. CONCLUSION

It is seen that, Image fusion using wavelet transform is best method for fusion of the data as compared to the averaging, maxima selection. Power of Signal to noise ratio of focused image is getting improved. Haar is simple wavelet to understand which is used. Software product must be user friendly. To make this user friendly GUI has been used. There are several edge detection techniques. Sobel or high pass filter or prewitt operators are used for edge detection. Compass is rotation of prewitt which detect the edges in all directions.

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