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Multi-focus Image Fusion

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***Abstract*- Image fusion is the process of combining two or more multi-focus images into single image which contain more information than that of individual source images. This paper presents the algorithm for multi-focus image fusion in spatial domain using iterative segmentation and edge information of the source images. We have used Fixed Block Size and Adaptive Threshold and Adaptive Block Size and Adaptive Threshold algorithms for image fusion. These algorithms are performed in number of iterations. Image fusion improves quality of image. This technique has been tested on several pairs of multi-focus images.**

***Keywords*- : Fusion of images, Multi-Focus Image Fusion, Spatial Domain, etc.**

I.INTRODUCTION

Image fusion means the combining of two or more images into single image which is more informative than that of individual source images. Image fusion is widely used in the field of satellite imaging, surveillances, RADAR, biometrics. In satellite imaging and surveillances system fusion of images is obtained by using infrared and visible light cameras. In RADAR image fusion technique is used to improve the blurred image and we get clear focused image which contain maximum information.

An edge is a boundary of an image at which a significant change occurs in some physical aspect. Edge detection is used to find out the boundaries of objects within images and it filters out unwanted information. Hence it is an important tool in image analysis. Edge detection has application in the areas of image processing, computer vision and machine vision. There are various methods of edge detection such as 'Prewitt', 'Robert', 'Sobel', 'Laplacian of Gaussian' and 'Canny Edge Detector. In this paper we have used canny edge detector to detect the edges. The canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. Canny method applies two thresholds to the gradient. The basic idea is to detect at the zero crossings of the second directional derivative of the smoothed image in the direction of gradient where the magnitude of the gradient of the smoothed image being greater than threshold depending on image properties.

II.LITERATURE REVIEW

Image fusion can be divided into two types as fusion in frequency domain and fusion in spatial domain. In frequency domain method image is first transferred into frequency domain. Fourier transform is used for fusion and then Inverse Fourier transform is taken to get the result. But it is a very time consuming method so we go with spatial domain fusion. Spatial domain directly deals with image pixels. [1] [2].

'Mean' and 'maximum' methods are used both in spatial domain and frequency domain fusion. In mean method the average of two input images is calculated. After performing averaging we get fused image. In maximum method the comparison of two input images is carried out and the pixels with maximum value are selected for fused image. Also various multi-scale transforms such as wavelet transform and curve let transform are used for image fusion. In wavelet based fusion average weight of pixels is calculated. [3][4]

When we capture three dimensional images then it is necessary to have all the objects of the scene to be in focus. But it is not possible to capture all-in-focus image with the image capturing devices because of the limitations of depth of field of camera sensors. When we use single camera for capturing an image then we get blurred image. Also we get images with unequal luminance and spatial distortion. Multi-focus image fusion technique is used to improve the blurred image and we get clear focused image which contains maximum information with equal luminance.

III. PROPOSED ALGORITHM

In this paper an iterative approach is used for multi-focus image fusion. First the source images are divided into smaller blocks, then edge information of each block is computed and then the block with greater edge information is selected. For this purpose adaptive threshold is taken. Block size and threshold are made adaptive in each iteration to improve the quality of fused image. In each iteration the blocks with higher edge information becomes the part of fused image and remaining blocks are passed over the next iteration. The fused image we get at the end has better visual quality.

a)foreground in focus

b)background in focus

Figure.1 Source images

a)foreground in focus

b)background in focus

Figure.2 Source images with edge information

Figure.1 shows two source images with complementary regions in focus. In this (a) shows Foreground in focus and (b) shows Background in focus. Figure.2 shows the edges of input images calculated using canny edge detector.

A) FIXED BLOCK SIZE AND ADAPTIVE THRESHOLD (FBS-AT)

The input images are divided into fixed number of blocks after calculating the edge information. We divide the input images into 16 blocks. Then we compare the edge information of two input images. The blocks with higher edge information are incorporated into final fused image and the blocks which remain unselected are passed over the next iteration.

In Fixed Block Size and Adaptive Threshold (FBS-AT) selection is made in three iterations which are explained as follows:

1) The input images are divided into certain number of blocks. Then the difference between edge information for two input images is calculated then the mean of all differences is computed and it is set as adaptive threshold. Then the difference for each block is compared with the threshold and the blocks for which the difference exceeds the threshold become the part of fused image and the remaining blocks are passed to the next iteration.

2) To set a new threshold the mean of differences of the blocks which are passed from the first iteration is calculated. Then this mean is set as a new threshold. Then the differences for blocks for which the difference is greater than threshold are selected as a part of fused image and remaining blocks are passed over the last iteration.

3) The blocks passed from the second iteration for which no decision has been made are simply selected by observation. Means the blocks with higher edge information are incorporated into the final fused image.

Figure.3 shows the resultant images after each iteration.

B) ADAPTIVE BLOCK SIZE AND ADAPTIVE THRESHOLD (ABS-AT)

For improving the quality of resultant image ABS-AT is used. For making the further enhancement not only the threshold but also block size is made adaptive for each iteration. In this algorithm there may be number of iterations. This algorithm can be described as follows:

1) The input images are divided into certain blocks. Then the difference between edge information for two input images is calculated. Then the mean of all differences is computed and it is set as adaptive threshold. Then the difference for each block is compared with the threshold and the blocks for which the difference exceeds the threshold are incorporated as the part of fused image and the remaining blocks are passed to the second iteration.

2) In the second iteration the images are divided such that each block of an image is subdivided by twice the number of divisions used in first iteration. Then the mean of all the differences is calculated and it is set as a new threshold. Then the difference for each block is compared with threshold value. If the difference is greater than threshold then those blocks are selected as the part of fused image. Remaining blocks for which no selection is made are passed over the last iteration. Second iteration may be performed in the form of number of sub-iterations.

3) In the last iteration the blocks which passed from second iteration are simply selected by comparing the edges of input images. The blocks with higher edge information are selected as part of final fused image. Figure.4 shows the resultant images of ABS-AT.

IV. STATISTICAL PARAMETERS

Fusion is performed to improve quality of image. Image fusion is characterized by some parameters such as entropy, mean, gradient, variance, energy, cluster shade etc.

1] Entropy:

Entropy is nothing but an information content of an image.

It is given as,

$$E = -\sum_{i=0}^{255} P_i \log_2 P_i \qquad (1)$$

2] Mean:

It is given as,

$$\mu = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} f(i,j)}{m \times n} \quad (2)$$

Where f (i,j) is pixel intensity for position (i ,j)

3] Average gradient:

Average gradient is the contrast details of reflected image.

It is given as,

$$\bar{G} = \frac{\sqrt{\sum_i \sum_j \left(f(i,j) - f(i+1,j)\right)^2 + \left(f(i,j) - f(i,j+1)\right)^2}}{m \times n} \quad (3)$$

4] Variance:

Variance is used to measure the focus of the block of an image.

It is given as,

$$\sigma^2 = \frac{\sum_i \sum_j (f(i,j) - \text{mean})^2}{m \times n} \quad (4)$$

5] Standard Deviation:

It is used to weight information of an image.

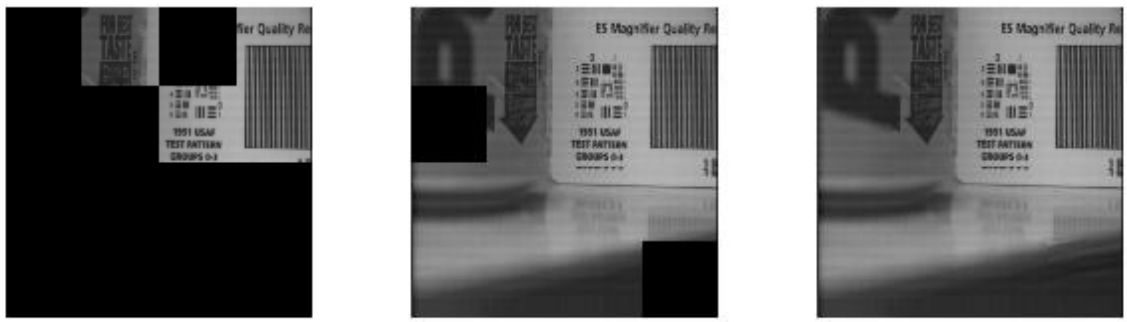
It is given as,

$$\sigma = \sqrt{\sigma^2} \quad (5)$$

V. EXPERIMENTAL RESULTS

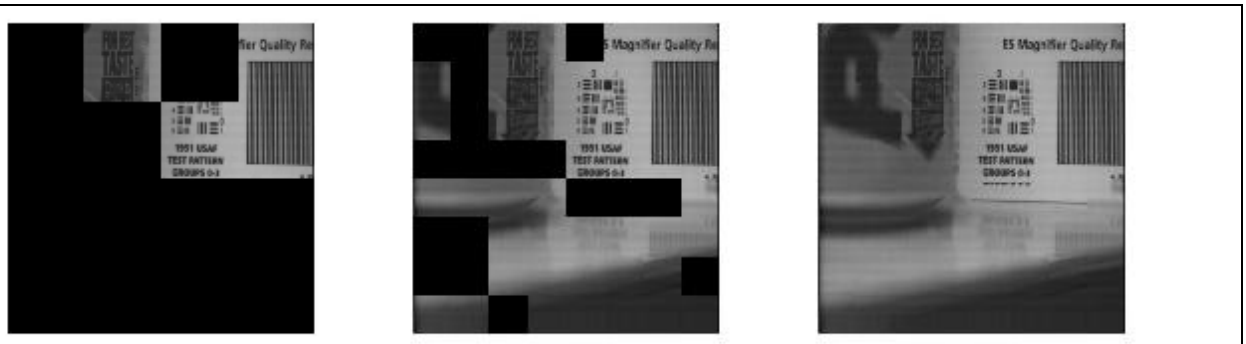
Table.1 Comparison of Quality Matrices for Mean, FBS-AT and ABS-AT methods.

Parameters	Algorithms		
	Mean	*FBS-AT*	*ABS-AT*
Entropy	5.1927	5.5761	5.5719
Mean	90.416	152.9635	152.9392
Variance	1210.8	139.685	139.574
Gradient	0.0186	0.009	0.009
Standard deviation	34.796	83.3608	83.3937
ClProm	1.0797	2.4058	2.0888
Clust-shade	-1.9425	-3.6993	-3.2222
Infomeas	-3.0268	-3.0309	-3.0309
LHomogrnty	7.6810	9.4465	9.3632
Contrast	4.1717	4.8383	4.6381
Energy	5.3801	7.8337	7.5574



a)first iteration b)second iteration c)final result

Figure.3 Fixed Block Size and Adaptive Threshold



a)first iteration b)second iteration c)final result

Figure.4 Adaptive Block Size and Adaptive Threshold

These image fusion algorithms are performed on two pairs of images namely, 'clock' and 'pepsi'.Table.1 shows the comparison of different quality matrices computed for 'pepsi' pair of image using the three methods.

VI.CONCLUSION

By using FBS-AT and ABS-AT algorithms we are getting 7.3% improvement in entropy as compared to mean method. The contrast is improved by 16% in FBS-AT and 11% in ABS-AT.FBS-AT and ABS-AT successfully gives 45% and 40% more energy content than mean method. Thus multi-focus image fusion technique ensures to achieve clear fused image which contains maximum information with equal luminance.

VII. REFERENCES

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