MULTI FOCUS IMAGE FUSION BASED ON THE INFORMATION LEVEL IN THE REGIONS OF THE IMAGES

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ABSTRACT

An image fusion algorithm based on activity measures like Spatial frequency and Visibility for fusing multi focus images is presented in this paper. For each sub window in the source multi focus images, the spatial frequency and Visibility is calculated. The fusion procedure is performed by a selection mode according to the magnitude of the spatial frequency and Visibility. The fused images are then assessed using the same activity measures that is used for fusion. Experiments results shows that the proposed algorithm works well in multi focus image fusion.

Keywords: *Information level, Spatial Frequency, Visibility, Multi focus, Image fusion*

1. INTRODUCTION

The concept of Image fusion has been used in wide variety of applications like medicine, remote sensing, machine vision, automatic change detection, biometrics etc. With the emergence of various image-capturing devices, it is not possible to obtain an image with all the information. Sometimes, a complete picture may not be always feasible since optical lenses of imaging sensor especially with long focal lengths, only have a limited depth of field. Image fusion helps to obtain an image with all the information. Image fusion is a concept of combining multiple images into composite products, through which more information than that of individual input images can be revealed. The goal of image fusion is to integrate complementary multi sensor, multi temporal and/or multi view data into a new image containing more information. With the availability multiple image sources, image fusion has emerged as new and promising research area. Many algorithms and image fusion software's are developed in recent years using various approaches for various applications.

The actual fusion process can take place at different levels of information representation, a generic categorization is to consider the different levels as, sorted in ascending order of abstraction: signal, pixel, feature and symbolic level. The lowest possible technique in image fusion is the pixel level, is called as nonlinear method, in which the intensity values of pixels of the source images are used for merging the images. The next level is the feature level, which operates on characteristics such as size, shape, edge etc. The next highest level called decision level fusion deals with symbolic representations of the images[1].

Currently, most of the image fusion has been performed using pixel based methods [2][3]. A new multi-focus image fusion algorithm, which is on the basis of the Ratio of Blurred and Original Image Intensities was proposed in [4]. A multi-focus image fusion method using spatial frequency (SF) and morphological operators was proposed in [5].The advantage of the pixel level image fusion is that images contain original information. Furthermore it is easy to implement. Image fusion methods based on wavelet transform have been widely used in recent years. A simple image fusion algorithm based on wavelet transform is proposed in reference [6] .A new multi-focus image fusion scheme based on wavelet contrast is given in reference [7].A novel multi focus image fusion algorithm based on contourlet transform and region statistics was proposed in [8]. A simple yet efficient algorithm for multi focus image fusion, using a multi resolution signal decomposition scheme was proposed in [9]. A paper given in reference [10] presents an overview on image fusion techniques using multi resolution decompositions. A paper in reference [11] is an image fusion tutorial based on wavelet decomposition, i.e. a multi resolution image fusion approach. Paper in reference [12] presents the use of balanced multi wavelets for image fusion. A new method is developed to merge two spatially registered images with different focus based on multi-resolution wavelet decomposition and evolutionary strategy (ES)[13]. A multi focus image fusion algorithm using the Haar transform is presented in the paper[14]. Paper[15] proposes a method for multi-focus image fusion using pulse coupled neural network (PCNN).The application of artificial neural networks to this pixel level multi focus image fusion problem based on the use of image blocks is explained in [16]. A novel adaptive multi-focus image fusion algorithm is given in this paper, which is based on the improved pulse coupled neural network(PCNN) model, the fundamental characteristics of the multi-focus image and the properties of visual imaging[17].

This paper discusses the fusion of multi focus images using the information level or activity level in the region of images. Section 2 gives a review of the spatial frequency and visibility. The scheme for fusing images and the experimental results are discussed in section 3. At the end of the section 3 performance assessment is discussed.

2. INFORMATION LEVEL MEASURES

Image fusion starts with dividing the source images into sub regions and then calculating a measure of information level in the regions (in the literature often referred to as a activity level -AL) and then utilizing some fusion rules to combine the images. In this paper , spatial frequency and visibility are used to measure the information level in the regions. The algorithm is computationally simple and efficient and can be used in real time applications

2.1 Spatial frequency

Spatial Frequency measures the overall information level in the regions (activity level) of an image . The spatial frequency for an M*N block of an image is calculated as follows

$$SF=\sqrt{(RF)^2+(CF)^2} \qquad (1)$$

Where RF and CF are the row frequency and column frequency respectively

$$RF=\sqrt{\frac{1}{MN}\sum_{m=1}^{m}\sum_{n=2}^{n}\left[F(m,n)-F(m,n-1)\right]^2} \qquad (2)$$

$$CF=\sqrt{\frac{1}{MN}\sum_{n=1}^{n}\sum_{m=2}^{m}\left[F(m,n)-F(m-1,n)\right]^2} \qquad (3)$$

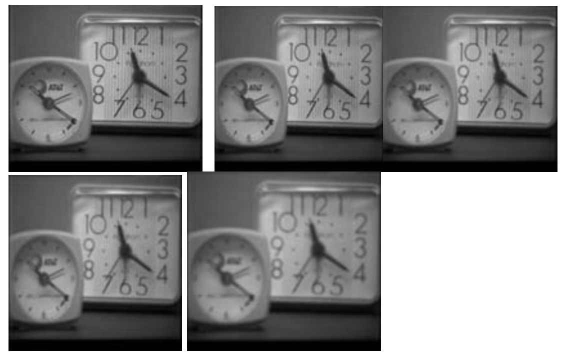
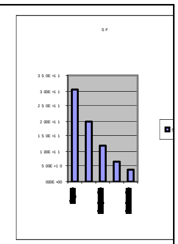


Fig-2.1 (a) shows the original clock image and Fig 1(b-e) shows the degraded version after blurring with the gaussian radius of 0.5,1.0,1.5 and 2.0 respectively.

The spatial frequency is calculated for all the above images and it is tabulated as follows.

Table-2.1-SF(Clock)

Clock Image	SF
Original	3.02E+11
Blur (.5 r)	1.99E+11
Blur(1.0.r)	1.18E+11
Blur (1.5r)	6.43E+10
Blur (2.0r)	3.73E+10



As can be seen from Table-2.1 when the images gets more blurred, the spatial frequency also gets reduced accordingly. Higher the value of spatial frequency , higher will be the contrast and quality of the image .

2.2 Visibility

The visibility of an image block is defined as

$$VI=\sum_{M-1}^{M}\sum_{N-1}^{N}\omega(\mu).\,|\,\frac{f(m,n-\mu)}{\mu} \qquad (4)$$

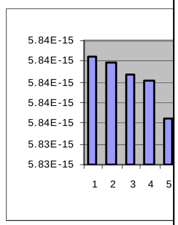
where μ is the intensity mean value of the block, and

$$\omega(\mu)=(1/\mu)$$

The visibility is calculated for the above blurred images and it is tabulated as follows

Table-2.2 VI(Clock)

Clock Image	VI
Original	5.8425E-15
Blur (.5r)	5.8419E-15
Blur(1.0.r)	5.8406E-15
Blur (1.5r)	5.8401E-15
Blur (2.0r)	5.8365E-15



As can be seen from the table 2.2,when the images gets more blurred, the Visibility also decreases accordingly.

3. MULTI FOCUS IMAGE FUSION

Optics of lenses with a high degree of magnification suffers from the problem of a limited depth of field. The larger the focal length and magnification of the lens the smaller the depth of field becomes. As a result, fewer objects in the image are in focus. Multi focus digital image fusion attempts to increase the apparent depth of field through the fusion of object within several different fields of focus. Multi Focus Image Fusion fuses images which are partly focused and partly defocused. This study focuses only the multi focus image fusion. The method used and implemented in this study are as follows.

3.1 Information Level Approach

Image fusion starts with dividing the source images into sub regions and then calculating a measure of information level in the regions (in the literature often referred to as a activity level -AL) and then utilizing some fusion rules to combine the images. In this paper , spatial frequency and visibility are used to measure the information level in the regions.

Let A and B are the source images, and if $ILA_i > ILB_i$ then $F_i = A_i$. The multi focus images are fused by calculating the information level using measures like Spatial frequency and Visibility in the regions of the images using the equation (1) and (4) respectively .The combined approach is also discussed and the resultant fused images are also given.

3.1 Combined approach

In combined approach ,the set of multi focus images are fused using the spatial frequency method. The same set of images are fused using the visibility method. The fused images from both the methods are again fused using Visibility or spatial frequency. The diagrammatic representation of the above approach is as follows.

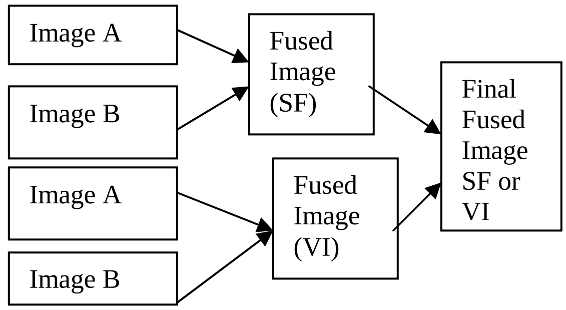
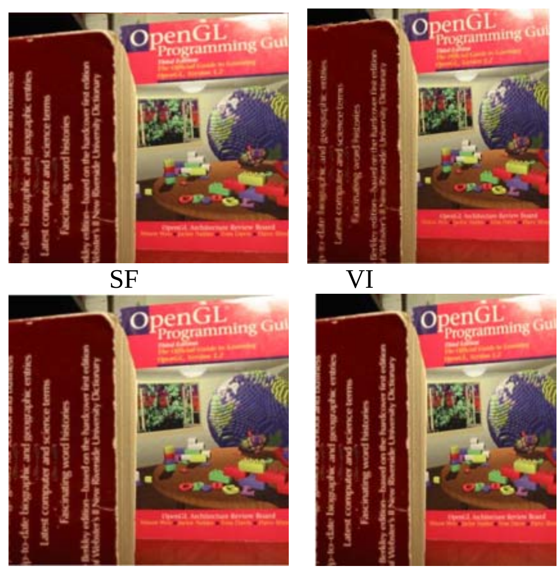


Fig 3.1 SFVIVI or SFVISF

3.2 Experimental results

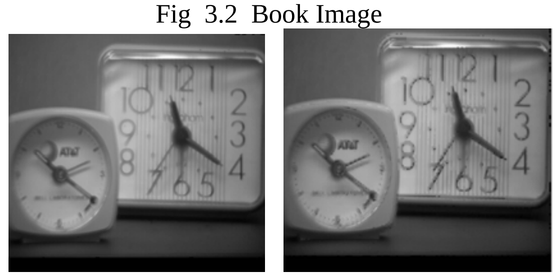
The left focus and right focus images are fused using the information level based methods like SF,VI,SFVIVI and SFVISF to produce a full focus images and are listed as follows. The input images are not shown here.



SF VI

SFVIVI SFVISF

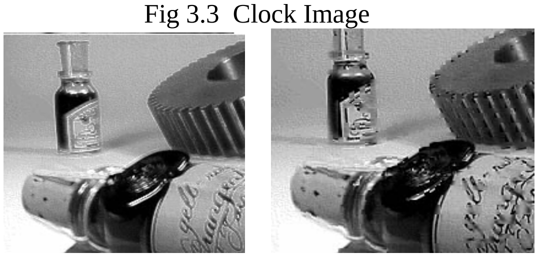
Fig 3.2 Book Image



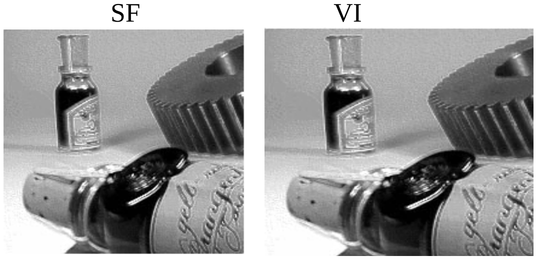
SF VI

SFVIVI SFVISF

Fig 3.3 Clock Image

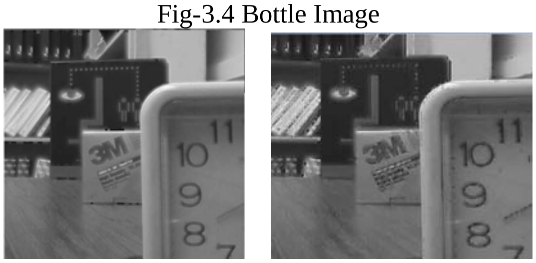


SF VI



SFVIVI SFVISF

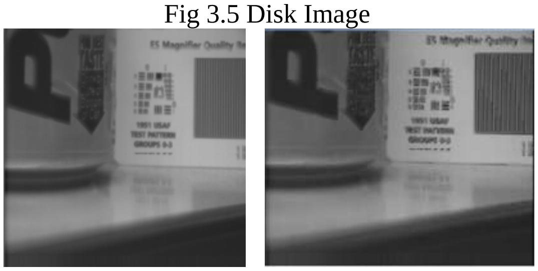
Fig-3.4 Bottle Image



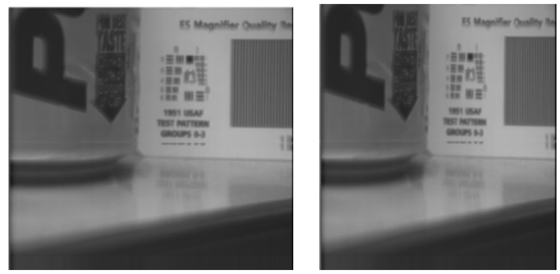
SF VI

SFVIVI SFVISF

Fig 3.5 Disk Image



SF VI



SFVIVI SFVISF

Fig-3.6 Cup Image

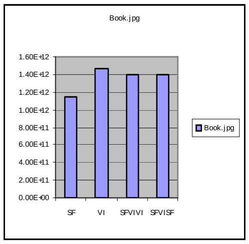
4. PERFORMANCE ASSESSMENT

Image quality measures -IQMs are figures of merit used for the evaluation of imaging systems or of coding/ processing techniques. A lot of image fusion algorithm have been proposed by various groups. Each algorithm has shown some promising aspects, their seems to be a lack of universal criteria to measure the quality of the fusion algorithms. In many cases qualitative criteria such as visual analysis are used to assess the resulting fused images. An accurate and reliable conclusion is made by doing both subjective and objective tests on large number of standard images including test images of different resolution and different image types etc. Researches have been made to review image fusion techniques and assess their qualities. An assessment paradigm combining both qualitative and quantitative assessment will be most appropriate in order to achieve the best assessment result. The quantitative assessment is done on the fused images using some objective quality measures. It helps better in assessing the quality of images. In this study the quality of the fused images are assessed using the information level measures like spatial frequency and visibility is calculated which is used in the fusion approach and are tabulated.

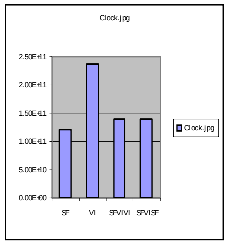
Table 4.1 Spatial frequency

S .No	SF	VI	SFVIVI	SFVISF
Book. jpg	1.15E +12	**1.46E +12**	1.39E+ 12	1.39E+ 12
Clock .jpg	1.21E +11	**2.37E +11**	1.39E+ 11	1.39E+ 11
Bottle. jpg	3.09E +12	**4.46E +12**	3.43E+ 12	3.43E+ 12
Disk .gif	3.95E +11	**6.76E +11**	5.16E+ 11	5.16E+ 11
Cup. gif	2.97E +11	**4.11E +11**	3.15E+ 11	3.15E+ 11

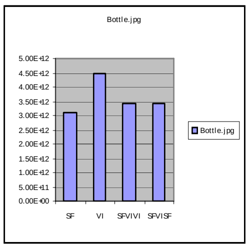
Graph 4.1 SF



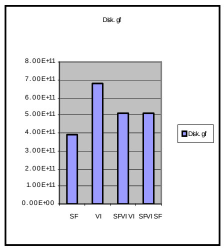
Book .Image



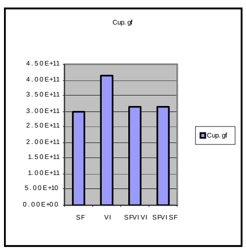
Clock Image



Bottle Image



Disk Image



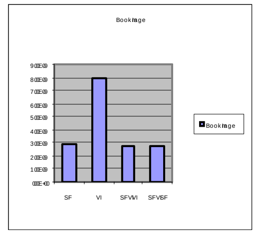
Cup image

From the above table values and graphs ,it is found that the spatial frequency of the fused images is high in VI method for all the images. Even though it is high the image obtained is not as much clear as the other methods and it is high in contrast. In SF it is still low .In the case of the combined approach , it is more less equal, the image is with balanced contrast ,when compared to SF method which is low and VI method which is high. So the combined approach works well in this case.

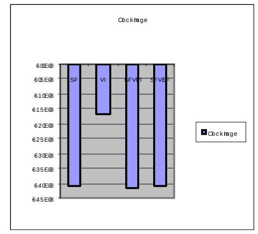
Table 4.2 Visibility

S.No	SF	VI	SFVIVI	SFVISF
Book. jpg	2.88E -09	**7.89E -09**	2.76E-09	2.76E-09
Clock .jpg	- 6.41E -08	**- 6.17E -08**	-6.41E-08	-6.41E-08
Bottle .jpg	2.21E -08	**2.78E -08**	2.21E-08	2.21E-08
Disk. gif	1.03E -08	**1.16E -08**	1.01E-08	1.01E-08
Cup. gif	- 6.35E -08	**- 6.06E -08**	-6.35E-08	-6.35E-08

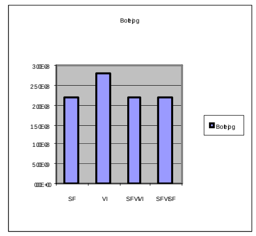
Graph 4.2 VI



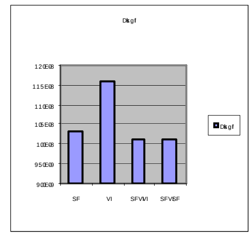
Book Image



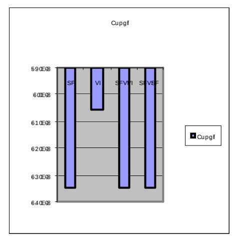
Clock Image



Bottle Image



Disk Image



Cup Image

From the above table and graph it is evident that the information level measure visibility coincides with the results of the spatial frequency. Here also the combined approach shows similar visibility values.

5. CONCLUSION

In this study **,**some image fusion methods based on information level in the regions of the images using spatial frequency and visibility are demonstrated to fuse the diverse focus images also some quality metrics are also calculated for these fused images. In real applications, information from different sensors is not likely to be treated equally important. That is, information from some sensors is more emphasized than information from other sensors. This may suggest that performance of image fusion algorithms depends on images of specific applications. . Furthermore, since fused images are used to enhance visual information for human users, performance assessment of image fusion should be first judged by the users based on the mission of specific applications. In situations where it is hard to take decision about the quality of fused image objective measures are calculated.

Quantitative measures should only serve as a useful tool to assist human users to make difficult judgments whenever necessary. The performance assessment of image fusion should continue to be shared between qualitative and quantitative methods, with increasing weight being placed toward new quantitative assessment techniques.

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