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Performance Analysis of Image Fusion Techniques

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Abstract: In Image processing it requires high spatial and spectral resolution in a single image at several situations. However, the instruments are not capable of providing an image of good resolution. So, one of the possible solution is IMAGE FUSION. It is a process of combining the relevant information from a set of images into a single image which contains more informative and resolution than input images. Image fusion increases the quality of image. Several applications of image fusion such as medical diagnosis, remote sensing, military and security for surveillance areas etc., It is not possible to develop a universal technique for all applications. Hence a specific image fusion technique is employed for specific application. Now, image fusion techniques such as filtering methods and DWT technique are employed in medical application. The performance analysis of proposed methods is obtained and compared through various quality evaluation parameters.

Keywords: Image Fusion, Quality Metrics, Image Processing, Filtering, DWT

I. INTRODUCTION

The concept of Image fusion goes back to the 1950'sand 1960's, with the search for practical methods of merging images from various sensors to provide a composite image which could be used to better identify natural and manmade objects. However, the general instruments are not capable of providing an image of good resolution. So, one of the possible solution is IMAGE FUSION. The term FUSION [1] gets several words to appear, such as merging, combination, synergy, integration … and several others that express more or less the same concept. Image fusion is a process of combining the relevant information from a set of images into a single image which contains more informative and resolution than input images. Image fusion increases the quality of image.

II. CLASSIFICATION OF IMAGE FUSION METHODS

Based on the input images considered for fusion process, they broadly classified into four categories[1] such as multimodality images, multifocal images, multi-temporal images, multi-view images.

A. Multimodal Images

For the fusion process the images taken from different instruments, like visible and infrared, CT and MRI, or panchromatic and multispectral satellite images. The goal of the multimodal image fusion system is to decrease the amount of data and to emphasize band-specific information.

B. Multifocal Image Fusion

For the fusion process the images of different focal values are considered. In applications of digital cameras, when a lens focuses on a subject at a certain distance, all subjects at that distance are not sharply focused. The goal of this type of fusion is to obtain a single all-in focus image.

C. Multi-view Image Fusion

In multi-view image fusion, a set of images of the same scene is taken by the same sensor but from different viewpoints or several 3D acquisitions of the same specimen taken from different viewpoints are fused to obtain an image with higher resolution. The goal of this type of fusion is to provide complementary information from different viewpoints.

D. Multi-temporal Image Fusion

For the fusion process the images taken at different time intervals are used. Images taken at different times (seconds to years) in order to detect changes between them are fused together to obtain one single image.

III. IMAGE FUSION TECHNIQUES

In this paper the fusion of low level or pixel level multimodal images are performed. In medical diagnosis applications, Let us consider the MRI scanned image and CT scanned images of brain are selected for fusion process.

A. Filtering Methods

Here the pixel wide operations are performed[2]. The required operations performed on the corresponding pixels values of images to be fused to obtain a fused image. As the operations are performed on pixel these are also called as pixel based image fusion technique.

I. Average Filter

The two input images that are to be processed are read into MATLAB and the corresponding size of the images are identified. The images are resized to the larger image size. Now the two images are of equal size. These images are fused using the average filter technique and the resultant output image is obtained. In this method the resultant fused image is obtained by taking the average intensity of corresponding pixels from both the input image. The equation used to find the average value is given in equation below.

$$P(i, j)=\{x(i, j) + y(i, j)\}/2$$

Where p(i, j) is pixel value of the output image

X(i, j) and y(i, j) are the pixel values of the input images

The average filter technique uses the simple average principle in which the first pixel of the two input image are averaged and the resultant obtained value is the first pixel of the resultant output image. Now the second pixels of the input image are averaged and stored as the second pixel of the output image. Similarly the same procedure is applied to all the pixels and the resultant output image is the average of the input pixels of input images.

II. Min filter

The two input images that are to be processed are read into MATLAB and the corresponding size of the images are identified. The images are resized to the larger image size. Now the two images are of equal size. These images are fused using the max filter technique and the resultant output image is obtained. In this method a selection process is performed wherein, for every corresponding pixel in the input images, the pixel with minimum intensity is selected, respectively, and is put in as the resultant pixel of the fused image. The equation used to find the minimum value is given in equation below.

$$P(i, j)= \sum^{n}_{i=}0[\min\{x(i, j)\ y(i, j)\}]$$

where p(i, j) is pixel value of the output image

x(i, j) and y(i, j) are the pixel values of the input images

The min filter technique uses the simple minimum value selection principle in which the first pixel of the two input image are compared and the resultant minimum pixel value is the first pixel of the resultant output image. Now the second pixels of the input image are selected and stored as the second pixel of the output image. Similarly the same procedure is applied to all the pixels and the resultant output image is the minimum valued pixels of input images.

III. Max filter

The two input images that are to be processed are read into MATLAB and the corresponding size of the images are identified. The images are resized to the larger image size. Now the two images are of equal size. These images are fused using the max filter technique and the resultant output image is obtained. In this method a selection process is performed wherein, for every corresponding pixel in the input images, the pixel with maximum intensity is selected, respectively, and is put in as the resultant pixel of the fused image. The equation used to find the max value is given in equation below.

$$P(i, j)= \sum^{n}_{i=}0[\max\{x(i, j)\ y(i, j)\}]$$

Where p(i, j) is pixel value of the output image

x(i, j) and y(i, j) are the pixel values of the input images

The max filter technique uses the simple maximum value selection principle in which the first pixel of the two input image are compared and the resultant obtained value is the first pixel of the resultant output image. Now the second pixels of the input image are compared and stored as the second pixel of the output image. Similarly the same procedure is applied to all the pixels and the resultant output image is the minimum valued pixels of input images.

B. Discrete Wavelet Transform (DWT) Technique

Image is filtered[3] by low pass (for smooth variation between gray level pixels) and high pass filter (for high variation between gray level pixels). Image is decomposed into single level which include approximation details (LL1 sub band), horizontal detail (HL1 sub band), vertical (LH1 sub band) and diagonal details (HH1 sub band). Again this approximation details is filtered by low pass and high pass filter and decomposed into second level that includes approximation details (LL2 sub band), horizontal detail (HL2 sub band), vertical (LH2 sub band) and diagonal details (HH2 sub band).

I. Steps Involved

1. Read the two input images, I1 and I2 to be fused.
2. Perform independent wavelet decomposition of the two images
3. Apply pixel based algorithm for approximations which involves fusion based on taking the average valued pixels from approximations of source images I1and I2
4. By selecting the maximum valued pixels from the detail coefficients, gives the fused image.
5. The final fused transform corresponding to approximations through maximum selection pixel rule is obtained.
6. Concatenation of fused approximations and details gives the new coefficient matrix.
7. Apply inverse wavelet transform to reconstruct the resultant fused image and display the result

IV. RESULTS AND DISCUSSIONS

In this project the fusion of low level or pixel level multimodal images are performed. In medical applications, the MRI scanned image and CT scanned images of brain are selected for fusion. The MRI and CT scan images of brain are shown in the Figure 1 and 2.

MRI scanned image contains – texture details (soft tissues) information

CT scanned image contains - edge details (hard tissues) information

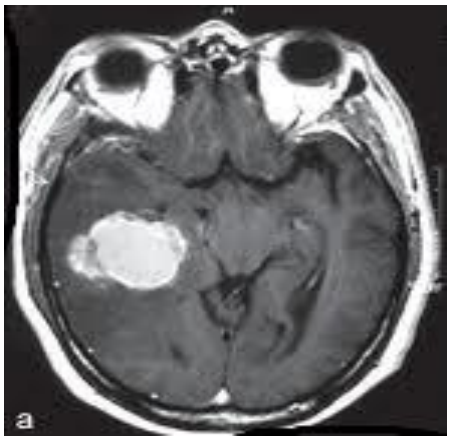

Fig 1. MRI Scan Image

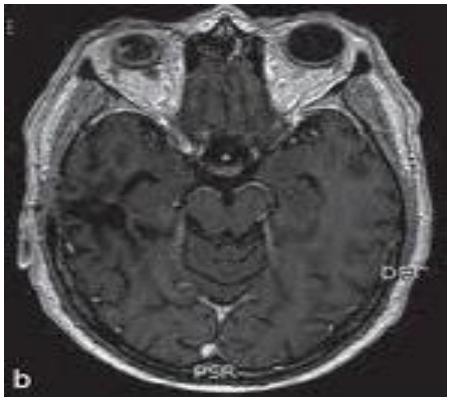

Fig 2. CT scan Image

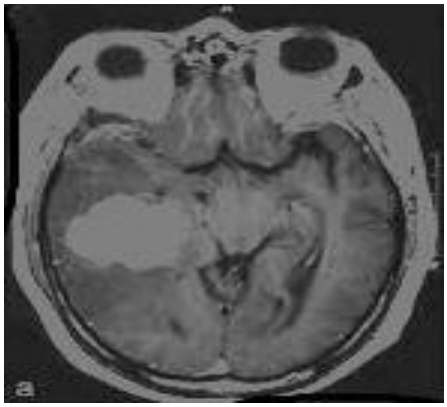

Fig 3. Fused image using average filter

Fig 4. Fused image using min filter

Fig 5. Fused image using max filter

Fig 6. Fused image using DWT

A. Quality Evaluation Parameters

Image quality metrics[4] are used to benchmark different image fusion techniques by comparing the objective metrics.

Table 1. Quality Evaluation Measures of Different Image fusion Techniques.

Parameter	FILTERING METHODS			DWT
	AVG FILTER	MAX FILTER	MIN FILTER	
Image Quality Index(IQI)	0.3539	0.5218	0.3270	0.9882
Mutual Information Measure(MIM)	1.0854	1.9887	1.0570	1.287
Fusion Factor(FF)	1.8039	3.6197	1.7749	2.2607
Fusion Index(FI)	0.6620	0.8202	0.6792	0.7538
Fusion Symmetry(FS)	0.1017	0.0494	0.0955	0.0702
RMSE	11.3018	12.3972	12.0733	4.3904
PSNR	48.3490	48.2004	48.3484	48.214
Entropy(E)	6.6763	7.4029	7.3796	6.9765

The value of each quality assessment parameters of all mentioned fusion approaches are depicted in Table 1. Our experimental results show that proposed discrete wavelet transform (DWT) based image fusion approach provides better performance and quality on compared to pixel based image fusion techniques. Due to efficiency of the proposed method the image quality index (IQI), that gives the similarity between reference and fused image are higher for haar wavelet and max filter technique case than the other techniques. The higher values of fusion factor (FF) obtained from the pixel based (max filter) fusion approach indicates that fused image contains moderately good amount of information present in both the images compared to FF values obtained from wavelet transform.

The amount of information of one image in another, mutual information measure (MIM) is also significantly better which shows that proposed wavelet based fusion method (haar wavelet) and max filter technique preserves more information compared to other techniques. The other evaluation measures like root mean square error (RMSE) with lower value and peak signal to noise ratio (PSNR) with higher values are also comparatively better for DWT fusion approach. Finally entropy (E), the amount of information that can be used to characterize the input image also better for images obtained from DWT fusion technique.

V. CONCLUSION

The fusion of multimodal pixel level images have been computed using pixel based and wavelet based image fusion techniques and the corresponding results have been obtained. The quality evaluation parameters of these results are performed and compared each other and tabulated.

In pixel based image fusion technique, the fusion corresponding to the average filter gives blurring of image, the max filter gives better results compared to average filter and min filter result also better but some of the data is lost.

Among these three techniques, max filter images are better than other two techniques. The resolution, clarity, edge and texture details are better in max filter and next min filter later average filter is preferred.

Quality of the resultant images is obtained by various quality evaluation parameters and all these values are tabulated and compared. By the comparison it is observed that the wavelet based image fusion gives good quality images than pixel based image fusion methods

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