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Performance Comparison of various levels of fusion of Multi-focus image using Wavelet

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Abstract **- The objective of this paper is to provide novel hybrid architecture (algorithm) for wavelet Based image fusion combining the principles of frequency and region based rules to utilize the capabilities of image fusion at end user level. Frequency based rules operate on individual pixels in the image, but does not take into account some important details like edges, boundaries and salient features larger than a single pixel. Region based fusion may reduce the contrast in some images and does not always succeed in effectively removing ringing artifacts and noise in source images. The inadequacies of these two types of fusion rules point to the importance of developing a hybrid algorithm based architecture combining the advantages of both. A standalone executable has been developed for the targeted image fusion application using Matlab Compiler Runtime library.**

Keywords: **Hybrid Architecture; Wavelets based Image fusion; Frequency based rules; Region based rules.**

I.INTRODUCTION

With the rapid advancements in technology, it is now possible to obtain information from multisource images. However, all the physical and geometrical information required for detailed assessment might not be available by analyzing the images separately. In multisensory images, there is often a trade-off between spatial and spectral resolutions resulting in information loss. Image fusion combines perfectly registered images from multiple sources to produce a high quality fused image with spatial and spectral information [1]. It integrates complementary information from various modalities based on specific rules to give a better visual picture of a scenario, suitable for processing. An image can be represented either by its original spatial representation or in frequency domain. By Heisenberg's uncertainty, information cannot be compact in both spatial and frequency domains simultaneously. It motivates the use of wavelet transform which provides a multi-resolution solution based on time-scale analysis [2]. Each sub band is processed at a different resolution, capturing localized time-frequency data of image to provide unique directional information useful for image representation and feature extraction across different scales. Several approaches have been proposed for wavelet based image fusions which are either frequency or region based [3, 4]. In order to represent salient features more clearly and enrich the information content in multisensory fusion, region based methods involving segmentation and energy based fusion were introduced [6].

Other fusion methods are based on saliency measurement, local gradient and edge fusion. Frequency based algorithms concentrate on increasing image contrast where as region based algorithms provide edge enhancement and feature extraction [5]. A few attempts have been made to combine these algorithms in a single fused image. The integration of image fusion algorithms offers immense potential for future research as each rule emphasizes on different characteristics of the source image. This paper proposes novel hybrid architecture (algorithm) for wavelet Based image fusion combining the principles of frequency and region based rules. To utilize the capabilities of image fusion at end user level. A standalone executable has been developed for the targeted image fusion application using Matlab Compiler Runtime library.

II.LITERATURE REVIEW

A. Fusion:

The term fusion means in general an approach to extraction of information acquired in several domains. The goal of image fusion (IF) is to integrate complementary multisensor, multitemporal and/or multiview information in to one new image containing information the quality of which cannot be achieved otherwise. The term quality, its meaning and measurement depend on the particular application. Image fusion has been used in many application areas.

In remote sensing and in astronomy, multisensor Fusion is used to achieve high spatial and spectral resolutions by combining images from two sensors, one of which has high spatial resolution and the other one high spectral resolution. Numerous fusion applications have appeared in medical imaging like simultaneous evaluation of CT, MRI, and/or PET images. Plenty of Applications which use multisensor fusion of visible and infrared images have appeared in military, security, and surveillance areas.

B. Wavelet based image fusion:

Image fusion is the process of combining two or more source images into composite images with extended information Content [7].

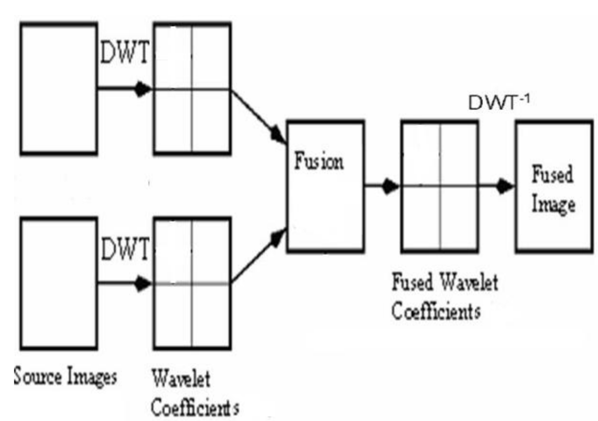

Fig 1: Fusion of the wavelet transforms of Two images

Fusion based levels are

(1) Frequency based Image fusion.
(2)Region based Image fusion.
(3) Hybrid based Image fusion.

C. Frequency based image fusion:

Frequency based algorithms concentrate on increasing image contrast where as region based algorithms provide edge enhancement and feature extraction

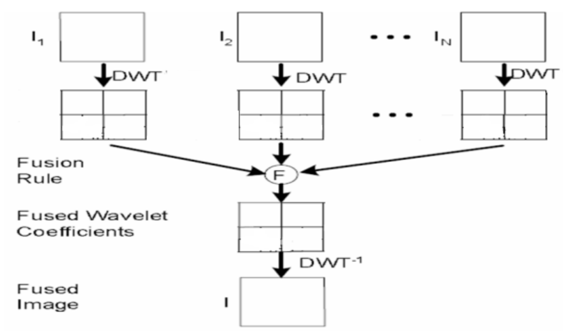

Fig 2: The Frequency-based image fusion scheme using the wavelet

D. Region based image fusion:

The proposed algorithm is using on discrete wavelet transform, normalized cut segmentation algorithm and high boost filtering approach which is describe brief in this section [8].

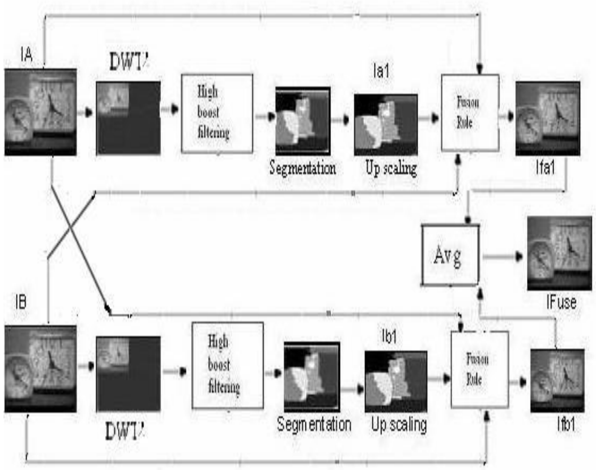

Fig 3: Block diagram of region based

E. Hybrid based image fusion:

A hybrid fusion method which integrates both frequency and region based rules in a single fused image. Frequency based rules operate on individual pixels in the image, but does not take into account some important details like edges, boundaries and salient features larger than a single pixel. Region based fusion may reduce the contrast in some images and does not always succeed in effectively removing ringing artifacts and noise in source images. The inadequacies of these two types of fusion rules point to the importance of developing a hybrid algorithm based architecture combining the advantages of both.

III.METHODOLOGY

A hybrid fusion method which integrates both frequency and region based rules in a single fused image. Frequency based rules operate on individual pixels in the image, but does not take into account some important details like edges, boundaries and salient features larger than a single pixel. Region based fusion may reduce the contrast in some images and does not always succeed in effectively removing ringing artifacts and noise in source images. The inadequacies of these two types of fusion rules point to the importance of developing a hybrid algorithm based architecture combining the advantages of both. Hybrid architecture in Fig.4 uses different rules for fusing low and high frequency sub images of wavelet decomposition.

A frequency based maximum selection algorithm is used for approximations while square and averaging filter masks are applied to detail coefficients. High pass square filter mask helps in enhancing the salient features and edges. Averaging filter mask

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removes noise by taking the mean of the gray values of the window surrounding the centre pixel. The key feature is the combination of advantages of frequency and region based fusion in a multiful images. This can help the development of sophisticated algorithms enhancing the edges and structural details.

A. Hybrid architecture:

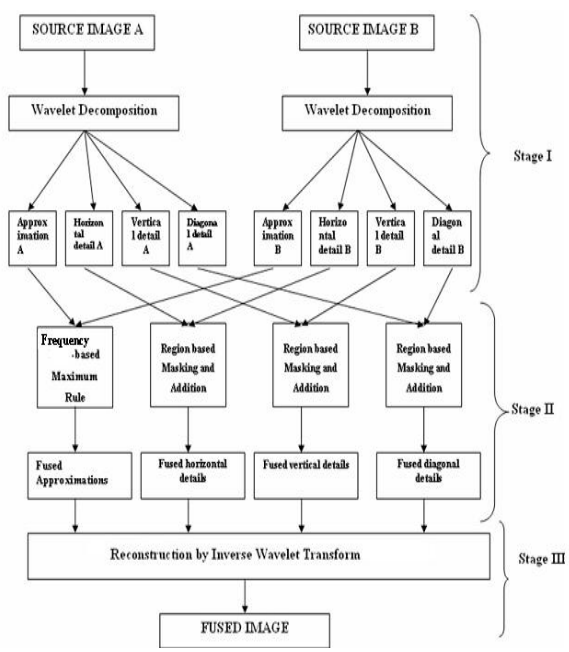

Fig 4: Mask based image fusion

The approximations are subjected to pixel based maximum selection rule. a (3X3) square mask and odd order rectangular averaging masks (5X7) are each applied to detail images. The new sets of coefficients from each source image are added to get new approximations and details. Final fused coefficient matrix is obtained by concatenation of new approximations and details.

B. Hybrid Algorithm:

The algorithm for hybrid fusion rule can be divided into three different stages with reference to above fig 4.

Stage I

Read the two source images A and B to be fused.

- Perform independent wavelet decomposition of the two images to get the approximation and detail coefficients.

Stage II

1) Select frequency based algorithm for approximations which involves fusion based on taking the maximum valued pixels fro approximations of source images A and B.

2) A binary decision map is formulated based on the maximum valued pixels between the approximations. The decision rule D (i, j) for fusion of approximation coefficients. In the two source images A and B is thus given by

$$D (I, J) = 1 \quad A (I, J) > B (I, J)$$
$$= 0, \text{otherwise}$$

3) A small window of size 3X3 (or) 5X7 is selected from the detail sub bands based on whether the type of filter mask used is square or rectangular.

4) Perform region level fusion of details by applying (3X3) square and (5X7) averaging filter mask to detail coefficients. The resultant coefficients are added from each sub band

LH = mask (LHA) +mask (LHB)

HL= mask (HLA) +mask (HLB)

HH=mask (HHA) +mask (HHB)

LH, LHA , LHB are vertical high frequency, HL, HLA, HLB are horizontal high frequencies, HH, HH, HH are diagonal high frequencies of the fused and input detail sub bands respectively.

Stage III

1) We obtain the final fused transform approximations through frequency rules and the vertical, horizontal and diagonal details by mask based fusion.

2) The new coefficient matrix is obtained by fused approximations and details.

3) Fused image is reconstructed using inverse wavelet transform and displayed.

The high pass square filter mask helps in enhancing the salient features and edges. Averaging filter mask removes noise by taking the mean of the gray values of the window surrounding the centre pixel.

IV.RESULT AND ANALYSIS

A. Performance evaluation:

The objective performance evaluation is done by taking Mean Square Error (MSE) and Peak Signal-to-Noise Ratio (PSNR) as given by (1) and (2) respectively.

$$MSE = \sum\sum [S(i, j) - F(i, j)]^2 / MXN \quad --- \quad (1)$$

$$PSNR = 10\log10(255^2/MSE) \quad ----- \quad (2)$$

Where **S** is the source image and **F** is the fused image. Table 2 consolidates the results obtained.Fig.4 shows that the hybrid fusion rule gives least values for MSE and the highest value of PSNR for all test cases. The 5X7 averaging filter mask gives a better performance with less noise when compared to a square mask, in all test cases as evident from Tables.

Source Image type	**Source images**	**File format**	**Size**
1. Clocks	Left side focused	JPEG	249X249
	Right side focused	JPEG	249X24
2. Brain	C T Scan	JPEG	258X247
	MRI Scan	JPEG	258X247
1. My images	Left side focused	JPEG	250x252
	Right side focused	JPEG	250x252

Table 1: The Source Images used for Fusion Experiments

Source Images	**Fusion rules**	**MSE**	**PSNR in decibels**
Clocks	Frequency	1.9964e-007	105.1506
	Region	1.9862e-006	105.1606
	Hybrid	1.7884e-007	**125.6861**
Brains	Frequency	5.7118e-008	101.7982
	Region	5.0932e-007	108.5436
	Hybrid	4.7118e-008	**120.7982**
My images	Frequency	1.0064e-007	108.1029
	Region	1.5018e-006	116.3646
	Hybrid	0.5472e-007	**120.6901**

Table 2: Comparison between FREQUENCY, REGION and HYBRID fusion rule based on MSE and PSNR

B. Results:

Image A

Image B

Hybrid based C

Region based D

Frequency based E

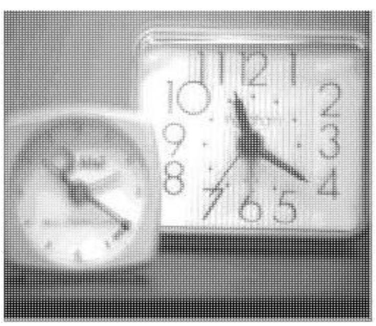

Fig 5: (A) Source image1: Focus on large clock (B) Source image 2: Focus on small clock. (A) and (B) are fused using pixel based maximum selection rule to give the fused image in (E), energy based rule to give the fused image in (D) while (C) give the fused images for hybrid rule using 5X7 averaging filter masks respectively

V. CONCLUSIONS

The work done in this project forms the basis for further research in wavelet based fusion and other methods which integrate the fusion algorithms in a single image. Studies about the type of source image noises will have for developing intelligent image fusion techniques capable of choosing the best rule depending on the type of degradation models used in images. The hybrid architecture presented here gives promising results in all test cases when compared to the frequency and region. And can be further extended to all types of images by using different averaging, high-pass and low-pass filter masks.

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