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Implementation of Image Fusion Technique Using Wavelet Transform.

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Abstract— **Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images. There are several approaches by which image fusion can be achieved. For this purpose, the images are transformed either in spatial or another domain and then images are fused. Among all, Wavelet Transform is the best approach . For such method, selection of wavelet as well as fusion rule is an important task. In this paper, 54 types of wavelet, 9 fused rules are analyzed and compared for the fusion of multiple images. The fused image produces better quality as well as similarity towards the individual images.**

Keywords: Image fusion, DWT, Fusion Rules. Similarity Measure.

I. INTRODUCTION

Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images. Image fusion combines perfectly registered images from multiple sources to produce a high quality fused image with spatial and spectral information [1].

Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images. The fusion of images is often required for images acquired from different instrument modalities or capture techniques of the same scene or objects. Important applications of the fusion of images include medical imaging, microscopic imaging, remote sensing, computer vision, and robotics. Fusion techniques include the simplest method of pixel averaging to more complicated methods such as principal component analysis and wavelet transform fusion. Several approaches to image fusion can be distinguished, depending on whether the images are fused in the spatial domain or they are transformed into another domain, and their transforms fused. The actual fusion process can take place at different levels of information representation [2]. A generic categorization is to consider the different levels as, sorted in ascending order of abstraction: signal, pixel, feature and decision level[3]. A Pixel-based fusion is performed on a pixel-by-pixel basis. It generates a fused image in which information associated with each pixel is determined from a set of pixels in source images to improve the performance of image processing tasks such as segmentation. Feature-based fusion at feature level requires an extraction of objects recognized in the various data sources. It requires the extraction of salient features which are depending on their environment such as pixel intensities, edges or textures. Decision-level fusion consists of merging information at a higher level of abstraction, combines the results from multiple algorithms to yield a final fused decision. Input images are processed individually for information extraction. The obtained information is then combined by applying decision rules.

There are two important questions in image fusion field: selection of wavelet name and fusion rule when wavelet transform is applied to multi-focus image fusion. Fusion rule is the kernel of image fusion and it directly influences the speed and quality of image fusion. So, this paper not only study these two questions, but also involve the important part of image fusion rule, fusion operator and conduct fusion experiments on these aspects. Since multiple evaluation criteria of image fusion exist, this paper mainly compares the fusion effect through the Similitude Measure so as to select the best wavelet basis function, the best fusion rule.

Preprocessing of image Fusion.

Two images taken in different angles of scene sometimes cause distortion. Most of objects are the same but the shapes change a little. At the beginning of fusing images, image registration make sure that each pixel at correlated images has the connection between images in order to fix the problem of distortion image[3] . Two images having same scene can register together using software to connect several control points. After registration, resampling is done to adjust each image that about to fuse to the same dimension. After resampling, each image will be of the same size. Images with the same size will be easy for fusing process. Inverse transfer is necessary if image has been transferred into another domain. Figure 1 summarizes these steps called, preprocessing of image fusion.

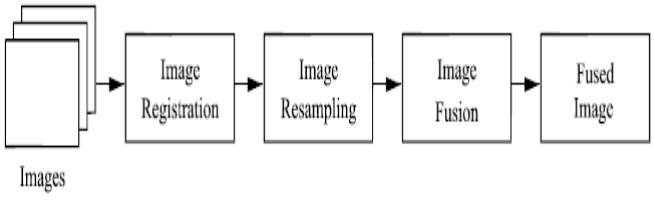

Figure 1. Preprocessing of Image Fusion

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II. WAVELET BASED IMAGE FUSION

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There are various methods that have been developed to perform image fusion. Some well-known image fusion methods are listed below [3]:- (1) Intensity-hue-saturation (IHS) transform based fusion (2) Principal component analysis (PCA) based fusion (3) Multi scale transform based fusion:- (a) High-pass filtering method (b) Pyramid method:-(i) Gaussian pyramid (ii) Laplacian Pyramid (iii) Gradient pyramid (iv) Morphological pyramid (v) Ratio of low pass pyramid (c) Wavelet transforms:- (i) Discrete wavelet transforms (DWT) (ii) Stationary wavelet transforms (iii) Multi-wavelet transforms. The most common form of transform image fusion is wavelet transform fusion. Wavelet transform is a mathematical tool developed originally in the field of signal processing. It can also be applied to fuse image data following the concept of the multi-resolution analysis (MRA) [4]. The multi-resolution wavelet transform is an intermediate representation between Fourier and spatial representations; it can provide good localization properties in both spatial and Fourier domains. In common with all transform domain fusion techniques the transformed images are combined in the transform domain using a defined fusion rule then transformed back to the spatial domain to give the resulting fused image. Wavelet transform fusion is more formally defined by considering the wavelet transforms ω of the two registered input images $I_1(x, y)$ and $I_2(x, y)$ together with the fusion rule φ. Then, the inverse wavelet transform ω^{-1} is computed, and the fused image $I(x, y)$ is reconstructed

$$I(x, y) = \omega^{-1}(\varphi(\omega(I_1(x, y)), \omega(I_2(x, y)))). \qquad (1)$$

The process is depicted in Figure2

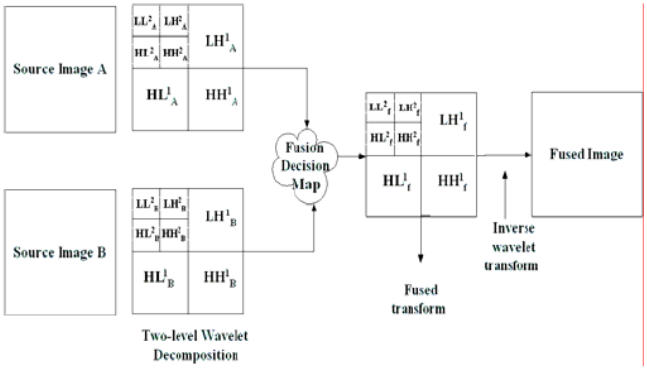

Figure 2: Fusion of two images using wavelet transform

A 2-D Discrete Wavelet Transform of an image yields four components: approximation coefficients, horizontal coefficients, vertical coefficients and diagonal coefficients[5]. The approximation image and detail images derived from decomposition are usually organized as shown in Figure 3. The image S_j corresponds to the lowest frequencies, W_j gives the vertical high frequencies (horizontal edges), W_j^2 gives the horizontal high.The image S_j corresponds to the lowest frequencies, W_j gives the vertical high frequencies (horizontal edges), $W_j{}^2$ gives the horizontal high frequencies (vertical edges), and $W_j{}^3$ is the high frequencies in both directions (diagonal).

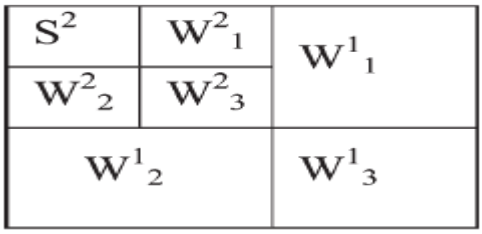

Figure 3 : The disposition of the approximation and detail coefficeient.

The principle of image fusion using wavelets is to merge the wavelet decompositions of the two original images using fusion methods applied to approximations coefficients and details coefficients. The low-frequency content is the most important part in the image. It gives the image its maximum energy or information. The high-frequency content, on the other hand, imparts flavor or nuance. In wavelet analysis, the approximations are the high-scale, low-frequency components of the signal. The details are the low-scale, high-frequency components.

Image fusion rule

The image fusion techniques mainly perform a very basic operation like pixel selection, addition, subtraction or averaging. These methods are not always effective but are at times critical based on the kind of image under consideration [2]. The image fusion techniques studied and developed as part of the project.

Average Method

Here, the resultant image is obtained by averaging every corresponding pixel in the input images.

Select Maximum/Minimum Method

A selection process if performed here wherein, for every corresponding pixels in the input images, the pixel with maximum/minimum intensity is selected, respectively, and is put in as the resultant pixel of the fused image.

The wavelet-based image fusion methods can be performed in two ways [5] replacement and selection method. Figure 4 gives the general flow diagram for Selection method.

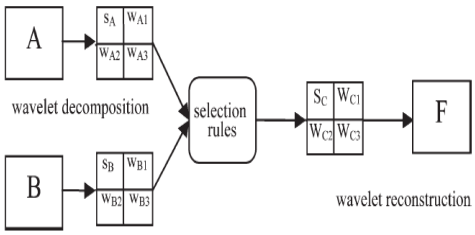

Figure 4: General flow diagram for replacing wavelet based image fusion.

III. THE EVOLUTION OF IMAGE FUSION

There are so many evolution techniques are used. We mainly compare the effect of image fusion through similarity measures (SM) to find out the best fusion effect and then best fusion method.(wavelet basic function, fusion rule) will be found.

Similarity Measures (SM)

Similarity Measures is the correlation of the fused images[1]. These measure provide a quantitative measure of the degree of match between two images, or image patches. Image similarity measures play an important role in many image fusion algorithms and applications including retrieval, classification, change detection, quality evaluation and registration.

$$SM = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} F(i,j) \cdot R(i,j)}{\sum_{i=1}^{M}\sum_{j=1}^{N} [F(i,j)^2 + R(i,j)^2]} \qquad (2)$$

Where, M, N indicate the size of the image is M×N, *F(i,j)*, *R(i,j)* indicate the gray value of the pixel which is in the row i and in the column j of the image. The more close SM is to 1, the fusion effect is better.

IV. RESULT AND DISSCUSSION

The function wfusimg() outputs the fused image according to the parameters input, which are image 1, image 2, the name of the wavelet basis function, decomposing level, fusion operator. 54 kinds of wavelet basis functions and 9 kinds of fusion operators, which are showed in Table 1, are tested and compared in this experiment.

54 kinds wavelet
Haar, db1, db2, db3, db4, db5, db6, db7, db8, db9, db10, sym2, sym3, sym4 sym5, sym6, sym7, sym8, coif1, coif2, coif3, coif4, coif5, bior1.1, bior1.3, bior1.5, bior2.2, bior2.4, bior2.6, bior2.8, bior3.1, bior3.3, bior3.5, bior3.7, bior3.9, bior4.4, bior5.5, bior6.8, rbio1.1, rbio1.3, rbio1.5, rbio2.2, rbio2.4, rbio2.6, rbio2.8, rbio3.1, rbio3.3, rbio3.5, rbio3, rbio3.9, rbio4.4, rbio5.5, rbio6.8, dmey
9 kinds of Operator
Max-max, max-mean, max-min mean-max, mean-mean, mean-min min-max min—mean, min-min

Figure 5 shows the image 1 and image 3 which are to be fused with best similarity measures which is near to 1.

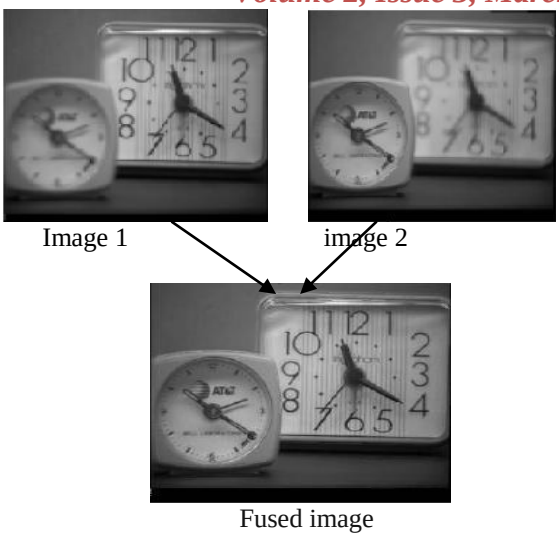

Figure 5 Result Of Image Fusion

V. CONCLUSION

For the image fusion, we have compared 486 kinds of wavelet based fusion methods with 54 wavelet basic function and 9 operators, and the use of Similarity Measure (SM) as an image fusion evaluation criteria, it reflects the image fusion results. Finally we summarized the best wavelet as Haar, the and the best fusion operator as Mean-Max . The fused images we got were nearly identical to the ideal images since the similarity measures of them were all more than 0.999. It is much more precise.

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