Implementation of Land-sat Image Fusion FPGA based Hardware Using Wavelet Transform
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Abstract: Image fusion is the fusion process of combining two or more images into a single image by considering the important features from each real image. Lot of approaches was there to achieve Image fusion. The images are transformed in the spatial or another domain so that images are fused. Therefore Wavelet Transform is the best method. There are 54 wavelet types, 9 rules of fused are compared and analyzed in multiple image fusion process. The fused image produces better quality equal to the separate images. Similarity Measures is the correlation of the fused images. These measures provide a quantitative measure of the degree of match between two images or image patches. Image similarity measures play an important role in applications including retrieval, change detection, classification, registration and quality evaluation and many image fusion algorithms. DWT can be interpreted as signal decomposition in a spatially oriented frequency channel. The signal S passed through two complementary filters and emerges as two signals, Details and approximation. This is called as analysis or decomposition.

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

I. INTRODUCTION

Image fusion is the process of combining two or more images into a single image by considering the important features from each real image. It combines registered images from multiple sources to produce a high quality fused image, with spatial and spectral information [1].

The image fusion can be required for images acquired from different instrument capture techniques of the same objects. The important applications of fusions of images are included in medical imaging, remote sensing, computer vision, microscopic imaging and robotics. Fusion techniques contains the simplest method of pixel averaging to more complicated methods such as wavelet transform and principal component analysis. Image fusion can be distinguished in several approaches, depending on the images are fused in the spatial domain or they are transformed into another domain, and then they transforms fused. The normal fusion process can take place at different levels of information representation [2]. A Pixel-based fusion is performed on a pixel-by-pixel basis. This fusion 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, on feature levels require an extraction of objects recognized in different data sources. This fusion requires the extraction of the salient features which are depending on their environment such as edges, pixel intensities or textures. Decision-level fusion consists of connecting information at a higher level of abstraction, multiple algorithms to a last fused decision results are combines there. Input images are processed separately for information extraction. The applying decision rules are combined the obtained information.

Two main questions in image fusion field: selection of fusion rule and wavelet name, when wavelet transform is applied to the multiple focus image fusion. Fusion rule is the kernel of image fusion field. It directly influences the image fusion speed and quality. So this paper not only studies these questions, but also involves the important part of fusion operator, image fusion rule and conduct fusion experiments. Since multiple evaluation criteria of image fusion exist, mainly compares the fusion effect through the Similitude Measure so as to select the wavelet basis function and the fusion rule.
A. Image Fusion Processing

Two images are taken at different angles, cause distortion in processing of image fusion. A lot of objects are the same, but the shapes change a little. At the beginning of the 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]. These two images having same scene can register together using software to connect many control points. After registration the resampling is done to adjust each image that about to fuse to the same dimensions. Each image will be of the same size after resampling. The same size images will be easy for fusing process. Inverse transfer is necessary if the image has been transferred into another domain.

II. WAVELET BASED IMAGE FUSION

Image fusion has been developed by various methods. Some best image fusion methods [3]: (1) Principal component analysis (PCA) based fusion , (2) Intensity-hue-saturation (IHS) transform based fusion , (3) Multi scale transform based fusion: (a) High pass filtering, (b) Wavelet transforms: (i) Multi wavelet transforms, (ii) Discrete wavelet transforms (DWT), (iii) Stationary wavelet transforms. (c) Pyramid method: (i) Gradient pyramid, (ii) Gaussian pyramid, (iii) Palladian Pyramid, (iv) Ratio of low pass pyramid, (v) Morphological pyramid. The wavelet transform fusion is the most common form of the transform image fusion. The wavelet transform is a mathematical tool developed real in the signal processing field. It can 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 spatial and Fourier representations. It can provide best localization properties in both Fourier and spatial domains.

![Figure 1. Image Fusion Processing](image1)

![Figure 2. Wavelet transforms using to Fusion of two images](image2)
In common with all transform domain fusion techniques the transformed images are combined using defined fusion rule in the transform domain, and then transformed back to the spatial domain to give the fused image result. Wavelet transform fusion is more formally defined by considering the wavelet transforms $\omega$ of the two registered input images $I_1(x, y)$ and $I_2(x, y)$ together with the fusion rule $\varphi$. So the inverse wavelet transform $\omega^{-1}$ is computed, and then the fused image reconstructed in $I(x, y)$

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

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

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

A. Image fusion rule

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

B. Average Method

The resultant image is produced by averaging every consistent pixel in the input images.

C. Select Maximum/Minimum Method

A selection process can be performed here wherein, for every consist pixels in the input images. That corresponding pixel with maximum/minimum intensity selected and put as the resultant pixel of the fused image.
The wavelet based image fusion methods can be performed in two ways [5]. One is selection method and another one is replacement method. General flow diagram for Selection method is below figure.

**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 the best fusion method. (Wavelet basic function, fusion rule) will be found.

**A. Similarity Measures (SM)**

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

\[
SM = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} F(i, j) + R(i, j)}{\sum_{i=1}^{M} \sum_{j=1}^{N} [F(i, j)^2 + R(i, j)^2]} \tag{3}
\]

Where, M, N indicates the size of the image is MxN, 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. When the fusion effect is better, the SM is closer to 1.

**IV. RESULT AND DISCUSSION**

The function `wfusimg()` [wavelets(w) fusion(fus) image(img)] outputs the fused image according to the parameter input, which are two images `image1`, `image2`, the name of the wavelet basis function, decomposing level, fusion operator.

Below table shows the 54 kinds of wavelet basis functions and 9 kinds of fusion operators, which are compared and tested in this experiment.

<table>
<thead>
<tr>
<th>54 KINDS WAVELET</th>
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<tr>
<td>Haar, db1, db2, db3, db 4, db5, db6, db7, db8, db9, db10, sym2, sym3, sym4 sym5, sym6, sym7, sym8, 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</td>
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<tr>
<th>9 kinds of Operator</th>
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<tr>
<td>Max-max, max-min, max-mean, mean-max, mean-mean, mean-min min-max min-mean, min-min</td>
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Table 1. The image 1 and image 3 which are to be fused with best similarity measures
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; it also reflects the image fusion results. Finally we summarized the best wavelet as Haar, and the best fusion operator as Mean Max. The fused images, we got to be identical to that two images. Since them similarity measures range more than 0.999. It is much more precise. Land-sat is a high resolution satellite provided standardized orthorectified form. Finally fused image are dumped into cyclone FPGA board.

VI. REFERENCES