

# Wavelet Transform based Reconstruction of Image from Multi-Scenes

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## ABSTRACT

Image Fusion, a technique which combines complimentary information from different images of the same scene so that the fused image is more suitable for segmentation, feature extraction, object recognition and Human Visual System. In the proposed thesis work, a fast and efficient algorithm based on wavelet transform for multi-sensor image data has been proposed that could retrieve the prime features from the multi-sensor data image. The proposed paper work is aimed to develop a fast and efficient algorithm for multi-sensor image fusion based on wavelet transform. The images from multi-sensor sources after fusion gives more identifiable information rather than a single image from single source. The purpose of image fusion is to provide information integrated from different images, to eliminate redundancy and contradiction existed between the information, to form a clear and accurate description for the observed target, to enhance the transparency of the image information, and to improve the interpretation accuracy, reliability, and utilization of the information.

## I. INTRODUCTION

Recent developments in satellite and sensor technologies have provided high-resolution satellite images. Image fusion techniques can improve the quality, and increase the application of these data. Image fusion technology is the synthesis process to obtain one image from multiple images of the same scene collected from multiple channels or at different times with certain algorithms. The purpose of image fusion is to provide information integrated from different images, to eliminate redundancy and contradiction existed between the information, to form a clear and accurate description for the observed target, to enhance the transparency of the image information, and to improve the interpretation accuracy, reliability, and utilization of the information. Wavelet transform is the local transformation from time and frequency domain, with zoom and pan features similar to a mathematical microscope, can easily generate a variety of different resolution images, and has been widely used in image processing.

## II. BRIEF LITERATURE SURVEY

With 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 [1]. Image fusion combines perfectly registered images from multiple sources to produce a high quality fused image with spatial and spectral information. 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 [2]. It motivates the use of wavelet transform which provides a multi-resolution solution based on time-scale analysis. Each subband 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 [3]. Several approaches have been proposed for wavelet based image fusion which are either pixel [4], [5] or region [6]. 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 [8], [9]. Other fusion methods are based on saliency measurement, local gradient and edge fusion [1], [7], [10].

## III. WAVELET BASED IMAGE FUSION

Image fusion is the process that combines information from multiple images of the same scene. These images may be captured from different sensors, acquired at different times, or having different spatial and spectral characteristics. The object of the image fusion is to retain the most desirable characteristics of each image. With the availability of multi-sensor data in many fields, image fusion has been receiving increasing attention in the researches for a wide spectrum of applications. 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 two images must be of the same size and are supposed to be associated with indexed images on a common color map. Multi-sensor data fusion can be performed at four different processing levels, according to the stage at which the fusion takes place: signal level, pixel level, feature level, and decision level.

In signal-based fusion, signals from different sensors are combined to create a new signal with a better signal-to noise ratio than the original signals. 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 applying decision rules to reinforce common interpretation.

#### IV. IMAGE REGISTRATION

In image fusion, it is essential that the image information from all the constituent images be adequately aligned and registered prior to combining the images, ensuring that the information from each sensor is referring to the same physical structures in the environment. This is an important point in image fusion, as a misalignment produces severe edge artifacts in the combined images. This is particularly significant in images where the edges are abundant.

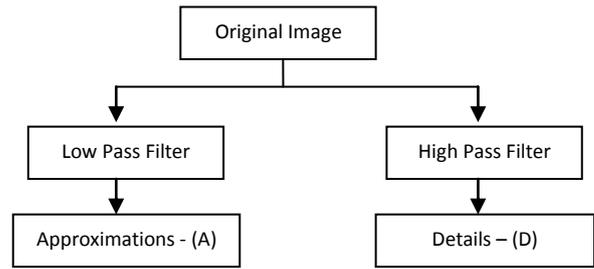
#### V. IMAGE RE-SAMPLING

As required by the wavelet transform, the coefficients must be merged or superimposed when the images are in the same scale. This means that the images must be re-scaled when their scales do not match. For example, one of the first steps for registration SPECT with MRI or CT images is to expand the  $64 \times 64$  SPECT image to the  $256 \times 256$  or even to  $512 \times 512$  matrix, the usual size of the MRI or CT images, respectively. This is carried out by a well-known interpolation technique (nearest neighbor, bilinear, bicubic, etc.).

The main idea behind the wavelet approach is to extract the signals or information from an image at multi-resolution levels. Some information from an image is not visible at one particular resolution, may be prominent at some other different resolution. In general, the problem that image fusion tries to solve is to combine information from several images (sensors) taken from the same scene in order to achieve a new fused image, which contains the best information coming from the original images. Hence, the fused image has better quality than any of the original images.

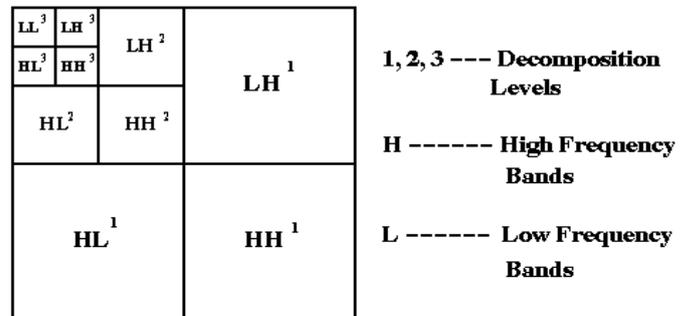
#### VI. ALGORITHM

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 is what gives the image its maximum energy or information. The high-frequency content, on the other hand, imparts flavor or nuance. In wavelet analysis, we often speak of approximations and details. The approximations are the high-scale, low-frequency components of the signal. The details are the low-scale, high-frequency components. This filtering process looks like as below:



The original image passes through two complementary filters and emerges as two signals Approximations (A) and Details (D). Since the analysis process is iterative, in theory it can be continued indefinitely. In reality, the decomposition can proceed only until the individual details consist of a single sample or pixel.

The following figures show the structures of 2-D DWT with 3 decomposition levels:



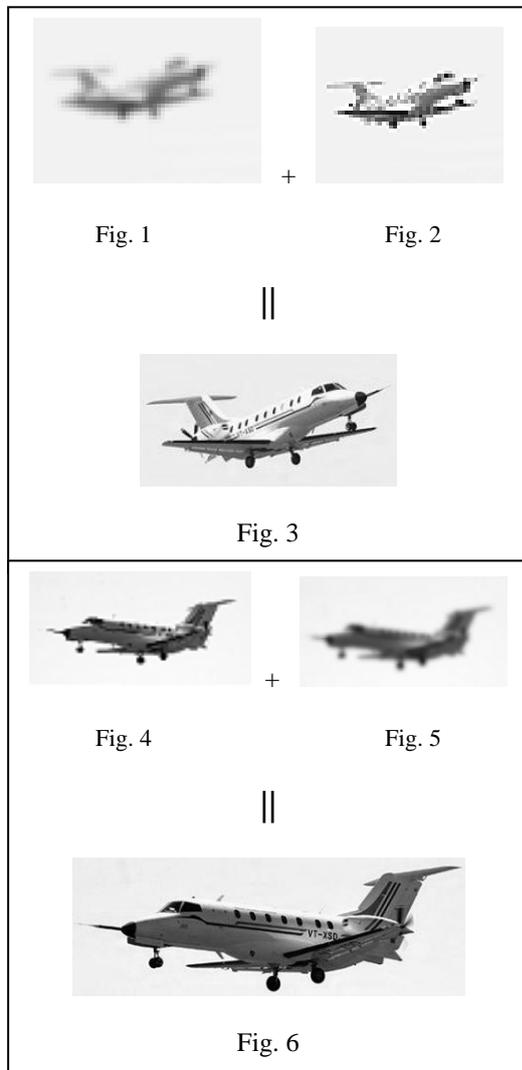
After one level of decomposition, there will be four frequency bands, namely Low-Low (LL), Low-High (LH), High-Low (HL) and High-High (HH). The next level decomposition is just apply to the LL band of the current decomposition stage, which forms a recursive decomposition procedure. Thus, an N-level decomposition will finally have  $3N+1$  different frequency bands, which include  $3N$  high frequency bands and just one LL frequency band. The 2-D DWT will have a pyramid structure shown in the above figure. The frequency bands in higher decomposition levels will have smaller size.

#### VII. STEPS IN ALGORITHM

1. Load images
2. Load the two original images: two aero-plane images A1 and A2.  
load A1;  
load A2;
3. Perform decompositions at different levels.
4. Merge the two images from wavelet decompositions at level 5 using db2 by taking two different fusion methods: fusion by taking the mean for both approximations and details.  
`XFUSmean=wfusing(X1,X2,'db2','5','mean','mean')`
5. Restore images from their decompositions
6. Save image after fusion.

## VIII. RESULTS

Pairs of Fig 1, 2 and 3, 4 are the images at different resolution. However, the fig. in 3 and 6 shows the results of the wavelet based image fusion algorithm.



## Conclusion

Multi-sensor image fusion seeks to combine information from different images to obtain more inferences than can be derived from a single sensor. It is widely recognized as an efficient tool for improving overall performance in image based application. The spectral quality of the images is preserved better than using the other approaches. The reason that we can find more spatial detail from the fused composite images is that many mixed pixels in the original composite image are decomposed into many different categories in a fused image with the improvement of the spatial resolution. The work done in this paper forms the basis for further research in wavelet based fusion and other methods which integrate the fusion algorithms in a single image. The novel hybrid architecture presented here gives promising results in all test cases 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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