Satellite Image Fusion using Wavelet Transform

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Abstract - *In this project we applied implementation and evaluation of wavelet transformation based image fusion. Discrete wavelet transformation is presented concisely to facility the understanding of the wavelet based image fusion method. To best retain the quality of the input images, the strategy that minimizes the necessary resampling operations to limit potential image quality deterioration. In the proposed fusion approach, the wavelet coefficients for the fused images are selected based on the suggested maximum magnitude criterion. To evaluate the outcome images, other popular fusion methods including principal component transformation, Brovey and IHS transformation , DCT approaches are applied to the same images and the results are compared to the ones from the wavelet based approach. Fusion results are evaluated both visually and numerically. A quality matrix is calculated based on the correlation coefficients between the fused image and the original image. It is shown that this quality measure can indicate the information content of the fused image comparing to the input panchromatic and multispectral images. Our results clearly suggest that the wavelet based fusion can yield superior properties to other existing methods in terms of both spatial and spectral resolutions, and their visual appearance.*

1. INTRODUCTION

Image fusion is a process in which two or more images are combine to form a single image. The main objective of the image fusion is to preserve maximum spectral information from the original input image with increasing the spatial resolution. The fused image should contain all the spatial and spectral information instead of artifacts in it because artifacts damages the quality of the fused image. There are three levels of fusion techniques. They are pixel level representation, feature level representation and decision level representation. Image fusion techniques is used widely in medical ranging, military, computer vision, robotic industry and remote sensing field. Our project is related to remote sensing satellite image fusion.

Hence our project is based on fusion of satellite images,we are mainly focusing on Remote sensing area. Remote sensing is a process in which we will get essential information about objects or areas from a distance through satellites using sensors. Remote sensing is having wide applications in map providing for geographic references, spectral analysis based extraction of mineral deposits, assessing buildings and peoples during natural calamity, agriculture mapping and surveys, during wars in military etc.

In Remote sensing, when sensor becomes sensitive to huge amount of light bands panchromatic image is created which is having high spatial resolution but low spectral information. This images has very wide signal range. When image produced by the multispectral sensors within the specific spectral bands which gives red, blue, green and infrared images, the image is said to be multispectral image. It accepts the signals in various narrow band separately. It contains high spectral resolution information but with low spatial resolution information. The panchromatic images have very high signal compared to multispectral bands which enables us to see a smaller portion of the area. Hence when we merge both images together we will get high spatial and high spectral resolution which gives fine information.

There are many methods used for image fusion namely pixel based, Intensity Hue Saturation(IHS) based, Principal Component Analysis etc .But they are resulted in poor spectral information. Later the improved method is introduced with multiresolution analysis with several decomposition theme based on Discrete wavelet transform.

WAVELET TRANSFORM:

Wavelet transform tell us which frequency is present in our signal and also gives the information about changing in time. It holds good for non stationary signals also. It gives good frequency resolution for low frequency components which are basically average density value of the image and high temporal resolution for high frequency components which are edges of the images. Wavelet transform is starts with mother wavelet namely "Haar", "Daubechies" , "Morlet" etc. The signals are translated into these mother wavelets with shifted and scaled version.

Wavelet transform is used to divide the information of the image into approximation sub signal and detailed sub signal. The approximation subsignal gives the general trend of sub signal values and detail sub signals includes detail of the images in horizontal, vertical and diagonal. In the image fusion, if both input images pixel sizes are then resampling is not required. If pixel size of the input images does not satisfies the 2^n multiplier relationship resampling is required. After that wavelet coefficients of two images are fused iThis document is template. We ask that authors follow some simple guidelines. In essence, we ask you to make your paper look exactly like this document. The easiest way to do this is simply to download the template, and replace(copypaste) the content with your own material. Number the reference items consecutively in square brackets (e.g. [1]). However the authors name can be used along with the reference number in the running text. The order of reference in the running text should match with the list of references at the end of the paper.

2. PROJECT IMPLEMENTATION:

Fusion algorithm of Wavelet transform:

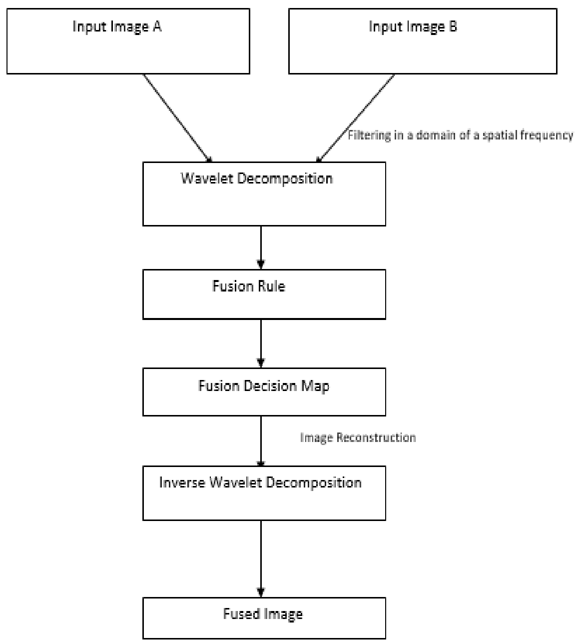


Figure 1 Fusion Algorithm

1. Insertion of the images:
   The input images are taken in order to undergo the image fusion.

2. Wavelet decomposition:
   Wavelet decomposition results in the feature extraction of the images where we can get approximation signal and details of the signal in vertical, horizontal and diagonal way.It is performed by filtering the domain of spatial frequency .It can be achieved by convolution method with appropriate kernal.Kernal is used for image blurring, sharpening and edge detection etc. Filtering in the domain of the spatial frequency helps in removing of noises in the signal.

3. Fusion Rules:
   The wavelet cofficient values obtained from one of the input image is compared with values of other image in terms of both time and frequency .

4. 4.Fusion Decision Map:
   Fusion decision map involves in merging or combining information at higher level after the each coefficients values are classified individually.

5. 5.Inverse wavelet decomposition:
   It helps to preserve the informations taken from the combined cofficients. Hence it helps in Image reconstruction which preserves the image quality.

Then fusion of the images are takes place.

3. BLOCK DIAGRAM:

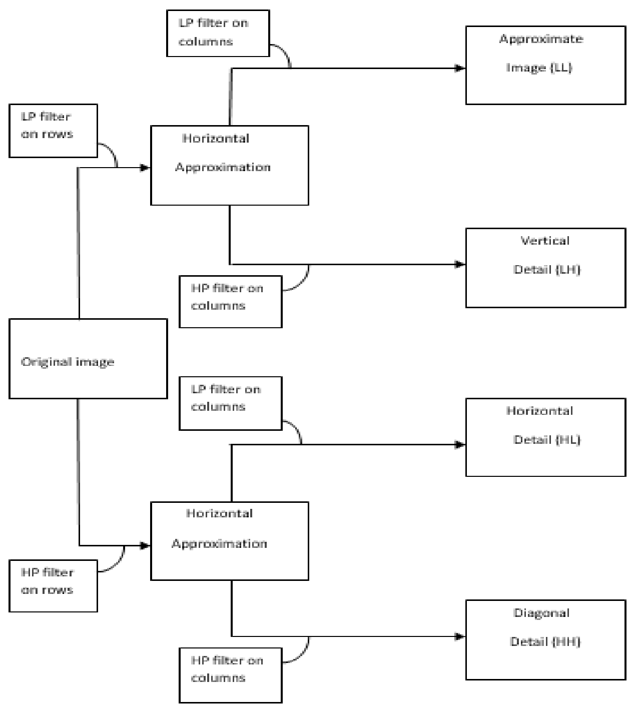


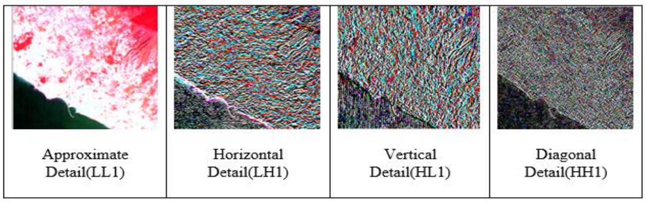
Figure 2 Block Diagram

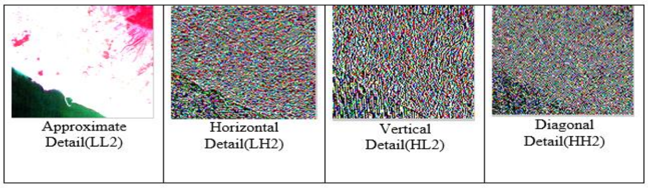
We have to apply low pass filter and high pass filter to the both of the dimensions i.e along Rows and Columns. When we apply the low pass filter, it gives horizontal approximation values and also preserves low frequency components. When we apply high pass filter, we will get the horizontal details with preserving high frequency components. When we again apply low pass filter and high pass filter to Horizontal approximation we will get Approximate Image (LL) component and Vertical Detail (LH) component of the image respectively. Similarly applying on Horizontal Detail gives Horizontal Detail(HL) and Diagonal Detail(HH) components of the image. If these details are small it can be set to zero without any change in the image. Hence filtering and compression of the image can be achieved using wavelet transform.

When signal is decomposed into a two parts namely detailed part(high frequency) and approximation part(low frequency). The subsignal produced from low filter will have highest frequency which is equal to the half of the original. Hence according to Nyquist Sampling theorem this change in the frequency range means that only half of original samples need to be kept in order to perfectly reconstruct the signal.

By applying low pass filter and high pass filter image is subsampled by 2 .The resultant is again subsampled by 2 by applying low pass filter and high pass filter in column wise. This subsampling results in four images called Approximate detail LL) of image, Vertical Detail (LH) of image, Horizontal detail (HL) of image and Diagonal detail (HH) of image.

To reconstruct the image, we have to again follow the sampling of image in reverse order. The image is reproduced by the upsampling in columns and rows. The resultant approximate image is equal to the original image.





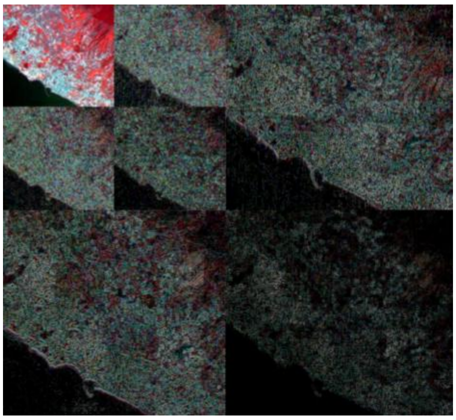


Figure 3 Wavelet decomposition of Image

4. DISCRETE WAVELET TRANSFORM BASED PRINCIPLE COMPONENT AVERAGING FUSION:

In this method the LL, LH, HL and HH coefficients are processed to evaluate a principal components. Let us consider the X1 and X2 are the approximate coefficients of two source images. These elements from the source images are expressed in the column vector V. These undergoes the decompositions in discrete wavelet transform in which covariance between two vectors , mean of the pixels and normalized components m1 and m2 are obtained identified.

Average of the m1 and m2 constitute weights are fused with the elements of the source image.

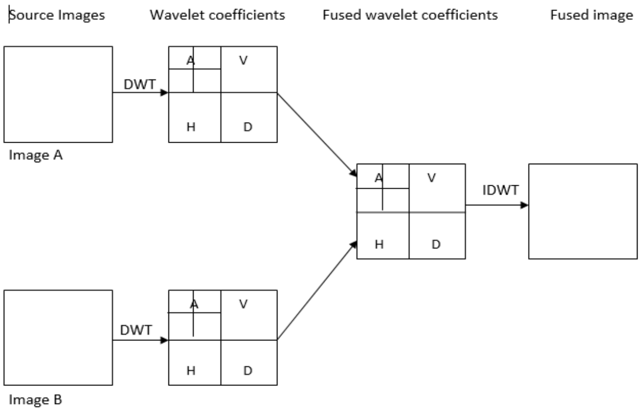


Figure 4 Wavelet Fusion Process

Formula used:

covariance between two vectors

$$Cov(x_j^1, x_j^2)=E[(x_j^1 - \mu_{x_j}^1)(x_j^2 - \mu_{x_j}^2)]$$

Mean of all pixels

$$\mu_{x_j}^1 = \left(\frac{1}{k}\right) \sum x_j^1$$

$$\mu_{x_j}^2 = \left(\frac{1}{k}\right) \sum x_j^2$$

Normalized components m1 and m2

$$m_1 LL_n^{1,2} = \frac{V(1,1)}{V(1,1)+V(2,1)} \quad m_1 LL_n^{1,2} = \frac{V(1,2)}{V(1,2)+V(2,2)}$$

$$m_2 LL_n^{1,2} = \frac{V(2,1)}{V(1,1)+V(2,1)} \quad m_2 LL_n^{1,2} = \frac{V(2,2)}{V(1,2)+V(2,2)}$$

Mean of m1 and m2:

$$m_{1(av)} = \frac{m_1 LL_n^{1,2} + m_1 LH_n^{1,2} + m_1 HL_n^{1,2} + m_1 HH_n^{1,2}}{N}$$

$$m_{2(av)} = \frac{m_2 LL_n^{1,2} + m_2 LH_n^{1,2} + m_2 HL_n^{1,2} + m_2 HH_n^{1,2}}{N}$$

Fused image(z)= $m_{1(av)}$ *IM1+ $m_{2(av)}$ *IM2

Fusion Algorithm:

1)Evaluating DWT of source images IM1 and IM2 with one or two decomposition levels and applying db3 wavelets.

2)Applying principal component analysis for approximate coefficient and detailed coefficient of images.

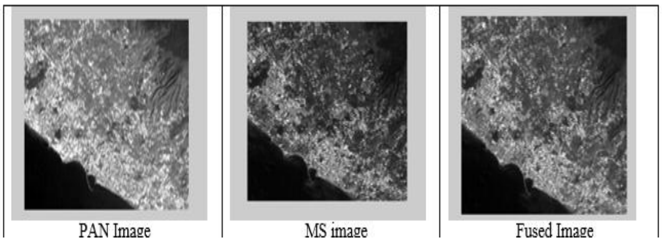
3)Finding principal components of coefficients of source images.

4)Evaluate average of m_1 and m_2.

5)Apply PCA fusion to source images using average of principal components.

6)Evaluate the performance measurements for the proposed and existing algorithm.

5. RESULT:



6. CONCLUSION

This paper proposes fusion method by the weightage of representation of multiscale into simple PCA fusion method using DWT. This fusion is carried in spatial domain and PCA fusion holds the advantage of weighed intregration of information of image.

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