A Review on: Image Fusion using Wavelet Transform

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***Abstract*— Recently digital image processing has wide areas of application. One of the most important applications of image processing is in image fusion. Image fusion is a technique which is used for combining relevant information from two or more images into a single image. This fused image contains more information than any of the two input images. The fused image can have complimentary spatial and spectral resolution characteristics. We can apply this method in remote sensing application as well as satellite imaging application. In this proposed work, two images are fused based on the wavelet transform using different fusion technique. The objective of the fusion technique is to fuse two images in such a way that we can get better result which contain more information. The respected results will evaluate using parameters like PSNR and MSE.**

***Keywords*— Image Fusion, Wavelet Transform, PSNR, MSE, Spatial resolution, Spectral resolution.**

I. Introduction

Image fusion technique is very important in digital image processing. In this technique, two images are merge to get more and accurate information. In traditional data fusion, data fusion can be divided into three levels these levels are pixel level fusion, feature level fusion and decision level fusion. These different fusion levels have different algorithms and have different application. The fusion is a technique is used for remote sensing and mapping application. For that purpose different types of sensor technology is used. There are different types of sensor are available.

In many remote sensing and mapping application the fusion of multispectral and panchromatic image is very important issue. In the field of satellite image classification the quality of the image classifier is affected by the fused image quality. For that purpose many image fusion techniques and software tools have been developed. The well-known method include the Brovery, the IHS(Intensity. Hue, Saturation) colour model, the PCA (Principal Component Analysis) method and wavelet based method. Image fusion is also having an application in satellite image fusion as well as in medical image fusion.

II. Related work

Various types of method are proposed in literature review which are used for image fusion. Myungjin Choi, Rae Young Kim, Myeong-Ryong NAM, and Hong Oh Kim[2] introduced a new method based on a curvelet transform, which represents edges better than wavelets. Since edges play a fundamental role in image representation, one effective means to enhance spatial resolution is to enhance the edges. The curvelet-based image fusion method provides richer information in the spatial and spectral domains simultaneously. They performed Landsat ETM+ image fusion and found that the proposed method provides optimum fusion results[1].

Sweta Mehta, Prof. Bijith Marakarkandy introduced the Curvelet Transform and uses it to fuse images. The experiments show that the method could extract useful information from source images to fused images so that clear images are obtained. In this paper we put forward an image fusion algorithm based on Wavelet Transform and the Curvelet Transform. Low and high frequency coefficients are choosen according to different frequency domain after Wavelet and the Curvelet Transform. In choosing the low-frequency coefficients, the concept of local area variance was chosen to measuring criteria. In choosing the high frequency coefficients, the window property and local characteristics of pixels were analyzed. Finally, the proposed algorithm in this article was applied to experiments of multi-focus image fusion and complementary image fusion[3].

Yufeng Zheng, Edward A. Essock and Bruce C. Hansen Dept. of Psychological & Brain Science, Presented The fusion performance of the advanced DWT (*a*DWT) method proposed here was compared with six other common methods, and, based on the four quantitative measures, was found to perform the best when tested on the four input image types. Since the different image sources used here varied with respect to intensity, contrast, noise, and intrinsic characteristics, the *a*DWT is a promising image fusion procedure for inhomogeneous imagery[4].

Alparone L.,Baronti S., Garzelli A., & Nencini F. presented a novel image fusion method, suitable for pan-sharpening of multispectral (MS) bands, based on multi-resolution analysis (MRA). The low-resolution MS bands are sharpened by injecting high-pass directional details extracted from the high-resolution panchromatic (Pan) image by means of the curvelet transform, which is a non-separable MRA, whose basis function are directional edges with progressively increasing resolution[7].

The algorithm proposed by the authors has its own pros and cons, with respect to that we will going to propose efficient architecture for image fusion which will be used in various domain, also the statistical parameters like peak signal to noise ratio, entropy, standard deviation and root mean square error will be evaluated to prove our method will be efficient with respect to others proposed method.

III. Proposed block diagram

Image processing is a very efficient tool which conveys information more precisely. Image fusion is a technique where we add or merge two images, the resultant image is a combination of both images which contain more information and precise information. The proposed technique in this paper is based on the wavelet transform. In this paper different types of Wavelet transforms are used. Accordingly results are evaluated by comparing all the technique.

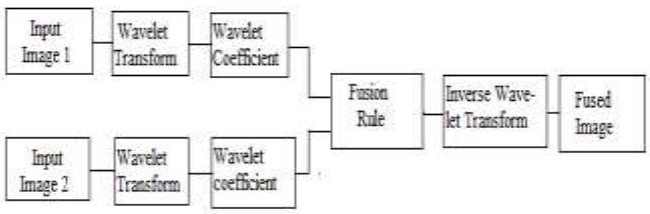

Fig.1 Wavelet Transform Based Image Fusion

Above fig. shows the block diagram of wavelet transform. This block diagram can be explained using few steps:

A. Image Acquisition

First, we have to take two images i.e. input image first and input image second.

B. Wavelet Transform and Inverse Wavelet Transform Analysis.

After taking two images, we have to apply wavelet transform to that images. The different types of wavelet transform are as follows:

Discrete Wavelet Transform: The discrete wavelet transform (DWT) is an implementation of the wavelet transform using a discrete set of the wavelet scales and translations obeying some defined rules. In other words, this transform decomposes the signal into mutually orthogonal set of wavelets, which is the main difference from the continuous wavelet transform (CWT), or its implementation for the discrete time series sometimes called discrete time continuous wavelet transform (DTCWT).

The wavelet can be constructed from a scaling function which describes its scaling properties. The restriction that the scaling functions must be orthogonal to its discrete translations implies some mathematical conditions on them which are mentioned everywhere, e.g. the dilation equation[20].

$$\phi(x) = \sum_{k=-\infty}^{\infty} a_k \phi(Sx - k)$$

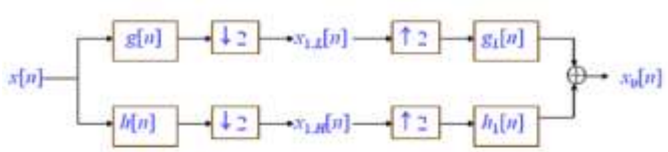

Fig.2 Block diagram of DWT and IDWT

Above block diagram shows the reconstruction process of inverse discrete wavelet transform from discrete wavelet transform. Where h(n), g(n), h1(n) and g1(n) can be constructed by using quadrature mirror filter(QMF)[17].

Stationary Wavelet Transform: Discrete Wavelet Transform is not a time invariant transform. This means that, even with periodic signal extension, the DWT of a translated version of a signal *X* is not, in general, the translated version of the DWT of *X*. The idea is to average some slightly different DWT, called ε-decimated DWT, to define the stationary wavelet transform (SWT). This property is useful for several applications such as breakdown points detection. The main application of the SWT is denoising. The principle is to average several denoised signals. The SWT algorithm is very simple and is close to the DWT one. More precisely, for level 1, all the decimated DWT (only two at this level) for a given signal can be obtained by convolving the signal with the appropriate filters as in the DWT case but without down sampling. Then the approximation and detail coefficients at level 1 are both of size *N*, which is the signal length. This can be visualized in the following figure

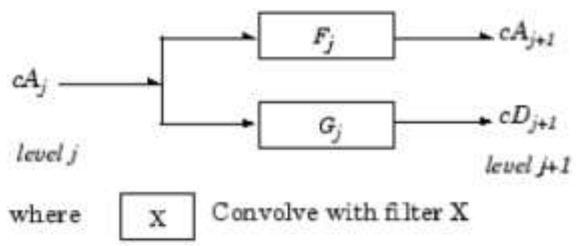

Fig.3 Stationary wavelet transform decomposition step.

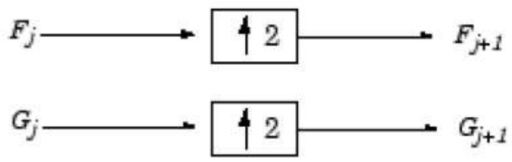

Fig.4 Filter computation up-sample by 2

Above fig shows the representation of stationary wavelet transform and its decomposition. As well as it shows filter computation of stationary wavelet transform[19].

Continuous Wavelet Transform: Continuous wavelet transform (CWT) is an implementation of the wavelet transform using arbitrary scales and almost arbitrary wavelets. The wavelets used are not orthogonal and the data obtained by this transform are highly correlated. For the discrete time series we can use this transform as well, with the limitation that the smallest wavelet translations must be equal to the data sampling. This is sometimes called Discrete Time Continuous Wavelet Transform (DTCWT) and it is the most used way of computing CWT in real applications. In principle the continuous wavelet transform works by using directly the definition of the wavelet transform, i.e. we are computing a convolution of the signal with the scaled wavelet. For each scale we obtain by this way an array of the same length *N* as the signal has. By using *M* arbitrarily chosen scales we obtain a field $N \times M$ that represents the time frequency plane directly[20].

Lifting Wavelet Transform: In the lifting scheme version of the Haar transform, the prediction step predicts that the odd element will be equal to the even element. The difference between the predicted value (the even element) and the actual value of the odd element replaces the odd element. For the forward transform iteration *j* and element *i*, the new odd element, *j+1,i* would be[21]

$$odd_{j+1,i} = odd_{j,i} - even_{j,i}$$

In the lifting scheme version of the Haar transform the update step replaces an even element In the lifting scheme version of the Haar transform the update step replaces an even element with the average of the even/odd pair (e.g., the even elements and its odd successor, s):

$$even_{j+1,i} = \frac{even_{j,i} + odd_{j,i}}{2}$$

with the average of the even/odd pair (e.g., the even element s and its odd successor, The original value of the odd element has been replaced by the difference between this element and its even predecessor. Simple algebra lets us recover the original value:

$$odd_{j,i} = even_{j,i} + odd_{j+1,i}$$

Substituting this into the average, we get

$$even_{j+1,i} = \frac{even_{j,i} + even_{j,i} + odd_{j+1,i}}{2}$$

$$even_{j+1,i} = even_{j,i} + \frac{odd_{j+1,i}}{2}$$

The averages (even elements) become the input for the next recursive step of the forward transform. This is shown in Fig, below.

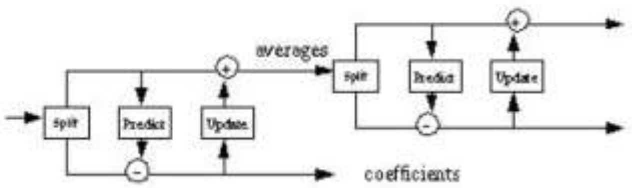

Fig.5 Forward scheme of lifting wavelet transform[21].

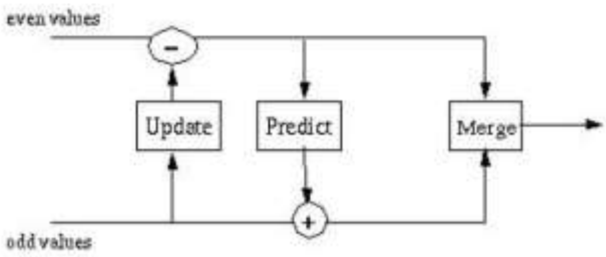

Fig.6 Inverse scheme of lifting wavelet transform[21].

Above fig. shows the scheme of Inverse lifting wavelet transform In the inverse transform, the inverse predict stage has returned the odd elements to their original values. The inverse scaling function is calculating by via the inverse of the average[21].

C. *Wavelet Coefficient*

After application of wavelet transform, wavelet coefficients are generated.

D. *Fusion Rule*

As the wavelet coefficients are generated, we have to apply fusion rules to those coefficients. Various types of fusion rules are used which helps us to compute fusion decision map:

High activity level preferred over low activity level.

Edge points preferred over non-edge.

Small regions preferred over large regions.

Make decision on non edge point first and consider their neighbors when making the decision on edge points

A void isolated points in decision map[22].

E. *Fused Image*

Eventually we get the fused image. This image is a combination of two input images. This contains the information of both input images.

IV. CONCLUSION and FUTURE SCOPE

In this paper, image fusion method is introduced which is based on the wavelet transform, which incorporated the statistical parameters like peak signal to noise ratio, entropy, standard deviation and root mean square error will be evaluated to prove our method will be efficient with respect to others proposed method. Multi Wavelets based image fusion can be performed to achieve a better image fusion quality explains the efficiency of multi wavelets over the usual DWT methods in fusing images involved in remote sensing. The same can be applied in this project too and can be verified based on the image quality metrics developed. Assessing the image fusion algorithms was performed by ranking them based upon the image quality metric readings. One important issue to be noted down here is that the all the quality metrics have been assigned equal weightage irrespective of their accepted efficiency. The metrics could be given weightage so as to obtain a better assessment list[18].

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