Image Fusion in Remote Sensing Using Wavelet Transform

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Abstract— **The fusion of images is the process of combining two or more images into a single image retaining important features from each. Fusion is an important technique within many disparate fields such as remote sensing, robotics and medical applications. Wavelet based fusion techniques have been reasonably effective in combining perceptually important image features. The successful fusion of images acquired from different modalities or instruments is of great importance in many applications, such as medical imaging, microscopic imaging, remote sensing, computer vision, and robotics. With 2D imaging and image processing becoming widely used, there is a growing need for new 2-D image fusion algorithms capable of combining 2D multimodality or multisource images. Such algorithms can be used in areas such as 2D e.g. fusion of images in Target tracking system, Synthetic Aperture Radar (SAR) etc. In case of target tracking system the time is the very important factor. So we take time as a comparison factor to compare different methods which we implement. In order to improve the efficiency of the project, Elapsed time for the fusion to run is being formulated.**

Index Terms— **Image fusion, remote sensing, DWT and types of wavelet, inverse DWT.**

I. Introduction

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 multisensor data in many fields, image fusion has been receiving increasing attention in the researches for a wide spectrum of applications. The main application of image fusion is merging the gray-level high-resolution panchromatic image and the colored low-resolution multispectral image.

Standard fusion methods perform well spatially but usually introduce spectral distortion. To overcome this problem, numerous multiscale transform based fusion schemes have been proposed. In this project, we focus on the fusion method based on the discrete wavelet transform (DWT), the most popular tool for image processing. Due to the numerous multiscale transform, different fusion rules have been proposed for different purpose and applications.

Image fusion methods

There are various methods that have been developed to perform image fusion. Some well-known image fusion methods are listed below [5-9].

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(1) Intensity-hue-saturation (IHS) transform based fusion
(2) Principal component analysis (PCA) based fusion
(3) Arithmetic combinations
(4) Multiscale transform based fusion
(a) High-pass filtering method
(b) Pyramid method
(c) Wavelet transform
(i) Discrete wavelet transform (DWT)
(ii) Stationary wavelet transform
(iii) Dual tree discrete wavelet transform
(iv) Lifting wavelet transform
(v) Multi-wavelet transform
(d) Curvelet transform
(5) Total probability density fusion
(6) Biologically inspired information fusion

A. Satellite image fusion

Above methods are used for merging satellite images. In satellite imagery we can have two types of images,

1) Panchromatic Images-

The panchromatic (PAN) images has high spatial resolution but without color information.

2) Multispectral images-

In optical remote sensing fields, the multispectral (MS) image which contains color information is produced by three sensors covering the red, green and blue spectral wavelengths. Because of the trade-off imposed by the physical constraint between spatial and spectral resolutions, the MS image has poor spatial resolution.

(a) Multispectral low resolution input image, (contains color information is produced by three sensors covering the red, green and blue spectral wavelengths. & having poor spatial resolution.)

(b) Panchromatic high resolution input image (high spatial resolution but without color information.)

The standard merging methods are based on the transformation of the red–green–blue (RGB) multispectral channels into the intensity–hue–saturation components. Intensity refers to the total color brightness, hue refers to the dominant or average wavelength that contributes to a color, and saturation refers to the purity of a color relative to gray. With the standard methods the usual steps to perform are the following:

1. Register the low-resolution multispectral image to the same size as the high-resolution panchromatic image so that it is superimposed.

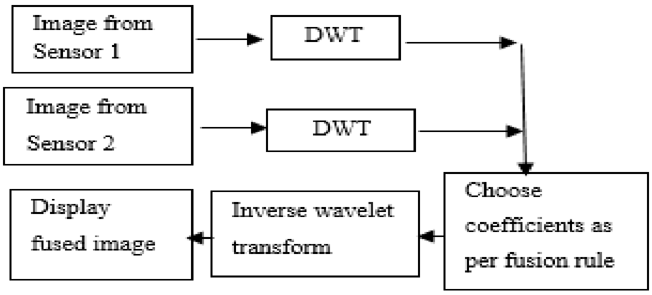
2. Transform the R, G, and B bands of the multispectral image into the intensity–hue–saturation components.

3. Modify the high-resolution panchromatic image to take into account the spectral differences with respect to the multispectral image, the different atmospheric and illumination conditions, etc.

4. Replace the intensity component with the panchromatic image, and perform the inverse transformation to obtain the merged RGB image with merged panchromatic information.
This is usually performed by conventional histogram matching between the panchromatic image and the intensity component of the intensity–hue–saturation representation. Specifically, after computation of the histogram of both the panchromatic image and the intensity component of the multispectral image, the histogram of the intensity (of the multispectral image) is used as a reference to which we match the histogram of the panchromatic image.

The standard image fusion techniques, such as IHS based method, PCA based method and Brovey transform method operate under spatial domain. However, the spatial domain fusions may produce spectral degradation. This is particularly crucial in optical remote sensing if the images to fuse were not acquired at the same time. Therefore, compared with the ideal output of the fusion, these methods often produce poor result. Over the past decade, new approaches or improvements on the existing approaches are regularly being proposed to overcome the problems in the standard techniques.
As multiresolution analysis has become one of the most promising methods in image processing, the wavelet transform has become a very useful tool for image fusion. It has been found that wavelet-based fusion techniques outperform the standard fusion techniques in spatial and spectral quality, especially in minimizing color distortion. Schemes that combine the standard methods (HIS or PCA) with wavelet transforms produce superior results than either standard methods or simple wavelet-based methods alone. However, the tradeoff is higher complexity and cost.

1.3 BLOCK DIAGRAM



1.4 BLOCK DIAGRAM DISCRIPTION

1. IMAGES OF SAME SIZE :-

One of the main issues in image fusion is image alignment, which refers to pixel-by-pixel alignment of the images. For the resultant output image to be distinct and have a better visual interpretation than the multi-spectral and panchromatic images it is necessary to have both the MS & PAN images of same size. Same size of images also becomes a basic requirement for point to point correspondence between two pixel values. There have been many studies on pan sharpening and many, many algorithms have been developed.
Pan sharpening algorithms depends on the input images being co-registered because all they perform operations on corresponding pixels in both images. They all do something with the multispectral pixel and the panchromatic pixels to Crete new pixels. If the images are not co-registered, the processing will use the wrong pixels, not the corresponding ones and the result will not look natural. For this purpose images should be registered.

2. DECOMPOSITION BY DWT:-

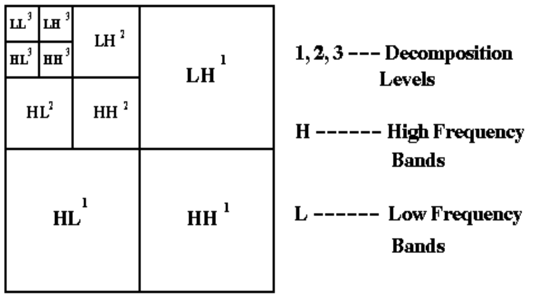


Fig.2 DECOMPOSITION BY DWT:-

❖ Discrete Wavelet Transform

In this project, we only introduce the discrete wavelet transform (DWT) based fusion schemes because DWT is the basic and simplest transform among numerous multiscale transform and other type of wavelet based fusion schemes are usually similar to the DWT fusion scheme. Therefore, we give a brief introduction of the DWT in this section.

➢ Continuous wavelet transform (CWT):-

Given a input signal x (t), the CWT of x (t) is defined as

$$X_w(a,b)=\frac{1}{\sqrt{b}}\int_{-\infty}^{\infty}x(t)\psi\left(\frac{t-a}{b}\right)dt,$$

Where location factor a can be any real number, and scaling factor b can be positive real number. It is obvious that as b is larger, ψ ((t−a) / b) is more like a high-frequency signal, and thus output Xw (a, b) would represent the high-frequency component of x (t) after inner product with ψ ((t−a) / b). Also, larger b implies the window size of ψ ((t−a) / b) is smaller; that is, the location (time) resolution is smaller. Therefore, the location-scaling (time-frequency) resolution plane is as Fig. 2

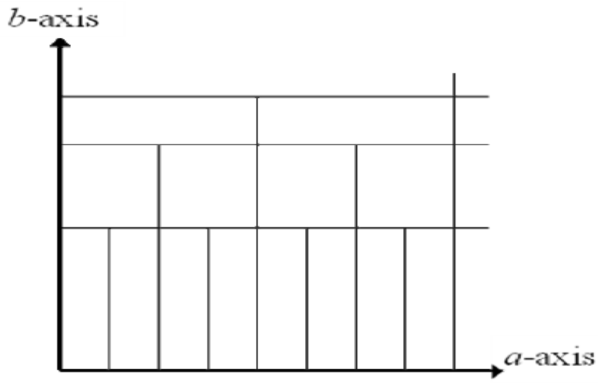


Fig .3 Time-frequency resolution plane for wavelet transform.

➢ Discrete wavelet transform (DWT)

1. 1-D discrete wavelet transform

The DWT is similar to the DC-CWT except that the input signal is discrete. Therefore, the design rules for ψ (t), φ (t), g[k] and h[k] are similar as in the DC-CWT. The block diagram of the 1-D DWT is illustrated in Fig. 3

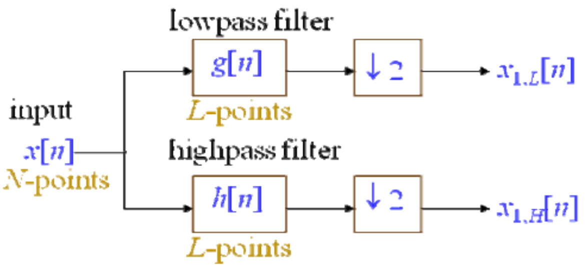


Fig.4. The block diagram of the 1-D DWT

2. Multi-level 1-D discrete wavelet transform

Furthermore, the 1-D DWT confidents can be decomposed again using the 1-D DWT. This scheme is called multi-level 1-D DWT (see Fig. 4.3 for 2-level 1-D DWT).

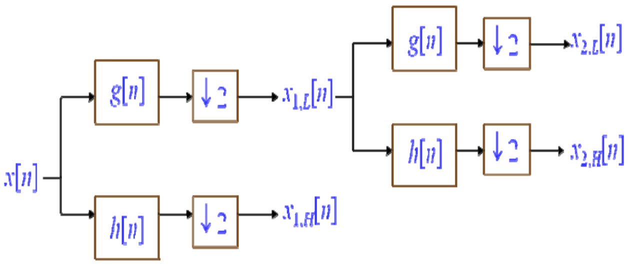


Fig.5.Multi-level 1-D discrete wavelet transform

➢ **2-D discrete wavelet transform**

2-D DWT is very useful for image processing because the image data are discrete and the spatial-spectral resolution is dependent on the frequency. An example is shown in Fig. 4.5. The DWT has the property that the spatial resolution is small in low-frequency bands but large in high-frequency bands. The left-top sub-image (the band with lowest frequencies) has the smallest spatial resolution and represents the approximation information of the original image. Thus, the DWT is suitable for image compression. On the contrast, the other sub-images (the bands with high frequencies) show the detailed information of the original image. Therefore, these sub-images can be used for edge detection or corner detection.

2. EXTRACTION AND CONCATENATION OF COEFFICENTS:-

After applying the simplified level decomposition using DWT the approximate and detailed coefficients are extracted. The detailed coefficients are further filtered to increase the luminance. After filtering of coefficients the approximate coefficients of multispectral image and detailed coefficients of panchromatic image concatenated. This is the step where actual image fusion take place.

4. INVERSE DWT (IDWT).

The reconstruction process from the DWT coefficients is shown in the right part of Fig. 4.5, called inverse DWT (IDWT).

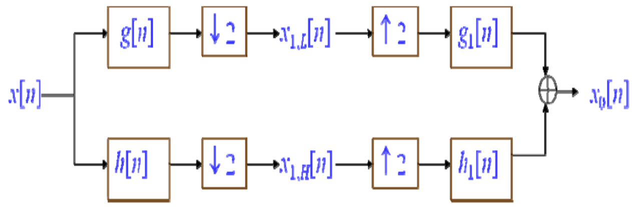


Fig .6 the block diagrams of DWT and IDWT.

5. DISPLAY FUSED IMAGE:

After taking IDWT we get fused image, which is combination of PAN & MS images. Fused image is multispectral as well as high resolution image.

II. ALGORITHM:

- Start.
- Read First And Second Image From Database.
- Take Dwt On Both Images To Transform Into Wavelet Domain.
- Choose Coefficients As Per Fusion Rules.
- Take Inverse Wavelet Transform.
- Display The Fused Image.
- Stop.

III. TESTING

1] Multispectral image:-

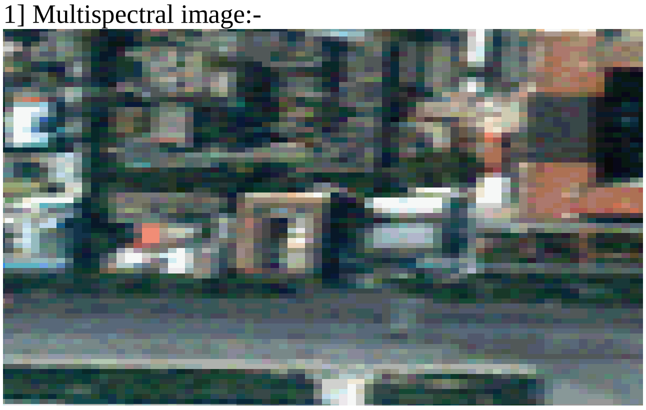


Fig.7. Multispectral Image

In optical remote sensing fields, the multispectral (MS) image which contains color information is produced by three sensors covering the red, green and blue spectral wavelengths. Because of the trade-off imposed by the physical constraint between spatial and spectral resolutions, the MS image has poor spatial resolution.

2] Panchromatic image:-

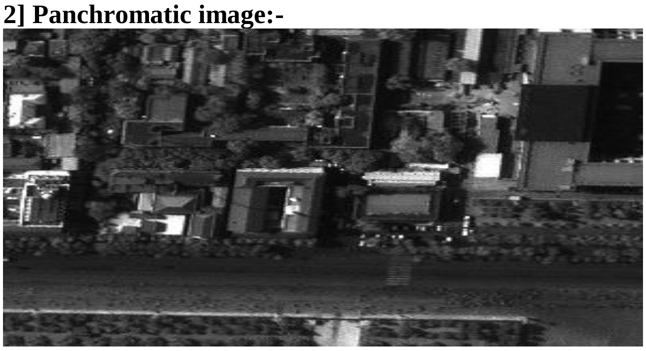


Fig.8.Panchromatic image

The panchromatic (PAN) images has high spatial resolution but without color information.

IV. RESULT:-

(a)

(b)

Fig.9. (a) and (b) Before fusion

After fusion

(a) Result for HAAR wavelet:-

(b)Result for DB wavelet:-

(c)Result for SYMLET wavelet:-

V. APPLICATIONS

The main application of image fusion is merging the gray-level high-resolution panchromatic image and the colored low-resolution multispectral image. It technology has been used in several applications such as

- In medical application
- In Human perceptibility
- object detection & target recognition
- Observation of the environment
- Feature detection & Feature matching.
- Aerial and satellite imaging

VI. FUTURE SCOPE

Image fusion is expected to play a vital role in the future of Digital image processing. This paper mainly aims to implement fusion of 2-D images taken from remote sensors. However, this application can also be developed in future by integrating more number of sensors to fuse 3-d images using wavelet transform.

VII. CONCLUSION

We conclude that, wavelet transform leads to accuracy which is far improved and leads to extraction of maximum information as compared to other methods. And also Wavelet Transform shows better resemblance with HUMAN VISUAL SYSTEM. That is Wavelet transform fusion diagrams have been introduced as a convenient tool to visually describe different image fusion schemes

REFERENCES

[1] Patil Gaurav Jaywantrao,'' **Application of Image Fusion Using Wavelet Transform In Target Tracking system**'' RKDF, Institute of Science & Technology, Bhopal, October – 2012.

[2] Shih-Gu Huang," **Wavelet for Image Fusion**", Graduate Institute of Communication Engineering & Department of Electrical Engineering, National Taiwan University,2011.

[3] Timo Bretschneider, Odej Kao,'' **Image Fusion in Remote Sensing**'' Department of Computer Science Technical University of Clausthal, Germany, 2012.

[4] Jorge Nu´n˜ez, Xavier Otazu, and Octavi Fors,'' **Image fusion with additive multiresolution wavelet decomposition. Applications to SPOT**1**Landsat images**''
Department d'Astronomia i Meteorologia, Universitat de Barcelona, E-08028 Barcelona, and Observatori Fabra, Barcelona, Spain Albert Prades, March 1999.

[5] Lee A. Barford, R. Shane Fazzio, David R. Smith," **An Introduction to Wavelets**", Instruments and Photonics Laboratory HPL-92-124 September, 1992.

[6] Jan Flusser, Filip ˇSroubek, and Barbara Zitov´a**," Image Fusion: Principles, Methods, and Applications"**, Institute of Information Theory and Automation Academy of Sciences of the Czech Republic, Czech Republic, Tutorial EUSIPCO 2007.

[7]. Gonzalo Pajares∗, Jes*us Manuel de la Cruz, "A **wavelet-based image fusion tutorial**", pp 1855 – 1872 IEEE 2004.

[8]. Hong Zhang, Lei Liu, Nan Lin "A **Novel Wavelet Medical Image Fusion Method**", International Conference on Multimedia and Ubiquitous Engineering, 2007.

[9]. Debasish Patnaik, "**Biomedical Image Fusion Using Wavelet Transform and SOFM Neural Network**", pp 1189-1194, IEEE-2006.

[10]. A.Umaamaheshvari, K.Thanushkodi, "**Image fusion techniques** ", IJRRAS 4 (1), pp 69-74, July 2010.

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