International Journal of Engineering Research and General Science Volume 2, Issue 3, April-May 2014
ISSN 2091-2730

A Review on Multi Sensor Image Fusion Techniques

Priyanka Chaudhari[1], Prof.M.B.Chaudhari[2], Prof. S.D.Panchal[2]

[1]Research Scholar (ME), CSE, Government Engineering College, Gandhinagar, Gujarat

E-mail- priyanka07.chaudhari@gmail.com

ABSTRACT - Most Earth observational satellites are not able to acquire high spatial and spectral resolution data simultaneously because of design or observational constraints. To overcome such limitations, image fusion techniques are use. Image fusion is process combine different satellite images on a pixel by pixel basis to produce fused images of higher value. The value adding is meant in terms of information extraction capability, reliability and increased accuracy. The objective of this paper is to describe basics of image fusion, various pixel level mage fusion techniques for evaluating and assessing the performance of these fusion algorithms.

Keywords— -Image Fusion, Pixel Level, Multi-sensor, IHS, PCA, Multiplicative, Brovey, DCT, DWT.

INTRODUCTION

Image Fusion is process of combine two different images which are acquired by different sensor or single sensor. Output image contain more information than input images and more suitable for human visual perception or for machine perception. Objectives of Image Fusion Schemes are Extract all the useful information from the source images.

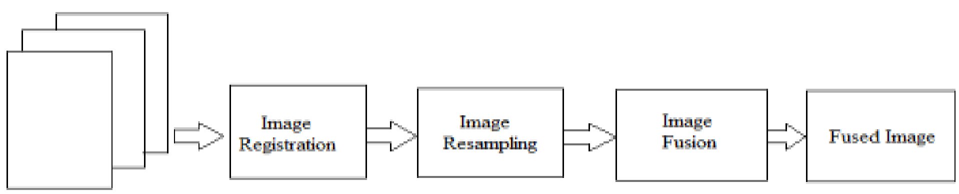

Figure1.1 Pre-processing of image fusion [1].

Image fusion is applicable at different fields that are: defense systems, remote sensing and geosciences, robotics and industrial engineering, and medical imaging. Goal of image registration is to find a transformation that aligns one image to another. In image registration, one dataset is regarded as the reference data and other as sensed data. Sensed data is matched relative to the reference data, Image registration at a very basic level.

Image re-sampling [2] is the process to produce new image with eight in different size. Re-sampling can change the size of the image. Increasing the size is called up-sampling; decreasing the size is called down-sampling. Note that the spatial resolution would not change after the RS procedure, either up-sampling or down-sampling. In multi-sensor image fusion, the images of the same scene come from different sensors of different resolution. In multi-focus image fusion, the images of the same scene come from the same sensor are combined to produce an image in which all the objects are in focus.

Pohl & Genderen 1998 presents three types of image fusion levels: pixel, feature, and decision levels, In this paper, we are only concerned about pixel level fusion.

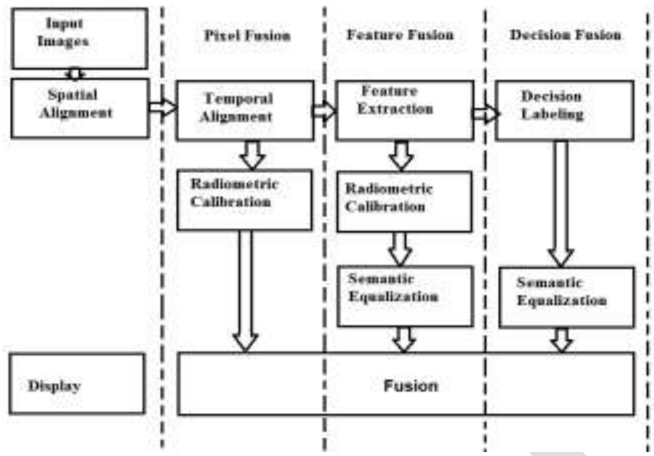

Figure 1.2 Level of Image Fusion [3].

Image Fusion Techniques

Image fusion techniques are classified into several techniques, which are described below

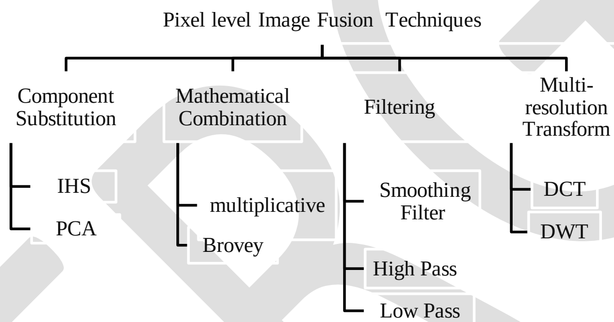

Figure1.3 The categorization of pixel level image fusion techniques [4].

IHS (Intensity, Hue, Saturation)

IHS is a color space, intensity relates to the total amount of light that reaches the eye, hue is defined as the predominant wavelength of a color, and saturation is defined as total amount of white light of a color.

Steps

1. first converts a RGB image into intensity (I),

$$\begin{bmatrix} I \\ v1 \\ v2 \end{bmatrix} = \begin{bmatrix} 1/3 & 1/3 & 1/3 \\ -\sqrt{2}/6 & -\sqrt{2}/6 & 2-\sqrt{2}/6 \\ 1/\sqrt{2} & -1/\sqrt{2} & 0 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

   Hue (H) and Saturation (S) components.

2. Replacement of I by high resolution image,

$$\begin{bmatrix} F(R) \\ F(G) \\ F(B) \end{bmatrix} = \begin{bmatrix} 1 & -1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/\sqrt{2} & -1/\sqrt{2} \\ 1 & \sqrt{2} & 0 \end{bmatrix} \begin{bmatrix} PAN \\ v1 \\ v2 \end{bmatrix}$$

3. Reverse IHS, converting IHS components into RGB colors.

$$\begin{bmatrix} F(R) \\ F(G) \\ F(B) \end{bmatrix} = \begin{bmatrix} R + PAN - 1 \\ G + PAN - 1 \\ B + PAN - 1 \end{bmatrix}$$

Merit of IHS is simplicity and high sharpening ability, it separates the spatial information as an intensity (I) component from the spectral information represented by the hue (H) and saturation (S) components, and demerit of IHS is that it only processes three multispectral bands, Cause Color distortion [5].

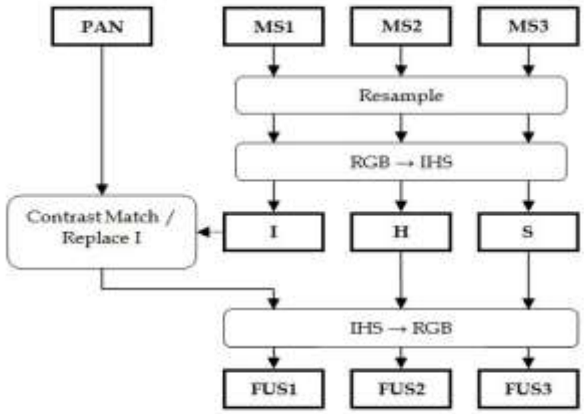

Figure 1.4 Block Diagram of the IHS fusion method [6].

PCA (PRINCIPAL COMPONENT ANALYSIS)

PCA maintain image clarity, spectral information loss is slightly better than that of the IHS fusion method.
Steps

1. Produce the column vectors from input images
2. Calculate the covariance matrix of the two column vectors formed in step1.
3. Calculate the Eigen values and the Eigen vectors of the covariance.
4. Normalize the column vectors.
5. Normalized Eigen vector act as the weight values which, multiply it with each pixel of the input images.
6. Fuse the two scaled matrices will be the fused images matrix.

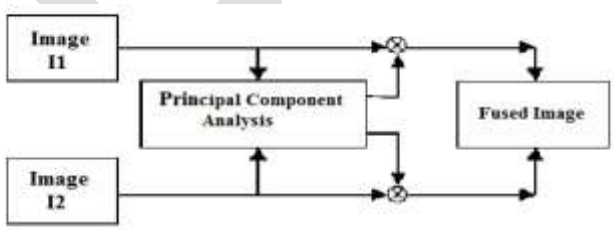

Figure.1.5 Block Diagram of the PCA fusion method [7].

Merits of PCA is it can transforms number of correlated variable into number of uncorrelated variables, demerits is that have spatial domain fusion may produce spectral degradation.

Multiplicative

The algorithm is derived from the four-component technique, as described by Crippen (1989). The four possible arithmetic methods that can be used to produce an intensity image into a chromatic image (addition, subtraction, division, and multiplication), only multiplication is unlikely to distort the color.

The merits of this method is straightforward and simple [8] multiplicative algorithm can be used to merge PAN and MS images, however special attention has to be given to color preservation. This method can produce spectral bands of a higher correlation which means that it does alter the spectral characteristics of the original image data. Demerits are that resulting image does not retain the radiometry of the input multispectral image.

Red=(LR Band1 * HR Band1)
Green = (LR Band2 * HR Band2)
Blue = (LR Band3 * HR Band3) [9].

Brovey

The Brovey transformation Overcomes to demerits of the multiplicative method. Brovey is also called the color normalization transform because it involves a red-green-blue (RGB) color transform method.

Merit of Brovey is it hold the corresponding spectral feature of each pixel, and transforms all the brightness information into a panchromatic image of high resolution. Brovey Transform not be used in preserving the original scene radiometry. It is good for producing RGB images with a contrast higher degree in the low and high ends of the image histogram and for getting "visually appealing" images.

Red = (band1/Σ band n)* High Resolution Band
Green = (band2/Σ band n)* High Resolution Band
Blue = (band3/Σ band n)* High Resolution Band
High resolution band = PAN [9].

DCT (DISCRETE COSINE TRANSFORM)

The 2D discrete cosine transform of an image or 2D signal x(nl,n2) of size NI xN2 is defined as,

$$\mathrm{X}(k_1, k_2) = \propto (k_1) \propto (k_2)$$

$$\sum_{n_1=0}^{N_1-1} \sum_{n_2=0}^{N_2-1} X(n_1, n_2)\, COS\left(\frac{\pi(2n_1+1)k_1}{2N_1}\right)$$

$$\cos\left(\frac{\pi(2n_2+1)k_2}{2N_2}\right)$$

For $0 \le k_1 \le N_1 - 1$ and $0 \le k_2 \le N_2 - 1$

Where in [10]

$$\propto (k_1) = \begin{cases} \sqrt{1/N_1}, & k_1 = 0 \\ \sqrt{2/N_1}, & 1 \le k_1 \le N_1 - 1 \end{cases}$$

$$\propto (k_2) = \begin{cases} \sqrt{1/N_2}, & k_2 = 0 \\ \sqrt{2/N_2}, & 1 \le k_2 \le N_2 - 1 \end{cases}$$

$k_1 and\ k_2$ are discrete frequency variables $n_1 and\ n_2$ are pixel index.

The 2D inverse discrete cosine transform is
Defined as,

$$X(n_1, n_2) = \propto (k_1) \propto (k_2)$$

$$\sum_{k_1=0}^{N_1-1} \sum_{k_2=0}^{N_2-1} \propto (k_1) \propto (k_2) X(k_1, k_2)\ COS\left(\frac{\pi(2n_1+1)k_1}{2N_1}\right)$$

$$\cos\left(\frac{\pi(2n_2+1)k_2}{2N_2}\right)$$

For $0 \leq n_1 \leq N_1 - 1$ and $0 \leq n_2 \leq N_2 - 1$

Merits of DCT Provides excellent result on spectral domain [11], it is complex and time consuming which are hard to be performed on real time applications.

DISCRETE WAVELET TRANSFORM (DWT)

The wavelet transform contains the low-high bands, the high-low bands and the high-high bands of the image at different scales. Then a fusion rule is to be selected. And in this way the fusion takes place in all the resolution levels.

1. Generate one PAN image for each MS band, histogram-matched to that band.
2. Apply one of the DWTs described above to both the MS and the new PAN images.
3. Add the detail images from the transformed PAN images to those of the transformed MS images,
4. Perform the inverse transform on the MS images with added PAN images and the resulting wavelet planes added directly to the MS image; no inverse transform is then needed[12].

Advantage of DWT fusion method may outperform the slandered fusion method in terms of minimizing the spectral distortion. It also provide better signal to noise ratio than pixel based approach. Disadvantage In this method final fused image has a less spatial resolution.

CONCLUSION:

The review shows that the suitable selection of a proper pixel-level fusion algorithm depend on characteristics. The combination of existing fusion methods and further development of new techniques are expected to surely guide and improve the fusion performance more appropriate for human visual perception or for machine perception, chosen suitable method will improve quality of image by determine visual analysis result and quantity analysis result. We can use DCT with filter which are still not used in image fusion to improve quality.

REFERENCES:

[1] R.J.Sapkal, S.M.Kulkarni, "Image Fusion based on Wavelet Transform for Medical Application", International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622, Vol. 2, Issue 5, pp.624-627, , September- October 2012.

[2] Nisthula P, Mr. Yadhu.R.B, "A Novel Method To Detect Bone Cancer Using Image Fusion And Edge Detection" International Journal Of Engineering And Computer Science ISSN: 2319-7242 Volume 2 Issue 6 June, 2013.

[3] H.B.Mitchell. "Image Fusion Theories,Techniques And Application" ,Verlag Berlin HeidelbergSpringer ISBN 978-3-642-11215-7, Springer 2010.

[4] Nemir Al-Azzawi and Wan Ahmed K. Wan Abdullah, "Medical Image Fusion Schemes using Contourlet Transform and PCA Based" ,Biomedical Electronics group, University Sains Malaysia Penang, Malaysia, June 2011.

[5] Wen Doua, Yunhao Chenb, " An Improved Ihs Image Fusion Method With High Spectral Fidelity", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B7. Beijing 2008.

[6] Leila Fonseca, Laercio Namikawa, Emiliano Castejon, " Image Fusion for Remote Sensing Applications", National Institute for Space Research, INPE São Paulo State University, Unesp Brazi, Jun 24, 2011.

[7] Jagdeep Singh, Vijay Kumar Banga,"An Enhanced DCT based Image Fusion using Adaptive Histogram Equalization", International Journal of Computer Applications (0975 – 8887) Volume 87 – No.12, February 2014.

[8] Sascha Klonus, Manfred Ehlers, "Performance of evaluation methods in image fusion", 12th International Conference on Information Fusion, Seattle, WA, USA, July 6-9, 2009.

[9] Rohan Ashok Mandhare, Pragati Upadhyay, Sudha Gupta"Pixel-Level Image Fusion Using Brovey Transform And Wavelet Transform" International Journal Of Advanced Research In Electrical, Electronics And Instrumentation Engineering Vol. 2, Issue 6, June 2013.

[10] VPS Naidu, "Discrete Cosine Transform based Image Fusion Techniques", Journal of Communication, Navigation and Signal Processing, Vol. 1, No. 1, pp. 35-45, January 2012.

[11] Mandeep Kaur Sandhu, Ajay Kumar Dogra, "A Detailed Comparative Study Of Pixel Based Image Fusion Techniques", International Journal of Recent Scientific Research, Vol. 4, Issue, 12, pp.1949-1951, December, 2013.

[12] Song Qiang, Wang Jiawen, Zhang Hongbin, "An Overview on Fusion of Panchromatic Image and Multispectral Image", 978-1-4244-4994-1/09/$25.00 ©2009 IEEE.