Remote Sensing Image Fusion and Its Application

Panchal Abhishek Jagdishchandra[1]
[1]Department of Electronics Communication Engineering
[1]Silver Oak College of Engineering and Technology, Gujarat Technology University, Ahmedabad India

Abstract— Remote sensing delivers multi-modal and -temporal data. Image fusion is a valuable tool to optimize multisensor image exploitation. It has developed into a usable image processing technique to extract information of higher quality and reliability. This paper is describe about the image fusion important in the remote sensing area along with its various application using image classification. Fusion basically applied to MS (Multispectral Image) to PAN Image (Monochromatic Image) for obtaining better enhance and information image. Use smooth filter like HPF, Modified Brovery, Multiplication, IHS, Principle component analysis Transform (PCA) methods for the fusion experiment.

Key words High pass filter, Wavelet, PCA, SFIM, HIS , PAN image , MS image , Reomte Sensing, Sensor,Earth Orbit, Landsat 7, Classification

I. INTRODUCTION

Image fusion has come a long way from experimental processing trials to an operational image exploitation technique. By definition image fusion combines different images from single or multiple sensors at pixel level to produce enhanced images for image visual and computer-based image interpretation (Pohl and Genderen 1998). Image fusion can produce information that is not available in the single data alone. [1]

1) What is the objective/application of the user?
2) Which types of data are the most useful for meeting these needs?
3) Which is the `best' technique of fusing these data types for that particular application?
4) What are the necessary pre-processing steps involved?
5) Which combination of the data is the most successful?

Image fusion requires well-defined techniques as well as a good understanding of the input data. This review is meant to contribute to the comprehension of image fusion including the definition of terms, the explanation of existing techniques and the assessment of achievements in image fusion.

II. IMAGE FUSION

Image Fusion is basically defined by four ways i.e. Signal, Pixel, Feature and decision Level for dealing with the data and information of the various input images.

Pixel level dealing with the lowest meauring value and get the better result. Feature level dealing the data related to specific object. Decision level, it's basically defined as per given inputs by the source to derive specific output.

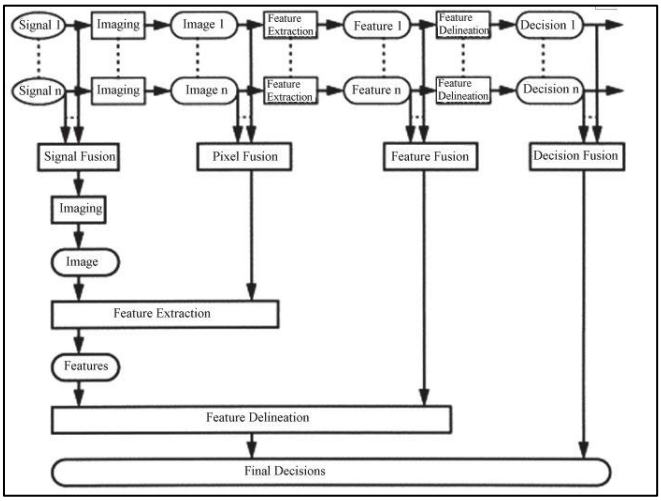

Fig. 1: Image Fusion Classification [2].

III. IMAGE FUSION TECHNIQUES

There are several method are defined for gaining the more contextual information from various input sources. Basically, it is works on high resolution image. There are several standard methods like: [13]

1) High pass filtering technique
2) IHS transform based image fusion
3) PCA based image fusion
4) Wavelet transform image fusion
5) Pair-wise spatial frequency matching

A. IHS Color Model

1) HIS method is transforming R, G and B bands of multispectral image in to HIS Components. Using the intensity of panchromatic image, then fused by performing the inverse transformation.
2) Using IHS transform, the MS image is transformed into IHS components. The PAN image is histogram matched to that of the Intensity image (I) to get a new PAN.
3) The new PAN image and Intensity image (I) are -level decomposed using DWPT. For each frequency the sequence of directive contrast is found. The directive contrast for PAN and Intensity image is denoted as where and is the decomposition level. High frequency components are fused using directive contrast of corresponding pixels in both images

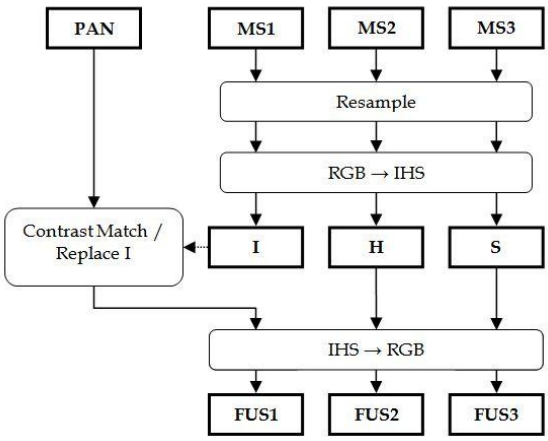

Fig. 2: IHS Transformation [3]

B. PCA Transformation:

Principal component analysis (PCA) is a vector space transform often used to reduce multidimensional data sets to lower dimensions for analysis. It reveals the internal structure of data in an unbiased way.

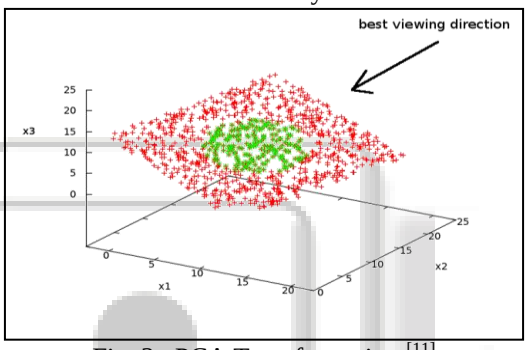

Fig. 3: PCA Transformation [11]

The first principal component, which contains maximum variance, is replaced by PAN image. Such replacement maximizes the effect of panchromatic image in the fused product. One solution could be stretching the principal component to give a spherical distribution. Besides, the PCA approach is sensitive to the choice of area to be fused. Other problem is related to the fact that the first principal component can be also significantly different from the PAN image. If the grey values of the PAN image are adjusted to the grey values similar to PC1 component before the replacement, the color distortion is significantly reduced.

$C_f = E((f- \mu_f)) . ((f- \mu_f)^T)$ FIGURE 4 PCA ST

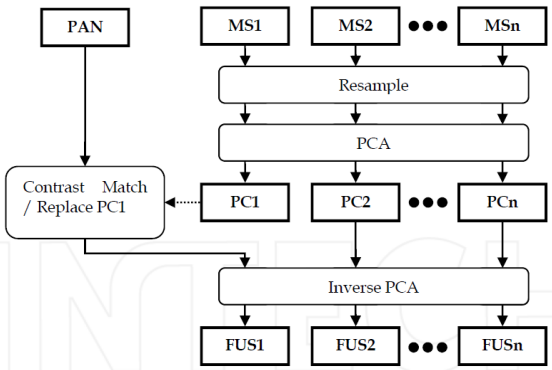

Fig. 4:

C. Uses:

1) Data Visualization
2) Data Reduction
3) Data Classification
4) Trend Analysis
5) Factor Analysis
6) Noise Reduction
7) Some Common Mistakes

IV. WAVELET TRANSFORM (WT) [11]

In the fusion methods based on wavelet transform (Mallat, 1989), the images are decomposed into pyramid domain, in which coefficients are selected to be fused (Garguet- Duport et al., 1996). Basically, Two images are decomposed using wavelet transform, with the approximate sub band of MS and details sub band of PAN image of respective co-efficient. Then, The image is fused by applying the inverse wavelet transform.

In wavelet fusion, a high-resolution Pan image is first decomposed into a set of low-resolution Pan images with corresponding wavelet coefficients (spatial details) for each level. Individual bands of the MS image then replace the low-resolution Pan at the resolution level of the original MS image. The high resolution spatial detail is injected into each MS band by performing a reverse wavelet transform on each MS band together with the corresponding wavelet coefficients.

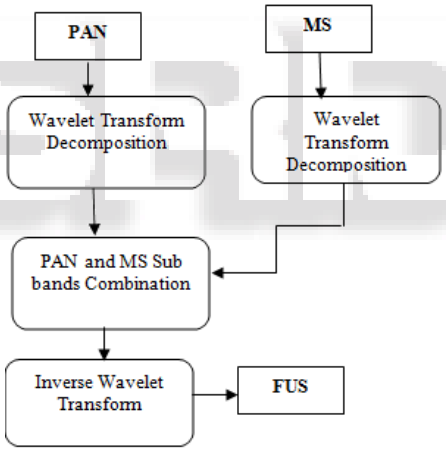

Fig. 5: Wavelet Transformation Step [7]

Provide a consistent estimate of the high-resolution MS image. Comparing with WT and PCA methods, preserves more significant spectral information at the cost of slightly lower improvement on spatial quality.

V. MOSAIC/OTHER TECHNIQUES

In order to solve the cloud cover problem effectively, the mosaic approach offers wide variety of possibilities in connection with other fusion techniques. SAR data is introduced to areas of no information on the optical data, i.e., clouds and their shadows. Likewise, SAR data from di€ erent sensors or orbits can reduce the regions of foreshortening, layover and shadow. The idea to input optical data often fails because the mountainous areas which are causing these geometric distortions in the SAR are also the reason for cloud coverage. Therefore, the contribution of other SAR imagery represents the more operational solution. Once the cloud/shadow (VIR) and

layover/foreshortening/shadow mask (SAR) has been produced, it is possible to introduce all types of data in the various elements of the mask (Pohl 1996).

VI. IMAGE FUSION PARAMETER [14]

There are main parameter like: SVD, DWT, PSNR, SNR, UIQI for Image fusion.

The basic principle used in linear algebra for SVD is the factorization of rectangular real or complex matrix into diagonal symmetric or Hermitian square matrices using eigenvectors.

$$X = U_x \sum_x V_x^T$$

Root mean square error (RMSE) corresponds to pixels in the reference image r I and the fused image f I.

$$RMSE = \sqrt{1/MN \sum_{x=1}^{M} \sum_{y=1}^{N} (I_r(x,y) - I_f(x,y)}$$

Peak signal to noise ratio (PSNR) value will be high when the fused and reference images are alike and higher value implies better fusion. PSNR is calculated by follow equation

$$PSNR = 20 \log_{10} \left(\frac{L^2}{\sqrt{1/MN \sum_{x=1}^{M} \sum_{y=1}^{N} (I_r(x,y) - I_f(x,y)}} \right)$$

The image quality index was introduced by two researchers Z. Wang and A. C. Bovik. Given two sequences X= (X1 ,...Xn,) and Y= (Y1 ,...Yn,) let x denote the mean of x, and x · and xy · denote the variance of x and Covariance of x and y, respectively. The global quality index of two vectors is defined as

$$UIQI = \left(\frac{1/MN \sum_{x=1}^{M} \sum_{y=1}^{N} ((I_r(x,y) - I_f(x,y))^2}{\sum_{x=1}^{M} \sum_{y=1}^{N} I_r(x,y)} \right)$$

VII. LIMITATIONS OF EXISTING FUSION TECHNIQUES [13]

Many research papers have reported the limitations of existing fusion techniques. The most significant problem is color distortion. Another common problem is that the fusion quality often depends upon the operator's fusion experience, and upon the data set being fused.

No automatic solution has been achieved to consistently produce high quality fusion for different data sets.

To reduce the color distortion and improve the fusion quality, a wide variety of strategies have been developed, each specific to a particular fusion technique or image set. For example:[6]

1) For IHS fusion, a common strategy is to match the Pan to the I band before the replacement, stretch the H and S bands before the reverse IHS transform, or stretch individual I, H or S bands with respect to individual data sets.
2) In PCA fusion, suggested solutions have been, for example, stretching the principal components to give a spherical distribution, or discarding the first principal component.
3) With arithmetic combination methods, color distortion varies depending upon the band combinations being fused. Preprocessing and operator's fusion experience are important to achieving a good fusion result.
4) In wavelet fusion, many variants of wavelet fusion have been developed to deal with color distortion problems. By selecting a proper fusion technique and applying an appropriate adjustment strategy, successful results can be achieved for the fusion of SPOT Pan or IRS Pan images with other low-resolution MS images, such as Landsat TM, SPOT MS, or IRS MS. But, the operator's experience plays an important role for the success.
5) However, quality results are rarely obtained for the fusion of Pan and MS images obtained from many satellites launched post-1999 (e.g. IKONOS, QuickBird, OrbView, Landsat 7). This is true regardless of fusion technique or color adjustment strategy employed. When traditional fusion and adjustment techniques are used with this newer imagery, significant color distortion becomes a significant problem.
6) Different arithmetic combinations have been developed for image fusion. The Brovey Transform, SVR (Synthetic Variable Ratio), and RE (Ratio Enhancement) techniques are some successful examples. The basic procedure of the Brovey
7) Transform first multiplies each MS band by the high-resolution Pan band, and then divides each product by the sum of the MS bands. The SVR and RE techniques are similar, but involve more sophisticated calculations for the MS sum for better fusion quality.

VIII. COMPARATIVE ANALYSIS OF IMAGE FUSION TECHNIQUES [1]

Measuring Parameter	Average Method	Maxima /Minima method	Brovey Method	IHS	PCA
Simplicity	Simple	Simple method	fast method	Simple	Simple
Type of resources	Same Sensor	Same type of Sensor	Diff. Sensor	Diff. Sensor	Diff. Sensor
Disadvantage	Reduced	Create blurring	spectral	color	spectral

	Contrast.	effects	distortion	distortion	degradation
Disadvantage	Noisy.	Pixel intensity is good but information is lacl.	Absent of spectral information.	Suffer from noise cause blur.	Not able to content of color image.

Table 1:

IX. Potential Applications of Image Fusion Positioning [11]

Image Fusion can be used in different sector for different purpose. The main applicaion where fusion can be adopted are as under:

1) Intelligent robots
2) Medical image
3) Manufacturing
4) Military and law enforcement
5) Remote sensing

A. Examples of Image Fusion:

There is an increasing number of applications in which multisensor images are used to improve and enhance image interpretation. This section gives a couple of examples of multisensor image fusion comprising the combination of multiple images and ancillary data with remote sensing images:

1) Topographic mapping and map updating,
2) Land use, agriculture and forestry,
3) Flood monitoring,
4) Ice- and snow-monitoring and
5) Geology.

These are the main board area where fusion can be utilized for various segment like: motion control, night pilot guidance, Battle-field monitoring, detection and tracking of the object, Classification of the land.

X. Conclusion

In this paper , we have customize the various method using for the fusion and shown the comparative among them which will be provide a handy tools for adopting in the practice. The method of wavelet can be more fruitful when comes to more information data when compare to time and motion.

References

[1] Image Fusion for Remote Sensing Applications Leila Fonseca1, Laercio Namikawa1, Emiliano Castejon1, Lino Carvalho1, Carolina Pinho1 and Aylton Pagamisse2 1National Institute for Space Research, INPE 2São Paulo State University, Unesp, Brazil. Year 2009.

[2] Multispectral Image Fusion And Merging Using Multiscale Fundamental Forms , P. Scheunders and S. De BackerK. Elissa, " Year 0-7803-6725-1/01/$10.00200 01 IEEE

[3] Study Of Remote Sensing Image Fusion And Its Application In Image Classification, Wu Wenbo,Yao Jing∗,Kang Tingjun , School Of Geomatics,Liaoning Technical University, 123000, Zhonghua street, Fuxin, China yaojing1124@163.com.

[4] International Journal of Remote Sensing : Concepts, methods and applications C. Pohl & J. L. Van Genderen Published online: 25 Nov 2010.

[5] Challenges of remote sensing image fusion to Optimize earth observation data exploitation, Christine Pohl, PhD Institute of Geospatial Science & Technology (INSTeG), Universiti Teknologi Malaysia, Malaysia

[6] Image Fusion in Remote Sensing, Timo Bretschneider, Odej Kao, Department of Computer Science Technical University of Clausthal Julius-Albert-Str. 4 38678 Clausthal, Germany Year 2008.

[7] Wang Wenjie,2006. Image fusion technology based on wavelet transform.Chinese Academy of Sciences, a master's degree thesis.

[8] Different Levels of Image Fusion Techniques in Remote Sensing Applications and Image Classification by D. Padmini © 2014, IJARCSSE

[9] Data Fusion for Multi-sources Remotely Sensed Images Based on IHS Transformation and Wavelet Analysis, Wang Guang-jun School of Land Science and Technology China University of Geosciences Beijing, China, smartwgj@sohu.com, 2009 International Conference on Environmental Science and Information Application Technology

[10] A Way of Image Fusion Based on Wavelet Transform, Huaxun Zhang Electronic Engineering College Changchun University, Changchun, China, ccdxzhx@163.com, , 2013 IEEE 9th International Conference on Mobile Ad-hoc and Sensor Networks

[11] Wikipedia

[12] Firooz Sadjadi, "Comparative Image Fusion Analysis"

[13] Deepak Kumar Sahu, M.P.Parsai, "Different Image Fusion Techniques –A Critical Review", IJMER, Vol. 2, Issue. 5, Sep.-Oct. 2012 pp-4298-4301 ISSN: 2249-6645

[14] IMAGE FUSION PARAMETER ESTIMATION AND COMPARISON BETWEEN SVD AND DWT TECHNIQUE Gagandeep Kour1, Sharad P. Singh2 , M. Tech Student, Department of EEE, Arni University, Kathgarh, Himachal Pardesh, India-176401 ,Vol. 2, Issue 11, November 2013

