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Multi Temporal Image Fusion of Earthquake Satellite Images

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Abstract: The work presented here is concerned with the problem of Earthquake damage assessment using multi temporal satellite images. Remotely sensed data can provide valuable information for disaster assessment such as Earthquakes, Volcanic Eruptions, Landslides, Floods, Storm Surge, Hurricanes, Fires and Drought etc. Earthquake is one of the unavoidable natural hazards that cause lots of damages and problems to the economy, environment and the whole life of people. Prevention of earthquake is rarely achieved and such events continue to pose increasing threat to life and property. After the earthquakes, there is a need for rapid, accurate and reliable damage information in the critical post event hours to guide response activities. Disaster damage assessment using remotely sensed data can be carried out using multi temporal approach, which requires two images pre-damage and post-damage of the affected area that are compared to identify changes. However, the quality of the satellite images is not good as required to identify the changes. Therefore, image fusion methods are used to enhance the quality of the images. In the present work, we have performed the image fusion based quality enhancement of Earthquake satellite images. We have proposed an IHS and Wavelet transform based integrated image fusion technique for fusion of pre and post panchromatic and multispectral satellite images. We have also performed the comparison of proposed integrated technique with other techniques and the results of the proposed approach are quite promising.

Keywords: image fusion; damage assessment; wavelet transform; IHS; remote sensing

I. INTRODUCTION

A natural disaster can be defined as some impact of an extreme natural event on the ecosystem and environment, and on human activities and society. The concept relies on the interaction of a natural agent—the hazard—with human vulnerability to produce a risk that is likely to eventually materialize as a destructive impact.

In this context natural disaster are distinguished—earthquake, tsunami, landslide, flood, cyclone etc that we normally face in our country [19]. Earthquake is one of the unavoidable natural hazards that cause lots of damages and problems to the economy, environment and the whole life of people. Prevention of earthquake is rarely achieved and such events continue to pose increasing threat to life and property.

After the earthquakes, there is a need for rapid, accurate and reliable damage information in the critical post event hours to guide response activities. In reality it is still difficult to obtain that information rapidly, because of interruptions in communication systems and access difficulties in remote areas [20].

Disaster damage assessment is an important task. Remotely sensed data provide valuable information for disaster damage assessment. Rao, examines the use of remotely sensed data in three different phases (Mitigation, Preparedness and Recovery/Response) of disaster management for different disasters such as Earthquakes, Volcanic Eruptions, Landslides, Floods, Storm surge, Hurricanes, Fires and Drought [10].

The most important and challenging part of the disaster management is the recovery phase, since the situation after the event is usually not clear little is known about what happened exactly, where it happened and how many people were affected. For effective allocation of limited resources, there is a need for information about the extent and the concentration of damaged area in critical hours following a disaster. Moreover, this information needs to be accurate, reliable and provided in a timely and appropriate manner.

After a disaster, damage to critical lifelines, in particular telecommunication, roads, and power supply systems, creates limitations for the communication with the emergency agencies to get information about the current situation. In the case of the 2001 Gujarat earthquake, identification of affected villages took three days (Economic & Political Weekly, 2001). On the other hand, information coming from the field may not be reliable and accurate due to the stress and confusion in disaster area. Therefore, there is a strong need for information, which does not depend on actual access to the disaster area.

Remote sensing systems can provide valuable information for response activities. The use of remote sensing technology provides quantitative base information about damage and aftermath monitoring to assist recovery/response operations and help response and relief specialist in the decision making. Earthquake damage assessment using remotely sensed data can be carried out using multi temporal approach, which requires two images pre-damage and post-damage of the affected area that are compared to identify changes.

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. However, the quality of the satellite images is not good as required to identify the changes in the pre and post earthquake images.

Image fusion is used to enhance the quality of the multi temporal satellite images. Image fusion (IF) refers to the process of combining two or more images into one composite image, which integrates the information contained within the individual images. The result is an image that has a higher information content compared to any of the input images. Various techniques have been suggested for image fusion such as IHS, PCA, wavelet transform, Laplasian pyramid etc.

The proposed work presented the novel image fusion method for enhancing the quality of the earthquake satellite images. The rest of the paper is organized as follows. Section 2 gives the review of work that has already been done in this area. Section 3 gives the overview of the proposed methodology. Section 4 describes the experimental results and their analysis. Section 5 concludes the paper.

II. LITERATURE REVIEW

The goal of multi temporal image fusion is to integrate complementary and redundant information to provide a composite image which could be used to better understanding of the entire scene. Image fusion for change detection takes advantage of the different configurations of the platforms carrying the sensors.

The combination of these temporal images in same place enhances information on changes that might have occurred in the area observed. It has been widely used in many fields of remote sensing, such as object identification, classification, and change detection and disaster damage assessment etc.

Pohl, C. explained the concepts, methods and applications of image fusion as a contribution to multi-sensor integration oriented data processing [11]. Few survey papers have been published recently, providing overviews of the history, developments, and the current state of the art of image fusion in the image-based application fields [1, 3, 14]. Simone *et al.* describe three typical applications of data fusion in remote sensing, such as obtaining elevation maps from synthetic aperture radar (SAR) interferometers, the fusion of multi-sensor and multi-temporal images, and the fusion of multi-frequency, multi-polarization and multi-resolution SAR images [13].

Vijayaraj provided the concepts of image fusion in remote sensing applications [15]. The Standard fusion algorithms have been widely used for relatively simple and time efficient fusion schemes. Standard image fusion methods are often successful at improves the spatial resolution, however, they tend to distort the original spectral signatures to some extent [12,16].

Wavelet transforms provide a framework in which an image is decomposed, with each level corresponding to a coarser resolution band. Mallat et. Al, put all the methods of wavelet construction into the framework of functional analysis and described the fast wavelet transform algorithm and general method of constructing wavelet ortho-normal basis[5, 8, 9]. Candes provided a method for fusing SAR and visible MS images using the Curvelet transformation. The method was proven to be more efficient for detecting edge information and denoising than wavelet transformation [2].

Wavelet-based fusion could evidently perform better than convenient methods in terms of minimizing color distortion and denoising effects. However, problems associated with wavelet based fusion include computational complexity compared to the standard methods and Spectral content of small objects often lost in the fused images.

Artificial neural networks (ANNs) have proven to be a more powerful and self-adaptive method of pattern recognition as compared to traditional linear and simple nonlinear analyses [4, 7]. Quite a few researchers have focused on incorporating the traditional IHS method into wavelet transforms, since the IHS fusion method performs well spatially while the wavelet methods perform well spectrally [6, 17]. However, selection and arrangement of those candidate fusion schemes are quite arbitrary and often depends upon the user's experience.

D. Ozisik presented a post earth quake damage assessment using satellite and serial video imagery [10]. However, the use of remote sensing technology in disasters damage assessment is still limited.

III. PROPOSED METHODOLOGY

The overall schematic diagram of the proposed work is shown in figure 1.

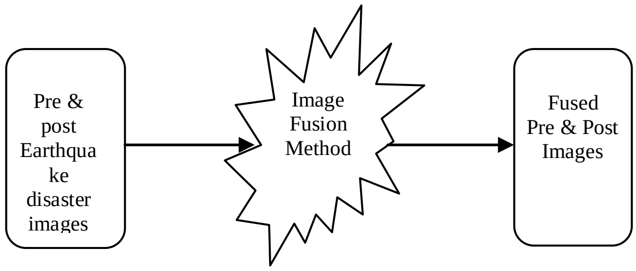

Figure 1. Schematic Diagram for earthquake disaster damage assessment using multi temporal images

The aim of designing a fusion scheme is to enhance the quality of the pre damage and post damage images of the earthquake disaster area. The technical objectives of the image fusion are to reduce color distortion and remove spatial distortion. Various techniques have been suggested for image fusion such as IHS, PCA, Brovey transform, wavelet transform, and Artificial Neural Network (ANN) and so on.

IHS fusion method usually can integrate color and spatial features smoothly. The color depth (or intensity) of the IHS fusion results is high (rich in color) and, if the correlation between the IHS intensity image and the panchromatic image is high, the IHS fusion can well preserve the color information. In the real cases, however, the color distortion is significant due to the low correlation between the intensity image and the panchromatic image.

On the other hand, the wavelet image fusion usually can better preserve color information than other conventional fusion methods, because the high-resolution spatial information from a panchromatic image is injected into all the three low-resolution multi spectral bands. However, the spatial detail from a panchromatic image is often different from that of a multi spectral band having the same spatial resolution. This difference may introduce color distortion into the wavelet fusion results.

Therefore, for better utilize the advantages of the IHS and the wavelet fusion techniques and to overcome the shortcomings of the two techniques, we have proposed here an IHS and wavelet based integrated image fusion approach to enhance the quality of the satellite images. The Similar approach also proposed by Zhang & Hong[17] to improve the pan sharpening quality of QuickBird and IKONOS images.

The detailed steps of this combined fusion method are as follows:

a. Transforming the multi spectral image into the IHS components (Forward IHS transforms). Before the IHS transform, the multi spectral image must be co-registered to the panchromatic image and re-sampled to the pixel spacing of the panchromatic image.
b. Applying histogram matching to match the histogram of the panchromatic image to that of the Intensity component (I), and obtaining a new panchromatic image.
c. Decomposing the new panchromatic image and the intensity component (I) into wavelet planes (a two-level decomposition is applied), respectively. The intensity image has the same pixel size as the panchromatic image.
d. Replacing the approximation image of the panchromatic decomposition (LLP) by that of the intensity decomposition (LLI) to inject grey value information of the intensity image into the panchromatic image. To avoid an over injection of the intensity information, the LLP at the second decomposition level is not completely, but partially, replaced by the LLI at the same level, namely a new approximation image (LLI) is first generated through a weighted combination of LLP and LLI, and then replaces the LLP of the panchromatic decomposition.
e. Performing an inverse wavelet transform to obtain a new intensity image, this has similar grey value distribution to that of the intensity image of IHS transform and contains the same spatial detail of the original panchromatic image.

Transforming the new intensity together with the hue and saturation components back into RGB space (inverse IHS transform).

IV. EXPERIMENTAL RESULTS

The image fusion system is implemented using MATLAB. One of the screens is shown in figure 2. For experimental purpose, we have collected the pre and post panchromatic and multi-spectral images of Haiti earthquake which was occurred in 12 Jan 2010. These images are the collection of Digital Global Imagery [18]. Figure 3 (a) and (b) shows the panchromatic and Multi Spectral images of Haiti earthquake, respectively. The PCA, IHS, Wavelet, and the proposed IHS and wavelet integrated transform are employed to fuse the two image data sets. Figure 3 (c) to (f) shows the fused images.

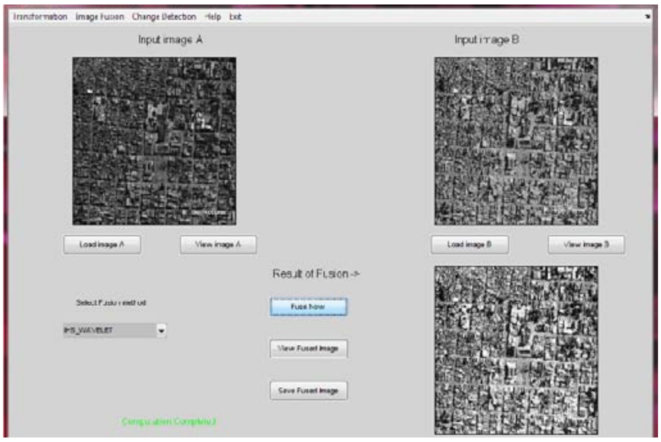

Figure 2. Screen shot of Image Fusion

(a)

(b)

(c)

(d)

(e)

(f)

Figure 3. (a) Original panchromatic image; (b) Original multispectral image with bands 1, 2, and 3; (c) PCA fusion result; (d) Wavelet fusion result; (e) IHS fusion result; (f) Result of the proposed IHS and wavelet integration

All the fused images have better quality than original non-fused images. The sharpness of the fused images has been significantly enhanced. First, we analyzed the performance of the various image fusion methods by qualitative approach i.e. visual observation of the generated results and we found that the result generated by the proposed integrated IHS Wavelet method is quite promising in comparison to other approaches. Second, we have applied the quantitative approach for result analysis of various image fusion methods. We have used deviation index(DI) spectral quality index measure, which measure the normalized global absolute difference of the fused image with low-resolution multispectral image. Spectral quality of fused images is shown in a better way by this measure.

Figure 4 shows deviation index for the fused images using PCA, IHS, Wavelet and IHS-Wavelet methods. It can be seen that the minimum values for all of the three bands belong to the integrated IHS wavelet image fusion method. We have also analyzed the control of the radiometric correspondence of the two images at a local scale, which can be performed by measuring the correlation coefficient(CC) between the two images.

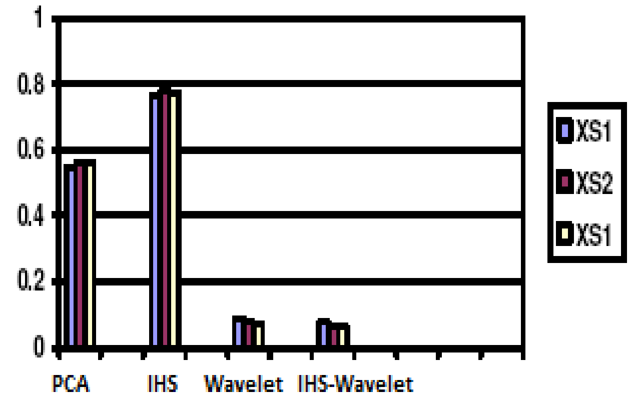

Figure 4. Deviation index of fused images

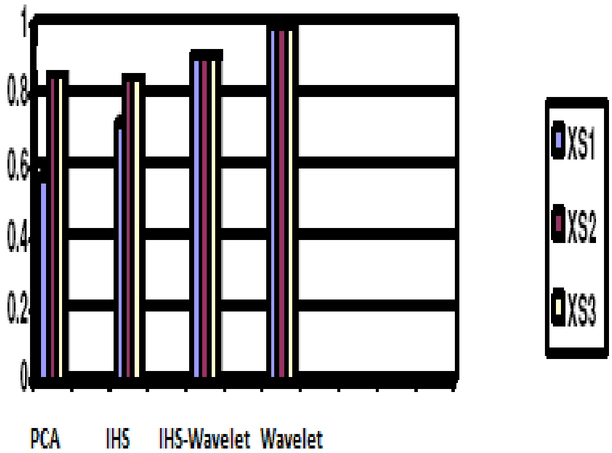

Figure 5. Correlation coefficients between images

Figure 5 show that the fused image with wavelet transform fusion method has the maximum correlation in all the three bands. Since the correlation coefficient represents the degree of similarity, the value of the correlation coefficient is desirable to be as higher as possible, but it cannot reach to 1 which means that the fused image is the same with the original multi-spectral image and no spatial information from panchromatic image is added to the fused image. In this sense, it shows that the wavelet based fusion method results has a very higher similarity between original multi-spectral image and the fused images. On the other hand, IHS-Wavelet integrated method has added some spatial information from the PAN image with spectral information of the MS image. The result analysis indicates that the generated results of the proposed approach are quite promising in comparison to other approaches.

V. CONCLUSIONS

This research was developed a novel image fusion method based on wavelet and IHS transform. The method was applied the IHS transform to fuse spatial information of the high-resolution image into the low-resolution multispectral image, through using the wavelet transform to generate a new high resolution component that highly correlates to the intensity component of the IHS transform. Then, the new component was used to replace the intensity image for a reverse IHS transform. The fused image was obtained after the reverse IHS transform.

Various image fusion methods such as PCA, Wavelet and IHS were also analyzed, and their fusion results were compared to the IHS and wavelet integrated method using qualitative as well as quantitative approaches. We were performed the experiment on various image data sets of Haiti Earthquake. The results of image fusion methods on one image data set of Haiti earthquake were shown in the experimental results section. Promising results were achieved with the new fusion method in comparison to other methods.

VI. REFERENCES

[1] Blum R.S. and Liu Z. (2006), "Multi-Sensor Image Fusion and Its Applications," special series on Signal Processing and Communications, CRC Press: Boca Raton, FL, USA.

[2] Candes E.J. and Donoho D.L. (2000), "Curvelets-A Surprisingly Effective Non-adaptive Representation for Objects with Edges," Curves and Surfaces, Vanderbilt University Press: Nashville, TN, USA, pp. 105–120.

[3] Dasarathy B.V. (2007), "A special issue on image fusion: advances in the state of the art," International Journal of Information Fusion.

[4] Dong J. et al. (2004), "An artificial neural network model for estimating crop yields using remotely sensed information," International Journal of Remote Sensing, vol. 25, pp. 1723–1732.

[5] Ganzalo P. and Jesus M.A. (2004), "Wavelet-based image fusion tutorial," Pattern Recognition.vol. 37, pp. 1855–1872.

[6] Krista A. et al. (2007), "Wavelet based image fusion techniques–An introduction, review and comparison," International Journal of Photogrammetric Engineering & Remote sensing vol. 62, pp. 249–263.

[7] Louis E.K. and Yan X.H. (1998), "A neural network model for estimating sea surface chlorophyll and sediments from thematic mapper imagery," International Journal of Remote Sensing Environment. Vol. 66, pp. 153–165.

[8] Ma H. et al. (2005), "Multisource image fusion based on wavelet transforms fusion," International Journal of Information Technology, vol. 11, pp. 81–91.

[9] Mallat S.G. (1989), "Theory for multi resolution signal decomposition: the wavelet representation," IEEE Trans. Pattern Analysis Machine Intelligence, pp. 674–693.

[10] Ozisik D.(2004), "Post earth quake damage assessment using satellite and serial video imagery," M.S. Thesis pp. 1-145.

[11] Pohl, C. and Van Genderen (1998), "Multi sensor image fusion in remote sensing: concepts, methods and applications," International Journal of Remote Sensing Vol. 19, pp. 823–854.

[12] Pouran, B. (2005), "Comparison between four methods for data fusion of ETM+ multispectral and pan images," International Journal of Geo-spatial Information Science. Vol. 8, pp. 112–122.

[13] Simone G. et al. (2002), "Image fusion techniques for remote sensing applications,' International Journal of Image Fusion vol. 3, pp. 3–15.

[14] Singh A. (1989), "Digital change detection techniques using remotely-sensed data," International Journal of Remote Sensing., vol. 10, no. 6, pp. 989–1003.

[15] Vijayaraj V. Et al. (2006), "Concepts of image fusion in remote sensing applications," In Proceedings of IEEE International Conference on Geo science and Remote Sensing Symposium, Denver, CO, USA, pp. 3798–3801.

[16] Yun Z. (2004), "Understanding image fusion," International Journal of Photogrammetric Engineering and Remote Sensing, vol. 6, pp. 657–661.

[17] Zhang Y. and Hong G. (2005), "An HIS and wavelet integrated approach to improve pan-sharpening visual quality of natural color IKONOS and QuickBird image fusion," International Journal of Information Fusion, vol. 6, pp. 225–234.

[18] http://www.digitalglobe.com/index.php/27/Sample+Imagery

[19] http://en.wikipedia.org/wiki/Natural _Disaster

[20] http://en.wikipedia.org/wiki/Earthquake

