Implementation of Wavelet Based Enhanced Pyramid Decomposition Algorithm for Pixel-Level Image Fusion

Naik Ashwini S.[1], Bhaskar P.C.[2]

[1, 2]Department of Technology, Shivaji University, Kolhapur, Kolhapur, India

Abstract: ***This paper presents concept of software simulation of enhanced wavelet based pyramid decomposition algorithm for application of image fusion using MATLAB Simulink Library. Simulink library Blockset is used to implement a model which is able to do the pixel level averaging image fusion. DWT is implemented with the filter banks whose levels can be adjusted. The perfect reconstruction can be obtained with the down sampling of the images. Wavelet decomposition provides a simple hierarchical framework to fuse images with different spatial resolution. It is a powerful tool to separate the spectral content of an image from the spatial information.***

Keywords: Image fusion, DWT, Simulink

1. Introduction

Image fusion is emerging and powerful technology in image processing. Image fusion is the process of combining relevant information from two or more images into a single image. The resultant image is more informative than any of the input image. The term "image fusion" often refers to the process of combining information from different imaging modalities of scene in a single composite image representation that is more informative and appropriate for visual perception or further processing [2]. Image fusion has wide range of applications such as object detection, automatic target recognition, flight vision, remote sensing, computer vision, robotics etc. image fusion is usually done in three different levels of image representation they are Data fusion(low level), feature fusion(Intermediate level) and Decision level. In Pixel fusion method, integration is performed at a level where pixels are least processed and each pixel in fused image is calculated from the input images. Feature level fusion method requires extraction of features from the input images, and fusion is done based on features that matches certain selection criteria.

Decision level fusion combines decisions coming from several experts. A large number of different image fusion methods have been proposed mainly due to the different available data types and various applications. The wavelet transform emerged in the field of image/signal processing as an alternative to the well-known Fourier Transform (FT) and its related transforms. In the Fourier theory an image is considered as a finite 2-D signal is expressed as a sum, theoretically infinite, of sines and cosines, making the FT suitable for infinite and periodic signal analysis[4]. The wavelet transform could perform multi-resolution time-frequency analysis. This great property makes wavelet transform suitable for image fusion along with applications such as image compression, edge detection, and filter design[6]. Pixel-level techniques that work in the spatial domain have gained significant interest mainly due to their simplicity and linearity. Multi resolution analysis is another popular approach for pixel level image fusion using filters with increasing spatial level in order to produce a pyramid sequence of images at different resolutions. In most of these approaches, at each position of the transformed image, the value in the pyramid that corresponds to the highest saliency is used. Finally, an inverse transformation of the composite image is employed in order to derive the fused image [9].

2. Related Work

Bouden Toufik1 and Nibouche Mokhtar2 1Automatic Department, Laboratory of Non Destructive Testing, Jijel University Bristol Robotic Laboratory, Department of Electrical and Computer Engineering, University of the West of England has explained in " The Wavelet Transform for Image Processing Applications" adoption of some wavelet-based schemes to add features inherent to the transform, such as time-scale localisation and multiresolution capabilities.

A Reconfigurable Computing Primer, Multimedia Systems Design, pp. 44-47 Bradley, J.; Brislawn, C. & Hopper, T. (1993). The FBI Wavelet/Scalar Quantization Standard for Gray-scale Fingerprint Image Compression, Tech. Report LA-UR-93- 1659, Los Alamon Nat'l Lab, Los Alamos focused on basic concepts of the wavelet transform.

Burt, P. J. & Adelson, A. E. (1983). The Laplacian pyramid as a compact imageode, IEEE on Communications, Vol. 31, No. 4, (Apr 1983), pp. 532-540, ISSN 0090-6778 in this historical development of the wavelet transform and its advent to the field of signal and image processing were reviewed.

Burrus, C. S.; Gopinath, R. A. & Guo, H. (1998). Introduction to Wavelets and Wavelet Transforms: A primer, Prentice Hall presented features and the mathematical foundations behind the wavelet transforms and also advantages over fourier transform.

Chrysafis, C. & Ortega, A. (2000). Line based reduced memory wavelet image compression,IEEE Transactions on Image Processing, Vol. 9, No. 3, pp. 378-389, 010-1024, ISSN 1057-7149 describes various terms related such as the scaling function, multi resolution, filter bank and others with wavelet transform and discrete wavelet transform.

M. N. & Vetterli, M. (January 2003). The finite ridgelet transform for image representation. IEEE Transactions on Image Processing, Vol. 12, No. 1, pp. 6–28, ISSN 1057-7149 explained the image presentation and processing using the various tools required for image data enhancement.

Daubechies, I. (1988). Orthonormal bases of compactly supported wavelets, Communications on Pure and Applied Mathematics, Vol. 41, pp. 909-996 described the image processing techniques using the spatial wavelet transform.

A.Goshtaby and S. Nikolov, "Image fusion: Advances in the state of the art," Inf. Fusion, vol. 8, no. 2, pp. 114–118, Apr. 2007 describes the basics related to the image fusion and relevant advances in the image processing for fusing image.

R. S. Blum and Z. Liu, Eds., Multi-Sensor Image Fusion and Its Applications (Special Series on Signal Processing and Communications).New York: Taylor & Francis, 2006 elaborated need for image fusion that are obtained using multi sensor and its application area such as remote sensing, satellite, night vision and manyothers.

V. Tsagaris and V. Anastassopoulos, "Multispectral image fusion for improved RGB representation based on perceptual attributes," Int. J. Remote Sens., vol. 26, no.15, pp. 3241–3254, Aug. 2005 in this paper it is explained that the multispectral and multi resolution images are exctracted using algorithm and then images are fused to enhance the image properties. G. Piella, "A general framework for multiresolution image fusion: From pixels to regions," Inf. Fusion, vol. 4, no. 4, pp. 259–280, Dec. 2003 described a design flow for multi resolution image fusion.

C. Thomas, T. Ranchin, L. Wald, and J. Chanussot, "Synthesis of multispectral images to high spatial resolution: A critical review of fusion methods based on remote sensing physics," IEEE Trans. Geosci. Remote Sens., vol. 46, no. 5, pp. 1301–1312,

May 2008 in this review paper various approaches towards the image fusion. W. Zhang and J. Kang, "QuickBird panchromatic and multi-spectral image fusion using wavelet packet transform," in Lecture Notes in Control and Information Sciences, vol. 344. Berlin, Germany: Springer-Verlag, 2006, pp. 976–981.this paper describes the integration of the wavelet packet transform for multi spectral image fusion which are required for remote sensing.

Dimitrios Besiris, Vassilis Tsagaris, Member, IEEE, Nikolaos Fragoulis, Member, IEEE, and Christos Theoharatos, Member, IEEE in An FPGA-Based Hardware Implementationof Configurable image fusion explained the hardware implementation of the image fusion algorithm.

3. Proposed Method

The literature study emphases fact that even though lot of work has been done in pixel level image fusion there is still scope in this area. Sensor data fusion has become a discipline which demands more formal solutions to number of application cases. Several situations in image processing requires both high spatial and high spectral information in single image. However instruments are not capable of providing such information either by design or because of observational constraints. One possible solution for this is data fusion or image fusion.

Image fusion can be done either in spatial domain or transform domain. But spatial domain methods tends to produce spatial distortion in resultant image. Spatial distortion can be very well handled by frequency domain approach. Among different transform domain approach Discrete Wavelet transform has become a very powerful tool. Multi resolution representation of images by pyramid data structures has become very popular in several areas image processing. The most known hierarchical transform structures are the Gaussian and Laplacian pyramids. The reconstruction of the image by the Gaussian expand operation is not perfect, but some image blurring occurs. The difference between the original and the interpolated images gives Laplacian pyramid.

In image coding and transmission applications the Laplacian pyramid operation is frequently used to generate the exact reconstruction. The effective solutions to the image fusion problem are making fast implementations in order to boost related techniques and, therefore, be successfully used in area of computer vision applications. Real-time implementation of image fusion systems is very demanding, since it employs algorithms with a relatively high runtime complexity. Hardware implementations have emerged as a mean to achieve Real-time performance in image processing systems. The complementary nature of visible and nonvisible sensors makes it possible to obtain useful image under varying conditions. In these types of applications FPGA is best suited as it is flexible and having the better power efficiency. FPGAs have higher speed and smaller size for real time application than the other platforms. So we are proposing a method that integrates Laplacian pyramid algorithm, spatial frequency and wavelets. The proposed system is shown in Fig 1.

First step is preprocessing an images. Presence of noise degrades the image quality hence noise removal is one of the most important preprocessing task. Denoised images are then decomposed by using 2D-DWT. The decomposed coefficients are then fused using Enhanced Pyramid algorithm. The final step is reconstructing image in to its original form. Fused image is obtained by performing Inverse DWT.

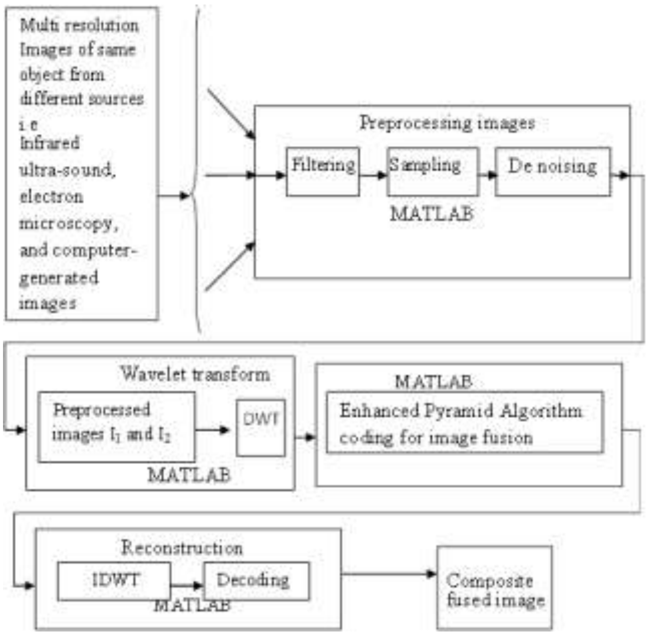


Figure 1: Block Diagram of proposed method

4. Implementation

Simulink is an additional toolbox that runs on top of MATLAB. To start this, type “Simulink” in the Command Window or click on the Simulink icon. Simulink library provides various blocks that particularly for image processing applications. Image source and image viewer are Simulink block sets by using these blocks image can give as input and output image can be viewed on video display block set. Image pre-processing and image post-processing unite are common for all the image processing applications which are designed using Simulink blocksets.

Here in this model some of the image processing blocks are used such as image from file which is used to browse the required image. Along with this resize block is used to equalize the number of pixels before the R’G’B’ to intensity block that performs the gray conversion of image. Thus the two images are preprocessed using the preprocessing blocks in the Simulink library. These images are then given as input to the Discrete FIR filter which are designed as Low Pass Filter and High Pass filter respectively. Thus these images are filtered and up sampled to decompose the images with level of 2. Thus the low frequency components i.e low pixel value and high frequency component i.e high pixel values are separated and then added in the ADD block of the Simulink library.

Low valued pixels as well as high valued pixels from individual images are added together to fuse the two different images but as when two pixels are added its value increases beyond limits. Therefore there is need to divide the pixel value by two so that Divide Block of Simulink library is used. These images are then up sampled to form a composite image. Simulink library provides two separate sampling blocks such as up sample and down sample along with this to display the images the block Video display is used. Thus the model is divided in the three sections such as 1) Image acquisition and preprocessing 2) Wavelet decomposition 3) Image fusion

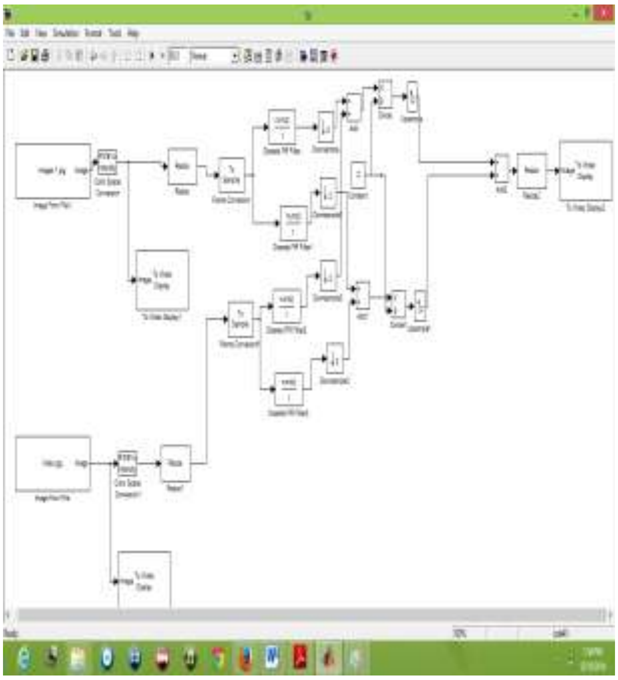


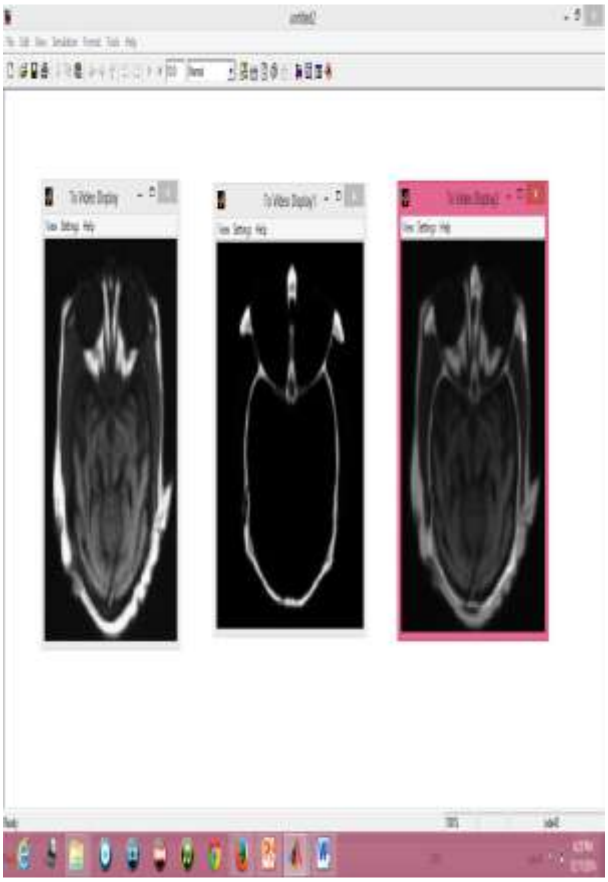
Image fusion is obtained using the averaging method the mean value is calculated of two different images after the decomposition of images. Matlab Simulink environment which can be directly utilized for building algorithmic model. The algorithms are developed and models are built for image fusion application using wavelet decomposition These models are simulated in Matlab Simulink environment with suitable simulation time and simulation mode and tested. The reflected results can be seen on a video display

5. Future Scope

Enhanced pyramid algorithm will then applied as fusion algorithm and the fused image which is more informative than two input images is obtained. As a hardware implementation enhanced wavelet based pyramid decomposition algorithm will be verified on FPGA for the application of image fusion. A hardware implementation of a real-time fusion system is proposed. The system is based on SPARTAN or VERTEX FPGA and implements a configurable linear pixel level algorithm which is able to result in color fused images using VHSIC or VHDL hardware description language. The overall architecture is based on a DWT module, pyramid decomposition algorithm and IDWT module for reconstruction.

6. Results

The results of the image fusion based on the wavelet decomposition algorithm which is implemented using MATLAB Simulink Library is as shown in the fig. The composite fused image obtained is having the resolution as per the variable size which is designed using resize block.



7. Conclusion

The MATLAB tool Simulink library is a new application in image processing and offers a friendly environment design for the processing, because processing units are designed by blocks. This tool support software simulation, but the most important is that can be used synthesize in FPGAs hardware using system generator, with the parallelism, robust and speed, this features are essentials in image processing.

The Wavelet transforms is the very good technique for the image fusion provide a high quality spectral content. But a good fused image have both quality so the combination of DWT & spatial domain fusion method (like PCA) fusion algorithm improves the performance as compared to use of individual DWT and PCA algorithm.

References

[1] A Reconfigurable Computing Primer, Multimedia Systems Design, pp. 44-47Bradley, J.; Brislawn, C. & Hopper, T. (1993). The FBI Wavelet/Scalar Quantization Standard for Gray-scale Fingerprint Image Compression, Tech. Report LA-UR-93-1659, Los Alamon Nat'l Lab, Los Alamos

[2] Burt, P. J. & Adelson, A. E. (1983). The Laplacian pyramid as a compact image code, IEEE Transactions on Communications, Vol. 31, No. 4, (Apr 1983), pp. 532-540, ISSN 0090

[3] Burrus, C. S.; Gopinath, R. A. & Guo, H. (1998). Introduction to Wavelets and Wavelet Transforms: A primer, Prentice Hall

[4] Chrysafis, C. & Ortega, A. (2000). Line based reduced memory wavelet image compression,IEEE Transactions on Image Processing, Vol. 9, No. 3, pp. 378-389, 010-1024, ISSN 1057-7149

[5] M. N. & Vetterli, M. (January 2003). The finite ridgelet transform for image representation. IEEE Transactions on Image Processing, Vol. 12, No. 1, pp. 6–28, ISSN 1057-7149

[6] Daubechies, I. (1988). Orthonormal bases of compactly supported wavelets, Communications on Pure and Applied Mathematics, Vol. 41, pp. 909-996

[7] A. Goshtaby and S. Nikolov, "Image fusion: Advances in the state of the art," Inf. Fusion, vol. 8, no. 2, pp. 114–118, Apr. 2007

[8] R. S. Blum and Z. Liu, Eds., Multi-Sensor Image Fusion and Its Applications (Special Series on Signal Processing and Communications).New York: Taylor & Francis, 2006

[9] V. Tsagaris and V. Anastassopoulos, "Multispectral image fusion for improved RGB representation based on perceptual attributes," Int. J. Remote Sens., vol. 26, no. 15, pp. 3241–3254, Aug. 2005

[10] G. Piella, "A general framework for multiresolution image fusion: From pixels to regions," Inf. Fusion, vol. 4, no. 4, pp. 259–280, Dec. 2003

[11] C. Thomas, T. Ranchin, L. Wald, and J. Chanussot, "Synthesis of multispectral images to high spatial resolution: A critical review of fusion methods based on remote sensing physics," IEEE Trans. Geosci. Remote Sens., vol. 46, no. 5, pp. 1301–1312, May 2008

[12] W. Zhang and J. Kang, "QuickBird panchromatic and multi-spectral image fusion using wavelet packet transform," in Lecture Notes in Control and Information Sciences, vol. 344. Berlin, Germany: Springer-Verlag, 2006, pp. 976–981.

[13] Dimitrios Besiris, Vassilis Tsagaris, Member, IEEE, Nikolaos Fragoulis, Member, IEEE, and Christos Theoharatos, Member, IEEE in An FPGA-Based Hardware Implementation of Configurable Image Fusion

[14] Nibouche, M.; Nibouche, O. & Bouridane, A. (Dec. 2003). Design and implementation of a wavelet based system, Electronics, Circuits and Systems, 2003. ICECS 2003.Proceedings of the 2003 10th IEEE International Conference, Vol. 2, pp. 463-466, ISBN 0-7803-8163-7

[15] V. Tsagaris and V. Anastassopoulos, "Multispectral image fusion for improved RGB representation based on perceptual attributes," Int. J. Remote Sens., vol. 26, no. 15, pp. 3241–3254, Aug. 2005.