Image Fusion Scheme for 2D Images Based On Wavelet Transform Domain

D.Y. Anil
P.G Student,
Department of Computer Science & Engineering, AIT
Chikmagalur
anilyogaraj@gmail.com

Mrs. Pushpa
Associate Professor & HOD
Department of Computer Science & Engineering
Chikmagalur
flowersunpr@yagoo.co.in

Abstract— **In this paper we have presented a method for fusing 2-D images using wavelet transform under the combine gradient and smoothness criterion. The usefulness of the method had been illustrated using various experimental image pairs such as multi-focus, multi-sensor satellite image and CT and MR images of cross-section of human brain. The result of the proposed method have been compared with that of some widely used wavelet transform based image fusion methods both qualitatively and quantitatively. Experimental results reveal that the proposed method produces better fused image than other methods. The use of both gradient and relative smoothness criterion forms two fold effects. The gradient criterion ensure that edges in the image are included in the fused image, while the relative smoothness criterion ensure that the areas of uniform intensity are also included in the fused image thus the effect of noise is minimized.**

***Index Terms*—image fusion, wavelet transform, multi-resolution**

I .INTRODUCTION

Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images. The fusions of image is often required for image acquired from different instrument modalities or capture techniques of the same scene or object like multi-sensor, multi-focus and multi-modal images.

For example, in multi-focus imaging one or more object may be in focus in a particular image, while other objects in the scene may be in focus in other images. For the remotely sensed images, some have good spectral information whereas other have high geometric resolution. In the field of medical imaging, two widely used modalities, namely the magnetic resonance imaging (MRI) and the computed tomography (CT) scan do not provide every detail of brain structure. The CT scan is especially suitable for imaging bone structure and hard tissues, while the MR images are skull base. These images are thus complementary in many ways and no single image is totally sufficient in terms of their respective information content. Important applications of the fusion of images are medical imaging, microscopic imaging, remote sensing and robotics.

The first step toward image fusion is the registration which brings down the constituting images to a common coordinate system as fusion of images is meaningful only when common Objects in image have identical geometric configuration. With respect to size, location and orientation in all the images. In the next step, the images are combined to form a single fused image through a judicious selection of proportions of different features from different images.

II. LITERATURE SURVEY

Fusion techniques include the simple method of pixel averaging to more complicated method such as principal component analysis and wavelet transform fusion. Several approaches to image fusion can be distinguished, depending on whether the image are fused in the spatial domain or they are transformed into another domain, and their transforms fused.

In 1989 Li et al. [1] have suggested a multisensory image fusion using wavelet transform in which a cascaded sequence of forward and reverse wavelet transform on multimodal images produces a fused image. Other common wavelet transforms coefficients in each sub-band with largest magnitude. Burt and Kolczynski used a normalized correlation between the two images sub-bands over a small local-area and the resultant coefficients is calculated from this measure via a weighted average of the two images coefficients.

In 1995 H. Li, B.S. Manjunath, S.K. Mitra. [4] Proposed a Multi Sensor Image Fusion using Wavelet Transform in which the image fusion scheme is presented, the wavelet transforms of the input images are appropriately combined, and the new image is obtained by taking the inverse wavelet transform of the fused wavelet coefficients. An area-based maximum selection rule and a consistency verification step are used for feature selection. A performance measure using specially generated test images is also suggested.

In 2002, Zhu Shu-long [7] Image Fusion using Wavelet Transform is proposed. Extracting more information from multi-source images is an attractive thing in remotely sensed image processing, which is recently called as image fusion is presented. In the paper, the image fusion algorithm based on wavelet transform is proposed to improve the geometric resolution of the images, In which two images to be processed are firstly decompose into sub-images with different frequency, and then the image fusion is performed using these images under the certain criterion, and finally these images are reconstructed into the result image with plentiful information.

In 2002, Paul Hill, Nishan Canagarajah and Dave Bul [6], proposed a Image Fusion using Complex Wavelets in which 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. Shift invariance of the wavelet transform is important in ensuring robust sub band fusion. Therefore, the novel application of the shift invariant and directionally selective Dual Tree Complex Wavelet Transform (DT-CWT) to image fusion is now introduced. This novel technique provides improved qualitative and quantitative results compared to previous wavelet fusion methods.

In this paper, an image fusion algorithm based on wavelet transform is proposed. In the proposed scheme, the image to be processed are decomposed into sub-images with the same resolution at same level and different resolution at different resolution at different levels and the information fusion is performed using high-frequency sub-images under combined 'gradient' and ' relative smoothness' criterion and finally this images are reconstructed into a resultant image having plentiful information. The developed scheme is applied to fuse multi-focus, multi-modal and remotely sensed multi-sensor images.

III. METHODOLOGY

Wavelet transform is a powerful mathematical tool used in the fields of signal processing. It is used to divide the given function or signal into different scale components such that each scale component can be studied with a resolution that it matches.

In a multi-focus and multi-sensor image acquisition system, the size, orientation and location of an object relative to its own background may not be identical in all the image of different modalities. The fusion of multi-focus or multi-sensor information is possible only if the images are registered or positioned with respect to a common coordinate system.

The most common form of transform image fusion is wavelet transform fusion. In common with all transform domain fusion techniques the transformed images are combined in the transform domain using a defined fusion rule then transformed back to the spatial domain to give the resulting fused image.

Wavelet transform fusion is more formally defined by considering the wavelet transform 'w' of the 'n' registered input images Ij(x,y), j=1,2… n together with the fusion rule 'f'. Then, the inverse wavelet transform 'w^{-1}' is computed, and the fused resulting image I(x,y) is reconstructed as depicted in figure 1.

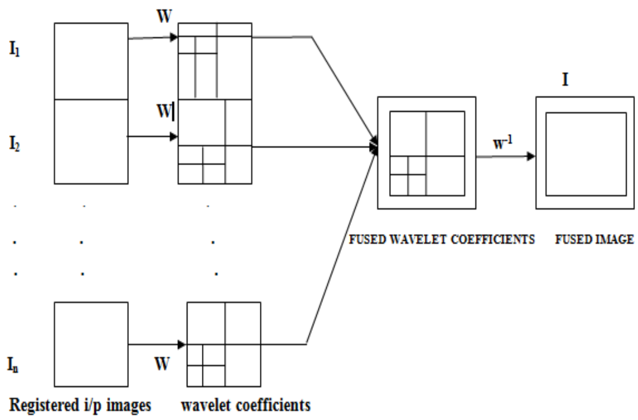

Figure1: Image fusion using wavelet transform

In the above figure we have got 'n' registered input images. Firstly we are going to apply wavelet transform 'W' (levels=6) to these registered images after that we wish to combine the coefficients of high frequency sub bands under the combined smoothness and gradient criterion and the coefficients of low frequency sub bands are added up then finally in order to get the fused image inverse wavelet transform W^{-1} is performed.

III. PROPOSED IMAGE FUSION ALGORITHM

We proposed a scheme for fusion of 'n' registered set of images of same scene obtained through different modalities. The basic idea is to decompose each registered image into sub-images using forward wavelet transform which have same resolution at same level and different resolution at different levels. The proposed scheme uses two criterions namely the gradient and smoothness.

A. THE GRADIENT CRITERION

Given a gray image I(x,y), the gradient at any pixel location (x,y) is obtained by applying two dimensional direction [7].

Derivative [ ] [ ] (1)

The gradient magnitude and two fast decreasing approximations [7], can be obtained as:

G=| | √ | | | | (2)

The equation (2) is used to find the gradient values of the decomposed input images.

B. THE RELATIVE SMOOTHNESS CRITERION

The second criterion of the relative smoothness uses the statistical moments of gray-level histogram of the region in the neighborhood of the pixel (x,y). let z be the random variable denoting gray level and p(z_i), i=1,2…L-1,be the corresponding histogram of the region in the neighborhood of pixels(x,y), where L is the number of distinct gray levels. The second moment or variance of z about mean is given by

$$\sum \qquad (3)$$

Where m is the mean gray level of z given by

$$\sum \qquad (4)$$

The equation (3) and (4) is used to determine the variance and mean of z respectively.

The measure for relative smoothness in the neighborhood of pixel (x,y) can be thus established as:

$$R(x,y)= 1 - \frac{\;}{\;} \qquad (5)$$

The equation (5) measure near zero in neighborhoods of constant intensity and approaches one of the large variances.

C.IMAGE FUSION

Let $I_1(x,y)$, $I_2(x,y)$, ….,I_n (x,y) be the n registered image to be fused. The decomposed low frequency also referred to as the approximation coefficients sub-images be $1I_{1j}(x,y)$,$1I_{2j}$,…$1I_{nj}(x,y)$ and decomposed high frequency also called as the detailed coefficients be $hI_{1j}^k(x,y)$, $hI_{2j}^k(x,y)$,… $hI_{nj}^k(x,y)$ respectively, where 'j' is the parameter of resolution, j=1,2…J and for every 'j', 'K' = 1,2,3 which represent directional sensitive wavelet decomposition namely along horizontal, vertical and diagonal directions. For every even parameter of resolution i.e. j=2, 4…J, the magnitude of the gradient of the image generated from the high frequency components be GIijk(x, y), i=1, 2…n. For every odd parameter of resolution i.e. j=1, 3, J, the relative smoothness of the image generated from the high frequency components be $RI_{ij}^K(x, y)$, i=1, 2…n.

The fused high frequency sub-images are evaluated as:

$$I_n^k(x,y)=hI_{pj}^k(x,y) \qquad (6)$$

Where $GI_p^k(x,y)=max_i\{GI_{ij}^k(x,y)\}$

For j=2,4….J, k=1,2,3

$$I_j^k(x,y)=hIpj^k(x,y) \qquad (7)$$

If $RI_{pj}^k(x,y)=maxi\{RI_{ij}^k(x,y)\}$

For j=1,3..J , k=1,2,3

The fused low frequency sub-images are:

$$Ij(x,y)= \sum \qquad (8)$$

Where c_i is the parameter which determine the contribution from each image.

IV. DISCUSSION AND ANALYSIS

The fusing ability of the algorithm is measured quantitatively by means of, say, pixel-gray-level correlation between two images. The correlation between two images f(x, y) and g(x,y) [7],is defined as

$$(f,g)=\frac{\sum}{\sqrt{\sum}\sqrt{\sum}} \qquad (9)$$

Where = mean (f(x,y)) and ¯= mean(g(x,y))

Equation (9) is used to find the correlation between the two input images or between the input image and the fused image. By finding the values of CR the quality of fused image is found.

The Haar Wavelet was used as the mother wave and the resolution parameter 'j' was taken up to 6. The use of Haar wavelet was for the ease of implementation. Our aim was to go for a multi-resolution description of the image prior to fusion for which we need a filter, without loss of generality we chose Haar wavelet. The fused image enjoys relatively high correlation with either of the images. This implies features of both the images are transported to the fused image. We did not restrict our algorithm to work on any specific type/class of images. Equal contribution of each low frequency sub image was considered in the experiments.

Figure .2(a)

Figure 2(a) – shows the input image1 where the clock in front is in focus.

Figure.2 (b)

Figure 2(a) – shows the input image1 where the clock in front is in focus.

Figure 2(c) – shows the output image obtained after fusion

.

In the first experiment a pair of multi-focus image was taken. In figure 2(a) the clock in front is in focus while in figure 2(b) the clock at the back is focused. Figure 2(c) shows the image obtained after fusion.

Sl No	CR(originalimage1,originalimage2)	CR(fuseimage,originalimage1)	CR(fuseimage,originalimage2)
1	0.9544	0.9887	0.9866

The fused images enjoy relatively high correlation with either of the images.

In our experiment the computed values of *CR* (FuseImage, originalImg1), *CR* (FuseImage, OriginalImg2) and *CR* (OriginalImage1, OriginalImage2) is computed.

A. Comparison with existing fusion algorithms

Wavelet based image fusion is one of the most commonly used methods to achieve image fusion. Many different schemes have been proposed for the same. The following three previously developed fusion rule schemes were implemented using discrete wavelet transform based image fusion and the results were compared with the proposed scheme.

(i) Maximum selection (MS) scheme: This simple scheme just picks the coefficient in each sub-band with the largest magnitude

(ii) Weighted average (WA) scheme: The resultant coefficient for reconstruction is calculated from weighted average of the two images‟ coefficients.

(iii) Gradient criterion selection ($GS) scheme: This was proposed by Zhu Shu-long in [7]. The scheme picks the coefficient in each sub-band with the largest magnitude of the gradient defined over the neighborhood.

TABLE II. CORRELATION MEASURE BETWEEN FUSION SCHEMES

Fusion scheme	CR(fuseimage, originalmage1)	CR(fuseimage, originalmage2) .
Proposed scheme	0.9887	0.9866
MS	0.9885	0.9864
WA	0.9885	0.9866
GS	0.9883	0.9867

The comparative results of measure of correlation are shown in TABLE II.

In the proposed algorithm the quality of the fused image is improved and from this fused image more information can be reconstructed thus improving the human and machine perception.

V. CONCLUSIONS

A scheme for fusion of multi-resolution 2D gray level images based on wavelet transform is presented in this project. If the images are not already registered, a point-based registration, using affine transformation is performed prior to fusion. The images to be fused are first decomposed into sub images with different frequency and then information fusion is performed using these images under the proposed gradient and relative smoothness criterion. Finally these sub images are reconstructed into the result image with plentiful information. A quantitative measure of the degree of fusion is estimated by cross-correlation coefficient and comparison with some of the existing wavelet transform based image fusion techniques is carried out. It should be noted that the proposed algorithm is domain independent. Therefore, it can be applied to fusion of different kinds of multi-modal images. Second, as the actual fusion is done during the construction of modified coefficients, the scheme has been extended to fusion of 'n' images as already proposed in the algorithm. As stated earlier we can use the same method for fusing colored images. We can covert the colored images from RGB (Red, Green, Blue) to HIS

(Hue, Saturation, Intensity) space and process only the Intensity component of the HIS space to acquire the fused image However, our method is computationally more expensive and needs more space for implementation. We wish to extend our work for fusing multi-resolution images.

VI.REFERENCES

[1] Stephane G. Mallat, "A Theory for Multi-resolution Signal Decomposition: The Wavelet Representation", IEEE Transaction on Pattern Analysis and Machine Intelligence. Vol. II No. 7, pages 671-693, July 1989.

[2] A. Colligon, D. Vandermeulen, P. Seutens, G. Marchal, "Registration of 3D multimodality medical imaging using surfaces and point landmarks", Pattern Recognition Lett. 15, pp.461-467, (1994).

[3] S. Banerjee, D.P. Mukherjee, D. Dutta Majumdar, "Point landmarks for the registration of CT and MR images", Pattern Recognition Lett. 16, 1033- 1042, (1995).

[4] H. Li, B.S. Manjunath, S.K. Mitra, "Multisensor image fusion using the wavelet transform", GMIP: Graphical Models Image Process. 57(3) pp.235-245 (1995).

[5] A.A. Goshtasby, J.L. Moigne, "Image registration Guest Editor's introduction", Pattern Recognition 32, 1-2, (1999).

[6]PAUL Hill, Nishan Canagarajah and Dave Bull, "Image Fusion using Complex Wavelets", BVMC 2002.

[7] Zhu Shu-long, "Image Fusion Using Wavelet Transform", Symposium on Geospatial Theory, Process and Applications, Ottawa 2002.

[8] Paul Hill, Nishan Canagarajah and Dave Bull, "Image Fusion using Complex Wavelets", BVMC 2002.

[9] Image fusion by H.B Mitchell.(theories ,techniques and application of image fusion 2008).