Medical Image fusion with Stationary Wavelet Transform and Genetic Algorithm

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ABSTRACT
The complementary nature of medical imaging sensors of different modalities, (X-ray, Magnetic Resonance Imaging (MRI), Computed Tomography (CT)), all brought a great need of image fusion to extract relevant information from medical images. Medical image fusion using Stationary wavelet transform (SWT) and optimize result using genetic algorithm (GA) has been implemented and demonstrated in PC MATLAB. In this paper medical CT and MRI images are fused. To overcomes the discrete wavelet transform (DWT) problems that suffers from translation variant property which may extract different feature from two source images taken from same sensor with only slight movement. This paper utilizes SWT instead of DWT to get rid of these restrictions and performance of purposed algorithm is measured by peak signal to noise ratio (PSNR), entropy, root mean square error (RMSE), standard deviation.

General Terms
Stationary Wavelet Transform (SWT). Genetic Algorithm (GA).

Keywords
Medical image Fusion, Stationary Wavelet Transform, Genetic Algorithm, PSNR

1. INTRODUCTION
In computer vision, multisensory image fusion is technique to extract relevant information from two or more source images into single fused image that contains great quality feature often means highest spatial or higher spectral resolution as well as more reliable and accurate informative as compared to any of the source image. Generally, Image fusion methods can be classified into three categories depending on the stage at which fusion takes place. It is often divided into three levels, namely: pixel level, feature level and decision level of representation. Pixel fusion is the lowest –level fusion, which analyzes and integrates the information before the original information is estimated and recognized. Feature fusion is done in the middle level, which analyzes and deals with the feature information such as edge, contour, direction obtained by pretreatment and feature extraction. Decision fusion is the highest –level fusion, which points to the actual target. Before fusion, the data should be procured to gain the independent decision result, so the information lose cannot be avoided and at the same time the cost is high [3]-[4].

Image fusion is necessary techniques in some cases where it is not possible to obtain an image that contain all important objects in focus due to limited focus depth of optical lenses in CCD devices. Consequently, resultant image will not be in focus everywhere. Image fusion process is required to achieve all objects in focus so that all focused objects are selected. In recent years, image fusion has been widely used in many field ranges from remote sensing to medical field. In addition, an increasing number of applications, such as feature detection, change monitoring and land cover classification; often demand the highest spatial and spectral resolution for the best accomplishment of their objectives. In response to those needs, image fusion has become a powerful solution providing a single image with simultaneously the multispectral content of the source image and an enhanced spatial resolution [5].

Medical imaging technique helps to create visual details of the internal structure of human body for analysis. The complementary nature of medical imaging sensors of different modalities, (X-ray, Magnetic Resonance Imaging (MRI), Computed Tomography (CT)) all brought a great need of image fusion to extract relevant information from medical images. The significance of fusion process is important for multimodal images as single modal medical images provides only specific information; thus it is not feasible to get all the requisite information from image generated by single modality In medical imaging [6-7]. This paper utilizes computed tomography (CT) and a magnetic resonance (MRI) images from the human skull of the same patient. The goal of fusion scheme for the proposed work is to achieve a single image with functional and anatomical information and with the best resolution.

2. PROPOSED FUSION APPROACHES

2.1 Motivation
The aim of this research is to study the image fusion in medical applications. In proposed work, Stationary wavelet transform (SWT) was performed on source image and optimize result using genetic algorithm. Richa Gupta and Deepak Awasthi [1] employed image fusion using discrete wavelet packet transform and genetic algorithm as the fused rule. To overcomes the discrete wavelet transform (DWT) problems that suffers from translation variant property which may extract different feature from two source images taken from same sensor with only slight movement and edges are not preserved. This paper utilizes SWT instead of DWT to get rid of these restrictions.

2.2 Stationary Wavelet Transform (SWT)
Wavelet Transform is basically used in feature detection of MRI, signal de-noising, pattern recognition and brain image classification. However, the discrete wavelet transform is lack of translation variant property, as result misalignment between wavelet coefficients of MS& PAN imaginary may lead aliasing effects and may also extract different feature from two source images taken from same sensor with only slight movement. To solve this entire problem, this paper utilizes SWT to get rid of these restrictions.

SWT is similar to DWT is more commonly known as "algorithm a trous" [9] in French meaning "with holes" which refers to inserts zeros in the filter for up sampling the filter and suppressing the down sampling step of the DWT [10].As with DWT, First the filters is applied to the rows and then the columns as results four images are produced (one approximation and three horizontal, vertical and diagonal detail images as shown in figure 1.

Translation invariance of is achieved by removing the down samples and up samples in the DWT and up sampling the coefficients by the factor of 2^{j-1} in the jth level of the algorithm. Therefore, The SWT is redundant technique as the output of each level of SWT contains the same number of samples as input.

2.3 Genetic Algorithm (GA)

Genetic algorithm (GA) are based on natural selection discovered by Charles Drawn [11].In computer world, the natural selection is replaced by fitness function.

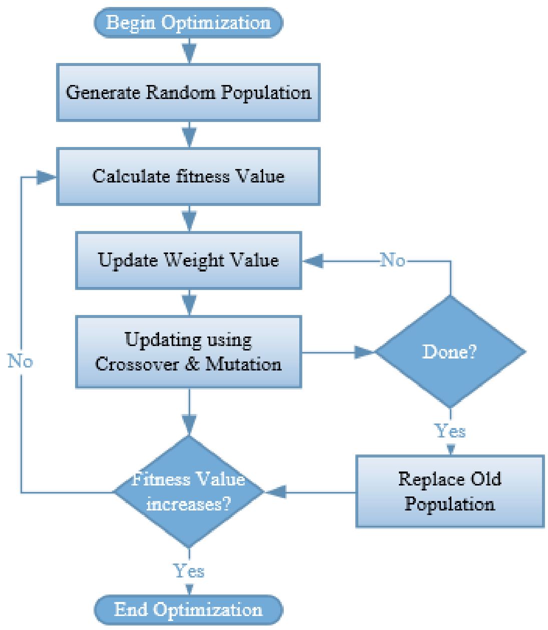

Figure 2 Flow Diagram of Genetic Algorithm

Genetic algorithm is "intelligent" probabilistic search algorithm often viewed as functional optimizes, although the variety of combinations of problems to which genetic algorithm have been applied is quite broad.

The theoretical foundation of GA were originally developed by Holland [12].The implementation of GA begin with a random set of solutions usually coded in binary string called population. Every selection is assigned a fitness which is directly related to the optimization problem. Thereafter, these populations which represent a better solution to the target problem are given more chance to reproduce than those which are poorer solution by applying three operations: reproduction, crossover, mutation. It works iteratively by successively applying these operators in each generation until a termination criterion is satisfied [13-14].

2.4 Proposed Algorithm

In proposed algorithm, First register source images than perform pre-processing of source images which include re-sampling and histogram matching. After that SWT is applied to decompose images. The whole process is shown in figure3.

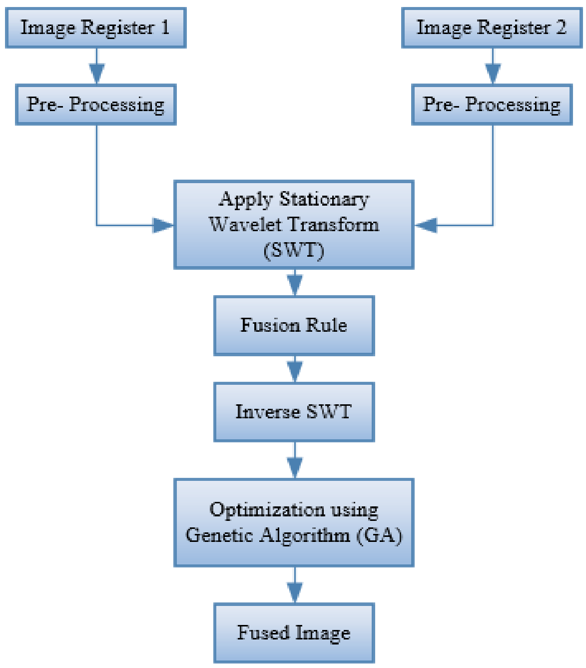

Figure 3 Flow Chart of Proposed Algorithm

3. OBJECTIVE EVALUATION OF PROPOSED ALGORITHM

The quantitative evaluation parameters are as follow. The parameter evaluated mainly peak signal to noise ratio, root mean square error, mutual information etc.

3.1 Peak Signal to Noise Ratio (PSNR)

PSNR will be high when the fused and source images are alike. Higher value means better fusion. It is computed as:

$$\mathrm{PSNR} = 20 \log_{10}\left(\frac{L^2}{\mathrm{RMSE}}\right) \tag{1}$$

Where 'L' is the number of gray level in the image

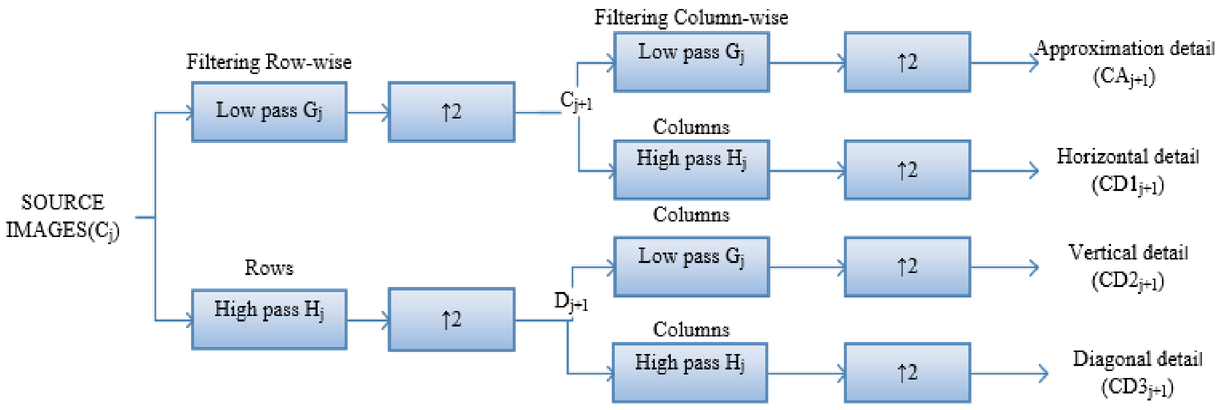

Fig 1: 2-D Decomposition of Stationary Wavelet Transform (SWT)

3.2 Root Mean Square Error (RMSE)

It is proposed by wald (2002).It is computed by the difference of the standard deviation and the mean of the fused image and the original image. The best possible value is 0.

$$\mathrm{RMSE} = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[I_x(i,j) - I_f(i,j)]^2} \quad (2)$$

Where $I_x(i,j)$ = source image and

$I_f(i,j)$ =fused image.

3.3 Standard Deviation

It is known that standard deviation is composed of the signal and noise parts and it is more efficient in the absence of noise. It measures the contrast in the fused image. An image with high contrast would have a high standard deviation.

$$\sigma = \sqrt{\sum_{i=0}^{L}(i - \bar{i})^2 h_{I_f}(i)}\ ,\ \bar{i} = \sum_{i=0}^{L} i h_{I_f} \quad (3)$$

Where $h_{I_f}(i)$ is the normalize histogram of the fused image $I_f(x,y)$ and L is number of frequency bins in the histogram.

3.4 Mutual Information (MI)

Larger value of mutual information indicates better image quality.

$$\mathrm{MI} = \sum_{i=1}^{M}\sum_{j=1}^{N} h_{I_x I_f}(i,j)\log_2\left(\frac{h_{I_x I_f}(i,j)}{h_{I_x}(i,j)h_{I_f}(i,j)}\right) \quad (4)$$

Where I_x is original image and I_f is fused image.

3.5 Mean Square Error (MSE)

It computed as the mean absolute error of the corresponding pixels in source and fused image. The value is given relative to the mean value of the original image. The ideal value is 0.

$$\mathrm{MSE} = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}|I_x(i,j) - I_f(i,j)| \quad (5)$$

3.6 Entropy

Entropy is defined as amount of information contained in an image. Shanon was the first person to introduce entropy to quantify the information. Entropy is sensitive to noise and other unwanted rapid fluctuation. If entropy of the fused image is higher than parent image then it indicates that the fused image contains more information. Using the entropy, the information content of a fused image I_f is:

$$\mathrm{He} = -\sum_{i=0}^{L} h_{I_f}(i)\log_2 h_{I_f}(i) \quad (6)$$

3.7 Variance

Variance filter is basically used to determine the edge detection and to find how each pixel varies from the neighboring pixel. It is computed as:

$$\sigma^2 = \frac{\sum(X-\mu)^2}{N} \quad (7)$$

X=Source image, μ= mean of the population and N=number of source images.

4. RESULTS AND DISCUSSION

This section contains the qualitative and quantitative analysis of the fused images taken from the proposed algorithms.

4.1 Data Set

The purposed algorithm is tested with computed tomography (CT) and a magnetic resonance (MRI) images from the human skull of the same patient as shown in figure 4. Evaluation parameter play vital role in measuring the quality of image obtained from purposed fusion algorithm. The parameter evaluated mainly peak signal to noise ratio, root mean square error, mutual information etc.

4.2 Qualitative and quantitative analysis

Qualitative analysis result for data set is shown in figure 5, while the quantitative results are outlined in table 1.

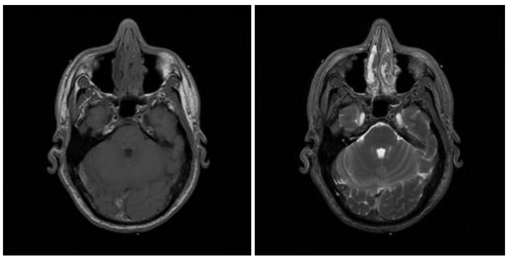

Figure 4.(a)CT image (Skull), (b) MRI image (skull)

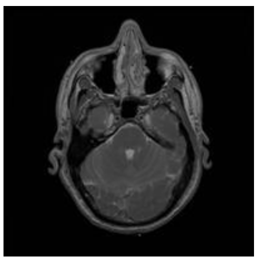

Figure 5.Resultant fused image by proposed algorithms

It has been observed that proposed method gave high values of the parameters. By using the stationary wavelet transform, the edges of the fused image is preserved more than discrete wavelet transform and genetic algorithm give the best value of PSNR by de-noising the image.

Table 1.Quantitative analysis of proposed algorithms

Peak signal to Noise ratio	26.48
Mean square Error	0.14
Standard deviation	0.34
Entropy	17.00
Variance	12.16
Root Mean square Error	2.32
Mutual Information	1.57

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5. CONCLUSION AND FUTURE SCOPE

In this paper, two images from same sensor are fused using stationary wavelet transform and optimize results using genetic algorithm. Entropy is taken as selection criteria in stationary wavelet decomposition in proposed work and it found that proposed method is proved superior to the DWT in term of edge preservation of the fused image. Results obtained have high value of PSNR implying that present work is capable of giving good quality fused image with more informative contents In future further explored this fusion method and increase the value of PSNR as noise is the problem of image fusion in robust mechanisms for avoiding the situation where noise dominates the fused image, Therefore, an alternative interpolation approaches could be added to improve the image fusion results which is part of the future work of research.

6. ACKNOWLEDGMENTS

I would like to express my greatest gratitude to Reecha Sharma (Assistant Professor, Punjabi University, Patiala) for her invaluable guidance throughout the work and arrangement of this paper.

7. REFERENCES

[1] R.Gupta, D. Awasthi.2014. Wave-packet image fusion technique based on Genetic Algorithm. 5th International Conference on the Next Generation Information Technology Summit (Confluence) IEEE, 280-285.

[2] K. Rani, R.Sharma. 2013. Study of Image Fusion using Discrete wavelet and Multi wavelet Transform. International Journal of Innovative Research in Computer and Communication Engineering 1, 795-799.

[3] F.Abdullah Al-Wassai., N.V. Kalyankar and A. A Al-Zuky. 2011. The IHS Transformation based image fusion. Computer Vision and Pattern Recognition.

[4] M.R. Metwali, A. H. Nasr, O.S. Farag Allah and S.El-Rabaie. 2009. Image fusion based on principal component analysis and high pass filter. International conference on computer engineering & systems (ICCES), 63-70.

[5] X. Otazu, M. González-Audícana, O. Fors, and J. Nunez. 2005. Introduction of sensor spectral response into image fusion methods Application to wavelet-based methods. IEEE Transactions on Geoscience and Remote Sensing 43, 2376-2385.

[6] K. Abhinav, V. Bhateja and A. Sahu. 2014. Medical image fusion using combination of PCA and wavelet analysis. In Advances in Computing Communications and Informatics (ICACCI) IEEE, 986-991.

[7] G. Pajares and J. Manuel De La Cruz 2004. A wavelet-based image fusion tutorial. Pattern recognition 37, 1855-1872.

[8] Y. Zhang. 2004. Understanding image fusion. Photogrammetric engineering and remote sensing 70, 657-661.

[9] G.P. Nason and B.W. Silverman. 1995. The stationary wavelet transform and some statistical applications. Lecture Notes in Statistics-New York-Springer Verlag, 281.

[10] M. Beaulieu, S. Foucher and L. Gagnon. 2003. Multi-spectral image resolution refinement using stationary wavelet transform. In International Geo Science and Remote Sensing Symposium 6, VI-4032.

[11] M. Paulinas and A. Usinkas. 2007. A survey of genetic algorithms applications for image enhancement and segmentation 36, 278-284.

[12] J.E. Beasley and P.C. Chu. 1996. A genetic algorithm for the set covering problem. European Journal of Operational Research 94, 392-404.

[13] M. Asif Iquebal. 2009. Genetic Algorithms and their Applications: An Overview. Ind. J. Agric. Sci 79, 399-401.

[14] D. Whitley. 1994. A genetic algorithm tutorial. Statistics and computing 4, 65-85.

[15] Z. Wang and A. C. Bovik. 2002. A universal image quality index. Signal Processing Letters IEEE XX, 81-84.