African Journal of Basic & Applied Sciences 7 (3): 176-180, 2015
ISSN 2079-2034

DOI: 10.5829/idosi.ajbas.2015.7.3.22304

Multimodal Medical Image Fusion Based on Lifting Wavelet Transform and Neuro Fuzzy

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Abstract: The medical image fusion is useful for extracting the information from the multimodality images. The aim of the proposed work is to improve the image quality by fusing CT (Computer Tomography) and MRI (Magnetic Resonance Image). The fused image provides precise information to the doctor and also for clinical treatment planning systems. The wavelet is used to perform a multiscale decomposition of each image. The proposed system uses lifting wavelet transform due to its decorrelating property. The neuro fuzzy is used for fusing the wavelet coefficients. The performance of the proposed system is compared with DWT. The experimental result shows that the proposed fusion scheme can be effectively used to provide discriminatory information and are more suitable for human vision.

Key words: Image Fusion · Neuro Fuzzy · Lifting Wavelet Transform CT · MRI and Multimodality

INTRODUCTION

Medical image fusion is one of the techniques that encompassed from image fusion, where as image fusion is the process of combining multiple input images into a single image without loss of information or data. The improved reliability and compatibility is one of the major advantages in image fusion [1, 2]. Medical Image fusion can be performed either in spatial domain or transformation domain. In spatial domain the pixel values are calculated to get the desired output. The techniques include high pass filtering, HIS (Hue, Intensity, Saturation) PCA (Principal Component Analysis) and Bravey method. The fused image contains spatial and spectral distortion. In transformation domain the images are transformed into frequency domain and the operations are carried out in that domain. Then the inverse transform is performed to get the resultant image. Spatial distortion is easily handled in the transformation domain. The multimodality imaging plays a vital role in the clinical treatment. When fusing the CT and MRI images can generate the new image with more accuracy, so as to provide better information to the doctor and the clinical treatment. The medical imaging technique such as MRI, CT scan provides rich complementary and occasionally redundant information that are used for diagnosis. A major issue in medical image processing is information computation achieved by fusion of multimodal information [3]. The combination of medical images yields additional clinical information which is required in several diagnosis cases for better analysis. In literature it is found that many solutions to medical diagnostic image fusion were proposed [4, 5]. Most of the existing algorithm uses DWT for medical image fusion. The DWT contains stable form of different frequency information and have a good temporal localization problem. The major drawbacks of DWT are that it does not provide shift invariance which reflects a major change in wavelet coefficients even if for minor shift in the registered image. The shift invariance may lead t inaccuracy. This paper proposes a novel image fusion technique using lifting wavelet transform. It is a powerful tool for signal analysis because of its good decorrelating property. The registered MRI and CT images of the same person and the same spatial part are used for fusion. The input images are decomposed by LWT. The proposed systems uses neuro fuzzy rule for fusion. Membership functions are used to fuse the obtained wavelet coefficient. The ILWT is applied to the fused coefficient to obtain the fused image. The performance of the fused image is measured using mean, Standard deviation and average gradient.

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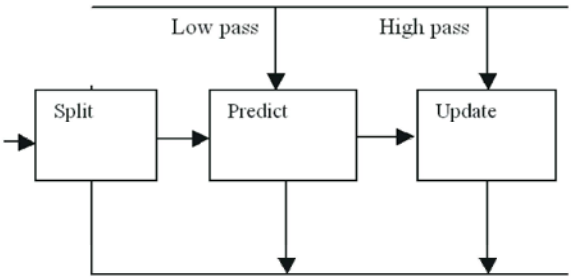

Fig. 1: Block Diagram for Lifting Scheme

Lifting Wavelet Theory: Lifting wavelet theory is a new approach for constructing wavelet, which is also called as second generation wavelet introduced by Sweden [6]. The objective of LWT is to transform coarser signal s_n-1 into a detailed signal dn-1. The major feature of lifting scheme is that all constructions are represented in spatial domain. Moreover lifting scheme is a simple and an efficient algorithm that any wavelet with FIR filters can be factorized into a sequence of lifting steps. Daubechives and Sweden establish that all the conventional WT based on Mallet algorithm have their equivalent lifting scheme. Construction of wavelet using lifting schemed composed of three steps. 1) Split 2) Predict 3) Update.

Split: Divide the input data *x(n)* into odd and even numbered samples, *xe(n)* and *xo(n)* and it is point out as lazy WT

$$X_e(n) = x(2n),\ x_0(n) = x(2n+1) \quad (1)$$

Predict: Maintain even samples as unpredictable and use *xe(n)* predicts *xo(n)*. The difference between the prediction value of *P [Xe (n)]* and the real value of *xo (n)* is defined as detail signal *d (n)*.

$$D(n) = x_0(n) - P[e_{x.}(n)] \quad (2)$$

Update: The genuine data set have some universal properties and the subsets are carried out this is performed by introducing update operator (U_N) and detailed signal (d_{en})

$$Sn\text{-}1 = even_{j,i} + u(dn\text{-}1) \quad (3)$$

Neuro Fuzzy: Neuro fuzzy refers to the combination of artificial intelligence and it is used for fusing the images. The fuzzy systems are tuning the membership functions. Neuro fuzzy systems directly incorporate the fuzzy system through the use of fuzzy set and a linguistic model consisting of fuzzy rules. The research on fuzzy modelling is divided into two areas called linguistic fuzzy modelling and precise fuzzy modelling. The learning algorithm is dived from neural network theory is used to train the fuzzy system. The learning algorithm operates on local information and causes local modification in the fuzzy system [7, 8]. Combining fuzzy logic and neural network are proving their effectiveness in a wide variety of real world problems. The proposed system incorporates the concept of fuzzy logic into the neural networks. To deal with the lognitive uncertainties. The neural networks are exploited to tune membership function of fuzzy system that are used as decision making systems for controlling the tools.

Membership Function: The membership function defines the fuzzy set is also called as characteristic function of the fuzzy set. The data of an element belongs to a fuzzy set is mentioned by a membership value between o and 1. A group of fuzzy set maps an input value to its corresponding membership value based on the defined membership function. The simplest membership functions are formed using straight lines and can be of any shape or type based on which the sets are defined. In this paper we selected as triangular membership function.

Genfis 1: Genfis is referred as Generate Fuzzy Inference System. It is used to generate a FIS structure from the data without data clustering. Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic It is also generate the Sugeno type fuzzy inference system and it is used as initial condition for Anfis. Grid partition is used in the Sugeno type fuzzy inference system.

ANFIS: ANFIS is mentioned as Artificial Neuro-Fuzzy Inference System which is referred as adaptive networks used in FIS [7]. Sugeno type fuzzy inference system is used in ANFIS. It gives the hybrid learning algorithm for identifying parameters of the fuzzy system.

MATERIALS AND METHODS

This paper focus on fusing the medical images such as CT, MRI of brain image of the same person. The lifting wavelet transform is applied to compute a multiresolution representation. Then they obtained wavelet co-efficient are fused using neuro fuzzy. The target image is obtained by performing inverse of LWT. This algorithm for the proposed system is as follows.

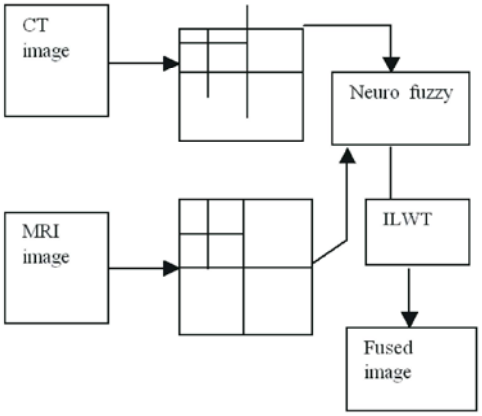

Fig. 3: Block Diagram for Proposed System

Algorithm:

- Read the first image (CT) in variable M1 and find its size (rows×column s1)
- Read the second image (MRI) in variable M2 and find it size (row×column s2)
- Convert the input image s1 and s2 to gray scale image
- Compare rows and column of both input images and make sure that the image to be fused in same size.
- Decompose the obtained input image using LWT
- Decide the type of membership function for both the input image and make a neuro fuzzy structure using genfis and anfis.
- Convert the column form to matrix form and obtain the fused coefficients.
- Then the inverse ILWT to get the fused image.
- The mean, standard deviation and average Gradient are calculated to measure the performance of the system.

Mean: The mean value of an image with size defined as $m \times n$

$$\mu = \frac{1}{m \times n} \sum_{i=1}^{m} \sum_{j=1}^{n} f(i,j)$$

where f(i, j) denotes the amplitude value with coordinate (i, j). The mean value indicates that the average intensity of an image.

Standard Deviation: The standard deviation of an image size is defined as m × n

$$\sigma = \frac{1}{m \times n} \sum_{i=1}^{m} \sum_{j=1}^{n} \sqrt{f(i,j) - \mu}$$

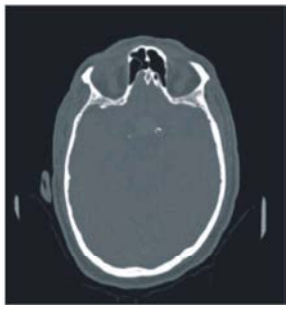

Fig. 4: CT Image

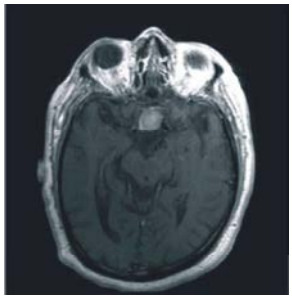

Fig. 5: MRI Image

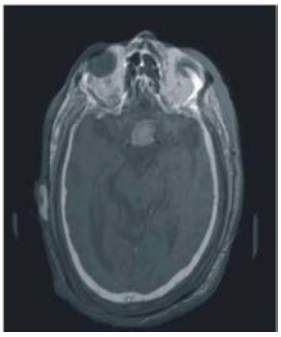

Fig. 6: Fused Image

where μ is the mean value of an image. The standard deviation is the common measure of statistical dispersion. It is used to measure how widely spread the gray values in an image so, the larger standard deviation has the better result.

Average Gradient: The average gradient of an image size is explain as m×n

$$\text{Avg} = \frac{1}{(M-1) \times (N-1)} \times \sum_{m=1}^{M-1} \sum_{n=1}^{N-1} \sqrt{\left[\left(\frac{\partial f(m,n)}{\partial m} \right)^2 + \left(\frac{\partial f(m,n)}{\partial n} \right)^2 \right] / 2},$$

where f (m, n) is the same meaning as in the standard deviation. The average gradient evince the clarity of the fused image which is used to measure the spatial resolution of the fused image.

Table 1: Result Analysis

Fusion Method	Mean value	Standard Deviation	Average Gradient
DWT (sub band coding) for pair 1	22.7902	39.2630	14.6800
LWT (lifting scheme) for pair 1	35.9446	48.7726	15.2629
DWT (sub band coding) for pair 2	47.2581	49.5830	15.6652
LWT (Lifting scheme) for pair 2	51.1420	53.3457	17.7302

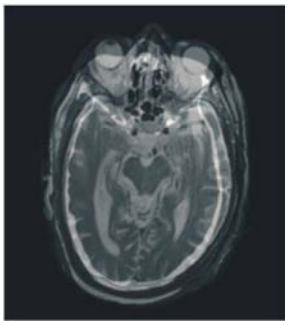

Fig. 7: Fused Image LWT based Neuro fuzzy

Experimental Results: This work investigate that the CT and MRI image of the same person and the same spatial part are fused by lifting wavelet transform and neuro fuzzy are shown in the Fig 4 & 5.

The triangular membership function is used and in the proposed method LWT has performed better and hence proved. It has compared with DWT based neuro fuzzy algorithm. The performance analysis can measured under the mean, standard deviation, average gradient [9]. The results are shown in the Table 1.

The proposed method demonstrates that the measuring attributes (mean, standard deviation and average gradient) values are high. The fused image exhibit that the both input image have good amount of information. The qualitative measures shows that the proposed algorithm has perform better when compared with the DWT based image fusion [10, 11].

CONCLUSION

A new algorithm for fusion rule is proposed using the Lifting Wavelet Transform and neuro fuzzy. Due to the decorrelating property LWT provides clearly identifying the details information of an image. Membership function is used for fusion and generates the generalized bell shaped built-in membership function. The algorithm has carried to complete the fusion rule using lifting wavelet transform and neuro- fuzzy. The input image specifies that the fused image contains good amount of information.

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