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HYBRID MEDICAL IMAGE FUSION BASED ON CURVELET TRANSFORM WITH PULSE COUPLED NEURAL NETWORK

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ABSTRACT

Medical image fusion is developed from dissimilar modalities and enhances the quality of integrated outcome image that provides additional anatomical and functional data to the experts. In this paper, a new hybrid progression is proposed to integrate images obtained from Computer Tomography and Magnetic Resonance Imaging using Curvelet transform technique and pulse coupled neural networks. Along with sub-band coding, scale explore algorithm was also used for filtering and image scaling operations was used for decomposition of image. Curvelet transform used along with radon transformation to carry out image transition from 1-D to 3-D during rebuilding phase of integrated images. The output of the image was evaluated using objective metrics of Entropy (H), Root Mean Square Error (RMSE) and Peak Signal to Noise Ratio (PSNR). The statistical results showed that the proposed method has generated better information in terms of undertaken performance than the past techniques.

Keywords: *Medical images, Hybrid fusion, Curvelet transform, Sub-band coding, Scaling algorithm, Radon transform, Coupled Neural Networks.*

1. INTRODUCTION

Image fusion has increasingly become the promising area of research and has also attracted the researchers over the years, and its importance continually on the rising side [1]. In general, fusion of the image is a procedure of merging two or more images of the similar view to improve content of the resulting image. Numerous image fusion studies has been carried out by the researchers in both spatial and transform domains with dissimilar merge rules such as pixel and weighted average, region variance, maximum value selection and more [2-6]. The major purpose of image fusion is to provide resulting image information with increased accuracy and reliability to improve the reading efficiency of both structural and functional information of images [7]. Various Image fusion techniques were proposed such as PCA, HIS, Averaging technique, and pyramid based, wavelet based, curvelet based, contourlet based transform techniques to serve and support various applications such as medical imaging, satellite imaging, robot vision, battlefield monitoring and remote sensing areas of research and so forth. Each of these techniques has their own merits and demerits when used for different types of image enhancement purposes [9].

A. Hybrid medical image fusion

Medical image fusion is having several imaging modalities which can be used as prime inputs to analyze the undertaken study. But, the most difficult part of the study is the selection of image modality and fusion method for the targeted clinical study. Moreover, having one image modality would not ensure any accuracy, robustness and reliability for the analysis and resulting diagnosis. Therefore, in order to improve the accuracy as well as robustness of the analysis and resulting diagnosis. More image modalities were considered. Furthermore, the researchers were also convinced that looking at images from multiple modalities can offer them better results in terms of reducing randomness, redundancy and improving accuracy, robustness and reliability. As a result, the resulting assessment information is more reliable and accurate [12,13]. In hybrid fusion, the reward of dissimilar fusion techniques and rules were integrated to obtain single fused output image with better quality results by minimizing MSV and maximizing SNR value [14].

B. Image modalities used

Magnetic Resonance Imaging acting crucial position in non-invasive analysis of brain tumors where segmentation is used to extract dissimilar types of tissues and to recognize irregular regions of input images but, it suffers of relative sensitivity to movement which makes it inefficient in assessing organs such as mouth tumors. Though, there are various methodological advancements such as Structure Similarity Match Measure (SSIM) in improving the fusion of MR images, this study has considered tissue classification. It is widely known that MR images are highly efficient in presenting soft tissue structure in organs such as eyes, heart and brain with better accuracy [15]. Computerized Tomography (CT) method has a key force on medical analysis and assessment due to its short scan times and high imaging resolutions. Unlike MR images, a CT image reveals more information about the hard tissues as its scan process transverse into every slices of human brain or skull etc [17]. Therefore, the advantages of both MRI and CT images can be combined to bring better results by adopting image addition operation. Arithmetic image fusion is a commonly used scheme which applies a weight (Wn) to each input image (In) and combines these two to form a single output image (f),

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$$f(x) = w_1 i_1(x) + w_2 i_2(x) + \ldots\ldots + w_n i_n(x) \rightarrow \quad (1)$$

In most cases, weights are assigned to give an average effect (i.e.Wn=1/n). This research study has considered MRI and CT scanned images preferred as input images.

2. TRANSFORM TECHNIQUES AND METHODS

Curvelet transform: Curvelet transform technique is a part which bisects the input image into number of minute for overlapping strips. Curvelet transform is applied to every strips to carry out edge recognition [17]. The final outcome image gives more data by preventing image de-noising. Curvelet transform outcomes in improved presentation than existing transform (wavelet) in terms of SNR value [16]. The following levels were performed in curvelet transform technique (Figure 1).

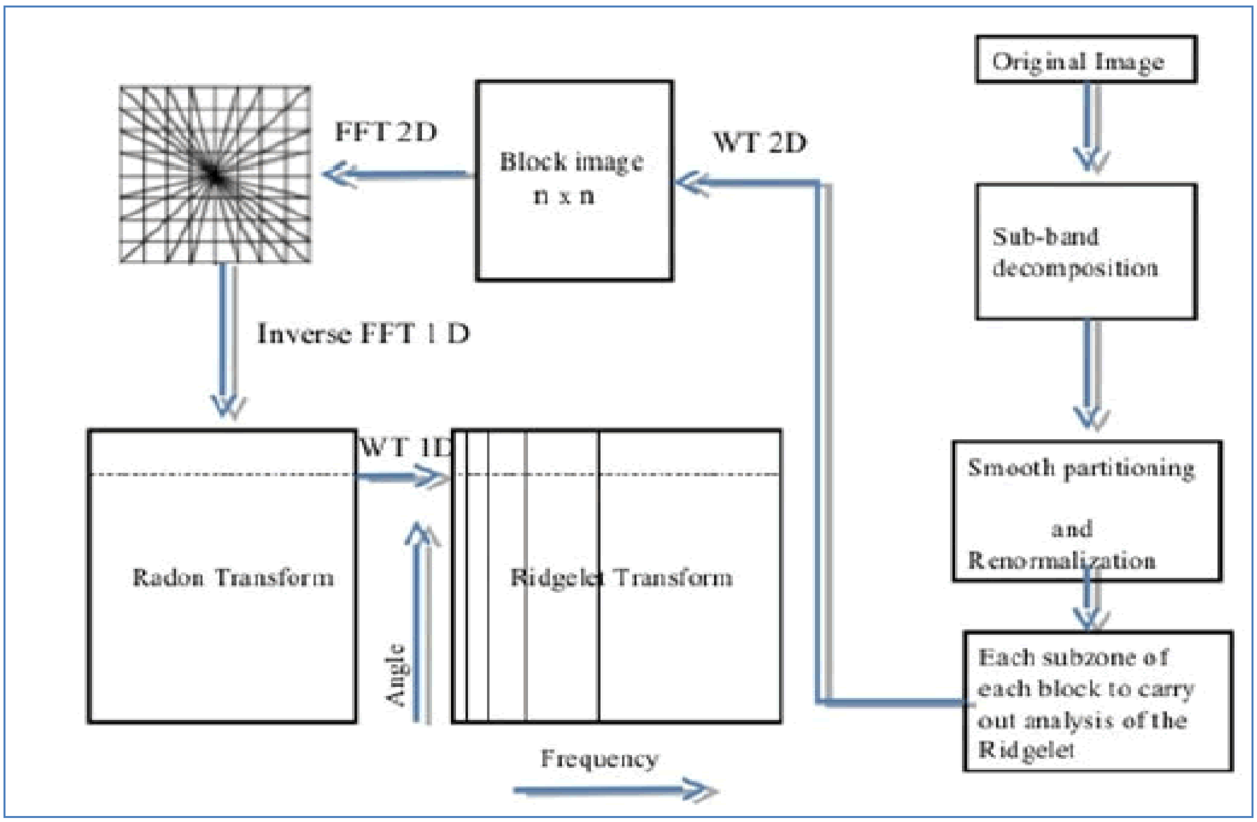

Figure [1.] Process of curvelet transforms

Sub-band coding: The objective of sub-band coding is to perform Multi-Resolution Analysis (MRA), where input images are decomposed into various band limited components using digital filters, called as sub-bands. 2D sub-band

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coding was used for decomposing the input image into sub-bands. In general, a system that isolates certain frequency is called a filter, namely low pass filter, high pass filter and band pass filter (Figures 2 and 3).

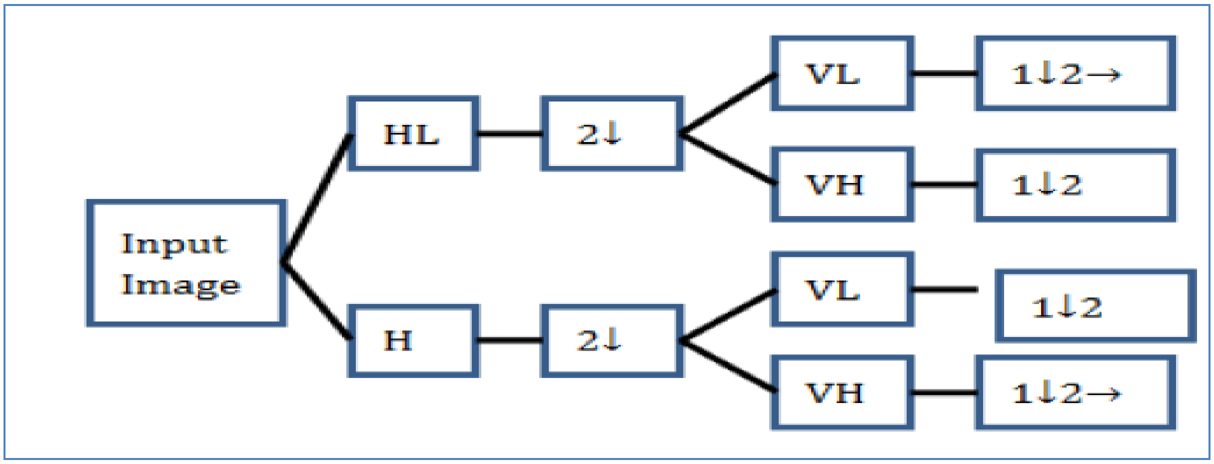

Figure 2. Filtering operations on image

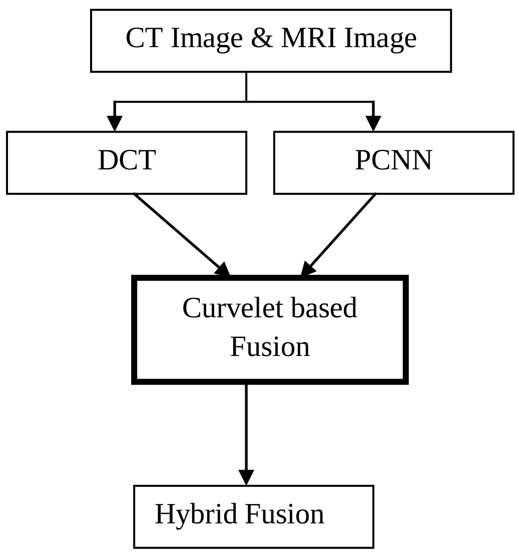

Figure 3. Proposed approach framework

Low pass filter lets through image components below a certain frequency (f_0), high pass filters blocks image components below a certain frequency (f_0) and band pass filter lets through the image components lies at the frequencies (f_1, f_2). Figure 2 represents the sub-band process of 3D filters. Sub-band decomposition process can be defined mathematically as follows,

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$$f \longrightarrow (\rho_0 f, \Delta_1 f, \Delta_2 f, \ \ldots) \longrightarrow \quad (2)$$

Tiling: This technique is used to split the image into overlap tiles, the same will then be used for conversion of curved lines that are present in the sub-bands into straight lines which helps in handling curved edges. A scale selection algorithm [15] is working in the projected method which changes the default curvelet selection of the scales J. This algorithm ensures that centered high frequency area is curved. The scale selection's algorithms optimum scale is given by,

$$\mathrm{J} = \left[\log_2 = \left(\frac{\min(\mathrm{N1}, \mathrm{N2})}{D}\right)\right] \rightarrow \quad (3)$$

Where, D represents the length of the square casing the high frequency scale values,

Performance metrics

There are various number of objective metrics exists of varying degree of complexity and a host of different approaches. Our research work has considered the following three metrics to assess the presentation of the proposed process.

Entropy (H): The entropy value used to conclude the content of the merged image in similarity with the input image i.e. higher value of H represents better information and lower value of H represents the minimum information. Entropy was calculated using the following equation,

$$H = -\sum_{g=0}^{L-1} p(g)\log_2 p(q) \rightarrow \quad (4)$$

Root mean square error (RMSE): These metric dealings the dissimilarity amid the input indication image with the fused output image and is calculate with the RMSE equation,

$$RMSE = \sqrt{\frac{1}{MN}\sum_{n=1}^{M}\sum_{n=1}^{N}(R(m,n) - F(m,n))^2} \rightarrow \quad (5)$$

Where M, N represents the dimensions of images, R (m, n) represents the reference of input images and F(m, n) represents the references of fused output image.

Peak signal to noise ratio (PSNR): It represent the ratio amid the utmost control of a signal and the percentage of debasing blare that affect the consistency of its illustration. It can be mathematically measured as follows,

$$PSNR = 10X\log\frac{(f_{\max})^2}{(RMSE)^2} \longrightarrow \quad (6)$$

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3. PCNN MODEL

The major of the system lies in the neural analysis that is prepared of pulse coupled Neurons, which proceed like home analysis cells (Figure 4. PCNN). The pulse train generated by the neurons is a direct result of stimulus excitation and on the other side communication amid neurons. And then interface and further inspiration of the neurons to fire in synchrony in the similar fields associated to the image. This property can be broken down in image segments. Our preparation is that the pulse training of the neurons captures morphological information from the image. The intractable era is imitation by growing the threshold, when the neuron fires and decline exponentially after firing.

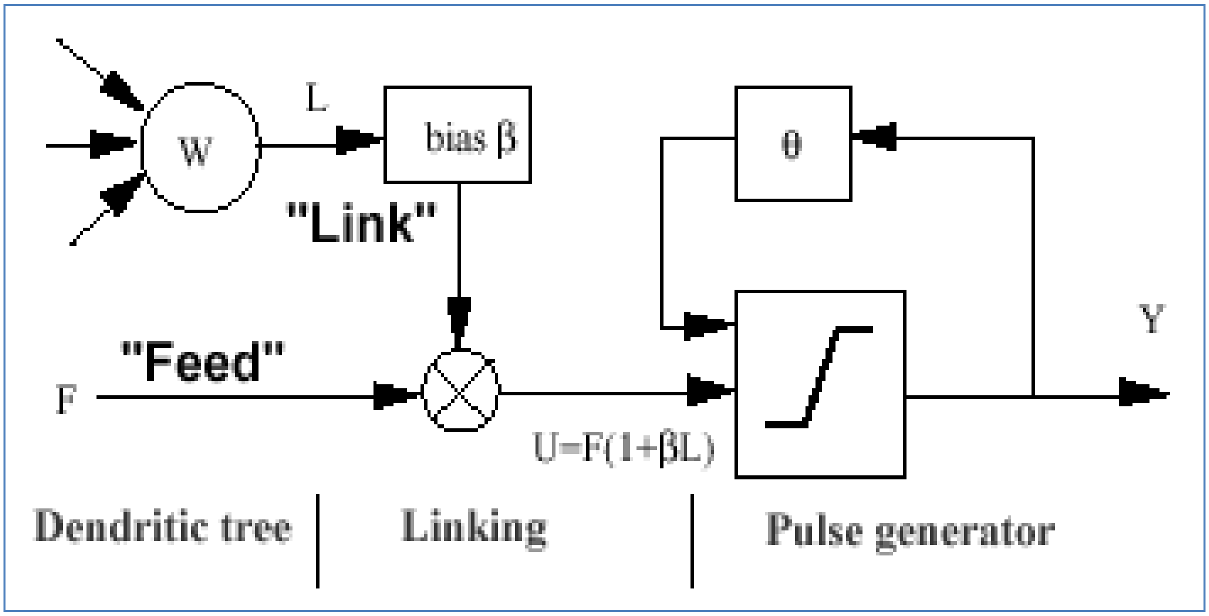

Figure 4. The block diagram of the pulse-coupled neuron

Computing the DCT and correlating the input signal with each basis function. The DCT yields two shorter signals to be processed. We used the imaginary segment of the DCT in additional computing but a mixture may be possible as well. Our choice had been motivated by practical explanation that demonstrates a relative constancy of the real part over all the shapes used for testing. We also improved speed by using only the imaginary part in the superior levels [18].

4. RESULT ANALYSIS

As mentioned earlier in this paper, hybrid image fusion has been proposed and the same has been implemented using two input images, CT and MRI respectively. The information obtained by the fused resultant image was verified with three metrics, namely, entropy, MSE and PSNR. Both the input images used for image fusion and the resultant fused image are presented below (Figures 5a-5g). The performance metrics and its value information are presented on Table [1.] From Table 1, it is clear that the proposed algorithm performs better than other methods.

Table [1.] Comparison of transform techniques

Performance Metrics	**Transform Techniques**		
	Wavelet	**Curvelet**	**Hybrid**
Entropy	9.31	8.94	8.76
Root mean square error	3.83	3.53	3.29
Peak signal to noise ratio	32.73	38.09	43.1

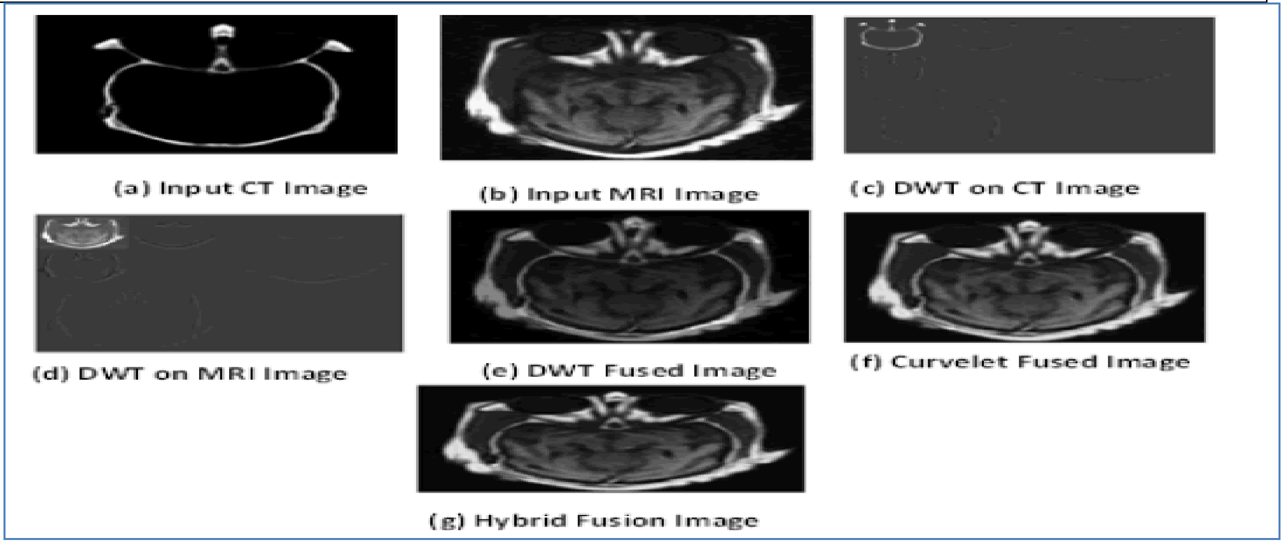

Figure 5. Experimentation results from (a) to (g)

5. CONCLUSION

Though, there have been too many image fusion methods available to enhance the features of a resulting fused image, there still exist an engineering need to develop more efficient hybrid methods that could result in improved accuracy and reliability. From the obtained results, it is evident that the proposed approach has delivered better results in comparison with wavelet, curvelet methods alone. In addition, the results were better when compared with the hybrid fusion method. In our future work, a different scaling algorithm will be considered along with other possible fusion methods such as contourlet transform, wave atom transform etc.

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