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An Enhanced Approach for Medical Image Fusion Using Hybrid of GWO and State Transition

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Abstract— Medical image fusion defines the process of fusing two similar medical images to create a single image which is rich in information. The medical image fusion is done to enhance the quality of diagnosis and treatments. This paper introduces a novel image fusion approach HSWGWO (Hybridization of State Transition with Grey Wolf Optimization) for medical images such as MRI, SPECT, PET, and CT images etc. The objective of this work is to overcome the issues of traditional GWO based image fusion technique. In this work, the SWT mechanism is used to extract the features from the input images and then the hybrid mechanism i.e. GWO and ST are applied for fusing the images. The proposed work is compared with the traditional techniques. The comparison is done by considering the sets of various images such as MRI-SPECT, MRI-PET, and MRI- CT images. After analyzing the proposed work is found to be effective and efficient than the traditional image fusion techniques.

Keywords— Medical Image Fusion, Magnetic Resonance, Transform Domain, Spatial Domain, Frequency Domain.

I. INTRODUCTION

Medical image fusion is the most prominent topic nowadays due its variety of applications such as remote control, medical imaging, micro-scope imaging etc. Due to the technological advancements in the medical field [1], the concept of medical image fusion has gained popularity. All of the medical diagnosis is done in the form of images such as X-Ray, CT scan, MRI, PET etc. Therefore the decision regarding detection of disease is done on the basis of the images. But there are possibilities that the scanned images could be of bad quality [2]. Thus the concept of image fusion comes to the existence in which the two incomplete images are fused together to generate a single meaningful and informative image [3]. Then the final fused image is used for decision making purpose.

A variety of methods have been available to perform the image fusion in an successful manner without losing the actual content from the images. For example, the ideal image fusion technique should be capable to extract the full spatial information from the medical images by maintaining the features of frequency domain.

There are various techniques that are specifically used for image fusion such as principal component analysis, Fast Fourier Transform [4] [5], Stationary Wavelet Transformation, Discrete Cosine Transform etc. But all of these techniques lack somewhere [6]. Thus a large number of authors develop solutions to recover the drawbacks of traditional image fusion techniques by using advanced optimization techniques such as Particle Swarm Optimization, Grey Wolf Optimization etc [7].

This study is organized into 5 sections. The section I defines a review of the role of image fusion in medical science. Along with this, the methods used for image fusion are also discussed in section I. Section II gives a briefing to the backlogs of traditional medical image fusion mechanism. These backlogs act as a motivation to develop the novel image fusion technique. The data in section III comprises the details of proposed work and the techniques that are used in proposed work. The graph in section IV show the experimental results that are obtained by implementing the propose work in MATLAB. The results prove the efficiency of proposed work over traditional work. The last section of this study i.e. Section V concludes this work and also discusses the amendments that is possible in this work.

II. PROBLEM FORMULATION

In image fusion information from the multiple images of the same scene is combined that are captured from the different sensors at different times having different spatial and spectral characteristic. In standard image fusion technique, the final fused image is created by determining the each pixel value that is generated from a set of pixels of input images. A large number of image fusion techniques such as Fast Fourier Transform, Intensity Hue Saturation, Principal Component Analysis and High pass filters etc have been developed till now that fuses the images in an informative way. All these methods were used for the image fusion but these methods were not efficient as using frequency transform mechanism can extract the feature from frequency domain only. But this fusion can limit the performance of the system. Another drawback is that traditionally grey wolf mechanism was used for optimizing the results which performs optimization after multiplying the coefficients of frequency domain. GWO is an optimal selection of scale values from multi scaled images [11]. Hence there is a need to develop a mechanism which can extract the more features form image and also optimize the results so that the performance can get enhanced.

III. Proposed Work

The image fusion is the process in which two images are fused to get the single image that is more informative than the input images. Many method of image fusion have been proposed earlier but were not as efficient as required. So in this, a new method is proposed for the image fusion where the traditional FFT is replaced by SWT because it extract the features from spatial domain as well as frequency domain and is more descriptive in nature which makes it better than FFT. Another GWO (gray wolf optimization) is collaborated with state transition.

A. SWT

The SWT is a Stationery Wavelet Transformation technique which is developed to overthrown the vulnerabilities of Discrete Wavelet Transformation technique. The accumulation of DWT is that it lacks at translation invariance. This backlog can be recovered by eliminating the down sampler and up sampler. Along with this the other solution is to apply sampling on filter coefficients in the jth level of algorithm by applying the following formulation.

$$2^{(j-1)} \quad (1)$$

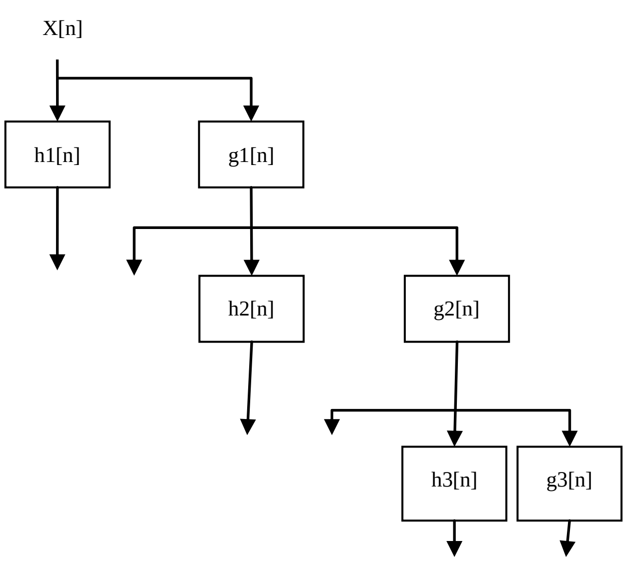

Figure 1 3-level SWT filter bank.

It is an inordinate technique as a result of the number in the each level of output is correlative to the number in resembling input which leads to the N number of redundancy resembling to the N number wavelet coefficients. It is an amplified or modified version of DWT which does not despoil coexistent at every transformation level. The following diagram explains the procedure of SWT:

B. State Transition

State transition is a proficient mechanism that is considered as a suitable approach for decision making. It is extensively applicable to the pronouncement analytical modeling sphere of influence. It is created by collaborating the Markov model cohort simulation and stand alone simulation model. This mechanism reflects the states and corresponding transitions respectively. It is broadly accepted by the users in the field of clinical decision analysis, medical domain, industrial decision making etc. It is less complex and easy to use. Its major objective is to evaluate or detect the hidden risk factor, screening of the system, procedure diagnosing procedures, program management etc. This model is in essence used for expounding the time dependent systems specifically. The major characteristic of state transition is that its working criteria did not get affected by the variations in the surrounding environment. State transition is the only term that used in this method. In this state is defined as an observed behavior and nature of the system and transition manipulates the internal happening of the system. Transition event depicts the action which is taken with respect to any event.

C. Grey Wolf Optimization Technique

The Grey Wolf Optimization reproduces the leadership chain of command and hunting scheme of grey wolves in nature. In this mechanism the grey wolves are accounted to be on the food chain and the wolves tried to survive within a bunch or group. There are total 4 types of grey wolves that are considered for simulation purpose such as alpha, beta, delta and omega.

For fusing the images we need to enter the two images which will result in single fused image. For this purpose first step is to select two input images. Second step is to apply SWT on both of the selected images individually. The purpose behind applying SWT is to extract the features of the images. After this the hybridization of GWO and ST is applied to extracted features in order to fuse them in single one. Next step is to apply scale selection and fusion rules to the images. After that the fused data is obtained. In this step the Inverse SWT is applied to the fused data so that final fused image can be obtained.

The methodology of proposed work is as below:

Step 1. For fusing the images we need to enter the two images which will result in single fused image. For this purpose first step is to select two input images.

Step 2. Second step is to apply SWT on both of the selected images individually. The purpose behind applying SWT is to extract the features of the images.
Step 3. After this the hybridization of GWO and ST is applied to extracted features in order to fuse them in single one.
Step 4. Next step is to apply scale selection and fusion rules to the images. After that the fused data is obtained.
Step 5. In this step the Inverse SWT is applied to the fused data so that final fused image can be obtained.

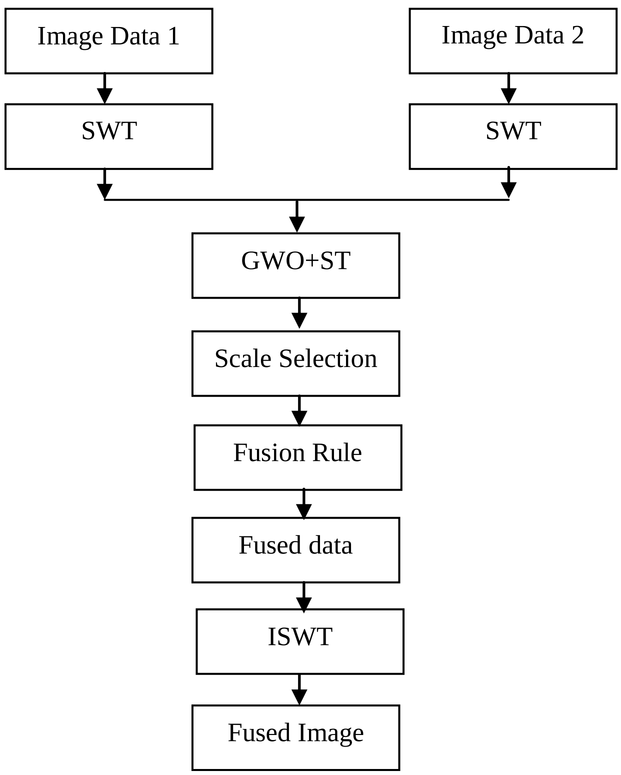

Figure 2 Framework of Propose Work

IV. Experimental Resulst

The present work implements the medical image fusion by using SWT for feature extraction and GWO+ST for image fusion. The objective of the propose work is to replace the traditional DWT feature extraction technique with SWT feature extraction and to perform the fusion of the images of extracted features by using enhanced image fusion technique i.e. GWO and ST.

In proposed work first step is to select the input images from the dataset of medical images. In these the medical images related to the MRI, CT and PET. The figure 3 defines the input images that are used for image fusion and further processing.

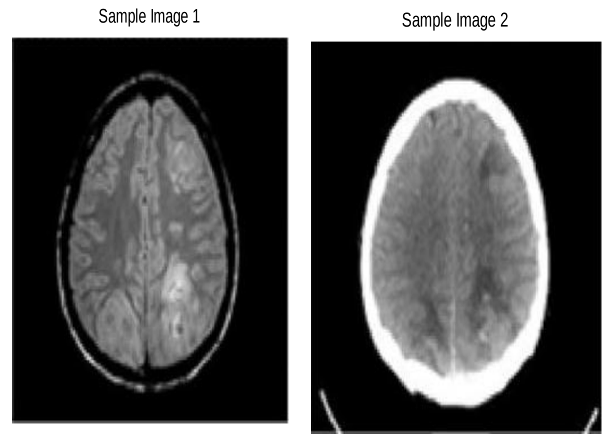

Figure 3 Input images for image fusion

After selecting the input images the next step is to apply the SWT for extracting the features from the selected images. This is done to extract the meaningful content from both of the images and then the extracted features are fused. In order to fuse the both images by using the hybrid image fusion technique that is developed by using GWO and ST. The image in figure 4 shows the final fused image.

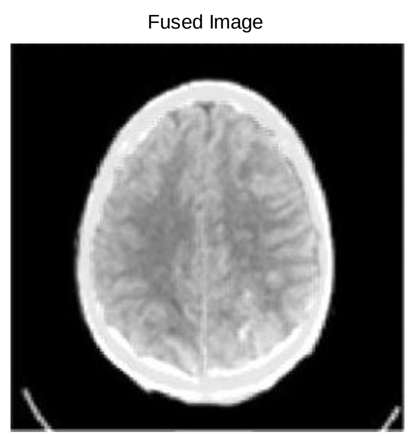

Figure 4 Final Fused image

After fusing the images, in next step the performance of the proposed work is evaluated in the terms of performance metrics i.e. MI, Entropy and Q(AB\F). The MI is a parameter that define sthe level of mutual information. The following is the mathematical euation fro MI.

$$MI(x,Y) = \sum_{x}\sum_{y} P(x,y) log \frac{P(x,y)}{P(x)P(y)} \ldots\ldots (2)$$

$P(x,y) is\ the\ probability\ of\ distributed\ function,$ $P(x) and\ P(y)$ is the marginal function of both modalities.

The graph in figure 5 depicts the comparison of proposed and traditional techniques in the terms of MI. On the basis of the graph, it is observed that the MI of proposed work is higher than rest of the traditional techniques that are considered in this work. Whereas the MI of DWT is found to be quite lower in comparison to all of the techniqiues.The comparison is done for MRI-SPECT images.

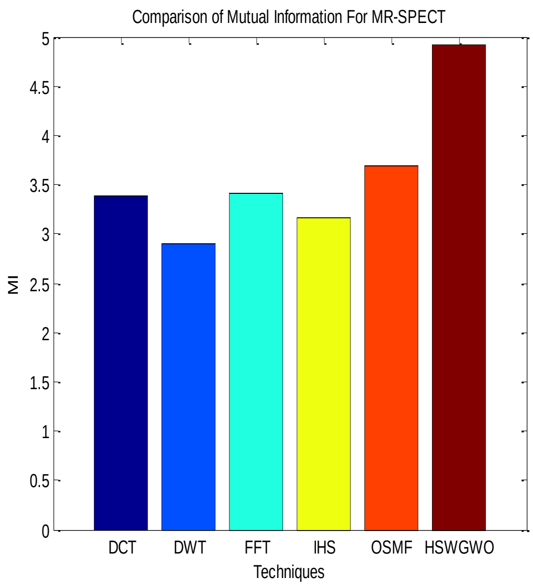

Figure 5 MI of MR-SPECT image

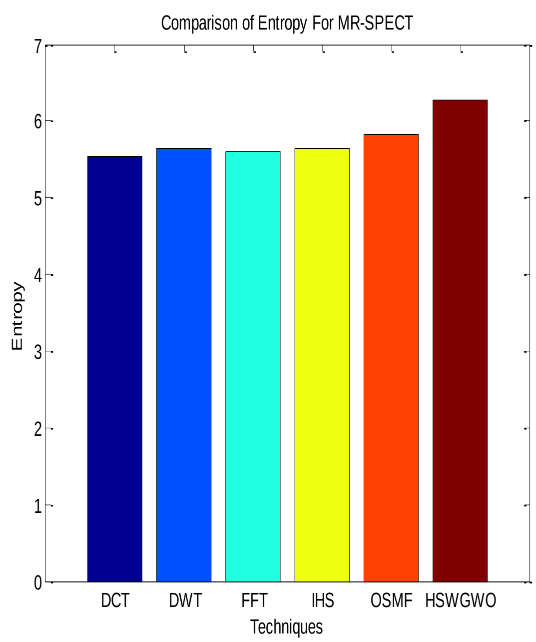

Figure 6 Entropy of MR-SPECT images

Similarly, the comparison graph in figure 6 represents the entropy of proposed technique, DCT, DWT, FFT, HIS and OSMF. The entropy is evaluated for the final fused image in order to measure the quality of the image in terms of redundant information. Following is the formulation of the entropy:

$$Entropy = -\sum_{L=0}^{L-1} P_l Log_2 P_l \ldots .3$$

The comparison is done for MR-SPECT images. The graph explains that the entropy of the proposed work is higher than the entropy of other traditional techniques.

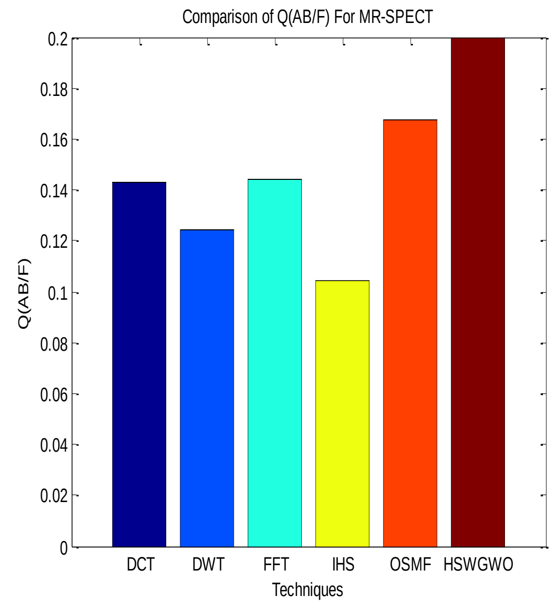

Figure 7 Q (AB/F) of MR-SPECT image

The graph in figure 7 delineates the comparison of proposed and traditional work, in terms of Q(AB/F). It is parameter that is used to edge based similarity in the images. It measures the edge details in the final fused image. The Q(AB/F) can be evaluated as follows:

$$Q^{\frac{AB}{F}}(m,n) = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} Q^{\frac{A}{F}}(i,j) g_A(i,j) + Q^{\frac{AB}{F}}(i,j) g_B(i,j)}{\sum_{i=1}^{M}\sum_{j=1}^{N} g_A(i,j) + g_B(i,j)} \ldots .(4)$$

The graph proves that the edge based similarity of the proposed work is higher than the edge based similarity of the traditional works.

Table 1 Performance Analysis for MR-SPECT images

Techniques	MI	Entropy	Q(AB/F)
DCT	3.38	5.54	0.143
DWT	2.91	5.64	0.124
FFT	3.41	5.59	0.144
IHS	3.16	5.65	0.105
OSMF	3.69	5.83	0.168
HSWGWO	4.91	6.27	0.2

The above graphs show the comparison of traditional and proposed work by using MR-SPECT images. Similarly, the comparison analysis for MR-PET and MR-CT images are performed and the observed facts are shown as follows.

Table 2 Performance Analysis for MR-PET images

Techniques	MI	Entropy	Q(AB/F)
DCT	3.21	5.25	0.0529
DWT	2.91	5.29	0.0486
FFT	3.2	5.25	0.0531
IHS	2.86	5.38	0.0338
OSMF	3.42	5.5	0.0683
HSWGWO	4.81	6.23	0.2

Table 3 Performance Analysis for MR-CT images

Techniques	MI	Entropy	Q(AB/F)
DCT	3.51	4.1	0.0387
DWT	3.12	4.19	0.0325
FFT	3.52	4.11	0.0386
IHS	3.59	4.13	0.0386
OSMF	3.74	4.26	0.0399
HSWGWO	4.75	4.77	0.2

V. CONCLUSION

To sum up the present medical image fusion technique, it can be said that the proposed work is found to be better and effective than the traditional techniques i.e. DCT, DWT, FFT, IHS and OSMF in terms of MI, Entropy and Q (AB/F). the reason behind the efficiency of the propose work is that the SWT feature extraction technique is used on both input images individually before fusing them to a single image. After this the combination of GWO and ST is applied for fusing the both images. The simulation is done by using various images such as MRI, PET, CT and SPECT images. The MI, Entropy and Q(AB/F) of proposed work is higher in all cases.

More amendments in the proposed work could be possible on feature extraction techniques. Along with this the concept of ROI can also be used to fuse the interested region of the images only.

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Authors Profile

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