A New Approach for Medical Image Fusion using GWO with Modified Ferature Extraction Technique

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Abstract— Medical image fusion is a process which is used to minimize the redundancy while increasing the required information from input images acquired from different medical imaging sensors. The process of image fusion is done by using the fusion techniques. Therefore, many advanced image fusion techniques have been developed till now to improve the process of image fusion and the quality of the final fused image. Similarly, this study is organized to develop a novel image fusion mechanism named as H-FFT-IHS. In this technique the features of frequency domain and spatial domain has been extracted by using the FFT and IHS feature extraction technique. Moreover the proposed work is hybridized with grey wolf optimization technique in order to attain more optimized results in terms of MI, STD and Qab/F. The H-FFT-HIS is simulated by using MRI, CT, SPECT and PET images. After implementing the work, the proposed work is observed to be prior than traditional image fusion techniques such as DCT, DWT, FFT, IHS and OSMF.

Keywords— *Fast Fourier Transform, IHS, Gray wolf Optimization, Medical Image fusion*

I. INTRODUCTION

Bringing together two or more than two images into a single and developing a more enhanced image is a technique of Image fusion [1]. This is done for the purpose of obtaining more enhanced or meaningful image so that effective decision making can be done with the help of the fused image [2]. In layman, the image fusion can be defined as a process which combines the two incomplete images in order to form a complete one. Sometimes, we have more than two images and all of them are lacking somewhere, thus storing all of such images will consume large memory space and almost all of the images does not consist relevant information exclusively [3], in such cases the need of image fusion arises [4], thus the concept comes to the existence. The process of image fusion commences by introducing two images as input and then these input images are extracted to a single image by implementing suitable fusion technique which consists of all of the meaningful content of the image that was original. The problems of memory area consumption in excess and incomplete meaningless images are solved by the image fusion [5].

The principle of image fusion is to maintain the enrich section of the image. The meaningful information of the image can be preserved by associating multiple images. On domain of the input images, there are no constraints or limitations. The input image can be related to multi focus, multi sensor or other domains [6].

II. PROBLEM FORMULATION

Image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images. 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. Standard Image Fusion generates a fused image in which each pixel is determined from a set of pixels in each source image Many techniques of image fusion have been discovered so far, that help in the fusing the images and the resultant image is more informative. Some techniques like FFT (Fast Fourier Transform) were used for the image fusion but this method was 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 in base paper fitness function, they have only considered the Mutual Information (MI) that restricts its performance. Hence there is a need to develop a mechanism which can extract the more features form image and also add more formulas in fitness function 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. Standard Image Fusion generates a fused image in which each pixel is determined from a set of pixels in each source image. 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 hybrid of traditional FFT is used along with HIS. So, in proposed model frequency domain features are extracted using FFT and spatial features are extracted using HIS. Another new work will be done is the use of Mutual Information (MI), Standard Deviation (STD), Entropy and Edge Strength while making fitness rather than using only MI. Now, in the proposed model both frequency and spatial features has been extracted and more than one parameter is used while calculating fitness that improve the performance of the system.

This hybrid technique of mage fusion is considered to be better than the previously used techniques. The results obtained are better, efficient than the conventional techniques.

The methodology of proposed work has been explained in the figure 4.2.

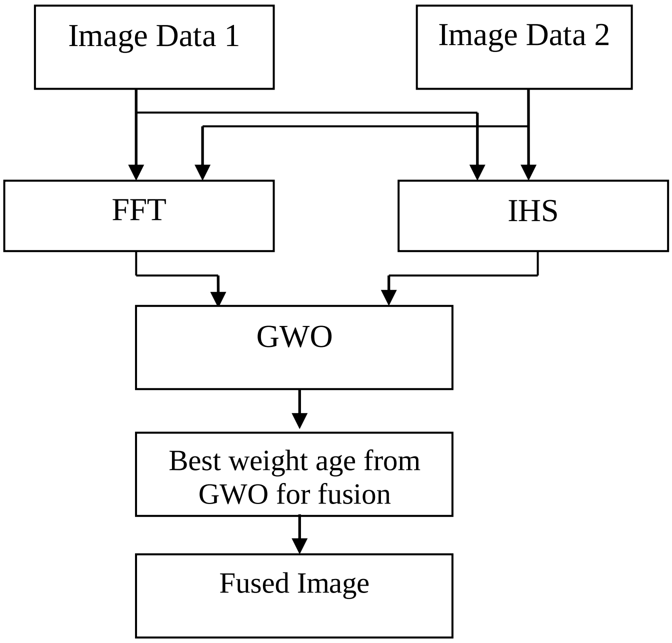


Figure 1 Block Diagram of proposed work

The methodology of proposed work is as below:

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.
2. Second step is to apply FFT and HIS on both of the selected images. The purpose behind applying these both is to extract the features of the images.
3. After this the GWO Algorithm is applied to extracted features in order to fuse them in single one.
4. Fitness will be calculated using different parameters like Mutual Information (MI), Standard Deviation (STD), Entropy and Edge Strength.

In this step the Inverse SWT is applied to the fused data so that final fused image can be obtained.

IV. RESULTS

The simulation analysis has been performed using proposed and traditional wavelet approaches. For the comparison purpose different versions of discrete wavelet techniques has been taken. The performance parameters such as Entropy, STD, Mutual Information and Edge based similarity measure are taken into consideration for evaluation of both techniques. These parameters assist the user to estimate the performance of individual approach. The acquired results are shown in the below section with the brief introduction of different performance parameters.

a. Fusion Metrics

The fusion metrics explained the performance of fusion techniques. In order to evaluate the objective of fused image below metrics are used:

- **Entropy (E):**

The entropy parameter is used to describe the information content in an image. The equation used for the evaluation is as:

$$E = \sum_{L=0}^{L-1} P_l log_2 P_l \qquad (1)$$

- **Standard Deviation (STD):**

Another parameter considered for the evaluation is SD. The higher standard deviation value signifies better contrast in the gray levels of the image. The equation used for the evaluation is as follows:

$$STD = \left(\frac{1}{m*n}\sum_l^m \sum_l^n (f(n,m)-\mu)^2\right)^{1/2} \qquad (2)$$

- **Mutual Information (MI):**

In the multimodal fusion the mutual information is utilized as a performance measure, the mutual information is expressed as:

$$MI = I_{AF} + I_{BF} \qquad (3)$$

Here, the values of I_{AF} *and* I_{BF} are measured through the equation number 4. The fused image consists of the much parental image knowledge if the values of the MI are large. The I_{AF} *and* I_{BF} are the mutual information within the fused frame among initial modality and fused frame among other modality.

$$\text{MI (x, y)} = \sum_x \sum_y P(x,y) log \frac{P(x,y)}{P(x)P(y)} \qquad (4)$$

- **Edge Based Similarity Measure $Q^{AB}/_F$:**

In the fused image the edge based similarity measures can offer the quantity of the edge details and the array of the significances in 0-1. The significance of the $Q^{AB}/_F$ is near to 1 for the maximum superiority fusion. The value of the $Q^{AB}/_F$ is expressed as below:

$$Q^{AB}/_F\,(m,n) = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} Q^{A}/_F(i,j) g_A(i,j) + Q^{AB}/_F(i,j) g_B(i,j)}{\sum_{i=1}^{M}\sum_{j=1}^{N} g_A(i,j) + g_B(i,j)} \qquad (5)$$

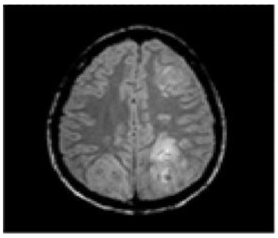
$$Q^{A}/_F(i,j) = Q_g^{A}/^F(m,n) Q_\propto^{A}/^F(m,n), Q_g^{B}/^F(i,j)$$

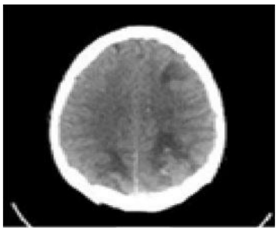
$$= Q_g^{B}/^F(m,n) Q_\propto^{B}/^F(m,n) \qquad (6)$$

Here, g_A = g_B = weight values

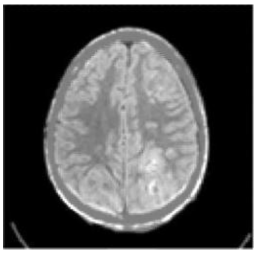
$Q^{A}/_F$= $Q^{B}/_F$= Reflect edge information preservation values.

The simulation results acquired from the implementation of proposed technique is shown in this section. Along with this the comparison of traditional techniques and proposed work has been also calibrated in this. In order to perform Image fusion, two blur images are taken to form a single enhanced image. The simulation analysis is performed on medical images using MATLAB.





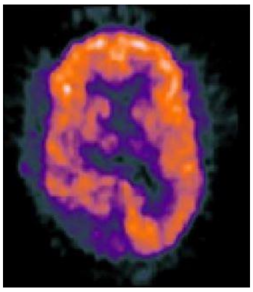
(a) MRI Image (b) CT Image



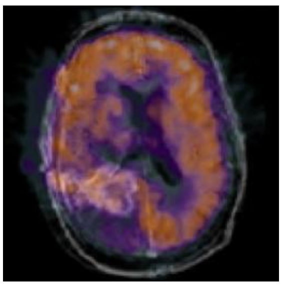
(c) Fused image (MRI +CT image)

Figure 2 Image Fusion of MRI and CT images

The figure 2 comprised of two of the input images i.e. image of MRI and CT. then these two images are fused by using proposed work and shown in figure 2(c). Similarly, the proposed work is also simulated by using other medical images i.e. MRI and PET images as shown in figure 3.



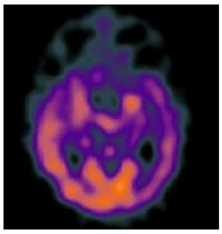
(a) MRI Image (b) PET Image



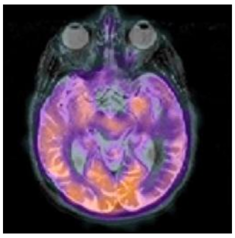
(c) Fused image (MRI +PET image)

Figure 3 Image Fusion of MRI and PET images

The above shown Figure 3(a) and Figure 3(b) show the input MRI image and the PET image. Here the MATLAB 2015b is utilized for simulation analysis. However, the fusion of both the images is demonstrated in the Figure 3(c) that is the fused image (MRI +PET image) of the MRI image and PET image.



(a) MRI Image (b) SPECT Image



(c) Fused Image (MRI +SPECT image)

Figure 4 Image Fusion of MRI and SPECT images

The above shown Figure 4(a) demonstrates the process of image fusion for MRI and SPECT images.

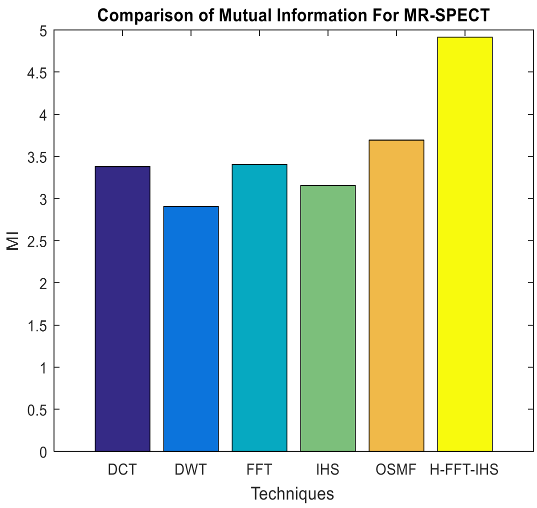


Figure 5 Comparison of Mutual Information for MRI-SPECT

The graph of Figure 5 illustrates the comparison of Mutual Information for the fusion of the MRI and Single Photon Emission Computed Tomography image sample 1. The graph represents the comparison between the MRI values for different techniques as DCT, DWT, FFT, IHS, OSMF and H-FFT-IHS. In values those are achieved for the different techniques are as: DCT= 3.3805, DWT= 2.9074, FFT= 3.4069, HIS= 3.1579, OSMF= 3.6933 and H-FFT-HIS= 4.9146. From the figure it is analyzed that the Mutual Information achieved by the proposed model that is hybrid FFT-HIS approach using GWO is high comparative to the other mechanisms.

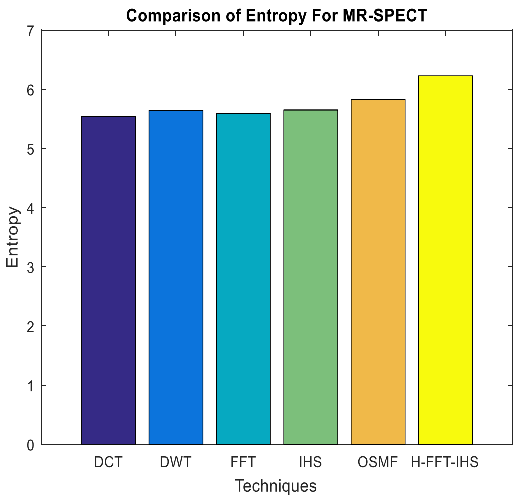


Figure 6 Comparison of Entropy for MRI-SPECT

The graph in figure 6 depicts the comparison of Entropy analysis for the fusion of the MRI and Single Photon Emission Computed Tomography medical image sample 1. The graph delineates that the entropy of analysis for the fusion of the MRI and Single Photon Emission Computed Tomography image sample 1 is evaluated to be high in comparison to the traditional techniques. The MRI values for different techniques as DCT, DWT, FFT, IHS, OSMF and H-FFT-HIS are 5.5414, 5.6390, 5.5915, 5.6486, 5.8282 and 6.2263 for the Entropy analysis for the fusion of the MRI and Single Photon Emission Computed Tomography medical image sample 1.

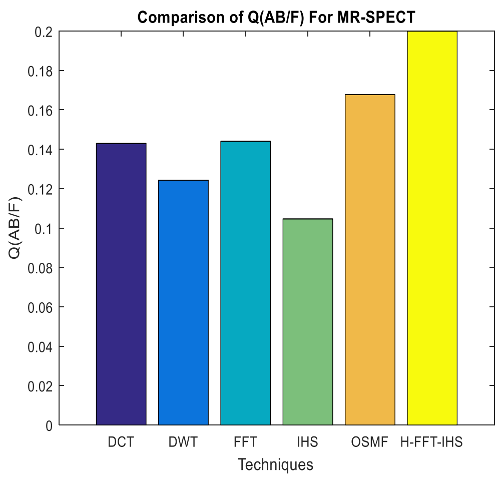


Figure 7 Comparison of Q (AB/F) For MRI-SPECT

The graph of Figure 7 demonstrates the comparison of Q (AB/F) for the fusion of the MRI and Single Photon Emission Computed Tomography image sample 1. For the comparison between the MRI values for different techniques as DCT, DWT, FFT, IHS, OSMF and H-FFT-IHS are attained in the graph. In this graph the values those are achieved for the different techniques are as: DCT= 0.1429, DWT= 0.1243, FFT= 0.1440, IHS= 0.1046, OSMF= 0.1677 and H-FFT-HIS= 0.1999. From the figure it is analyzed that the Mutual Information achieved by the proposed model that is hybrid FFT-HIS approach using GWO is high comparative to the other mechanisms.

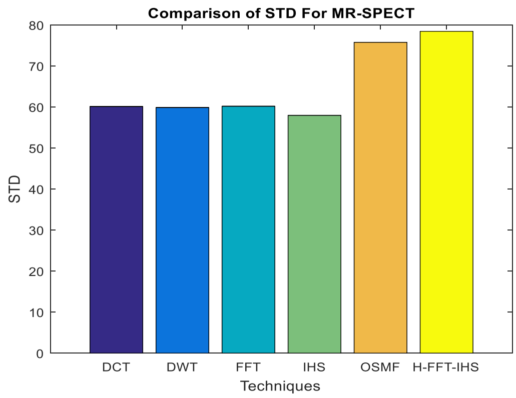


Figure 8 Comparison of STD for MRI-SPECT

The standard deviation of proposed image fusion technique has been analyzed in figure 8. On the basis of the graph, it is observed that the STD of proposed technique is efficient than the DCT, DWT, FFT, IHS and OSMF. The evaluated STD for the fusion of the MRI and Single Photon Emission Computed Tomography image sample 1 is 78.4312 that is enhanced comparative to the other mechanisms.

Table 1 Results of MR-SPECT image Fusion Analysis

MR-SPECT	DCT	DWT	FFT	IHS	OSMF	H-FFT-IHS
Mutual	3.3805	2.9074	3.4069	3.1579	3.6933	4.9146
Entropy	5.5414	5.6390	5.5915	5.6486	5.8282	6.2263
Q(AB/F)	0.1429	0.1243	0.1440	0.1046	0.1677	0.1999
STD	60.0994	59.8453	60.1742	57.9662	75.7581	78.4312

For the fusion of the MRI and Single Photon Emission Computed Tomography image sample 1through analyzing the Mutual Information, Entropy, Q (AB/F) and STD for this the projected mechanism that is hybrid FFT-IHS approach using GWO is much effective and efficient comparative to the conventional mechanisms that are DCT, DWT, FFT, IHS, OSMF techniques as illustrated in the Table 1.

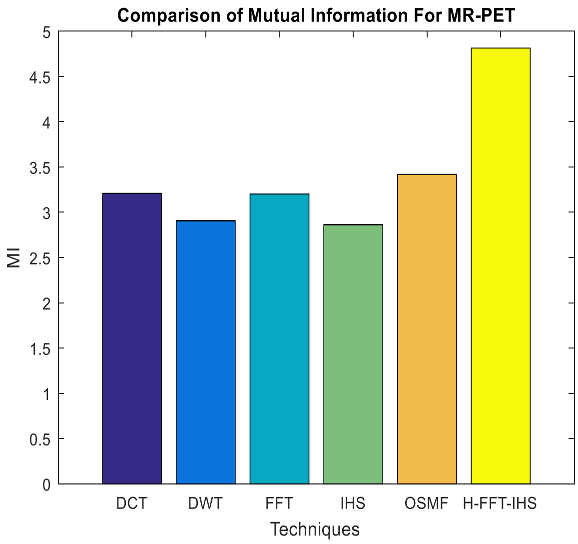


Figure 9 Comparison of Mutual Information for MR-PET

The graph of Figure 9 illustrates the comparison of Mutual Information for the fusion of the MRI and Position Emission Tomography sample 2. The graph represents the comparison between the MRI values for different techniques as DCT, DWT, FFT, IHS, OSMF and H-FFT-IHS are attained in the graph. In this graph the values those are achieved for the different techniques are as: DCT= 3.2080, DWT= 2.9068, FFT= 3.2013, IHS= 2.8624, OSMF= 3.4180 and H-FFT-IHS= 4.8137. From the figure it is analyzed that the Mutual Information achieved by the proposed model that is hybrid FFT-HIS approach using GWO is high comparative to the other mechanisms.

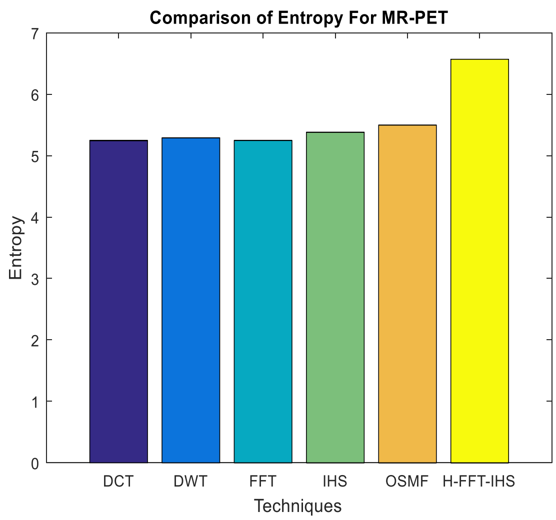


Figure 10 Comparison of Entropy for MR-PET

The graph in figure 10 depicts the Entropy analysis for proposed technique. The graph delineates that the entropy the fusion of the MRI and Position Emission Tomography sample 2 is evaluated to be high in comparison to the traditional techniques. The values those are achieved for the different techniques are as: DCT, DWT, FFT, IHS, OSMF and H-FFT-IHS are 5.2456, 5.2884, 5.2465, 5.3807, 5.4968 and 6.5686 for the Entropy for the fusion of the MRI and Position Emission Tomography sample 2.

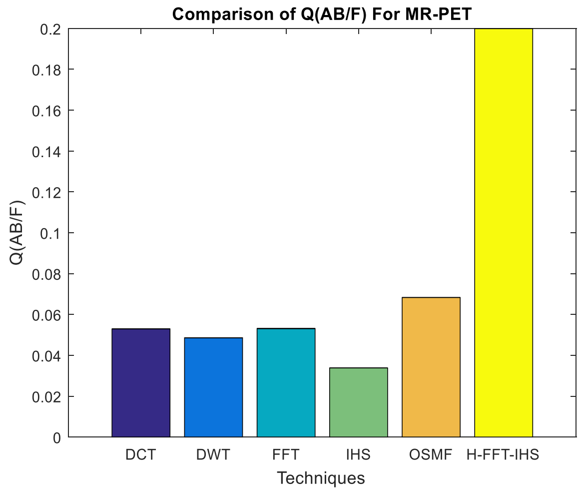


Figure 11 Comparison of Q (AB/F) for MR-PET

The graph of Figure 11 demonstrates the comparison of Q (AB/F) for the fusion of the MRI and Position Emission Tomography sample 2. The graph represents the comparison between the MRI values for different techniques as DCT, DWT, FFT, IHS, OSMF and H-FFT-IHS are attained in the graph. In this graph the values those are achieved for the different techniques are as: DCT= 0.0529, DWT= 0.0486, FFT= 0.0531, IHS= 0.0338, OSMF= 0.0683and H-FFT-HIS= 0.1999. From the figure it is analyzed that the Mutual Information achieved by the proposed model that is hybrid FFT-IHS approach using GWO is high comparative to the other mechanisms.

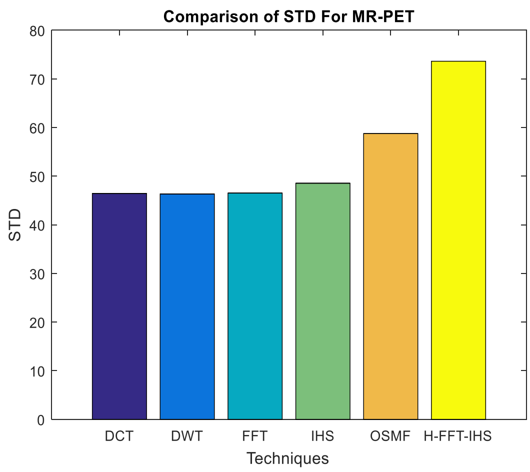


Figure 12 Comparison of STD for MR-PET

The standard deviation of proposed image fusion technique has been analyzed in figure 12. On the basis of the graph, it is observed that the STD of proposed technique is efficient than the DCT, DWT, FFT, IHS and OSMF techniques. The evaluated STD for the fusion of the MRI and Position Emission Tomography sample 2 is 73.6188 that is enhanced comparative to the other mechanisms.

Table 2 Results of MR-PET image Fusion Analysis

MR-PET	DCT	DWT	FFT	IHS	OSMF	H-FFT-IHS
Mutual	3.2080	2.9068	3.2013	2.8624	3.4180	4.8137
Entropy	5.2456	5.2884	5.2465	5.3807	5.4968	6.5686
Q(AB/F)	0.0529	0.0486	0.0531	0.0338	0.0683	0.1999
STD	46.4373	46.3463	46.5180	48.5425	58.7578	73.6188

For the fusion of the MRI and Position Emission Tomography image sample 1through analyzing the Mutual Information, Entropy, Q (AB/F) and STD for this the projected mechanism that is hybrid Fast Fourier Transform-Intensity Hue Saturation approach using GWO is much effective and efficient comparative to the conventional mechanisms that are DCT, DWT, FFT, IHS, OSMF techniques as illustrated in the Table 2.

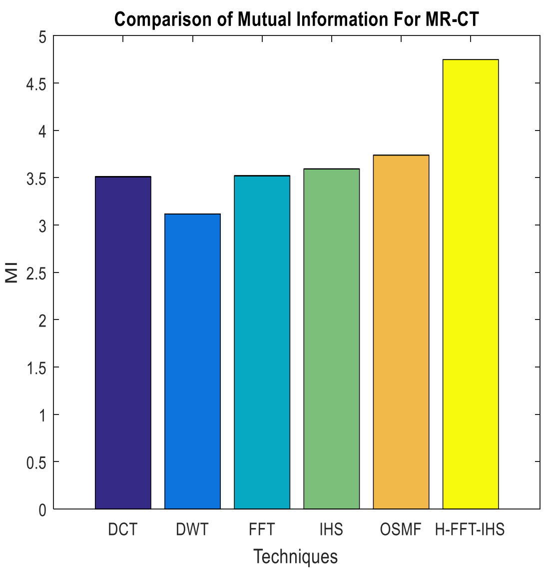


Figure 13 Comparison of Mutual Information for MR-CT

The graph of Figure 13 illustrates the comparison of Mutual Information for the fusion of the MRI and Computed Tomography sample 3. The graph represents the comparison between the MRI values for different techniques as DCT, DWT, FFT, IHS, OSMF and H-FFT-IHS are attained in the graph. . In this graph the values those are achieved for the different techniques are as: DCT= 3.5102, DWT= 3.1169, FFT= 3.5205, IHS= 3.7381, OSMF= 3.7381and H-FFT-HIS= 4.7481. From the figure it is shown that the Mutual Information for the fusion of the MRI and Computed Tomography is high comparative to the other mechanisms.

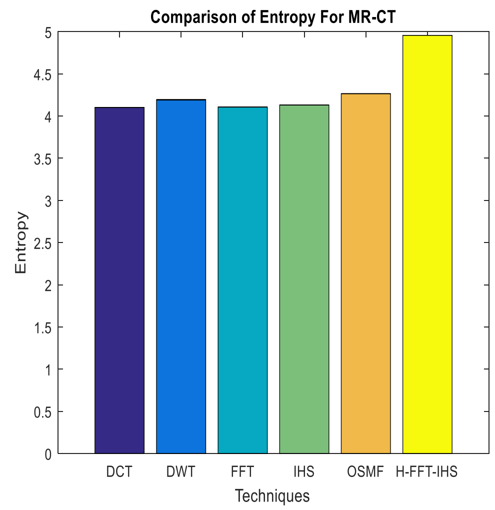


Figure 14 Comparison of Entropy for MR-CT

The graph in figure 14 depicts the Entropy analysis for proposed technique that is the MR-CT. The graph delineates that the entropy for the fusion of the MRI and Computed Tomography sample 3is evaluated to be high in comparison to the traditional techniques. The graph represents the comparison between the MRI values for different techniques as DCT, DWT, FFT, IHS, OSMF and H-FFT-IHS are 4.1007, 4.1929, 4.1075, 4.1306, 4.2649and 4.9560for the Entropy for the fusion of the MRI and Computed Tomography sample 3that are less comparative to the fusion of the MRI and Position Emission Tomography sample 2 and the fusion of the MRI and Single Photon Emission Computed Tomography image sample 1. But the Entropy of the projected mechanism for MR-CT is high rather than the conventional mechanisms.

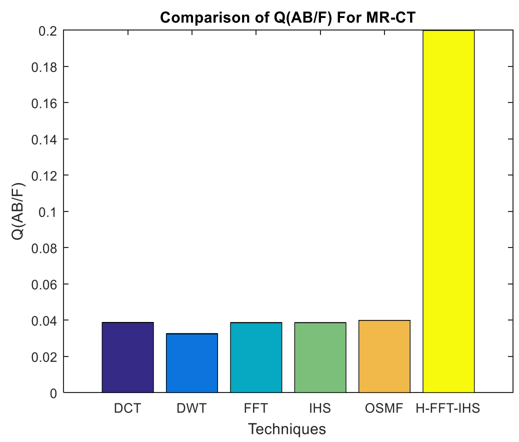


Figure 15 Comparison of Q (AB/F) for MR-CT

The graph of Figure 15 shows the comparison of Q (AB/F) for the fusion of the MRI and Computed Tomography sample 3. The graph represents the comparison between the MRI values for different techniques as DCT, DWT, FFT, IHS, OSMF and H-FFT-IHS are attained in the graph. In this graph the values those are achieved for the different techniques are as: DCT= 0.0387, DWT= 0.0325, FFT= 0.0386, IHS= 0.0386, OSMF= 0.0399and H-FFT-HIS= 0.1998. From the figure it is shown that the Q (AB/F) for the fusion of the MRI and Computed Tomography is very much high comparative to the other methods.

The graph of Figure 16 illustrates the standard deviation of projected image fusion mechanism and has been analyzed. On the basis of the graph, it is observed that the STD of projected mechanism is much effective comparative to the DCT, DWT, FFT, IHS and OSMF mechanisms. The calculated STD for the fusion of the MRI and Computed Tomography sample 3 is 93.9660 that is superior comparative to the other mechanisms.

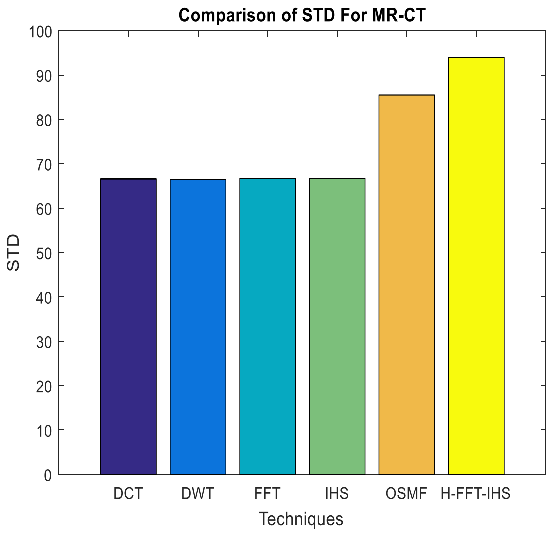


Figure 16 Comparison of STD for MR-CT

Table 3 Results of MR-CT image Fusion Analysis

MR-SPECT	DCT	DWT	FFT	IHS	OSMF	H-FFT-IHS
Mutual	3.5102	3.1169	3.5205	3.7381	3.7381	4.7481
Entropy	4.1007	4.1929	4.1075	4.1306	4.2649	4.9560
Q(AB/F)	0.0387	0.0325	0.0386	0.0386	0.0399	0.1998
STD	66.5852	66.6945	66.6945	66.7188	85.4942	93.9660

For the fusion of the MRI and Computed Tomography image sample 3 through analyzing the Mutual Information, Entropy, Q (AB/F) and STD for this the projected mechanism that is hybrid Fast Fourier Transform-Intensity Hue Saturation approach using GWO is much effective and efficient comparative to the conventional mechanisms that are DCT, DWT, FFT, IHS, OSMF techniques as illustrated in the Table 3. The Table 3 shows the facts that are observed on the simulated results. The table explains that the projected image fusion mechanism outperforms the conventional methods with respect to the evaluated parameters. If we can see the table 1, 2, 3 show the same parameters but with different values of the different techniques and demonstrated for different fusion mechanisms that are as follows: the first table shows the values for the fusion of the MRI and Single Photon Emission Computed Tomography image sample 1, Second table illustrates the values for the fusion of the MRI and Position Emission Tomography image sample 2 and the third table illustrates the values for the fusion of the MRI and Computed Tomography image sample 3.

V. CONCLUSION

Image fusion is considered as a process that combines two blur images to form a single enhanced image. There are several wavelet based techniques have been developed. However, these techniques have been suffering from several issues such as low quality image and high noise in the acquired image. Considering a novel approach has been proposed in this work. Initially Hybrid Fast Fourier Transform and Intensity Hue saturation approach is used to extract the features from set of images and then Gray Wolf Optimization is applied to acquire optimum solution for the process of fusion. The performance of proposed approach is computed under MATLAB software. From the simulation analysis, it has concluded that proposed technique outperformed the traditional technique in terms of different performance parameters such as Mutual Information, Entropy, Q (AB/F), Standard Deviation. The proposed technique in every aspect performs significantly in comparison with traditional approach. Furthermore, the acquired fused image from proposed technique is of high quality with less noise. Additionally, the fused image generated through the proposed technique is highly similar to the original image that shows the optimality of the Hybrid FFT-IHS technique.

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