Wave-packet image fusion technique based on Genetic Algorithm

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Abstract: **Image fusion is area of digital image processing which deals with combining the two complimentary images obtained from different sensors into one single image containing the most relevant information of the provided scene. Research domain of image fusion process is very vast. Application of image fusion ranges from medical field to satellite technology. This fused Image obtained after fusion process has characteristics of each input image. Here in our purposed work we want to fuse CT and MRI images. There are various standard method used for image fusion produce that produce good result spatial result but cause spatial noise. In this paper we represent image fusion technique that will provide better result using Discrete Wave Packet decomposition (DWPT) and optimize result using genetic algorithm (GA) than compare it with Intensity Hue Saturation (IHS) used for image fusion. Performance of purposed fusion technique is measured by mean, standard deviation, entropy, variance, mutual information, peak signal to noise ratio (PSNR) and structure similarity.**

Keywords—image fusion; discrete wavelet packet transform; genetic algorithm; performance measures

I. INTRODUCTION

With the development of various images sensors, number of images of one scene can be obtained from these sensors. Every image provided by these different sensors contains specific information of the given scene based on the properties of sensors [1]. Image fusion can be used to improve or extend the information provided by these sensors by combining these images together. Fused image contain most relevant information of the given scene. Image fusion technique can be used in medical field, military operations, in conceived weapon detection, in satellite etc[2]. in this paper we will fuse CT images and MRI images obtained from two different sensors. We studied number of fusion techniques so that accurate result can be obtained. By studying these techniques we have found that current techniques simply merge the input images without analyzing them, and few techniques introduce spatial noise to the output image.

The easiest method to fuse two different images was pixel by pixel [3] .In this method two images are simply fused together and result obtained by this method was very poor. This method introduced various noises to the output. With the advancement of technology number of fusion techniques are introduced which are Laplacian pyramid [4], Hue-intensity-saturation, principle component analysis (PCA), Discrete wavelet transform method with genetic algorithm [5] and multi-resolution method [6, 7].

Here in our paper we have introduced two techniques. These techniques are IHS and hybrid technique which uses wavelet packet and genetic algorithm. We also compared our purposed technique with HIS to show which method is better in providing accurate results.

Outline of the paper is as follow:

Section 2 shows the brief information about DWPT and genetic algorithm ,section 3 explain the purposed algorithm ,section 4 gives various measure to evaluate the performance of given algorithm, section 5 gives the experimental result and comparison between techniques, Section 5 draw the conclusion.

II. BACKGROUND INFORMATION OF TECHNIQUES

A. Genetic Algorithms:

Theory of natural selection and genetic algorithm is discovered by Charles Darwin [8]. He purposed in his theory of evaluation that individual which is fittest will survive and get chance to increase its population. Here fittest individual will act as an optimizing problem solver [9]. This property of genetic algorithm can be used in digital image processing for image enhancement and filtering.

In digital world strings of bit are mapped to genetic material and fitness function used to replace natural selection, matting operation is represented by crossover and mutation [8].

GAs was proven to be the most powerful optimization technique in a large solution space.

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In digital image processing GA proved to be very useful in image enhancement and segmentation.GA are very helpful in optimizing a problem in large solution space which explains why these algorithm become so important and famous in the area of image processing. In GA random population is chosen then we apply fitness function to the random population to find fittest individuals, then these individual are allowed to produce offspring and when stop criteria is met we replace the old population with the new one.

B. Discrete wavelet packet transforms.

DWPT or discrete wavelet packet transform is extension to traditional DWT, which is basically used for lossy compression technique for the decomposition of image [10]. Wavelet packet transform decompose image into small frequency level based on entropy which act as selection criteria for, the various approximation levels of decomposed image.

The traditional DWT only decompose image into sequence of energy level called low frequency level or approximation level, where as in discrete wavelet packet not only approximation level but every 'detail' of image is further decomposed resulting into complete binary tree. One advantage of using DWPT is that it provide better frequency localization which is more helpful in analysing its properties[5] .Discrete wavelet packet decomposition provide more information than DWT and hence can be used as a tool for signal processing. Whenever DWPT implemented for decomposition it will always result into a binary tree showing both approximation as well as the details of the image as shown in fig 1.

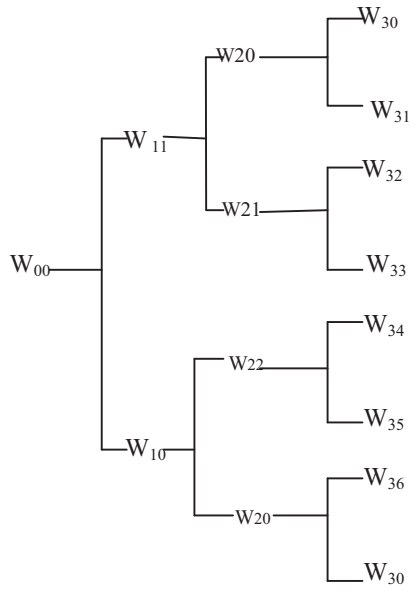


Figure 1. The wave packet decomposition tree

III. PURPOSED ALGORITHM

In our purposed algorithm we have first we register input images than perform pre-processing of input images which include re-sampling and histogram matching .After that DWPT is applied to decompose images. This whole method is shown in figure 2.

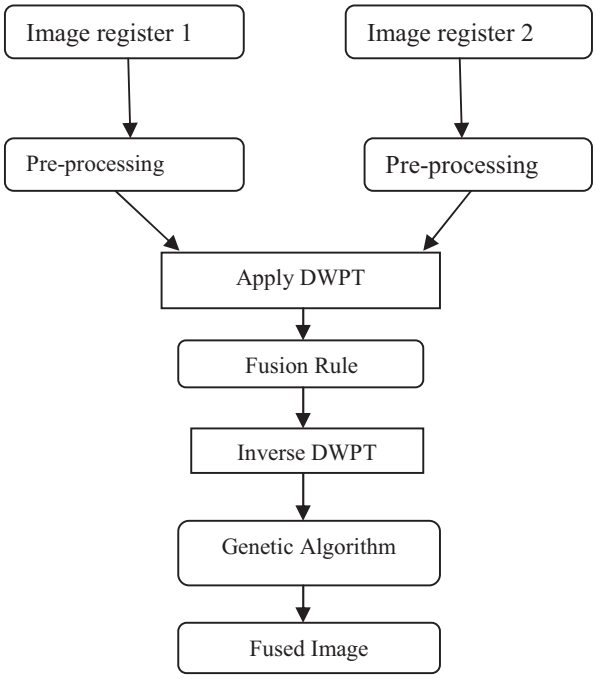


Figure 2. Purposed Algorithm

IV. VARIOUS PERFORMANCE MEASURES OF IMAGE FUSION:

There are 5 various performances measures of quality of fused images.

Definition of these measures and their physical meanings are given as follows [11].

1. Entropy:

Entropy is very important characteristic of an image. It represents the amount of information contained in the form of energy. To know the quality of image after fusion entropy plays a very crucial role as higher value of entropy depicts better fusion results.

Numerically, Entropy is given as:

$$\text{Entropy} \quad E = -\sum_i^n p(x_i) \ln\, p\,(x_i) \tag{1}$$

2. Mean and Standard Deviation:

In the field of image processing mean is statistical quantity and it is simply obtained by taking the average values of the number of pixel in particular row and column.

$$\text{SD,} \quad \sigma^2 = \frac{1}{N-1}\sum_i^n (x-\mu)^2 \tag{2}$$

μ: represent the population size (pixels)

3. Peak Signal to Noise Ratio:

The PSNR is an empirical method to predict the quality of an image. It may be defined as quotient of maximum value of signal to the disturbance present in image. The closer the value of PSNR to the original image, better the fused image is and better will be the algorithm.

$$\text{PSNR} = 10\, log \frac{255}{RMSE^2} \quad (3)$$

4. Root Mean Square Error:

Here RMSE stands for root mean square error, and if RMSE is zero it shows perfect fusion.

Here $\text{RMSE}^2 = \frac{1}{MN} \sum \sum [C(i,j) - M(i,j)]$ (4)

Where c is CT image and M is MRI image.

5. Mutual Information:

In mathematics and digital image processing, mutual information may be seen as the metric used to display the dependence between two variables, variables in image processing are replaced by pixel values. This parameter shows the correlation between two images. For the process of image fusion we must need to calculate the mutual information index. If MI tends to zero or become images are considered totally independent of each other.

Numerically, MI $= \sum_{y \in Y} \sum_{x \in X} p(x,y) log \left(\frac{p(x,y)}{p(x)p(y)} \right)$ (5)

V. EXPERIMENTAL RESULT

There are varieties of image fusion techniques which vary depending upon the specific application. Our purposed algorithm work on variety of data image set.

Performance of algorithm can be calculated by variety of metrics which were explained earlier. This section represents the experimental result obtained by analysis of purposed system.

A. Data Set:

Purposed algorithm is tested with 7 different data set .These image data set is obtained from different sensors. Images represent the situation where, due to the limited depth-of-focus of optical lenses in cameras, it is not possible to get an image which is in focus everywhere. Therefore not fit for analysis, whereas some data set shows situation where images are obtained from different sensors i.e. one from infrared and one from simple camera. Evaluation metrics play very vital role in measuring the quality of image obtained from purposed fusion algorithm.

There are seven evaluation parameters used for measuring the performance of algorithm and they are PSNR, mean square error (mse), variance, Entropy, standard deviation, mutual information and mean.

B. *Performance Analysis:*

Visual result of our algorithm is shown in Fig 3.By taking the entropy as selection criteria in wavelet packet decomposition and applying the PSNR as the fitness function to sat of data images, we get better result as compared to HIS .GA gives the best PSNR value by de-noising the images.

Now by applying the evaluation measures to given data set

Following are result of image Fusion using wave packet and genetic algorithm.

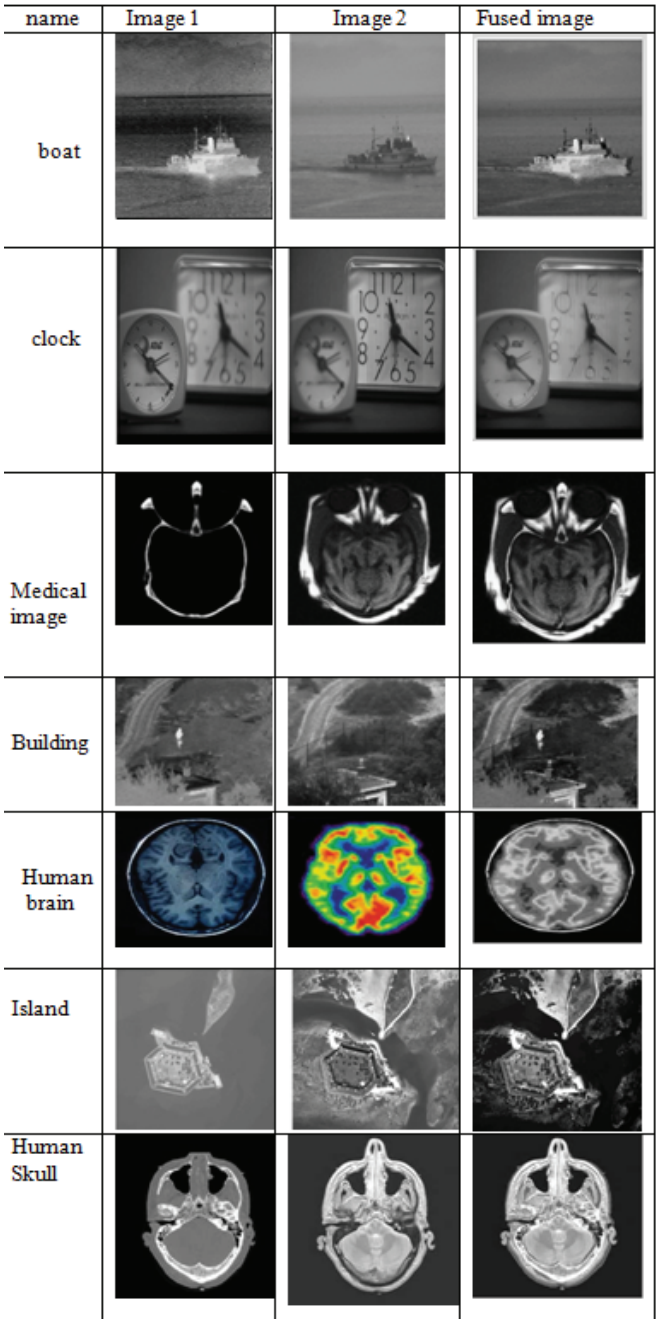


Figure 3. Visual results of approach

1. Result of wave-packet image fusion and Genetic algorithm is shown in table 2.

2. In the purposed algorithm we have used genetic algorithm which is used for image enhancement.

TABLE 1.PARAMETER SETTING FOR GENETIC ALGORITHM

Parameter	Definition	value
μ	Population size	25
P	Crossover probability	0 .4
P(m)	Mutation Probability	0.02
Numitr	Number of iteration	21
Numgn	Number of genes	7

TABLE 2. THE RESULT OF APPLYING PURPOSED ALGORITHM.

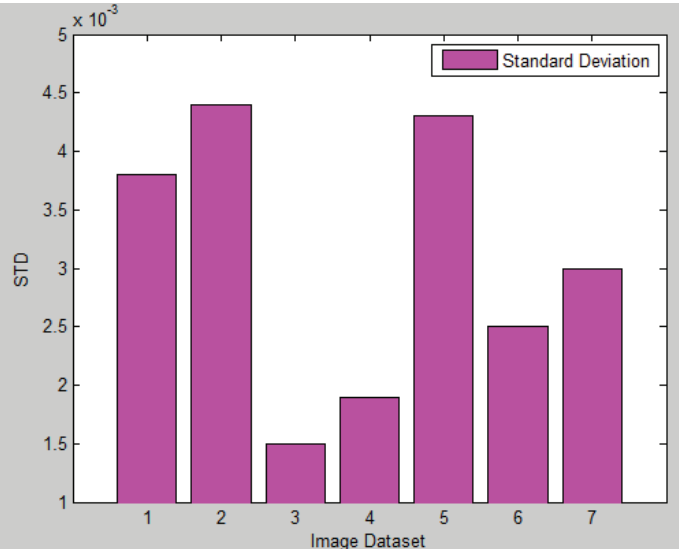
Image	Entropy	PSNR	MI	SD	mean	mse
Boat	16.0293	17.8565	1.0497	.0015	33.1587	1.0652
clock	15.9477	17.8095	2.2558	.0030	33.1558	1.0768
Medical image	15.9157	17.7759	.4214	.0038	33.1537	1.0852
building	16.994	17.8087	.6622	.0019	33.1569	1.0770
Human brain	14.6481	17.7908	.8074	.0043	33.1548	1.0814
island	15.3780	17.8452	.5711	.0025	33.1587	1.0680
Human skull	10.1188	17.8178	1.4185	.0044	33.1565	1.0747

Comparison with Intensity hue saturation method:
In this paper we have compared purposed algorithm with the Intensity –Hue-Saturation algorithm and result of the both algorithm are shown below in table 3

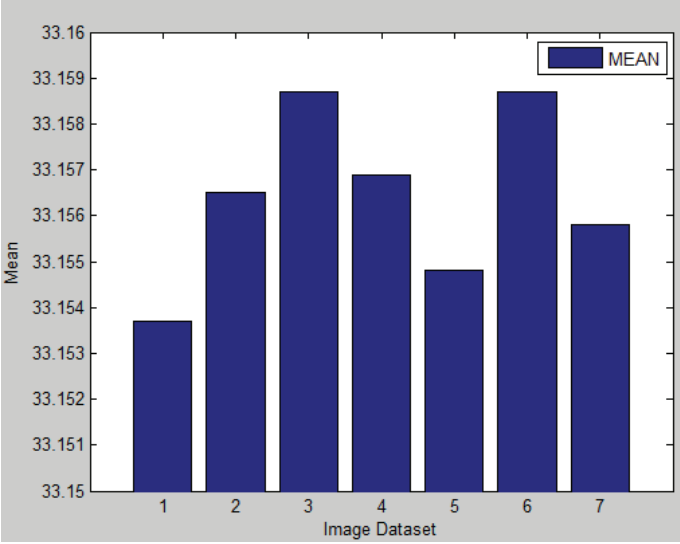
TABLE 3.COMPARISON BETWEEN IHS AND WAVELET PACKET

Image		Boat	clock	Medical image	Building image	Human brain	Island	Human Skull
Variance	DWPT	5.9080	2.4019	1.4541	3.4598	1.982	8.7890	--------
	IHS	5.5709	2.3067	1.4562	3.4080	1.240	8.1294	----------
Entropy	DWPT	16.0293	15.9477	15.9157	16.0994	14.6481	15.3780	10.1188
	IHS	5.9627	7.3544	6.7442	6.6842	12.2990	6.3415	4.7800

2. Graph of results for given image data set



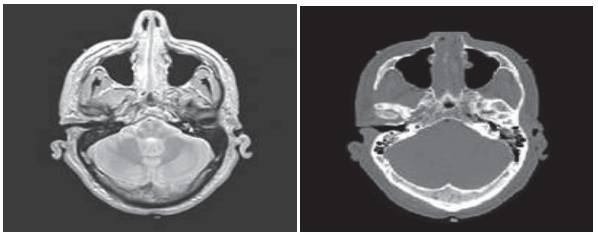
Graph for standard deviation



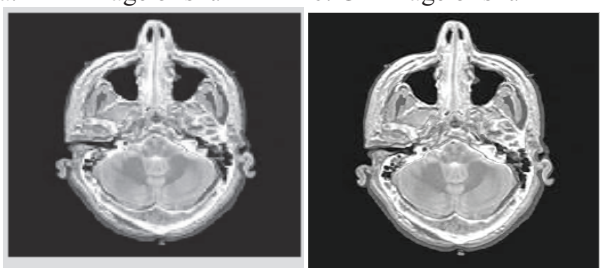
Graph for standard deviation

Comparison with IHS:

We have demonstrated our algorithm using MATLAB on different images. All the images are of same size i.e. 256×256. For evaluating the performance of both algorithms, two measures have been used and they are entropy and variance. These measures are used because they can accurately show the performance of both algorithm .Below is result of both algorithms on the

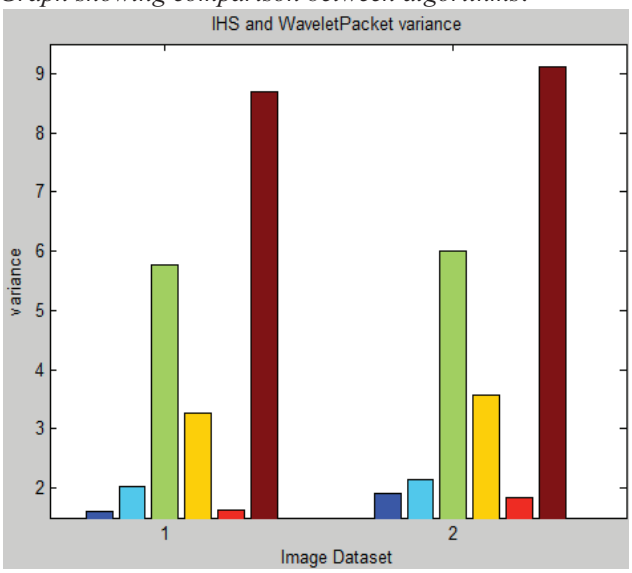


a. MRI image of skull b. CT image of skull

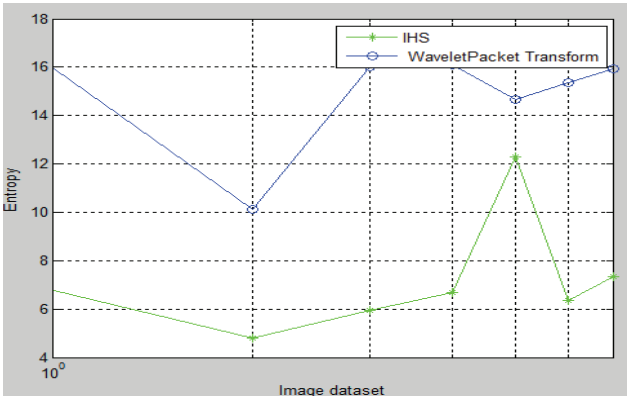


c. Fused by IHS d. Purposed algorithm

Graph showing comparison between algorithms:



Based on variance



Based on entropy

CONCLUSION

Here we developed a fusion method using wavelet packet and genetic algorithm. In this paper we have compared the result of purposed algorithm with the IHS method for fusion. We have found that purposed algorithm provide better result than that of IHS method. In this method we have used two grey scale images. We have first fused image using WPT and then use genetic method to fuse the image.

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