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An Improved Image Fusion Algorithm based on Wavelet Transforms using SOM Neural Network Model

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Abstract - Image Fusion is a process of joining the information from multiple images of the same scenario. As the different images of same scenario contains different form of information. The output of fused image is a new image that contains the desirable information of the fused image. The main application of image fusion is also in field of medical science for the detection of serious medical diseases. The brain stroke or tumor detection in head is very difficult task because of the complications in human body. To analyze or to examine the internal body parts, different techniques for scanning can be used. Some most commonly used technique for scanning include the computerized tomography scan (CT scan) and magnetic resonance imaging scan (MRI scan) but images of parts of body taken by using these techniques have their advantages and disadvantages. MRI scan is capable of showing image of soft tissues clearly but it cannot show the image of hard tissues and bones. The CT scan is capable show the images of hard tissues like bones but it cannot show the images of soft tissues clearly like membranes covering the brain. If the CT scan and MRI scan both images are joined then the fused image will have the advantages of both CT scan and MRI scan images. Image fusion technique described in this paper can be used to combine both CT scan and MRI scan images so it will be easy to detect brain stroke condition. In this paper, we focus on the fusion methods based on Wavelet Transforms using SOM Neural Network Model. The proposed algorithm performs better in comparison of previous method such as WT and IWT transform method.

Keywords: Image fusion, SOM Neural Network Model, fusion of CT scan and MRI scan images, enhancement of medical imagery, CT scan, MRI scan.

I. INTRODUCTION

Computers are most frequently used in our daily lives, they can handle large amount of data and computation more efficiently and accurately as compared to humans. Therefore, it is desirable to extend the capabilities of computers to perform more intelligent work, e.g. analysis of visual scenes (images or videos) or audios, which is requires logical reasoning. For humans, this task of analyzing is done many times every day so humans can do this task easily sometimes even without any awareness. In applications of computer vision, one of the largest problem is combining different images of the same scene. Since images are captured by the use of different devices which may have different sensing techniques. Because of the different kind of sensors used in devices for capturing image and their sensing principle of sensing, due to limiting depth of focus of optical lenses used in cameras, it is feasible to get various images of the scene giving different data. There are several image fusion process that can be utilized to create high-resolution images from a high-resolutional panchromatic images and low-resolutional multispectral image. If we Start from physical principle of formation of image, fuzzy theory and Neural network are the two important methods of intelligence, image fusion techniques based on this two methods is capable of simulating intelligent human behavior.

II. INTRODUCTION OF CT SCAN AND MRI SCAN IMAGES

A. CT scanning:

Computerized Tomography is a type of X-ray machine. In simple x-ray, small amount of rays are passed through the body which records an image on photographic film. In CT scan instead of single X-ray beam, many X-ray beams are sent through many angles in body simultaneously. In human body different parts stops the X-ray beams in different manner. The X-rays passing through the less dense area like lungs will be stronger, but beams passing by more denser tissue like bone will be weaker.

B. MRI scanning:

Magnetic Resonance Imaging scanning use both magnetic and radio waves. In MRI scan the patient is kept inside a large, cylinderial magnet. Radio waves very much stronger than magnetic field of earth are passed from the body.

Affecting the atomic structure of body and forces nuclei into another position as they return back into place they leave radio waves himself. The scanner detects this signals reflected by atoms; then computer turns theses signals into a picture based on the strength and location of the coming reflected signals.

Medical image fusion used to extract meaningfull information from medical image. The idea is to improving the content of image by fusing images such as computer tomography (CT) and magnetic resonance imaging (MRI) images, for providing more information to doctors. Stroke is a condition that affects vessels supplying blood to brain. A stroke happens when there is stopping of blood in vessel or bursting of blood vessel in brain because of this, nerve cells in affected area is unable to function. Experienced doctors and radiologists are very well to judge CT and MRI to decide that a patient is suffering by minor stroke or not, but imperfect judgment by general radiologist can cause patient to miss best time for treatment. So, merging of CT scan and MRI scan images can help doctors for making proper decisions.

III. IMAGE FUSION TECHNIQUES

Because of the complications and strong relationship of image information difficulties in modeling will occur at all layers of the process of image fusion. The main intelligent methods used for image fusion are as follows:-

3.1 NEURAL NETWORK

Neural network theory is a major research field in artificial intelligence, suitable for non-linear modeling, with self-organization, self-learning and greater accuracy, have good flexibility and generality for different object modeling, but the structure is complicated, not suitable as the steady-state model of optimization method for complex systems.

3.2 FUZZY THEORY

Fuzzy theory is now applied in the field of data fusion, because it provides an effective process to express uncertainty, thus it can establish the corresponding mathematical model to a lot of uncertain data in data fusion issues. It can also deal with knowledge in digital format, with a similar way for thinking of people to build knowledge.

3.3 ROUGH SET THEORY

Rough set theory has provided new scientific logic and research methods for information science and also provided an effective treatment technology for intelligent information processing. Rough set theory has abilities of analysis, reasoning for incomplete data, and finding the intrinsic relationship between the data extracting useful features.

3.4 WAVELET THEORY

Wavelet transform generate multi-resolution expression of image data, even in low resolution the vast majority of the important features of the raw data is retained, when showing the strong features. The main problems are: the imperfect characteristics of matching rules; how to choose suitable wavelet for purpose of feature extraction; huge amount of operation for optimization search process.

3.5 GENETIC ALGORITHMS

These are search techniques that are capable of solving many optimization problems based on the theory of natural selection and genetics. These algorithms can efficiently and quickly find a solution to a complex problem by searching through a large search space. Figure 1 shows the flow diagram of GA. Four entities that help defining a GA problem are assisting in finding optimal or near optimal solution and specific knowledge for the problem such as variables.

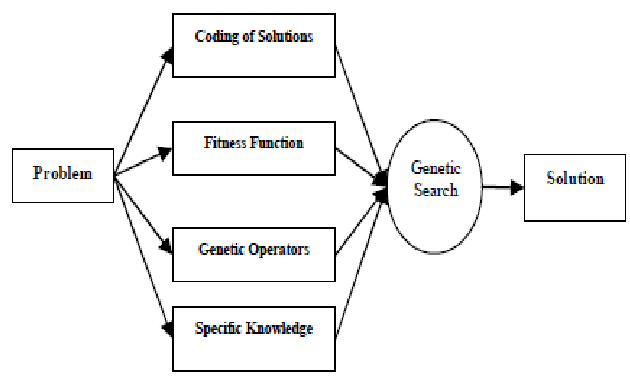


Figure 1: Flow diagram of GA.

3.6 DATA ASSIMILATION

Assimilation means changing the different objects to be close to each other or to be the same. Take assimilating A and B for example, there are five meanings of data assimilation in numeric prediction: 1) A is unchanged, change B to be close to or the same as A; 2) A is unchanged on the whole, change B to A; 3) Change A and B to each other to be similar or the same; 4) B is unchanged, change A to be close to or the same as B; 5) B is unchanged on the whole, change A to B.

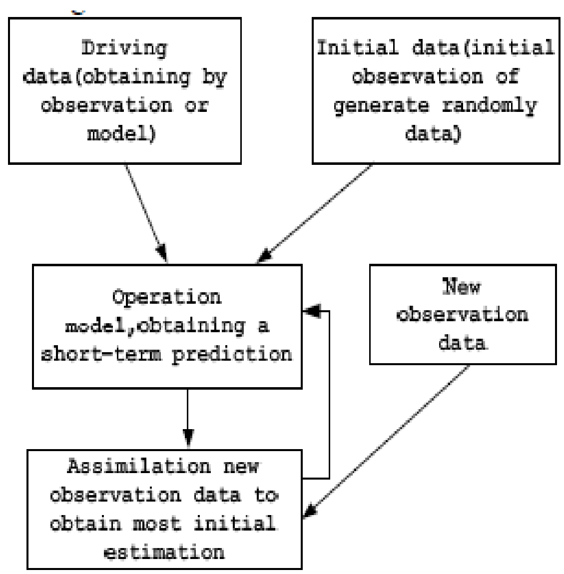


Figure 2: The flow chart of DATA Assimilation

IV. SOM NEURAL NETWORK MODEL

The self-organizing map (SOM) is among popular algorithms in compression of images with great performance. The SOM model is majorly used unsupervised neural network. SOM is used for clustering the high dimensional input data and mapping this input data into a two-dimensional representation space. The SOM is capable of mapping signals from high-dimensional space to one or two dimensional discrete lattice of neuron units. Each neuron use to store a weight. The SOM can organize unknown data in groups of similar patterns, according to a similarity criterion. Such networks are able for learning to detect the correlations and regularities in their input and also adapt their future responses to input accordingly. An important feature of this neural network is its ability to process noisy data.

The learning is based only upon the input data and is independent of the desired output data no error is calculated to train a network. This learning is called unsupervised learning and the input data are called unlabeled data. In this case, the net may react to several output categories on training. But only one of the several neurons has to react. Hence extra structure can be built-in in the network so that the net is forced to make a decision but only one unit will respond. The process of choosing that one unit is called competition. Here only one neuron in competing group will possess a non-zero output signal when the competition is completed. This form of learning depends on the purpose for which the net is being trained.

In Kohonen learning approach the units update their weights by forming a new weight vector that is a linear combination of the old weight vector and the current input vector. Whose weight vector is closest to the input vector, that unit is allowed to learn.

There are two methods are used for the determination of the winner unit.

Method 1: In this method the squared Euclidean distance between the input vector and the weight vector is used, and chooses the unit whose weight vector has the smallest Euclidean distance from the input vector.

Method 2: In this method the dot product of the input vector and the weight vector is used. The net input to the corresponding cluster unit is the dot product of an input vector with a given weight vector. The largest dot product corresponds to the smallest angle between the input and weight vectors if they are both of unit length.

Kohonen worked in the development of the theory of competition as a result the competitive processing elements are referred to as Kohonen unit. These SOM can be termed as topology-preserving maps.

In a topology- preserving map, units located physically next to each other will respond to classes of input vectors that are likewise located next to one another. Although, it is easy to visualize units located to each other in a two dimensional array, it is not easy to determine which classes of vectors are next to each other in a high-dimensional space. Large dimensional input vectors are, in a sense, projected down on the two-dimensional map in a way that maintains the natural order of the input vectors the dimensional reduction could allow us to visualize easily important relationships among the data that otherwise might go unnoticed. The SOM developed by Kohonen, groups the input data into clusters which are, commonly used for unsupervised training. The topological structure property is observed in the brain, but is not found in any other artificial neural networks expect SOM. There are 'm' cluster units, arranged in a one-or two dimensional array and the signals are n-tuples. The exemplar of the input patterns associated with that cluster is weight vector for a cluster unit. The cluster unit whose weight vector matches the input pattern closely is selected as the winner in the self oraganizing process. The winning and the neighboring units update their weights. The neighboring unit weight vectors are not close to the input pattern but differ to some extent. Hence the signal sent from the input units to the cluster units is not multiplied with connection weight.

The architecture of the Kohonen self organizing is shown in fig.4.3. This architecture is similar to the competitive net architecture.

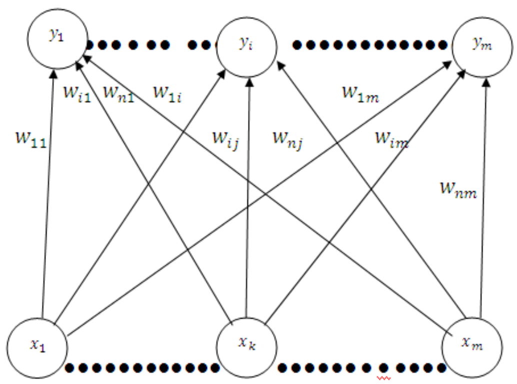


Fig 3. Kohonen Self Organizing Map

The logic of map formation is training should take place in extended region of network centered on maximally active mode. Hence "neighborhood" should be defined for the net. This may be fixed by a relationship between nodes in the self organizing layer. Two neighborhood schemes are shown based on two-dimensional arrays in the form of rectangular and hexagonal grids. In every case, neighborhoods are shown surrounded with respect to a shaded unit at distance of 1, 2 and 3 arrays from this node. Therefore the rectangular and hexagonal arrays have 25 and 19 nodes respectively in their distance-2 neighborhoods (including the central node). All through three dimensional arrays of nodes are imaginable, they are not used owing to their complexity. Because of these connections the output nodes tend to compete to represent the current input pattern.

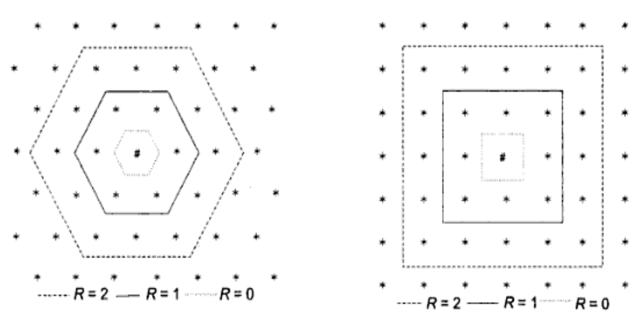


Figure 4: Neighborhood scheme for SOMs (Rectangular and Hexagonal)

The winning unit is represented by '#' and the other inputs are represented by '*' in the rectangular grid and two in the linear grid. Initially, the weights and learning rate are set. The input vectors which are to be clustered are presented to the network. Based on the initial weights on one occasion the input vectors are provided, the winner unit is calculated either by Euclidean distance method or sum of product method. Based on the winner unit selection, the weights are updated for that exacting winner unit using competitive learning rule discussed. By updating the learning rate, several distinct events of training may be performed.

Step 1: Learning rate is set, weights are initialized, Set topological neighborhood parameters.

Step 2: While stopping condition is false, repeat Step 3 – 9

Step 3: For every input vector x, repeat Step 4 - 6

Step 4: For every j, squared Euclidean distance is computed.

$$D(j) = \sum (w_{ij} - x_i)^2 \quad I = 1 \text{ to } n \quad \text{and} \quad j = 1 \text{ to } m$$

Step 5: When $D(j)$ is minimum find index J,

Step 6: For all units J, with the specified neighborhood of J, and for all i, update the weights.

$$w_{ij}(new) = w_{ij}(old) + \alpha[x_i - w_{ij(old)}]$$

Step 7: Update the learning rate.

Step 8: Decrease the radius of topological neighborhood at specified times.

Step 9: Test the stopping condition.

The map formation occurs in two phases:

1. Initial formation of perfect (correct) order
2. Final convergence

The second phase takes a longer duration then the first phase and requires a small value of learning rate. The learning rate is a steadily decreasing function of time and the radius of the neighborhood around a cluster unit also decreases as the clustering process is in progress. The initial weights are considered with random values. The learning rate is updated by, $\alpha(t+1) = 0.5\alpha(t)$.

V. PROPOSED METHODOLOGY

In this section we discuss the proposed methodology of image fusion technique based on wavelet transform function and SOM neural network model. Here the wavelet transforms function process the feature extraction task and SOM neural network model process the function of feature optimization and feature selection task. The task of SOM neural network is proceeding in two phases first in cluster mapping and second is pattern formation. The formation of pattern proceeds for the process of fusion. For the process of fusion estimate the difference of two patterns if the distance of two patterns is minimum approx 0 then image fusion task is performed.

The network receives the 36 Boolean vector values as a 436-element input vector. It is then required to identify the texture feature by responding with a 36-element output vector. The 36 elements of output vector each represent a texture feature. To operate correctly, the network should respond with a 1 in the position of the texture feature being presented to the network. All other values in the output vector should be 0. In addition, the network should be able for handling noise. In practice, the network does not receive a perfect Boolean vector as input. The neural network needs 36 inputs and 26 neurons in its output layer to identify the texture features. The network is a two-layer matrix network. The Gaussian transfer function was picked because its output range (0 to 1) is perfect for learning to output Boolean values. The hidden (first) layer has 22 neurons. This number was picked by guesswork and experience. If the network has trouble learning, then neurons can be added to this layer. The network is trained to output a 1 in the correct position of the output vector and to fill the rest of the output vector with 0's. However, noisy input vectors may result in the network not creating perfect 1's and 0's. After the network is trained the output is passed through the competitive transfer function compete. This makes sure that the output corresponding to the texture feature most like the noisy input vector takes on a value of 1, and all others have a value of 0. The result of this post-processing is the output that is actually used. There are two sets of weights; input-hidden layer weights and hidden-output layer weights. These weights represent the memory of the neural network, where final training weights can be used when running the network. Initial weights are generated randomly there, after; weights are updated using the error (difference) between the actual output of the network and the desired (target) output. Weight updating occurs each iteration, and the network learns while iterating repeatedly until a net minimum error value is achieved. Additional layers of weight can be added but additional layers are unable to adopt. Inputs arrive from left and each incoming connection has an weight associated whit it, W_{ji}. The perception processing unit performs a weighted sum at its input value.

Step1. Initially input image passes through wavelet transform function and decomposed into two layers approximate and details layer. The part of details is preserve and approximate part is proceeding. The approximate part creates the process of feature matrix.

Step2.The original and reference image feature matrix process for vector conversion.

Step3. After conversion of feature vector image data passes through self organized map network

Step4. In phase of feature mapping in feature space of SOM network create a fixed cluster according to threshold of details of image part.

Step5. Here show steps of processing of SOM network

1) Initialize each node's weights.
2) Choose a random vector from training data and present it to the SOM.
3) Every node is examined to find the Best Matching Unit (BMU).
4) The radius of the neighborhood around the BMU is calculated. The size of the neighborhood decreases with each iteration.
5) Each node in the BMU's neighborhood has its weights adjusted to become more like the BMU. Nodes closest to the BMU are altered more than the nodes furthest away in the neighborhood.
6) Repeat from step 2 for enough iteration for convergence.
7) Calculating the BMU is done according to the Euclidean distance among the node's weights (W_1, W_2, … , W_n) and the input vector's values (V_1, V_2, … , V_n).This gives a good measurement of how similar the two sets of data are to each other.
8) The new weight for a node is the old weight, plus a fraction (L) of the difference between the old weight

and the input vector… adjusted (theta) based on distance from the BMU.

9) The learning rate, L, is also an exponential *decay* function. This ensures that the SOM will converge.

10) The lambda represents a time constant, and t is the time step.

Steps 6. After processing of SOM network two pattern matrixes is obtained

Step 7. Measure the distance between two patterns

Step 8. If the value of distance is 0 then fusion process is done.

Step 9. Finally measure the value of MSER, PSNR and IQI.

VI. PROPOSED MODEL

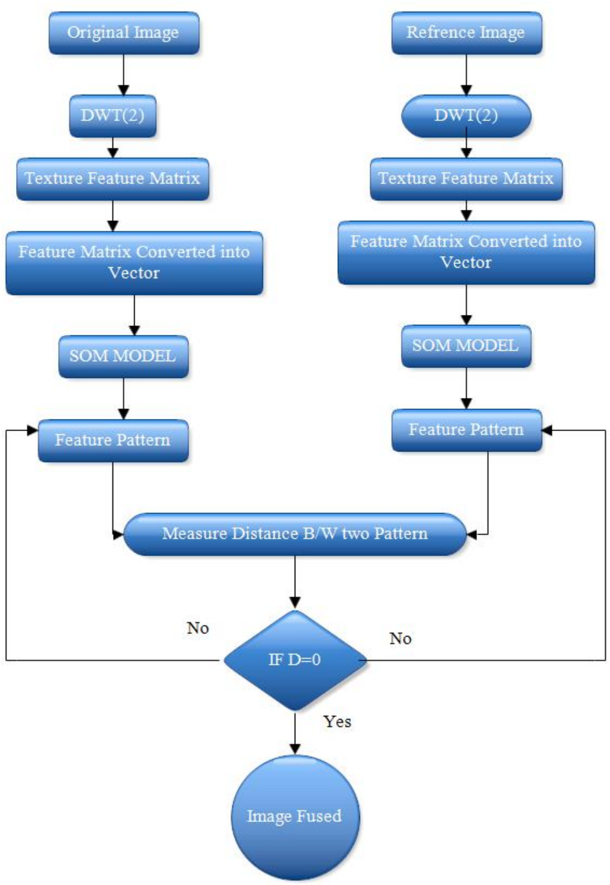


Figure 5: proposed Model of our Algorithm.

VII. DESCRIPTION OF MODEL

In this section describe the process of proposed model. The proposed model contain with wavelet transform function and SOM neural network model. The SOM neural network model used for the feature optimization process. Here discuss step of proposed model.

Step 1. Initially put the original image and reference image for the processing of feature extraction

Step 2. After processing of image discrete wavelet transform function are applied for the texture feature extraction

Step 3. After the texture feature extraction calculate the maximum value of feature using mean standard formula.

Step 4. The value of texture feature matrix converted into feature vector

Step 5. The value of texture feature vector passes through SOM neural network Model

Step 6. The SOM neural network Model cerates pattern matrix

Step 7. If the value of d is 0 images are going on process of image fusion.

Step 8. If value of d not equal to 0 the processing going to pattern matrix

VIII. EXPERIMENTAL ANALYSIS

This section discuss the comparative result analysis of previous algorithm used for the performance evaluation of in the form of MSER, PSNR and IQI parameters value for the resultant image obtained after Fusion. Theses all images are gray scale image of size 512 * 512. The performance measuring parameters are MSER, PSNR and IQI.

To check the effect of the proposed method for image fusion based on wavelet transform function and SOM neural network model. We used MATLAB software 7.8.0.347 (R2009a) and some reputed image used for experimental task such as the name given CT Scan images and MRI Scan images of human abdomen and brain shown below.

MSER = Maximally Stable Extremal Regions,

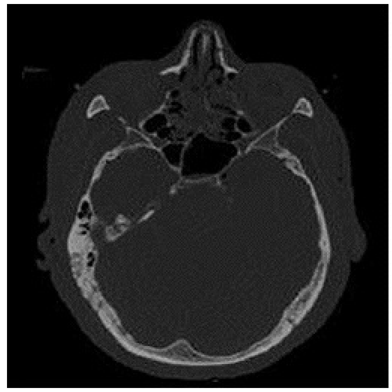
PSNR = Peak Signal-to-Noise Ratio and

IQI = Image Quality Index.

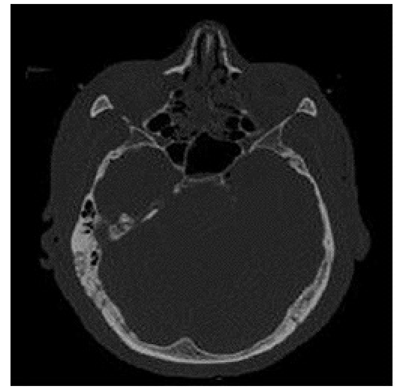
WT = Wavelet Transformation

IWT = Integer Wavelet Transformation

AHCT1



BHCT1

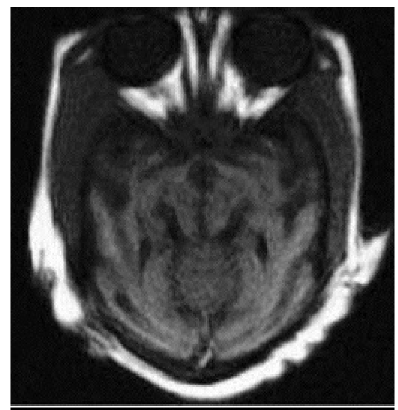


BHCT2

Figure 6: Shows the various name given CT SCAN images

AHMRI1

BHMRI1



BHMRI2

Figure 7: Shows the various name given MRI images

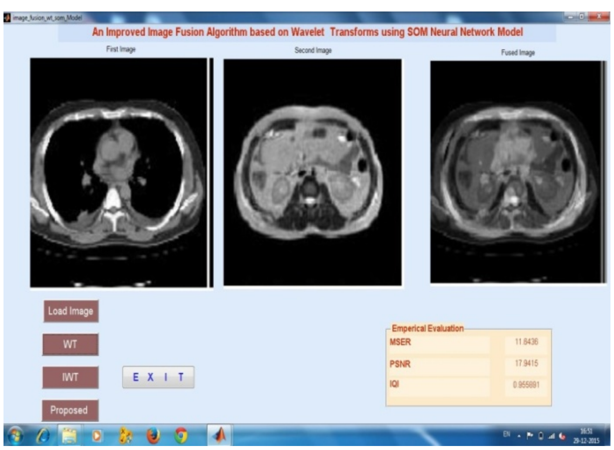


Figure 8: Shows the fused image obtained after fusion of AHCT1 & AHMRI1 for the method Wavelet Transformation(WT) and values of MSER, PSNR and IQI for that image.

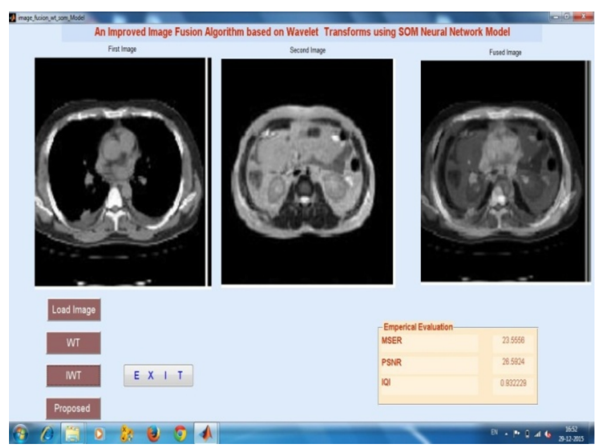


Figure 9: Shows that the fused image obtained after fusion of AHCT1 & AHMRI1 for the method Integer Wavelet Transformation(IWT) and values of MSER, PSNR and IQI for that image.

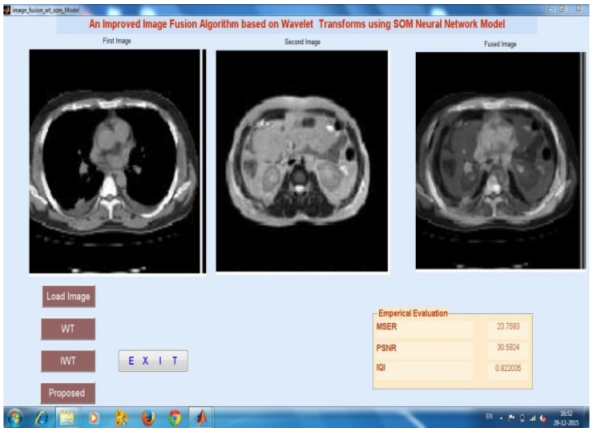


Figure 10: Shows that the fused image obtained after fusion of AHCT1 & AHMRI1 for the method Proposed method and values of MSER, PSNR and IQI.

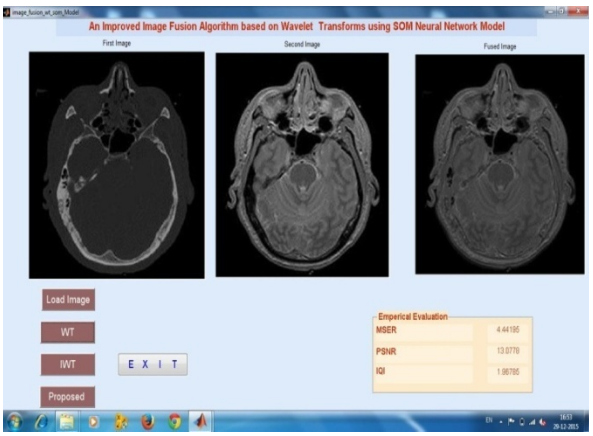


Figure 11: Shows that the fused Image obtained after fusion of BHCT1 & BHMRI1 images for the method Wavelet Transformation(WT) and values of MSER, PSNR and IQI.

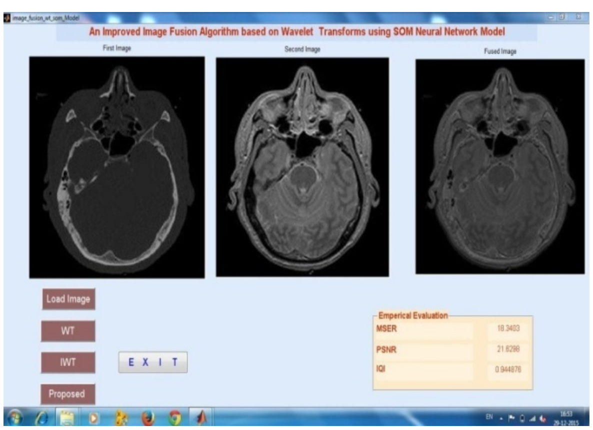


Figure 12: Shows that the fused Image obtained after fusion of BHCT1 & BHMRI1 images for the method Integer Wavelet Transformation(IWT) and values of MSER, PSNR and IQI.

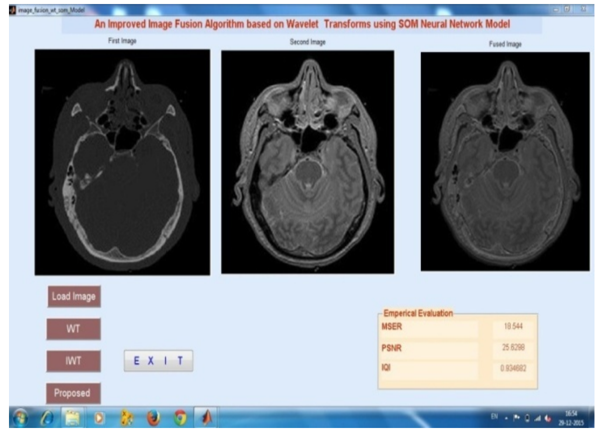


Figure 13: Shows that the fused Image obtained after fusion of BHCT1 & BHMRI1 images for the method Proposed method and values of MSER, PSNR and IQI.

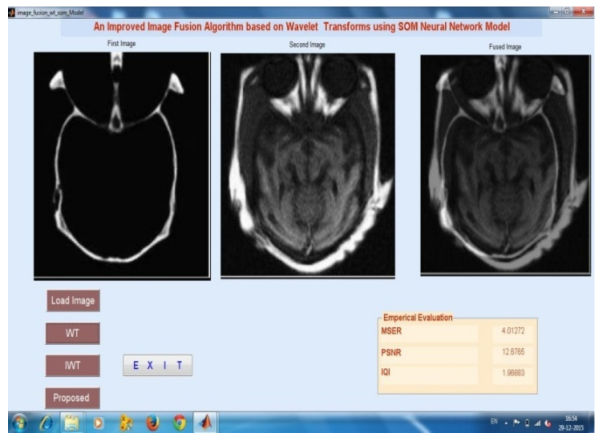


Figure 14: Shows that the fused Image obtained after fusion of BHCT2 & BHMRI2 for the method Wavelet Transformation(WT) and values of MSER, PSNR and IQI.

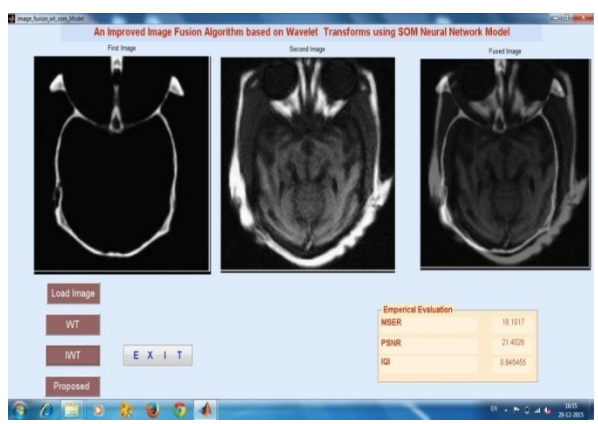


Figure 15: Shows that the fused Image obtained after fusion of BHCT2 & BHMRI2 for the method Integer Wavelet Transformation(IWT) and values of MSER, PSNR and IQI.

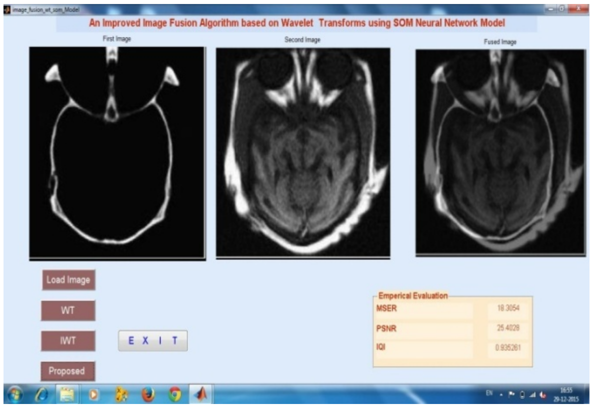


Figure 5.18: Shows that the fused Image obtained after fusion of BHCT2 & BHMRI2 for the method Proposed method and values of MSER, PSNR and IQI.

IMAGE NAME	Name of method	WT	IWT	Proposed method
Image obtained after fusion of AHCT1 & AHMRI1	MSER	11.6436	23.5558	23.7593
	PSNR	17.9415	26.5924	30.5924
	IQI	0.95589	0.932229	0.922035

Table 1: Comparative result analysis for the Image obtained after fusion of AHCT1 & AHMRI1 images using WT, IWT and Proposed method and the values of MSER, PSNR and IQI.

IMAGE NAME	Name of method	WT	IWT	Proposed method
Image obtained after fusion of BHCT1 & BHMRI1	MSER	4.44195	18.3403	18.544
	PSNR	13.0778	21.6298	25.6298
	IQI	1.96785	0.944876	0.934682

Table 2: Comparative result analysis for the Image obtained after fusion of BHCT1 & BHMRI1 image using WT, IWT and Proposed method and the values of MSER, PSNR and IQI.

IMAGE NAME	Name of method	WT	IWT	Proposed method
Image obtained after fusion of BHCT2 & BHMRI2	MSER	4.01272	18.1017	18.3054
	PSNR	12.6765	21.4028	25.4028
	IQI	1.96883	0.945455	0.935261

Table 3: Comparative result analysis for the Image obtained after fusion of BHCT2 & BHMRI2 image using WT, IWT and Proposed method and the values of MSER, PSNR and IQI.

5.7 COMPARATIVE RESULT GRAPH

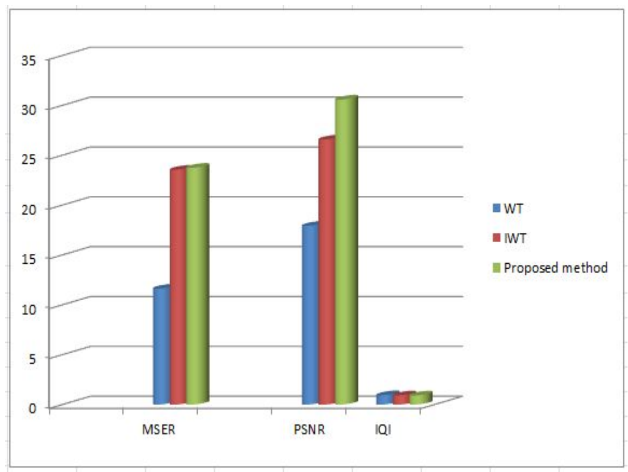


Figure 16: Shows that the comparative result graph for Image obtained after fusion of AHCT1 & AHMRI1 images using WT, IWT and Proposed method and the values of MSER, PSNR and IQI.

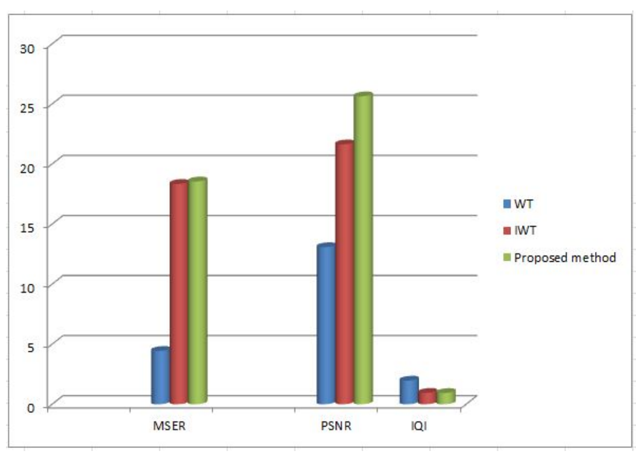


Figure 17: Shows that the comparative result graph for Image obtained after fusion of BHCT1 & BHMRI1 images

using WT, IWT and Proposed method and the values of MSER, PSNR and IQI.

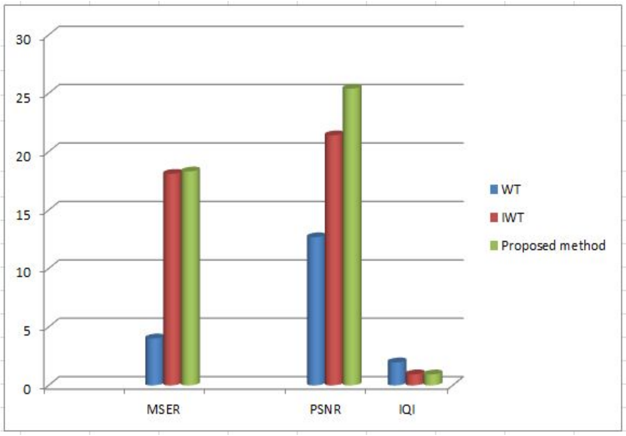


Figure 18: Shows that the comparative result graph for Image obtained after fusion of BHCT2 & BHMRI2 images using WT, IWT and Proposed method and the values of MSER, PSNR and IQI.

IX. CONCLUSION

In this this paper we proposed a feature based image fusion technique for the improvement of quality of image of distorted and damage image. The process of proposed algorithm used wavelet transform function for the feature extraction process. The wavelet transforms function extract the lower content of texture feature. The lower content of texture feature used for the process of feature optimization process. The SOM neural network model is self learned neural network model. This model creates the trained pattern of original image and reference image. The distance coefficient factor estimates the relation of original image and reference image. If the value of distance is 0 then image are fused. If the value of relation is not equal to zero the estimation factor recall. Measures the quality of fused image measures is considered. These measures play an important role in various Image Processing applications. Goal of image quality assessment is to supply quality metrics that can predict perceived image quality automatically. While visual inspection has limitation due to human judgment, quantitative approach based on the evaluation of “distortion” in the resulting fused image is more desirable for mathematical modeling. The goals of the quantitative measures are normally used for the result of visual inspection due to the limitations of human eyes. In Mathematical modeling, quantitative measure is desirable. One can develop quantitative measure to predict perceived image quality. In this paper PSNR, IQI and MSER are used for estimation of quality of image. Proposed algorithm performed better in comparison of previous method such as WT and IWT transform method.

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