ADAPTIVE NEURO FUZZY INFERENCE SYSTEM BASED FUSION OF MEDICAL IMAGE

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***Abstract*—** Medical Image fusion is considered to be the process in which the multiple image information belonging to similar characteristics are merged to produce an output image. The features of input image and its adorable information is retained at the output. This process results in extended operational range, minimized uncertainties and expanded reliabilities. In field of medical images, various images of similar treated region of a patient using different imagery system is obtained and the visualized information from these imaging devices seems adulatory to each other. The patient abnormality is localized precisely utilizing the embedded information in the fused images. The present research proposes the digitalized fusion of medical images through implementation in ANFIS and its performance is simulated.

Keywords— *Medical Image Fusion, ANFIS, PCA.*

I. INTRODUCTION

Image Fusion process combines the related image information to an image in which the fused image comprises better information when compared to input. Such technique results in providing improved quality and increased data application. Significant image fusion application involves medical imagery, tiny images, computer optical areas, remote sensing fields, and robotics [1-2].

The image fusion aims at reduction of bulk data amount through constructing wider images suitable for human/machine intention, image processing like detaching, physical object identification or recognizing target objects especially in the field of remote area detection and medical imagery. One such example involves the fusion of infrared and visible-band images for helping the pilot to land the aircraft successfully under poor visible circumstances. Figure 1 shows the fusion of two images in which the output complementary information indicates a clear and visualized data [3-4].

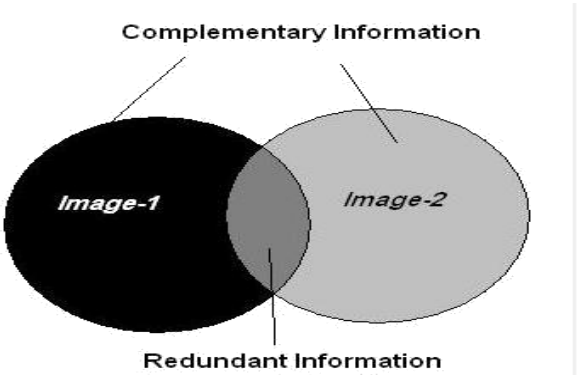

Figure 1: Venn diagram of Image Fusion

While considering the intelligent system, various information is fused to produce output image from a well-defined input. The output fused results produce easily recognizable information for both machine and human [5-6]. Image fusion mainly aims at extracting input image information thereby the fused images are obtained with desirable data than that of input. Combination of perfect multiple source registered images results in production of images with better eminent qualities comprising dimensional and spectral data. The complemented data from different models are fused on the basis of specified procedures so that better quality scenario images can be achieved to perform processing tasks [7-8].

(a) Applications Of Image Fusion

The operational ranges are extended by operating multiple sensor at varied operating circumstances. Illustrate an example in which various sensors are used to perform operation at day and night times.

Decreased uncertainties: - Multiple source information minimizes the uncertainties for better decision making.

Reliable output: - Noises are reduced by fusing numerous measurements

Compact representative information: - Fusin indicates the densely represented images. Consider the remote sensing field, rather than storing the images obtained from several illusion bands, the fused images are stored to obtain effective results [9-10].

(b) Medical Image Fusion

Medical images are assessed quantitatively through computer aid approach thereby the ability for medical practitioner to arrive at irregular time and decision objectives within shorter time span tends to improve. Utilizing multiple image sources and sensors results in offering better diversities especially in appliance of performing medical tests and also extracts the valuable information which seems unviewable for human beings. This information localizes the abnormalities present in any parts of humans [11-12].

The anatomy features of bone tissues are keenly visualized by the CT medical image. In alternative to this, utilizing MRI, the canal structural characteristics of smooth surfaced tissue, blood vessels and organs are reflected. Various mode of medical image such as CT, MRI etc produces rebounded human information at different angle. While diagnosing clinical treatments, the comparative drawbacks are analyzed among the different devices. CT and MRI are found to be the subsequently used equip mental images in all appliance of real time utilities [13-14].

II. PROBLEM IDENTIFICATION

The objective of this research work is fusion of Medical images using Adaptive Neuro Fuzzy Inference System (ANFIS). Literature review deals with different methods to integrate various source information to get knowledgeable information. Image fusion (CT and MRI) based on fuzzy logic already presented and implemented. In this work, we present image fusion model based on ANFIS that can also be used for color image. The main aim of FIS relies on mapping several input characteristic features to input membership function, then input member functionalities to appropriate rule procedures, followed by it rule procedures to specific output feature sets, and then further output features to its suitable member functional values which is then mapped to a single output value. Here, ANFIS is utilized to implement FIS through adopting data modelled approach. Fuzzy inference shape of member totally depends upon parameter, as parameter changes shape of membership function also changes. But when we compared with ANFIS membership parameters are chosen automatically. The aim is to amend the quality of data from set of images. There are many fusing techniques including PCA, Fuzzy Logic, Neuro Fuzzy, etc.

The surgical abilities of fusing images seem complex because of the digitized image processing technique. Hence, various solution for diagnosing image fusion and color image fusion has been proposed today. ANFIS is used which not only improve the fused image quality but also give reliable redundant data with enhanced capability because of the presence of complemented information. These approaches are experimented on various medical images. This method has used to fuse CT and MRI images and Color images. The model has been framed by means of Neural Network and Fuzzy Logic. PCA (Principal Component Analysis) method also fuses the images but it focuses only on the major part of image so to avoid this problem we proposed ANFIS which work other than that part also[15].

Generalized bell-shaped membership function

The generalized bell function is expressed as the function of 3 parameters a, b, and c and is illustrated as

$$f(x;a,b,c)=\frac{1}{1+\left|\frac{x-c}{a}\right|^{2b}}$$

In which the factor b seems to be positive and c indicates the curve center. The figure 2 shows the variation of the argument vector gbellmf, with respect to different factors a, b, and c, [16].

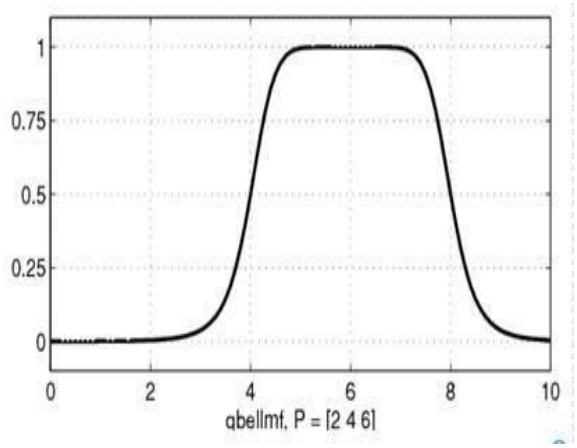

Figure .2: Generalized bell-shaped function

Gaussian curve membership function

$$f(x;\sigma,c)=e^{\frac{-(x-c)^2}{2\sigma^2}}$$

The parameters for gaussmf represent the parameters σ and c listed in order in the vector [sig c].

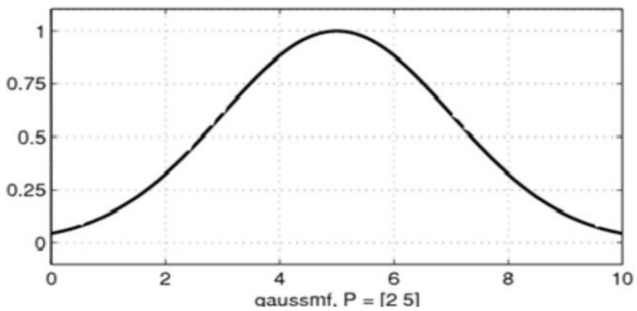

Figure 3: Gaussian curve function [31]

III. PROPOSED METHODOLOGY

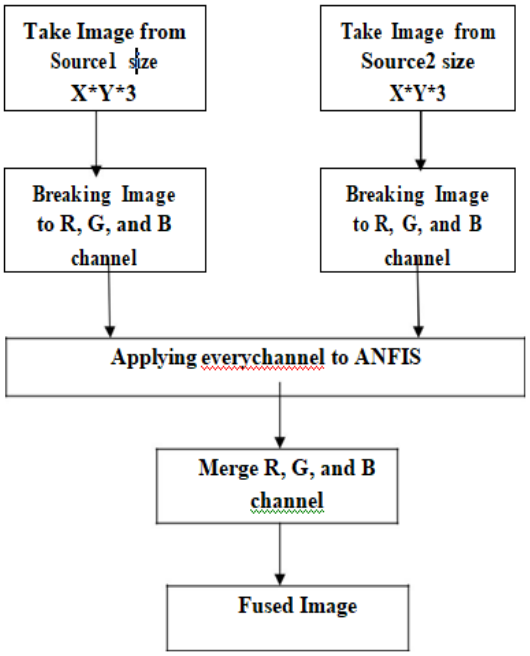

Figure4: Work Flow Diagram of Image Fusion using Adaptive Neuro Fuzzy

This proposed model divided into four parts: Read image, Separate Image into color channel(for RGB images) ,applying to ANFIS and finally merge color channels.

Take Image: Take two input images of same size and focused on same part or same scene. If the images are not of the same size then stop the process.

Breaking of Color Channel: This step is not required for medical image. Each input image is separated into 3 channel colors such as Red, Green and Blue represented as R, G and B. Generally, it specifies the conversion of image1 and image2 to (R1, G1 and B1) and (R2, G2 and B2) respectively. Every channel present in vectorized columns are converted and further vectorized R1 component is merged with R2 column wise and form Red_input matrix, G1vector with G2 vector column wise and form Green_input matrix, B1vector and B2 vector column wise and form Blue_input matrix. Means for seperate pair of RGB image, there are three matrixesor grid (each with two column) will be formed. For gray image (Medical image CT image and MRI image) form a matrix (with two column) .

Applying to Anfis:

Each color channel input is applying to fuzzy inference engine separately. Fuzzy inference systems (FIS) establishes a nonlinear relation among pair of input-output vectorized data by following fuzzy procedures. This mapped rule imply input/output functional member relation, FL operatives, fuzzy if–then rules, output dataset aggregation, and defuzzification.

The present research uses ANFIS model to generate FIS. Figure 6 shows FIS Property consists of two inputs, one output and 25 rules .These rules are generated by surgeon.

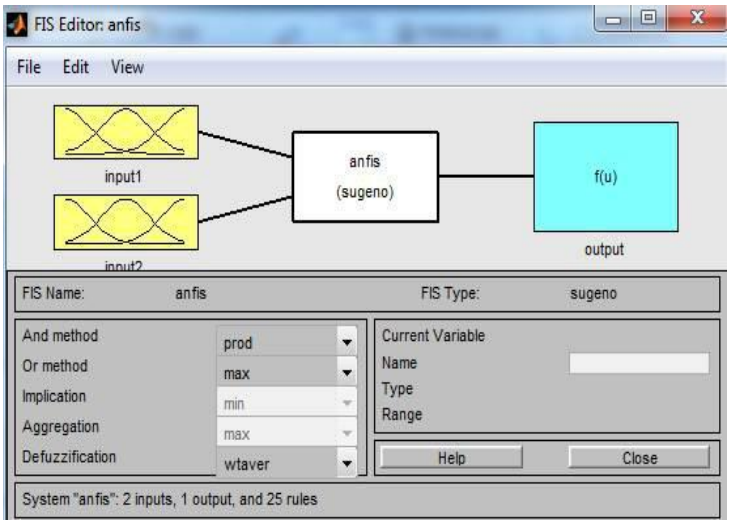

Figure 5: FIS Property

Membership Function: For individual input 6 membership functions passed down and generalized bell-shaped membership function used shown in Figure 7 .

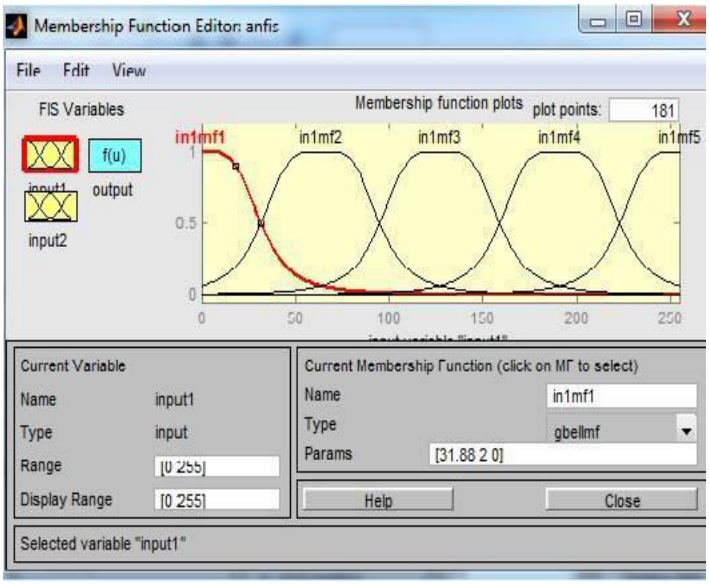

Figure 6: Input Membership Function

ANFIS structure:

fis = name: 'anfis'
type: 'sugeno'
andMethod: 'prod'
orMethod: 'max'
defuzzMethod: 'wtaver'
impMethod: 'prod'
aggMethod: 'max'
input: [1x2 struct]
output: [1x1 struct]
rule: [1x25 struct]

Figure 2 depicts the structural schematic of ANFIS with a dependence relation between 2 input and a single output.

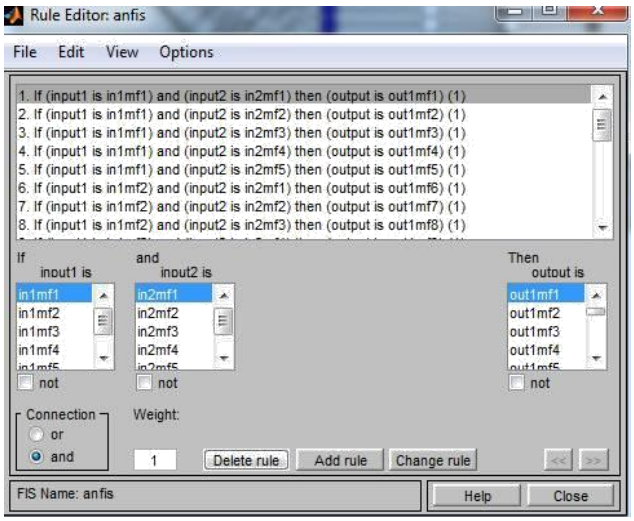

Figure 7: ANFIS Structure

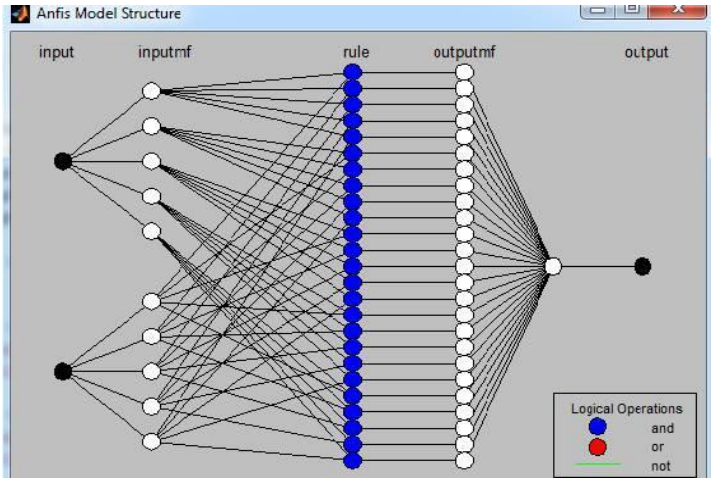

Figure 8: Anfis rule editor

RULES

1. When input1 and input2 is in1mf1 and in2mf1 respectively, it produces an output out1mf1
2. When input1 and input2 is in1mf1 and in2mf2 respectively, it produces an output out1mf2.
3. When input1 and input2 is in1mf1 and in2mf3 respectively, it produces an output out1mf3.
4. When input1 and input2 is in1mf1 and in2mf4 respectively, it produces an output out1mf4.
5. When input1 and input2 is in1mf1 and in2mf5 respectively, it produces an output out1mf5.
6. For in1mf2 and in2mf1 inputs, the output is out1mf6.
7. For in1mf2 and in2mf2 inputs, the output is out1mf7.
8. For in1mf2 and in2mf3 inputs, the output is out1mf8.
9. For in1mf2 and in2mf4 inputs, the output is out1mf9.
10. For in1mf2 and in2mf5 inputs, the output is out1mf10.
11. The output out1mf11 is produced for two respective inputs in1mf3 and in2mf1.
12. The output out1mf12 is produced for two respective inputs in1mf3 and in2mf2.
13. The output out1mf13 is produced for two respective inputs in1mf3 and in2mf3.
14. The output out1mf14 is produced for two respective inputs in1mf3 and in2mf4.
15. The output out1mf15 is produced for two respective inputs in1mf3 and in2mf5.
16. In case of inputs in1mf4 and in2mf1, out1mf16 is produced at the output.
17. In case of inputs in1mf4 and in2mf2, out1mf17 is produced at the output.
18. In case of inputs in1mf4 and in2mf3, out1mf18 is produced at the output.
19. In case of inputs in1mf4 and in2mf4, out1mf19 is produced at the output.In case of inputs in1mf4 and in2mf5, out1mf20 is produced at the output
20. The output out1mf21 is obtained from in1mf5 and in2mf1 inputs.
21. The output out1mf22 is obtained from in1mf5 and in2mf2 inputs.
22. The output out1mf23 is obtained from in1mf5 and in2mf3 inputs.
23. The output out1mf24 is obtained from in1mf5 and in2mf4 inputs.
24. The output out1mf25 is obtained from in1mf5 and in2mf5 inputs.

For medical image (CT image and MRI image), output of ANFIS is one column vector that will be converted into matrix (size same as size of input image) , and on display it as image(Fused Image). In suit of color image (RGB), each color channel input are applying o ANFIS separately that is for each pair of image there is three one column vector as outputs from ANFIS, these output vectors are converted into matrices then merge to form image(Fused Image)

IV. SIMULATION RESULT AND DISCUSSIONS

Figure 9 show GUI through which user can easily perform image fusion task. This GUI developed using MATLAB. Here input image pair selected using two push buttons Select_image_1 and Select_Image_2. Fused Image push button used to fuse selected image. The selected image pair and Fused image are displayed in axes.

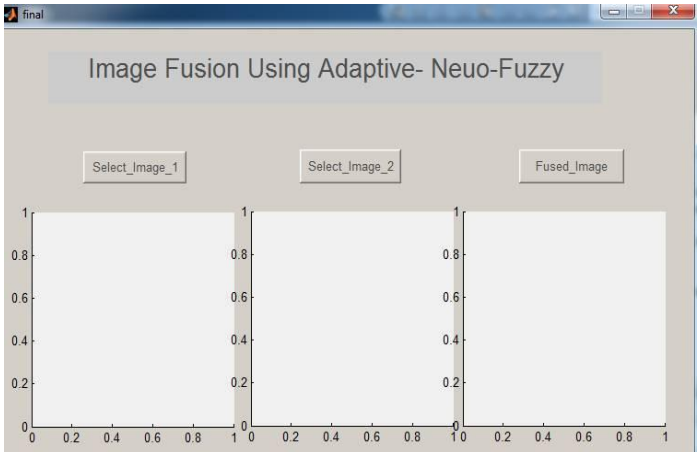

Figure 9: Image Fusion Using Adaptive Neuro Fuzzy

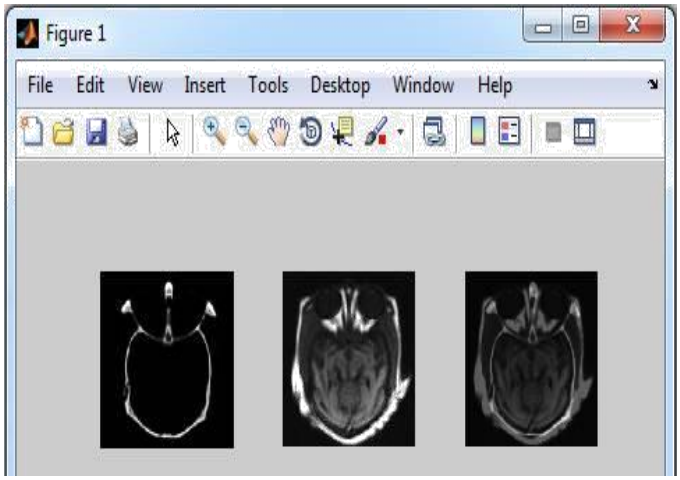

Figure 10: A snap shot CT and MRI image fusion (Fused image are displayed for gray scale image or on medical image)

Performance Analysis

Performance analysis of implemented model ANFIS and PCA has done in term of mean and entropy.

Table 1 Shows Performance Analysis based on entropy and mean value which is calculated for both method i.e. ANFIS and PCA .

Experiment set	Images	Mean	Entropy
Pair 1	med_img1	9.9346	1.9247
	med_img2	54.2295	6.6325
	PCA	**51.7376**	**4.1160**
	ANFIS	**31.0090**	**5.9541**
Pair 2	CT_1	57.4428	5.9577
	MRI_1	90.4375	7.4750
	PCA	**73.7856**	**5.3044**
	ANFIS(AN_fused_CT_MRI_1.jpg)	**72.3977**	**7.2537**
Pair 3	CT_2	65.0086	6.1814
	MRI_2	76.1966	7.2999
	PCA	**70.7966**	**5.2790**
	ANFIS(An_fused_CT_MRI_2.jpg)	**70.5307**	**7.2047**
Pair 4	CT_3	72.2441	6.8271
	MRI_3	84.3076	7.5085
	PCA	**76.1967**	**5.4060**
	ANFIS	**77.6928**	**7.4029**

The comparison of both of methods that is ANFIS based, and PCA based compared by using the parameter known as entropy, and mean. From table 1 show results calculated from both methods are good and satisfactory.

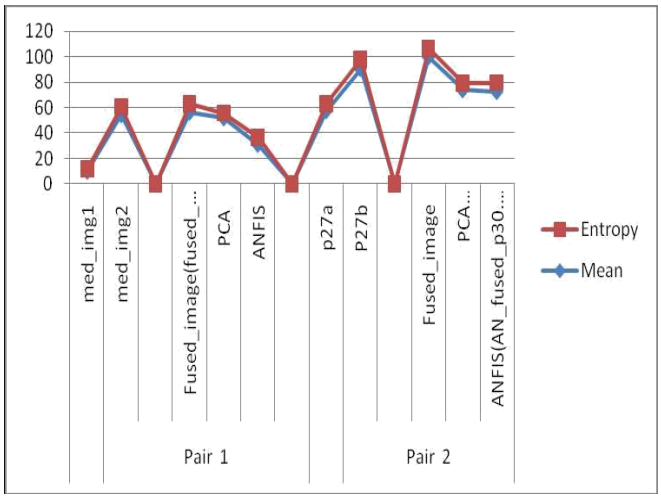

Figure 11: PCA and ANFIS Performance regarding Medical and color images

V. CONCLUSION AND FURTHER SCOPE

Considerable amount of work has been done on various images using different approach. The present work has been carried out for color images and medical image using image fusion techniques. ANFIS has been adapted to study and analyze image fusion for fusing the variety of images. The contributions made in the thesis have been summarized and future scope of the work has been spelt out. In the present work ANFIS has been applied for fusing the color images. The work has been carried out in the following phase: firstly, we read the two sources color image from same scene then separate them into three channels such as R, G and B in next phase after that apply each channel to Adaptive Neuro Fuzzy Inference System. Then in next stage merging or concatenating the entire

three channel. At last the final result we get is the fused image or one output of the two source image which can also be said as complementary information obtained from two images is more informative and clearer. Conclusions of the work stated are defined below: Sugeno based Fuzzy Inference System implemented to fuse image pair (CT and MRI medical images and pair color image). The fused results relatively clear from the visual point of view. Satisfactory entropy and means as compared with (PCA) principal component analysis.

Preprocessing the information before mounding is carried so as to take out the outliers. The ANFIS method has to be very flexible. It means it not only works with present research problem but also can be salutary for other research problems also. The performance analysis of ANFIS has been compared only with PCA method in the present work but in future it can be compared with other method.

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