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Implementation of Medical Image Fusion using Neuro-Fuzzy Logic

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Abstract: *This paper gets a handle on medical image fusion (MIF) problems. These problems are simply known as image fusion problems. We can use RPCNN(Reduced Pulse coupled neural network)to provide better performance. The RPCNN linking dependents on fuzzy membership values. This value serves their significance in the analogous source image. The RPCNN has less complex structure key advantage of such structure is that RPCNN require a smaller number of parameters. The less complex structure and less parameter improve computational efficiency. This computational efficiency is important requirement of point-of-care (POC) health care technologies. The proposed scheme is free from the trivial defalcation of the modernization of MIF techniques: contrast reduction, loss of image fine details and unwanted image degradations etc.*
Keywords *- Artificial neural network, fuzzy logic, image analysis,image fusion (IF), medical imaging (MI).*

I. Introduction

We can have various types of medical images. These different images reverberate different information of human organ and tissues, and have their relevant application. A peerless medical image cannot yield widespread and accurate information. Hence it is unavoidable to correlate one medical image with another. Manual process of correlating medical images is time consuming and costly also. Then researchers move towards automatic image fusion technique [1],[2].

Images are captured using various sensors. Image fusion artistry binds them into a single image containing all weighty data from source images and provides results with more useful complete information. Image Fusion applications areas are such as object detection, automatic target recognition, remote sensing, computer vision, flight vision, robotics etc.

This paper makes a go ofNeuro-Fuzzy. Five different image fusion techniques are SWT(Stationary wavelet transforms), fuzzy, Neuro-Fuzzy, Fuzzy let and Neuro-Fuzzylet algorithms. The Neuro-fuzzy algorithm tested with mono-spectral and multi-spectral datasets.

II. Mage Fusion Techniques

Five contrasting image fusion artistry isSWT,fuzzy,Neuro-Fuzzy, Fuzzy let and Neuro-Fuzzyletalgorithms. Pixel level image fusion techniques are SWT(Stationary wavelet transforms) typing, Fuzzy and Fuzzylet which are developed in Matlab. It is proved that SWT with higher decomposition levels and Fuzzy logic with greater number of membership functions gives the better result. Fuzzylet algorithm is formed by combining SWT with 4 levels of decomposition and Fuzzy with 5 membership functions.

III. Neuro-Fuzzy Approach For Image Fusion

Neural Network (NN) is a network which stores the empirical knowledge and uses it for test data. Neuro- Fuzzy is a unification of Artificial Neural Network (ANN) and Fuzzy logic. Using this tactic, we can convoy the ideology with input dataset and desired output. After training the system, this system can be used for any other set of input data. A Neuro-fuzzy system is a fuzzy system which is trained by any of neural network learning algorithms and according to the training data system parameters are modified automatically. Excretion of Neuro-Fuzzy system is done using ANFIS. ANFIS stance for Adaptive Neural Fuzzy Inference System.

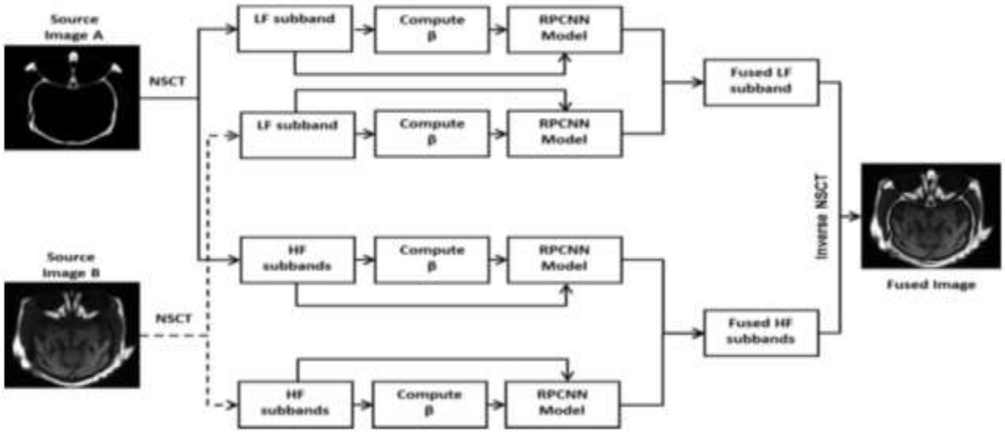


Fig. 1.Block diagram of Medical Image Fusion

Fig.1. Shows block diagram of medical image fusion. It is shown that two images correlate with each other. These images contain different information of human organ and tissues. This image is captured by various sensors. Image fusion combines them into a single image. This combined image gives useful information.

A. *Pulse coupled neural network (PCNN)*

In 1990, Eckhorn*et al.* acquaint the linking field network model for the systems flaunt the synchronous pulse bursts [5]. Refitting and alteration of the linking field modelfor image processing applications known as the pulsecoupled neural networks (PCNNs) [6]–[7]. The PCNN have signs of the concoct utensil of the cat's visual area and is portrayed by universalyoke and the pulse harmony of neurons. The PCNN and its mutatedvariant have been used in the IF/MIF demesne by various researchers [3], [4], [8], [9]. The PCNN has quite a few parameters with complex structures, and optimal reckoning ofthese frameworks is a major snag to automatization and generalization of PCNN. In utmost of the PCNN-based IF/MIF artistry, this groundwork are kept the ditto and set as a constant. But, according to the human ocular system (HVS),the kick-back to a region with the eminent featuresis stronger than a region with frivolous features.

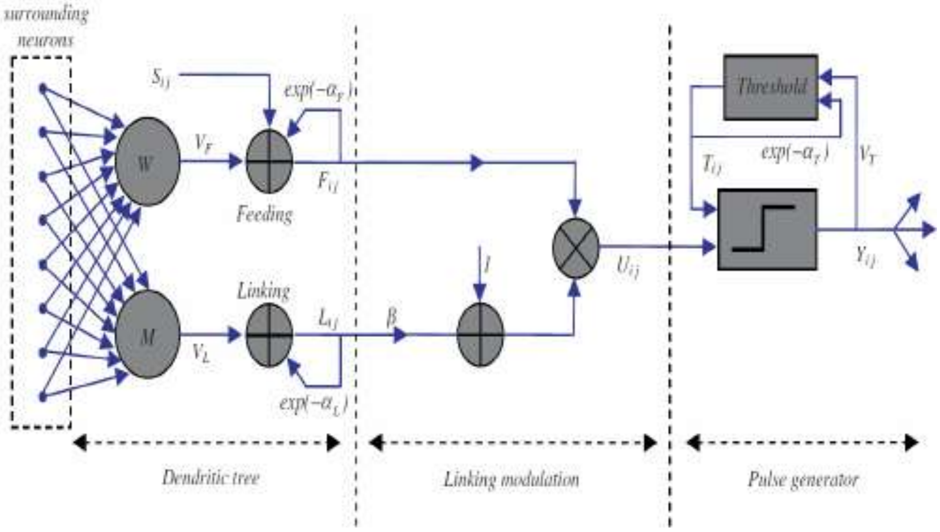


Fig.2. Structure of PCNN

Fig.2. shows structure of PCNN. PCNN is anidiosyncratic bedded, 2-D, obliquely akin neural network of pulse-coupled neurons [6], [7]. The neuron abides of an admission part, associating part, and a pulse generator as shown in Fig. 2. The neuron reaps the admission beacon from the banquet and associating inputs.Seeing the usance of multimodal MIF, and in order to revamp the computational capableness (in terms of reducing the number of optimizable parameters),we use an RPCNN model[12].

IV. Fuzzy Inference System(Fis)

FIS model is used for mapping. This mapping is carried out in following manner

- A set of the input characteristics to input membership functions.
- Input membership functions in rules.
- Rules to a set of output idiosyncratic.
- Output idiosyncratic to output membership functions and.
- The output membership functions to a single-appraisal output.

A FIS has the following snags:

- Membership functions are immovable and bearably arbitrarily chosen.
- Fuzzy Inference is applied for modelling systems in which the rules are predetermined strictly based on the viewpoint of users to the model.

We can change the shape of membership function by changing membership function parameters. In a humdrum FIS, these criteria are tabbed arbitrarily in a distortion test basis just looking into the available data.

A. ANFIS training structure obtained for two inputs and three membership functions

Using the input-output data given, ANFIS erects a FIS whose association province parameters are tuned using any neural network algorithm. This acquiesce the FIS to capitalize on the data that are given as the test data. There is an ANFIS editor toolbox in MATLAB which does all this learning.

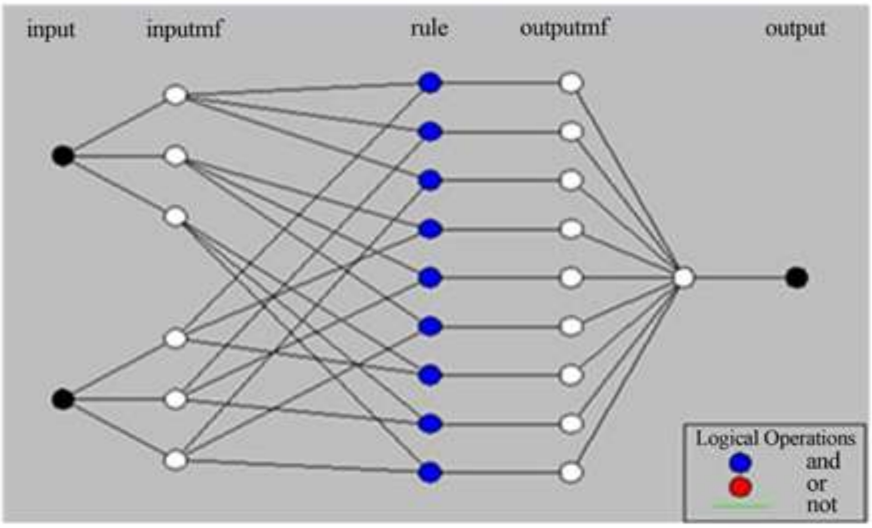


Fig.3. Structure of ANFIS

Fig.3. shows structure of ANFIS. In the ANFIS training structure shown in figure the left side nodes represent the inputs and the right-side node represents the output. The branches are coded using different colors to indicate the logical operations used in rule formation, that is, it indicates whether *and, or* or*not* is used to combine antecedences to consequences. For image fusion, the pixel values of input images and reference (desired) image are given to the ANFIS for training the FIS, so that the system will produce a fused image which is closer to the reference image from the input images.

V. Fusion Rules

A number of fusion rules have been proposed for pixel-based fusion. Averaging is generally used only for the low-pass coefficients since averaging of the high-pass sub-bands gravitate to obscure images and diminish the contrast of features appearing in only one image. Fusion rules applied to immense-pass sub-bands include:

A. Maximum Selection

It selectslargest absolute coefficient from input image as agreeing in blend image.This is motivated by wavelets tending to pick out the salient features in an image. Maximum-selection results fulfil most of the obligations for fused results. Relevant information is generally preserved in the blend image and few noticeable artefacts are introduced.

B. Model-based weighted average

The corollary agreeing for reformation is reckoned via a weighted humdrum of input image coefficients. As wavelet coefficients exhibit non-Gaussian characteristics, the household of generalised Gaussian distribution (GGD) and symmetric alpha-stable distribution (S_S) have abide used for carving image wavelet agreeing. The fusion results of visible/IR images show improvement over conventional weighted average. ACauchy'sdissemination is used for context enhancement via fusion in. The Meridian distribution is employed in for medical images. The weights in the two latter techniques are optimised via Maximum Likelihood (ML) estimation. Recently, the timid function for removing noise has been combined with the model-based weighted average using bivariate Laplacian-based and bivariate Cauchy-based techniques. This method produces excellent fusion aftereffect in many usance, including medical imaging and various multiband sensors.

VI. Medical Image Fusion Methods

Medical Image fusion rituals are:
1. Morphological Methods
2. Knowledge based Method
3. Wavelet based Method
4. Neural Network based method
5. Fuzzy-logic based method
6. Other method

A. Morphological Method

This method is used to revisingdimensionallyaccordantknowledge from the medical images.This method is used in brain diagnosis. These methods are eminentlykeen to the inhume-image volatility culminate from eccentricity, blare, size and shape of the mien.

B. Knowledge based Method

In medical imaging, there ishardly anyspecimen where the medical practitioner's judgment can be used in conniving autopsy, labelling and registration of the images. Generally, the territory-dependent judgment is vital to firm impulsion on province-based autopsy and to make straightforward the likelihood of the advent of the dissection nether the imaging tone at the stage of configurations the revels suburb of affection. This method can be used with the pixel intensity method. The use of disposing ofroutine in images can revamp

C. Wavelet based Method

The idiopathicperception used by the wavelet situated image fusion is in essence the triviality propaganda from uncommon image and imbue it into another. The trivia propaganda in images is habitually in the towering frequency and wavelets would have the aptitude to pick the frequencies in both space and time. Theensuing weld image would have the "pleasing" essence in terms of the appearance from the paired images that revamp the trait of the imaging.

D. Neural network-based method

Artificial neural networks (ANN) are inspired from the idea of biological neural networks having the ability to learn from inputs for processing features and for making global decisions. The artificial neural network models lack an input build-up set to pinpoint the bent of parameters of the network invoke to use weights. The aptitude of the neural network figure to augur, assay and infer knowledge from a disposed data without going through a rigorous mathematical solution is often seen as an advantage.

E. Fuzzy-logic based method

The unanimous and accord belongings of the fuzzy logic have been generally probed in image deal with and have demonstrated to be fruitful in image fusion. The fuzzy logic enforces both as a mien revamp operator or a decision operator for image fusion [13]. There are quite a few appliances of fuzzy logic base image blend such as brain interprets [13], cancer cure, image autopsy and assimilation, upsurge communal information, deep brain stimulation, brain tumour autopsy, image healing, spatial weighted decay, feature fusion, multimodal image blend, ovarian cancer investigation, sensor blend, natural computing methods and gene definition.

The election of association functions and fuzzy sets that conclusion in the best image blend is an agape problem. The enhancement of aspect deal with and analysis can be revised to fit the fuzzy arena exceptional when joined with probabilistic accession, such as fuzzy-neural network, fuzzy-ancestral-neural network-bumpy set, fuzzy-probability and Neuro-fuzzy-wavelet.

F. Other method

There is manifoldhabit that isestablished on ambientcontractioncraft such as independent component analysis (ICA) and principal component analysis (PCA). Thisambientdevaluationknow-how often finds their adoption as elementdeal withplan and are used in merger with techniques such as the ones established on wavelets.

VII.Imaging Modalities Used In Image Fusion

The imaging method used in image fusion is as follows:
1. Magnetic Resonance Imaging(MRI)
2. Computerised tomography(CT)
3. Positron Emission tomography(PET)
4. Single photon emission computed tomography(SPECT)
5. Ultrasound
6. Other modalities.

A. Magnetic Resonance Imaging(MRI)

Magnetic Resonance Imaging (MRI) farces an imperative role in non-invasive diagnosis of brain tumour and is one of the ultimateextensively used imaging modalities in medical studies in trusted clinical settings. Previous work announcement the fortunate fusion of MR images with distincttypes of manner. The image blendingrecipeisextensivelydevoted for brain interpretation and medication [13], at which point the blendingcraft have been exposed to the pageantbetteredblending and indicativeattainment. The advantage of MRI is that it is very snug for caring a child women and babies as it does not commit any hazard to emission. In extension, the delicatecontroversyarrangement in organs such as brain, heart and eyes areocular with immensetruthfulness. The dominant prejudice of the MRI images is its analogues sympathy to migration, composing it a crucial craft for estimate organs that implicate transformation such as with mouth tumors. The use of image blending can bury this curb in a multi-modal imaging ambiance. It revamps veracity and factual clinical appropriateness when mingled with another procedure.

B. Computerised tomography

Computerized tomography (CT) is a medical depict craft that has contrived anoutstandingbrunt on medical scrutiny and appraisal. This is a trendyprocedureworn in multi-modal medical image blending. Analogous to MR figure, the CT figureisrecycled in anenormouslength of medical utilization under practicablescientificenvironment. Computerized estimateworkings CT figure has been one of the newpursuitsagainstcontemporary medical illustrate.

C. Positron Emission Tomography(PET)

Positron emission tomography, widely known as PET illustration or a PET scan, is a useful type of nuclear pharmaceuticalportray.Analogues to CT and MRI, a major utilization of PET is in radiology examination for brain analysis and cure.There is an extensivedimension of the operation of image blending using PET, a few of which are for cancer cure, image autopsy and alliance , 3D tumour simulation, gynaecological cancer analysis,husky tumour volume detection, diagnosis of local repetition ofbowel cancer, tumour detection and treatment, paediatric solid extra cranial tumour’s, telemedicine, breast cancer detection, oral cancer treatment, lung cancer diagnosis, cervical cancer treatment, oesophageal cancer diagnosis, and pancreatic tumour’s characterization.

The resolution limits of PET image are one of the central challenges. There is often an integrated approach to reduce the limitations by modelling, finite resolution effects in image reconstruction, and improved detector design. The immensesubtletybring by the molecular imaging is off time seen as an advantage of PET images. There is heightened interest in using fusion techniques to raise the figuring quality.

D. Single photon Emission computed Tomography(SPET)

Single photon emission computed tomography (SPECT) scan is a useful nuclear imaging method that is extensivelypre-owned to inspect the blood outflow to ornament and organs. The utilizationfieldcomprises brain analysis and cure [13], lung cancer treatment, liver diagnosis, tumour detection, fusion of multi-processfigure, multi-spatialvisual imagery, FMRI guidedcore, prone cancer treatment, gynaecological cancer analysis, image filling, pelvis glare cure, breast cancer assessment, vulvar cancer treatment, bone cancer diagnosis, and biopsy.

Elaborating the sense of the SPECT without compressing the image settlement is one of the importantthreats in SPECT figuring. The evolution in pinhole SPECT is used to build up the verdictpotentialforalternate millimetre range. The imaging nature is yet still impressed by the signal noise, and bettering the figureaspect and settlementcraveafter-processing craft.

E. Ultrasound

Ultrasound imaging is sonar-based imaging technique that has been recycled widely due to its low cost and no admitted reactionof the patients. There is a broaddimension of utilizationsite the ultrasound figures are used to assume medical goods. Some of these are for prostate cancer treatment, conformal radiation therapy, brachytherapy prostate implant, image fusion, breast cancer detection, liver tumour diagnosis, prostate biopsy, and oesophageal cancer diagnosis.

There are a fewbigconstraints of the ultrasound figuring that are solidly allied to the engineering skills, such as the obligation to build no air chasm between the examination and frame, and the need to avoid bone structures in the path of organ imaged. These major failuressent ail the obligation to benefit other modalities to ensure the accuracy of imaging and localization of the regions under test for diagnostic measurements. Examples of figuringcraft that blend ultrasound on it areultrasound-CT, ultrasound-uoroscopic, nuclear medicine-ultrasound, microscopy-ultrasound, ultrasound-CAD-mammograms-infrared, ultrasound-MRI and PET-CT-ultrasound.

F. Other Modalities

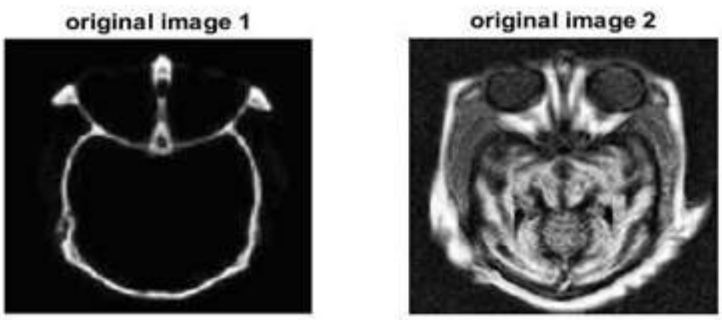
There are distinct other figuringplans, such as cardinal, luminous, microwave and microscopic figuring that find application through medical image fusion. Infrared as afiguringmethod is used in the function of breast cancer analysis. A fusion blending that combines infrared can be detected in where the fusingstillnessof ultrasound, CAD, mammograms and infrared images. Fluorescent figuring has been recycled as an operation to vocal cancer analysisand supine brachytherapy and cure. Microwave imaging is used in breast cancer detection and tumour identification.Anotherprocedure to point out is the microscopic figuring used in image blending. Microscopic blending is worn in blending methods as adischarge to image dapple, multi-aspectblending, feature drawing, and global/local admission.

VIII. Algorithm

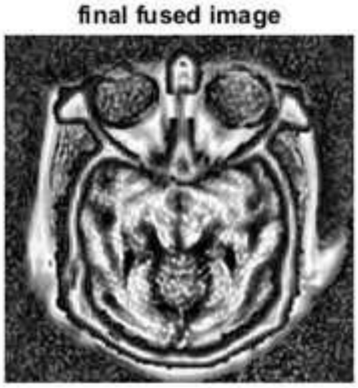
Algorithm for image fusion using Neuro-Fuzzy logic (abbreviated as ***NF (I1,I2)***) is as follows:
Step 1: Read the images (*I1 & I2*) to be blended into two variables.
Step 2: Obtain a training data, which is a matrix with three columns (2 columns of input data and one column ofoutput data).
Step3: Obtain a check data, which is a matrix of pixel values of two input images in column format.
Step 4: Decide number and type of enrolmentactivity for both the input images.
Step5: Generate a FIS structure of the training data and train the FIS.
Step 6: Provide check data to the FIS structure for processing and obtain the output image in column format.
Step 7: Convert the column form into a matrix pattern to get the fused image *If*.

IX. Experimental Results

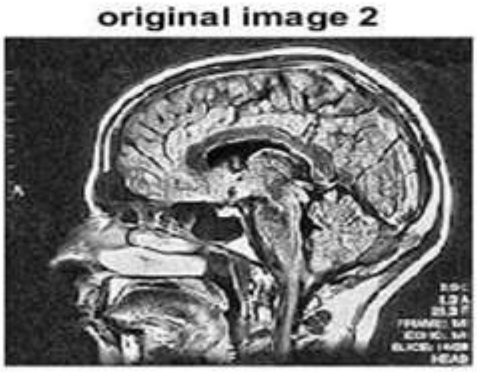
Group 1



Fused Image of Group 1:



Group 2:



Fused Image of Group 2:

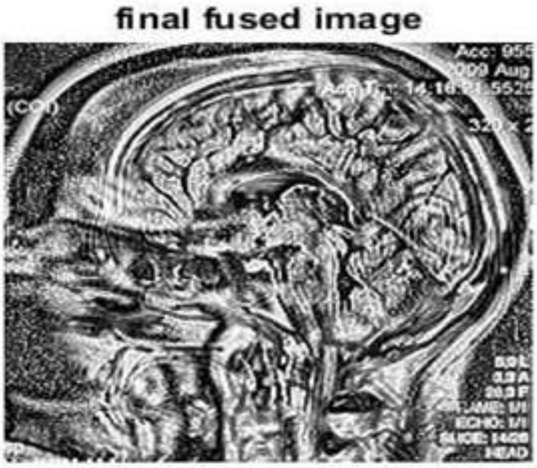


Fig.4. Image fusion using Neuro Fuzzy logic

Group	Source Image				Fused Image		
	NO	SF	EN	STD	SF	EN	STD
1	A1	0.3354	2.2249	80.9892	127.6523	7.8192	99.4078
	B1	0.4358	6.6328	90.9462			
2	A2	0.7951	6.8029	89.7836	213.9076	7.7262	104.1823
	B2	0.7928	7.4399	98.3741			

Table.1. Performance Evolution for MIF

Fig.4. shows image fusion using neuro fuzzy logic. To produce the above result, we fused only two medical images which areshowing Group1 and Group2, however, we can make fusion of n-number of images. The results are compared using fusion quality performance evaluation metrics. The fused image of individual

group is captured and named as the Fused Image of Group1 and Group2. Image fusion is executed for blend images attain from contrasting sensors, which turnout a unique image accommodates all pertinent data from the source images. There are certain parameter's which is useful in image fusion are the entropy of the first image, entropy of the second image, degeneration of the fused image similarly standard deviation on the first image, standard deviation of second image & the standard deviation of the fused image shown in Table.1.

X. Conclusion

We proposed a MIF method hinge on Neuro-fuzzy approach. This approach is useful over traditional MIF schemes. RPCNN,Fuzzy is used to integrate information with fused image. The experimental results show that the proposed method can perpetuate more fruitful clue in the blended image with surpassinggeographicalsettlement and less disparity to the origin images.

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