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PERFORMANCE ASSESSMENT OF FUZZY AND NEURO FUZZY BASED ITERATIVE IMAGE FUSION OF MEDICAL IMAGES

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ABSTRACT

Medical image fusion is a significant job to regain an image which delivers as much as evidence of the same body part at the similar time it also assistances to decrease the storing capability to a particular image. In this paper an assessment is completed between conventional image fusion methods; principal component analysis (PCA), discrete wavelet transform (DWT) and the projected fuzzy and neuro fuzzy based iterative image fusion techniques. The proposed method fuses images based on fuzzy inference system (fis) prepared. Experimentations have been finished on two different sets of multimodal medical images of brain. The projected technique is perceivably and significant related with the present approaches. For the assessment of the projected image fusion technique ten diverse measures is prepared and utilized of, namely Image Quality Index (IQI), Mutual Information Measure (MIM), Fusion Factor (FF), Fusion Symmetry(FS), Fusion Index (FI), Root Mean Square Error (RMSE), Peak Signal To Noise Ratio(PSNR), Entropy(E), Correlation Coefficient (CC) and Spatial Frequency (SF). Assessment outcomes demonstrated that the projected image fusion technique mechanisms improved than any of the conventional image fusion techniques.

Keywords: *Medical image fusion; Fusion Index; neuro fuzzy*

1. INTRODUCTION

In medical domain, together the characteristics of spectral and spatial data in a single image is extremely preferred by the treatment centres for multiple aspirations like analysis, exploration, supervise, precise diseases analyzing and as well for conduct remedy progression. By means of solitary modality image, it is bit tricky to gain evidence of this kind given that, Computed Tomography (CT) images are the majority accepted for screening bone arrangements and shortage in provided that evidence concerning the goods; at the identical instance. Thus, each particular modality image has its own pitfalls in given that required evidence for the reason that every image is obtained with unusual emission control. So as to conquer this it is extremely essential to attain evidence from multiple modalities which are utilized for medical analysis. This fused evidence of image is utilized in many domains for instance Medication, Cultivation, Aeronautics, Law Enforcement etc. Numerous techniques for conducting fusion Magnetic resonance imaging (MRI) and Positron emission tomography PET images by now had been available. On the other hand, it has a stern side achieve of color deformation. Different determination originate techniques be planned to produce output through low pigment deformation however requiring the difficulty of misplaced exhaustive organizational evidence. Medical domain needs images with complete, precise, consistent and accurate information. Images obtained from different sources are not ready for analysis/ investigation. Hence an effective image fusion procedure is required to generate a fused image with enhance spatial and spectral evidence as well.

Multimodal medical image fusion is a vital function in medical diagnostics and handling health conditions. Extensively utilized transform domain found

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image fusion techniques in the vein of DWT, CVT, CT, NCST affected from spatial contradiction and high difficulty. Only just planned guided filter found spatial domain image fusion methods are too imperfect by disparity decline and halo artifacts. The presented guided filter found image fusion method is adapted by using Gaussian disintegration with local usual energy and average gradient ground saliency maps for stand layer and aspect layer correspondingly. Simulation outcomes illustrate that the customized fusion method is further efficient in preserving difference and superior information than the accessible guided filter found and DWT ground fusion technique. Proposed image fusion approach enhance contrast and fine-tuned information through enriched bonded instructions and directed filter [1].

Medical image fusion is a significant function in analysis and handling of diseases. Even though various medical image fusion techniques have been projected, the majority of these methods is receptive to the sound and typically guide to fusion image deformation, and image evidence defeat. In addition they deficiency universality when commerce with diverse classes of medical images. Proposed a novel medical image fusion to defeat the aforesaid concern of the presented techniques. It is accomplished by converging with rolling guidance filter (RGF) and spiking cortical model (SCM). Initially, importance of medical images can be obtained by RGF. Furthermore, a self-adaptive threshold of SCM is obtained by exploiting the mean and variance of the host images. Lastly, output fused image can be produced by SCM provoked by RGF factors. Investigational outcomes demonstrate that the projected technique is advanced to additional existing well-liked ones in equally instinctively visual interpretation and intention standards. The proposed fused technique can augment robustness to noise and encompass SCM to fuse additional types of medical images. Investigational outcomes determine that the projected technique is improved than advanced medical image fusion approaches in equally visual attendance and objective standards [2].

A narrative multistage geometric analysis contrivance, sparse depiction has exposed numerous compensations in excess of the usual image depiction techniques. On the other hand, the regular sparse depiction does not take intrinsic arrangement and its time complexity into contemplation. A different image fusion process for multimodal medical images found on sparse representation and decision map is planned to contract with these troubles concurrently. Three decision maps are considered together with structure information map (SM) and energy information map (EM) in addition to structure and energy map (SEM) to build the outcome preserve more liveliness and edge evidence. SM comprises the local structure feature obtained by the Laplacian of a Gaussian (LOG) and EM holds the energy and energy distribution feature noticed by the mean square deviation. The decision map is put on to the normal sparse depiction based method to progress the pace of the methodology. Here are three foremost upgrading associated with the conservative SR founded fusion approaches. Primarily, proposed result maps to progress superiority of the SR grounded image fusion approaches in mining the construction and drive sorts of the input images. Furthermore, method adds the conclusion map in to the SR based approaches to progress the quickness of the procedure. Thirdly, toting the arrangement and drive evidence of input images into the conclusion plan expand the eminence of the output image a great deal. [3].

2. LITERATURE SURVEY

Image fusion achieves supreme consequence as the on the whole excellence of scans can be enhanced. Thus, fusing diverse multi modal medical images keen on to a different image with additional exhaustive objective evidence and elevated spectral confidence is extremely preferred in medical conclusions. MRI and PET images are prepared together with improving the excellence of the inputs is tainted and un-comprehensible because of assorted aspects by means of spatial filtering methods approximating Gaussian filters. The improved image is subsequently processed ground on Discrete Wavelet Transform (DWT) for head constituencies with distant movement stages. Experimentations confirmed that fused outcomes for normal axial, normal coronal and Alzheimer's illness brain imageries have fewer color alteration and wealthier organizational evidence than those found from the further standing image fusion procedures [4]. The intention of the fusion work to center on remedial image cataloguing in addition to health related image synthesis, the work describes the widespread diagnostic images together with the most important uniqueness of each of them. The work also depicts mainly renowned toolkits that have been advanced to assist the functioning with the registration and fusion methods. The investigational outcomes obtained from projected technique outdone the further techniques. The planned method accepts that source images stood noise-free[5].The fusion of information for medical imaging has turn into an important concern in such biomedical relevance as image-guided operation and radiotherapy. The multi-level local extrema (MLE) illustration has been exposed to have numerous benefits in excess of predictable image depiction techniques. Planned a novel image fusion method for multi-modal medical images found on MLE. Proposed method

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enables the disintegration of host images into common and exhaustive layers in the MLE format, and exploits local power and distinction image fusion regulations for coefficient collection in the dissimilar layers and it conserve additional feature in the host images and supplementary enhances the eminence of the outcome image. The output fused image is attained after the envelope of preferred factors in the common and comprehensive layers [6].

Medical image fusion is the method of cataloging and converge various images into a single or numerous imaging techniques to advance the imaging eminence and decrease arbitrariness and idleness so as to augment the medical usage of clinical images for judgment and evaluation of medicinal troubles. Multi-modal medical image fusion techniques and instruments have exposed prominent accomplishments in enhancing clinical correctness of conclusions found on medical images [7].Multimodal medical image fusion shows a very important position in clinical diagnosis and treatment development. In numerous image fusion techniques found on pulse coupled neural network (PCNN), normalized factors are utilized to induce the PCNN, and this generate the fused image vague impression, information defeat, and reduced distinction. Furthermore, they are incomplete in handling with medical images with different modalities. A new multimodal medical image fusion technique ground on discrete Tchebichef moments and pulse coupled neural network to conquer the abovementioned troubles. Primarily medical images are separated into uniform-size blocks and the Tchebichef instants are computed to distinguish image outline, and power of blocks is calculated as the sum of squared non-DC instant ideals. Then to hold edges and textures, the power of Tchebichef instants for blocks is imported to inspire the PCNN with compatible connecting power. Lastly, great sacking period are chosen as factors of the output fused image [8].

Medical imaging is a promptly developing extent of exploration for the preceding thirty year span. X-ray, ultrasound, MRI and CT are a few examples of medical imaging sensors which are utilized for mining medical evidence. These sensors provide complementary information about patient's pathology, anatomy, and physiology. For example, CT is widely used for tumor and anatomical detection, whereas information about soft tissues is obtained by MRI. Correspondingly, other medicinal imaging procedures like functional MRI, PET SPECT (single positron emission computed tomography) deliver practical and metabolic evidence. Further, T1-MRI image offers particulars about anatomical construction of tissues, while T2-MRI image provides evidence about standard and irregular tissues. Hence, one can effortlessly accomplish that no one of mentioned methods is talented to convey all significant evidence in a one image. Consequently, multimodal medical image fusion is essential to attain all conceivable pertinent evidence in a one combined image for better diagnosis and treatment. Spatial and transform domain approaches have been widely used for medical image fusion. These techniques include PCA (principal component analysis), linear fusion etc., and multi-resolution fusion scheme using wavelet and pyramid transforms. Subjective and objective evaluations are the two possible ways to assess fusion algorithms. Subjective evaluation can be performed by medical experts, whereas for objective evaluation, reference and non-reference metrics have been used. For medical image fusion, non-reference metrics are more suitable as we do not have any reference medical image for comparison of fused image. However, combined subjective and objective evaluation of fusion algorithms has been found beneficial for better analysis of fusion results [9]. A fusion method is projected to merge one pairs of medical images, for instance the CT-MRI images and CT-MRA images. The host medical inputs are primarily disintegrated by the quaternion wavelet transform. In this technique, the clarity aspects yield to human image system is compatible to fuse the quaternion wavelet factors. Outstanding to the shift-invariance of the quaternion wavelet factors, the projected technique is efficient and can obtain acceptable fusion outcomes. This novel technique produces enhanced subjective and objectives outcomes as relate to preceding image fusion techniques found on the outmoded discrete wavelet transform, non-subsampled contour let transform, ripplet transform, and the NSDFB-DTCWT change [10]. The survey paper affords a realistic listing of techniques and précises the extensive scientific contests confronted in the ground of medical image fusion. Paper distinguish the medical image fusion investigation grounded on (1) the commonly exploited image fusion approaches, (2) imaging modalities, and (3) imaging of body part that are beneath revision. Examination also accomplishes that even yet there occurs numerous exposed technical and systematic encounters, the fusion of medical images has demonstrated to be valuable for progressing the medical dependability by means of medical imaging for medicinal diagnostics and investigation, and is a scientific domain that has the prospective to suggestively nurture in the upcoming time [11].

3. PRINCIPAL COMPONENT ANALYSIS (PCA)

Proposed PCA based multi-focus image fusion on shearlet area. Concept explores two steps, i) convert the input image into shearlet-image by utilizing shearlet transform (ST), ii) practice of PCA method in low-pass sub-band by which the preeminent pixels in plane

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portions are designated conferring to their preparation. The conformations of various high-pass sub-band factors accomplished by the ST disintegration are comprehended. Later, the subsequent output image is reassembled by execution of the inverse shearlet transform (IST). The investigational outcomes, demonstrated that projected approach can improved process outcomes over standing procedures. This relative evaluation completed in the illuminations of subjective and objective evaluation parameters [12]. Projected method utilizes the PCA convert to the spatial evidence of the adjacent pixels. Outstanding to the information that the factors of PCA are attained from numerical possessions of information are flexible and strong. A novel mixture procedure is projected merging the spectral PCA and spatial PCA approaches, by an ideal filter to create the fused outcome additional comparable to equivalent multi-sensors would perceive at the great-determination stage. The assessment of the fusion process utilizing universal endorsement catalogues exposes that the projected methodology progresses the fusion eminence associated with existing techniques [13].

A measured method that changes an amount of related parameters interested in a quantity of unrelated parameters done the Principal Component Analysis [14].

a) Phases in PCA Procedure

1. Input image are transformed in to column directions.
2. Since two column directions attained from previous phase, covariance matrix is calculated.
3. Starting with the output obtained from the previous step compute the representative values and the consistent representative directions.
4. Together the column vector and Eigen vectors got regularized.
5. By combining the two ascended matrices attained result is calculated.

b) PCA based Image Fusion

Deliberate two inputs are signified by A(x, y) and B (x, y) and transform these inputs into corresponding two column vectors and deduct their mean values. The facet of the yield vector is n x 2, anywhere n is the extent of the data direction. The Eigen values and follows Eigen vectors for this result vector is calculated and similarly calculates the Eigen vectors associated to the bigger Eigen values. P1 and P2 are regularized constituents calculated from covariance matrix to attain Eigen vector and the output image is gained from it [14].

$$\text{If } (x, y) = P1A(x, y) + P2\ B(x, y) \ldots\ldots \ldots (1)$$

4. IMAGE FUSION USING DWT

DWT based fusion discovers the prospect of expending the particular wavelet methodology in fusion and de-noising. These procedures are associated on digital optical microscope imageries. The methodology practices an affine transform founded image cataloguing trailed by wavelet based fusion. Later least squares support vector machine grounded frequency group assortment for image denoising can be assimilated to decrease the work of art. The scoops are to exploit determination, reduce artifacts and distorting in the concluding super image [15]. Paper on outline to wavelet transform concept and a summary of image fusion methods are specified, and the outcomes from a various wavelet-based image fusion approaches are associated. It has proved that common, wavelet-based systems achieved better outcomes compared to regular techniques, mostly in standings of minimizing color misrepresentation. Systems that associate regular approaches with wavelet transforms create greater outcomes compared to whichever regular approaches or modest wavelet-based approaches only. The outcomes from wavelet-based approaches can also be upgraded by utilizing more refined prototypes for inserting aspect evidence; conversely, these arrangements regularly obligate superior arrangement necessities [16].

The wavelet transform based image fusion approach is suggested to demonstrate the geometric determination of the images, in which two source images to be administered are primarily disintegrated into substitute images and then the confirmation is achieved by means of these imageries underneath the certain principles and as a final point these substitute images are recreated interested in outcome fused image with plentiful evidence.

Procedure steps in DWT based fusion as following [17]

1. Get the source images, Img1 and Img2 to conduct fusion.
2. Operate autonomous wavelet dissolution of the Img1 and Img2.
3. Implement pixel founded method for likeness so forth comprises fusion placed on in view of the upper appreciated pixels from similarities of inputs Img1and Img2
4. Depends on the upper appreciated pixels between the resemblances; a binate outcome map is created permits the resolution instruction for convergence of nearness coefficients in the source t images Img1and Img2.

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5. The result alteration correlative to similarities over ultimate chosen pixel rule is composed.
6. Concatenation of fused approximations and details gives the different coefficient matrix.
7. Employ the reverse wavelet transform to rebuild the yield fused result.

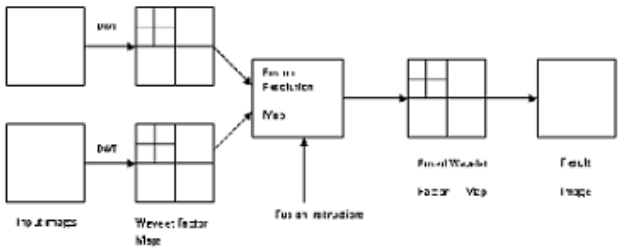

Figure 1: The General Outline For DWT Based Image Fusion.

5. IMAGE PROCESSING WITH FUZZY LOGIC

a) Fuzzy image procedure is not a exclusive concept. Fuzzy image procedure is the gathering of all methods that comprehend, epitomize and course the inputs, their sections and structures as Fuzzy sets. The illustration and treating hinge on the designated fuzzy method and on the tricky to be resolved. It requires three foremost steps

- Fuzzification of an image((Utilizing association utilities to explicitly designate a condition)
- Membership values modification((Utilization of fuzzy instructions)
- Defuzzification of an image((Producing the crisp or definite outcomes)

Fuzzy instructions, embership functions (MSF) are exploited as follows

Axiom-1:
[I/P_1 is MSF _1] and [I/P_2 is MSF _2] → [O/P_1 is MSF _1]

Axiom-2:
I/P_1 → MSF_2] and [I/P_2 is mSf_2] → [O/P_1 is MSF_2]

Axiom-3:
[I/P_1 → MSF_ 2] and [I/P_2 is MSF_2] → [O/P_1 is MSF_ 2]

Axiom-4:
[I/P_1 → MSF_3] or [I/P_2 is MSF_2] → [O/P_1 is MSF_3]

Axiom-5:
[I/P_1 → MSF_1] and [I/P_2 is MSF_3] → [O/P_1 is MSF_ 1]

Axiom-6:
[I/P_1 → MSF_3] or [I/P_2 is MSF_3] → [O/P_1 is MSF_ 2]

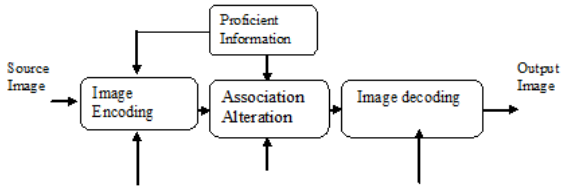

Figure: 2: The Common Outline For The Fuzzy Based Image Handling Procedure.

a) Fuzzy Based Iterative Fusion

In direction to progress the superiority of fused image Fuzzy based iterative fusion is proposed everyplace output attained from image fusion procedure completed former determination be the one of the two source images for the fusion process from consequent image fusion process onwards.

The procedure steps for fuzzy based iterative image fusion is as follows

- Get primary source in I1 and catch its dimension (rows: r1, columns: c1).
- Get secondary source in I2 and catch its dimension (rows: r2, columns: c2).
- I1 and I2 are in matrix practice someplace individual pixel gray flat significance of assortment from 0 to 255.
- Associate rows and columns of mutually input images. If inputs are not of the equivalent dimension, choose the ration are of equivalent dimension.
- Translate the inputs in column form which ensures C = r1×c1 records.
- Mark a fis file, which has two inputs.
- Determine quantity and category of association utilities for both inputs by fine-tuning the association utilities.
- Source inputs are in predecessor are determined to a grade of association vacillating 0 to 255.

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- Mark fuzzy if-then procedures for source inputs, whose determination is two qualifications between 0 to 255.
- For num = 1 to C in steps of 1, utilize fuzzification by means of the rules industrialized over head on the matching pixel gray level values of the source images, which provides fuzzy sets characterized by association functions and outcomes in fused result in column arrangement.
- Endure the fusion procedure with two source images, in which one of the participations is the newest fused image and additional one is the essential source image.
- Translate the column arrangement to matrix arrangement and exhibit the output image.

6. NEURO FUZZY BASED ITERATIVE IMAGE FUSION

The procedure steps for pixel based iterative image fusion utilizing neuro fuzzy logic is as follows.

a) Interpret primary input in I1 and catch its size (rows: zl, columns: sl).
b) Interpret subsequent input in I2 and catch its size (rows: z2. columns: s2).
c) Inputs I1 and I2 are inputting in matrix arrangement wherever individual pixel worth is in the assortment from 0-255. Utilize gray color map.
d) Associate rows and columns of corresponding inputs. Choice the portions which remain of equal size if the two input images are not of the equal size.
e) Transform the inputs in column arrangement which has C= Zl*sl entrances.
f) Custom preparation information in a matrix format with three columns and items individual columns are arrangement 0 to 255 in steps of 1.
g) Custom a check data which is a matrix format of pixels of two source images in column arrangement.
h) Determine quantity and category of association utilities for dual inputs by modulating the association purposes.
i) For training, fuzzy inference system arrangement is utilized, which is created by exploiting genfis1 function through training data, the number of association occupations and category of association utilities as input.
j) To begin operating, compatible neuro fuzzy inference system is employed whose inputs are produced fuzzy inference system arrangement and proficient information and returns proficient information.
k) For num=1 to C in paces of one, utilize fuzzification through produced fuzzy inference system arrangement with check data and competent information as participations which yields result image in column format.
l) Endure the image fusion procedure with two involvements, in which individual of the participations is the most recent fused image and succeeding are the requisite participation image.
m) Transform the column arrangement to matrix arrangement and exhibit the result.

7. EVALUATION PARAMETERS

Fused images obtained from proposed and other fusion approaches are evaluated based on spatial (IQI, MIM ,FF, FS, FI and SF)and spectral(RMSE, PSNR, Entropy and CC) quality assessment criteria. Qualitative (subjective) evaluation is done through statistical parameters listed as follows.

a) Image Quality Index (IQI)

IQI calculates the likeliness between inputs (I1 & I2) and its significance sorts from -1 to 1. IQI value is 1 if both images are alike [18]. IQI quantity is given by

$$IQI = \frac{m_{ab}\ 2xy\ 2m_a m_b}{m_a m_b x^2 + y^2 m_a^2 + m_b^2} \quad \ldots\ldots\ldots\ldots (2)$$

Where x and y indicate the mean values of images I1 and I2 and m_a^2, m_b^2 and m_{ab} designates the variance of I1, I2 and covariance of I1 and I2.

b) Mutual Information Measure (MIM)

MIM provides the quantity of evidence of one input image present in one more image. This provides the strategies for choosing the finest fusion technique. Assumed dual images *M (i, j) and N (i, j) ;* MIM is defined as [19]:

$$I_{MN} = \sum_{x,y} P_{MN}(x,y) \log \frac{P_{MN}(x,y)}{P_M(x) P_N(y)} \quad \ldots\ldots\ldots (3)$$

Where, P_M (x) and P_N (y) are the possibility compactness function in the separate images, and P_{MN} *(x, y)* is combined possibility compactness function. The approximations for the combined and adjoining density functions are attained by simple regulating of the combined and marginal histograms of two inputs.

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c) Fusion Factor (FF)

Specified inputs A and B and output is F, then FF [20] is illustrated as:

$$FF = I_{AF} + I_{BF} \quad \text{..... (4)}$$

a greater worth of FF specifies that output comprises reasonably respectable volume of evidence existing in input images. However, a great worth of FF does not indicate that the evidence from both inputs are equally fuse.

d) Fusion Symmetry (FS)

FS is a signal of the grade of equilibrium in the evidence pleased from inputs.

$$FS = abs\left(\frac{I_{AF}}{I_{AF} + I_{BF}} - 0.5\right) \quad \text{..... (5)}$$

The superiority of fusion method rest on the grade of fusion symmetry. Since FS is the equilibrium aspect, when the devices are of decent superiority, FS must be as short as conceivable so that the output develops characteristics from source.

e) Fusion Index (FI)

FI is computed as

$$FI = \frac{I_{AF}}{I_{BF}} \quad \text{..... (6)}$$

Where I_{AF} is the MIM between MS image and fused image and I_{BF} is MIM between PAN and output image. The excellence of fusion method rest on the grade of fusion index.

f) Root Mean Square Error (RMSE)

The RMSE is quantity of modification per pixel as a result of the fusion process [11]. The RMSE between an ideal image R and the output image F is given by

$$RMSE = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(R(i,j) - F(i,j)\right)} \quad \text{.... (7)}$$

g) Peak Signal to Noise Ratio (PSNR)

PSNR can be computed by expending the principle

$$PSNR = 20\log_{10}\left[\frac{L^2}{MSE}\right] \quad \text{..... (8)}$$

Where MSE is mean square error and L is the amount of gray planes in the fused image.

h) Entropy (E)

The E of an image is an indication of evidence present in the image. It is the typical amount of bits desired to compute the strengths in the fused image. It is formulated as:

$$E = -sum(p * \log_2(p)) \quad \text{..... (9)}$$

Where p comprises the histogram amount obtained from imhist.

i) Correlation Coefficient (CC)

The CC is utilized to conclude how associate the source and fused images co-vary. CC is broadly utilized for equating imageries. It is commonly exploited in arithmetical investigation, configuration appreciation, and image processing

$$CC = \frac{\sum_{i=1}^{n}(Xi - X)(Yi - Y)}{\sqrt{\sum_{i=1}^{n}(Xi - \overline{X})^2}\sqrt{\sum_{i=1}^{n}(Yi - \overline{Y})^2}} \quad \text{.....(10)}$$

Where, X_i is the strength of the i^{th} pixel in input1, Y_i is the strength of the i^{th} pixel in input2, X is the mean strength of input1 and Y is the mean strength of input2.

j) Spatial Frequency

The Spatial Frequency in dimensional area specifies the complete movement levels in the output image.

$$SF = \sqrt{(RF)^2 + (CF)^2} \quad \text{..... (11)}$$

8. RESULTS AND DISCUSSIONS

Proposed method for image fusion implemented in MATLAB R2010 and images are taken for the fusion process are pre-processed and ready for fusion implementation.Two sets (Dataset1 and Dataset 2) of MRI and CT image are fused using various fusion approaches. Fused outcomes are illustrated as follows

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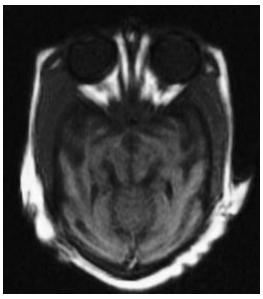
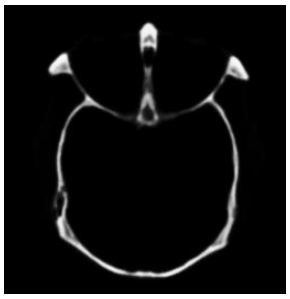
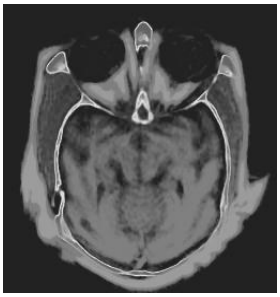
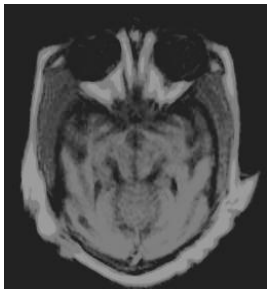
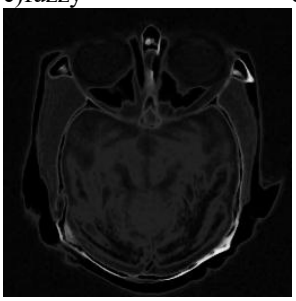
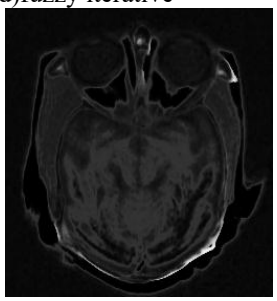



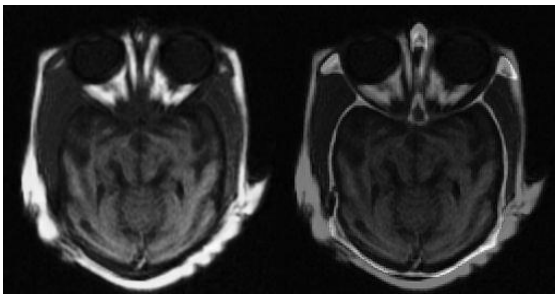
Fig.3 a) MRI image b) CT image

c)fuzzy d)fuzzy iterative

e) neuro fuzzy f) neuro fuzzy iterative



PCA h) wavelet based fused image

g)

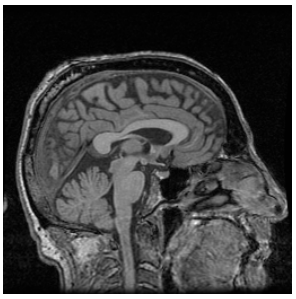
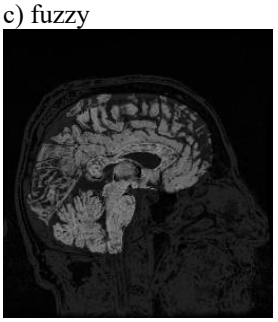
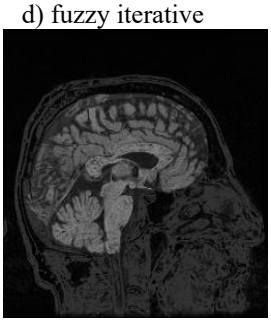
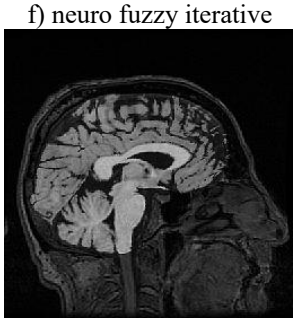



Fig.4 a) MRI image b) CT image


c) fuzzy d) fuzzy iterative

e) neuro fuzzy f) neuro fuzzy iterative

g) PCA h) wavelet based fused images

Table. 1. Assessment Of Fused Results Obtained From Various Fusion Techniques For Dataset 1

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Method	IQI	MIM	FF	FS	FI	RMSE	PSNR	E	CC	SF
Fuzzy	0.8638	2.7097	3.2383	0.3368	5.1262	42.0907	15.6811	7.9063	0.8536	19.5568
Fuzzy Iterative	0.9092	2.4884	2.7813	0.3947	8.4957	31.8682	18.0976	7.9174	0.9047	10.6946
Neuro Fuzzy	0.8484	2.1976	2.6698	0.3231	4.6540	35.6428	17.0914	8.0231	0.8288	12.7491
Neuro Fuzzy Iterative	0.7958	2.8934	3.2739	0.3838	7.6042	37.2497	16.7423	8.3214	0.7931	13.7590
PCA	0.7914	2.6991	2.7044	0.4289	6.0745	44.8400	15.1306	7.7432	0.7593	12.3165
Wavelet	0.7492	2.5339	2.3507	0.4360	5.0966	42.4850	15.5661	7.8946	0.7807	13.8116

Table 2. Assessment of fused results obtained from various fusion techniques for Dataset 2

Method	IQI	MIM	FF	FS	FI	RMSE	PSNR	E	CC	SF
Fuzzy	0.7696	1.5073	2.3845	0.0321	1.7183	41.8933	15.7219	7.1684	0.8941	23.4044
Fuzzy Iterative	0.8624	1.5131	1.9350	0.0820	3.5864	30.7798	18.3995	7.2641	0.9658	19.0790
Neuro Fuzzy	0.9332	0.8958	1.6504	0.0428	1.1871	37.6309	16.6539	7.6776	0.8630	16.4852
Neuro Fuzzy Iterative	0.9326	1.0436	1.7324	0.1024	1.5151	31.3825	18.2310	7.7597	0.8901	14.9199
PCA	0.8106	1.0231	2.0843	0.0619	1.2826	45.6851	14.9693	7.2566	0.6637	16.4450
Wavelet	0.8443	1.1992	1.6402	0.0830	1.3978	34.6623	17.4327	7.5766	0.7820	15.5462

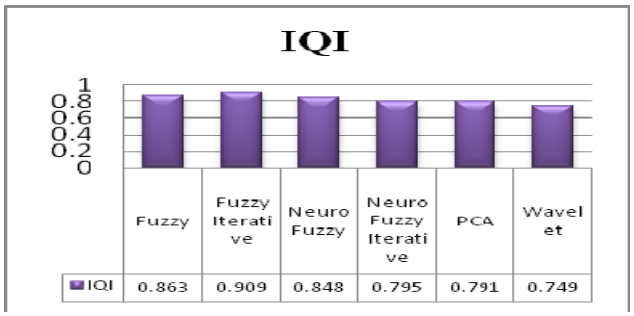

Fig.5 IQI Assessment Of Fusion Approaches

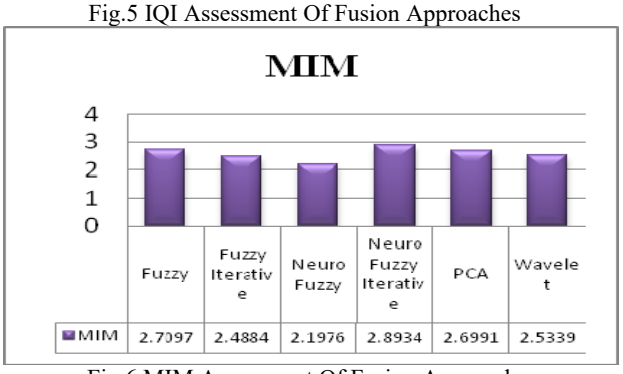

Fig.6 MIM Assessment Of Fusion Approaches

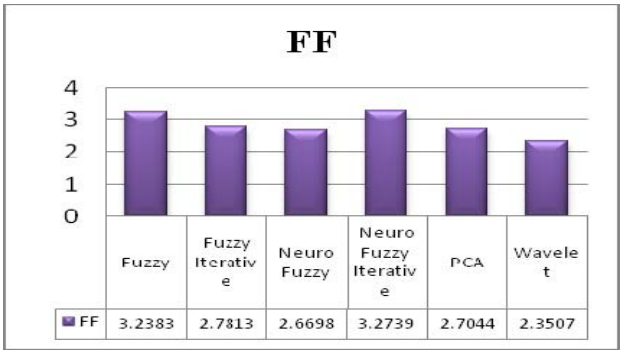

Fig.7 FF Assessment Of Fusion Approaches

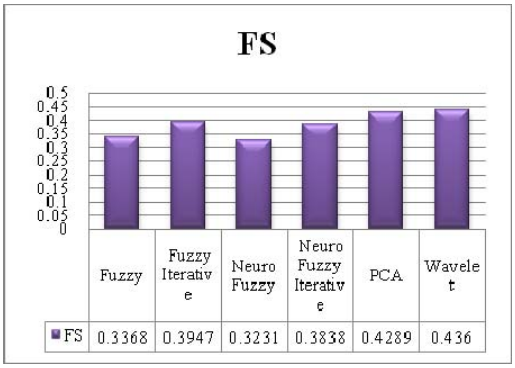

Fig.8 FS Assessment Of Fusion Approaches

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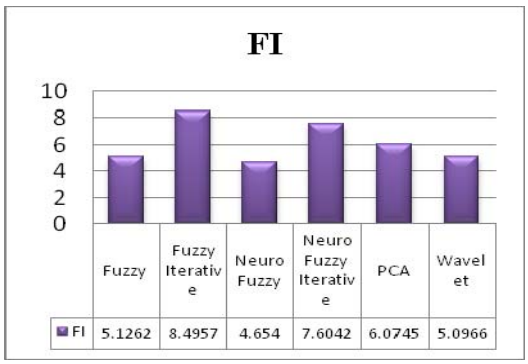

Fig.9 FI Assessment Of Fusion Approaches

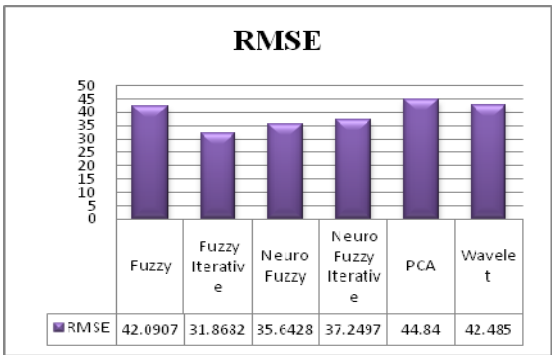

Fig.10 RMSE Assessment Of Fusion Approaches

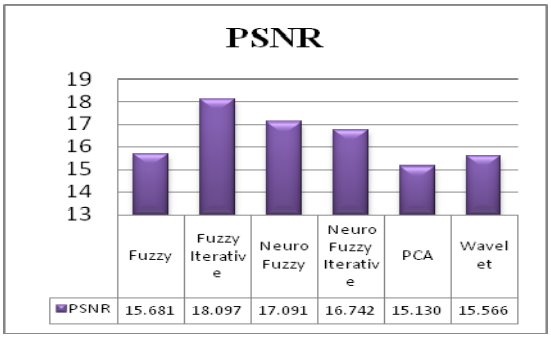

Fig.11 RMSE Assessment Of Fusion Approaches

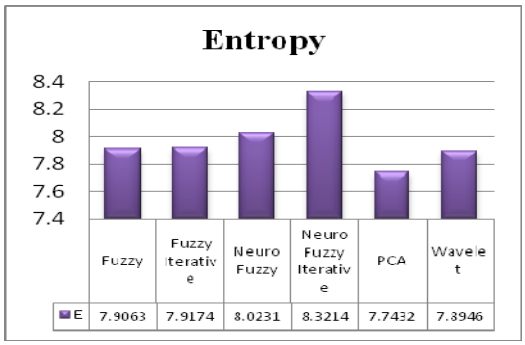

Fig.12 PSNR Assessment Of Fusion Approaches

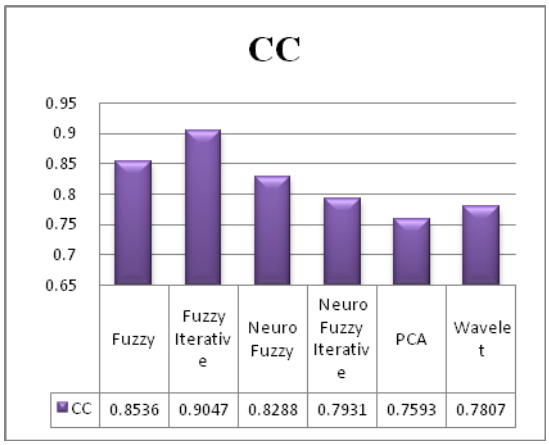

Fig.13 CC Assessment Of Fusion Approaches

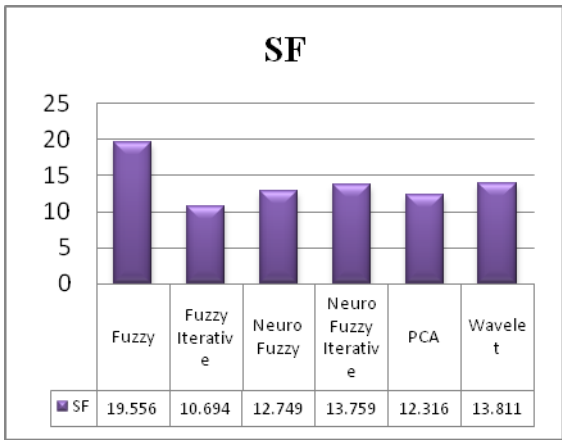

Fig.14 SF Assessment Of Fusion Approaches For Dataset 1

The IQI value for proposed fuzzy iterative fusion (0.9092) is more compared to PCA (0.7914) and wavelet based (0.7492) fusion approaches indicates that content similarity between reference image and fused image is better for the proposed method. Higher MIM value (2.8934) computed from projected neuro fuzzy based iterative image fusion indicates that quantity of confirmation of one source image extant in one more image related to PCA (2.6991) and wavelet (2.5339) based fusion approaches. The higher FF value (3.2739) obtained from suggested neuro fuzzy based iterative image fusion designates that FF indicates that fused image comprises reasonably decent quantity of evidence associated to remaining fusion approaches. The low FS value (0.3231) acquired from recommended neuro fuzzy based image fusion indicates that the degree of symmetry is small and better for projected neuro fuzzy based image fusion. The higher value of FI (8.4957) computed from projected fuzzy based iterative fusion specifies that degree of fused index is more for proposed method related to other image fusion techniques. The lower RMSE (31.8682) value obtained from proposed fuzzy based iterative fusion designates

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that the proposed fusion approach succeeded to improve image quality through fusion process. The higher PSNR value (18.0976) acquired from projected fuzzy based iterative image fusion specifies that the number of gray levels in the fused image is better compared to other fusion approaches. The higher entropy value (8.3214) obtained from projected neuro fuzzy based iterative image fusion designates that the amount of information present in the fused image is more compared to PCA and wavelet based fusion techniques. The elevated CC (0.9047) value acquired from proposed fuzzy based fusion approach and excessive SF value (19.5568) obtained from projected fuzzy based image fusion approach designates that proposed fusion approaches enhances the image evidence through fusion process.

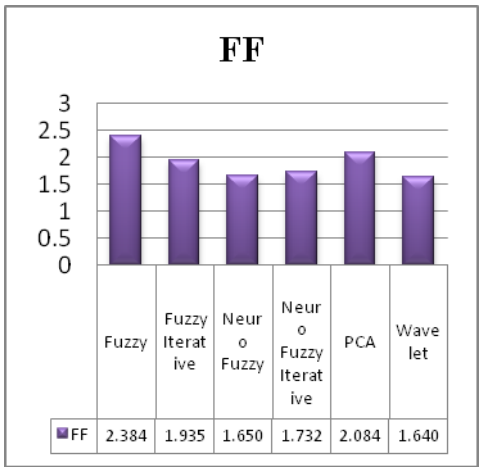

Fig.17 FF assessment of fusion approaches

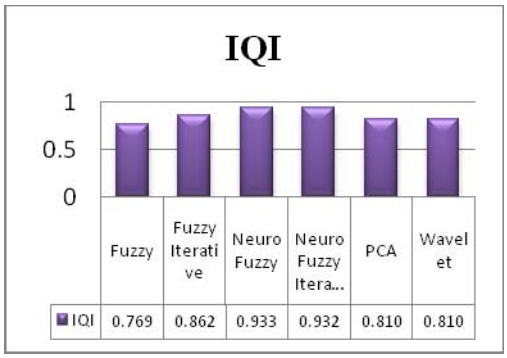

Fig.15 IQI assessment of fusion approaches

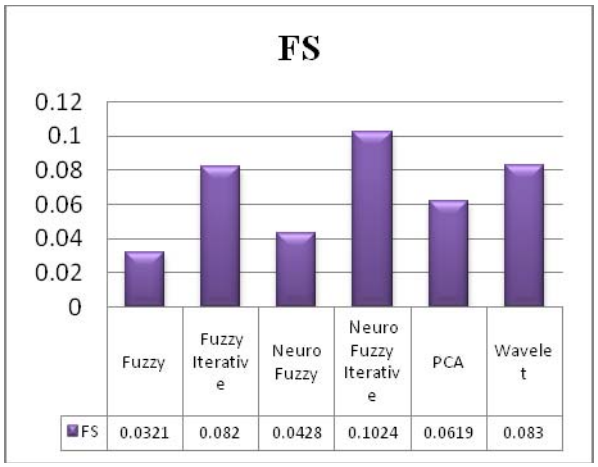

Fig.18 FS assessment of fusion approaches

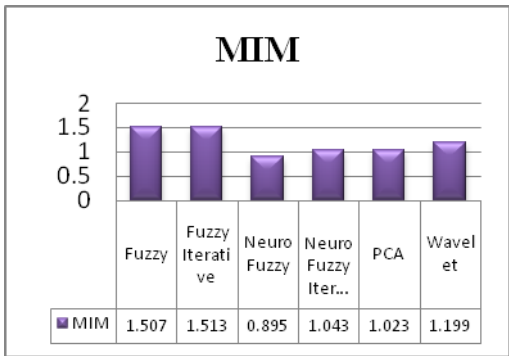

Fig.16 MIM assessment of fusion approaches

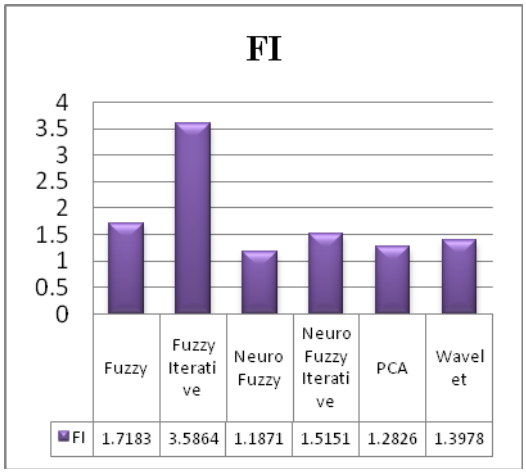

Fig.19 FI assessment of fusion approaches

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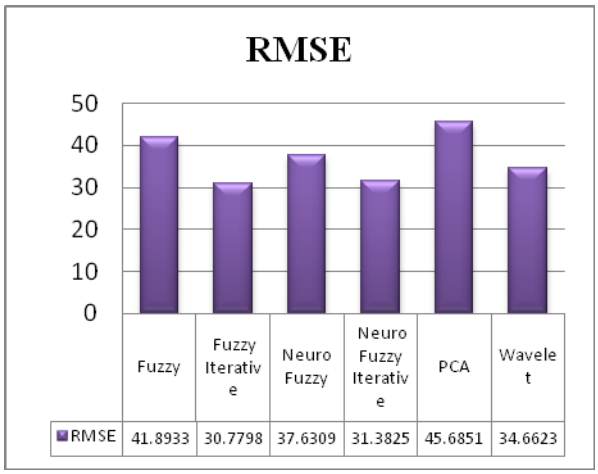

Fig.20 RMSE assessment of fusion approaches

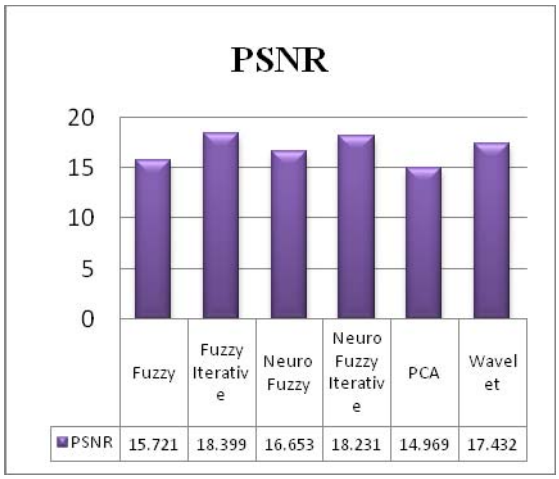

Fig.21 PSNR assessment of fusion approaches

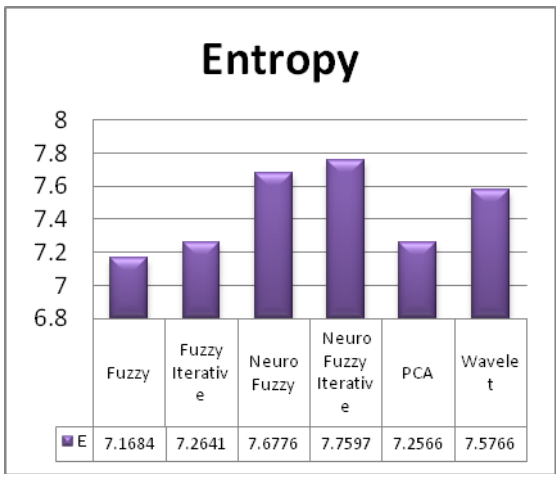

Fig.22 Entropy assessment of fusion approaches

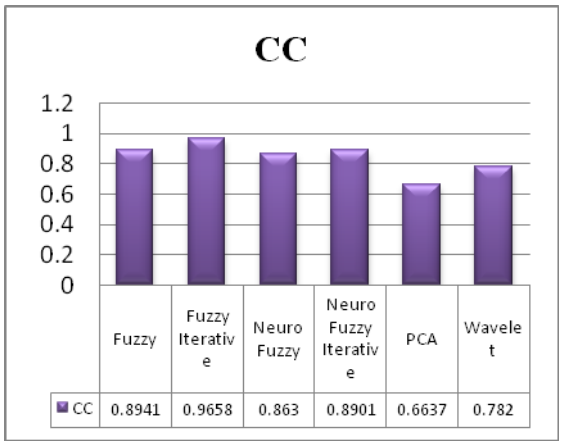

Fig.23 CC assessment of fusion approaches

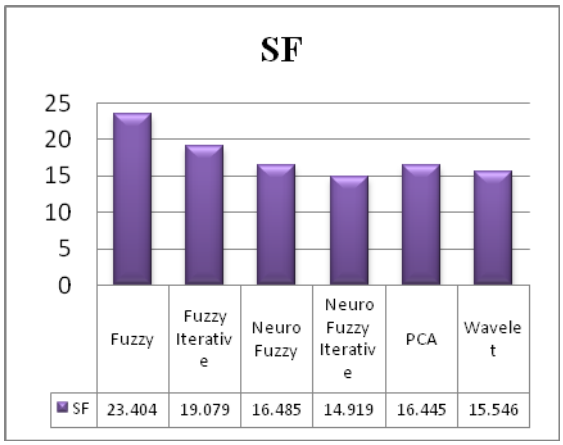

Fig.24 SF assessment of fusion approaches for Dataset 2

The IQI value for proposed neuro fuzzy based fusion (0.9332) is more compared to PCA (0.8106) and wavelet based (0.8106) fusion approaches indicates that content similarity between reference image and fused image is better for the projected approach. Higher MIM value (1.5131) computed from planned fuzzy based iterative image fusion indicates that capacity of validation of one source image extant in one more image related to PCA (1.0231) and wavelet (1.1992) based fusion methodologies. The higher FF value (2.3845) attained from recommended fuzzy based image fusion designates that FF indicates that fused image encompasses practically attired magnitude of confirmation associated to PCA (2.0843) and wavelet (1.6402) based fusion methodologies. The low FS value (0.0321) assimilated from recommended fuzzy based image fusion designates that the degree of symmetry is small and improved for recommended neuro fuzzy based image fusion approach. The higher value of FI (3.5864) gained from anticipated fuzzy based iterative fusion postulates that degree of fused index is further for recommended fusion approach related to values (1.2826,1.3978) attained from PCA and wavelet based

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image fusion approaches. The lower RMSE (30.7798) value attained from projected fuzzy based iterative fusion specifies that the projected fusion methodology succeeded to progress image eminence over fusion process. The advanced PSNR value (18.3995) attained from anticipated fuzzy based iterative image fusion postulates that the number of gray levels in the fused image is improved compared to values (14.9693, 17.4327) attained from PCA and wavelet based fusion methods. The developed entropy value (7.7597) attained from anticipated neuro fuzzy based iterative image fusion specifies that the quantity of evidence extant in the fused image is added associated to values (7.2566, 7.5766) attained from PCA and wavelet based fusion procedures. The preeminent CC (0.9658) value attained from projected fuzzy based iterative fusion method and excessive SF value (23.4044) attained from anticipated fuzzy based image fusion method entitles that proposed fusion methods improves the image evidence through fusion process.

The proposed method outcomes are compared with PCA and DWT based image fusion approaches. In all assessment parameters taken for subjective evaluation stated proposed method outperforms PCA and DWT based fusion techniques.

The investigational outcomes demonstrated that the projected technique can reserve additionally convenient evidence in the fused image with developed spatial resolution and a smaller amount of change to the source images. The possessions of the enriched fusion rules and trained set give us the better visual perception and objective results.

Difference between current proposal work and prior work is as follows

1. In difference with regular fusion process iterative image fusion algorithms are planned here.

2. A new iterative image fusion based on fuzzy and neuro fuzzy based methods are proposed for fusing MRI and CT images.

3. Potentials of Fuzzy and neuro fuzzy approaches are explored to enhance the quality of fused image.

4. Fuzzy instructions and Membership functions are accurately designed to advance competencies of the fuzzy and neuro fuzzy grounded image fusion procedure.

5. Projected image fusion procedure conserves additionally spectral and spatial evidence as well.

6. In all assessment parameters proposed image fusion method gives better results compared to regular fusion techniques

7. Hence iInvestigational outcomes demonstrate that the projected technique is superior to current regular image fusion methodologies.

Conclusions:

The fusion of medical images shows a significant part in numerous medical solicitations for they can sustenance additional precise evidence than any distinct source image. This paper explores a novel fuzzy and neuro fuzzy based iterative fusion for medical images, which comprises of three steps. In the first step, fuzzy inference system (fis) is prepared by determining membership functions, fuzzy rules. In the second step, after considering the fis algorithm is implemented and executed to conduct fuzzy and neuro fuzzy based iterative image fusion. In third step fused results obtained from various fusion approaches are assessed by typical parameters. The enactment of the projected technique is excellence and assessable associated with some current fusion approaches. Investigational outcomes demonstrated that the projected fuzzy and neuro fuzzy based image fusion techniques can holds supplementary beneficial evidence in the output fused image with sophisticated spatial determination and lower variance to the basis images.

LIMITATIONS OF THIS WORK:

Determination of precise fuzzy membership values of inputs, output and preparation compatible of fuzzy rules may be optimized. Proposed method executed on static images it can also be extended for fusion of videos obtained from various sources and can be additionally stretched to different categories of images, for fusion of numerous sensor images and to integrate effective assessment methods of image fusion.

REFERENCES:

[1] Pritika and Sumit Budhiraja.," Multimodal medical image fusion using modified fusion rules and guided filter", International Conference on Computing, Communication & Automation (ICCCA), IEEE Xplore 2015.

[2] Liu Shuaiqi, Zhao Jie and Shi Mingzhu., "Medical Image Fusion Based on Rolling Guidance Filter and Spiking Cortical Model", Computational and Mathematical Methods in Medicine, 2015.

[3] Yin Fei, Gao Wei and Song Zongxi.,"Medical Image Fusion Based on Feature Extraction and Sparse Representation", International Journal of Biomedical Imaging, 2017.

[4] Bhavana.V and Krishnappa H.K.," Multi-Modality Medical Image Fusion using Discrete Wavelet Transform", Procedia Computer Science, vol.70, pp.625-631,2015.

[5] Fatma El-Zahraa Ahmed El-Gamal, Mohammed Elmogy and Ahmed Atwan,"Current trends in medical image registration and fusion", Egyptian Informatics Journal, vol.17, pp.99-124, 2016.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[6] Zhiping Xu, "Medical image fusion using multi-level local extrema", Information Fusion, vol.19, pp.38-48, 2014.

[7] Alex Pappachen James and Belur V. Dasarathy, "Medical image fusion: A survey of the state of the art", vol.19, pp.4-19, 2014.

[8] Lu Tang, Jiansheng Qian, Leida Li, Junfeng Hu and Xiang Wu, "Multimodal medical image fusion based on discrete Tchebichef moments and pulse coupled neural network", International Journal of Imaging Systems and Technology, vol.27, pp.57-65, 2017.

[9] Rajiv Singh, "Medical image fusion: applications, approaches and evaluation", OMICS Journal of Radiology, International Conference on Medical Imaging and Diagnosis, vol.5, 2016

[10] Peng Geng, Xing Su and Tan Xu, "Medical Image Fusion Based on Quaternion Wavelet Transform and Visibility Feature", IJAMML, vol. 2, pp. 9-26, 2015.

[11] Alex Pappachen James and Belur V.Dasarathy, "Medical image fusion: A survey of the state of the art", Information Fusion, Vol.19, pp. 4-19, 2014.

[12] Biswajit Biswas, Ritamshirsa Choudhuri, Kashi Nath Dey and Amlan Chakraparti, "A New Multi-focus Image Fusion Method Using Principal Component Analysis in Shearlet Domain", Proceedings of the 2nd International Conference on Perception and Machine Intelligence, pp.92-98, 2015.

[13] Hamid RezaShahdoosti and HassanGhassemian, "Combining the spectral PCA and spatial PCA fusion methods by an optimal filter", Information fusion,Vol. 27, pp.150-160, 2016.

[14] Naidu, V.P.S. and Rao, J.R., "Pixel-level Image Fusion using Wavelets and Principal Component Analysis", Defense Science Journal, 2008.

[15] A.Anoop Suraj, MathewFrancis, T.S.Kavya and T.M.Nirmal, "Discrete wavelet transform based image fusion and de-noising in FPGA", Journal of Electrical Systems and Information Technology,Vol.1, no. 1, pp. 72-81, 2014.

[16] KristaAmolins, YunZhang and PeterDare, "Wavelet based image fusion techniques-An introduction, review and comparison", ISPRS Journal of Photogrammetry and Remote Sensing, Vol.62, no. 4, pp. 249-263, 2007.

[17] Sivakumar N and Helenprabha K.," Hybrid medical image fusion using wavelet and curvelet transform with multi-resolution processing", Biomedical Research vol.28,no.6, pp.2758-2762, 2017.

[18] Wang,Z. and Bovic, A.C., "A Universal Image Quality Index", IEEE Signal Processing Letters, 2002.

[19] S. Kumaraswamy, D. Srinivasa Rao and N. Naveen Kumar.," Satellite image fusion using fuzzy logic", Acta Univ. Sapientiae, Informatica, Vol.8,no.2,pp. 241 53,2016.

[20] D. Srinivasa Rao, P.China Yalamanda Rao, G.Minni and Sayeed Yasin.," Performance Evaluation of Fuzzy and Neuro Fuzzy Based Image Fusion",International Journal of Innovative Research in Computer and Communication Engineering,Vol.4,no.10,2016.