International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-8 Issue-9, July, 2019

Dual Filter Based Images Fusion Algorithm for CT and MRI Medical Images

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Abstract— A novel image fusion algorithm based on two filters, one is laplacian filter for de-nosing the detailed coefficients and second filter is Guided Filter (GF) used to refine the approximation as well as detailed coefficient for Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) medical images is proposed. Because of using wavelet transform, we obtained approximation coefficient and other three coefficients of CT and MRI images. Now two weight maps are obtained after the process of denoising. Another reason for obtaining two weight maps is because of comparison. Here comparison is done between two approximation coefficient and six detailed coefficients. By using the approximation coefficients and detailed coefficients, GF is designed. Here GF will guide an image corresponding to the weight maps. Here the weight maps are smoothed using GF and this is mainly served as input image. Hence the weighted fusion algorithm will fuse the both CT and MRI images. A pure fused image is obtained only when the CT and MRI images are refined by inverse wavelet transform. From the comparison results, it can observe that the proposed system gives better results compared to existing system. As well as the proposed system will give maximum amount of input in detail manner.

Keywords— Fusion, Guided Filter, Registration, Weighted Fusion, Wavelet Transform, Tumor. Laplacian Filter.

I. INTRODUCTION

Basically, medical diagnosis uses mainly two technologies to give input for clinical diagnosis. The technologies are computer tomography (CT) and magnetic resonance images (MRI) [1]. The main intent of CT technique is to scan the human body. In the same way CT gives different radial absorption rate and different densities depend on the computer controlled X-ray human tissues. These X-ray human tissues are divided into two types they are hard tissues and soft tissues. Hard tissues consist of high density resolution and soft tissues consist of low density resolution.

Here for the purpose of lung diagnosis and interstitial lung disease, we use mainly CT technique. In this lung diagnosis, CT mainly uses high density resolution instead of low resolution. By using CT scanner we can gives an overview about the tumor target region and outline of normal tissues. The important parameters to obtain perfect CT scanner are, doctors clinical experience, anatomical structure and target value [2]. Hence this is the overview about CT scanner let us discuss about MRI images in detail manner. Here soft tissues are used in MRI images to obtain suitable input. MRI scanning is mainly used to give input about nervous system, muscle, feet, articular cartilage and soft tissues. Similarly, MRI images does not provide input about density bone, gas lung and calcification [3]. Now when we compare the CT scanning and MRI scanning, we came to know that they are totally different to each other. For example, MRI scanning is used only in soft tissues and the CT scanning is used in both soft and hard tissues [4]. Here MRI provides modality for heart diseases and cardiac function test and as well as it consists of small cardiac elements.

The clinical disease diagnosis uses mainly two imaging techniques, they are CT and MRI. These techniques will fuse the images of new patient. Basically, the fuse image will use mainly two techniques to overcome the deficiency of single image pattern. Here the fused image consists of visual, comprehensive abundant input. This input will give an overview about the size, location, shape of the image. At last it will increase the accuracy of diagnosis in effective way [5].

Here to transform radiation therapy from one form to another form, Radiation oncology is used. This radiation oncology will transform the external irradiation to precision radiotherapy. This transformation will modulate the intensity in three dimensional patterns. The normal tissue and gross tumor values are obtained to assess the tumor radiotherapy plan [6]. The main purpose of using radiotherapist is to determine the values of MRI target value, CT target value and fused image target value of both T and MRI images. After determining these values, we obtain high accuracy. This accuracy will help the patient to precision the targeted therapy [7]. By using MRI and CT scanning, the radiotherapist will identify the post operative target. The CT and MRI Scanning will reduce the volume of normal tissues. This two scanning’s will radiate the target value and as well as radiation source [8].

The medical image fusion algorithm is implemented using the different decomposition levels, different resolutions and different scales [9]. Here the host images are decomposed by multi resolution coefficients. These coefficients will choose the fusion algorithm to get the resultant image [10]. This image fusion algorithm will give input input about the noise sensitive and weighted average fusion. This will mainly reduce the image contrast and edge input input and as well as it has ability to mark about the reduction of signal to noise ratio [11]. Mainly to reduce the signal to noise ratio in an image we should use intuitionist fuzzy interference based algorithm.

This algorithm will produce the results in easy way. In this mis-adjustment is obtained because of division of pixel. Due to this there will be no proper selection of degree function [12].

Revised Manuscript Received on July 10, 2019.

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Basically, we use the fusion algorithm, fixed weighted coefficients for an image processing field. But in this various types of filters should be adopted for better processing. These filters will smooth the image and as well as it performs the edge extraction, image enhancement and other operations. After performing all these operations, linear shift invariant filter and shift invariant filter are used. These filters will group the weights of obtained input. This process is similar to median filter process. But here the shift variant filter will not give the fixed weight related to our input. Here if the obtained weight is remained constant then that image is called as guided image. In the same way the input that is determined from guided image that is known as guided filter (GF). The guided filter not only will produce the input of source image but also it gives the characteristics of that guided image. Here the bi lateral filter is used to construct the gauss filter [13].

The main intent of bilateral filter is that it produces the input of pixels in input image. The main disadvantage of bilateral filter is that it does not measure the distance between image pixels. Because of this there will be no smoothing process in image. But it will reduce the noise in image processing using bilateral filter. Here instead of bilateral filter, we use joint bilateral filter to get input from input image in effective way. While designing the kernel filter the input image requires an image which plays an effective role for both positions [14]. The joint bi lateral filter consists of two different images which guide the input to carry the partial input in effective way. In the same way we can determine the weight of obtained input. But there are some limitations in the both bilateral filter and joint bi lateral filter. These filters will use the clear edge gradient inversion process [15].

[16] To eliminate the image noise we proposed a GF method. This GF method consists of characteristics of edge. This GF method will overcome the limitations and as well as this algorithm will produce high efficiency, uses small size and linearity. Basically, invariant filters are used as Gaussian filters. These Gaussian filters are independent to carry the input from guided image. Here GF will determine the concept of guided image in effective way [16]. Here the main purpose of guided image is to smooth the edges. In the same way we take the guided image as either input image or other image[16]. In image enhancement technique the input image produces efficient results compared to others [17]. Similarly, it produces noise reduction [18], image dehazing [19] and image fusion [20] by using the Gaussian filter.

A weighted image fusion algorithm using CT and MRI medical images is proposed in this paper. This system will intertwine the images adaptively and then Wavelet transform is utilized. Basically one approximate coefficient, three detailed coefficient of CT and MRI image are acquired by using wavelet transform on CT and MRI helpful images independently. Two approximation coefficients are used to keep up the general condition of source image. After two approximations, six wavelet coefficients are utilized after de-nosing with laplacian filter. These are compared by pixel by pixel to obtain the weight maps. The weight maps are normally large and edge darkening. In order to obtain the fused image the weight maps filling in as the data and the contrasting furthest reaches of significant worth and positive coefficient filling in as the guided image. GF is used to smooth the weight maps and refined weight maps are gotten, along these lines refined guide of each image is one of a kind and fixed out by the characteristics of the image to be intertwined with help of refined weight maps.

Correlation of proposed calculation with existing calculation like pick more fusion calculation and Intutionistic fluffy obstruction fusion calculation demonstrates that the fused image dependent on this calculation keeps up a more prominent measure of data, clear edges and more subtleties. The fused image is unmistakably better on both abstract and target assessments, assessment parameters demonstrates that this calculation is more worthwhile than the current other three calculations so as to find the position and state of the objective qualities and furthermore improves the objective esteem outline proficiency, In treatment process, this calculation can more readily keep away from the encompassing wellbeing organs by radiation, and ensure the health of patient.

This paper is sorted out as pursues the strategy is presented in section 2, GF filter, GF parameters determination, and GF based CT and MRI images fusion existing calculations is discussed in section 3, proposed calculations are examined in section 4, experimental results are in section 5, at long last the conclusion is presented in section 6.

II. METHODOLOGY

2.1 Introduction to GF

The output image 'O' of GF is a linear transform of a guided image I [16] in a window displayed at pixel 'k' and the filter yield at pixel I is settled as seeks after

$$O_i = a_k I_i + b_k \quad \forall, i \in \; w_k \tag{1}$$

Where w_k is the square window of sweep 'r' From condition (1) we can observe that ∇O = a ∇I, where ∇O and ∇I are the inclination of output image 'O' and guided image 'I', from this we can know 'O' has an edge just if 'I' has an edge, and are linear coefficients in w_k and can be surveyed by restricting the underneath cost work in adjacent window.

$$E(a_k, b_k) = \sum_{\mathrm{i}\in \mathrm{w_k}}((a_k I_i + b_k - p_i)^2 + \varepsilon {a_k}^2) \tag{2}$$

Here ε is used to modify the filtering impact which is taken as significant parameter. Coming to the parameter p_i, this is the input image value at pixel I, at last least-square technique is used to determinea_k, b_k

$$a_k = \frac{\frac{1}{|\omega|}\sum_{\mathrm{i}\in \mathrm{w_k}} I_i p_i - \mu_k \bar{p}_k}{{\sigma_k}^2 + \varepsilon}$$

$$b_k = \bar{p}_k - \; a_k \mu_k \tag{3}$$

Where μ_k and ${\sigma_k}^2$are mean and deviation values of the guided image in w_k.|ω | means pixel number in w_k , $\bar{p}_k$ is mean value of input image in w_k. For the values of linear coefficients of every pixel is portrayed by various direct capacities, and the value of o_i is assorted when it is determined in various windows so as to tackle this issue every conceivable esteem of o_i should be averaged first

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$$o_i = \frac{1}{|\omega|}\sum_{i\in w_k}(a_k I_i + b_k) = \bar{a}_i I_i + \bar{b}_i \quad (4)$$

Where $\bar{a}_i = \frac{1}{|\omega|}\sum_{k\in w_i} a_k$ and $\bar{b}_i = \frac{1}{|\omega|}\sum_{k\in w_i} b_k$

From the above equations ∇O is the linear transform of ∇I on the grounds that the direct coefficients $\bar{a}_i$, $\bar{b}_i$ transforms spatially. The coefficients are nothing but output of an average filter and their angle ought to be a lot littler than that of I close to the solid edges, when all is said in done coefficients are subsequently still we have ∇O= a ∇I. That implies clear edges in I can be for the most part kept up in 'O' which signifies the edge preserving quality of the GF.

2.2 Determination of parameter of the GF:

$G_{r,\varepsilon}$(P, I) is utilized to signify basically the both input image and guided image are shown separately in this paper. Next r and ε coefficients will determine the size of filter and as well as it determine the GF individually.

$$a_k = \frac{\sigma_k{}^2}{\sigma_k{}^2+\varepsilon}$$
$$b_k = (1-a_k)\mu_k \quad (5)$$

In the above condition that ε=0 clearly a_k=1, b_k=0 from the above equations, when O = I for this situation no filtering impact is available right now if ε>0 let us think about two cases.

Case 1: "High varies", i.e $\sigma_k{}^2 >> \varepsilon$, so $a_k \approx 1$ and $b_k = 0$ then the filtering impact of those values are very weak and it can be utilized keep up edges of image.

Case 2: "Flat patch", i.e $\sigma_k{}^2 << \varepsilon$, (In w_k, the value of guided image is remains constant so $a_k \approx 0$ and $b_k = \mu_k$. Hence the GF is known as weighted average filter.

From the above examination the parameter ε is the criteria to choose a high fluctuation or level fix. The patches with a difference significantly smaller than ε are smooth and with a transform greater than ε are secured under the condition that window size can't be transformed i.e the more diminutive the ε the more apparent component of edge defending, the greater ε the more clear sifting effect.

$\varepsilon = \sigma^2 10^{-5}$is considered in this paper dependent on the reference, with the basic input of GF, the base estimations of 'r' is '1' and the best estimation of 'r' is (Min (width-1, stature 1))/2 where width is the pixel number of guided image in X-bearing and height is the pixel number of guided image in Y-course, Min is the activity for least.

2.3 Evaluation Parameters

In order to measure the fusion execution of various calculations impartially , and the melded images are broke down as far as three evaluation parameters: Standard Deviation, Average Gradient, Edge Strength, consider that image of B of size M x N where M and N are the lines and sections of the image separately , B shows intertwined image. B I, j demonstrates the incentive at pixel (I, j) the mean value of the fused image $\bar{B}$

$$\bar{B} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} B_{i,j}}{\text{MXN}} \quad (6)$$

$\bar{G}$ Demonstrates the marginalization degree and small detail contrast of an image, if the normal inclination is huge, it shows that the higher image clearness [21]. Sobel operator is utilized to figure the principal request partiall subsidiary of image B and the normal angle G is characterized as pursues:

$$\bar{G} = \frac{1}{(\text{M}-1)(\text{N}-1)}\sum_{i=1}^{M}\sum_{j=1}^{N}\sqrt{\frac{s_x(i,j)^2+s_y(i,j)^2}{2}} \quad (7)$$

Where Sx (I, j) and Sy (I, j) indicates the principal request halfway subordinate in even and vertical course at point (I, j)

Image clarity degree is implied by the edge quality, if the image detail and edge is more and higher the image clearness [22]. A system proposed by Wu Lin is used to choose the edge quality [23] where the neighboring pixel regards are used to register the second solicitation midway subordinates in course (horizontal, vertical, diagonal , and back-diagonal) which are implied as HOE (I, j), VOE (I, j), DOE (I, j) and BOE (I, j) separately the most outrageous motivating force in the four headings is picked as edge quality at pixel (I, j), the edge quality ES of image B is managed by averaging most of the edge nature of each pixel.

$$ES = \frac{1}{MXN}\sum_{i=1}^{M}\sum_{j=1}^{N} Max\begin{vmatrix}HOE(i,j), VOE(i,j)\\ DOE(i,j), BOE(i,j)\end{vmatrix} \quad (8)$$

III. EXISTING ALGORITHMS

In this article proposed algorithm is compared with the following three existing fusion algorithms

3.1 Choose-max fusion algorithm

Contrasting the dark estimation of each pixel in the input image and think about the bigger gray value as a estimation of the fused image. The different steps in Choose-max fusion calculation is according to the accompanying

Step1: CT image is decomposed in to approximate coefficient A1 and three detailed coefficients H1, V1, and D1 by the use of wavelet transform after the registration.

So also MRI image is decomposed in to approximation coefficient A2 and three wavelet coefficients H2, V2, and D3.

Step2: After the examination of four arrangements of coefficients of the two images the fused approximation and detailed coefficients Ac, Hc, Vc and Dc can be obtained according to the following formula

s_1= s_1, s_1>=s_2

s_2, s_2>=s_1

Where s_1 and s_2 means approximation and wavelet coefficients A1, A2, H1, H2, D1, D2, s denotes the fused approximation and wavelet coefficients Ac, Hc, Vc and Dc.

Step3: A fused image can be obtained by Application of inverse wavelet transform of the fused approximate and wavelet coefficients Ac, Hc, Vc and Dc.

3.2 Intuitionistic fuzzy interference fusion algorithm

It is an innovation identified with the man-made reasoning and in this technique the strategy for impedance is obtained by copying the human reasoning. This technique understands the mapping among input and output. Canadas

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A Nejatali and IR Ciric applied first fuzzy inference to the image fusion theory in 1998 [24], because of the improvements in research in recent years, there are less number of fusion calculations dependent on intuitionistic fluffy obstruction frame function [25, 26].

The steps involved in fuzzy interference algorithm are as follows

Step 1: CT and MRI input image registration

Step 2: By the usage of wavelet transform CT image is deteriorated into estimation coefficient A1 and three nitty gritty coefficients H1, V1, D1. So additionally MRI image is deteriorated into worth coefficient A2 and three wavelet coefficients H2, V2, D2.

Step 3: Value and coefficients after the fusion A1, H1, V1 and D1 can be obtained by intutionistic fuzzy obstruction technique individually

Step 4: fused image can be acquired after the usage of reverse wavelet transform of intertwined rough coefficients and three wavelet coefficients A1, H1, V1 and D1.

Intutionistic fluffy impediment methodology in stage 3 suggests Mamdani type intutionistic fluffy derivation proposed by Qi Sun [28].

3.3 GF based CT and MRI images fusion algorithm

Step 1: CT and MRI input image registration

Step 2: CT image is deteriorated into surmised coefficient A1 and three point by point coefficients H1, V1 and D1 by the utilization of wavelet transform. In like manner MRI image is deteriorated into surmised coefficient A2 and three nitty gritty coefficients H2, V2 and D2.

Step 3: By looking at the pixel values of approximation coefficients of CT and MRI images the weight maps are obtained and these weight maps are filling in as input image and relating approximate coefficients filling in as the guided image for the guided filter.

$$W1 = \begin{cases} 1, & \text{if } A1>A2 \\ 0, & \text{otherwise} \end{cases}$$
$$W2 = \begin{cases} 1, & \text{if } A2>A1 \\ 0, & \text{otherwise} \end{cases}$$

Guided filter refine the weight maps and produce the new weight maps which are known as refined weight maps

$$M_1 = G_{r,\varepsilon}(W1, A1)$$
$$M_2 = G_{r,\varepsilon}(W2, A2)$$

Step 4: By the weighted fusion calculation, fused approximation and detailed coefficients can be obtained

Step 5: fused image can be obtained by the use of inverse wavelet transform of the fused value and coefficients.

IV. SCHEME OF PROPOSED ALGORITHM

At first after the image enlistment, wavelet transform is connected to each source image, which disintegrates CT image into estimate coefficient. A1 and three wavelet coefficients H1, V1, D1and MRI image is deteriorated into guess coefficient A2 and three point by point coefficients H2, V2, D2. The wavelet transform hopes to decay each source image into low recurrence coefficient which contains enormous scale esteem input and three wavelet coefficients which contains little scale detail input, and the A1, A2 are used maintain boundaries of the source image and H1, V1, D1 and H2, V2, D2 are utilized to keep up the data inside the image. The weighted maps W1 and W2 are obtained by comparison of pixel values of approximation coefficients and detailed coefficients that is on the off chance that A1>A2, H1>H2,V1>V2 and D1>D2 then W1=1 generally 0 also on the off chance that A2>A1, H2>H1,V2>V1 and D2>D1 then W2=1 generally 0

$$W_1 = \max(A_1, H_1, V_1, D_1)$$
$$W_2 = \max(A_2, H_2, V_2, D_2)$$

Weight maps obtained by the above equation commonly noisy and have edge blur, if images are fused by utilizing weight maps the fused image linear forwardly will create relics, consequently. So as to discover the position all the more precisely we have to give an fused image clear edges, a GF is constructed with W1 and W2 filling in as input image separately and the relating approximation coefficient A1 and A2 filling in as guided image individually. At that point GF is utilized to smooth the weight maps, the values of r and ε are obtained from area 2.2. Distinctive image gatherings may have various qualities and refined weight maps are M1 and M2 are obtained.

$$M_1 = G_{r,\varepsilon}(W1, A1)$$
$$M_2 = G_{r,\varepsilon}(W2, A2)$$

The two estimate coefficients A1 and A2 are melded to get the combined guess coefficients A by weighted fusion calculation utilizing refined weight maps also three point by point H1and H2, V1and V2, D1 and D2 are intertwined separately to get melded approximate coefficients H,V,D by utilizing the weighted fusion calculation

$$A = A1 \times M1 + A2 \times M2$$
$$H = H1 \times M1 + H2 \times M2$$
$$V = V1 \times M1 + V2 \times M2$$
$$D = D1 \times M1 + D2 \times M2$$

Toward the end fused image approximate and coefficients A, H, V, D are functioned by converse wavelet transform to acquire an fused image.

4.1 Schematic

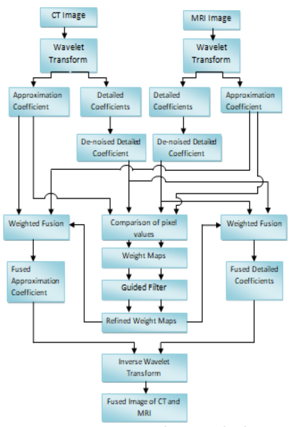

Fig 1: Scheme of CT and MRI images fusion of proposed algorithm

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Step 1: CT and MRI input image registration

Step 2: CT image is disintegrated into worth coefficient A1 and three wavelet coefficients H1, V1 and D1 by the use of wavelet transform. Therefore MRI image is disintegrated into guess coefficient A2 and three wavelet coefficients H2, V2 and D2 and the clear coefficients of CT and MR images are de-noised by using a filter.

Step 3: By looking at the pixel estimations of approximate coefficients and wavelet coefficients of CT and MRI images, the weight maps are gotten and these weight maps filling in as the input image, related approximate coefficients filling in as the guided image for the guided filter, in the event that A1>A2, H1>H2,V1>V2 and D1>D2 then W1=1 otherwise 0 comparably on the off chance that A2>A1, H2>H1,V2>V1 and D2>D1 then W2=1 otherwise 0

$$W1=Max\ (A1, H1, V1, D1)$$
$$W2=Max\ (A2, H2, V2, D2)$$

Guided filter refine the weight maps and create the new weight maps which are known as refined weight maps

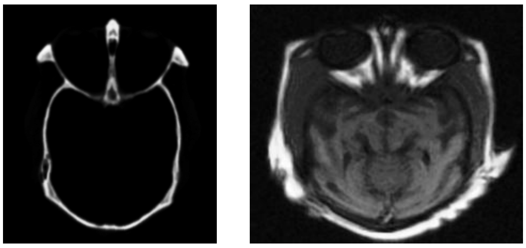
$$M1= G\ (W1, A1)$$
$$M2= G\ (W2, A2)$$

Step 4: By the weighted fusion algorithm, fused approximate and detailed coefficients can be obtained

Step 5: fused image can be obtained by the use of inverse wavelet transform of the fused approximation coefficients and wavelet coefficients

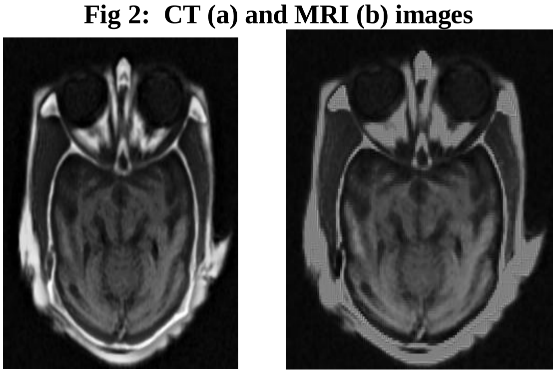
V. EXPERIMENTAL RESULTS AND DISCUSSION

Examinations are performed on one lot of testing images as appeared in figure 2,pair of CT and MRI images is a similar body portions of a similar individual after the registration.



a b

Fig 2: CT (a) and MRI (b) images



(a) (b)

Fig 3: Existing (a) and Proposed (b) Fused image of CT and MRI

Table: 1. Evaluation parameters of fused images of existing and proposed algorithms

Algorithm	Standard Deviation	Average Gradient	Edge Strength
Choose-m	0.128938	0.188799	0.037942
Fuzzy	0.129394	0.206837	0.041739
Existing	0.150644	0.248909	0.043825
Proposed	0.205963	0.259743	0.053901

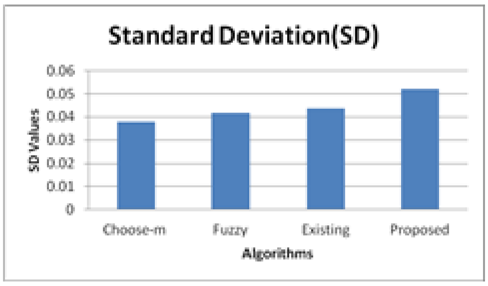


Fig 4: Comparison of Standard Deviation using existing and proposed algorithm

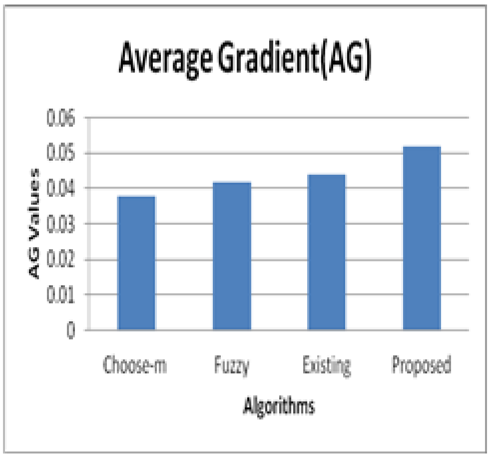


Fig 5: Comparison of Average Gradient using existing and proposed algorithm

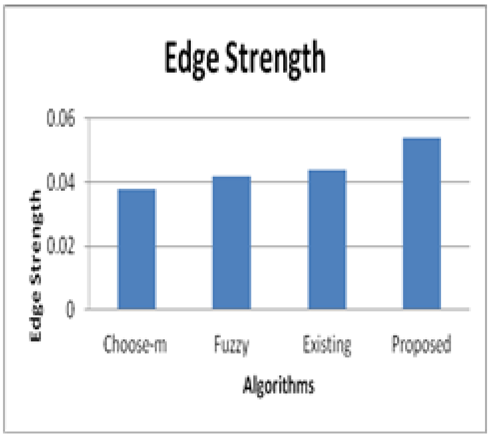


Fig 6: Comparison of Edge Strength using existing and proposed algorithm

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VI. CONCLUSION

Basically in transform domain, we use mainly weighted coefficients for weighted fusion algorithm. Here in proposed GF design, the weight maps are served as input image and approximate coefficients are termed as guided image. To get a refined weight map in the system GF is used. These refined weight maps are unique in nature and uses fuzzy logic. Hence the proposed system fuses the system adaptively.

By applying the wavelet transform on the CT and MRI images, approximate coefficients and 3 wavelet coefficients are obtained. However the two approximate coefficients are compared to each other by pixel to pixel. Now to smooth the refined weight maps, GF is used. Here refined weight maps fuse the values of wavelet coefficients of CT and MRI images. At last by using inverse wavelet transform, fused CT and MRI images are obtained.

Compared to the other systems, the proposed system gives the effective details of CT and MRI images. Hence the proposed system will improve the volume description in the system.

In future work GF is combined with multi-layer and multi-scale transform for the purpose of fusion algorithm.

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