

Mediative Intuitionistic Fuzzy Generator for the Analysis of Medical Images Enhancement

M. K. Sharma and Nitesh Dhiman

Department of Mathematics
C.C.S. University, Meerut-250004, India
Email: drmukeshsharma@gmail.com

(Received April 30, 2018)

Abstract: In the medical field, for the study of different medical images, the image enhancement is essential part of the process because the images are not properly illuminated. Many image enhancement techniques have been studied in the literatures available in the past but the medical image enhancement is much difficult. In this present research paper, we have presented a new technique by using meditative intuitionistic fuzzy generator for image enhancement in medical field. We will use the intuitionistic fuzzy entropy to optimize the parameter presents in the intuitionistic fuzzy image. In our proposed method, we have also shown the better enhanced image process which will help for the proper diagnostic of the patient.

Keywords: Medical Image Enhancement, Mediative Intuitionistic Fuzzy Generator, Generalized Intuitionistic Fuzzy Set, Intuitionistic Fuzzy Entropy.

2010 AMS Classification Number: 93C42.

1. Introduction

Due to poorly illumination of Medical images, the major structures in the image are not visible properly, cause of this reason many regions in medical images are vague. To remove that kind of uncertainty a proper enhancement of medical image is more essential for clearer and more distinguishable boundaries. Enhancement process is used to increases the overall visual contrast of the medical image, it is also helpful where the contract between object and background is less. There are so many methods and techniques for image enhancement have been studied but due to the various uncertainty presents in medical images, fuzzy logic¹ based method

plays a vital role to handle that kind of uncertainties. These uncertainties can represent in the form of membership function it may be triangular, trapezoidal, Gaussian and many more, which denotes the truth value of the pixel in image. Many fuzzy logic technique-based image enhancements have been studied^{2,3} but the ability of intuitionistic logic⁴ is more precise in order to compare with fuzzy because it can handle two types of uncertainty membership and non-membership lies between $[0, 1]$ together with hesitation part and the sum of these three parts are always equal to one. Many intuitionistic fuzzy logic-based image enhancements have been used to handle the uncertainty^{5,6}.

This research paper has been divided into five sections, in the second section; we have defined some basic and relevant definitions based on meditative fuzzy logic, intuitionistic fuzzy set and intuitionistic fuzzy generators. In third section of the research we propose an algorithm based on the meditative intuitionistic fuzzy generator for developing an enhancement technique for medical images to diagnosis the patients properly. In this section we also provide a block diagram for our technique as shown in fig. 1. In the fourth of the research paper we have given the Matlab coding for our technique and the last section we have drawn some conclusion based on our proposed technique and have shown the enhanced images.

2. Basic Definitions

2.1. Mediative Fuzzy Logic: Since knowledge provided by experts can have big variations and sometimes can be contradictory, we are proposing to use a Contradiction fuzzy set to calculate a mediation value for solving the conflict. Mediative Fuzzy Logic is proposed as an extension of Intuitionistic fuzzy Logic (in the sense of Atanassov 1999) in⁷. Mediative fuzzy logic (MFL) is based in traditional fuzzy logic with the ability of handling contradictory and doubtful information, so we can say that also it is an intuitionistic and paraconsistent fuzzy system.

2.2. Mediative Intuitionistic Fuzzy Sets: Intuitionistic fuzzy sets instead of fuzzy sets means the introduction of another degree of freedom. Fuzzy inference in intuitionistic has to consider the fact that we have the membership function μ as well as the non-membership ν . Hence, the output of an intuitionistic fuzzy system can be calculated as follows (Castillo and Melin 2003)⁸:

$$IFS = (1-\pi)FS_{\mu} + \pi FS_{\nu}$$

Where FS_{μ} the traditional output of a fuzzy system using the membership is function μ , and FS_{ν} is the output of a fuzzy system using the non-membership function ν . When $\pi=0$ the IFS is reduced to the output of a traditional fuzzy system, but if we take into account the hesitation margin of π the resulting IFS will be different.

In a similar manner, a contradiction fuzzy sets C in X is given by $\zeta_C(x) = \min(\mu_C(x), \nu_C(x))$, where $\mu_C(x)$ represents the agreement membership function and for the variable $\nu_C(x)$, we have the non-agreement membership function. We are using the agreement and non-agreement instead of membership and non-membership due to contradictory fuzzy sets. The expressions based on the agreement, non-agreement and contradiction for evaluating the output though inference can be given as

$$MFS = \left(1 - \pi - \frac{\zeta}{2}\right) FS_{\mu} + \left(\pi + \frac{\zeta}{2}\right) FS_{\nu},$$

$$MFS = \min \left\{ \left((1 - \pi) * FS_{\mu} \right) + \pi * FS_{\nu}, 1 - \frac{\zeta}{2} \right\},$$

$$MFS = \left\{ (1 - \pi) * FS_{\mu} + \pi * FS_{\nu} * \left(1 - \frac{\zeta}{2}\right) \right\}.$$

From these expressions we can observe that if we have no contradiction then the contradictory index ζ is equal to zero and the output of the system through inference will be reduced to intuitionistic fuzzy output. When the hesitation part is zero then from the above expression we can conclude that we will get a traditional fuzzy output.

2.3. Intuitionistic Fuzzy Set: Let $A \subseteq X$ be the subset of a Universal Set X and let $\mu_A(x), \nu_A(x), \pi_A(x): X \rightarrow [0, 1]$ be three functions Such that $0 \leq \mu_A(x) + \nu_A(x) + \pi_A(x) \leq 1$ called the Membership, Non-Membership and Hesitation part respectively, then any collection of triplets $A = \left[(x, a, b): x \in X, a, b \in \{\mu_A(x), \nu_A(x), \pi_A(x)\} \right]$ called intuitionistic fuzzy set in X .

2.4. Intuitionistic Fuzzy Generator: Let $f(x): [0, 1] \rightarrow [0, 1]$ then f called intuitionistic fuzzy generator⁹ if;

- a) f is monotonic,
- b) $f(x) \leq (1-x), \forall x \in [0,1]$,
- c) $f(0) \leq 1$ and $f(1) = 0$.

2.5. Generalized Intuitionistic Fuzzy Set: Let

$$\phi(\mu(x)) = \frac{1 - \mu(x)}{1 + (e^\lambda - 1)\mu(x)}, \lambda \geq 0 \text{ be an H. Bustince, J. Kacprzyk and}$$

Mohedano¹⁰ generalized intuitionistic fuzzy generator then generalized intuitionistic fuzzy set is defined as;

$$IFS = \langle (x, \mu(x), \phi(\mu(x))) : x \in X, \lambda \geq 0 \rangle.$$

3. Generalized Mediative Intuitionistic Fuzzy Enhancement Technique

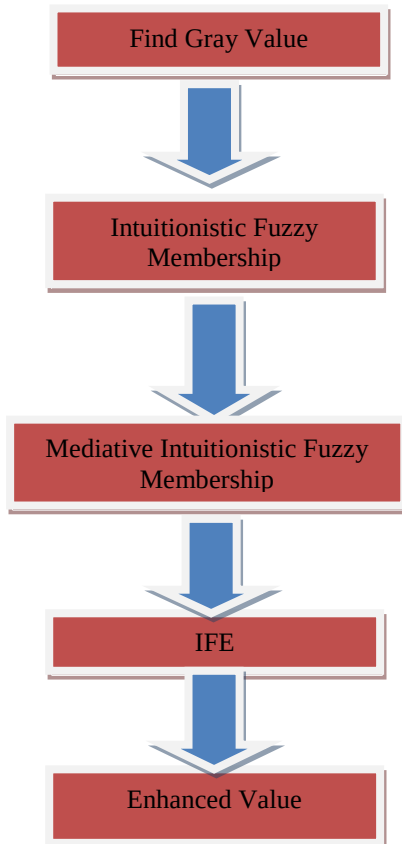


Figure 1. Block Diagram for the technique for Enhancing the Image

Step 1: The image is initially fuzzified as $\mu(g) = \frac{g - g_{\min}}{g_{\max} - g_{\min}}$, where g is

the gray value of the image and $g_{\min}$, $g_{\max}$ are the minimum and maximum gray values of the image respectively.

Step 2: The intuitionistic fuzzy membership function from our intuitionistic fuzzy complement is given as;

$$\mu'(g) = 1 - \frac{1 - \mu(g)}{1 - \gamma(1 - e^\lambda)\mu(g)} = \frac{(1 - \gamma(1 - e^\lambda))\mu(g)}{1 - \gamma(1 - e^\lambda)\mu(g)}.$$

And the non-membership value is calculated as;

$$\begin{aligned} \phi(\mu(g)) &= \frac{1 - \mu'(g)}{1 - \gamma(1 - e^\lambda)\mu'(g)} = \frac{1 - \frac{(1 - \gamma(1 - e^\lambda))\mu(g)}{1 - \gamma(1 - e^\lambda)\mu(g)}}{1 - \gamma(1 - e^\lambda)\frac{(1 - \gamma(1 - e^\lambda))\mu(g)}{1 - \gamma(1 - e^\lambda)\mu(g)}} \\ &= \frac{1 - \mu(g)}{1 - \gamma(1 - e^\lambda)\mu(g) + (\gamma(1 - e^\lambda))^2 \mu(g)}, \end{aligned}$$

with $\pi'(g) = 1 - \mu'(g) - \phi(\mu(g))$ be the hesitation degree.

Step 3: Using intuitionistic fuzzy entropy (IFE), we can easily calculate the value of γ and λ which is defined as; $IFE = \frac{1}{N} \sum_{i,j=1}^n \pi'(g_{ij}) \cdot e^{1 - \pi'(g_{ij})}$, among

all the different entropy values for different values of γ and λ , we can write

$$\gamma_{opt} = \max_{\gamma} (IFE(\gamma)) \text{ and } \lambda_{opt} = \max_{\lambda} (IFE(\lambda)).$$

Step 4: The fuzzy hedge is given as; $\mu'_{new}(g) = (\mu'(g))^{1.25}$ then finally the enhanced intuitionistic fuzzy image μ''_{new} is given by;

$$\mu''_{new}(g) = \begin{cases} 2(\mu'_{new}(g))^2, & 0 \leq \mu'_{new}(g) \leq 0.5 \\ 1 - 2(1 - \mu'_{new}(g))^2, & 0 < \mu'_{new}(g) \leq 1. \end{cases}$$

4. Coding for the Mediative Intuitionistic Fuzzy Logic Image Processing

```

4.1. Irgb = imread('C:\Users\\Image Processing\Lung.tif');
Igray = 0.2989 * Irgb(:, :, 1) + 0.5870 * Irgb(:, :, 2) + 0.1140 * Irgb(:, :, 3);
figure; image(Igray, 'CDataMapping', 'scaled'); colormap('gray');
title('Input Image in Grayscale'), I = double(Igray);
Class Type = class(Igray); scalingFactor = double(intmax(classType));
I = I / scalingFactor;  $G_x = [-1 \ 1]$ ;  $G_y = G_x'$ ;  $G_z = [-1 \ 1]$ ;  $G_t = G_z'$ ;
 $I_x = \text{conv2}(I, G_x, \text{'same'})$ ;  $I_y = \text{conv2}(I, G_y, \text{'same'})$ ;
 $I_z = \text{conv2}(I, G_z, \text{'same'})$ ;  $I_t = \text{conv2}(I, G_t, \text{'same'})$ ;
figure; image( $I_x$ , 'CDataMapping', 'scaled'); colormap('gray'); title('  $I_x$  ');
figure; image( $I_y$ , 'CDataMapping', 'scaled'); colormap('gray'); title('  $I_y$  ');
figure; image( $I_z$ , 'CDataMapping', 'scaled'); colormap('gray'); title('  $I_z$  ');
figure; image( $I_t$ , 'CDataMapping', 'scaled'); colormap('gray'); title('  $I_t$  ');

```

4.2. Define Mediative Intuitionistic Fuzzy Inference System for Image Enhancement:

```

edgeFIS = newfis('enhancement');
edgeFIS = addvar(edgeFIS, 'input', '  $I_x$  ', [-1 1]);
edgeFIS = addvar(edgeFIS, 'input', '  $I_y$  ', [-1 1]);
edgeFIS = addvar(edgeFIS, 'input', '  $I_z$  ', [-1 1]);
edgeFIS = addvar(edgeFIS, 'input', '  $I_t$  ', [-1 1]);
sx = 0.1; sy = 0.1; pz = 0.1; pt = 0.1;
edgeFIS = addmf(edgeFIS, 'input', 1, 'zero', 'gaussmf', [sx 0]);
edgeFIS = addmf(edgeFIS, 'input', 2, 'zero', '1-gaussmf', [pz 0]);
edgeFIS = addmf(edgeFIS, 'input', 3, 'zero', 'gaussmf', [sy 0]);
edgeFIS = addmf(edgeFIS, 'input', 4, 'zero', '1-gaussmf', [pt 0]);
edgeFIS = addvar(edgeFIS, 'output', 'Iout1', [0 1]);
edgeFIS = addvar(edgeFIS, 'output', 'Iout2', [0 1]);
Specify the triangular membership functions, white and black, for |Iout|.
wa = 0.1; wb = 1; wc = 1; ba = 0; bb = 0; bc = .7; ua = 0.1; ub = 1; uc = 1;
va = 0; vb = 0; vc = .7;
edgeFIS = addmf(edgeFIS, 'output', 1, 'white', 'trimf', [wa wb wc]);
edgeFIS = addmf(edgeFIS, 'output', 2, 'white', '1-trimf', [ua ub uc]);
edgeFIS = addmf(edgeFIS, 'output', 1, 'black', 'trimf', [ba bb bc]);

```

```

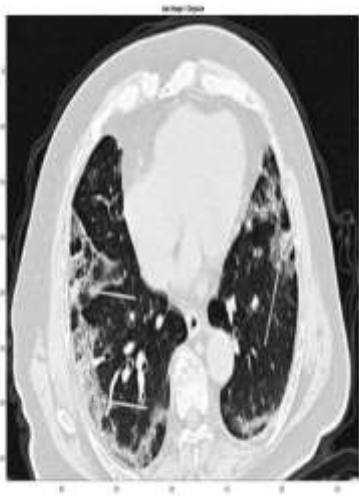
edgeFIS = addmf(edgeFIS,'output', 2,'Black','1-trimf',[va vb vc]);
subplot(3, 2, 1); plotmf(edgeFIS,'input', 1); title('Ix');
subplot(3, 2, 2); plotmf(edgeFIS,'input', 2); title('Iy');
subplot(3, 2, 3); plotmf(edgeFIS,'input', 3); title('Iz');
subplot(3, 2, 4); plotmf(edgeFIS,'input', 4); title('It');
subplot(3, 2, 5); plotmf(edgeFIS,'output', 1); title('Iout 1')
subplot(3, 2, 6); plotmf(edgeFIS,'output', 2); title('Iout 2')
Specify FIS Rules
Add rules to make a pixel white if it belongs to a uniform region.
Otherwise, make the pixel black.
r1 = 'If Ix is zero and Iy is zero then Iout1 is white';
r2 = 'If Ix is not zero or Iy is not zero then Iout 1 is black';
r3 = 'If Iz is one and It is one then Iout 2 is Black';
r4 = 'If It is not one or It is not one then Iout 2 is White';
r = char(r1,r2,r3,r4); edgeFIS = parsrule(edgeFIS, r); showrule(edgeFIS)
Evaluate FIS
Evaluate the output of the edge detector for each row of pixels in |I|
using corresponding rows of |Ix| and |Iy| as inputs.
Ieval = zeros(size(I)); Preallocate the output matrix
for ii = 1:size(I,2)
Ieval(ii,:) = evalfis([(Ix(ii,:));(Iy(ii,:));(Iz(ii,:));(It(ii,:))]',edgeFIS);
end

```

5. Conclusion

Proposed generalized meditative intuitionistic fuzzy enhancement technique is used to reduce the fuzziness and increase the image contrast. The width range of membership function allows us to increase the dynamic range of the image. While we are doing study of different kind of medical images such as; CT scan, brain image, Blood vessel image etc.; imperfect, imprecise and inaccurate situation arises in the picture. The proposed generalized intuitionistic fuzzy generator can be useful in such conditions, where we can have a suitable range for the membership value to generate the intuitionistic fuzzy set. We have provided a suitable method to handle the medical image enhance process. Generalized meditative intuitionistic fuzzy generator based on two different parameters has number of properties

that makes it appropriate based for a particular image study in medical field. A CT scanned images of lung has taken as shown by fig. 2 [(a), (b), (c), (d), (e).(f)] and their original and enhanced images have also been shown as;



(a)



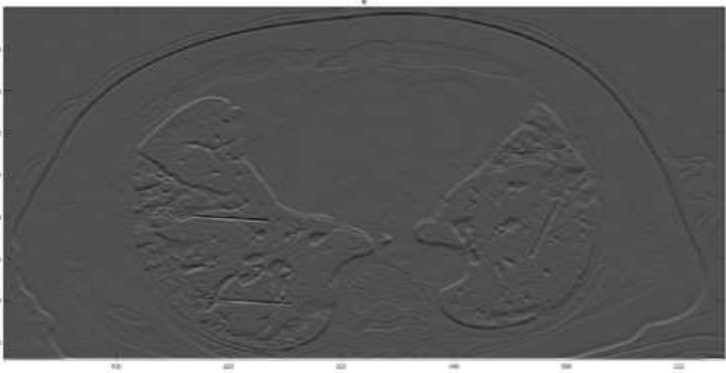
(b)



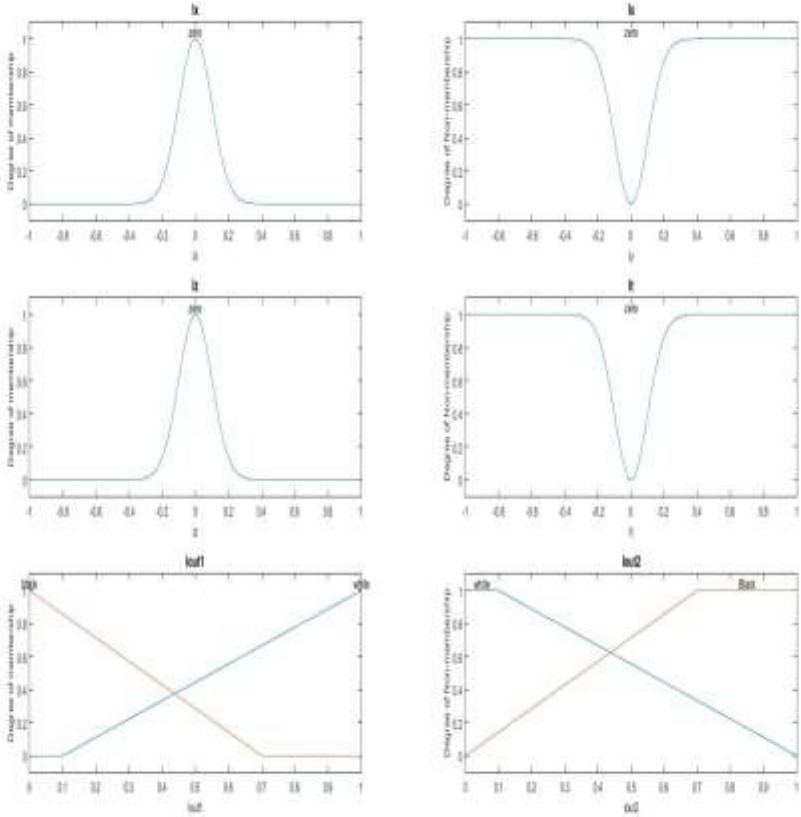
(c)



(d)



(e)



(f)

Figure 2. Enhance images of lung data shown by [(a), (b), (c), (d), (e),(f)]

References

1. L. A. Zadeh, Fuzzy Sets, *Information and Control*, **8** (1965), 338-353.
2. A. E. Hassanien and A. Badr, A Comparative Study on Digital Mammography Enhancement Algorithm Based on Fuzzy Set Theory, *Studies In Information and Control*, **12** (2003), 21-31.
3. H. R. Tizhoosh and M. Fochem, Fuzzy Histogram Hyperbolization for Image Enhancement, *Proc. of EUFIT*, **95(3)** (1995).
4. K. T. Atanassov, Intuitionistic Fuzzy Set, *Fuzzy Sets and Systems*, **20** (1986), 87-97.
5. I. K. Vlachos and G. D. Sergiadis, Role of Entropy in Intuitionistic Fuzzy Contrast Enhancement, *Lecture Notes in Artificial Intelligence- 4529*, Springer, (2007), 104-113.
6. T. Chaira, Construction of Intuitionistic Fuzzy Contrast Enhanced Medical Images, *IEEE Proceedings of 4th International Conference on Intelligent Human Computer Interaction*, Kharagpur, India, December 27-29, 2012.
7. K. Atanassov, *Intuitionistic Fuzzy Sets: Theory and Applications*, Springer, Heidelberg, 1999.
8. O. Castillo and P. A. Melin, New Method for Fuzzy Inference in Intuitionistic Fuzzy Systems, *Proceedings of The International Conference NAFIPS*, (2003), 20-25.
9. H. Bustince, J. Kacprzyk and Mohedano, Intuitionistic Fuzzy Generators-Application to Intuitionistic Fuzzy Complementation, *Fuzzy sets and systems*, **11** (2000), 485-504.
10. H. Bustince, J. Kacprzyk and Mohedano, Intuitionistic Fuzzy Generators-Application to Intuitionistic Fuzzy Complementation, *Fuzzy sets and systems*, **11** (2000), 485-504.