On Contrast Enhancement Techniques for Medical Images with Edge Detection: A Comparative Analysis

Randeep Kaur[1,2], Meenu Chawla[1,2], Navdeep Kaur Khiva[1,2] and Mohd Dilshad Ansari[1,3]
[1]*Department of Computer Science & Engineering*
[2]*Giani Zail Singh Campus, Bhatinda, Punjab, India*
[3]*Jaypee University of Information Technology, Waknaghat, Himachal Pradesh, India*
meenuchawla011@gmail.com

***Abstract*—The main role of contrast enhancement is increasing the quality of any image. This technique plays fundamental role in medical images. Edge detection is also playing an instrumental role in medical imaging because all information has preserved in edges. Digital image includes a pixel which has fixed number of rows and columns. People can see the internal structure of the body through digital image. Five images have taken as an example in this paper, namely hand, brain, head, ankle and knee. Three enhancement techniques have used, namely Fuzzy Type-II, INT Operator and Fuzzy Type-I. These different three techniques have applied on different images which are used in this paper. Three parameters have used to compare three contrast enhancement techniques. Peak signal to noise ratio (PSNR), root mean square error (RMSE) and mean square error (MSE) quality parameters have been used. The result has produced after comparison of three approaches on five images. In the end, Fuzzy Type-I technique produces the better resultant image.**

***Index Terms*—Contrast Enhancement; Edge Detection; INT Operator; Fuzzy Type-I; Fuzzy Type-I.**

I. Introduction

The basic importance of contrast enhancement is to improve the pixel brightness that are the main reason in medical field. Digital image plays an instrumental role in medical. Digital image includes a pixel which has fixed number of rows and columns. Persons can see organs and the internal structure of the body through digital image. It is mostly the change in pictorial effects of an image. It also increases the eminence or quality of images. Fuzzy rule based edge detection approach is applied to the input image. Edges are very important part in medical because it is one of the most important information on image processing. Three linear filters are used for processing such as high pass, edge enhanced filter and low pass filter [27].

Contrast enhancement comforts us to upturn the vividness of an image. Medical type images always suffer with low contrast. This is a mammoth problem and this problem is intensifying day by day. In this paper, three contrast enhancement techniques have been used. INT operator stands for intensification operator. The fuzziness (means dullness) of an image is decreased by INT operator. This approach holds specific parameters to examine the improvement (enhancement) of the digital images [13].

Fuzzy type-1 and fuzzy type-2 approaches helps to increase a contrast of an image. The type-I fuzzy logic system produces a single numeric value in the result. Only one membership function is performing in this logic system. The fuzzy hyperbolization technique is used for calculating membership values. This technique is basically having three stages, namely fuzzification, membership modification and defuzzification [2]. Gray level converts into membership values by fuzzification. Defuzzification has produced new gray levels. Four modules have worked for processing such as fuzzifier, rulebase, inference engine and defuzzifier. It produces single numeric values.

Type-II fuzzy set is helpful to recover demerits of type-I fuzzy set. Fuzzy hyperbolization approach is applied for computing new gray levels. Three steps are performed by fuzzy hyperbolization technique such as fuzzification, membership modification and defuzzification [2]. Four components are used in type-II fuzzy set namely fuzzifier, rulebase, inference engine and output processor. The output processor holds type reduction and defuzzifier. Rule base covers rules and database. Rules and database contain IF-THEN rules of the domain and membership functions respectively. Type-2 fuzzy sets are fundamentally expressing the uncertainty. It works on two membership functions, namely upper and lower membership function.

Three quality parameters MSE, PSNR and RMSE are used for comparing contrast enhancement techniques. RMSE and MSE are stands for root mean square error and mean square error respectively. PSNR stands for peak signal to noise ration.

The remaining part of the paper is designed as follows. Section II describes a literature survey of this paper and section III briefly discusses the contrast enhancement techniques, i.e. INT Operator, type-I fuzzy & type-II fuzzy. Section IV describes the performance analysis and simulation results by considering different performance quality parameters. Finally, Section V concludes the paper and discusses the future scope of work.

II. Literature Survey

Sri Hartati et al. [2] proposed fuzzy hyperbolization. Fuzzy hyperbolization is used to increase the clarity of the image. The artificial neural network is mainly applied for detecting anomaly. The three steps are performed for fuzzy hyperbolization such as fuzzification, membership modification and defuzzification. This paper proves the fuzzy hyperbolization is the best method for improving image quality.

Castillo et al. [7] have proposed a brief overview of the basic thoughts of type-2 fuzzy systems are presented. This overview is intended to provide the simple concepts necessary to comprehend the approaches and algorithms. The basic ideas that are concealed in this paper are: type-2 fuzzy sets, membership functions, type-2 inference, type reduction and defuzzification.

TamalikaChaira et al. [9] developed a technique for medical images using type-II fuzzy set. In this paper, new membership functions are computed by using hamacher t-conorm. The result of proposed type-II fuzzy approach is compared with the existing type-II fuzzy method, intuitionistic fuzzy, non-fuzzy and fuzzy. This method is able to produce the best result.

Pushpa Devi Patel et al. [14] presented a survey and overview of image enhancement using fuzzy technique. This paper provides different algorithms of fuzzy image enhancement. The main advantage of these techniques is to enhance the contrast and improve the quality of the image. There are lots of fuzzy approaches like fuzzy hyperbolization, fuzzy expected values, minimization of fuzziness and fuzzy rules.

Sesadri et al. [24] has proposed type 2 fuzzy computing techniques for image enhancement. Firstly, the fisher criterion function has applied. This function is used to generate membership values of type-I fuzzy. After that, we fuzzy rules are applied to generate the enhanced image.

Gonzalez et al. [26] has proposed Edge detection method based on interval type-II fuzzy systems for color images. Firstly, morphological gradient filter has applied to the input image. After that, interval type-II fuzzy system edge detector has applied to that image. This algorithm produces better result as compared interval type-I fuzzy system edge detection. The proposed method has applied to real images.

Harleen Kaur et al. [27] has developed an improved fuzzy rule based edge detection technique. In this paper, three linear filters have used. These three filters are used to produce better result. They have used various filters such as first order edge detector filter, high pass and low pass.

III. CONTRAST ENHANCEMENT TECHNIQUES

Edge Detection Approach- Fuzzy rule based edge detection approach is applied to the input image. Edges are very important part in medical because it is one of the most important information on image processing. Fuzzy rules are used in this approach. Fuzzy system output is classified into three classes, namely low, medium and high. Three linear filters are used for processing such as high pass, edge enhanced filter and low pass filter [27].

Three contrast enhancement techniques are given below:-

A. INT Operator

INT operator stands for intensification operator. The fuzziness (means dullness) of an image is decreased by INT operator. This approach holds specific parameters to examine the improvement (enhancement) of the digital images [13].

Step 1: Defining membership functions

$$\mu_{mn} = G(g_{mn}) = \left[1 + \frac{g_{max} - g_{mn}}{F_d}\right]^{-F_e} \quad (1)$$

where:

g_{mn} = Intensity value of pixel
g_{max} = maximum gray level
F_d = Denomination fuzzifier
F_e = Exponential fuzzifier

Denomination fuzzifier helps to decline the fuzzified value and incline the value in the range [0, 1].

Step 2: Membership modification

$$\mu'_{mn} = \begin{cases} 2 \cdot [\mu_{mn}]^2 & 0 \le \mu_{mn} \le 0.5 \\ 1 - 2 \cdot [1 - \mu_{mn}]^2 & 0.5 \le \mu_{mn} \le 1 \end{cases} \quad (2)$$

where μ_{mn}= fuzzy set and 0.5 is a cross over point. The intensification operator continuously escalates the value of μ_{mn} with growing the values of cross over point from 0 to 1. This operator is applied on image again and again.

Step 3: Generate new gray levels

$$g'_{mn} = G^{-1}(\mu'_{mn}) = g_{max} - F_d\left((\mu'_{mn})^{\frac{-1}{F_e}} - 1\right) \quad (3)$$

The contrast depends on the increasing value of cross over point.

B. B. Fuzzy Type-I

The type-I fuzzy logic system produces a single numeric value in the result. Only one membership function is performed in this logic system. The fuzzy hyperbolization technique is used for calculating membership values. This technique basically has three stages, namely fuzzification, membership modification and defuzzification [2]. Gray level converts into membership values by fuzzification. Defuzzification has produced new gray levels. Four modules have worked for processing such as fuzzifier, rule base, inference engine and defuzzifier. It generates single numeric values. Fuzzifier converts crisp input to fuzzy value. Rule base covers rules and database. Rules and database contain IF-THEN rules of the domain and membership functions respectively. The Inference engine converts fuzzy input to fuzzy output using IF-THEN rules. Defuzzifier changes fuzzy output into crisp output value [5].

Step 1: Compute the type-I fuzzy membership value using the following equation:

$$\mu(g_{mn}) = \frac{g_{mn} - g_{min}}{g_{max} - g_{min}} \quad (4)$$

where:

g_{mn} = Intensity value
g_{min} = Minimum gray level
g_{max} = Maximum gray level

Step 2: Compute the new gray levels.

$$\tilde{g}_{mn} = \frac{L-1}{e^{-1}-1} \times \left[e^{-\mu(g_{mn})^{\beta}} - 1\right] \quad (5)$$

where the parameter β is set to 0.8 and L is a number of gray levels.

C. C. Fuzzy Type-II

Type-II fuzzy set is helpful to recover demerits of type-I fuzzy set. The fuzzy hyperbolization approach is applied for computing new gray levels. Three steps are performed by a fuzzy hyperbolization technique such as fuzzification, membership modification and defuzzification [2]. Four components are used in type-II fuzzy set namely, fuzzifier, rule base, inference engine and output processor. The output processor holds type reduction and defuzzifier. Fuzzifier converts crisp input to fuzzy value using stored membership functions. . Rule base covers rules and database. Rules and database contain IF-THEN rules of the domain and membership functions respectively. The inference engine converts fuzzy input to fuzzy output using IF-THEN rules. Defuzzifier changes fuzzy output into crisp output value [5]. Type-2 fuzzy sets are fundamentally expressing the uncertainty. It works on two membership functions, namely upper and lower membership function.

Step 1: Compute the upper and lower membership values by using the following equation (6) and (7):

$$\mu_{Lower}(x) = \mu(x)^2 \qquad (6)$$

and

$$\mu_{Upper}(x) = \mu(x)^{0.5} \qquad (7)$$

Compute a window of size 21×21.
Determine type-2 fuzzy membership function using the following equation

$$\mu_{T_{II}(g_{mn})} = (\mu_{Lower} \times \alpha) + \left(\mu_{Upper} \times (\alpha - 1)\right) \qquad (8)$$

where $\alpha = \frac{g_{mean}}{L}$

Step 2: calculate the new gray levels using Equation (5)

IV. Performance Analysis and Simulation Results

We have performed five types of experiment on given images and calculated the various performance metrics.

The following quality parameters are considered:

1) Mean Square Error: It measures the average of the squares of the errors.The value of that parameter closer to zero is better.

$$\text{MSE} = \sum \frac{\sum(Y-\hat{Y})}{m \times n} \qquad (9)$$

where Y= actual value, $\hat{Y}$= predicted value, m= actual size and n= predicted size.

2) Root Mean Square Error: It measures the difference between two similar images. If the value is low, then picture quality is high.

$$\text{RMSE}= \sqrt{MSE} \qquad (10)$$

3) Peak Signal to Noise Ratio: It is a ratio between the maximum signal power and noise power. A greater value of that parameter means the quality of the picture is high.

$$\text{PSNR}= 10\log_{10}\left(\frac{MAX_f}{\sqrt{MSE}}\right) \qquad (11)$$

Experiment 1: Three techniques have been applied on hand image as shown in Figure 1. Three quality parameters are also used such as MSE, RMSE and PSNR. These three techniques, performance are compared based on three parameters as shown in Table 1. The graph representation of head edge detected image is shown in Figure 2. It shows minimum values of MSE and maximum value of PSNR. It means, method has increased more clarity of the image.

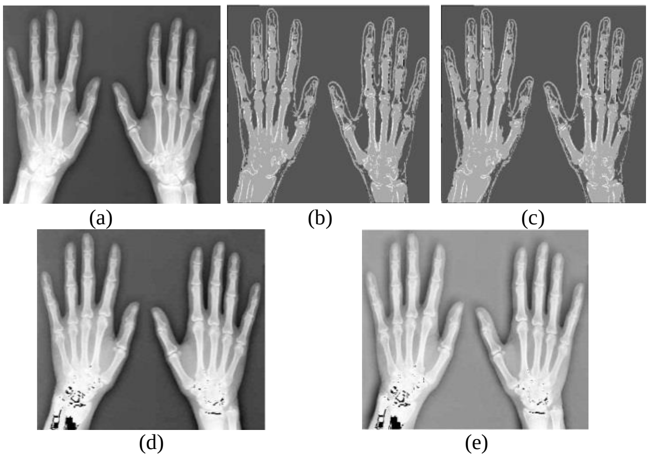

Figure 1: (a) Original image (b) Edge detected image (c) INT Operator (d) Fuzzy Type-I (e) Fuzzy Type-II

Table 1
Techniques Compare for Hand

Parameters	MSE	RMSE	PSNR
F-2	25.436	0.4134	57.7071
F-1	4.4168	0.1688	89.3736
INT	12.945	0.2932	68.32

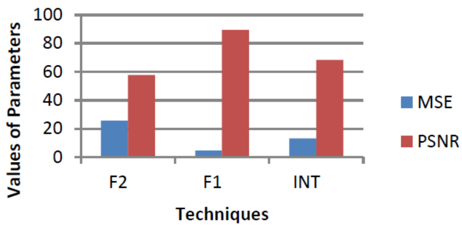

Figure 2: MSE and PSNR values comparison Graph

Experiment 2: Second experiment is performed on brain image and three techniques have applied to brain image are shown in Figure 3. Three quality parameters are used such as MSE, RMSE and PSNR. These three techniques are compared based on three parameters are shown in Table 2. The graph representation of head edge detected image is shown in Figure 4. Table 2 shows a lower value of MSE and RMSE means the quality of the image is high. Figure 4 shows a greater value of PSNR. If the value is high, then picture quality is high.

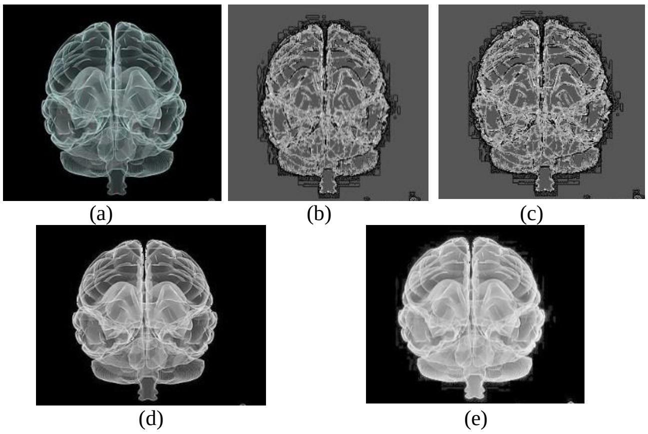

Figure 3: (a) Original image (b) Edge detected image (c) INT Operator (d) Fuzzy Type-I (e) Fuzzy Type-II

Table 2
Techniques Compare for Brain

Parameters	MSE	RMSE	PSNR
F-2	10.633	0.2416	57.0668
F-1	2.086	0.1038	85.7017
INT	35.578	0.4467	42.1967

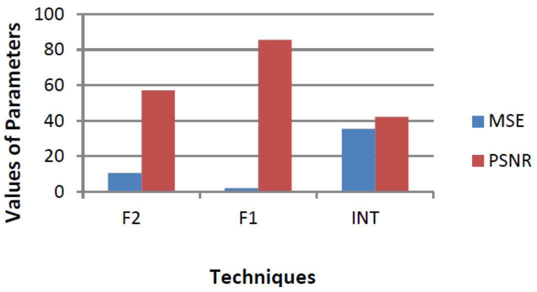

Figure 4: MSE and PSNR values comparison Graph

Experiment 3: In the third experiment, we have taken head image. Three techniques have been applied on third image is shown in Figure 5. Three quality parameters are used such as MSE, RMSE and PSNR. These three techniques are compared based on three parameters are shown in Table 3. The graph representation of head edge detected image is shown in Figure 6. More picture quality is high with growing the value of PSNR.

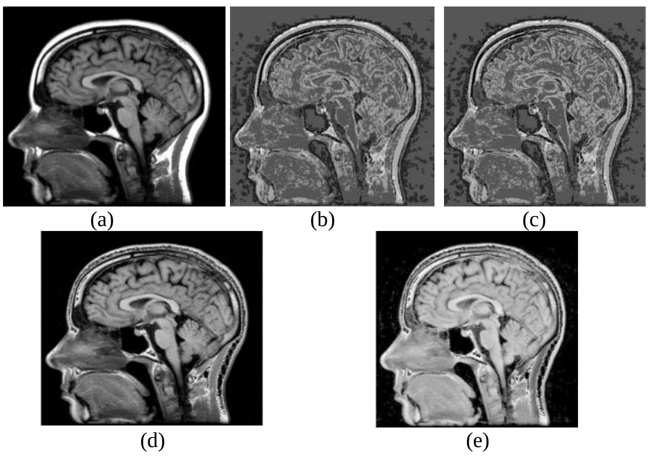

Figure 5: (a) Original image (b) Edge detected image (c) INT Operator (d) Fuzzy Type-I (e) Fuzzy Type-II

Table 3
Techniques Compare for Head

Parameters	MSE	RMSE	PSNR
F-2	40.5876	0.5393	55.3711
F-1	14.7652	0.3226	71.2939
INT	35.4501	0.5035	57.2765

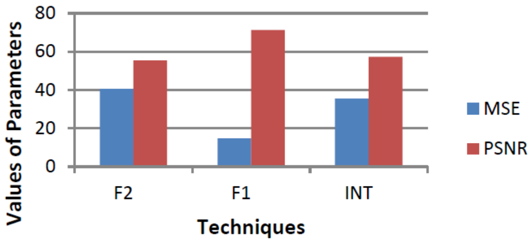

Figure 6: MSE and PSNR values comparison Graph

Experiment 4: This experiment was done on ankle image. Three techniques have applied on fourth image shown in Figure 7. Three quality parameters are used such as MSE, RMSE and PSNR. These three techniques are compared based on three parameters as shown in Table 4. The graph representation of ankle edge detected image is shown in Figure 8. Higher PSNR values mean good quality of image. Fuzzy Type-I always get higher PSNR values compared to other operators.

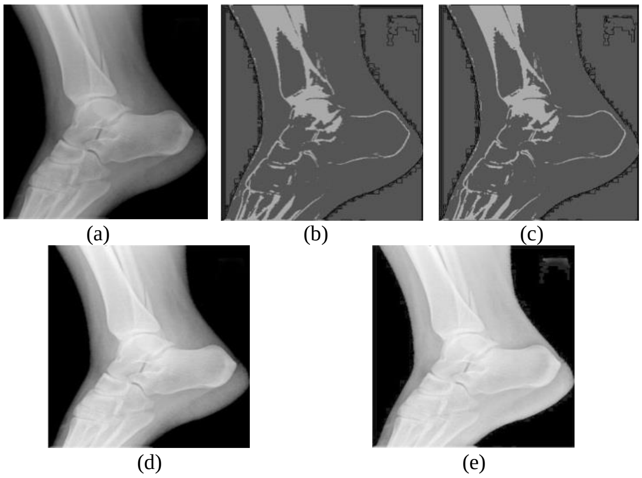

Figure 7: (a) Original image (b) Edge detected image (c) INT Operator (d) Fuzzy Type-I (e) Fuzzy Type-II

Table 4
Techniques Compare for Ankle

Parameters	MSE	RMSE	PSNR
F-2	26.3724	0.4264	58.7109
F-1	10.7263	0.2702	73.5142
INT	26.4924	0.4274	58.6443

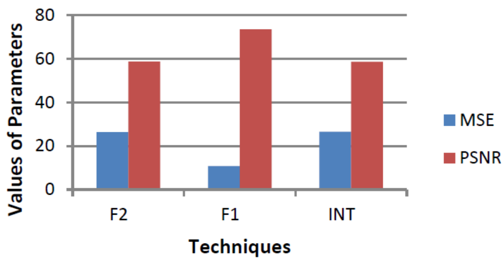

Figure 8: MSE and PSNR values comparison Graph

Experiment 5: Fifth experiment was performed on knee image. Three techniques have applied to fifth image are shown in Figure 9. Three quality parameters are used such as MSE, RMSE and PSNR. These three techniques are compared based on three parameters are shown in Table 5. The graph representation of ankle edge detected image is shown in Figure 10. It shows a higher value of PSNR and lower value of MSE. These are comparison parameters which illustration comparison value in power.

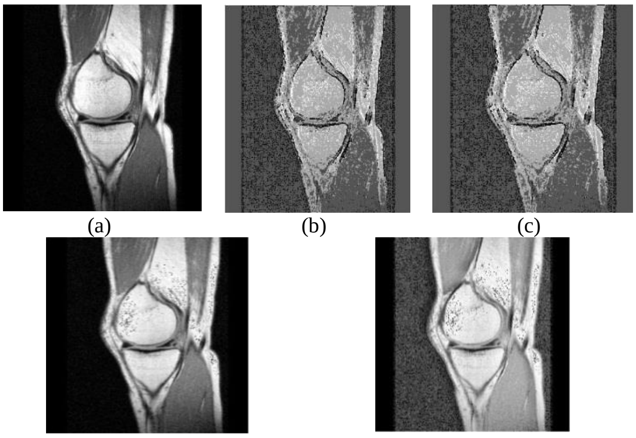

Figure 9: (a) Original image (b) Edge detected image (c) INT Operator (d) Fuzzy Type-I (e) Fuzzy Type-II

Table 5
Techniques Compare for Knee

Parameters	MSE	RMSE	PSNR
F-2	26.0647	0.435	63.3911
F-1	5.1535	0.1897	95.0419
INT	33.6863	0.4954	59.4541

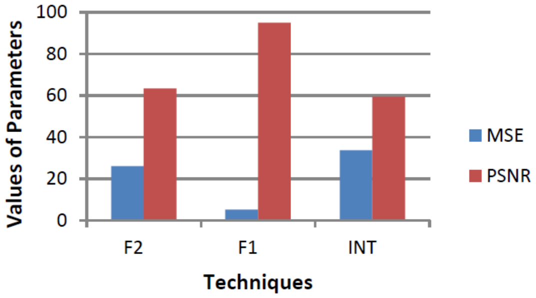

Figure 10: MSE and PSNR values comparison Graph

V. Comparative Study and Results

Table 6 displays results of all 3 techniques results with all 5 images. We can clearly observe from this table that Fuzzy Type-I is always having greater value of PSNR in all images. First three parameters, i.e. MSE, RMSE and PSNR are representing result for hand edge detected image. Similarly, we have calculated MSE, RMSE and PSNR values for other images also.

The comparison results show that the Fuzzy Type-I is better than other techniques to improve the contrast of the images for edge detection. It means this technique increase the brightness of the image in better way.

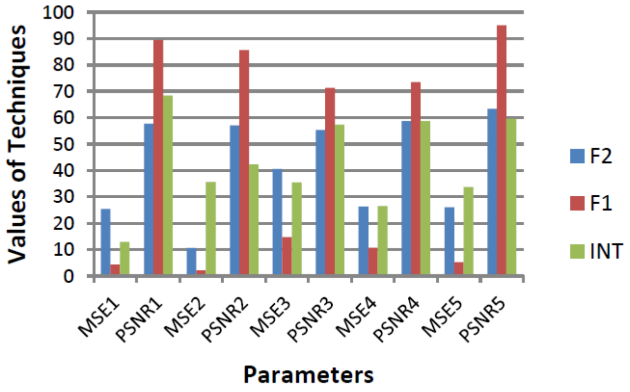

Figure 11: MSE and PSNR values comparison Graph

Table 6
Techniques Compare of Five Images

Examples	Parameters	F-2	F-1	INT
	MSE	25.436	4.4168	12.945
Hand	RMSE	0.4134	0.1688	0.2932
	PSNR	57.7071	89.3736	68.32
	MSE	10.633	2.086	35.578
Brain	RMSE	0.2416	0.1038	0.4467
	PSNR	57.0668	85.7017	42.1967
	MSE	40.5876	14.7652	35.4501
Head	RMSE	0.5393	0.3226	0.5035
	PSNR	55.3711	71.2939	57.2765
	MSE	26.3724	10.7263	26.4924
Ankle	RMSE	0.4264	0.2702	0.4274
	PSNR	58.7109	73.5142	58.6443
	MSE	26.0647	5.1535	33.6863
Knee	RMSE	0.435	0.1897	0.4954
	PSNR	63.3911	95.0419	59.4541

VI. Conclusion and Future Work

In this Paper, three contrast enhancement techniques have been discussed for medical images. The edges are detected from original image and three techniques have applied to edge detected images such as INT operator, Fuzzy Type-1 and Fuzzy Type-2. These techniques are compared based on three parameters that are MSE, RMSE and PSNR. Obtained with the results we can say that, the Fuzzy Type-1 is providing the better enhancement for edge detected medical images. Fuzzy Type-1 shows the higher value of PSNR and lower value of MSE and RMSE. It means this technique is useful to more bright the pixel rather than the other two techniques.

In future, to accomplish more perfect results of these enhancement techniques for medical images, we will apply for the fuzzy-n type and will study the results for any other possible measures.

References

[1] Ensafi and H.R. Tizhoosh, “Type-2 Fuzzy Image Enhancement”, *Systems Design Engineering, University of Waterloo*, pp. 159-166, 2005.

[2] Sri Hartati, Agus Harjoko, and Brad G. Nickerson, “Image Enhancement using Fuzzy Hyperbolization and Artificial Neural Network for Anomaly Detection”, *International Journal of Computer, Electrical, Automation, Control and Information Engineering*, vol.3, pp. 2089-2092, 2009.

[3] Harish Kundra, Aashima and Monika Verma, “Image Enhancement Based on Fuzzy Logic”, *IJCSNS International Journal of Computer Science and Network Security*, vol. 9, pp. 141-145, 2009.

[4] PunamBedi, Malvika Gaur, PayalArora, PritiSehgal, RoliBansal, "Fingerprint Image Enhancement Using Type-2 Fuzzy Sets", *Fuzzy*

Systems and Knowledge Discovery, Fourth International Conference on, vol. 3, pp. 412-417, 2009.

[5] Aboul Ella Hassanien, Omar S. Soliman, and Nashwa El-Bendary, "Contrast Enhancement Based on Fuzzy Type-II for MRI Images", *Springer-Verlag Berlin Heidelberg*, pp. 77-83, 2011.

[6] Hamid R. Tizhoush, Manfred Fochem, "Fuzzy Histogram Hyperbolization for Image Enhancement", *Published in Proc. Of FUFIT 95, Germany*, pp. 1695-1698, 2011.

[7] Castillo, O., Melin, P., "Type-2 Fuzzy System", *Springerbriefs in Computational Intelligence*, pp.7-12, 2012.

[8] AmitKamra, Kanchan Rani, "An Improved Method for Image Enhancement Using Fuzzy Approach", *IRACST - International Journal of Computer Science and Information Technology & Security (IJCSITS)*, pp. 1093-1095, 2012.

[9] TamalikaChaira, "A rank ordered filter for medical image edge enhancement and detection using intuitionistic fuzzy set", *Applied Soft Computing, Elsevier*, vol. 12, No.4, pp. 1259-1266, 2012.

[10] Prof. Mrs.Preethi S.J, Prof. Mrs. K. Rajeswari, "Membership Function modification for Image Enhancement using fuzzy logic", *International Journal of Emerging Trends & Technology in Computer Science (IJETTCS)*, pp. 114-118, 2013.

[11] Reshmalakshmi C, Sasikumar M, "Image Contrast Enhancement using Fuzzy Technique", *ICCPCT(International Conference on Circuits, Power and Computing Technologies)*, pp. 861-865, 2013.

[12] TarunMahashwari, AmitAsthana, "Image Enhancement Using Fuzzy Technique", *International Journal of Research Review in Engineering Science & Technology (IJRREST)*, vol. 2, No.2, pp. 1-4, 2013.

[13] Sudhavani, Srilakshmi, VenkateswaraRao, SatyaParsad, "Comparison of Fuzzy Contrast Enhancement Techniques", *International Journal of Computer Applications*, Vol. 95, no. 22, pp. 26-31, 2014.

[14] Pushpa Devi Patel, Prof. Vijay Kumar Trivedi, Dr.Sadhna Mishra, "Image Enhancement using Fuzzy Techniques: Survey and Overview", *International Journal of Science, Technology & Management*, vol. 03, No.12, pp. 154-160, 2014.

[15] DiwakarShrivastava, Dr.VineetRichhariya, "Adaptive Contrast Image Enhancement Based on Fuzzy Set Theory", *International Journal of Advanced Research in Computer Science and Software Engineering*, vol. 4, No.2, pp. 453-462, 2014.

[16] Neetu Gupta, "Comparative Study of Type-1 and Type-2 Fuzzy System", *International Journal of Engineering Research and General Science*, Vol. 2, No.4, pp. 195-198, 2014.

[17] Dongrui Wu, "A Brief Tutorial on Interval Type-2 Fuzzy Sets and Systems", *Signal and Image Processing Institute, University of Southern, California, Los Angeles*, pp. 1-13, 2014.

[18] Akanksha Singh, SiniShibu, Shatendra Dubey, "Recent Image Enhancement Techniques: A Review", *International Journal of Engineering and Advanced Technology (IJEAT)*, vol. 4, No.1, pp. 40-45, 2014.

[19] AmanTusia, Dr.Naresh Kumar, "Performance Analysis of Type-2 Fuzzy System for Image Enhancement using Optimization", *International Journal of Enhanced Research in Science Technology & Engineering*, vol. 3, No.7, pp. 108-116, 2014.

[20] Miss. Pooja Mishra,Mr.khomlalsinha, "A Survey Paper Based On Contrast Enhancement of Gray Image Using Fuzzy Based Contrast Intensification Operator" *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, vol. 3, No. 8, pp. 2618-2622, 2014.

[21] Dongrui Wu, Jerry M. Mendel, "Designing Practical Interval Type 2 Fuzzy Logic Systems Made Simple", *IEEE International Conference on Fuzzy Systems*, pp. 800-807, 2014.

[22] Swati Tyagi, Pradeep Jain, "Image Enhancement by Comparing Contrast value in Fuzzy Plane" *(IJCSIT) International Journal of Computer Science and Information Technologies*, vol. 6, No.3, pp. 2998-3001, 2015.

[23] Sonal Sharma, Avani Bhatia, "Contrast Enhancement of an Image using Fuzzy Logic", *International Journal of Computer Applications*, vol. 111, No.17, pp. 14-20, 2015.

[24] Sesadri, C. Nagaraju, "Type2 Fuzzy Computing Technique for Image Enhancement", *International Journal of Computer Science and Information Security (IJCSIS)*, vol. 13, No.11, pp. 94-105, 2015.

[25] Nirmala, "Review: Medical Image Contrast Enhancement Techniques", *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, vol. 6, No.3, pp. 321-329, 2015.

[26] Ansari, Mohd Dilshad, Satya Prakash Ghrera, and Vipin Tyagi. "Pixel-based image forgery detection: A review." IETE journal of education, Vol. 55, No.1, pp. 40-46, 2014.

[27] Ansari, M.D., Ghrera, S.P. "Intuitionistic fuzzy local binary pattern for features extraction" Int. J. Information and Communication Technology. In Press.

[28] Gonzalez, J. R. Castro, O. Mendoza, A. Rodríguez-Díaz, "Edge detection method based on Interval Type-2 Fuzzy Systems for color images", *IEEE*, 2015.

[29] Kapil, Shruti, Meenu Chawla, and Mohd Dilshad Ansari. "On K-means data clustering algorithm with genetic algorithm." IEEE Fourth International Conference on Parallel, Distributed and Grid Computing (PDGC), pp. 202-206, 2016.

[30] Ansari, M.D. and Ghrera, S.P. and Wajid, M. "An Approach for Identification of Copy-Move Image Forgery based on Projection Profiling, Pertanika Journal of Science & Technology, Vol.25, No.2, pp.507-518, 2017.

[31] HarleenKaur, Er.PriyankaJarial, Er. Gaurav Mittal, "An Improved Fuzzy Rule Based Edge Detection Technique", *International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE)*, vol. 5, No.5, pp. 411-416, 2015.

[32] Ansari, Mohd Dilshad, Garima Singh, Arjun Singh, and Ashwani Kumar. "An Efficient Salt and Pepper noise Removal and Edge preserving Scheme for Image Restoration." *Int. J. Computer Technology & Applications*, Vol.3, No.5, pp.1848-1854, 2012.

[33] Ansari, Mohd Dilshad and Ghrera, S.P., "Feature Extraction Method for Digital Images Based on Intuitionistic Fuzzy Local Binary Pattern" 5th IEEE International Conference on System Modeling & Advancement in Research Trends (SMART), pp.345-349, 2016.

[34] Ansari, M. D., Mishra, A. R., Ansari, F. T., & Chawla, M. "On edge detection based on new intuitionistic fuzzy divergence and entropy measures." IEEE Fourth International Conference on Parallel, Distributed and Grid Computing (PDGC), pp. 689-693, 2016.