IAES International Journal of Artificial Intelligence (IJ-AI)
Vol. 4, No. 3, September 2015, pp. 97~104
ISSN: 2252-8938

Type2 Fuzzy Soft Computing Technique for Image Enhancement

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Article Info

Article history:

Received May 24, 2015
Revised July 14, 2015
Accepted August 3, 2015

Keyword:

Fisher criterion
Fuzzy type1
Fuzzy type2
Membership function
Soft computing

ABSTRACT

The mainpurpose of Image enhancement is to process an image so that outcome is more appropriate than original image for definite application. The fuzzy logic isone of the soft computing techniques to enhance the images by eliminating uncertainty.In this paper efficient type2 fuzzy logic technique is used to get betterquality image. This method consists of two steps. In the First step fisher criterion function is useful to generate type1 fuzzy membership value. In the second step based on type1 membership value fuzzy rules are derived to enhance the image. The type2 fuzzy method is compared with type1 fuzzy. The table values and graphs provethat the proposed method gives better results compared with fuzzy type1 method.

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1. INTRODUCTION

Image enhancement is fundamentally improving theinterpretability or perception of information in images for humanviewers and providing better input for other automated imageprocessing methods. The primary objective of imageenhancement is to modify attributes of an image to make it moresuitable for a given task and anexact observer. Throughout thisprocess, one or more attribute values of the image are customized. Theselection of attribute values and the technique they are modified are specific toa knownjob. Furthermore, the observer-specificfactor values, such as thehuman beingillustration system and the observer's understanding, will bring inanimmense deal of subjectivity into the choice of image enhancementmethods. But no existing technique that can enhance a digitalimage without spoiling features. In [1], proposed algorithm based on contrast measure within the discrete cosine transform domain for image enhancement.The proposed algorithm is shown better result for low contrasted images. However it fails to retain significantcharacteristics. In [2], the author mainly focused on spatial domain methods which are histogram processing and point processing methods. It is not given any details regarding the computational cost of enhancement algorithms which play an important role for to choose an algorithm for real applications. In [3], the Mehter method with High-Pass Filtering, Histogram Equalization and Block Filtering used for enhancing the finger print image and the new Mehtre technique gives better performance compare to existing Mehtre method. In [4], by using aura alteration, the enhancement is applied on ultra sound images to predict the diseases of human body. It is not applicable to other medical images. In [5], used an erosion enhancement technique by using quality parameters like peak signal to noise ratio (PSNR) and mean square error (MSE) to enhance the gas burner images. This paper gives better results when PSNR is high and MSE with low value.

In [6], fuzzy logic and Artificial Bee Colonyoptimization method improve the quality of the images.This approach provides better performance than Ant Colony Optimization method. In [7], filtering and Histogram Equalization, gray scale manipulation and fast Fourier transforms used for enhancing the thermal images. In [8], genetic algorithm is used for enhancing and segmenting the image. In [9], the fingerprint images, color images and medical images are enhanced by using fuzzy logic approach. This method fails to enhance the video type images. In [10], fuzzy gray scale enhancement method used for enhancing the imageand is good for preserving and smoothing the edges. In [11], by using Dominant Brightness and Adaptive Intensity Transformation, the image enhancement is performed for low contrasted satellite images. The proposed technique is useful to avoid the over enhancement compare to existing techniques. In [12], adaptive thresholding and contrast stretching for enhancing the MRI knee images, which is used for medical applications.In preprocessing an image is processed for removing noise, automatic edge detection, edge or boundary enhancement, automatic contrast adjustment and segmentationand is not applicable for enhancing the damaged images when multiple noises are applied to an image. In [13], an Adaptive Contrast Enhancement Based on modified Sigmoid Function (ACEBSF) algorithm is used in various applications where images suffer from various contrast inconveniences and it giveshigh speed, good performance and lessCPU time for processing the natural images. In [14], the author presents fuzzy association rule mining for enhancing the mammogram image. This method has proven better for enhancing and it uses less processing time to enhance the image. In [15], based on novel algorithm with statistical operations and with neighbourhood computation, the image enhancement has been performed.This algorithm is good for preventing from side effects and it preserves the consistency and brightness of the image. In [16], Contrast Limited Adaptive Histogram Equalization (CLAHE) method for image enhancement and class 3 fuzzy C means clustering method for image segmenting. The proposed method issuperior for improving the threshold value at lesser CPU processing costand is not used for different objective functions like FCM (Fuzzy C-Mean) and C-mean. In [17], artificial intelligence used for image enhancement andprovides better results compare to spatial and frequency domain methods. It is not applicable for optimized enhancement and is not suitablefor computationaltime and faster response.In [18], the image enhancement performed based on fuzzy logic with histogram modifications for all color images and gray scale images. In [19], based on fuzzy type2 and morphological gradient method, the image edge detection is performed. But this method only used heights and approximations for defuzzification.

2. FUZZY TYPE 1

In a gray scale image the morphological gradient is defined as the difference between intensity values of two neighboring pixels. It belongs to structural element. ∇ Is a gradient operator and is a vector. ∇ is taken as

$$\nabla = i\frac{\partial}{\partial x} + j\frac{\partial}{\partial y} \tag{1}$$

and $g_c(x, y)$ is a continuous space image is defined by

$$\nabla g_c(x, y) = \frac{\partial g_c(x, y)}{\partial x} i + \frac{\partial g_c(x, y)}{\partial y} j \tag{2}$$

Where,i and j are the unit vectors along x and y directions respectively. Its magnitude at point (x_0,y_0) is $\left|\nabla g_c(x_0, y_0)\right|$, measures the maximum rate of change in the intensity. The local maxima is

$$\left|\nabla g_c(x, y)\right| = \sqrt{\left(\frac{\partial g_C(x, y)}{\partial x}\right)^2 + \left(\frac{\partial g_C(x, y)}{\partial y}\right)^2} \tag{3}$$

In this paper we use E_i instead of $\nabla g_c(x, y)$, apply 3X3 matrix in Figure 1, and calculate the coefficients of Z_i with (4) and the directions of the edge mentioned in figure (2)

$$
\begin{aligned}
E1 &= \sqrt{(z_5 - z_2)^2 + (z_5 - z_8)^2} \\
E2 &= \sqrt{(z_5 - z_4)^2 + (z_5 - z_6)^2} \\
E3 &= \sqrt{(z_5 - z_1)^2 + (z_5 - z_9)^2} \\
E4 &= \sqrt{(z_5 - z_3)^2 + (z_5 - z_7)^2}
\end{aligned} \tag{4}
$$

$$Sum = E1 + E2 + E3 + E4 \tag{5}$$

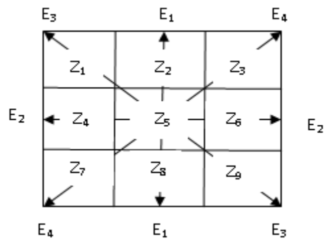

Figure 1. Matrix of 3X3 Representing the coefficients Z_i and the edge Directions E_i.

$$low_i = \min(E_i) \tag{6}$$

$$high_i = \max(E_i) \tag{7}$$

$$medium_i = low_i + (high_i - low_i)/2 \tag{8}$$

$$\sigma_i = high_i / 5 \tag{9}$$

$$mean_a = high_i \tag{10}$$

$$mean_b = mean_a + (mean_a * FOU), where FOU is in (0,1) \tag{11}$$

$$Avg mean(\mathrm{m}) = \frac{mean_a + mean_b}{2} \tag{12}$$

$$Var(\sigma_v) = \frac{\delta}{2\sqrt{6}} + \varepsilon \tag{13}$$

$$Q_k = gauss(k, [\sigma_k, mean_k]) = \exp\left[-\frac{1}{2}\left(\frac{k - mean_k}{\sigma_k}\right)^2\right] \tag{14}$$

3. PROPOSED SYSTEM

The proposed fuzzy type2 is used here to enhance the images efficiently for identifying the real objects for the processing of data. Two coordinates of the 2-D histogram expressed as L(i) and X(j) respectively, the mean and variance of the 2-D histogram of Fisher criterion can be given by the following equations

$$\mu_k = (\mu_k{}^i, \mu_k{}^j),\ k = 0,1 \tag{15}$$

$$\sigma_k{}^2 = \left(\sigma^2{}_{ki}, \sigma^2{}_{kj}\right),\ k = 0,1 \tag{16}$$

Where mean is calculated as follows

$$\mu_0{}^i = \int_{i=0}^{s} \frac{i * L(i)}{L(i)} di \tag{17}$$

$$\mu_0^j = \int_{j=0}^{t} \frac{j * X(j)}{X(j)} dj \tag{18}$$

$$\mu_1^i = \int_{i=s+1}^{L} \frac{i * L(i)}{L(i)} di \tag{19}$$

$$\mu_1^j = \int_{j=t+1}^{L} \frac{j * X(j)}{X(j)} dj \tag{20}$$

and the variance is considered as follows

$$\sigma_{oi}^2 = \int_{i=0}^{s} \left(i - \mu_0^i\right)^2 * L(i) di \tag{21}$$

$$\sigma_{oj}^2 = \int_{j=0}^{t} (j - \mu_0^j)^2 * X(j) dj \tag{22}$$

$$\sigma_{1i}^2 = \int_{i=s+1}^{L} \left(i - \mu_1^i\right)^2 * L(i) di \tag{23}$$

$$\sigma_{1j}^2 = \int_{j=t+1}^{L} \left(j - \mu_1^j\right)^2 * X(j) dj \tag{24}$$

$$L(i) = \int_{j=0}^{L-1} \int_{i=0}^{L-1} N(i,j) \tag{25}$$

$$X(j) = \int_{i=0}^{L-1} \int_{j=0}^{L-1} N(i,j) \tag{26}$$

Thus 2-D fisher criterion function is defined as below

$$D = \left(\left[\frac{\mu_0^i + \mu_0^j}{2} \right] - \left[\frac{\left[\mu_1^i + \mu_1^j\right]}{2} \right] \right) \tag{27}$$

$$J_F(s,t) = \frac{D * D^T}{\sigma_{oi}^2 + \sigma_{oj}^2 + \sigma_{1i}^2 + \sigma_{1j}^2} \tag{28}$$

In fuzzy systems for modelling the process, we consider the three rules that depict the previous relationships between the image gradients that fuzzy rules are

1. If (E1 is H) or (E2 is H) or (E3 is H) or (E4 is H) then S is EDGE, where H is HIGH
2. If (E1 is M) or (E2 is M) or (E3 is M) or (E4 is M) then S is EDGE, where M is MEDIUM
3. If (E1 is L) and (E2 is L) and (E3 is L) and (E4 is L) then S is No EDGE, where L is LOW

4. QUALITY PARAMETERS
4.1. Mean

Mean is used to find the average gray levels of the image. It is considered as:

$$mean(\mu)=\frac{1}{RS}\sum_{x=1}^{R}\sum_{y=1}^{S}f(x,y)$$

Where R and S are width and height of the image and f(x, y) is gray value.

4.2. Standard deviation

The standard deviation of gray level image is calculated as follows

$$st(\sigma)=\sqrt{\frac{1}{RS}\sum_{x=1}^{R}\sum_{y=1}^{S}(f(x,y)-\mu)^{2}}$$

Where R, S are the width and height of the image, μ is mean of the image, f(x, y) is gray level value of the image, $St(\sigma)$ is standard deviation.

4.3. Jaccard Index

Jaccard index is a statistic used for comparing the similarity and diversity of sample sets. It is calculated as:

$$Jac(P,Q)=\frac{|P\cap Q|}{|P\cup Q|}$$

Where P and Q are both empty, we define jac (P, Q) =1 and $0\leq jac(P,Q)\leq 1$.

5. EXPERIMENTAL RESULTS

In this paper, the fuzzy type2 method is used for image enhancement. The quality parameters mean, standard deviation and jaccard formulae, are used for finding the performance of the fuzzy type1 and type2 on skull, dog, signature, doll, mirchi, text, letter and blood cells images. The tables of values are shown in table1 to table3. The figure 2 shows the output comparisons of fuzzy type1 and type2. Figure are shown in Figure 3a to Figure 4b which demonstrate the results of Type1 and Type2 fuzzy techniques and proved that the type2 is better than type1and Figure 4 is the combination of all Type 1 and Type 2 fuzzy values. According to the graphs for mean, standard deviation and jaccard formula optimal threshold is generated to enhance the images.

Table 1. Fuzzy Type1 & 2 Mean

Image	Type1 Mean	Type2 Mean
Skull	0.4434	0.4068
Dog	0.4168	0.3924
Signature	0.362	0.3236
Doll	0.2165	0.2146
Mirchi	0.2183	0.2153
Text	0.264	0.223
Letter	0.3166	0.2151
Blood cells	0.3063	0.2304

Table 2. Fuzzy Type 1 & 2 Standard Deviation

Image	Type1 Std	Type2 Std
Skull	0.1167	0.1591
Dog	0.0985	0.0641
Signature	0.0892	0.0796
Doll	0.1984	0.1407
Mirchi	0.1567	0.1188
Text	0.0939	0.1364
Letter	0.0849	0.0627
Blood cells	0.0986	0.0589

Table 3. Fuzzy Type1 & 2 Jaccard Values

Image	Type1 JC	Type2 JC
Skull	0.5566	0.5932
Dog	0.5832	0.6076
Signature	0.638	0.6764
Doll	0.7835	0.8854
Mirchi	0.7817	0.8847
Text	0.736	0.777
Letter	0.6834	0.9849
Blood cells	0.6967	0.8696

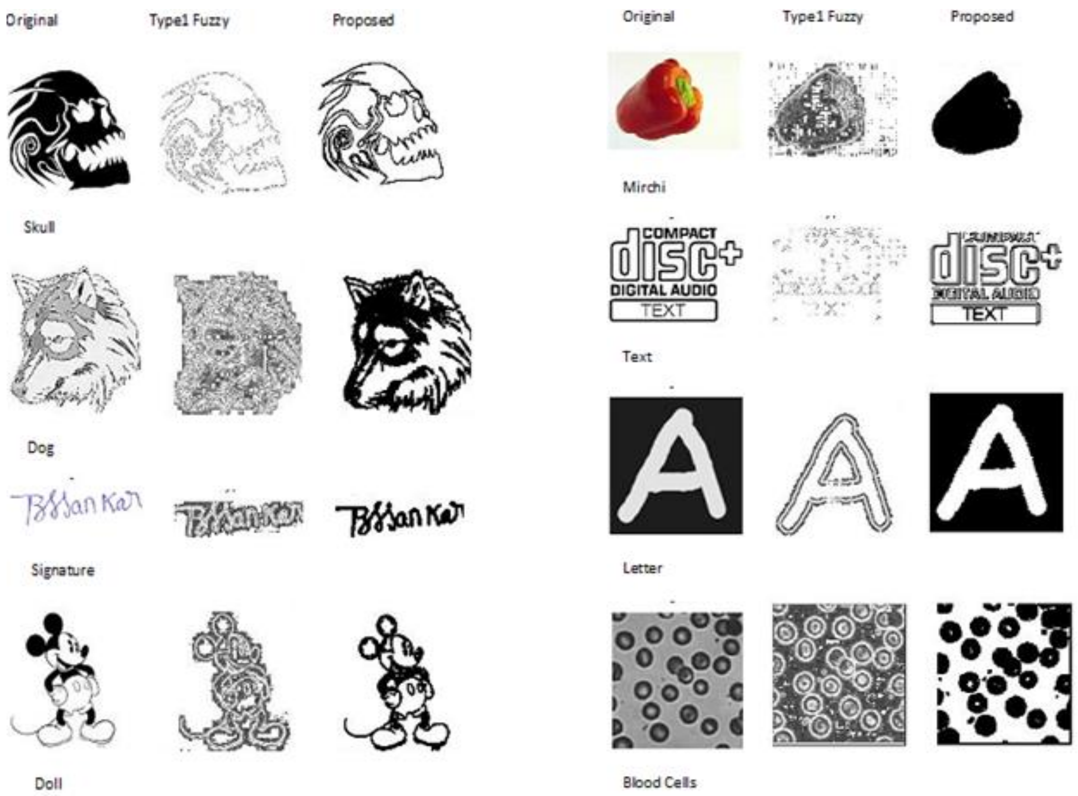

Figure 2. Comparisons of Fuzzy Type 1 and Type 2

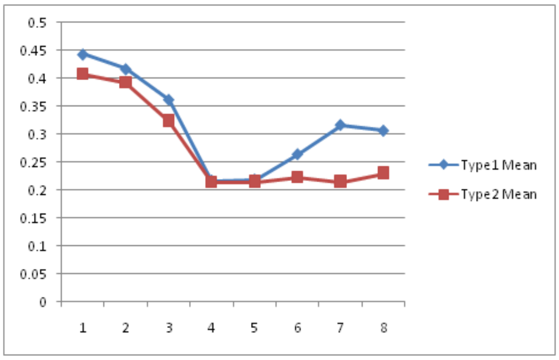

Figure 3a. Fuzzy Type 1 & Type 2 mean

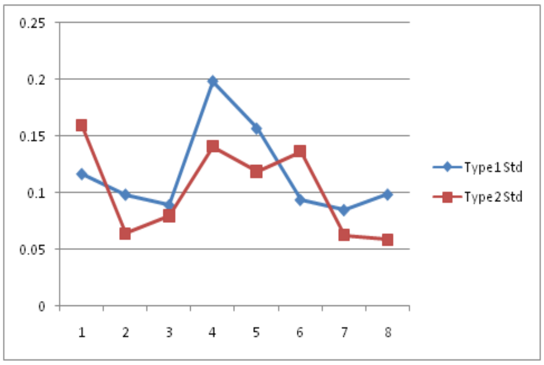

Figure 3b. Fuzzy Type 1 & Type 2 mean

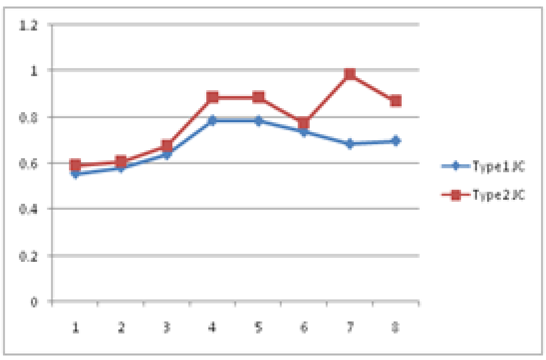

Figure 4a. Fuzzy Type 1 & Type 2 Jaccord

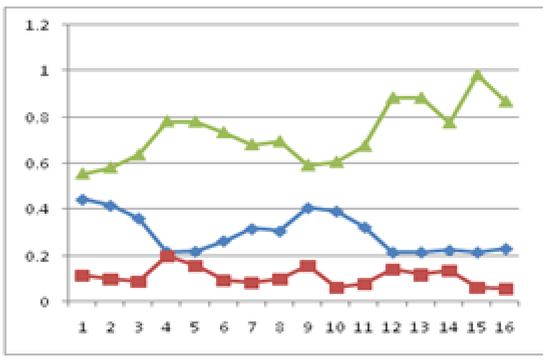

Figure 4b. Fuzzy Type 1 & Type 2 Jaccord

6. CONCLUSION

In this paper we performed theimage enhancement techniques by using fuzzy type2. The fuzzy type2 is compared with type1 ondifferent kinds of images and quality parameters are evaluated. In most of the test cases the proposed method is giving better resultthan traditional type1. However it is not practically suitable for document type images because the characters of documents are very small so important characters may be lost.

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