International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 8, Issue 7, July 2018)

Fuzzy Histogram Equalization for Image Enhancement

U. Sesadri[1], Dr. C. Nagaraju[2], Dr. M. Ramakrishna[3]
[1]*Research Scholar, Department of MCA, VTU, Belgaum*
[2]*Assoc.Professor & Head of CSE, YSR Engineering College of YVU, Proddatur.*
[3] *Professor & Head of CSE, Vemana IT, Bengaluru*

***Abstract*— computer vision and image processing Histogram equalization is a significant procedure to boost the images. Adaptive histogram equalization (AHE) is a powerful method to boost the neighborhood information on digital images. However, it fails the noise improvement and contrast overstretching. To overcome this new HE technique proposed predicated on fuzzy logic. In Fuzzy Histogram Equalization (FHE) technique first histogram is evaluated based on fuzzy logic to deal with uncertainty of gray level standards in an improved approach compare to traditional crisp. In the next phase, the fuzzy histogram is split into 2 associate histograms on the basis of the new image and then equalizes them separately to care for image intensity. This technique is in contrast to HE and AHE for different varieties of images. The Fuzzy Histogram Equalization technique has performed better results in comparison to HE and AHE.**

***Keywords*— Histogram, Histogram Equalization, fuzzy logic, crisp**

I. INTRODUCTION

In computer vision and image processing contrast enhancement, as some sort of considerable processing technique for both videos and images. Further it can improve the visual quality for human perception. In computer vision and image processing a powerful preprocessing procedure to emphasize the primary features of an images and videos. To boost the contrast of the real images varies enhancement techniques have already been introduced. Transform domain and spatial domain these are two primary groups to enhance the real images. Here the primary category Histogram equalization (HE), it can be later classified Local Histogram Equalization (LHE) and Global histogram equalization (GHE). Histogram information of the entire image into from its transformation function it explores the Global Histogram Equalization (GHE). The classical histogram equalization effectively utilize the display intensities, however, it has a tendency to over boost the contrast if you can find high peaks in the histogram, to ensure that noisy appears in the resulted image. For restrictive the degree of improvement Varies techniques have already been introduced, they obtained most of them by slit changing modifications on HE. As a result of flatting property of HE brightness of a picture may be changed.

To prevent this K.Shanti et.al [1] based on neighborhood metric the enhancement algorithm using Bi-Histogram Equalization technique was proposed. However Bi-HE don't produces the better results for natural images. To be able to overcome this David Menotti et.al [2] proposed Multi Histogram Equalization (MHE). Here the input image divided into varies sub images and then apply the normal HE method to everyone. H.Ibrahim et.al [3] proposed brightness preserving dynamic histogram equalization (BPDHE) to make the resultant image with the high quality image intensity almost corresponding to the average intensity of the input image. Tarik et.al [4] projected contrast enhancement has optimized which minimizes a price function by using modification of frame work in histogram equalization. Bi-HE and MHE techniques required predefined parameters from an individual, which produces the suitable results, can't be obtained automatically. To prevent this for image enhancement purpose Chen et.al [5] projected a plateau Level Bi-Histogram Equalization employing this technique excessive enhancement may be avoided. Yen et.al [6] proposed a straightforward histogram modification scheme using mapping and probability density functions. Debdoot et.al [7] projected dynamic fuzzy HE technique for brightness. This method avoids inexactness of gray level values. Later Chen et.al [8] proposed adaptive contrast enhancement methods. In [9], a computerized histogram threshold approach centered on index of fuzziness measure is presented. Thomas et.al [10] proposed specification procedures for histogram to boost the image contrast. For low contrasted images to boost the image adaptively Zhiwei et.al [11] projected a fresh technique predicated on cuckoo search and particle swarm optimization. Contrast limited adaptive histogram equalization (CLAHE) is a productive performance to improve the neighborhood information on an image. However, it faces noise enhancement problems for low contrasted images. To resolve Huang et.al [12] proposed discrete wavelet transform utilized in contrast limited adaptive histogram equalization. Mayank et.al [13] proposed top speed quantile-based histogram equalization technique which can be suited to high contrast digital images.

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 8, Issue 7, July 2018)

To preserve the brightness and maximize the entropy histogram modification technique was proposed to enhance the image by Chen and Yu-Ling WU in [14]. Zhijun Yao et al [15] proposed new algorithm for image enhancement by histogram equalization. This Bi-histogram equalization technique uses brightness preserving and non-parametric parameters. These parameters enhance the low contrasted images. In [16] projected fuzzy entropy optimal thresholding for low contrasted images for varies noisy images. In [17] proposed Fuzzy entropy triangular model for super resolution images. This method provides suitable for both symmetric and asymmetric shapes. Promising results were obtained for different varieties of images like uneven illumination, fog and shadow images. In section II we described Histogram Equalization, Adaptive Histogram Equalization are described in section III. In section IV Fuzzy Histogram Equalization is described, section V describes the results and discussion and performance evaluation shows the section VI. The section VII we conclude the FHE and give some route for future work.

II. Histogram Equalization

Let a digital image, $f=\{f(i,j)\}$, which involves total quantity of N pixel with range of gray level values [0,L-1]. For certain image f, $P(f_k)$ denotes the probability density function and is defined as

$$P(f_k)=\frac{n^k}{n} \quad (1)$$

For $k=0,1,2,3,...,L-1$, where n^k indicates how many of times that the gray level of input image f_k appear, f and n is the sum total amount of samples in the input image. Note that, $P(f_k)$ is related to the histogram of input image which represents the amount of pixels that have certain intensity f_k. In fact, a plot of f_k verses n_k is named histogram input image f. The respective cumulative function is defined as

$$C(f_k)=\sum_{j=0} P(f_j) \quad (2)$$

For $k=0,1,2,3,...,L-1$. Observe that $C(f_{L-1})=1$ by definition. Histogram equalization is a way that maps the participation image into complete dynamic array (f_0, f_{L-1}) by utilizing the cumulative distribution be a transform function. That is, let us define a transform function $T(f)$ predicted on cumulative function as

$$T(f)=\{f_0+[f_{L-1}-f_0]C(f_k)\} \quad (3)$$

Then a enhanced image of HE $g=g(i,j)$ may be expressed as

$$g(i,j)=T(f)=\{T(f(i,j))/\forall f(i,j)\in f\} \quad (4)$$

Where f and g are the initial and enhanced images. (i,j) Would be the 2D coordinates of the images, and T may be the intensity transform function, which maps the initial image into dynamic range (f_0, f_{L-1}). However, HE produces an adverse checkerboard property on enhanced images. Another difficulty of this approach is that it also improves the noises in the enter image combined with the image features. Several methods are introduces to overcome these problems, for several purpose.

III. Adaptive Histogram Equalization

Let f_i denote the gray value of ith gray level in the initial image. Position j of mapped gray level gi is decided by the ratio $\sum_{k=0}^{i-1} P_k \; and \; \sum_{k=i+1}^{m-1} P_k$.

To attain the homogeneous distribution or neighboring homogeneous distribution, the algorithm compares j with i: if j>i, then map backward; if j<i, then map forward.

$$j=(m-1)\frac{\sum_{k=0}^{i-1} P_k}{\sum_{k=0}^{i-1} P_k+\sum_{k=i+1}^{m-1} P_k} \; where \sum_{k=0}^{m-1} P_k=1, P_k=\frac{q_k}{Q} \quad (5)$$

The pixels are mapped with gray level values with large quantity of neighborhood pixels. Loss less used to avoid the information.

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 8, Issue 7, July 2018)

For mapping gray level values adaptive parameter β used. To obtain superior visual effects, the adaptive objective function β select on the basis of the gray level values of the input image. The gray level mapping relation is.

$$q_k = \log(q_k + 1) \tag{6}$$

$$j = (m-1)\frac{\sum_{k=0}^{i-1} P_k}{\sum_{k=0}^{i-1} P_k + \beta \sum_{k=i+1}^{m-1} P_k}, \beta \in (0,\infty) \tag{7}$$

Selection of adaptive parameter β

IV. Fuzzy Histogram Equalization

In the conventional histogram equalization method, the remapping of the histogram peaks (local maxima) takes place which leads to the introduction of undesirable artifacts and large change in mean image brightness. Hence, the proposed fuzzy logic Hence, the projected fuzzy logic-based histogram leveling is not only preserves the image brightness, however additionally the real images are changes to local contrast. First, the fuzzy histogram is created based on fuzzy logic to handle the inaccuracy of gray level values in a very higher manner and it's separated into 2 sub histogram supported the median value of the initial image. Then, every histogram is assigned to a replacement dynamic range. Lastly, the HE approach is applied separately on each associate histogram. The FHE procedure consists of the subsequent stages.

A. Image fuzzification and intensification:

Image fuzzification the gray level intensities are changed into fuzzy plane whose values lie between 0 and 1. An image f of size M*N and intensity level in the range $[0, L-1]$ can be considered. For equivalent image fuzzy matrix F can be represented as

$$F = \begin{bmatrix} \frac{\mu_{11}}{f_{11}} & \frac{\mu_{12}}{f_{12}} & \cdots & \frac{\mu_{1N}}{f_{1N}} \\ \frac{\mu_{21}}{f_{21}} & \frac{\mu_{22}}{f_{22}} & \cdots & \frac{\mu_{2N}}{f_{2N}} \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ \frac{\mu_{M1}}{f_{M1}} & \frac{\mu_{M2}}{f_{M2}} & \cdots & \frac{\mu_{MN}}{f_{MN}} \end{bmatrix} \tag{8}$$

Here $\mu_{ij} = 0$ indicate dark, and $\mu_{ij} = 1$ indicate bright. Any in-between value refers to the grade of maximum gray level of the pixel. A set consisting of μ_{ij} is called the fuzzy property plane of the image. In order to cut back quantity of image fuzziness, contrast intensification is applies to the fuzzy set F to return up with another fuzzy set, and thus the membership operate of that's expressed as

$$\mu_{F(i,j)} = \begin{cases} 2*(\mu_{ij})^2 & 0 \le \mu_{ij} \le 0.5 \\ 1-(2*(1-\mu_{ij})^2 & 0.5 \le \mu_{ij} \le 1 \end{cases} \tag{9}$$

B. Fuzzy Histogram calculation:

To enhance the original image it requires tendency to expectation of the contrast enhancement. Generally this can be achieved by building dark component extra darker and making bright component brighter. Hence, fuzzy histogram is computed exploitation (16). A fuzzy histogram may be a sequence of real numbers $h(i)$ is the frequency of prevalence of gray levels that are i. By considering the gray value $f(i, j)$ as a fuzzy number, the fuzzy histogram is computed as

$$F = h(i) + \sum_i \sum_j \mu_{F(i,j)} \tag{10}$$

Where $\mu_{F(i,j)}$ is the fuzzy membership function, Fuzzy statistics is able to handle the vagueness of gray values in much better way compared to classical crisp histogram thus producing a soft histogram.

C. Histogram partition and Equalization:

Based on input median M, the fuzzy histogram F is decomposed into two sub histogram F_L *and* F_U as

$$F = F_L \cup F_U \tag{11}$$

Where

$$F_L = \{F(i, j) / F(i, j) \le M, \forall F(i, j) \in F\}$$
$$F_U = \{F(i, j) / F(i, j) > M, \forall F(i, j) \in F\}$$

Next, define the respective probability density functions of the sub histogram F_L *and* F_U as

$$P_L(F_K) = \frac{n_L^K}{n_L} \tag{12}$$

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 8, Issue 7, July 2018)

Where $k = 0, 1, 2, ..., m$ and

$$P_U(F_K) = \frac{n_U^K}{n_U} \qquad (13)$$

Where $k = m+1, m+2, ..., L-1$, in which $n^k{}_U$ *and* $n^k{}_L$ stand for the respective numbers of F_k in F_L *and* F_U, and n_L *and* n_U are the total number of samples in F_L *and* F_U, respectively. Note that $P_L(F_K)$ *and* $P_U(F_K)$ are related to the fuzzy histogram of the input image that represents the amount of pixels that have a particular intensity F_k. The various additive density functions for sub histograms F_L *and* F_U are then outlined as

$$C_L(F_K) = \sum_{j=0}^{m} P_L(F_j)$$
$$C_U(F_K) = \sum_{j=m+1}^{L-1} P_U(F_j) \qquad (14)$$

Let us outline the subsequent transform function supported additive density functions as

$$T_L(F_K) = F_0 + (M - F_0)C_L(F_K)$$
$$T_U(F_K) = M + 1 + (F_{L-1} - M + 1)C_U(F_K) \qquad (15)$$

Based on these transform functions, the rotten sub images are equalized separately, and therefore composition of the ensuing equal sub images that represent the output image. The output image $g = g(i, j)$ is expressed as

$$g(i, j) = T_L(F_L) \cup T_U(F_U) \qquad (16)$$

Where

$$T_L(F_L) = \{T_L(F(i, j)) / \forall F(i, j) \in F_L\}$$
$$T_U(F_U) = \{T_U(F(i, j)) / \forall F(i, j) \in F_U\} \qquad (17)$$

D. Image defuzzification :

Inverse of fuzzification is Image defuzzification. Gray level intensities are mapped in deffuzification algorithm. Finally, inverse transformation of the enhanced image $G(i, j)$ can be represented as follows.

$$G(i, j) = T^{-1}(g(i, j)) = \bigcup_{i=1}^{M} \bigcup_{j=1}^{N} g(i, j) * (L-1) \qquad (18)$$

Where $G(i, j)$ indicates the gray level of the $(i, j)^{th}$ pixel in the enhanced image and inverse of T is T^{-1}. This brightness conserving procedure ensures that the mean intensity of the image obtained once the method is the same as that of the input image.

V. RESULTS AND ANALUSIS

In this paper, comparison between the proposed method Fuzzy Histogram Equalization and predictable methods such as histogram equalization and Adaptive histogram equalization are presented. In this paper images are in use with low contrast and brightness to analyze the performance of the fuzzy method various statistical performance metrics have been used. Performance analysis of HE, AHE and FHE using statistical parameters MSE, PSNR, SSIM and execution time.

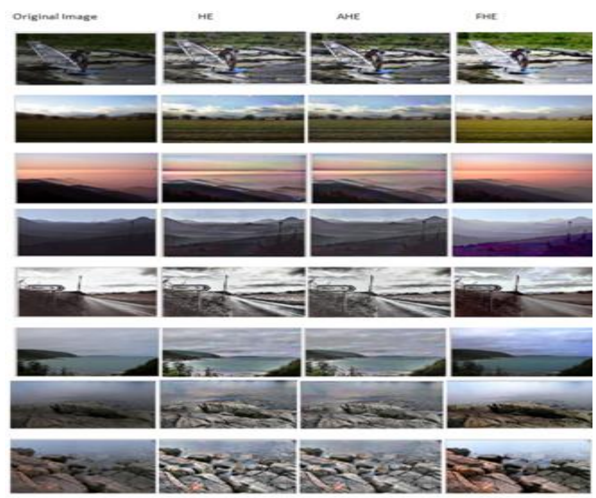

Figure 2. (a) Input Image; (b) Histogram Equalized Image; (c) Adaptive Histogram Equalized Image; (d) Fuzzy Histogram Equalized Image

Histograms of the above first two images are

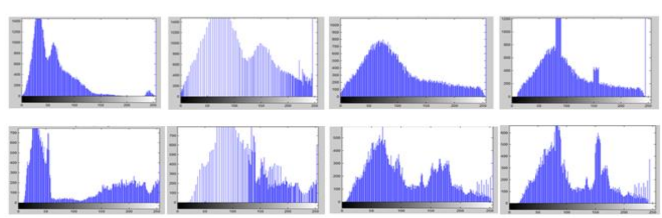

Figure 3. The Histograms of Above first two Images (a) Input Image; (b) Histogram Equalized Image; (c) Adaptive Histogram Equalized Image; (d) Fuzzy Enhanced Image .

IJETAE EXPLORING RESEARCH AND INNOVATIONS

International Journal of Emerging Technology and Advanced Engineering

Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 8, Issue 7, July 2018)

Mean Square Error in image processing measures the average of squares of errors.

$$MSE = \frac{1}{RC}\sum_{i=1}^{R}\sum_{j=1}^{C}\left[f(i,j) - f'(i,j)\right]^2 \qquad (19)$$

In the above equation R and C represents the number of rows and columns in the input images with index $i \text{ and } j$ respectively. $f(i,j)$ Represents the original image at location (i,j) and $f'(i,j)$ represents the degraded image at location (i,j).

TABLE I
MSE

S.No	MSE		
	HE	**AHE**	**FHE**
1	6.0282	3.4687	3.054
2	91.4526	83.7134	30.5694
3	14.5363	10.6069	3.501
4	9.1955	3.9175	1.1938
5	12.7433	10.6762	9.899
6	16.546	13.8244	12.8232
7	8.0764	6.7229	3.7603
8	31.0727	14.3773	6.8631

PSNR refer to the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the quality of image. Maximum value of PSNR represents the reconstruction is of maximum quality.

$$PSNR = 10\log_{10}\left(\frac{Max^2}{MSE}\right) = 20\log_{10}\left(\frac{Max}{MSE}\right) \qquad (20)$$

TABLE III
PSNR

S.No	PSNR		
	HE	**AHE**	**FHE**
1	40.3629	42.7631	43.3129
2	28.5528	28.9368	33.3119
3	26.6561	27.9279	42.7222
4	35.3328	42.2347	47.3955
5	26.6494	27.112	27.8807
6	27.5345	33.0497	37.0859
7	39.0926	39.8892	42.4126
8	33.241	36.588	39.7996

Table shows the PSNR value obtained when applying completely different enhancement techniques on different pictures. From the table values it's evident that the value obtained by FHE technique is higher as compared to traditional HE techniques.

Structure of Similarity Index is supported 3 terms, named as luminance, contrast and structural. The fundamental equation of SSIM is:

$$SSIM = \left[I(x,y)^{\alpha}\right]\left[C(x,y)^{\beta}\right]\left[S(x,y)^{\gamma}\right] \qquad (21)$$

TABLE IIIII
SSIM

S.No	SSIM		
	HE	**AHE**	**FHE**
1	0.5707	0.617	0.6399
2	0.7047	0.7251	0.7137
3	0.834	0.7505	0.7253
4	0.7419	0.8646	0.8452
5	0.8297	0.7461	0.7682
6	0.9276	0.779	0.7891
7	0.8105	0.6282	0.6558
8	0.8071	0.6518	0.6958

Table shows the results of SSIM value obtained after applying completely different improvement techniques on different pictures. It's vivid from the typical analysis that the worth obtained by FHE technique is higher as compared to traditional HE techniques.

To process the image time taken algorithm is the execution time. The following figure .4(d) represents the execution time taken by different enhancement techniques on different images. From the table values, it is evident that the value obtained by HE is faster as compared to conventional, AHE and FHE.

The following graphs shows MSE, PSNR, SSIM and Elapsed time.

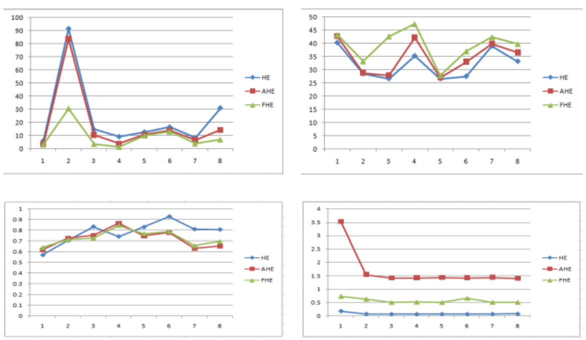

Fig .4 (a) MSE, (b) PSNR, (c) SSIM and (d) Elapsed time

VI. CONCLUSION

The objective of this paper is to evaluate the success of histogram and fuzzy based image enhancement for varied varieties of images. The fuzzy and histogram based mostly improvement has been enforced in MATLAB tool cabinet. Histogram equalization is a crucial technique to boost the digital image quality. Adaptive histogram equalization (AHE) is an efficient technique to native details of an image. However, it fails the distinction overstretching and noise improvement. To beat this we tend to use Fuzzy Histogram Equalization (FHE) technique. This method is compared with HE and AHE for varies varieties of images. Fuzzy Histogram Equalization method has performed higher results compared to HE and AHE.

REFERENCES

[1] K.Santi and R.S.D Wahida Banu, ", contrast enhancement of bi-histogram equalization with neighborhood metrics", ICCCNT international conference, July 2013

[2] David Menotti, Laurent, "Multi-Histogram Equalization methods for contrast enhancement and brightness preserving", IEEE transactions on consumer Electronics, Vol.53, No.3, Aug 2007

[3] H.Ibrahim and N.S.P Kong, "Brightness preserving dynamic histogram equalization for image contrast enhancement", IEEE transactions on consumer Electronics, Vol 5, Issue 4, Nov 2007, PP:1752-1758

[4] Tarik, Salih Dikbas, " A histogram modification frame work and its application for image contrast enhancement", IEEE transaction on image processing, Vol 18, No. 9, Sep 2009.

[5] Chen and H.Ibrahim, " Bi-histogram equalization with a plateau limit for digital image enhancement", IEEE transactions on consumer electronics, Vol 55, Issue 4 Nov 2009.

[6] Yen-Chin Chang and Chun-Ming, "A simple histogram modification scheme for contrast enhancement", IEEE transactions on consumer Electronics, Vol 56, Issue 2, May 2010

[7] Debdoot, Garud, " Brightness preserving dynamic fuzzy histogram equalization", IEEE transactions on consumer Electronics, Vol 56, Issue 4, November 2010.

[8] chen, Nor Ashidi, " Adaptive contrast enhancement methods with brightness preserving", IEEE transactions on Consumer Electronics, Vol 56, Issue 4 , November 2010.

[9] Nuno Vieira Lopes and Mogadouro, "Automatic histogram Threshold using fuzzy measures", IEEE transactions on image processing, Vol 19, Issue 1, Jan 2010.

[10] Thomas, Daniel and Pistorius, "Histogram specification: A fast and flexible method to process digital images", IEEE transactions on Instrumentation and measurement, Vol 60, No. 5, May 2011.

[11] Zhiwei, Wang and Zhengbing, "An adaptive image enhancement technique by combining cuckoo search and particle swarm optimization algorithm", Hindawi January 2015.

[12] Huang, Zhao and Wang, "Combination of contrast limited adaptive histogram equalization and discrete wavelet transform for image enhancement", IET Image processing, Vol 9, Issue 10, Sep 2015, PP: 908-915

[13] Tiwari, Gupta and Shrivastava, "High speed quantile-based histogram equalization for brightness preservation and contrast enhancement", IET Image processing, Vol 9, Issue 1, January 2015, PP: 80-89

[14] Chen and Yu-Ling Wu, "An entropy-preserving histogram modification algorithm for image contrast enhancement", Applied system innovation (ICASI), 2017 International Conference on May 2017.

[15] Yao, Lai and Wang, "Brightness preserving and non-parametric modified bi-histogram equalization for image enhancement",

[16] U.Sesadri and C.Nagaraju, "Optimal thresholding for enhancement of low contrasted images using soft computing", IEEE conference (PCCCTSG) Dec 2015, PP:273-277.

[17] U.Sesadri, C.Nagaraju and M.Ramakrishna,"Fuzzy Entropy triangular model for super resolution images", IJPAM, Vol 114, No.19, 2017, PP:65-73.