

Contrast Enhancement of an Image using Fuzzy Logic

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ABSTRACT

Image enhancement plays a significant role in vision applications. Many techniques have been proposed so far for enhancing the images. It has been found that the most of the existing techniques are based upon the transform domain methods; which may introduce the color artefacts and also may reduce the intensity of the input remote sensing image. To overcome this problem a modified approach is introduced in this research work. The new integrated approach has the capability to enhance the contrast in digital images in efficient manner by using the modified fuzzy based enhancement algorithm. Modified fuzzy image enhancement has integrated image gradients with input image for image enhancement. After image enhancement using modified fuzzy based algorithms the color normalization has come in action to reduce color artefacts. In order to evaluate the significant improvement of the proposed various well known images has been selected for experimental results. The experimental results have shown that the proposed technique has quite effective improvement over the available techniques.

Keywords

CD, CII ,EMEE, ME, Fuzzy enhancement.

1. INTRODUCTION

Image enhancement process consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or machine [1,2]. Image enhancement means as the improvement of an image appearance by increasing dominance of some features or by decreasing ambiguity between different regions of the image [2]. It is an indispensable tool for researchers in a wide variety of fields including medical imaging ,art studies, forensics and atmospheric sciences.It is application specific i.e an Image Enhancement technique suitable for one problem might be inadequate for another[3].

The objective of enhancement is to process an image so that the result is more suitable than the original image for a specific application[1,4]. Contrast enhancements improve the perceptibility of objects in the scene by enhancing the brightness difference between objects and their backgrounds [5,6]. Contrast enhancements are typically performed as a contrast stretch followed by a tonal enhancement, although these could both be performed in one step. A contrast stretch improves the brightness differences uniformly across the dynamic range of the image, whereas tonal enhancements improve the brightness differences in the shadow (dark), mid tone (grays), or highlight (bright) regions at the expense of the brightness differences in the other regions[5].

2. LITERATURE SURVEY

G. Maragatham [7] proposed an algorithm to model images using its local contrast measure to classify and distinguish between the images having different contrast level. The input image is classified either as low contrast or high contrast image using the model. If the classified image is low contrast

it is enhanced using the Stochastic Resonance principle. The results show that the proposed automated procedure enhances the low contrast image better than the conventional enhancement methods.

Thien Huynh- The and Thuong Le-Tien[8] an effective method Brightness Preserving Weighted Dynamic Range Histogram Equalization (BPWDRHE) has been proposed.It uses the weighted within-class variance as the new approach in separating out an original histogram The results prove that the BPWDRHE method is better than the other methods in many quantitative measures, such as the overall brightness, the discrete entropy and the local contrast.

Yingjie Zhang[9] proposed a novel algorithm for image enhancement and denoising based on anisotropic diffusion and fuzzy logic theory . The maximum fuzzy entropy principle is used to map the normalized image to the fuzzy domain. Then, the image is filtered by the fractional anisotropic diffusion process iteratively. Hasikin K [10] Fuzzy grayscale enhancement technique for low contrast image is proposed by maximizing fuzzy measures contained in the image. The membership function is then modified to enhance the image by using power-law transformation and saturation operator. The proposed method produced better quality enhanced image and required minimum processing time compared to other methods.

M. Abdullah-Al-Wadud [12] A user-specified histogram equalization (UHE) approach, which provides user with a single variable to have the control over the enhancement procedure. By tuning this single parameter, user can achieve the desired enhanced look of the intended objects in an image is developed.

Li and Yang [14] have demonstrated an efficient way of contrast enhancement based on the fuzzy relaxation technique with improved speed and quality. Different orders of fuzzy membership functions were tried out by various researchers in order to improve the speed and quality of contrast enhancement based on the fuzzy logic method. In the fuzzy method [9] gray tone is modelled into a fuzzy set using a membership function. Here the image is considered as an array of fuzzy singletons having a membership value that denotes the degree of some image property in the range. Applying an intensification operator globally modifies the membership function. Perona, P., And Malik, J. [11] proposed a new scale-space and edge detection algorithm using anisotropic diffusion method. In their technique, the diffusion coefficient is used in such a way to support the intra-region smoothing as comparative to inter-region smoothing,so as to extract the global information after removing the noise from the mage. This method does not necessitate any comparison of images at different scales, as the shape and position are preserved at every single scale and preserves the edge junctions. Dileep MD[13] A novel algorithm for image enhancement and denoising based on anisotropic diffusion and fuzzy logic theory is proposed. The maximum fuzzy entropy principle has been used to map the normalized image to the fuzzy domain. Then, the image was filtered by the fractional anisotropic

diffusion process. The experimental results proved that the proposed method have removed noise and enhance contrast sufficiently and fine details of bore scope images were well preserved. The good performance of the proposed approach was due to the following factors: the maximum fuzzy entropy principle have made the proposed approach to handle the fuzziness of the images well; the S-function had enhanced the images without over-enhancement; and the sub pixel fractional diffusion that have removed noise and preserve the edges and details of the images well.

In the fuzzy method [15] gray tone is modelled into a fuzzy set using a membership function. Here the image is considered as an array of fuzzy singletons having a membership value that denotes the degree of some image property in the range. Applying an intensification operator globally modifies the membership function.

3. PROPOSED METHODOLOGY

In this section a new integrated approach is introduced which has the capability to enhance the contrast in digital images in efficient manner by using the modified fuzzy based enhancement algorithm. Modified fuzzy image enhancement will integrate image gradients with input image for image enhancement. After image enhancement using modified fuzzy based algorithms the color normalization will come in action to reduce color artefacts. The selection of the color normalization seems to be justifiable as it has the ability to overcome the problem of color artefacts in the existing methods.

Step 1: Take an input image.

Step 2: The colour of image is identified. If it is gray scale image then image gradient is applied on the image. An image gradient is a directional change in the intensity or color in an image. Image gradients are used to extract information from images.

Step 3: If the image is coloured then it is divided into three channels i.e Red, Green and Blue. Then image gradient is applied on each channel.

Step 4: After applying image gradients on the image Fuzzy based enhancement of image is done which is followed by 3 steps i.e Fuzzification, Membership modification, Defuzzification.

Step 5: After applying Fuzzy Enhancement on an image all the channels of a coloured image will be merged to get a full colour image.

Step 6: After concatenation Colour normalization of an image is done. It helps in removing shadows and thus producing a good quality image.

This section contains the algorithm for Proposed Fuzzy Enhancement. The algorithm is able to preserve edges in an image and removing the artefacts in an image.

Input: Image I, x and y are dimensions of the image I,

Output: F

1. To Define Fuzzy Limit

```
f_lt =5;
fmt =f_lt(1)- abs(- f_lt( 1) : f_lt(1));
```

Where t stands for Fuzzy limits and fmt stands for fuzzy membership type

2. To Develop Histogram

```
[ch,gs]=I Hist(I(x,y))
```

Where ch stands for crisp histogram ,gs stands for grayscale values and IHist for image histogram.

3. To develop Fuzzy Histogram

While,

```
{
Ctr=num1(fmt)
fH=fH + fmt (ctr) * [zeros(ctr-1,1));ch;zeros(num1(fmt)-
ctr,1)];
}
End;
```

Where,

ctr stands for counter , fH stands for final Histogram , fmt stands for Fuzzy membership type and num1 stands for first number.

4. Develop Final Histogram

```
fH = fH(numel (fmt)=2) : end - (numl (fmt)=2));
```

```
del1_fH = [0; (fH(3 : end) - fH(1 : end - 2)) /2; 0];
```

```
del2fH = [0; (del1fH(3 : end) - del1fH(1 : end - 2))=2; 0];
```

```
LI = (2 : numel(fH) - 1) ^ + 1;
```

where del stands for delta.

5. Evaluate ambiguous values

```
MLAmbi = LI (((delfH(1 : end - 2) . * delfH(3 : end)) <
0) & (del2fH(2 : end - 1) < 0));
```

Where ML= Membership Locate Index

Ctr =1;

ML=1;

while

```
{
ct < num1 (ML Ambi)
}
if { ( MLAmbi(ctr)==(MLAmbi(ctr+1)-1) )
ML =[
ML ;
(MLAmbi(ctr)*(fHist(MLAmbi(ctr))>fHist(MLAmbi(ctr+1)
)) + (MLAmbi(ctr+1)
(fHist(MLAmbi(ctr))<=fHist(MLAmbi(ctr+1))))
];
ctr = ctr + 2;
}
else {
ML = [ML ; MLAmbi(ctr)];
ctr = ctr + 1;
}
```

6. Enhancement Variables

```
low = ML(1 : end - 1);
```

```
high = [ML(2 : end - 1) - 1;ML(end)];
```

```
span = high - low;
```

```
CH = cs(fHistogram);
```

```
M = CH(high) - CH(low);
```

```
factor = span.* log10(M);
```

```
range = max(gs) * factor/sum(factor);
```

```
tMap = zeros(numel(gs), 1);
```

Where gs=grayscale values , tMap= Transformation map

7. Evaluate Fuzzy Transformation map

```

While
{
ctr ≤1(low)
while { index ≤ high(ctr)
tm(index)= round((low(ctr)-1)
(range(ctr)*(sum(fHist(low(ctr):index))/
(sum(fHist(low(ctr):high(ctr)))))); }
end
end
end

```

```

8. Gradient Optimization
epsilon = 0:000001;
dt = 0:1; [Ix,Iy] = grd(grd((F(x; y)))) ;
c = 1:/ (sqrt(Ix2+Iy2) + epsilon);
[div1; div2] = grd(grd(c * Ix));
[div3; div4] = grd(grd(c * Iy));
div = div1 + div4;
F(x; y) = F(x; y) - (dt * div);
where grd stands for gradient

```

```

9. Color Normalization
Kr = 255/max(max((F(X; Y )(:; : 1)))));
Kg = 255/max(max((F(X; Y )(:; : 2)))));
Kb = 255/max(max((F(X; Y )(:; : 3)))));
F(:; : 1) = Kr * (F(X; Y )(:; : 1));
F(:; : 2) = Kg * (F(X; Y )(:; : 2));
F(:; : 3) = Kb * (F(X; Y )(:; : 3));

```

4. EXPERIMENTAL RESULTS

In the experiments, the proposed approach has been implemented to test a wide variety of images. The algorithm has been implemented in MATLAB. In this section, we have compared existing fuzzy based image enhancement [10] with our proposed algorithm showing their comparison through images. Then technique is compared on the basis of values generated by various parameters.



Fig1: Input Images (a) Wall Frame (b) Lake (c) Painting (d) Vegetables (e) Hills (f) Basketball Players

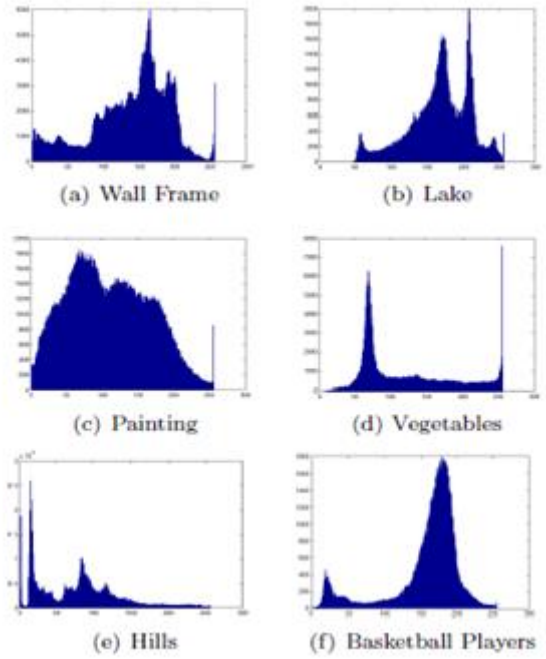


Figure 2: Histogram of Input Images (a) Wall Frame (b) Lake (c) Painting (d) Vegetables (e) Hills (f) Basketball Players



Figure 3: Images after applying Existing Fuzzy Enhancement Technique[16] (a) Wall Frame (b) Lake (c) Painting (d) Vegetables (e) Hills (f) Basketball Players

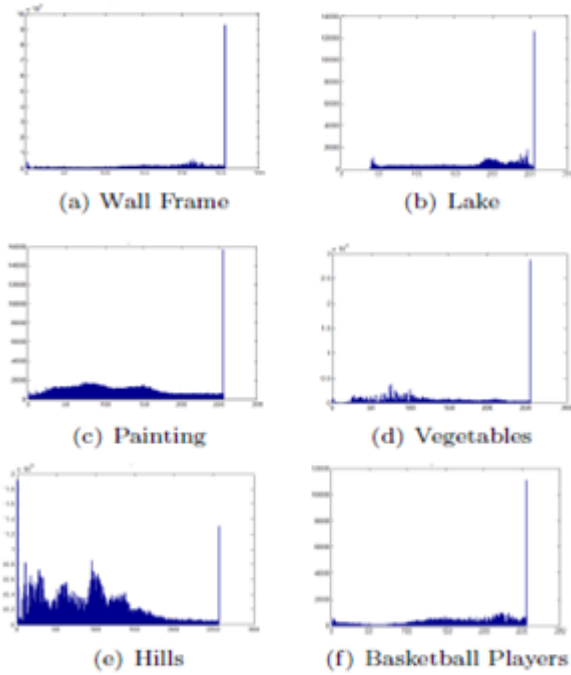


Figure 4 : Histogram of Images after applying Existing Fuzzy Enhancement Technique[16] (a) Wall Frame (b) Lake (c)Painting (d) Vegetables (e) Hills (f) Basketball Players

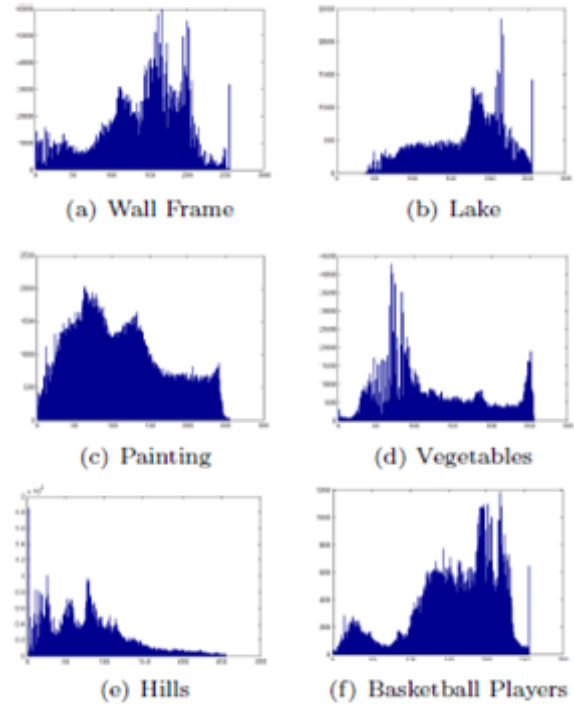


Figure 6 : Histogram of Images after applying Proposed Technique (a) Wall Frame (b) Lake (c)Painting (d) Vegetables (e) Hills (f) Basketball Players

The performance measure values shows that the proposed method gives better results compared to the conventional and advanced enhancement techniques.

A) Contrast Difference (CD):

Contrast difference is the difference between maximum (I_{max}) and minimum (I_{min}) pixel intensity of an image. High value of contrast difference stands for enhancing brighter (high gray level) pixel to brightest and darker (pixel with low value) to darkest pixel[16].It is defined as;

$$CD = I_{max} - I_{min}$$

Table 1 has shown the comparison among proposed and the existing strategy based on Contrast Difference. The graph obtained for Contrast Difference of these images is shown in figure 7 below:

Table1: CD Analysis

Image	Existing Technique[16]	Proposed Technique
IMG 1	0.1342	0.4395
IMG 2	0.1913	2.3078
IMG 3	0.7284	4.1480
IMG 4	0.1651	3.0094
IMG 5	0.0628	7.6090
IMG 6	0.2026	0.5029
IMG 7	0.4087	3.8035
IMG 8	0.1337	0.6948
IMG 9	0.1184	7.7292
IMG 10	0.1955	11.4909



Figure 5 : Images after applying Proposed Technique (a) Wall Frame (b) Lake (c)Painting (d) Vegetables (e) Hills (f) Basketball Players.

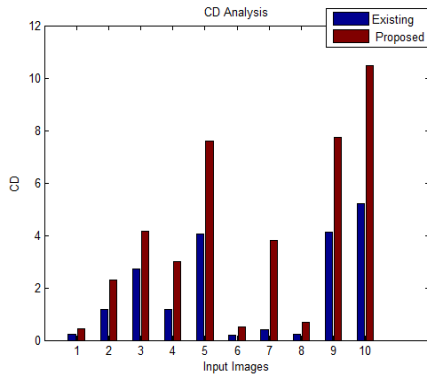


Figure 7: CD Analysis

B) Measure of Contrast Improvement Index (CII)

This metric is defined as the ratio of enhanced contrast (Cenhanced) to the original contrast (Coriginal). A higher value of contrast improvement index is always preferred. It is formulated as shown below[16]. Table 2 has shown the comparison among proposed and the existing strategy based on Contrast Improvement Index. As the value CII is more in almost every taken image; therefore the proposed strategy has shown significant results over the available technique. The graph obtained for Contrast Improvement Index of these images is shown in figure 8 below:

Table2: CII Analysis

Image	Existing Technique[16]	Proposed Technique
IMG 1	1.0047	1.4628
IMG 2	1.0051	1.3843
IMG 3	1.0064	1.3912
IMG 4	1.0083	1.5762
IMG 5	1.0073	1.5208
IMG 6	1.0071	1.5049
IMG 7	1.0062	1.4801
IMG 8	1.0055	1.3722
IMG 9	1.0085	1.4953
IMG 10	1.0058	1.3713

The graph obtained for Contrast Difference of these images is shown in figure 8 below:

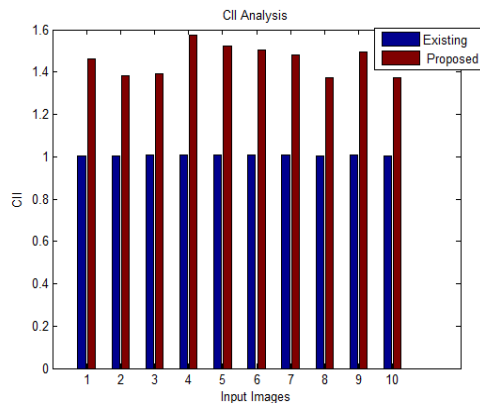


Figure 8: CII Analysis

C) Measure of Entropy (ME)

This metric is a statistical measure of randomness used to characterize the texture of an image. The entropy is calculated by using Shannon's entropy theorem. Whenever the entropy is high it is clear that the image has high contrast[16]. Table 3 has shown the comparison among proposed and the existing strategy based on Measure of Entropy. As the ME is more in almost every taken image.

Table3: ME Analysis

Image	Existing Technique[16]	Proposed Technique
IMG 1	3.5455	7.5822
IMG 2	3.7230	7.8731
IMG 3	3.8109	7.6708
IMG 4	3.2979	7.3732
IMG 5	3.7008	7.4645
IMG 6	3.0324	7.5577
IMG 7	3.7643	7.8192
IMG 8	3.4475	7.2078
IMG 9	3.4335	7.5996
IMG 10	3.2035	7.5856

The graph obtained for Measure of Entropy of these images is shown in figure 9 below:

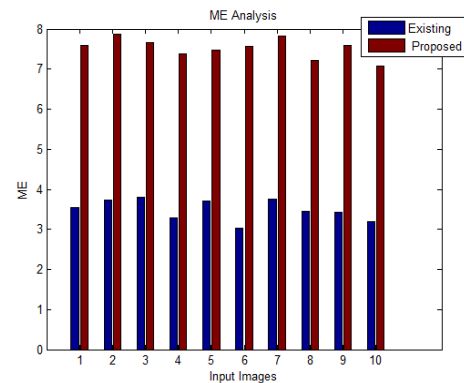


Figure 9: ME Analysis

D) Measure of enhancement by entropy (EMEE):

The metric entropy is defined as the average of ratio of maximum pixel intensity I_{max} to the I_{min} intensities in decibel and maximum and minimum intensities of enhanced image(I_{emax} , I_{emin}). This metric does not show human perception but measures the local contrast. For a high

contrast image, enhanced entropy will be high[16].Table 4 has shown the comparison among proposed and the existing strategy based on EMEE. As the value of EMEE is more in almost every taken image therefore our proposed strategy is better than the existing one.

Table4: EMEE Analysis

Image	Existing Technique[16]	Proposed Technique
IMG 1	5.8803	14.6556
IMG 2	7.5285	15.6384
IMG 3	6.7885	14.1374

IMG 4	6.8136	15.0809
IMG 5	6.4070	15.1713
IMG 6	7.4016	14.8707
IMG 7	5.1546	11.1012
IMG 8	7.4170	15.6847
IMG 9	6.9275	14.8147
IMG 10	5.7774	12.9167

The graph obtained for Measure of Enhancement by Entropy of these images is shown in figure 10

Below:

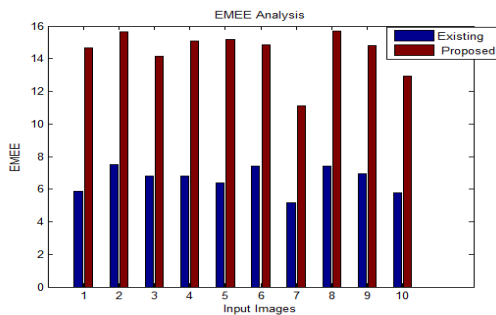


Figure 10: EMEE Analysis

E) Measure of Luminance Index (MLI)

This metric is defined as the ratio of mean (MI) of enhanced image I_e to the mean of original image I_o . In this case Luminance index is used as a measure of intensity. For a good quality image MLI must be of high value[16].

Table 5 has shown the comparison among proposed and the existing strategy based on MLI.As the value of MLI is more in almost every taken image therefore our proposed strategy is better than the existing one. The graph obtained for Measure of Enhancement by Entropy of these images is shown in figure 10 below.

Table5: MLI Analysis

Image	Existing Technique[16]	Proposed Technique
IMG 1	0.8908	0.9870
IMG 2	0.8893	0.9898
IMG 3	0.9662	0.9958
IMG 4	0.9138	0.9986
IMG 5	0.7714	0.9996
IMG 6	0.9687	0.9935
IMG 7	0.9546	0.9987
IMG 8	0.9944	0.9960
IMG 9	0.8363	0.9581
IMG 10	0.8677	0.9996

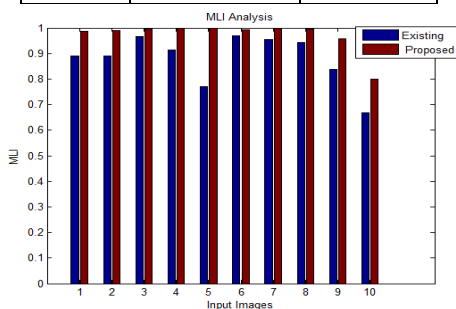


Figure 11: MLI Analysis

5. CONCLUSION AND FUTURE SCOPE

Aim of image enhancement is to improve the interpretability or perception of information in images for human viewers .Fuzzy techniques can manage the vagueness and ambiguity efficiently and provides a capability to characterize the uncertainty and imprecision and to incorporate human knowledge into problem solving process. To overcome this problem a modified approach is introduced in this research work. The new integrated approach has the capability to enhance the contrast in digital images in efficient manner by using the modified fuzzy based enhancement algorithm. Modified fuzzy image enhancement has integrated image gradients with input image for image enhancement. After image enhancement using modified fuzzy based algorithms the color normalization has come in action to reduce color artefacts. The selection of the color normalization seems to be justifiable as it has the ability to overcome the problem of color artefacts in the existing methods. In order to evaluate the significant improvement of the proposed various well known images has been selected for experimental results. The proposed technique has been designed and implemented in the MATLAB tool with the help of image processing and data analysis toolbox. The experimental results has shown that the proposed technique has quite effective improvement over the available techniques. Various kinds of quality metrics for objective evaluation has also been used to compare the proposed technique with the existing methods.

This work has not considered any optimization technique to find the optimistic adjustment function to improve the image enhancement further. Also the effect of the noise on the input images has also been neglected in the this paper. So in near future two improvements can be done. Firstly one can use the different kind of optimization techniques to find the optimistic adjustment function. Secondly one can proposed filtering based hybrid image enhancement to improve the image enhancement further.

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