A Brief Description of Enhancement of Grayscale Image using Fuzzy Technique

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Abstract

Image Enhancement is the one of the most powerful technique through which we can be improved the quality of any images. The aim motive is to use the image enhancement technique is to enhance the image visual appearance. There are many technique are used to enhance the image quality are Spatial domain method and frequency domain method. One of the spatial domain enhanced method that are operated directly on the image pixels. Spatial Domain Method are mainly be applied on the digital image to enhance their visual appearance. Image Enhancement technique are used in many fields like satellite ,print media, image processing, military and our real life photographs quality. Image enhancement technique also be improves the clarity of images of human viewing, removing noise, unambiguity and blurring also. This paper compares some images with some existing methods on the basis of PSNR value. After finding out the PSNR value for the given image, we find that the proposed algorithm gives much better result than other existing techniques and the whole work is implemented in MATLAB.
Keywords- Spatial Domain, Image Enhancement, Fuzzy Logic, Membership Function, Fuzzification, Defuzzification, PSNR, MSR

I. INTRODUCTION

Image Enhancement technique consists of collection of techniques that seek to improve visual appearance of an image or to convert an image to a better form that is suited for analysis by human or machine. Enhancement of noisy image data is a very challenging task in many research and application areas. Fuzzy Image Enhancement handles this problem effectively. Fuzzy Image processing is a collection of technique that understands, represent and process the image, their segments and features as fuzzy sets. The idea of fuzzy set is simple and natural. For instance we want to define a set of gray level that share the property dark. In classical set theory we need to define a threshold, say the gray level 100. All the gray level between 0 and 100 are elements of this set. But the darkness is a matter of degree. So, a fuzzy set can model this property much better. The basis of fuzzy logic is the basis for human communication. This observation underpins many of other statement about fuzzy logic. Because fuzzy logic is built on the structure of qualitative description used in everyday language, fuzzy logic is easy to use.

II. IMAGE DEFINITION

Image can be defined as a two dimensional light intensity function(x, y), where x, y denotes spatial co-ordinates and the value of 'f' at any point is directly proportional to the brightness (gray level) of the image at that point [30].

A. Digital Image Processing

An image may be state as a two dimensional functions f(x, y), where x and y are spatial plane co-ordinates, and the amplitude of f at any pair of coordinate (x,y) is called the intensity or grey level of image at that point. When x, y and the amplitude value of f are all finite, discrete quantity, the image is called as a digital image. Digital image processing starts with one image and produce modified version of that image. Digital Image Analysis is a process that converts the digital image into something other than a digital image, such as a set of measurement data, alphabet text, or a text. Image digitization is a process that converts a pictorial form to a numerical data.

III. TYPES OF DIGITAL IMAGE

Basically three types of digital images are:-
1) Grayscale Images
2) True color images
3) Binary Images

A. Grayscale Images

Grayscale images can be represented as binary images in three dimensional spaces, with the third dimension representing the brightness. Grayscale Image can be viewed as three dimension surface, with the height at each point equal to the brightness value. A black and white images is made up of pixels, which carried out a number equivalence to the gray level of the images at that specific points. It is defined as black-and-white are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest. For unit 8, value range from [0,255].For unit 16 vale range from [0, 65535]. For int 16 the value ranges from [-32768, 32767].

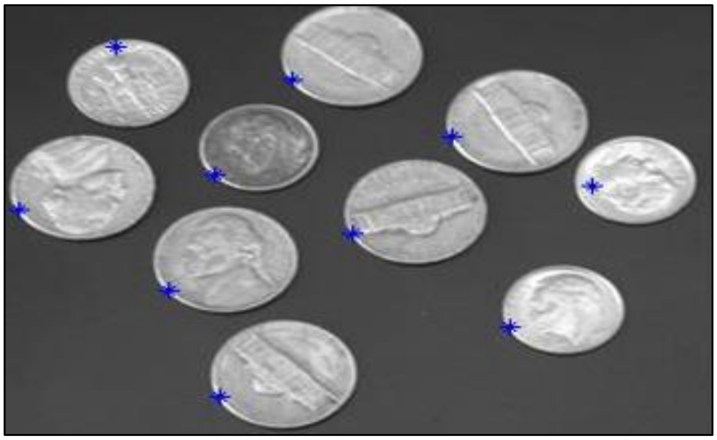

Fig. 1: GrayScale Image

B. Color Images

A true color image is that in which each pixel is specified by three values one each for red, green, blue component of pixel color. MATLAB stored the true color images as m by n by three data array that defined as red, green, blue component for each individual pixel. True color images do not use a map color. The color of each pixel is determined by the combination of red, blue, green intensities stored in each color plane at the pixel's location. True color images do not use a map color. The color of each pixel is determined by the combination of red, blue, green intensities stored in each color plane at the pixel's location.

C. Binary Images

Binary Images use only a single bit to represent each pixel. Since a bit can only exist in two states- on or off, every pixel in a binary image must be one of two colors, usually black and white. Binary images are produced from color image by segmentation. Segmentation is defined as the process of assigning each pixel in the source image to two or more classes. If there are more than classes then the usual results is several binary images.

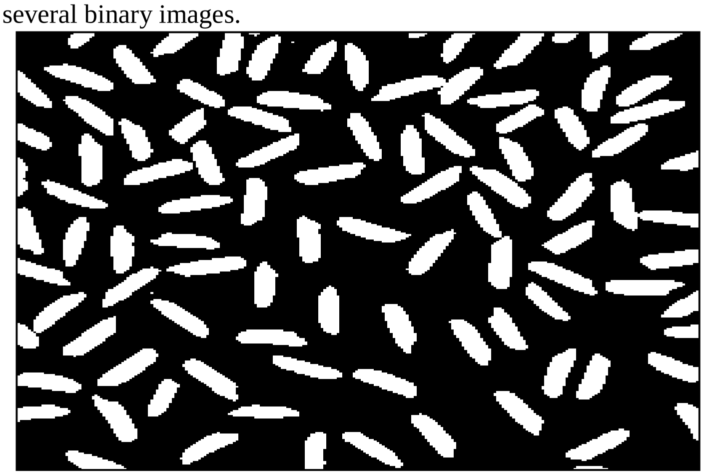

Fig. 2: Binary Image

IV. FUZZY IMAGE ENHANCEMENT TECHNIQUE

1) Spatial domain methods.
2) Frequency domain methods (DFT).
3) Fuzzy Domain.

A. Spatial Domain Methods
Spatial domain methods these are directly applied on the image pixels. Spatial domain method pixel values may be modified according to rules that depend on the original pixel value (local or point processes). Although, pixel values are compared with the neighbors pixels of the image in many of the methods. Consider the input image f(x, y) and processed image g(x, y) then the transformation g(x, y)=T[f(x, y)], Where T is an operator on f defined over some neighborhood of (x, y). The operator T is applied at each location (x, y) to yield output g at that location. The process uses pixels in the area of image spanned by neighborhood [16]. Example: Thresholding.

B. Frequency Domain Method
Frequency domain which operate on the Fourier transform of an image. Edges and sharp transitions (e.g., noise) in an image contribute significantly to high-frequency content of Fourier transform.
Low frequency contents in the Fourier transform are responsible to the general appearance of the image over smooth areas.
The concept of filtering is easier to visualize in the frequency domain. Therefore enhancement of image f(x, y) can be done in the frequency domain based on DFT. This is particularly useful in convolution .if the spatial extent of the point spread sequence h(x, y) is large then convolution theory.
g(x, y)=h(x, y)*f(x, y)
Where g(x, y) is enhanced image.

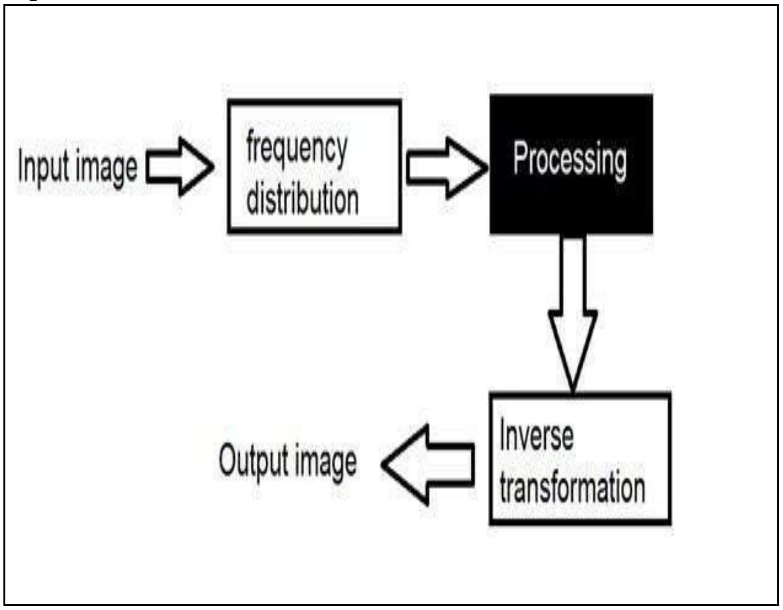

Fig. 3: Diagram of Frequency Domain Method

C. Fuzzy domain
Fuzzy set theory is thus useful in handling various uncertainties in computer vision and image processing applications. Fuzzy image processing is a collection of different fuzzy approaches to image processing that can understand, represent, and process the image. they can be following first is fuzzification and then membership function apply after that defuzzification process can be applied on that. Fuzzy image enhancement is based on gray level mapping into membership function. The main aim that an image of higher contrast than the original image by giving a larger weight to the gray levels that are closer to the mean gray level of the image that are farther from the mean.

V. IMPLEMENTATION

In classical set theory, a set is to define as a collection of numerous elements having a certain property, each belongs to the set. So the characteristic function takes the value of either 0 or 1.
Let us consider a classical set X, called universe whose elements are denoted by x , that is , X={x1,x2……….xn). Consider a subset A of set X is a member of A if
µA(x) =1 if x €A
µA(x) =0 otherwise
So Fuzzy set A is defined as
A={(x, µA(x) : x€X})
Where µA(x) is a membership function for a fuzzy set. Examples of membership functions are shown in Fig. 4:

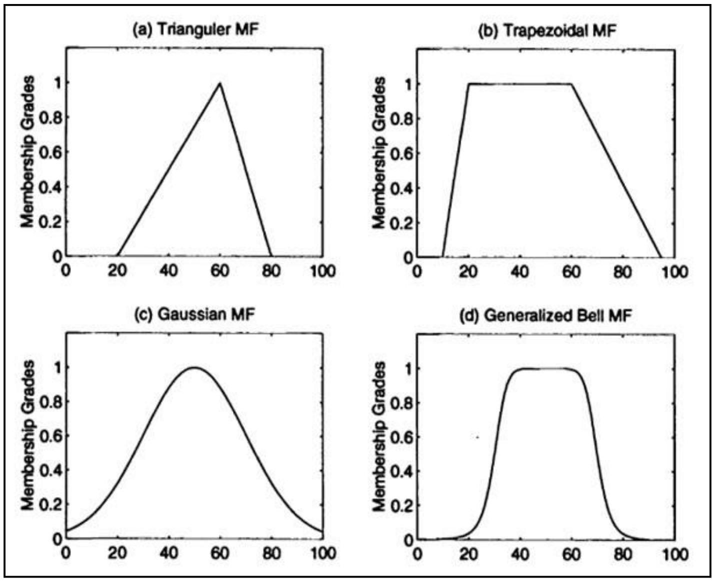

Fig. 4: Membership Functions Examples

Fuzzy image process is that assortment of approaches that facilitate to know, represent, and process the images and their options within the kind of fuzzy sets. The theory of Fuzzy image processing is used here, which can be divided into three phase–

- image fuzzification,
- membership value modification,
- Defuzzification of enhanced image.

Image Fuzzification and Membership modification are the main steps of Fuzzy Image Enhancement. Therefore, the conversion of image data into fuzzy data and then decoding of the results back into image data are steps that process images with fuzzy techniques. The steps for Fuzzy Image Enhancement Technique are shown in Fig. 5:-

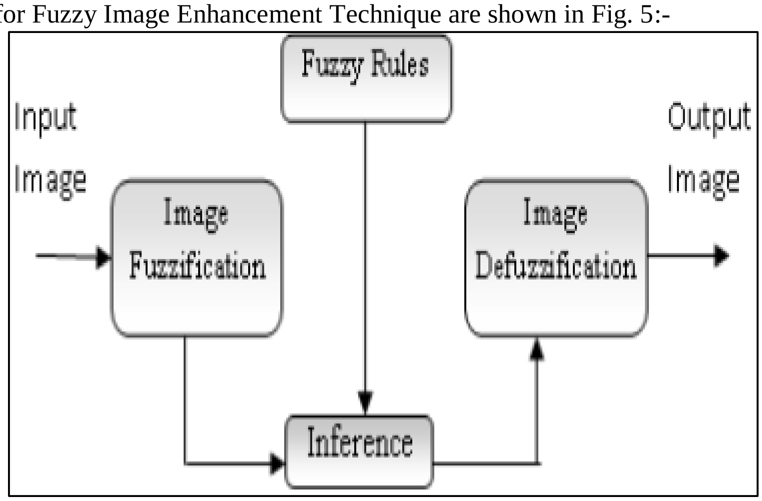

Fig. 5: Fuzzy Image Enhancement Technique

The three main basic steps of Fuzzy Image Enhancement can be explained as:-

A. Image Fuzzification

Gray Level Intensities of image are mapped into a fuzzy plane using a membership transformation function. Gray values lies in range of [0 255]. The aim is to transfer these values in range of 0 and 1.Gray level Intensity values lies in range={0,1,2,3……254,255}

Bright membership degree is calculated using following formula:

BM=Bright Membership Degree

BM = intensity_of_graylevel/255

So BW ={0,0.0039,………………..,1}

Dark membership degree is calculated using following formula:

DM = Dark Membership Degree

DM = 1 - (intensity_of_graylevel /255)

So DW={1,0.9960,…………………,0}.

B. Fuzzy Membership Modification

To enhance the quality of image, we need to modify the values of the pixel and this can be done by making dark pixels more darker and bright pixels more brighter. Membership modification algorithm can be expressed as:- if(BM <= 0.5)
input = 5*(BM)3;
else
input =1-5*(1 - BM)3
where BM is bright membership degree and input is modified membership degree.

C. Image Defuzzification

Image Defuzzification is inverse transformation in which the proposed algorithm maps the fuzzy sets back into gray level intensities in the range of [0 255].
BM values = {0,0.0039,………………..,1}
DM values= {0, 0.0039,………………..,1}
Gray level intensity = BM*255
OR
Gray level intensity = (1-DM)*255

VI. ALGORITHM USED

Step 1:- Read Grayscale image I and also find the size of image in terms of rows and columns [m n]
Step 2:-Crop the image and new image is d.
Step 3:- Find maximum and minimum intensity of I
mx = max(max (d)
mn = min(min(d))
Step 4:- Fuzzification
One image function μ_{mn} can be calculated as:-
μ = (d – mn)/(mx-mn)
where mn ,mx , d denotes minimum gray and maximum gray and any gray level.
Step-5:- Membership Modification
Define all the pixels (i,j)th inside the image
For i=1:m
For j=1:n
If((μ (i,j) >= 0)&&(μ (i,j) <= 0.5))
input (i,j) = 5*μ(i,j)^3
Elseif ((μ (i,j) > =0.5)&&(μ (i,j) <= 1))
input (i,j) =1-5*(1-μ(i,j))^3
end
Step-6 Defuzzification (if necessary)
Now convert fuzzy data into grayscale enhanced data.Set maximum intensity and minimum intensity for enhanced image.
maxI = 255 , minI = 0
For i=1:m
For j=1:n
if (d(i,j) <= mn)
enhanceimage(i,j) = 0
else if ((d(i,j) > mn)&&(d(i,j) < mx))
enhanceimage(i,j) = (maxI – minI)*input(i,j) +minI
else
enhanceimage(i,j) = 255
end
The proposed algorithm is compared for more than 5 images with some existing methods. On the basis of PSNR value we find that the proposed algorithm gives much better result.

VII. COMPARISON & RESULTS

To evaluate the performance of the presented approach several experiments have been conducted. The proposed Fuzzy technique is able to improve contrast of original image and is compared with some other existing technique using PSNR value The proposed algorithm has been tested on several grayscale images and the result has been compared with other existing methods. Fig. 6, Fig.7,

Fig.8 shows some experimental results. (a) is original image , (b) shows enhanced image by Histogram Equalizations Technique, (c) shows Adaptive Histogram Equalization technique ,(d) shows the enhanced image by proposed algorithm in this paper.

Fig. 6 (a)

Fig. 6 (b)

Fig. 6 (c)

Fig. 6 (d)

Fig. 6: Pout

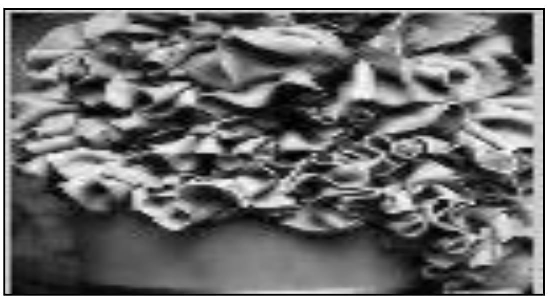

Fig. 7 (a)

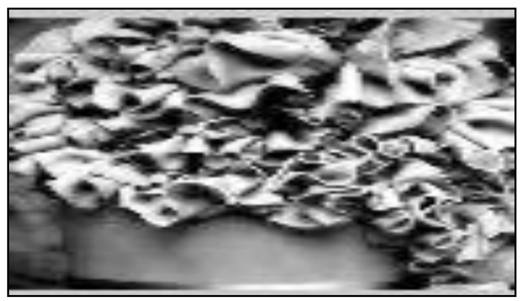

Fig. 7 (b)

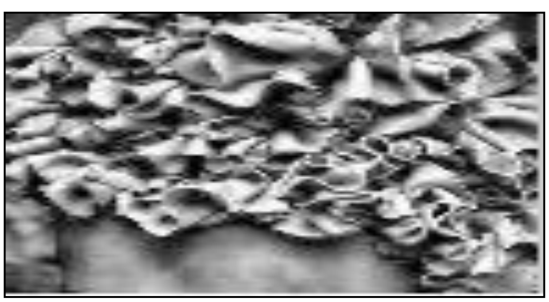

Fig. 7 (c)

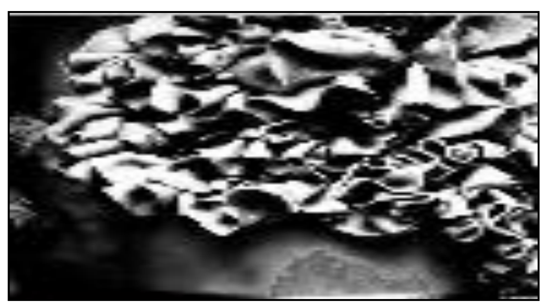

Fig. 7 (d)

Fig. 7: Cake

PSNR can be calculated using the mathematical models/formulas in Equations below. First MSE is calculated using the following equation:

$$MSE = \frac{i}{mn}\sum_{i=0}^{m-1}.\sum_{j=0}^{n-1} I(i,j) - K(i,j)^2$$

Where MSE is the Mean Squared Error of $m \times n$ grayscale images I and K, where one of the images is considered a noisy approximation of the other, where lower is better. Thereafter, PSNR can be calculated using the following equation:

$$PSNR = 10.\log_{10}\left(\frac{MAX_i^2}{MSE}\right) = 20.\log_{10}\left(\frac{MAX_i}{\sqrt{MSE}}\right)$$

Where, MAX_i is the maximum pixels value of the image. In other words $MAX_i = 2^b - 1$, where b is the bit depth of the original image (e.g., MAX_i = 255 in the case of 8 bits depth grayscale images).

VIII. CONCLUSION

The proposed technique is able to improve contrast of image which is a developing technique in artificial intelligence. This technique is able to give more accurate result and produce more value of PSNR. The proposed method is tested for several images which shows that the proposed technique produce better result as compare to other existing enhancement technique.

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