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A New Approach in a Gray-Level Image Contrast Enhancement by using Fuzzy Logic Technique

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ABSTRACT

Fuzzy Logic technique represents a new approach for gray level image contrast enhancement. The image contrast problem is one of the main problems that confront the researchers in the field of digital image processing, such as in the biomedical image processing like X-Ray and MRI image segmentation for disease classification. In this paper, presenting a new approach to enhancing the image contrast by using fuzzy logic algorithm, so based on the fuzzy rule, we present a new membership equation, which represents the variable threshold level. The proposed method we named it (Fuzzy Hyperbolic Threshold). By using Matlab was implemented the algorithm, and applied to difference gray level images such as old documents images, biomedical images, most of them gives very good results especially with the biomedical images, because of its significant impact on the adjustment of lighting in dark images, clarify its edges, clarify their features and improved image quality.

Keywords
Image Contrast Enhancement; Fuzzy logic; Fuzzy Hyperbolic Threshold; Intelligent Techniques.

I. INTRODUCTION

In recent years, was an increased to deal with digital images due to the availability of advanced technology that makes easy dealing with the images in the computers. In general, the working principle of digital image capture devices depends on the conversion of light into electrical charges (electrical signals), and then converts the electrical signals into a series of numbers, such as (zeros and ones) to represent all the colored dots in the image and save it as a digital file on the computers [1, 2]. The term Contrast is the amount of the difference between the different lighting for image elements. However, the ratio between the objects lighting and floor lighting objects that fall on objects [3]. The vision system in the human eye responds to a wide range of lighting levels, this response has varied depending on the rate of observed lighting, which specified by a two thresholds for the darkness and the brightness. Therefore, the light densities that are less than darkness threshold be very dark, so be invisible, and the light densities that are more than the brightness threshold be very luminous, where it is difficult to distinguish the image details [4, 5]. In the computers, the digital images are represented as a two dimensional array, and each element in this array is representation of light intensity of dot called a pixel. In addition, there are three main types of digital image, which is a binary image, gray level image and colored image [6].

With the progress in digital technology to capture images, the users and researchers in particular, they had been confronting a bad contrast problem, it is one of the main problems in the image processing field, therefore, began a need to improve some of the images that tainted by lack of clarity when capture images [7, 8]. The reasons due to the misuse of devices, use a not good and undeveloped device and sometimes, other reasons give bad images, like lack of proper lighting, such as cloudy weather, bright light, dark locations or take the picture from a distance, all these reasons leading to blurred image details and blurred colors in it [9].

FUZZY SYSTEM

Fuzzy systems are made of a knowledge base and reasoning mechanism called fuzzy inference system. A fuzzy inference system combines fuzzy if-then rules into a mapping from the inputs of the system into its outputs, using fuzzy reasoning methods. That is, fuzzy systems represent a nonlinear mapping accompanied by fuzzy if-then rules from the rule base. Each of these rules describes the local mappings. The rule base can be constructed either from human expert or from automatic generation that is extraction of rules using numerical input-output data [10, 11]. A fuzzy inference system (FIS) consists of four functional as shown in Figure 1.

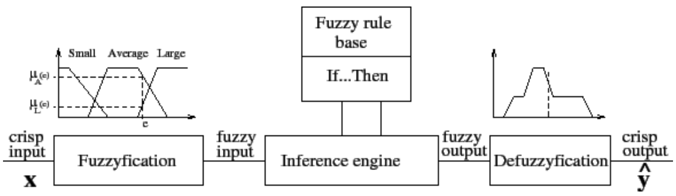

Figure 1: Fuzzy Inference System

- **Fuzzification:** transforms the crisp inputs into degrees of match with linguistic values.
- **Knowledge base:** consists of a rule base and a database. A rule base contains a number of fuzzy if-then rules. A database defines the membership function of the fuzzy sets used in the fuzzy rules.
- **Fuzzy inference engine:** performs the inference operations on the rules.
- **Defuzzification:** transforms the fuzzy results of the inference into a crisp output.

IMAGE ENHANCEMENT BY USING FUZZY LOGIC TECHNIQUES

Fuzzy logic is used to improve digital images this is because some of the images suffer from the ambiguity chromatography when processed in the classical methods, because they contain fogginess in the original. In addition, when processing a color of the pixel, there are two questions appear, which is it a color value of the current pixel becoming darker or brighter than the past? And what are the thresholds for the darkness and the brightness? Therefore, using fuzzy logic technique to improve the digital image, is a very appropriate for such that things. The fuzzy logic methods differ in the processing on how to choose suitable the membership function to obtain the desired results, but all fuzzy logic methods are sharing in a processing of various subjects at three basic stages, which is Image Fuzzification, Membership Modification and Image Defuzzification. Figure 2, Illustrates the stages of image processing using fuzzy logic.

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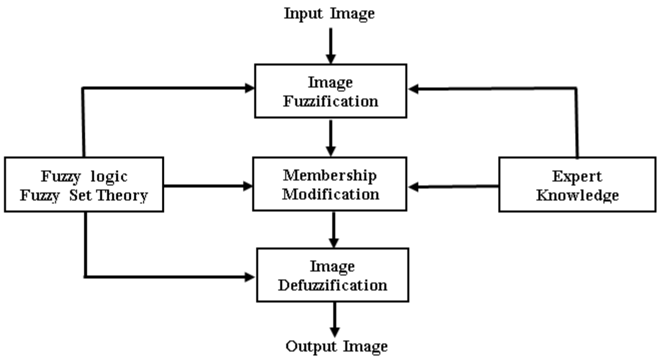


Figure 2: Block Diagram of The Proposed Technique

Membership function is selected or designed according to the desired application. For improving the contrast was used membership function that gives a degree of affiliation to the dark elements close to the (0), so do not reach to any bright element. Similarly, for the bright elements, they are gradually increases until reaches to close to the (1) or bright elements. And for the other elements, they are taking an affiliation degree between the (0, 1) which be an affiliation partly with group. Figure 3, Illustrates the results from a grayscale image processing and the same principle is applied to the color image.

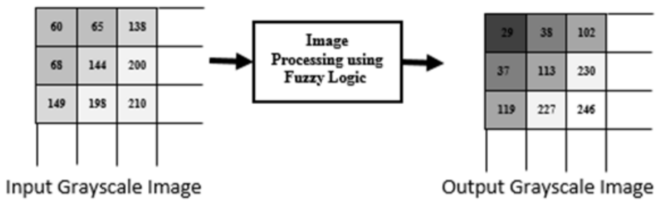


Figure 3: the process of improving the contrast in images using fuzzy logic

In this paper, was used three methods of fuzzy logic to improve the contrast, which is a Fuzzy Histogram Hyperbolization Method, Intensification Operator Method and Fuzzy Expected Value Method, and then compare the results obtained from these methods with the results from our proposed method, which named Fuzzy Hyperbolic Threshold Method.

II. METHODS AND MATERIAL

The procedure steps of proposed method including calculating the new membership function equation for the fuzzy logic for image enhancement technique has explained below. In the procedure steps we have two membership function equations 2 and 3, which are depending on the two factors, the first is a current pixel value and the second is the value of α. The value of α is a selecting by users between (0, 2), and setting it depending on the vision of the users for the resulting image. These steps are as follows:

- Read Image, *Img (r, c).*
- Find the following parameters:
  Maximum level *Max(Img)*, Minimum level *Min(Img)* and Middle level *Mid(Img)*.
  $$.Mid(Img) = \frac{Max(Img) + Min(Img)}{2} \quad \ldots 1$$
- Set *(α)* Between the Range (0, 2).
- Calculate the membership function value $m(r\ ,c)$ as the follows :

  For *Img(r, c) >= Mid(Img)*

  $$m(r,c) = 0.5 * \left[\frac{Img(r,c) - Min(Img)}{Max(Img) - Mid(Img)}\right]^2$$

  ….2

  For *Img(r, c) >= Min(Img) and Img(r, c) < Mid(Img)*

  $$m(r,c) = 1 - \left[2 * \left(\frac{Img(r,c) - Max(Img)}{Max(Img) - Mid(Img)}\right)\right]^2 \quad \ldots 3$$

- Modify the membership value where

  $$m'(r,c) = m(r,c)^{\propto} \quad \ldots 4$$

- Set the new pixel value as the following:

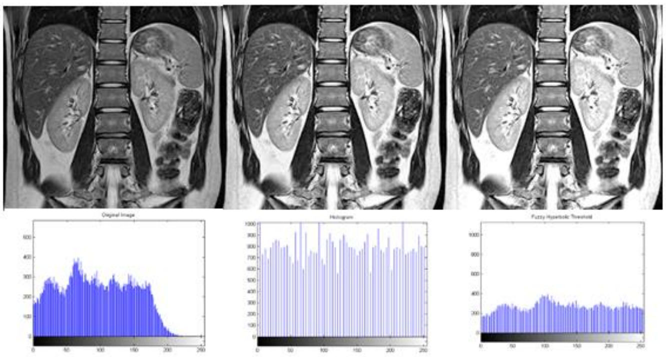
  $Img'(r, c) = m'(r, c) * Img(r, c)$ …5

- Repeat as at the last above three steps, for each pixel in the image.
- Show the new image *Img'(r, c).*

III. RESULTS AND DISCUSSION

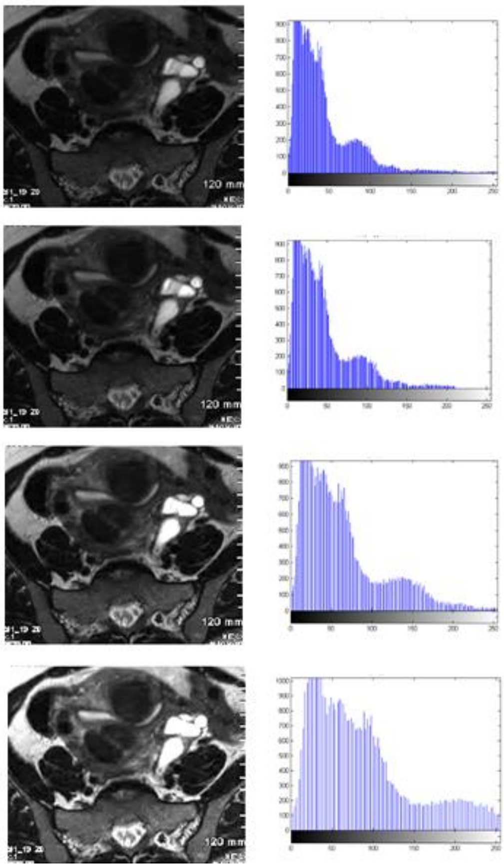
The proposed method results had been compared with the other contrast enhancement methods of a different selected digital image such as a scanned ECG image, X-ray images, MRI images, medical ultrasound images and other different images, as shown in the below figures. Can see the results through the difference in the contrast of the images, also through a new distribution of a gray level in the resulting images.

In figure 4, the results of the contrast enhancement in the MRI image show that a proposed method is much clearer (high quality contrast) compared with the Histogram contrast enhancement method. In this result, set α value to 1.5.



a) Original image b) Improved by Histogram Equalization image c) Improved by proposing method image

Figure 4: Medical MRI Image with them histogram diagram



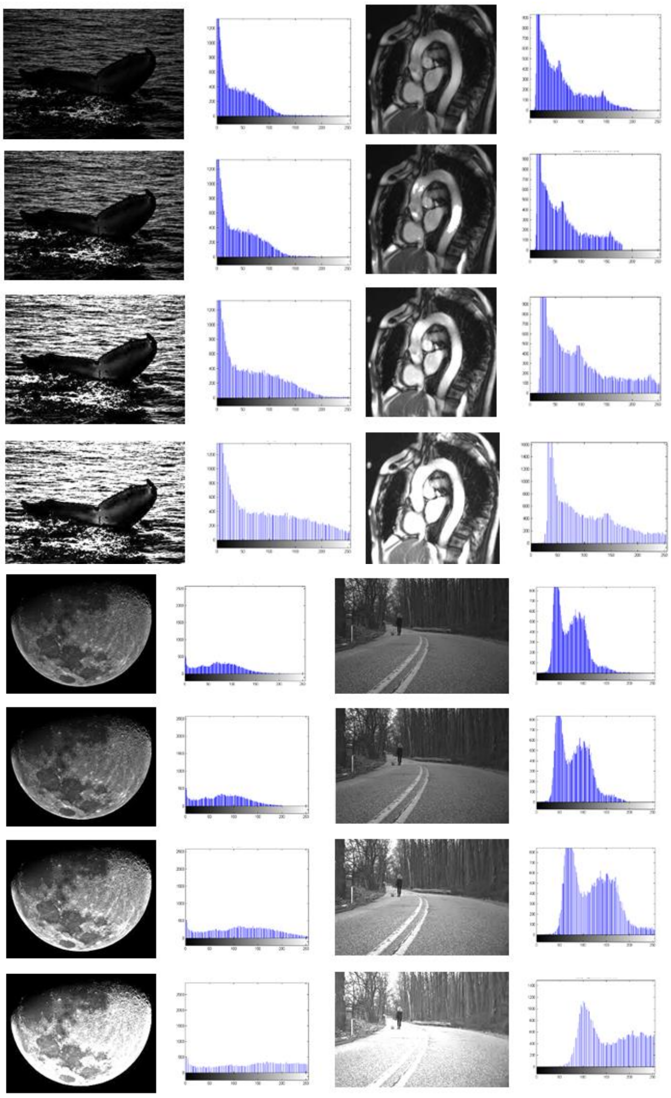


Figure 5: The results of different type of images with them histogram diagram, which is from the up to down are, Original images, improved by proposing method with α set to 0.1, 0.6 and 1.2 respectively.

In the figure 5, we present the results of gray level contrast enhancement for different images, for each one of them we selected three different values for α, which is 0.1, 0.6 and 1.2 respectively. The goal from that is to show the effects of α on the contrast for the resulting image.

IV. CONCLUSION AND RECOMMENDATIONS

There are many different types of contrast enhancement methods. In addition, there are different types of digital images. Therefore, There is no a general method that uses on all types of images. According to that, the method that is applied for the one of the image types, may be do not give good results when used with another type of images. Therefore, it is difficult to determine the general and the absolute algorithm for all kinds of images, but we have noticed by searching the following:

The performance measurement processes to improve the contrast in the images depends on several characteristics, such as the value of contrast in the image, the contrast in the local density of the image and the ratio of white to black. These characteristics can be used as tools to evaluate improvement, as well as, from observation the new distribution of colors on the level of the image, as it is needed and the acceptance of the image by the user or the application is the best measure.

In general, the contrast enhancement process in the images is Global Enhancement or Local Enhancement, each one have been advantages and disadvantages, but the disadvantage of the local enhancement processing is some noise appearance in the resulting image. The advantage of the proposed method, it increased the sharpness of the image details and show the edges well and kept the original colors of the image. But sometimes the resulting image looks little darker when compared with some other methods, the result varies depending on the nature of the image colors.

We recommend using the proposed method on the picture dark and medical images for maintaining colors.

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