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Soft Computing Approach for Image Contrast Enhancement for Improving Image Visuality

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***Abstract*—** The image enhancement is the well-known concept among the researchers as in the area of image enhancement a lot of work has been done by several authors but also more amendments can be done. In the image enhancement method not only a large number of techniques but also some ways to enhance the image are existed. The contrast enhancement or to improve the brightness of the image is one of the way to improve the quality of the image. This study develops a new approach for image contrast enhancement by considering HSI colour model and fuzzy inference system to improve the intensity of the image pixels. The simulation is done by taking a set of four different images into an account. The simulation results with respect to the Detail Variance and Background Variance of the images describes that the proposed work performs outstanding comparative to the traditional methods that are GLE, Enhanced AHE and original image.

***Keywords*—** Image Enhancement, Contrast Enhancement, Color Model, HIS Model, Fuzzy Inference Model

I. INTRODUCTION

The contrast enhancement is the most important phase of the image processing. The difference of brightness between the object and the background is enhanced in the process of contrast enhancement. The contrast enhancement is done in two consecutive ways [1]. In the first way, the difference of the brightness across the image dynamic range is enhanced and this way is called contrast stretch [2]. After contrast stretch the difference of the brightness between the dark, grey and bright region is enhanced this is termed as tonal enhancement [3]. Following are the techniques used to enhance the contrast of the image. This part remains a major concern for research and researchers are still working to find more efficient and optimum methods of contrast enhancement [4]. Histogram Equalization is the most effective technique of contrast enhancement and is commonly used for image enhancement [5]. The high performance and simplicity of HE technique makes it better than other techniques used for contrast enhancement. This technique is applicable for almost all types of images. Researchers have tried to improve this technique even more, for example the introduction of Adaptive Histogram Equalization technique, which can enhance the local contrast of the image [6]. In order to enhance the images, a new technique called mathematical morphology is utilized.

In image enhancement, the contrast plays a very important role in determining the details in the image [7]. To enhance the contrast of the image, the characteristics of the image are enhanced. Images are sometimes unclear/dark, these kinds of images are made brighter and clearer by enhancement of contrast of these images [8]. The contrast enhancement makes images much more clear and details from the images can easily be obtained. This technique of image enhancement is widely used in medical image enhancement where even minute detail is very crucial [9]. X-Ray defines the skeletal structure of the body. X-Ray images are used to determine the fractures in the bon but these images are very low in contrast [10]. Contrast enhancement extracts the details from the images and amplifies them so that every minute detail will becomes easily visible [11].

This paper is organized in three sections. In the Section I the brief introduction of the Contrast enhancement and the Image enhancement is given. The Section II of the paper is the Implementation in which the comparison results of the traditional and proposed method are explained. The III Section offers the Conclusion of the proposed work and also the future directions are provided in the last in this section of Conclusion.

II. IMPLEMENTATION

The traditional contrast enhancement mechanism implements the collaboration of local and global equalization technique but still it was less efficient and LHE

and GHE has their own limitations. Thus the present study implements the HSI model along with fuzzy based image enhancement mechanism. The hue and intensity domain of IHS is passed to fuzzy logics and after that the fuzzy based hue and intensity is combined with saturation of and thus the finalized improved and enhanced image is received. The fringe of the proposed work is that it overcomes the backlog of both global and local histogram equalization and also it incurs less computation cost.

Step 1: First step is to select an input image for further processing. The input image can be a RGB or greyscale image.
Step 2: After inserting the image, next step is to convert the input image to IHS format. Following formulation is used for conversion. First of all the RGB normalization is done to convert the image.

$$r = \frac{R}{R+G+B}, g = \frac{G}{R+G+B}, b = \frac{B}{R+G+B} \dots\dots (1.1)$$

Following normalized HIS component is observed:

$$h = \left\{\frac{0.5[(r-g)+(r-b)]}{[(r-g)^2+(r-g)(g-b)]^{1/2}}\right\} h \in [0,\pi] for\ b \leq g \dots \quad (1.2)$$

$$h = 2\pi - cos^{-1}\left\{\frac{0.5[(r-g)+(r-b)]}{[(r-g)^2+(r-g)(g-b)]^{1/2}}\right\} h \in [0,2\pi] for\ b > g \dots \quad (1.3)$$

$$s = 1 - 3.min(r,g,b); s \in [0,1] \dots. \quad (1.4)$$

$$i = \frac{R+G+B}{3.255}\ \ i \in [0,1] \dots\dots. \quad (1.5)$$

Step 3: Apply Fuzzy Equalizer to the intensity to obtain the new value of intensity.
Step 4: Convert image of IHS format to RGB format by applying following formulation:

$$h = H.{}^{\pi}/_{180} \dots. (1.6)$$

$$s = {}^{S}/_{100} \dots\dots (1.7)$$

$$i = I/255 \dots.. (1.8)$$

$$x = i.(1-s) \dots\dots (1.9)$$

$$y = i.\left[1 + \frac{s.cos(h)}{cos(\frac{\pi}{3}-h)}\right] \dots.. (1.10)$$

$$z = 3i - (x+y); \dots\dots (1.11)$$

$$When\ h < \frac{2\pi}{3}, b = x, r = y, g = z\ and\ when\ \frac{2\pi}{3} \leq h < \frac{4\pi}{3}, h = h - \frac{2\pi}{3}\ and\ r = x, g = y, b = z\ and\ when \frac{4\pi}{3}, h = h - \frac{4\pi}{3}, g = x, b = y, r = z$$

Step 5: Final Enhanced Image is obtained.
Step 6: Perform Performance Evaluation by measuring performance parameters.

This study performs the contrast enhancement to increase the quality of the image. For the purpose of contrast enhancement, the concept of HSI model and fuzzy inference system is applied. This section depicts the results that are obtained after implementing the proposed work in MATLAB. For the purpose of image contrast enhancement, the image is an important part. Thus, the first step is to enter the image to the proposed system. For this purpose three different images are used. In proposed work, the image of pout is considered as an input image. After entering the image, the image is converted to the HSI image. The HSI conversion is fully explained in methodology section of this work.

After converting the format of the image the fuzzy inference system is designed to optimize the intensity of the image. The proposed fuzzy inference system takes an input i.e. Pixel value.

The proposed fuzzy inference system implements MAMDANI fuzzy system and generates an output membership function on the basis of a single input membership function. To obtain the output, the system implements the set rules (2 rules). After receiving the final enhanced image, the performance of the proposed work is evaluated Detail Variance (DV) and Background Variance (BV) DV and BV is a performance matrix that is used to evaluate the level of enhancement in an image. This is evaluated by using local variance of n adjacent pixels from all images. To evaluate DV and BV, first of all, a variance matrix is created. Then each pixel is divided into two classes and the variance of each pixel is compared with the defined threshold value. If the variance is greater than the threshold value then the pixel is considered to be related with the image foreground else it is related to the image background. After classifying the pixel, the mean variance of belonging pixels is calculated and termed as DV and BV. It is necessary that the value of DV and BV should always high. The table 1 shows the observations of graph.

Table 1 Comparison for DV (Cameraman Image)

S.No	Technique	DV
1.	Proposed Work	10.9
2.	GLE (Global Local Image Enhancement)	7.6
3.	Enhanced AHE (Adaptive Histogram Equalization)	4.4
4.	Original Image	2.7

The graph in table 2 shows the comparison of BV for image of cameraman. The comparison is done among proposed,

GLE, Enhanced AHE and original image. The table 2 shows the facts and figures that are obtained after analyzing the comparison.

Table 2 Comparison for BV (Cameraman Image)

S.No	Technique	BV
1.	Proposed Work	10.9
2.	GLE (Global Local Image Enhancement)	6.4
3.	Enhanced AHE (Adaptive Histogram Equalization)	4.1
4.	Original Image	2

The graph in table 3 shows the DV comparison for image of pout. The comparison table explains that proposed work outperforms the other techniques. As the DV of pout in proposed work is 6 whereas the DV for GLE is 4.1, enhanced AHE is 4 and for original image it is 2.7.

Table 3 Comparison for DV (Pout Image)

S.No	Technique	DV
1.	Proposed Work	6
2.	GLE (Global Local Image Enhancement)	4.1
3.	Enhanced AHE (Adaptive Histogram Equalization)	4
4.	Original Image	2.7

The comparison for BV of pout image is presented in figure table 4 shows the values corresponding to the proposed work, GLE, Enhanced AHE and original image.

Table 4 Comparison for BV (Pout Image)

S.No	Technique	BV
1.	Proposed Work	5.99
2.	GLE (Global Local Image Enhancement)	3.4
3.	Enhanced AHE (Adaptive Histogram Equalization)	3.2
4.	Original Image	2.6

The DV and BV for image of moon is shown in table 5and 6. On the basis of the tables it is concluded that the DV and BV of proposed work is high for image of moon in comparison to other techniques and original image.

Table 5 Comparison for DV (Moon Image)

S.No	Technique	DV
1.	Proposed Work	10.5
2.	GLE (Global Local Image Enhancement)	3.6
3.	Enhanced AHE (Adaptive Histogram Equalization)	3.5
4.	Original Image	3.4

Table 6 Comparison for BV (Moon Image)

S.No	Technique	BV
1.	Proposed Work	10.5
2.	GLE (Global Local Image Enhancement)	3.3
3.	Enhanced AHE (Adaptive Histogram Equalization)	3.3
4.	Original Image	2.59

The Detail Variance and Background Variance for image tier are shown in table 7 and 8. The DV and BV for image of tier that observed in proposed work is compared with the DV and BV of same image in GLE, enhanced AHE and original image. The proposed work outperforms in both cases with respect to the rest of the traditional techniques. The tables comprised of vales corresponding to the proposed work, GLE, enhanced AHE and original image. In all cases the DV and BV of proposed work is better than the other mechanisms.

Table 7 Comparison for BV (Tier Image)

S.No	Technique	BV
1.	Proposed Work	9.26
2.	GLE (Global Local Image Enhancement)	3.5
3.	Enhanced AHE (Adaptive Histogram Equalization)	2.5
4.	Original Image	0.6

Table 8 Comparison for DV (Tier Image)

S.No	Technique	DV
1.	Proposed Work	9.26
2.	GLE (Global Local Image Enhancement)	5.2
3.	Enhanced AHE (Adaptive Histogram Equalization)	2.9
4.	Original Image	3.3

CONCLUSION

A contrast enhancement process is proposed in this work by employing the IHS image format and fuzzy inference system to extract the hue, saturation and intensity of the image. After that the Fuzzy inference system is applied to the observed Intensity values to optimize these intensity values. Therefore, in this way, the more enhanced image with improved contrast is obtained. By using two different performance matrices that are Detail Variance and Background Variance the performance of the proposed work is calculated. From the simulations it has been concluded that the proposed work performs well comparative to the traditional methods that are GLE, Enhanced AHE and Original image. By taking the four different images into an account the performance evaluation is accomplished.

The present work implements the single colour model i.e. IHS model to improve the contrast of the image. Wherever, in future the present system can be enhanced by implementing multi colour model such as YCbCr. Along with this the different hybridization of contrast enhancement techniques are also possible.

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