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Contrast Enhancement of Colour Images by Optimized Fuzzy Intensification

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ABSTRACT- Contrast enhancement is a critical and difficult issue because inappropriate enhancement by existing global image enhancement techniques might result in over or under enhancement. Varying areas of the image that are lighted indicate different shades and contrast in the output images. Projected technique uses local colour correction in the Hue Saturation Luminance (HSL) colour space. To control colour fidelity in initial phase an optimized fuzzy intensification parameters are extracted automatically form fuzzy inference system for that particular image. Finally optimized Fuzzy Intensification parameter constants are used to minimize overexposed and underexposed areas and offers elevated contrast improvement. Several lab test conducted to analyze the effectiveness of the proposed method with existing strategies. Many quality evaluation parameters are evaluated, and findings are compared to some known colour picture contrast enhancement approaches. The produced output comparatively better than many existing techniques which support a moderate measure to visual perception of the processed images.

Keywords: Local Colour Correction, Fast Fourier Transform, Local colour correction, fuzzy intensification, Fuzzy inference system

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1. INTRODUCTION

Image enhancement is very popular area of image processing which aim is to convert the image in more acceptable viewing and have least distortion or noise. Many real life application areas like satellite imaging, geographical information system, criminal identification and tracing, medical diagnostics, astronomy and visual cryptography uses an enhanced image to achieve their target. Among many image enhancement techniques most of them are satisfying the need of particular area of application like removing blur, removing extra noise, increasing contrast, improving optimal lightness or luminance. Contrast is difference between highest and lowest intensity values of pixel. It differentiates image object with its background. Contrast depend upon many factors like camera quality, available illuminance, differentiating power of human eye and surrounding environment etc. Often resultant image is not providing sufficient details which exhibit unnatural look due to washing out some part of image.

Contrast improvement algorithm tries to remove all obstacle mentioned above and also provide optimum contrast [1, 2]. Two fundamental and direct contrast measure [3, 4] algorithm are Michelson Contrast Measures and Weber Contrast Measures which can be used for periodic pattern or uniform luminance background. HE technique suffers from over or under enhancement and also produces unwanted artifact in bright regions. Adaptive Histogram Equalization (AHE) [5], Dynamic Histogram Equalization (DHA) [6] improves the performance to some extent on pixel level by using local histogram but fails on non-uniform illumination images. Many others Global Histogram Equalization (GHE) [7] algorithm such as, Brightness Preserving Bi-Histogram Equalization (BPBHE) [8], BPDHE [9], DSIHE [10] and MMBEBHW [11] [12] are sensitive to noise are not able to enhance up to a level.

To Increase the contrast of low lighting colour images Fuzzy Logic and Histogram (FLS) [12] based is better but the major drawback is that it fails to enhance dark images. An Averaging Histogram Equalization Technique (AVHEQ) [13] is provided for enhancement of contrast which controls the distortion and frequency offered in system but sometimes suffers from over enhancement.

Optimal Profile Compression and HE for colour images [14] is offered which maximize saturation operation. A specific method proposed named contrast limited adaptive histogram equalization with dual gamma correction [15] is used to boost the luminance and increase contrast of image. With the help of homomorphic decomposition an improved contrast is shown by Syed Zaheeruddin et al. [16] in uniform radiance images. B. Subramani and M. Veluchamy [17] presented quadrant dynamic clipped histogram equalization method using Gamma modification to reduce excess enhancement and contains more

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components. The proposed method has a high level of entropy, colourfulness, and saturation, as well as a smooth enhancement. R. Chandrasekharan et al. [18], has proposed a complex parametric variation for the differential enhancement of distinctly illuminated images with enhanced nature and preservation details.

Analysis results show that the algorithm takes lower calculation costs. Although Retinex is a colour photography technique, it still has issues with Gray-level refinement, distorted appearances, and strange colour reproduction. After reviewing the literature, we find that there are currently some possibilities for advancing in existing comparisons with the use of local colour correction and automatic enhancement of the image operator's capabilities through an abstract thinking system.

2. MATERIALS AND METHODS

The suggested model is simple and effective, and it addresses fundamental flaws in existing models. This is also my extended research of [19]. The proposed method's fundamental idea is to use the image after local colour correction in the Hue Saturation Luminance (HSL) domain and then apply the default automatic fuzzy intensification. Intensification operators are employed to manage the colour fidelity of the local colour correction images, allowing them to handle the problem of over-exposed and non-highlighted regions while also improving colour image contrast adjustment. The constant fuzzy intensification adjustment may not fit a particular image so the model has found the best reinforcement operator using an incomprehensible simulation system. A great deal of research has gone into determining the efficacy of the proposed strategy as well as the feasibility of comparing previous strategies.

Fuzzy Intensification operator is used to increase image contrast and reduce fuzziness. We need two parameters to measure operational strength operators. The first tau(τ) parameter defining the boundary operator. The second parameter is a membership function, which is required since the specified channel pixels modify the default distance between 0 and 1. Membership performance measures for any channel can now be obtained by equation (1).

$$fIc=([Ic-\min(Ic)])/(\max(Ic)-\min(Ic)) \qquad (1)$$

Where here c represents any colour red, green and blue and fIc represent membership function value for any channel red, green or blue. This way we calculate membership values. Now before processing the red, green and blue channel, image is passed to another function for calculating automatic fuzzy intensification operator by using fuzzy inference system.

Now role of τc {τR, τG, τB} is very crucial for calculating processed channel by intensification operator. We generally take the {τR, τG, τB} value as scalar but scalar values may not be appropriate for every types of images. Here we are proposing spontaneous cunning of {τR, τG, τB} values with the help of fuzzy inference system. Appropriate value of {τR, τG, τB} will lead to better enriched image and restore the novel content of image. *Figure 1* represent the proposed model for extracting automatic fuzzy intensification operator using fuzzy inference system.

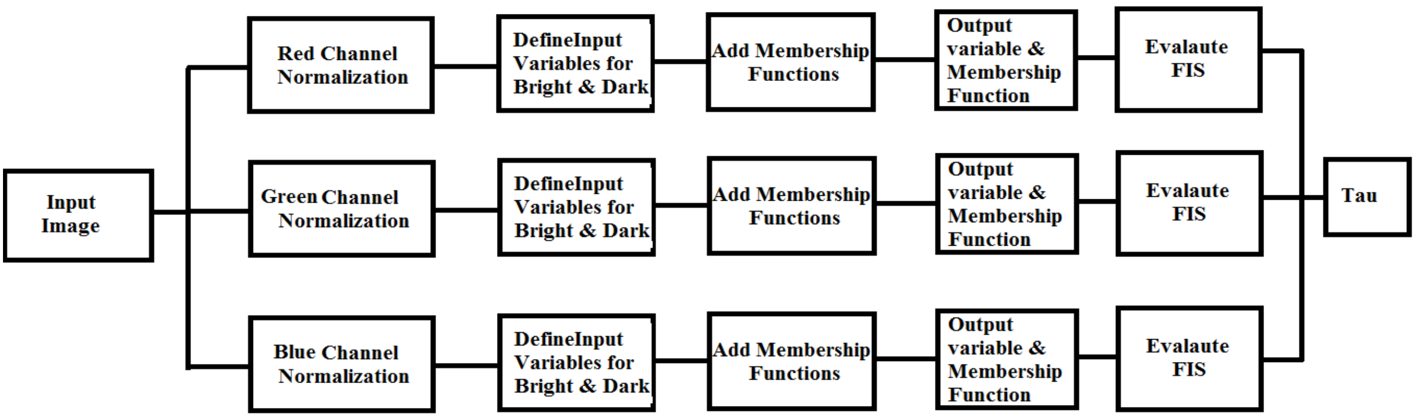

Figure 1. Automatic Fuzzy Intensification using Fuzzy Inference System

Algorithm: Automatic Fuzzy Intensification using Fuzzy Inference System

Step 1: Extract the Red, Green and Blue channel separately and normalize each channel for better input understanding by using equation (2)

$$Ir = Ir/255;\ Ig = Ig/255;\ Ib = Ib/255 \qquad (2)$$

Step 2: Define variable for bright and dark intensities for each normalize channel by using equation (3) and (4)

$$Td = addvar(Td, [Ir, Ig, Ib]\ D, [low, mid])\ \text{for dark} \qquad (3)$$
$$Tb = addvar(Tb, [Ir, Ig, Ib], B, [mid+1, high])\ \text{for bright} \qquad (4)$$

Where low=0, mid =0.5 and high=1

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Step 3: Add membership function for input defined variable by using Gaussian membership function by using equation (5) and (6)

Td = addmf(Td, [Ir, Ig, Ib], 1, zero, gaussmf, [sx, mid]) (5)
Tb = addmf(Tb, [Ir, Ig, Ib], 2,zero, gaussmf', [sy, high]) (6)

Step 4: define output variable and find out membership function by using equation (7) and (8)

Td = addmf(Td,output,1,dark,trimf,[wa, wb, wc]) (7)
Tb = addmf(Tb,output,1,bright,trimf,[ba, bb, bc]) (8)

Where wa = 0.0, wb = 0.2, wc = 0.4, ba = 0.6, bb = 0.7, bc = 0.9;

Step 5: By using above parameter and Fuzzy inference system an appropriate intensification operator $\{\tau R, \tau G, \tau B\}$ for the given image is calculated for each channel. Now by using $\{\tau R, \tau G, \tau B\}$, processed channel is calculated by formula (9)

$$kIc = \begin{cases} 2*(fIc(〚x,y))〛^{(2)} & \text{if } fIc(x,y)<\tau c \\ 1-2*(fIc(〚x,y))〛^{(2)} & \text{otherwise} \end{cases} \quad (9)$$

Where, τc is $\{\tau R, \tau G, \tau B\}$ for different colour channel and “kIc” is the processed channels by intensification operators for any channel red, green and blue. Formula (10) is used to observe the pixels of the output image.

$$uc = 〚(kIc)〛^{(\tau c+\xi)} \quad (10)$$

Where c represents any colour channel and “ξ” is the intensification tuning parameter, varies between 0 and 1. It also switches the actuality of hues in the image. Combining outcomes of different colour channels produces a colour image.

3. RESULTS AND DISCUSSION

The proposed framework was tested for contrast improvement in the CEED [20] and USD databases. Tests were performed on MATLAB R2018a on approximately 15 actual images from a database obtained from the CEED 2016 data for colour photographs. CEED features 15 photos, which include photographs that have been acquired as well as images that have been used by other specialists. All of the photographs in the database are true colour RGB images with 512x512 pixel height and width. The photographs include a variety of settings shot in varied lighting conditions both inside and outside, as well as landmark images such as Pepper and Barbara. Histogram Equalization [21], AGCWD [9], DHECI [22], Dong [23], AMSR [24], and JED [25] algorithms. The proposed framework receives a limited rating due to improved image visibility. An objective examination of any imaging process, measurement parameters used in most of the research activities. Some of the common concert steps that provide equal measurement of any image processing methods are MSE, LOE, PSNR, SSIM, NIQE, Colourfulness, Contrast and Entropy.

Following *Figure 2* shows the images of the results obtained using the various methods available and the proposed '*img13*' image from the CEED.

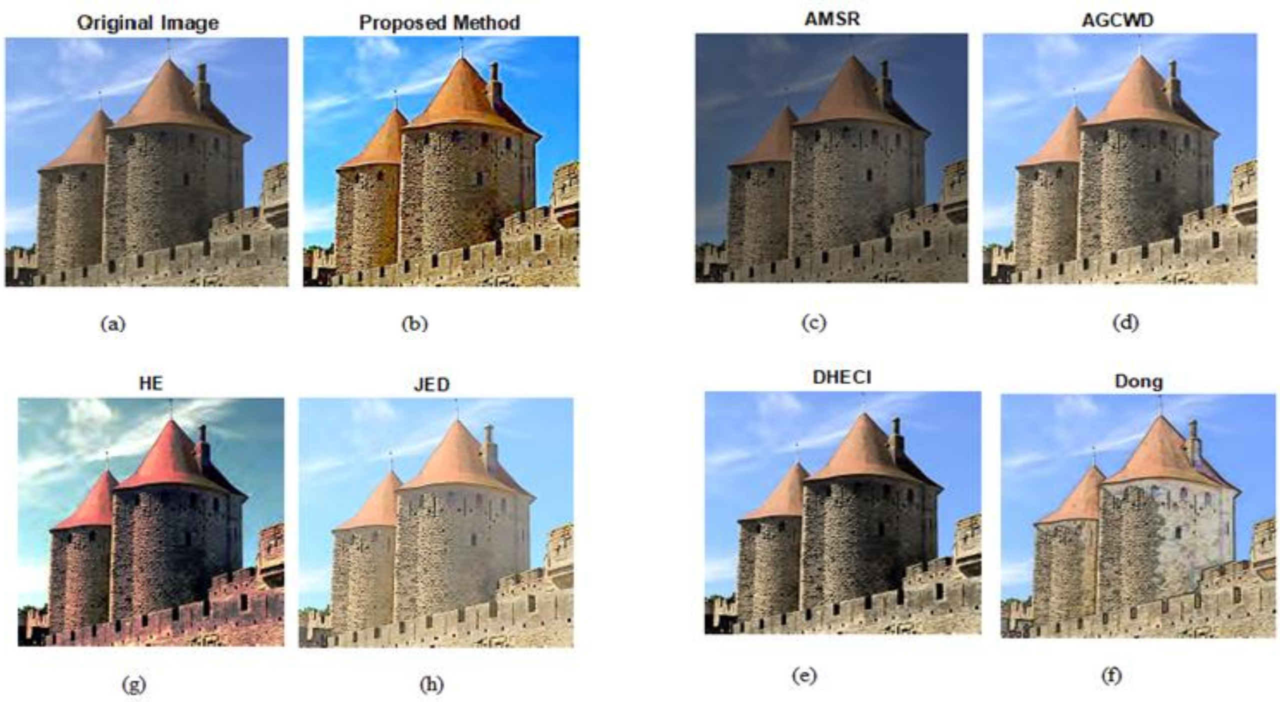

Figure 2. Results for img13 (a) Input Image (b) Proposed Method (c) AMSR (d) AGCWD (e) DHECI (f) Dong (g) HE (h) JED

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Table 1. Comparison of Different Techniques with Proposed Method

	MSE	LOE	PSNR	SSIM	NIQE	Contrast	Colourfulness	Entropy
Original						10.5260	48.7390	7.3265
Proposed	37.4409	82.2820	18.6187	0.7749	3.6940	10.8866	81.7955	7.3078
AMSR	4.7638	435.7716	11.6483	0.7772	4.0572	9.3890	23.8431	6.4876
AGCWD	64.3438	46.9328	20.1991	0.9572	3.8759	10.8924	52.5191	7.1480
DHECI	36.0801	32.0804	22.9528	0.9421	3.9766	11.1567	53.1613	7.3212
DONG	59.3594	352.6560	14.8907	0.8469	3.7049	10.3166	50.9585	7.0716
HE	23.1822	192.8052	19.0545	0.6947	3.3519	10.8571	48.6205	5.9651
JED	80.9166	253.8016	14.0340	0.8434	4.8640	10.6408	43.3156	6.5920

Table 1 demonstrate the test results of comparing revised methodologies using MSE, LOE, PSNR, SSIM, NIQE, contrast, colourfulness and entropy.

The experiments were also performed on MATLAB R2018a on 10 actual images from a database obtained from the Urban Scenery data form for colour images. Following *Figure 3* shows the images of the results obtained using the various available methods.

Figure 3. Results for usd4 of USD Dataset (a) Original Image (b) Proposed Method (c) AMSR (d) AGCWD (e) DHECI (f) Dong (g) HE (h) JED

Table 2. Comparison of Different Techniques with Proposed Method

	MSE	LOE	PSNR	SSIM	NIQE	Contrast	Colourfulness	Entropy
Original						10.3569	23.7515	6.8965
Proposed	29.5374	131.4596	20.1210	0.7051	2.8649	10.4953	49.5988	7.0894
AMSR	0.0102	355.5416	16.3706	0.8546	2.4873	9.5150	15.8797	6.3395
AGCWD	77.6057	41.2244	14.3827	0.8705	2.8745	11.1813	34.5519	7.2977
DHECI	58.8196	50.5416	15.3990	0.8355	2.8333	11.6178	34.0840	7.4268
DONG	81.3361	361.1464	12.4782	0.7574	3.1734	10.6750	34.7852	6.9515
HE	44.1605	168.2584	14.2906	0.6001	3.3643	10.7912	35.1711	5.8694
JED	84.3921	121.7740	12.5098	0.8069	4.1674	10.3741	34.8888	6.7996

Table 2, Fig. 5(a), 5(b), 5(c), 5(d), 5(e), 5(f), 5(g), and 5(h) show the test results of comparing various methodologies using MSE, LOE, PSNR, SSIM, NIQE, Contrast, Colourfulness, and Entropy parameters, as well as the corresponding graphs.

In this study, we used 15 test images from the CEED database in bmp format and 10 images from the Urban Scenery Database in jpeg format. All images are very different in strength, ready to test the feasibility of the proposed method. Subjective testing is performed on 15 CEED and 10 USD images. The proposed method is the most effective in this investigation since it improves brightness and colour contrast in all types of photos while maintaining brightness.

In the targeted quality test the analysis contained 15 CEED and 10 USD images of eight quality parameters (MSE, LOE, PSNR, SSIM, NIQE, Contrast, Colourful and Entropy). Now here we are with the image effects in *Figure 2* (*img13*). This measurement was used to compare all processing methods: Histogram Equalization [24], AGCWD [9], DHECI [25], Dong [27], AMSR [28], and JED [29]. In terms of several quality criteria, the suggested method is also compared to existing techniques in objective assessment, as indicated in *Table 1* of *img13*. Mean Square Error values of the proposed route are below all values except for one AMSR which shows the maximum interaction with the original image. Lightness Order Error LOE is much lower than AMSR, Dong, HE and JED which shows least lightness error in proposed algorithm. The PSNR values of *img13* are also better compared to many alternatives other than AGCWD and DHECI. The suggested method's SSIM values are better than HE only whereas the NIQE values are better than all other approaches, showing just some commitment to natural image quality. The image contrast is better than AMSR, Dong, HE and JED which shows that better comparison of the proposed method. The brightness in *Table 1* is higher than all the methods used which indicates that the proposed method incorporates information. The entropy value of the proposed route image is better than JED, HE, Dong, AGCWD, AMSR but lower than DHECI which indicated the proposed route produces a better image.

Now here we are presenting the results of images in *Figure 3* (*usd4*). In objective evaluation the proposed method is also compared with present methods when it comes to several excellence metrics as shown in *Table 2* of the *usd4* image. The MSE values for the projected method is lower than all methods except one AMSR representing greater association with the input image. Lightness Order Error LOE is much lower than AMSR, Dong, and HE which shows lesser lightness error in proposed algorithm. PSNR output of the *img13* is also enhanced as matched to available techniques which shows better signal component in perceived image. SSIM found for proposed technique is improved than HE only where as NIQE found are superior to AGCWD, Dong, HE and JED whereas slightly greater than DHECI and AMSR which shows that there is least deviation in natural image quality. Contrast of image is higher than AMSR, HE and JED and slightly lower than other methods showing that better contrast of proposed method. Colourfulness in *table 2* is higher than all methods used which shows that proposed method enriches the colour information. Entropy value of projected method is also improved than JED, HE, Dong, AMSR but lower than DHECI and AGCWD which shown the proposed method produces image having good contents.

Analysis of *table 1* and *table 2* shows a visual representation as a quality measure. Other methods better brightness values comparing with metrics namely PSNR, SSIM, NIQE, MSE, LOE and Entropy do not have a positive perception.

Visible compared to the proposed method. There is a trade-off among achievement measures and ability to view quality again, as shown in this study. As a result, the proposed method significantly outperforms the competition in terms of both design and measurement metrics.

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Table 3. Execution Time of different images

	Image		
Methods	Img13 	Img2 	USD4 
Proposed	**5.050**	**0.997**	**0.845**
AMSR	**0.834**	**0.412**	**0.391**
AGCWD	**0.188**	**0.100**	**0.072**
DHECI	**15.628**	**15.433**	**15.218**
DONG	**0.485**	**0.399**	**0.373**
HE	**0.063**	**0.024**	**0.010**
ZED	**7.499**	**7.101**	**7.245**

Figure 6 Shows the graphical chart for execution time of different images using different methods along with proposed method.

Table 3 shows the cost of computation in the proposed and available techniques for three randomly selected images. The duration taken of the proposed method for *Img13* image is lower than the DHECI and JED methods which are slightly higher than other methods. In *Img-2*, the performance time is often lower than DHECI and JED where as it is slightly larger than the other method and identical for the usd4 image. Although HE takes very little time to do so many of his barriers force him to ignore this approach. By evaluating the performance of quality and quantity the proposed algorithm offers satisfactory results in various studies and also works well in terms of execution time.

5. CONCLUSIONS

An excellent colour contrast algorithm programme with local LCC and enhanced fuzzy intensification is used in this work to improve viewing quality and retain crucial image material. The proposed approach addresses both the confined minima and comprehensive maxima complications. To stunned the difficulties and introduce the right enhancement method, The RGB colour space is converted to HSL colour space first. LCC is employed in the HSL colour space's luminance component to improve image contrast depending on the adjacent pixels. The overexposed and no exposed parts have been well brightened, and the obtained images exhibit sharp contrast. Intensification operators are retrieved using a fuzzy inference technique, which is employed to regulate the hue conformity of the native hue changed pixels. The method has been applied and verified on CEED and USD databank images, as well as many exiting strategies. Although projected method takes a little more execution time in comparison to some methods but delivers agreeable output and formed natural contrast images with least or no artifacts and outclassed the many present CE techniques while comparing with quality parameters like MSE, LOE, PSNR, SSIM, NIQE, Contrast, Colourfulness and Entropy image evaluation parameters.

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