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Enhancement of Low-Quality Images using Bi-Histogram Equalization adaptive sigmoid function based on Shifted Gomphertz Distribution

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Abstract— Image enhancement participate crucial role in image processing area and its main agenda is improves visual quality of an image. Histogram equalization is most prevalent method in contrast enhancement. But its major drawback is over-enhancement, therefore, it generates abnormal appearance. In this paper, proposed a method that solve over brightness problem by separate two histograms based on mean values of V-channel or intensity channel of HSV image. To calculate cumulative density function for each sub-histogram with two sigmoid function with their origins placed on the medians of sub-histogram after Shifted Gomphertz Distribution applied for each sub-histogram and equalized independently using histogram equalization. Experimental results demonstrate that proposed method gives good results compare to other state-of-the-arts methods with respect to over-enhancement.

Keywords— BBHE, Sigmoid function, Shifted Gomphertz Distribution, Under-water images.

I. INTRODUCTION

Image enhancement techniques have increased attention of researchers from last two decades [7,5]. Low contrast image enhancement methodology is viewed as a traditional and important in image processing area. It is used in different application arena such as, medical image analysis, photometric enhancement, microscopic imaging, remote-sensing imagery [1] etc. [2-4]. Human visual system is easily recognition of low-contrast natural images based on features like color, noises, illumination etc. There are several reasons behind low-quality natural scene images: 1) Lack of expertise operator to capture the image. 2) illumination effect at the time of capture example like sunset, sunrise and sunshine time. 3) low quality camera lens. Enhancement techniques can be broadly separated into two classes is spatial domain and transform domain. The first class operates directly on the pixel to pixel of an image and second class operates on frequency transform of an image [8]. In special domain techniques HE is effective methodology for low contrast enhancement and distributes uniformly over the entire range of the intensity in an image and improves visual quality based on histogram values. HE is stretching the histogram dynamic range by remapping probability density function (PDF) values [13]. Commonly HE provides effective calculation and results, but over-enhancement is main drawback. Brightness preserving Bi-Histogram Equalization (BBHE) is extension of HE method separates the histogram into two parts using brightness values of the image, that is the average intensity value of all pixels which construct the input image. After dividing histogram, the two histograms are equalized independently [6]. In this work, author discussed Bi-Histogram Equalization with Shifted Gomphertz Distribution function used for enhancement of a low contrast images. In the rest of this paper, the proposed approach is discussed in Section 2, Experimental results in Section 3. Finally, concluded the paper in Section 4.

II. RELATED WORK

In this section, the author describes the previous research works. [14] proposed contrast enhancement technique is solved problem of histogram equalization for gray-scale images. In this method, bi-histogram equalization and recursive mean-separate histogram equalization and RSIHE method yields better image compensation. The scanning electron microscope images are used as test images to evaluate the efficiency of the developed algorithm. [15] proposed in order to enhance image contrast without significant noise enhancement. The technique, derived from Gordon's algorithm, accounts for visual perception criteria, namely for contour detection. The efficiency of our algorithm is compared to Gordon's and to the classical ones. [11] This paper proposes a novel extension of BBHE referred to as minimum mean brightness error bi-histogram equalization (MMBEBHE) to provide maximum brightness preservation. BBHE separates the input image's histogram into two based on input mean before equalizing them independently. MMBEBHE demonstrate comparable performance with BBHE and DSIHE. [14] proposed contrast enhancement technique is solved problem of histogram equalization for gray-scale images. In this method, bi-histogram equalization and mean value separate two histograms. BBHE method yields better image compensation and efficiency of the developed algorithm. [12] image enhancement is presented. This measure is related with concepts of the human visual system. This article also offers a new class of the frequency domain based parametric image enhancement algorithms for the object detection and visualization. [17] proposed for enhancement of low contrast images. Contrast enhancement is a strong influence on contrast ratio to resolve power and detection capability of images. Normalization is one of the common methods for improving contrast digital images and very difficult to improve low contrast image which is the most widely used enhancement processes. Quality of low contrast images is poor due to three reasons. The reasons are camera resolution, light illumination and long distance to capture the images. In this paper, a novel method image Size Dependent Normalization Technique(ISDNT) is proposed to enhance low contrast bird images to high contrast bird images and enhancement measure in Edge Based Contrast Measurement(EBCM). [16] proposed sub-histogram using its mean value and its avoids over-brightness.

III. PROPOSED METHODOLOGY

Let's denote with X is V-component channel of size M * N with I possible intensity levels as in equation (1). In this work I is maximum intensity.

let m denote its mean intensity is defined as:

$$m = \frac{\sum_{r=0}^{m-1}\sum_{c=0}^{N-1} X(r,c)}{MN} \quad (1)$$

using the mean m as a separation point and separated the image histogram H into two sub-histograms H_L and H_U.

$$H = H_L - H_U \quad (2)$$

Where,

$$H_L = (H_0, H_1 \dots \dots \dots .. H_m) \quad (3)$$

$$H_U = (H_{m+1}, H_{m+2} \dots \dots \dots .. H_{I-1}) \quad (4)$$

After separating, calculated the probability density functions (pdf) of the two sub-histograms as shown in the equation (5).

$$pdf(k) = \begin{cases} \frac{H_L(k)}{\sum_{n=0}^{m} H_L(k)} & if\ k \le m \\ \frac{H_U(k)}{\sum_{n=m+1}^{I-1} H_U(k)} & if\ k > m \end{cases} \quad (5)$$

where $k \in \{0,1,...,I-1\}$ and it represents an intensity level. The first step to calculate a median is to calculate the cumulative distribution functions for both sub-histograms, which is shown in the equation (6).

$$cdf(k) = \begin{cases} \sum_{n=0}^{k} pdf(n)\ if\ k \le m \\ \sum_{n=m+1}^{I-1} pdf(n)\ if\ k > m \end{cases} \quad (6)$$

Then, the medians of H_L and H_U denoted by μ_L and μ_U respectively can be found when equations (7) and (8) are satisfied.

$$cdf(\mu_L) = 0.5\ if\ k \le m \quad (7)$$
$$cdf(\mu_U) = 0.5\ if\ k > m \quad (8)$$

A. *Shifted Gomphertz Distribution*

The idea of probability and statistics the Shifted Gompertz

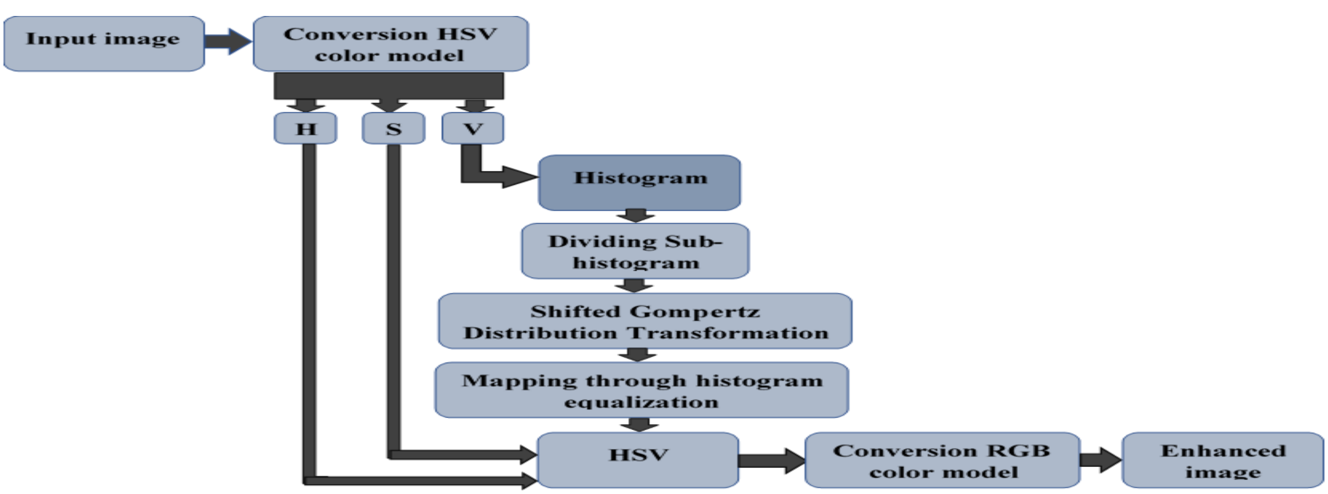


Figure.1: Functionality of proposed work.

Distribution is a continues probability Distribution. In this function three parameters are used in non-linear Shifted Gomphertz Distribution functions shown in the equation (10) with their origins located on the medians of the corresponding sub-histogram. The input values k needs to be normalized, as shown in equation (9), and, the resulting range of values will fit the Shifted Gomphertz chosen boundaries after this normalization, thus, generating z(k) ∊ [-5,5].

The Gumbel distribution functions described by equation (10) will take values inside the ranges [0, m] for k ≤ m and [m, I-1] for k > m.

When these functions are used for mapping, have smooth curve, hence avoiding severe affections y peaks on the histogram and thus avoid abrupt changes on the cumulative distribution function. Therefore, making this function noise tolerant and a good replacement of cumulative distribution function for each sub histograms.

$$z(k) = \begin{cases} \frac{5(k-\mu_L)}{m} if\ k \le m \\ \frac{5(k-\mu_U)}{I-1-m}\ if\ k > m \end{cases} \quad (9)$$

The Cumulative distribution function of the Shifted Gomphertz distribution.

$$g(k) = \begin{cases} (1-exp^{-bx})\, exp^{-nexp^{-bx}}\ if\ k \le m \\ (1-exp^{-bx})\, exp^{-nexp^{-bx}}\ if\ k > m \end{cases} \quad (10)$$

B. Mapping

The last step to performs the mapping through a histogram equalization and stretching. In order to obtain the histogram equalization as shown in Equation (11).

$$u(k) = \begin{cases} u_L = L_0 + (m - L_0)g(k)\ \ if\ k \le m \\ u_U = m + (L_f - m)g(k)\ \ if\ k > m \end{cases} \quad (11)$$

where L_0 and L_f represents the desired lower and upper limits respectively for the dynamic range of the output image. Here L_0=0 and L_f = I-1.

After obtaining the mappings u as in equation (11), proceeded to perform the histogram stretching by using eqn. (14). For this purpose, calculated α_L and α_U values given by equation (12) and equation (13).

$$\alpha_L = \frac{(m - L_0)}{max(u_L) - \min(u_L)} \quad (12)$$

$$\alpha_L = \frac{(L_f - m)}{max(u_U) - \min(u_U)} \quad (13)$$

$$T(k) = \begin{cases} L_0 + \alpha_L(u_L(k) - \min(u_L))\ when\ k \le m \\ m + \alpha_U(u_U(k) - \min(u_U))\ when\ k > m \end{cases} \quad (14)$$

Finally, the mapping function from equation (14) is applied to each pixel of the image X in order to obtain enhanced outcome Y as

$$Y = T(X) \quad (15)$$

IV. Results and Discussion

In this section, discussed results of the proposed method are compared with state-of-the-art methods such as histogram equalization (HE), Bi-histogram equalization (BBHE) and Bi-histogram equalization with adaptive sigmoid functions (BEASF), Enhancement of natural images using bi-histogram equalization using Gumbel distribution ENIBEGD. Dataset collected different scenarios like under water images [9]. Here evaluates the performance proposed method using Edge Based Contrast Measurement (EBCM) [10], Absolute Mean Brightness Error (AMBE) [11] and Enhancement Measure Error (EME) [12]. Fig.2-4 shows visual enhancement of proposed method comparison to other existing techniques. Table. 1 shows Comparison of proposed method result with other existing methods.

A. Edge Based Contrast Measurement (EBCM)

$$EBCM(X) = \sum_{i=1}^{H}\sum_{j=1}^{W}\frac{c(i,j)}{HW} \quad (16)$$

Where $c(i,j)$ is a contrast

$$c(i,j) = \frac{|x(i,j) - e(i,j)|}{|x(i,j) + e(i,j)|} \quad (17)$$

Where $e(i,j)$ is mean edge pixel values is

$$e(i,j) = \frac{\sum_{(k,l)\in N(i,j)} g(k,l)x(k,l)}{\sum_{(k,l)\in N(i,j)} g(k,l)} \quad (18)$$

Where *N(i,j)* is the set of all neighbouring pixels of pixel *(i,j)*, *g(k,l)* is the magnitude of the image gradient estimated using the Sobel operators [1].

It is projected that for an output image *Y* of an input image *X* the contrast is improved when

$$EBCM(Y) > EBCM(Y) \quad (19)$$

B. Enhancement Measure Error (EME):

$$EME = \frac{1}{r * c} \sum_{l=1}^{r} \sum_{k=1}^{c} 20log \frac{I_{max;k,l}}{I_{min;k,l}} \quad (20)$$

C. Entropy

It is used for how equally distribution is occurred, equal distribution leads to better enhancement. Higher the value indicates better enhancement. So, maximum entropy is achieved when uniform distribution of things or in other words when most randomness.

$$Entropy = -\sum_{i} p_{i\,log_i} \quad (21)$$

Where E is a scalar representing the entropy of an image and p represents the histograms counts.

D. AMBE

AMBE measure the absolute difference of mean brightness of original image and enhanced image. Lower the value indicates better mean brightness is preserved. This metric is defined as:

$$AMBE = |E(Y) - E(X)| \quad (22)$$

Where E(Y) and E(X) represents the mean brightness of the enhanced and original image respectively, given as

$$E(Y) = \frac{1}{m * n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} A(i,j)$$
$$E(X) = \frac{1}{m * n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} B(i,j) \quad (23)$$

Where *A(i,j)* is an enhanced image, *B(i,j)* is an original image and $m * n$ is represents size of an image.

(a) **(b)** **(c)**

(a) **(b)** **(c)**

Figure.2: Sample under water image-1 [9] used for enhancement using proposed methods. (a) Original image; (b) HE; (c) BBHE; (d) BEAFS; (e)ENIBEGD; (f) proposed method.

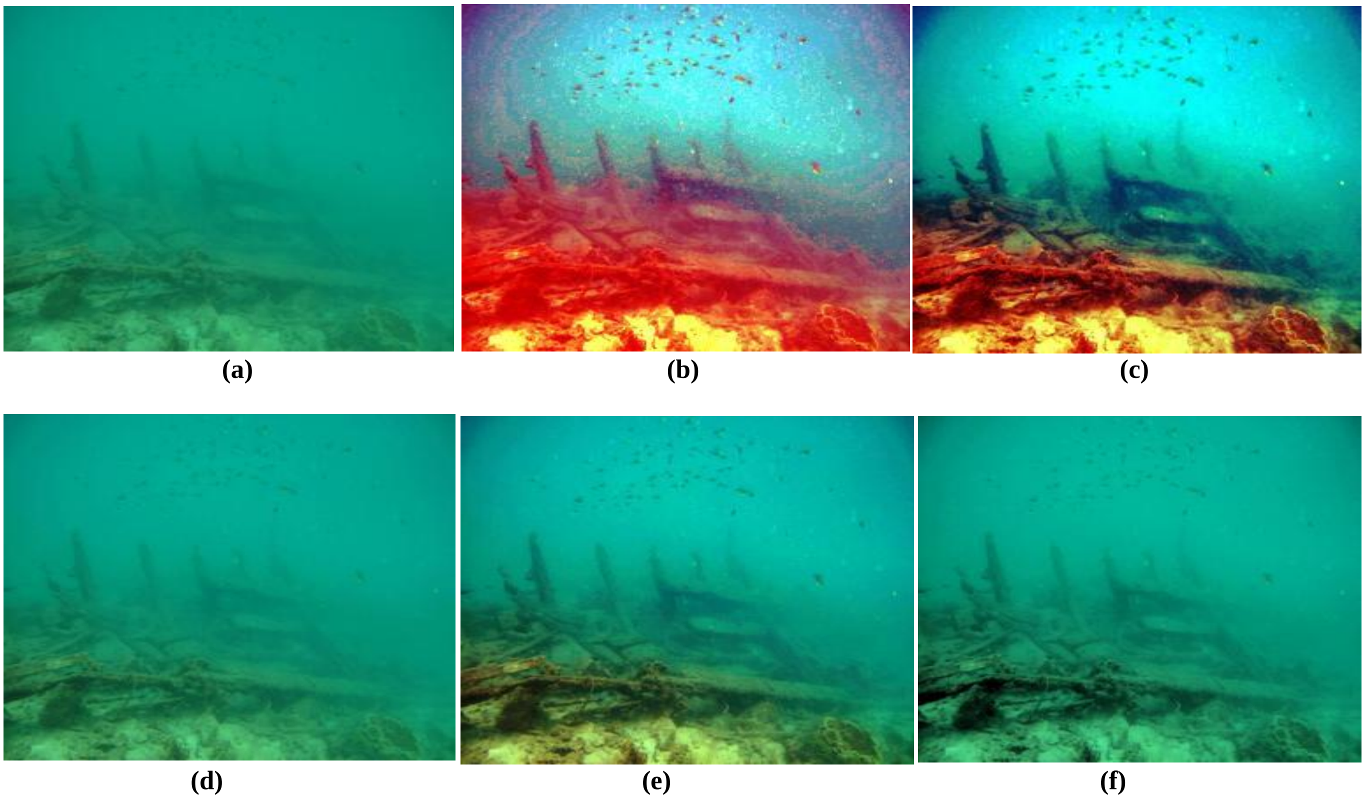
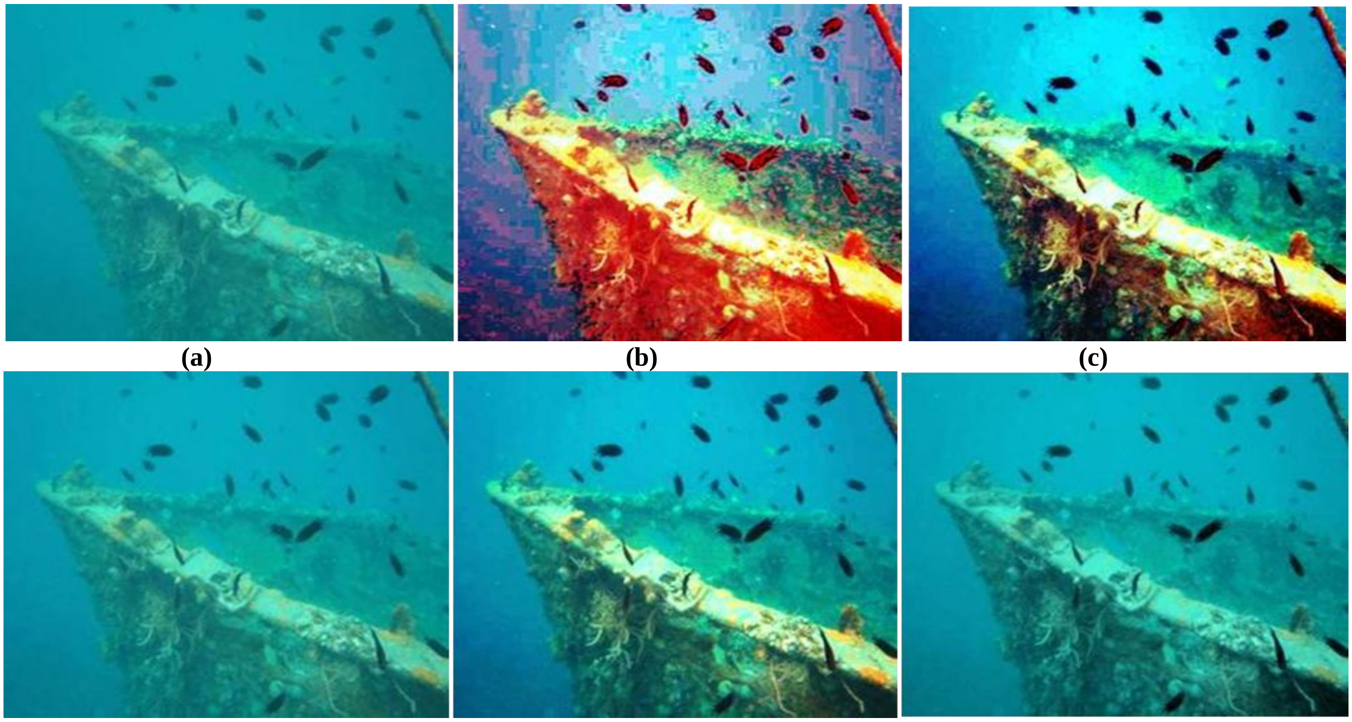


Figure.3: Sample under water image-1 [9] used for enhancement using proposed methods. (a) Original image; (b) HE; (c) BBHE; (d) BEAFS; (e)ENIBEGD; (f) proposed method.

Table1. Comparison of proposed method result with other existing methods

Image	**Method**	**Qualitative Results Analysis**			
		EBCM	**AMBE**	**EME**	**Entropy**
Under -water image-1	Original	125.6677		8.8874	7.2820
	HE	119.0229	0.0707	16.2475	5.9753
	BBHE	138.7285	0.0468	21.2465	7.5336
	BEASF	125.1954	0.0025	10.9508	6.8842
	ENIBEGD	125.5003	0.0041	18.2557	7.4118
	Proposed method	**133.5004**	**0.0200**	**14.0698**	**7.6331**
Under -water image-2	Original	5.0272		1.1900	6.5555
	HE	131.3819	0.1735	5.5661	5.5144
	BBHE	119.4765	0.0838	13.9502	6.4128
	ISDNT	238.7861	0.3541	8.0416	5.0060
	BEASF	75.7528	0.0189	9.0201	5.9337
	ENIBEGD	64.4222	0.0088	10.9242	6.3881
	Proposed method	**24.0734**	**0.0129**	**8.3181**	**6.8789**
Under -water image-3	Original	26.3623		10.5760	7.1459
	HE	119.3150	0.0656	10.1794	5.8289
	BBHE	91.4871	0.0210	14.8883	7.0141
	ISDNT	147.5552	0.2376	12.1453	6.9184
	BEASF	32.3723	0.0030	11.0358	6.5196
	ENIBEGD	56.7710	0.0047	11.8295	6.6622
	Proposed Method	**75.6676**	**0.0154**	**12.3523**	**7.2023**



(a) **(b)** **(c)**

(d) **(e)** **(f)**

Figure.4: Sample under water image-1 [9] used for enhancement using proposed method. (a) Original image; (b) HE; (c) BBHE; (d) BEAFS; (e)ENIBEGD; (f) proposed method.

V. CONCLUSION

This paper proposed an efficient method for enhancement of image contrast, and it produce output image is more visual quality compare to original image which avoiding brightness preservation and qualitative results are proved that brightness is preserved. In this approach, RGB image converted into HSV and extract only V channel to separates sub-histogram based on the mean value of histogram and applied shifted gomphertz distribution of intensity levels over the entire dynamic range. The experimental results have shown in this method can attain higher performance compared with state-of-the-art methods using some qualitative analysis such as EBCM, AMBE, EME and Entropy.

REFERENCES

[1] H. Yue, J. Yang, X. Sun et al., “Contrast enhancement based on intrinsic image decomposition”, IEEE Transactions on Image Processing, vol. **26**, no. **8**, pp. **3981–3994**, **2017**.

[2] M. Z. Iqbal, A. Ghafoor, and A. M. Siddiqui, “Satellite image resolution enhancement using dual-tree complex wavelet transform and nonlocal means”, IEEE Geoscience and Remote Sensing Letters, vol. **10**, no. **3**, pp. **451–455**, **2013**.

[3] M. M. Riaz, A. Ghafoor, and V. Sreeram, “Fuzzy C-means and principal component analysis based GPR image enhancement,” in Proceedings of IEEE International Conference on Radar, pp. **1–4**, IEEE, Ottawa, ON, Canada, **April 2013**.

[4] W. Roller, A. Berger, and D. Szentes, “Technology based training for radar image interpreters,” in Proceedings of 2013 6th IEEE International Conference on Recent Advances in Space Technologies, pp. **1173–1177**, IEEE, Istanbul, Turkey, **June 2013**.

[5] R. C. Gonzalez and R. E. Woods, Digital Image Processing, Pearson, New Delhi, India, 3rd edition, 2009.

[6] Y. T. Kim, “Contrast enhancement using brightness preserving bi-histogram equalization,” IEEE trans. Consum. Electron., **43(1)**, pp. **1-8**, **Feb**.**1997**.

[7] K. Singh and R. Kapoor, “Image enhancement using exposure based sub image histogram equalization,” Pattern Recognition Letters, vol. **36**, pp. **10–14**, **2014**.

[8] Gonzalez, R.C. and Woods, R.E, “Digital image processing”, 2002.

[9] OnlineAvailable:https://github.com/agaldran/UnderWater/tree/master/Im2.

[10] A. Beghdadi and A. L. Negrate, " Contrast enhancement technique based on local detection of edges”, Computer Vision, Graphics and Image Process, vol. 46, no. **2**, pp. **162–174**, **May 1989**.

[11] S.D. Chen and A. Ramli, " Minimum mean brightness error bi-histogram equalization in contrast enhancement," IEEE Transaction, Vol. **49**, No. **4**, pp. **1310–1319**, **2003**.

[12] Agaian Sos, Karen Panetta and M. Artyom, Grigoryan, " A new measure of image enhancement", IASTED International Conference on Signal Processing & Communication, pp. **19-22**, **2000**.

[13] S. C Huang, F. C Cheng and Y. S Chiu, "Efficient contrast enhancement using adaptive gamma correction with weighting distribution", IEEE Transactions on Image Processing, **22(3)**, pp.**1032-1041**, **2013**.

[14] K. S. Sim, C. P. Tso, and Y. Y. Tan, “Recursive sub-image histogram equalization applied to gray scale images,” pattern Recognition Letter, 28(10), pp. 1209-1221, Nov. 2007.

[15] A. Beghdadi and A. L. Negrate, " Contrast enhancement technique based on local detection of edges," Computer Vision, Graphics and Image Process, vol. 46, no. 2, pp. 162–174, May 1989.
[16] Y. T. Kim, "Contrast enhancement using brightness preserving bi-histogram equalization," IEEE trans. Consum. Electron., 43(1), pp. 1-8, Feb.1997.
[17] M. Suresha, Sandeep, 2017. Enhancement on low contrast bird images using image size dependent normalization technique, International Journal of Advanced Research in Computer Science 8(8), pp. 628-631.

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