Underwater Image Quality Measurement and Improvement

Report submitted for the partial fulfillment of the requirements for the degree of Bachelor of Technology in
Information Technology

Submitted by

SUMANA MAJUMDER (IT2014/034)
NISHA DUTTA (IT2014/041)
PRIYANKA MONDAL (IT2014/043)

Under the Guidance of Mr. Hiranmoy Roy
[Asst. Prof. Department of IT]

RCC Institute of Information Technology
Canal South Road, Beliaghata, Kolkata – 700 015
[Affiliated to West Bengal University of Technology]

Acknowledgement

We would like to express our sincere gratitude to Mr. Hiranmoy Roy of the department of Information Technology, whose role as project guide was invaluable for the project. We are extremely thankful for the keen interest he took in advising us, for the books and reference materials provided for the moral support extended to us.

Last but not the least we convey our gratitude to all the teachers for providing us the technical skill that will always remain as our asset and to all non-teaching staff for the gracious hospitality they offered us.

Place: RCCIIT, Kolkata

Date:

SUMANA MAJUMDER
NISHA DUTTA
PRIYANKA MONDAL

Department of Information Technology
RCCIIT, Beliaghata,
Kolkata – 700 015,
West Bengal, India

Approval

This is to certify that the project report entitled "***Underwater image quality measurement and Improvement***" prepared under my supervision by *Sumana Majumder (IT2014/034), Nisha Dutta (IT2014/041), Priyanka Mondal (IT2014/043)*,be accepted in partial fulfillment for the degree of Bachelor of Technology in Information Technology.

It is to be understood that by this approval, the undersigned does not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn thereof, but approves the report only for the purpose for which it has been submitted.

………………………………………..	… ………………………………………
Dr. Abhijit Das	Hiranmoy Roy
Assoc. Prof. & HOD	Asst. Prof.
Department of IT	Department of IT
RCCIIT	RCCIIT

Contents	***Page Numbers***
1. Introduction	**5**
2. Problem Definition	**6**
3. Literature Survey	**7**
4. SRS (Software Requirement Specification)	**13**
5. Planning	**14**
6. Design	**15**
7. Results	**16**
8. List of Tables	**16**
9. List of Figures	**18**
10.References / Bibliography	**20**

INTRODUCTION

The quality of underwater images plays a pivotal role in ocean engineering and scientific research, such as monitoring sea life, accessing geological environment, and ocean rescue. However, the absorption and scattering effects of the water limit the visibility of the underwater objects. Consequently, the images captured by underwater cameras usually suffer from low contrast, no uniform illumination, blurring, bright artifacts, diminished color, noise, and other distortions. Many algorithms have been proposed for restoring colors and enhancing contrast for observed underwater images. In the majority of these methods, visual inspection is used for evaluating the image processing algorithms' performances. However, subjective evaluation is biased, and it is expensive with respect to time and resources. More importantly, subjective evaluation cannot be automated. Therefore, it is important to have a reliable objective evaluation measure. Generally, objective evaluation methods can be classified into two categories: no reference measures and full-reference measures, depending on whether the images with the "true color" and "ideal contrast" are available. In underwater image processing scenarios, such ideal images are usually unavailable. Therefore, the non reference image quality measures are desired. This challenge is further exacerbated by the need to develop an underwater image quality measure that captures the objectivity and perception of the human visual system (HVS).

Contrast enhancement technique is widely used for underwater image processing to improve the contrast performance. The development of the contrast enhancement technique for underwater image has attracted considerable attention in recent years. Researchers are improving the image contrast to extract as many information as possible by applying various algorithms.

PROBLEM DEFINATION

Underwater images suffer from blurring effects, low contrast, and grayed out colors due to the absorption and scattering effects under the water. Few image segmentation algorithms have been developed for that image segmentation. Unfortunately, no well-accepted mechanism exists that can segment the underwater images similar to human perception. A lot of fuzziness is present in those images. Therefore, fuzzy concept based segmentation is more useful in that situation. A human visual system concepts based segmentation will be more accurate. To address the problem, a new non reference underwater image quality measure (UIQM) is presented. The UIQM comprises three underwater image attribute measures: the underwater image colourfulness measure (UICM), the underwater image sharpness measure (UISM), and the underwater image contrast measure (UIConM).

The quality of underwater image is poor due to the properties of water and its impurities. The properties of water cause attenuation of light travels through the water medium, resulting in low contrast, blur, inhomogeneous lighting, and color diminishing of the underwater images. Here a method of enhancing the quality of underwater image is proposed. The proposed method consists of two stages: 1) Modified Von Kries hypothesis and 2) Global histogram stretching.

LITERATURE SURVEY

From "Human-Visual-System-Inspired Underwater Image Quality Measurement" by Karen Panetta et al., we have learned about image quality measurement. Measurements of an underwater image are UICM (Underwater Image Colorfulness Measure), Underwater Image Sharpness Measure (UISM), Underwater Image Contrast Measure (UIConM).

A. Underwater Image Colorfulness Measure (UICM)

Many underwater images suffer from a severe color-casting problem. As the depth of the water increases, colors attenuate one by one depending on their wavelength. The color red disappears first due to it possessing the shortest wavelength. As a result, underwater images usually demonstrate a bluish or greenish appearance. Furthermore, limited lighting conditions also causes severe color de-saturation in underwater images. A good underwater image enhancement algorithm should produce good color rendition. The HVS captures colors in the opponent color plane. Therefore, the two opponent color components related with chrominance RG and YB are used in the UICM, as shown in

$$RG = R - G \tag{1}$$

$$YB = \frac{R+G}{2} - B \tag{2}$$

Underwater images usually suffer from heavy noise. Therefore, instead of using the regular statistical values, the asymmetric alpha-trimmed statistical values are used for measuring underwater image colorfulness. The mean is defined by:

$$\mu_{\alpha,RG} = \frac{1}{K - T_{\alpha L} - T_{\alpha R}} \sum_{i=T_{\alpha L}+1}^{K-T_{\alpha R}} Intensity_{RG,i} \tag{3}$$

The second-order statistic variance σ^2 in:

$$\sigma^2{}_{\alpha,RG} = \frac{1}{N} \sum_{p=1}^{N} (Intensity_{RG,p} - \mu_{\alpha,RG})^2 \tag{4}$$

The overall colourfulness metric used for measuring underwater image colourfulness is demonstrated in

$$UICM = -0.0268\sqrt{\mu^2{}_{\alpha,RG} + \mu^2{}_{\alpha,YB}} + 0.1586\sqrt{\sigma^2{}_{\alpha,RG} + \sigma^2{}_{\alpha,YB}} \quad (5)$$

B. Underwater Image Sharpness Measure (UISM)

Sharpness is the attribute related to the preservation of fine details and edges. For images captured under the water, severe blurring occurs due to the forward scattering. This blurring effect causes degradation of image sharpness. To measure the sharpness on edges, the Sobel edge detector is first applied on each RGB color component. The resultant edge map is then multiplied with the original image to get the grayscale edge map. By doing this, only the pixels on the edges from the original underwater image are preserved. It is known that the enhancement measure estimation (EME) measure is suitable for images with uniform background and shown non periodic patterns accordingly; the EME measure is used to measure the sharpness of edges.
The UISM is formulated as shown in

$$UISM = \sum_{c=1}^{3} \lambda_c EME(grayscale \quad edge_c) \quad (1)$$

$$EME = \frac{2}{k1k2} \sum_{l=1}^{k1} \sum_{k=1}^{k2} \log\left(\frac{I_{\max,k,l}}{I_{\min,k,l}}\right) \quad (2)$$

C. Underwater Image Contrast Measure (UIConM)

Contrast has been shown to correspond to underwater visual performance such as stereoscopic acuity. For underwater images, contrast degradation is usually caused by backward scattering.
The contrast is measured by applying the logAMEE measure on the intensity image as shown in

$$UIConM = \log AMEE(Intensity)$$

The logAMEE in

$$\log AMEE = \frac{1}{k1k2} \otimes \sum_{l=1}^{k1} \sum_{k=1}^{k2} \frac{I_{\max,k,l} \Theta I_{\min,k,l}}{I_{\max,k,l} \oplus I_{\min,k,l}} \times \log\left(\frac{I_{\max,k,l} \Theta I_{\min,k,l}}{I_{\max,k,l} \oplus I_{\min,k,l}}\right) \quad (1)$$

Underwater image quality enhancement through Rayleigh-stretching

A. Modified of Von Kries hypothesis

Image channels are applied with modified Von Kries hypothesis. First of all, the average values of each channel, Ravg, Gavg, Bavg are calculated

$$R_{avg} = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} I_R(i, j) \tag{1}$$

$$G_{avg} = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} I_G(i, j) \tag{2}$$

$$B_{avg} = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} I_B(i, j) \tag{3}$$

M x N indicates the number of pixels in a channel and $I_X(i,j)$ is the pixel value of respective channel at position of (i,j).

The median value is determined from these three average values and used as the reference or target value. The remaining color channels are determined with multipliers (A and B) in order to produce a balanced image. The equations are used to calculate the multipliers for maximum and minimum average values, respectively.

$$A = \frac{median(R_{avg}, G_{avg}, B_{avg})}{\min(R_{avg}, G_{avg}, B_{avg})} \tag{4}$$

$$B = \frac{median(R_{avg}, G_{avg}, B_{avg})}{\max(R_{avg}, G_{avg}, B_{avg})} \tag{5}$$

Based on the calculation in equations, the color channel with a minimum intensity value is multiplied with multiplier A whereas the color channel with a maximum intensity value is multiplied with multiplier B.

B. Global histogram stretching

In order to spread the pixels values of the image, the histogram of the image channels are applied with global stretching, where the histogram are stretched over the whole dynamic range of [0, 255]. This is also as preparation of the next step where the histogram will be divided into two regions based on its average value. The stretched-histogram will provide a better pixel distribution of the image channels and thus gives a more accurate average value of the channel which represents the average value of the channel for the whole dynamic range.
The following equation is used to stretch the histogram of respective color channel to the whole dynamic range.

$$P_{out} = (P_{in} - i_{\min})\left(\frac{o_{\max} - o_{\min}}{i_{\max} - i_{\min}}\right) + o_{\min} \tag{6}$$

Pin and Pout are the input and output pixels, respectively, and imin, imax, omin, and omax are the minimum and maximum intensity level values for the input and output images, respectively.

C. Division and stretching of image histogram with respect to Rayleigh distribution

The histogram is then divided into two regions based on this average value. By dividing the histogram at its average point, two regions are produced namely lower and upper regions. The lower region should have the intensity range between 0 to the average value of the image histogram whereas the upper region should have the intensity range between the average value to the maximum intensity range of 255.

For the next step, these two regions of histogram are stretched independently to produce two separated histograms. In addition to this step, these regions are stretched to follow the Rayleigh distribution over the entire dynamic range of [0, 255]. The lower region which has the intensity value between 0 to the average value will be stretched to the entire dynamic range of [0, 255]. The same process is applied to the upper region, where the initial range of the region, which lies from average value to 255 is stretched to the entire dynamic range of [0, 255].
The probability distribution function of Rayleigh distribution is given by the equation

$$PDF_{Rayleigh} = \left(\frac{x}{\alpha^2}\right) e^{\left(\frac{-x^2}{2\alpha^2}\right)} \quad for \;\; x \geq 0, \alpha \succ 0 \tag{7}$$

where α is the distribution parameter of Rayleigh distribution and x is the input data which is, in this case, the intensity value.

Rayleigh-stretched distribution in equation

$$Rayl.-stretched = \frac{\left[(P_{in} - i_{\min}) \left(\frac{o_{\max} - o_{\min}}{i_{\max} - i_{\min}} \right) + o_{\min} \right]}{\alpha^2} . e^{\frac{-\left[(P_{in} - i_{\min}) \left(\frac{o_{\max} - o_{\min}}{i_{\max} - i_{\min}} \right) + o_{\min} \right]^2}{2\alpha^2}} \tag{8}$$

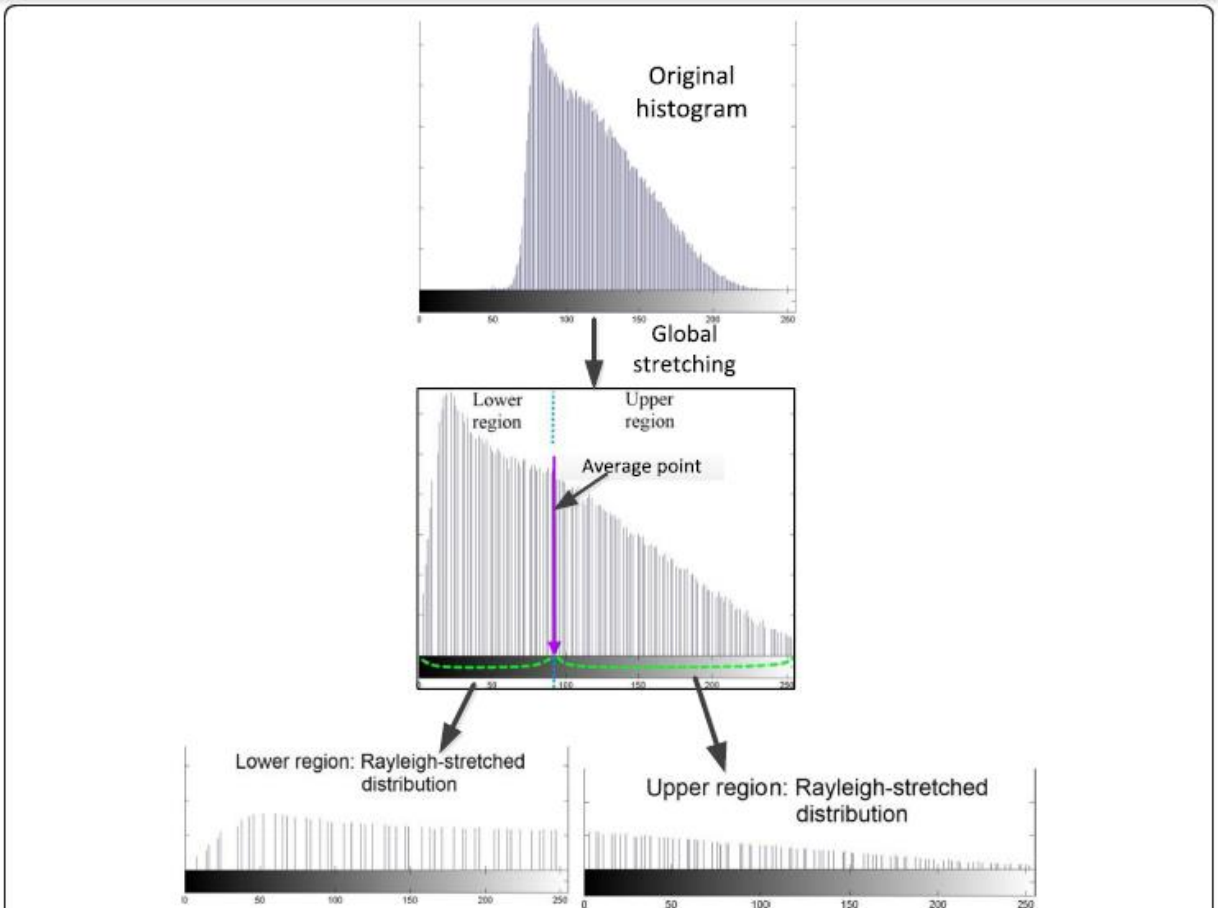


Figure 5 Original histogram is applied with global stretching and divided into two separate histograms at its average point.

The output histogram is stretched over the entire dynamic range of [0, 255]. Therefore, the values of o_{max} and o_{min} can be substituted with the values of 255 and 0, respectively. Thus, previous equation can be simplified as below equation:

$$Rayl.-stretched = \frac{255(P_{in} - i_{\min})}{\alpha^2 (i_{\max} - i_{\min})} . e^{\frac{-[255(P_{in} - i_{\min})]^2}{2\alpha^2 (i_{\max} - i_{\min})^2}}$$

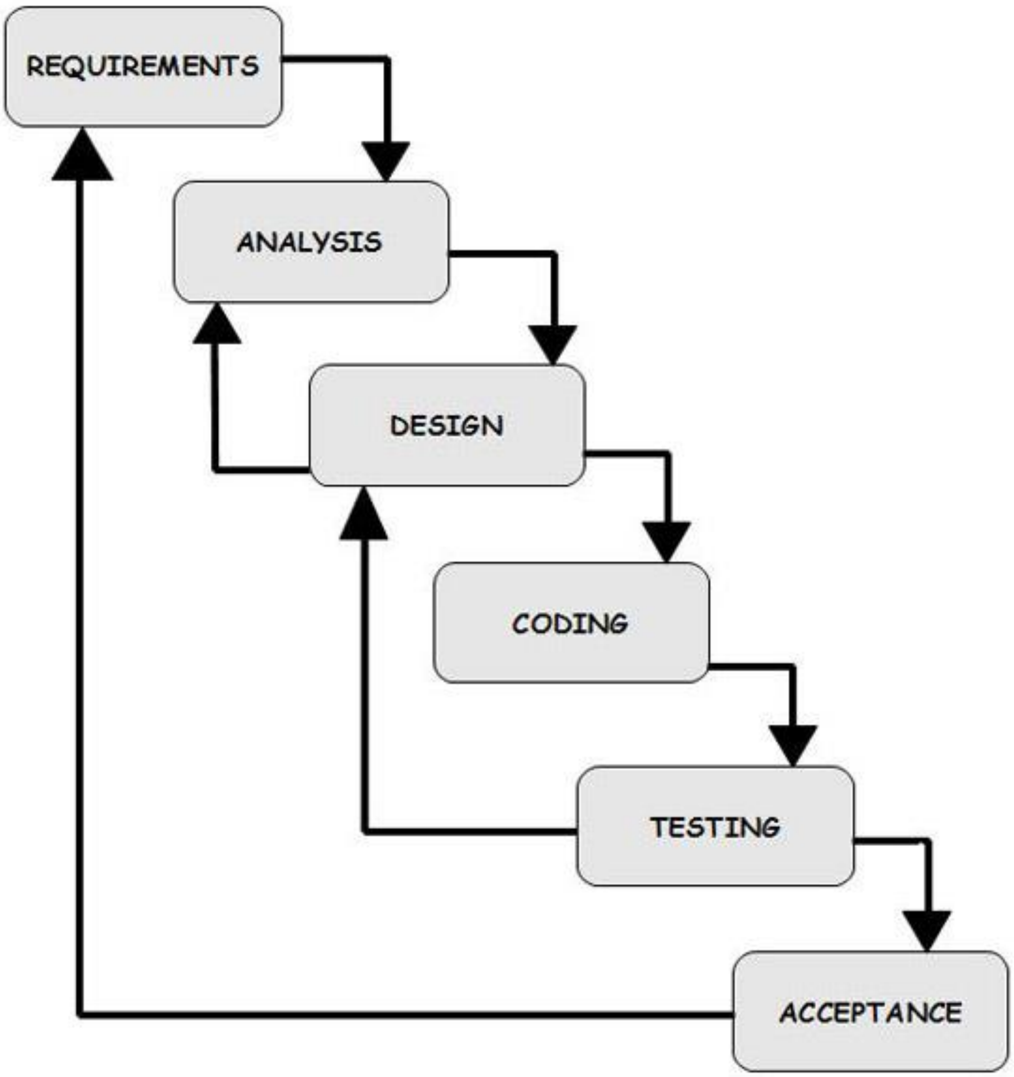
where i_{min} and i_{max} indicate the minimum and maximum intensity level values for input image in each region, respectively. For the lower region, i_{min} indicates the minimum intensity level value of the image histogram, and i_{max} indicates the maximum intensity level value in the region, which is equivalent to the average-value of the histogram. For the upper region, i_{min} indicates the minimum intensity level value in the region which is equivalent to the average-value of the image histogram, and i_{max} indicates the maximum intensity level value in the region which is equivalent to the maximum intensity level of the image.

SRS (Software Requirement Specification)

Operating System	Processor	Disk Space	RAM
Windows 10	Any Intel or AMD x 86-64 processor	2GB for MATLAB only	2GB

PLANNING

Software Life Cycle Model which one we have used is Iterative Waterfall Model



DESIGN

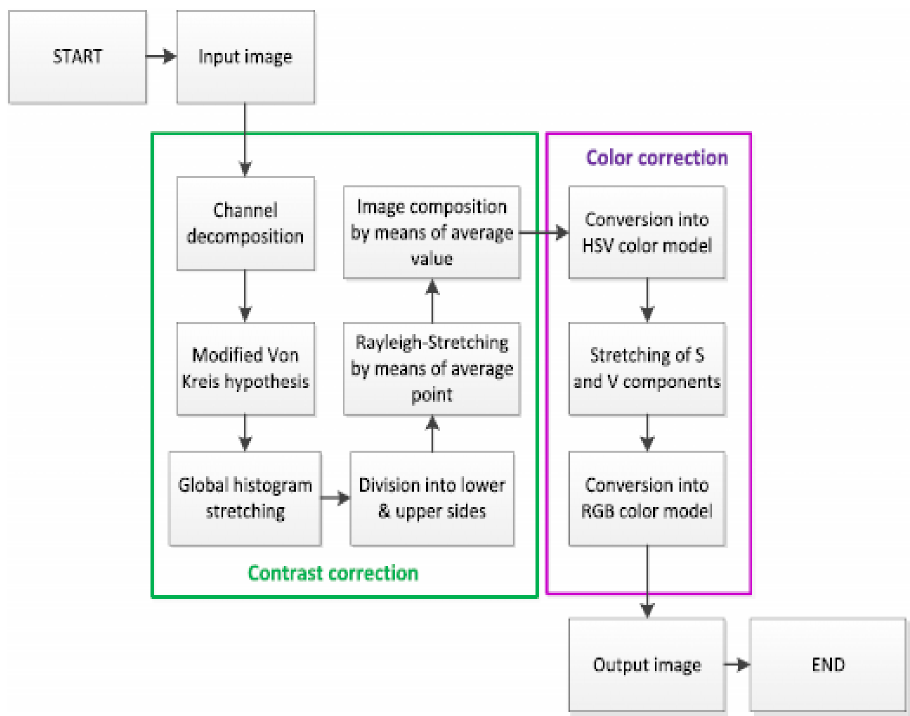


Figure 4 Overall process of the proposed method.

Results

Quality Measurement Table:

Images	Underwater Image Quality Measure		
	UICM	UISM	UIConM
Image 1	-3.3947	0.5940	-6.4732
Image 2	-5.6569	3.0707	-8.8825
Image 3	-4.6389	4.7524	-9.4221
Image 4	-8.2311	5.2647	-9.587
Image 5	-4.7714	5.2405	-9.3524
Image 6	-2.7894	3.0245	-7.2689
Image 7	-3.3154	1.0780	-10.3718

GUI Design:

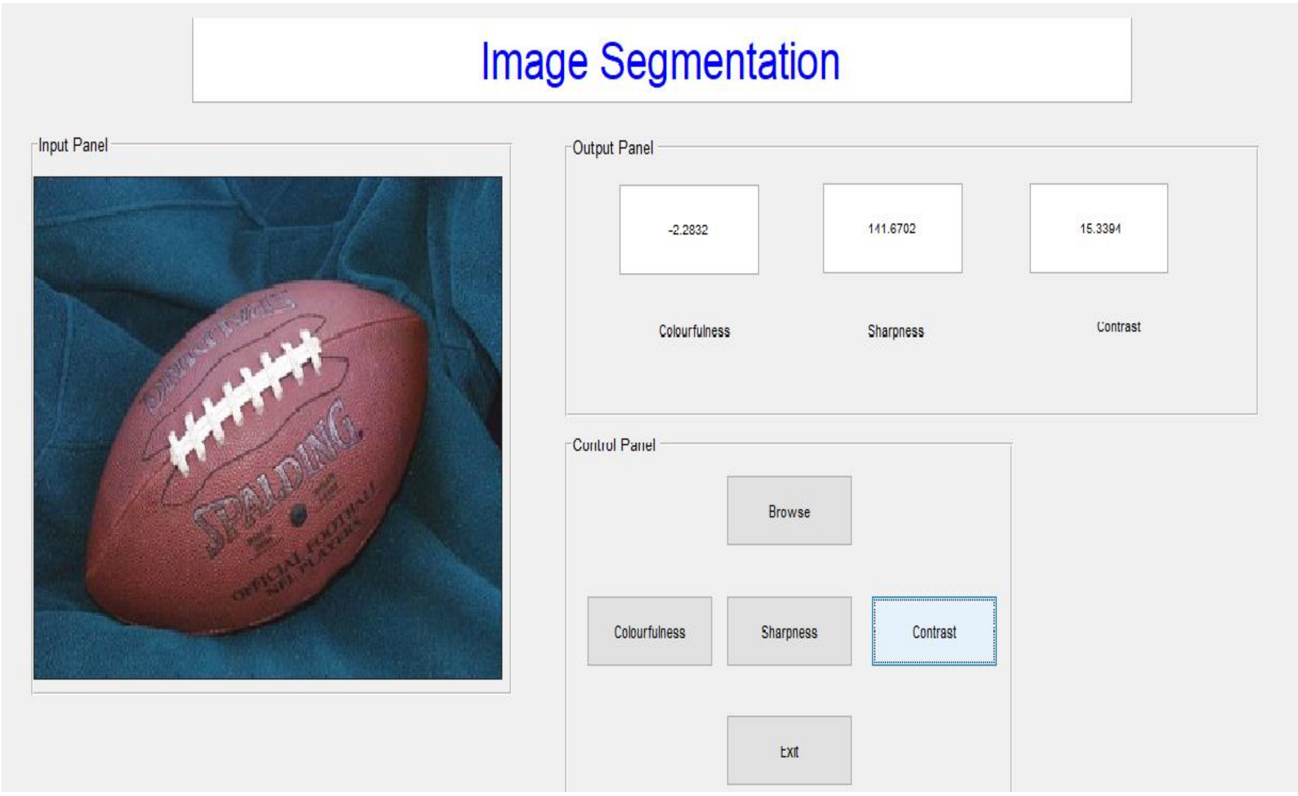


Image Segmentation
Input Panel
Output Panel
-2.2832
141.6702
15.3394
Colourfulness
Sharpness
Contrast
Control Panel
Browse
Colourfulness
Sharpness
Contrast
Exit

LIST OF FIGURES

(a)

(b)

(c)

(d)

(e)

(f)

(g)

Image Improvement:

Original Image

Output Image

Original Image

Output Image

Original Image

Output Image

REFERENCES / BIBLIOGRAPHY

1. K. Panetta, S. Agaian, Y. Zhou, and E. J. Wharton, “Parameterized logarithmic framework for image enhancement,” IEEE Trans. Syst. Man Cybern. B, Cybern., vol. 41, no. 2, pp. 460–473, Apr. 2011.

2. Karen Panetta, Fellow, IEEE, Chen Gao, Student Member, IEEE, and Sos Agaian, Senior Member, IEEE, “IEEE JOURNAL OF OCEANIC ENGINEERING”, VOL. 41, NO. 3, 541 Human-Visual-System-Inspired Underwater Image Quality Measures , JULY 2016.

3. Miao Yang, Member, IEEE, and Arcot Sowmya, Member, IEEE, “An Underwater Color Image Quality Evaluation Metric”, IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 24, NO. 12, DECEMBER 2015.

4. Ahmad Shahrizan Abdul Ghani and Nor Ashidi Mat Isa,” Underwater image quality enhancement through composition of dual-intensity images and Rayleigh-stretching”, Abdul Ghani and Mat Isa SpringerPlus 2014, 3:757.

5. Arici T, Dikbas S, Altunbasak Y (2009) A histogram modification framework and its application for image contrast enhancement. IEEE Trans Image Process 18:No. 9.

6. Barnard K, Cardei V, Funt B (2002) A comparison of computational color constancy algorithms-part I: experiments with image data. IEEE Trans Image Process Vol. II:No. 9.

7. Bassiou N, Kotropoulos C (2007) Color image histogram equalization by absolute discounting back-off. Comput Vis Image Und 107(1–2):108–122.

8. Church SC, White EM, Partridge UC (2003) Ultraviolet dermal reflection and mate choice in the guppy. Elsevier Science Ltd, pp 693–700.

9. Eustice R, Pizarro O, Singh H, Howland J (2002) Underwater image toolbox for optical image processing and mosaicking in MATLAB. In: Proceedings international symposium on underwater technology., pp 141-145.

10. Gasparini F, Schettini R (2003) Color correction for digital photographs. In: 12th International Conference on Image Analysis and Processing (ICIAP 2003)., pp 646-651.

11. Hitam MS, Yussof WNJW, Awalludin EA, Bachok Z (2013) Mixture contrast limited adaptive histogram equalization for underwater image enhancement. In: IEEE International Conference on Computer Applications Technology (ICCAT), Sousse, pp 1–5.

12. Iqbal K, Salam RA, Osman A, Talib AZ (2007) Underwater image enhancement using integrated color model. IAENG Int J Comput Sci 34:2 IJCS 34-2-12.

13. Iqbal K, Odetayo M, James A, Salam RA, Talib AZ (2010) Enhancing the low quality images using unsupervised color correction method. In: International conference on system man and cybernatics (SMC), Istanbul, pp 1703–1709.

14. Jaffe JS (1990) Computer modeling and the design of optimal underwater imaging systems. IEEE J Ocean Eng 15(2):101–111.

15. Kim Y (1997) Contrast enhancement using brightness preserving bi-histogram equalization. IEEE Trans Consum Electr 43(1):1–8.

16. Kumar R, Rattan M (2012) Analysis of various quality metrics for medical image processing. IJARCSSE 2:11–160.

17. McGlamery BL (1979) A computer model for underwater camera systems. Proc SPIE 208:221–231.

18. Naim MJNM, Mat Isa NA (2012) Pixel distribution shifting color correction for digital color images. Applied Soft Computing 12(Issue 9):2948–2962.

19. Padmavathi G, Muthukumar M, Thakur SK (2010) Non Linear Image Segmentation using Fuzzy C-means Clustering Method with Thresholding for underwater images. IJCSI 7(3):35.

20. Rizzi A, Gatta C, Marini D (2003) A new algorithm for unsupervised global and local color correction. Pattern Recogn Lett 24:No. 11:1663–1677.