

IMPROVEMENT OF UNDERWATER IMAGE CONTRAST ENHANCEMENT TECHNIQUE BASED ON HISTOGRAM MODIFICATION

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TECHNIQUE BASED ON HISTOGRAM MODIFICATION**

by

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	ii
TABLE OF CONTENTS.....	iv
LIST OF TABLES.....	viii
LIST OF FIGURES.....	xi
LIST OF ABBREVIATIONS.....	xix
ABSTRAK	xx
ABSTRACT	xxii
CHAPTER 1 – INTRODUCTION	
1.1 Background.....	1
1.2 Underwater Image Processing and Its Problems.....	4
1.3 Problem Statement.....	8
1.4 Research Objective.....	9
1.5 Research Scope.....	10
1.6 Thesis Outline.....	12
CHAPTER 2 – LITERATURE REVIEW	
2.1 Introduction.....	14
2.2 Underwater Image Formation and Its Problems.....	16
2.2.1 Image Restoration.....	22
2.2.2 Image Enhancement and Color Correction Techniques.....	36
2.3 State-of-the-art Methods and Their Visual Implementation	51
2.4 Performance Analysis.....	63

2.4.1 Qualitative Analysis.....	64
2.4.2 Quantitative Analysis.....	70
2.5 Summary.....	80

**CHAPTER 3 – UNDERWATER IMAGE QUALITY ENHANCEMENT
THROUGH INTEGRATED COLOR MODEL WITH RAYLEIGH
DISTRIBUTION**

3.1 Introduction.....	82
3.2 Motivation.....	83
3.3 Methodology of the Proposed ICM-RD Method.....	89
3.3.1 Color Channel Decomposition and Histogram Stretching in the RGB Color Model.....	90
3.3.2 Contrast Stretching of the Inferior (e.g. Red) and Dominant (e.g. Blue) Channels.....	92
3.3.3 Contrast Stretching of the Green Channel.....	95
3.3.4 Contrast Correction in the HSV color model.....	97
3.4 Data Samples.....	98
3.5 Result and Discussion.....	99
3.6 Limitation of the Proposed ICM-RD Method.....	129
3.7 Summary.....	130

**CHAPTER 4 – UNDERWATER IMAGE QUALITY ENHANCEMENT
THROUGH RAYLEIGH-STRETCHING AND AVERAGING
IMAGE PLANES**

4.1 Introduction.....	132
4.2 Methodology: Rayleigh-Stretching and Averaging of Image Planes.....	133

4.2.1 Histogram Stretching in the RGB Color Model with Respect to the Rayleigh Distribution.....	135
4.2.2 Stacking and Averaging Using z-Projection.....	140
4.2.3 Stretching of the S and V Components in the HSV Color Model.....	141
4.3 Result and Discussion.....	143
4.4 Comparison with the Previous ICM-RD Method.....	171
4.5 Limitation of the Proposed RSAIP Method.....	183
4.6 Conclusion.....	184
CHAPTER 5 – ENHANCEMENT OF LOW QUALITY UNDERWATER IMAGE THROUGH INTEGRATED GLOBAL AND LOCAL CONTRAST CORRECTION	
5.1 Introduction.....	186
5.2 Motivation.....	188
5.3 Methodology of DIRS-CLAHS Method.....	192
5.4 Global Contrast Correction Stage.....	194
5.4.1 Calculation of Minimum, Maximum, and Mid-points of the Original Histogram.....	195
5.4.2 Division and Stretching of Original Histogram within Limits.....	196
5.4.3 Composition of Region and Dual-intensity Images.....	197
5.5 Local Contrast Stretching: Contrast Limited Adaptive Histogram Specification (CLAHS).....	199
5.5.1 Division of Image into Tiles.....	200
5.5.2 Applying Clip-limit.....	201
5.5.3 Remapping to Rayleigh Distribution.....	202
5.5.4 Composition of Image Tiles.....	202

5.6 Applying Color Correction.....	203
5.6.1 Dividing S and V Components at Mid-point.....	204
5.6.2 Stretching the S and V Components	204
5.6.3 Components Composition.....	206
5.7 Results and Discussion.....	207
5.8 Comparative Study on the Proposed Contrast Enhancement Variants.....	230
5.9 Conclusion.....	253
CHAPTER 6 – CONCLUSION AND FUTURE WORK	
6.1 Conclusion.....	254
6.2 Future Works.....	257
6.2.1 Recursive Local Histogram Specification.....	257
6.2.2 Reduction of the Algorithm Complexity and Computational Consumption.....	259
6.2.3 Enhancement of the Background Areas.....	259
REFERENCES.....	261
APPENDIX A.....	271
APPENDIX B.....	273
LIST OF PUBLICATIONS.....	284

LIST OF TABLES

		Page
Table 2.1	Summary of the proposed methods by previous researchers in the perspectives of underwater image restoration and enhancement techniques	35
Table 2.2	Summary of the proposed methods by previous researchers in the perspective of underwater image enhancement	48
Table 2.3	Default parameter setting for CLAHE-Mix (Hitam et al., 2013) and CLAHS (Eustice et al., 2002)	53
Table 2.4	The resultant images of <i>branch</i> using the current state-of-the-art techniques with their 3D RGB color model	58
Table 2.5	The resultant images of <i>green fish</i> using the current state-of-the-art techniques with their 3D RGB color model	60
Table 2.6	The resultant images of <i>yellow fish</i> using the current state-of-the-art techniques with their 3D RGB color model	62
Table 3.1	Summary of the improvement in the proposed ICM-RD method over the conventional ICM and UCM methods	88
Table 3.2	Hypothesis of the proposed ICM-RD method as compared to conventional ICM and UCM methods	88
Table 3.3	Quantitative results for sample images in Figures 3.7 to 3.10	110
Table 3.4	Average values of entropy, MSE, PSNR, Sobel count, and average gradient for 300 underwater images	111

Table 3.5	Quantitative evaluation of image quality in terms of MSSIM, EME, EMEE, and NIQE with comparison between the state-of-the-art methods	124
Table 3.6	Average values of quantitative evaluation of underwater images in terms of MSSIM, EME, EMEE, and NIQE between the compared state-of-the-art methods for 300 underwater images	125
Table 4.1	Quantitative results of the compared state-of-the-art methods for images in Figures 4.7 to 4.10	153
Table 4.2	Average values of entropy, MSE, PSNR, Sobel count, and average gradient for 300 underwater images	154
Table 4.3	Quantitative evaluation of image quality in terms of MSSIM, EME, EMEE, and NIQE with comparison between the proposed RSAIP and state-of-the-art methods	166
Table 4.4	Average values of quantitative evaluation of underwater images in terms of MSSIM, EME, EMEE, and NIQE between the compared state-of-the-art methods and the proposed RSAIP method for 300 underwater images	167
Table 4.5	Comparison values of entropy, MSE, PSNR, Sobel count, and average gradient for the proposed methods (i.e. ICM-RD and RSAIP)	176
Table 4.6	Comparison values of MSSIM, EME, EMEE, and NIQE for the proposed methods (i.e. ICM-RD and RSAIP)	182
Table 4.7	Comparison of average values for 300 identical underwater images between the proposed methods (i.e. ICM-RD and RSAIP)	183
Table 5.1	Parameter setting for CLAHS process in the proposed DIRS-CLAHS method	200
Table 5.2	Quantitative comparison of resultant images in terms of entropy,	216

MSE, PSNR, Sobel count, and average gradient as shown in Figures 5.10 to 5.13

Table 5.3	Average quantitative values of 300 underwater images in comparison with state-of-the-art and the proposed DIRS-CLAHS methods	217
Table 5.4	Quantitative evaluation of image quality in terms of MSSIM, EME, EMEE, and NIQE with comparison between the proposed DIRS-CLAHS and state-of-the-art methods	228
Table 5.5	Average values of image quality metrics for the 300 sample images in terms of MSSIM, EME, EMEE, and NIQE	229
Table 5.6	Quantitative comparison of the resultant images for three proposed methods (i.e. ICM-RD, RSAIP, and DIRS-CLAHS)	243
Table 5.7	Comparison of the average value for 300 identical underwater images of the proposed methods	244
Table 5.8	Quantitative comparison of the resultant images as shown in Figures 5.14 to 5.24 in terms of quality assessment (i.e. MSSIM, EME, EMEE, NIQE) for all three proposed methods (i.e. ICM-RD, RSAIP, and DIRS-CLAHS)	250
Table 5.9	Average values of quantitative analysis for 300 identical underwater images between the proposed methods in terms of MSSIM, EME, EMEE, and NIQE	251

LIST OF FIGURES

		Page
Figure 1.1	Water surface effects (Shamsudin et al., 2012)	5
Figure 1.2	Illustration of diminishing underwater color (Hitam et al., 2013)	6
Figure 2.1	McGlamery model for underwater image formation through three basic components: direct, forward-scattered, and backscattered components (Schettini et al., 2010)	19
Figure 2.2	Coordinate system for McGlamery (1979) model of underwater image formation (Schettini et al., 2010)	21
Figure 2.3	Sequence of underwater images used by Rafael et al. (2002). (a) Original image sequences (b) Images enhanced through the illumination-reflectance model (multiplicative approach), using the Gaussian function; (c) Local histogram equalization considering a 61x61 neighborhood	28
Figure 2.4	Sequence of underwater images by Rafael et al. (2002) for correcting lighting artifacts. (a) Original image, (b) images enhanced through CLAHE, and (c) images corrected through homomorphic filtering	29
Figure 2.5	Result of non-uniform illumination removal by subtraction of additive shading effect (Rafael et al., 2002). (a) First sample image and (b) second sample image	30
Figure 2.6	Flowchart of the method proposed by Bazeille et al. (2006)	42
Figure 2.7	Sample image used by Bazeille et al. (2006) to evaluate their proposed method	43

Figure 2.8	Sample of underwater image, <i>coral</i> with respective histogram of color channels (a) original image, (b) pixels distribution of R, G, and B color channels, (c) pixels distribution of red color channel, (d) pixels distribution of green color channel, and (e) pixels distribution of blue color channel	54
Figure 2.9	Sample of underwater image with representation of 3D RGB color model. (a) Original image <i>branch</i> and (b) representation of image <i>branch</i> in 3D RGB color model	55
Figure 3.1	Flowchart of the proposed ICM-RD method	89
Figure 3.2	Rayleigh distribution wherein most of the pixels are concentrated around the middle range of the intensity level	91
Figure 3.3	Histogram stretching of red color channels toward the upper side with the minimum of 5% from the 0 point	93
Figure 3.4	Histogram stretching of blue color channels toward the lower side with the minimum of 5% from the maximum point of 255	95
Figure 3.5	Histogram stretching of green color channels toward the lower and upper sides within the limits of [0, 255]	96
Figure 3.6	HSV color model: (a) Illustration of Hue, Saturation, and Value components of HSV color model (b) New range of S and V components at 1% from minimum and maximum limits which is applied in the proposed ICM-RD method	98
Figure 3.7	Image of a <i>small fish</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) ICM-RD	101

Figure 3.8	Image of a <i>blue coral</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) ICM-RD	103
Figure 3.9	Image of a <i>stone wall</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) ICM-RD	105
Figure 3.10	Image of <i>branch</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) ICM-RD	107
Figure 3.11	Possible range of stretching process of the original image histogram	130
Figure 4.1	Flow chart of the implementation of RSAIP method	134
Figure 4.2	Original histogram is divided into two separate histograms at its mid-point and stretched to produce two independent histograms	139
Figure 4.3	Illustration of image channels decomposition and composition	139
Figure 4.4	Combination of the under- and over-enhanced images through stacking and averaging along the z-axis to produce the contrast-enhanced output image	140
Figure 4.5	New range of the V component of the HSV color model with 5% limit from the minimum value as implemented in RSAIP method	142
Figure 4.6	Comparison between the original (left) and stretched-histograms (right) of S and V components in HSV color model	142

Figure 4.7	Image of <i>jellyfish</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) RSAIP	145
Figure 4.8	Image of <i>blue fish</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) RSAIP	147
Figure 4.9	Image of <i>soft coral</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) RSAIP	149
Figure 4.10	Image of <i>red fish</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) RSAIP	151
Figure 4.11	Comparison of resultant images among the compared methods with concentration on a certain area for image <i>jellyfish</i>	165
Figure 4.12	Image of <i>small fish</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image, (b) ICM-RD, and (c) RSAIP	172
Figure 4.13	Image of <i>blue coral</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image, (b) ICM-RD, and (c) RSAIP	173

Figure 4.14	Image of <i>stone wall</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image, (b) ICM-RD, and (c) RSAIP	174
Figure 4.15	Image of <i>branch</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image, (b) ICM-RD, and (c) RSAIP	175
Figure 4.16	Comparison of image <i>small fish</i> with concentration on certain area between two proposed methods (a) ICM-RD and (b) RSAIP	178
Figure 4.17	Comparison of image <i>blue coral</i> between two proposed methods. (a) ICM-RD and (b) RSAIP	179
Figure 4.18	Comparison between two proposed methods (ICM-RD and RSAIP) and the ability of Sobel edge detection to detect the object's edge	179
Figure 4.19	Zooming in the pixel value for the resultant image of the proposed ICM-RD method in Chapter 3	180
Figure 4.20	Zooming in the pixels value for the proposed RSAIP method	181
Figure 5.1	Comparison of the resultant image of <i>stone wall</i> between the proposed methods: (a) Original image, and the other are resultant images produced by (b) ICM-RD and (c) RSAIP	188
Figure 5.2	Original image histograms (red, green, and blue) of <i>stone wall</i>	189
Figure 5.3	Illustration of dividing and stretching process of image histogram for the proposed RSAIP method	190
Figure 5.4	Flow chart of the implementation of the proposed DIRS-CLAHS technique	193
Figure 5.5	Illustration of the minimum, maximum, and mid-points of original input histogram	195

Figure 5.6	Illustration of division and stretching of original histogram of red color channel to produce lower- and upper-stretched regions	197
Figure 5.7	Integration of under- and over-enhanced images by means of average value	198
Figure 5.8	Illustration of applying clip-limit to the image histogram	201
Figure 5.9	HSV color model (a) Illustration of Hue, Saturation, and Value components of HSV color model (b) New range of S and V components at 5% from minimum and 1% from maximum limits which is applied in the proposed DIRS-CLAHS method	206
Figure 5.10	Image of <i>colorful coral</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) DIRS-CLAHS	208
Figure 5.11	Image of <i>green coral</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) DIRS-CLAHS	210
Figure 5.12	Image of <i>coral stone</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) DIRS-CLAHS	212
Figure 5.13	Image of <i>blue fish</i> with the 3D RGB color model and visual diagram of Sobel edge detection: (a) original image; the rest are the images processed using the following methods: (b) HE, (c) ICM, (d) UCM, (e) CLAHE-Mix, (f) CLAHS, (g) PDSCC, and (h) DIRS-CLAHS	214

Figure 5.14	Image of <i>small fish</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	232
Figure 5.15	Image of <i>blue coral</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	233
Figure 5.16	Image of <i>stone wall</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	234
Figure 5.17	Image of <i>branch</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	235
Figure 5.18	Image of <i>jellyfish</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	236
Figure 5.19	Image of <i>blue fish</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	237
Figure 5.20	Image of <i>soft coral</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	238
Figure 5.21	Image of <i>red fish</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	239
Figure 5.22	Image of <i>colorful coral</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	240

Figure 5.23	Image of <i>green coral</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	241
Figure 5.24	Image of <i>coral stone</i> . (a) Original image, and the rest is the resultant images produced by the following methods: (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	242
Figure 5.25	Comparison of image <i>small fish</i> between the proposed methods. (a) Original image, and the rest are the resultant images produced by other proposed methods, (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	245
Figure 5.26	Comparison of image <i>colorful coral</i> between the proposed methods. (a) Original image, and the rest are the resultant images produced by other proposed methods, (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	248
Figure 5.27	Comparison of image <i>green coral</i> between the proposed methods. (a) Original image, and the rest are the resultant images produced by other proposed methods, (b) ICM-RD, (c) RSAIP, and (d) DIRS-CLAHS	249

LIST OF ABBREVIATIONS

ACE	Automatic Color Equalization
CDF	Cumulative Distribution Function
CIELab	Also known as Lab color model. L =luminance/lightness, a and b are color component dimensions
CLAHE	Contrast Limited Adaptive Histogram Equalization
CLAHS	Contrast Limited Adaptive Histogram Specification
DOG	Difference of Gaussian
EME	Measure of Enhancement
EMEE	Measure of Enhancement by Entropy
GW	Gray World
HE	Histogram Equalization
HSI	Hue-Saturation-Intensity
HSV	Hue-Saturation-Value
HVS	Human Visual System
ICM	Integrated Color Model
IQM	Image Quality Metric
LUT	Look-Up Table
MSE	Mean Squared Error
MSSIM	Mean of Structural Similarity
MVG	Multivariate Gaussian
NIQE	Natural Image Quality Evaluator
NSS	Natural Scene Statistic
PDF	Probability Distribution Function
PDSCC	Pixel Distribution Shifted Color Correction
PSNR	Peak Signal to Noise Ratio
RGB	Red-Green-Blue
ROC	Receiver Operating Characteristic
SSIM	Structural Similarity
UCM	Unsupervised Color Correction Method
WCAG	Weighted Contrast Average Grad
WP	White Patch
YCbCr	Color model: Y =luminance, Cb =blue difference, and Cr =red difference Chroma component

PENAMBAHBAIKAN TEKNIK PENINGKATAN KONTRAS IMEJ BAWAH AIR BERASASKAN MODIFIKASI HISTOGRAM

ABSTRAK

Degradasi kontras adalah salah satu masalah imej bawah air yang mengakibatkan pengurangan keamatan cahaya. Kontras yang rendah menyumbang kepada masalah imej yang mempunyai kurang maklumat. Objek dalam imej dilihat tidak jelas. Tambahan juga, penyerapan cahaya menyebabkan imej yang diambil kelihatan berwarna biru-kehijauan seterusnya warna objek akan disalah tafsir. Selain itu, kewujudan kawasan yang gelap dan terlalu cerah menyebabkan pengurangan keperincian imej. Oleh itu, untuk mengurangkan masalah yang dinyatakan di atas, tiga teknik untuk meningkatkan kontras imej di bawah air telah dicadangkan dalam kajian ini, iaitu model warna bersepadu dengan pengagihan Rayleigh (ICM-RD), Rayleigh-regangan dan purata paksi imej (RSAIP), dan regangan-Rayleigh dua imej spesifikasi histogram penyesuaian terhad (DIRS-CLAHS). ICM-RD meningkatkan kontras imej di bawah air dengan mengintegrasikan pengagihan Rayleigh dalam proses regangan yang terhad. Seterusnya, pembetulan warna imej melalui model warna Hue-Ketepuan-Nilai (HSV) memperbaiki keseluruhan warna imej. Di samping itu, kaedah RSAIP dicadangkan bagi menyelesaikan masalah had regangan bagi proses regangan yang dihadapi oleh kaedah ICM-RD. Kaedah RSAIP menyediakan satu alternatif baharu bagi proses regangan, yang mana imej histogram akan dibahagi kepada dua bahagian dan diregangkan secara berasingan bagi memenuhi ruang dinamik imej yang ditetapkan. Proses pembahagian dan regangan ini menghasilkan dua imej yang berbeza keamatan. Kedua-dua imej yang dihasilkan akan digabungkan berdasarkan nilai purata dan diaplikasikan dengan kaedah pembetulan warna bagi menghasilkan imej akhir. Kaedah yang ketiga, DIRS-CLAHS, dicadangkan bagi meningkatkan keupayaan kaedah RSAIP dalam

mempertingkatkan kontras imej dengan mengintegrasikan pembedahan kontras global dan tempatan. Proses DIRS-CLAHS bermula dengan pembedahan kontras global yang diperkenalkan dalam kaedah RSAIP. Pembedahan kontras tempatan dilaksanakan dengan membahagikan imej kepada bahagian yang lebih kecil. Akhirnya, proses ini diaplikasikan dengan proses pembedahan warna yang merupakan modifikasi daripada proses pembedahan warna yang diperkenalkan dalam kaedah RSAIP dan ICM-RD. Secara prinsipnya, semua teknik yang dicadangkan mengatasi kualiti teknik terbaharu yang diperkenalkan secara kualiti dan kuantiti. Daripada tiga teknik yang dicadangkan, kaedah DIRS-CLAHS menunjukkan satu peningkatan yang baik dalam meningkatkan kontras imej bawah air dan warnanya. Secara kuantiti, perbandingan dengan enam teknik terbaharu yang diperkenalkan bagi 300 sampel imej, kaedah DIRS-CLAHS menghasilkan nilai purata entropi yang tertinggi iaitu 7.624 dan nilai purata MSE yang terendah iaitu 646.32. Malah, dari segi pengukuran peningkatan (EME) dan pengukuran peningkatan berdasarkan entropi (EMEE), DIRS-CLAHS menghasilkan nilai purata tertinggi iaitu masing-masing 27.096 dan 9.670.

IMPROVEMENT OF UNDERWATER IMAGE CONTRAST ENHANCEMENT TECHNIQUE BASED ON HISTOGRAM MODIFICATION

ABSTRACT

Contrast degradation is one of the problems of underwater image that resulted from the light attenuation. Low contrast contributes towards the less usable image where less information could be extracted from the image. The objects seen in the image are unclear. In addition, light absorption phenomenon causes the underwater image to be dominant by the blue-green illumination, resulting in misinterpretation of objects color. Therefore, to reduce the aforementioned problems of underwater image and increases underwater image contrast, three techniques of improving underwater image contrast are proposed in this study, namely integrated color model with Rayleigh distribution (ICM-RD), Rayleigh-stretching and averaging image planes (RSAIP), and dual-images Rayleigh-stretched contrast limited adaptive histogram specification (DIRS-CLAHS). ICM-RD improves the underwater image contrast by integrating the Rayleigh distribution in the limited stretching process. The correction of image color through Hue-Saturation-Value (HSV) color model further improves the overall image color. On the other hand, RSAIP method solves the limitation of stretching process that faced by ICM-RD method. The RSAIP method provides an alternative stretching technique, where the histogram of the original image is divided into two independent regions and stretched independently to occupy the limited dynamic intensity range. The dividing and stretching processes produce two different intensity images. These images are then combined by means of average value and applied with color correction technique to produce final resultant image. The third proposed method, DIRS-CLAHS method is designed to improve the capability of the RSAIP method in enhancing image contrast by integrating global and local contrast correction. DIRS-CLAHS is first applied with global contrast correction which

is introduced in the RSAIP method. Local contrast correction is then applied by dividing the image into smaller tiles. Finally, the method is applied with a new color correction process which is a modification of color correction process introduced in RSAIP and ICM-RD methods. All proposed techniques, principally outperform the state-of-the-art methods, qualitative and quantitatively. Out of the three proposed methods, DIRS-CLAHS method, is the best method and demonstrates a significant enhancement in improving the underwater image contrast and its color. Quantitatively, in comparison with six state-of-the-art methods for 300 samples of underwater images, the proposed DIRS-CLAHS produces the highest average entropy of 7.624 and the lowest average MSE value of 646.32. In addition, in terms of measure of enhancement (EME) and measure of enhancement by entropy (EMEE), DIRS-CLAHS produces the highest average values which are 27.096 and 9.670, respectively.