IMPROVEMENT OF UNDERWATER IMAGE CONTRAST ENHANCEMENT TECHNIQUE BASED ON HISTOGRAM MODIFICATION

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by

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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 pembetulan kontras global dan tempatan. Proses DIRS-CLAHS bermula dengan pembetulan kontras global yang diperkenalkan dalam kaedah RSAIP. Pembetulan kontras tempatan dilaksanakan dengan membahagikan imej kepada bahagian yang lebih kecil. Akhirnya, proses ini diaplikasikan dengan proses pembetulan warna yang merupakan modifikasi daripada proses pembetulan 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.

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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.