High Quality Underwater Image Reconstruction using Perceptable HSV Weighted Approach

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Abstract - The underwater image restoration is the trends among the ocean engineering researchers to make the information clearer after capturing the images in underwater or ocean images. The underwater photography is important from exploring point of view of various researchers to find out the hidden treasures beneath the sea. The exploration can be done in terms of pictures and videos by the divers later these would help to find out the objects, species, and plants to study the underwater habitat or scenario. Usually the pictures taken from the high quality cameras the picture are affected by the several effects like blurring, colour degradation, light reflection and underwater objects etc. For the proper and efficient exploration of the underwater situations there picture should be as clear as possible in terms of colour as well the clarity. In this paper the same context has been taken into consideration and the high quality image restoration technique is proposed which is based on the perceptible RGB weighted approach to enhance the colour quality as well as clarity in the image pixels. The proposed approach utilizes mainly two stage to restore the underwater image one is colour enhancement and second is contrast toning, which adjust the effects of light reflections and low light situation. From the simulation outcomes the proposed approach proved better than the previous methodologies from the restoration it made.

Keywords - Image Restoration, Underwater Degradation, low light images, oceanic photography.

I. INTRODUCTION

Underwater image processing has received considerable attention over the last few decades due to its challenging nature and its importance for the environment. Improving the underwater image quality can be separated into two different problems known as the image restoration problem and the image enhancement problem. Image restoration aims at estimating the true scene by removing the noise and inverting the degradation process. Doing this usually requires building mathematical models of the degradation and using various signal processing filtering techniques. Classical image restoration methods are Wiener filtering and blind image deconvolution. An example of the results of image restoration is shown in Figure 1.1. On the other hand image enhancement aims at making the images more aesthetically pleasing through subjective criteria and without relying on complex mathematical models. Colour correction, contrast and brightness adjustment are good examples of

Figure 1.1: Example of underwater image restoration [1].

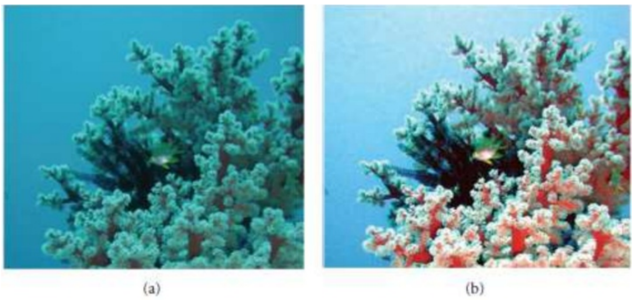

Figure 1.2: Example of colour correction of an underwater image. a) original image b) colour corrected image[2].

The purpose of this research is to restore the video recorded by an underwater surveillance camera back to its original quality using variations of state of the art methods. Focus will be laid on dealing with the video restoration problem and not on video enhancement. The data consists of video sequences whose quality deteriorates with time as more dirt gathers on the lens.

The deterioration of the images can be split into two different types. The first is a local blurring of the image in places where there is dirt. This blur can't be considered stationary throughout the sequence as it sometimes tends to shift slightly back and forth depending on the the water currents. The second is noise that is present from either floating particles or camera measurement noise (errors in the analog-to-digital conversion or during the quantization). In order to maintain the video quality at a standard that allows for the monitoring of underwater environment the lens must be cleaned in regular intervals. This procedure is costly and the frequency with which it is performed could be reduced if the image is restored using image restoration techniques.

Underwater vehicles are used to survey the ocean floor, much often with acoustic sensors for their capability of remote sensing. Optical sensors have been introduced into these vehicles and the use of video is well integrated by the underwater community for short range operations. However, these vehicles are usually remotely operated by human operators : the automated processing and analysis of video data is only emerging and first suffers from a poor quality of the images due to specific propagation properties of the light in the water. To summarize underwater images suffer from limited range, non uniform lighting, low contrast, diminished colors, important blur. . . Moreover many parameters can modify the optical properties of the water and underwater images show large temporal and spatial variations. So, it is necessary to pre-process those images before using usual image processing methods. Today pre-processing methods typically only concentrate on non uniform lighting or color correction and often require additional knowledge of the environment: as depth, distance object/camera or water quality [6][7]. The algorithm proposed in this paper is a parameter-free algorithm which reduces underwater perturbations, and improves image quality without using any knowledge and without any human parameter adjustment. It is composed of several successive independent processing steps which respectively correct non uniform illumination, suppress noise, enhance contrast and adjust colors [3][4][5][8]. The pre-processing step occurs before the segmentation. In most cases, a great improvement is observed while filtering, as it is showed by the edge detection criterion.

II. UNDERWATER DEGRADATION

A major difficulty to process underwater images comes from light attenuation. Light attenuation limits the visibility distance, at about twenty meters in clear water and five meters or less in turbid water. The light attenuation process is caused by the absorption (which removes light energy) and scattering (which changes the direction of light path). Absorption and scattering effects are due to the water itself and to other components such as dissolved organic matter or small observable floating particles. Dealing with this difficulty, underwater imaging faces to many problems [1][6]: first the rapid attenuation of light requires attaching a light source to the vehicle providing the necessary lighting. Unfortunately, artificial lights tend to illuminate the scene in a non uniform fashion producing a bright spot in the center of the image and poorly illuminated area surrounding. Then the distance between the camera and the scene usually induced prominent blue or green color (the wavelength corresponding to the red color disappears in only few meters). Then, the floating particles highly variable in kind and concentration, increase absorption and scattering effects: they blur image features (forward scattering), modify colors and produce bright artifacts known as "marine snow". At last the non stability of the underwater vehicle affects once again image contrast. Our preprocessing filter has been assessed on natural underwater images with and without additional synthetic underwater degradations as proposed in [1]. Underwater perturbations we added are typical perturbations observed and they have been tested with varying degrees of severity. We simulate blur and unequal illumination using Jaffe and McGlamery's model [14][16], gaussian and particles noise as additive contributions to the images and finally reduced color range by histogram operation.

III. PROPOSED METHODOLOGY

To restore underwater image perceptable HSV weighted approach is proposed in this work. Keeping in mind the end goal to process color image in RGB color space utilizing this plan, firstly image must be changed to hue, and saturation and luminance (HSV) color space. The Brightness can be represented as luminous intensity here. Hue represents to the impression identified with the predominant wavelength of the color stimulus Saturation demonstrates the relative color virtue (measure of white light in the color).

The Saturation and Hue are taken together is called the polar system or chromaticity coordinates.

$$HSV \rightarrow H, S, V$$

$$V \rightarrow V(equalize)$$

$$HSV(equalize) \rightarrow H, S, V(equalize)$$

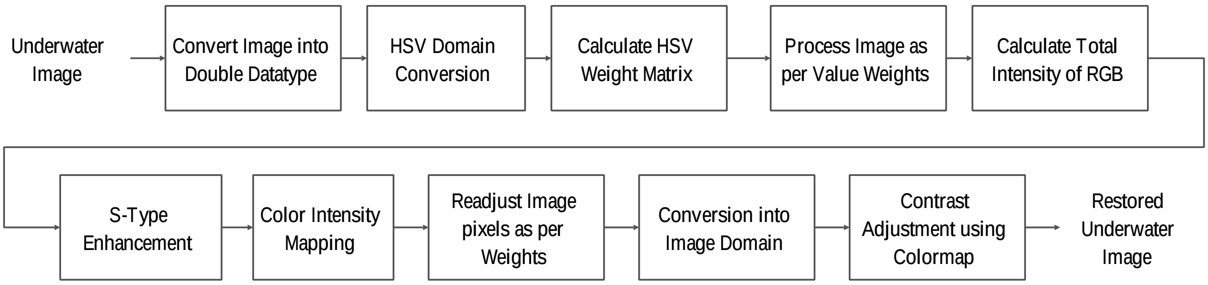

Fig. 3.1 Block Diagram of Proposed Underwater Image Restoration System.

Figure 3.1 Show the block diagram of proposed Underwater Image Restoration System. As shown in figure to enhance image is processed from different stages. Fist underwater degraded image is converted in to double type of data type. The doubled image data type is now converterd in to HSV domain. The HSV color model is obtained by doing a non-linear transformation of the RGB color model and is often represented as a hexcone color space. The purpose of the HSV color model is to provide an easier way to describe color specification in computer graphics by using the terms hue, saturation and value. The weights used to describe a colors content of the primaries will in the work be represented by a vector (I_R, I_G, I_B), where I is the weight or intensity of the primaries, and the subscripts are abbreviations for red, green and blue. Further process image and calculate RGB total intensity.

The brief presentation of the implemented Matlab routines that are used in this work is shown in Figure 3.2. A simplified overview of the routine work flow is shown in figure, where rectangles describe the different parts of the program and arrows indicates the flow of information.

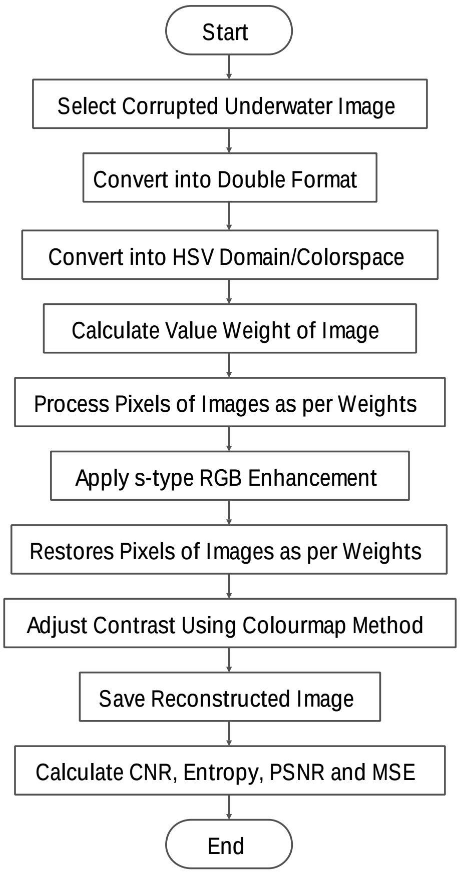

Figure 3.2 Flow Chart of Proposed Underwater Image Restoration System.

In HSV color model, the S and V parts are extracted from the picture and stretched accordingly within the limit of the minimum and the maximum intensity levels. This means that the S components are stretched from 5% to 99% in the output histogram. These limits are set in order to avoid the S components from their minimum and maximum points which could lead to under- and over- saturation as well as under- and over-brightness.

After dividing the histogram into two regions at mid-point, the histograms of S then stretched. The stretching process of S components is similar to the stretching process of histogram in RGB color model.

Steps involved to implementation and simulate proposed algorithm in Matlab are shown in figure the flow of process are follows.

1. Start Simulation in MATLAB

2. Select sample underwater image to process

3. Convert in to double format

4. Convert into HSV domain in / color space

5. Calculate value weight of image

6. Process pixels of image as per weights

7. Apply S-type RGB Enhancement

8. Restore Pixels of image as per weights

9. Adjust contrast using Colourmap method

10. Save reconstructed image

11. Calculate CNR, entropy, PSNR and MSE

12. End process with MATLAB

IV. SIMULATION RESULTS

The images that are used in the simulation experiment is the individual components histogram representation of the dark and light regime images displayed in figure, as well as use of the MATLAB Color Thresholder application in the Image Processing and Computer Vision toolbox.

The first evaluated component that is hue, which seems to have a high resemblance when comparing the histograms of the light and dark regime.

The range between these two distributions includes the hue found in most of the low contrast areas, like the mimosa pudica petiole and leaf edges.

Implementation underwater image reconstruction using perceptible HSV weighted approach is ineffective in order to improve the image contrast. In some cases, contrast of small areas should be considered to be increased in order to improve the image details. In some images, there are some areas which are hidden by the shadow of other objects, causing these areas to become under-exposed. In addition, there is an underwater image which has two different intensity-regions: one region is dark and another region is bright. Applying HSV stretching process may result in darkening the low intensity region while brightening the high intensity region.

Simulation results of few images are shown in figure 4.1 to figure 4.7 for different image samples. To evaluate the performance and image quality using proposed algorithm. The entropy CNR, PSNR, MSE is considered. Table I: Comparison of Entropy and CNR. Table II: Comparison of MSE and PSNR. From Figure 4.1 to Figure 4.7 at left hand side of image is a degraded underwater image where as at right hand side its corresponding resorted image is given.

Affected Underwater Image Restored Image

Figure 4.1 Input and Restored Version of Image 1

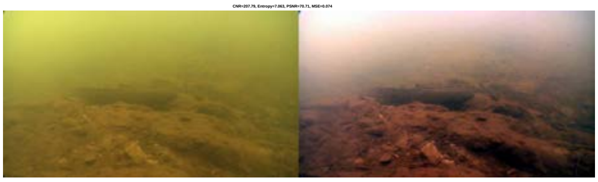

Figure 4.2 Input and Restored Version of Image 2

Figure 4.3 Input and Restored Version of Image 3

Figure 4.4 Input and Restored Version of Image 4

Figure 4.5 Input and Restored Version of Image 5

Figure 4.6 Input and Restored Version of Image 6

Figure 4.7 Input and Restored Version of Image 7

Table I: Comparison of Entropy and CNR

Images	**Entropy**		**CNR**	
	Previous	Proposed	Previous	Proposed
Image 1	7.13	5.978	120.32	217.60
Image 2	7.29	7.063	78.23	207.79
Image 3	7.1	7.677	86.55	232.29
Image 4	6.99	6.309	182.83	241.99
Image 5	7.03	7.304	130.1	229.23
Image 6	7.2	6.562	98.32	192.71
Image 7	6.98	7.167	85.32	114.82

Table II: Comparison of MSE and PSNR

Images	**MSE**		**PSNR**	
	Previous	Proposed	Previous	Proposed
Image 1	0.0242	0.071	67.78	71.09
Image 2	0.004	0.074	66.067	70.71
Image 3	0.01	0.043	59.927	75.52
Image 4	0.0405	0.147	62.09	64.78
Image 5	0.023	0.052	63.23	73.82
Image 6	0.0311	0.069	64.85	71.38
Image 7	0.015	0.019	61.52	82.43

Based on the results comparison of proposed work with existing work on same parameter. It is found that proposed algorithm has better performance and noise rejection capability compared to previous work.

V. CONCLUSION AND FUTURE SCOPE

In general, proposed method is composed of the perceptible RGB weighted approach, image decomposition process, color correction and dehazing process, the weighted fusion process is utilized to reconstruct the final result. In this algorithm, several states of the art are reviewed underwater image enhancement methods and proposed a novel high quality underwater image reconstruction using perceptable HSV weighted approach. The performance of proposed method is then compared with state of the arts by 7 sets of distorted images captured in the different water environments. Meanwhile, subjective visual evaluation index and several underwater image quality metric measurements such as PNSR, MSE, Entropy, CNR are utilized to evaluate and analyze the superiorities and drawbacks of image enhancement algorithms.

The proposed underwater image enhancement method is based on HSV weighted approach, image decomposition as well as image fusion technology. For future work research will try to find out an efficient way to estimate the vertical depth of arbitrary underwater images and optimize the transmission depth of underwater images more accurate, finally construct the comprehensive, effective and efficient algorithm.

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