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UNDER WATER DEPTH ESTIMATION AND IMAGE RESTORATION BASED ON SINGLE IMAGES

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Abstract:

Images captured beneath water are usually degraded due to the effects of absorption and scattering. Underwater imag- ing is very important in present technology for detecting object like fishes, algae, minor particles etc. Light scattering and color change are two dominant sources of distortion for underwater imaging that lowers the visibility and contrast of the images cap- tured, affects ambient underwater environments dominated by a bluish tone. Hence, the presented system demonstrates a novel approach to enhance underwater images by distance factor estimation along with a dehazing algorithm. The noise particles are removed before dehazing by implementing distance factor based on intensities of different color channels with gamma correction improving the brightness of dimmed images. The dark channel prior removes haze and noise effect, providing better visual quali- ty with adaptive exposure map estimation for adjusting too dark and too bright regions of underwater image. At the final stage, the motion blur and water transparency effect is removed using high frequency emphasizing filtering. The enhanced haze-free and natural appealing output can be used for display and analysis purpose.

Keywords: Underwater image dehazing, light scattering, distance factor, gamma correction, dark channel prior.

1. INTRODUCTION

Images captured under water are distorted due to the effects of absorption and scattering. The light received by the camera is gener- ated by three components [3]: a direct component reflecting light from the objects, forward scattering component randomly deviat- ing light on the camera and back scattering component reflects light towards camera before it reaches the objects. This causes ef- fects such as blurring, masking details of the image and may lead to produce noise. When the light wave propagates through the water medium, the different frequency components of light wave produces different absorption profile [1]. The absorbing property of water medium is different from the air medium. The absorption of light wave de- pends on different factors such as velocity of water, amount of suspended particle in water, turbidity of water, salinity of water etc. It is seen that, light wave becomes weaker after traveling few distance in water. Above figure shows the comparison between absorption of light wave of different colors. Red wave travel very low distance and can propagate only one to two meter in pure water, green light travels nearly about 26 meters while blue light travels the highest dis- tance and can propagate more than 30 meters in pure water. So any object lying more than 10 meters may lost its original color and the color of the objects seems to be blue. K. He et.al [7] proposed a dark channel prior for dehazing the natural images. Dark channel having minimum intensity value on image patch among three (R, G, B) color components. Y. Chiang et.al

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[4] derived wavelength compensation and image dehazing (WCID) method for restoration of underwater images based on residual energy ratios of different color channels present in back- ground light. Depending on the amount of attenuation related to each light wavelength, color change compensation is carried out to restore color balance. P. Dwivedi et.al [1] described a distance factor estimation with scattering loss reduction and high frequency emphasizing filtering to reduce blur and transparent layer of water providing enhanced images. Degraded underwater images shows some limitations when being used for display and extracting valuable information for further processing, such as marine biology and archaeology, marine ecological research, and aquatic robot inspection. Implementation of the dark channel prior is a novel approach to dehaze the underwater image. The distance between the objects and the camera is esti- mated that provides the estimation of each color channel by scene depth based on intensity level of three different color components. Gamma correction improves the brightness of underwater image and vignette correction enhances the visual quality by adjusting the focus of each patch, giving the natural appearance to output image. The dehazed image value is adjusted to lie between specified pixel values eliminating too dark and too bright regions. The blurness of the image is further enhanced by using high frequency em- phasizing filtering which also reduces the transparent layer of water medium.

2. RELATED WORK

John Y. Chiang and Ying-Ching Chen implemented a wavelength compensation and image dehazing (WCID) [8] algorithm to re- move the distortions caused by light change and color change simultaneously. They also used the dark channel prior method to es- timate the distance of the scene objects to the camera, called as depth map.

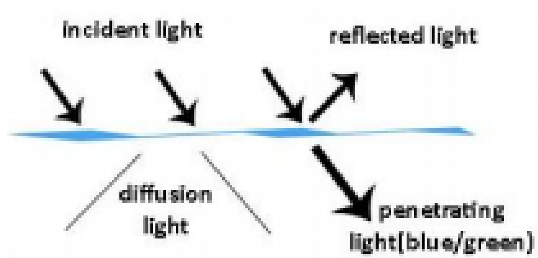

Fig.1.

Based on the derived depth map, the foreground and the background regions are compared to detect the existence of the artificial light source, if any. If an artificial light source is detected, then its luminance is removed form foreground region to prevent overcompensation. The WCID algorithm removes the haze effect and color change along the underwater propagation path to the camera. The residual energy ratio is employed to estimate the water depth within an underwater scene. Energy compensation for each channel is carried out subsequently to adjust the bluish tone to a natural color. WCID method obtains the highest signal-to-noise ratio (SNR) value, compared to low SNR obtained by traditional histogram equalization which decreases significantly as the depth increases. Scene depth estimation by dark channel prior may cause compensation errors where relatively large white shiny regions of a fore- ground object might be misjudged as far away ones. Adaptive histogram equalization (AHE) is used to magnify the contrast in images. It computes several histograms, each correspond- ing to a different part of the image, and then used to redistribute the brightness values of the image. However, AHE tends to over amplify noise in relatively uniform regions of an image. A modification of AHE called contrast limited adaptive histogram equalization (CLAHE) avoids this noise problem by limiting the amplification, The difference between underwater and free space haze image is that, all the chromes of light wave in free space are assumed to be attenuated equally, but in case of water medium the attenuation of different chrome of light wave is different. For free space haze image, particles are assumed to be steady but for underwater images steadiness of water medium is very seldom so the image suffer from multiple reflection.

3. PROPOSED SYSTEM

As intensity of light depends on the distance travelled by the light wave, so estimating scene depth or distance function using inten- sity of pixels. The main problem in present domain is that the absorption of the medium is different for different chrome of light, so distance factor will be different for different color component. The result obtained by dehazing method.

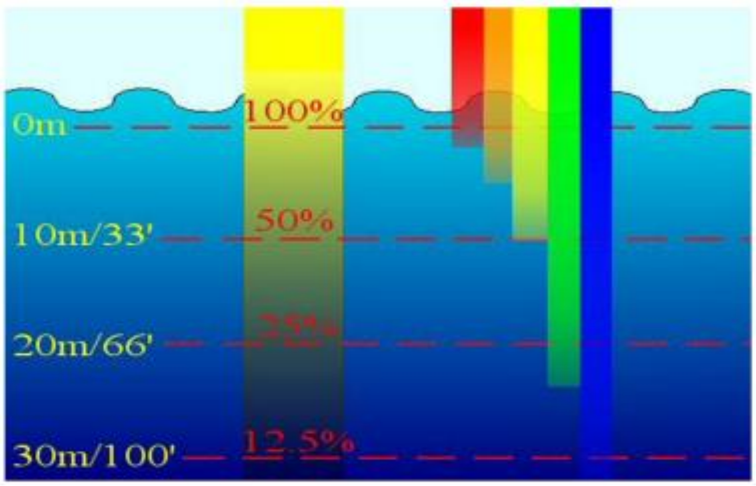

Fig.2.

The experiment performed in MATLAB R2014a on a database available at YouTube [11]. The video first converted into series of images and then these images are processed through derived al- gorithm. Gamma correction provides sufficient brightness and color contrast enhancement for dimmed images. The dark channel prior efficiently removes the effect of haze and noise in the image but output contains too dark or too bright regions. This problem is avoided by adaptive exposure map estimation adjusting the illumination intensities, providing better visual quality. The results are obtained up to this part. The difference between underwater and free space haze image is that, all the chromes of light wave in free space are assumed to be attenuated equally, but in case of water medium the attenuation of different chrome of light wave is different. For free space haze image, particles are assumed to be steady but for underwater images steadiness of water medium is very seldom so the image suffer from multiple reflection.

4. ANALYSIS

This paper proposes a novel approach for underwater image enhancement based on dark channel dehazing method along with gam- ma correction that improves the contrast and brightness of the dimmed images. Dehazing algorithm based on dark channel prior provides enhanced output by removing the effect of absorption and scattering, avoiding too dark and too bright regions of image by using adaptive exposure map adjusting the illumination intensities. Vignette correction wipes out the effect of gradual fade-out of the lightness around the focal point. At the final stage, the motion blur and water transparency effects eliminated using high fre- quency emphasizing filtering. The overall system provides noise free enhanced image, maintaining natural appearance with im- proved visibility that unveils more details and valuable information. In Ocean studies, underwater imaging plays a vital role in exploring the life under water. Underwater images are taken to conduct underwater surveys and to study about aquatic life and characteristics. But it is difficult to get clear images of objects under water due to poor visibility. As the light enters the water medium, it gets scattered by the suspended particles and also a portion of the light is absorbed by the medium. This can be explained by Beer - Lambert law which states that “the water layers having equal thickness will absorb equal fraction of light as it passes through the medium.

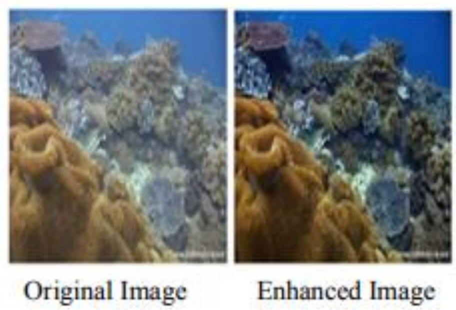

Fig.3.

” Due to the characteristics of water medium, the light components having longer wavelengths are absorbed easily at the surface and those with shorter wavelengths manage to travel deep. Many computer vision methods are proposed to enhance underwater images for variety of applications such as underwater telecommunication systems, pipeline detection, mine detection.. nvented a method which compensates for the attenuation effects along the propagation path and removes the influence of artificial light source from underwater images. A depth map was first estimated and then the foreground and background within a scene were segmented. The light intensities of foreground and background are compared to determine the presence of artificial light source and was compensated. The residual energy ratios of different color channels existing in the background light was exploited to estimate the water depth. Color balance was achieved by color change compensation based on the differential attenuation of each wavelength light. This way, the effect of light scattering and color change was compensated by the algorithm. Due to varying parameters, measurement of rate of light energy loss was not accurate and also calibration was required before processing.

CONCLUSION

This paper presents a comparative study on various methods for underwater image enhancement and restoration for the last few years. Earlier, hardware elements such as polarizers, sensors etc. are used to take a set of images of the same scene and are processed to obtain a clear image. With the development of computer vision techniques, optical models are derived for image formation both in outdoor as well as underwater environments suffering from visibility degradation. A single image with visibility degradation can be used in these models to get an enhanced output image. Other than histogram equalization and contrast stretching, most commonly used method for image enhancement is based on the optical model for degraded image. Recently, underwater image enhancement using multiscale fusion technique is introduced which reduced the computational complexity to an extent.

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