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# Enhancement and Restoration of Underwater Image Scene using Image Processing

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***Abstract:*** ***Getting clear images and videos in underwater environments is an important issue in ocean engineering. Restoration and enhancement of underwater images and videos are difficult tasks because of variations of physical properties. The scattering and absorption are the main causes in the underwater environment to make the images and videos decrease their visibility, for example, blurry, colour distortion, low contrast, and reducing visual range. In this paper, we proposed a method to restore an underwater scene using DCP (Dark Channel Prior), enhance it using HSV-CLAHE (Hue Saturation Value - Contrast Limited Adaptive Histogram Equalization) and also removes the blurriness and noises present in underwater scene, for getting real and synthesized underwater images and videos, which shows the better performance.***
***Keywords: Underwater image, light scattering, light absorption, image enhancement, image restoration***

## I. INTRODUCTION

Underwater exploration has become very important in recent years with increasing application demands. As the technology advances in manned and remotely operated submersibles allowing people to collect images and videos from a wide range of the undersea world. Waterproof cameras have become popular, allows to easily record underwater images and videos for various applications such as studies of marine species, wreckage exploration, inspection of underwater cables and pipelines, underwater scene analysis, search and rescue.

Fig. 1(a) depicts a simplified image formation model (IFM) to describe an underwater scene. Here I(x), the observed intensity at pixel x, consists of the scene radiance J(x) blended with the background light (BL) B according to the transmission map (TM) t(x). The TM describes the portion of the scene radiance that is not scattered or absorbed and reaches the camera. Therefore, a closer scene point has a larger value in the TM. Fig. 1(b)-(f) shows five underwater images with different BL. Noises present in under water image or video diminish the details that could contain significant information. Thus, noise free super-resolving underwater speckled images are important for ocean observation.

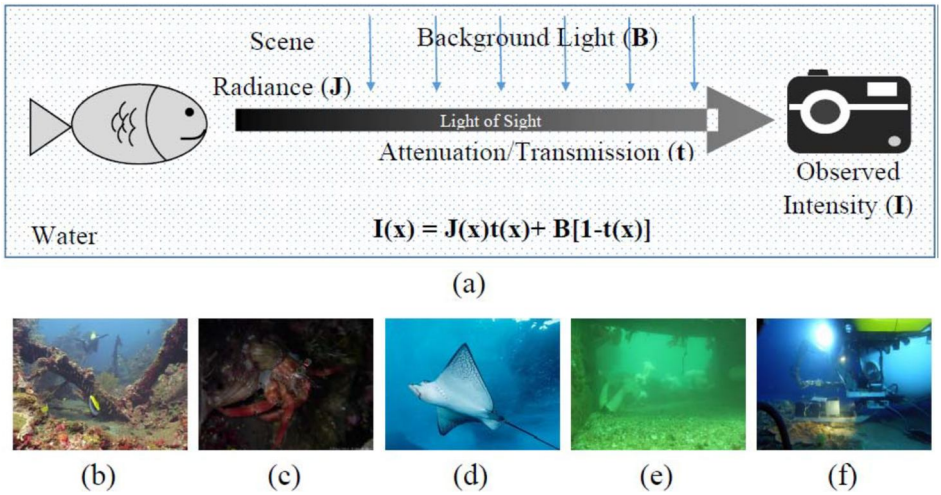


Fig 1.(a) Simplified image formation model. (b)–(f) Examples of underwater images having different underwater color tones.

Captured underwater images or videos often suffer from color distortion and low contrast due to the propagated light attenuation with distance from the camera, primarily resulting from absorption and scattering effects. Different approaches are proposed to obtain clear underwater scene which could be sorted into two categories. One is image restoration and the other one is image enhancement. The image enhancement technology does not consider the physical model and it can improve the image quality by

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image processing methods simply. The image restoration technology is based on the physical model of image formation. But this technology is not good at dealing with the color distortion. By combining two technologies, satisfying results can be obtained.

## II. LITERATURE REVIEW

For the last few years, a flourishing movement has been started towards the direction of the improvement of underwater scene using image processing. Various authors proposed methods in order to restore color and enhance contrast for such images.

Yan-Tsung Peng and Pamela C. Cosman [1] presented a method which uses image blurriness and light absorption based on depth estimation for the image restoration. First, the image blurriness is estimated.

According to that background light is selected from blurry regions in an underwater image. Then, based on the background light, the depth map and the transmission map are obtained to restore scene radiance. This depth estimation method works well for a wide variety of underwater images.

Yakun Gao, Haibin Li, and Shuhuan Wen [3] presented a method for underwater images based on bright channel prior for image restoration and enhancement which was inspired by the dark channel prior in image de-hazing field. They compared their algorithm with another five algorithms by using the quantities of two feature points. One is the amount of canny edge point and the other is the amount of sift feature point.

G. Sowmiyadevi and Dr. G. Kavitha [4] presented a method on RGB Color Dependability Algorithm(UCDA) for an Underwater Image Restoration. This algorithm is applied both on light illumination and shades color models to enhance underwater images. This method has dual approach (i) RGB color Attribute Extraction and (ii) color dependability algorithm. This method performs contrast stretching on RGB color model and performs saturation and intensity stretching on Weibull histogram color model. These algorithms are tested on synthetic images as well as real images.

Yan-Tsung Peng, Xiangyun Zhao and Pamela C. Cosman [6] proposed a method for single under water image enhancement using depth estimation based on blurriness. It is based on the observation that objects farther from the camera are more blurry for underwater images. Adopting image blurriness with the image formation model (IFM), they estimate the distance between scene points and the camera and thereby recover and enhance underwater images.

## III. PROPOSED WORK

Following is the block diagram and description of proposed work.

### *A. Block Diagram*

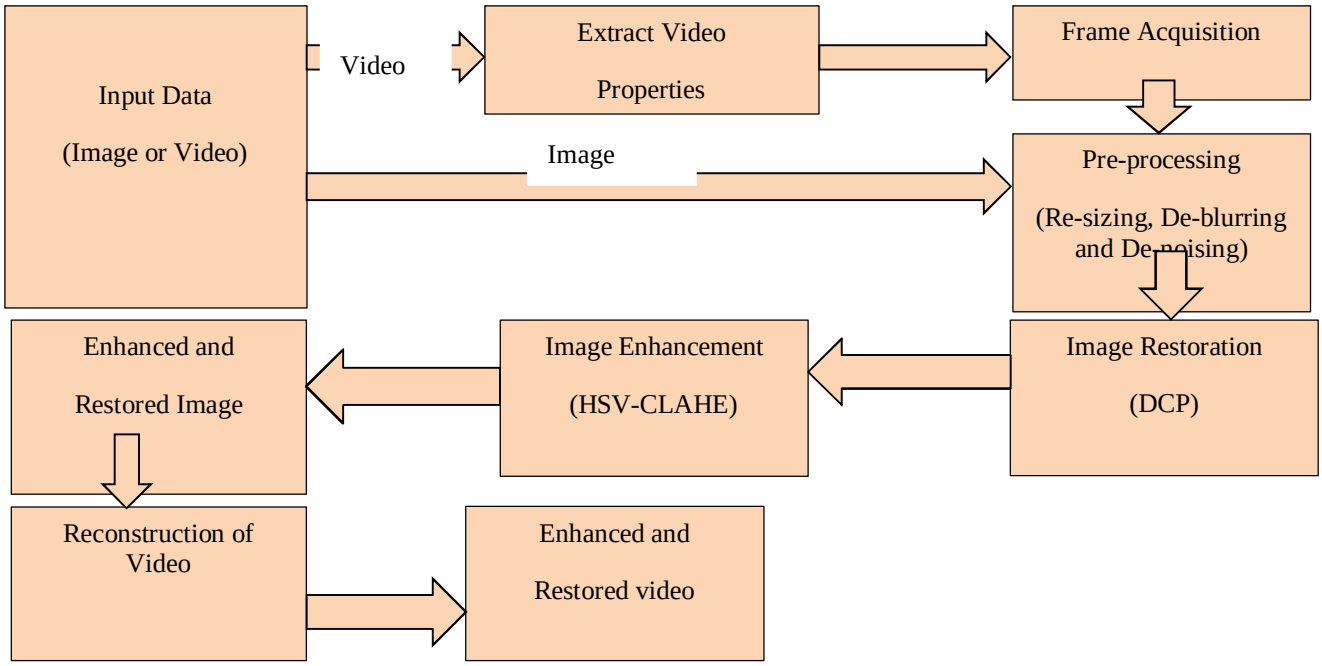


Fig 2: Block diagram of proposed method

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*B. Description*

1) *Input data:* Input data can be underwater image or video but it must be colored underwater scene which we have to enhanced and restored. Input image can be in the common form like .jpg, .png, .bmp, .tif etc. Likewise common input video formats are .mp4, .avi etc. Depending on the type of input that is image or video, further processing is applied.
2) *Extract Video Properties:* For the input video, Properties of video such as duration, name, path, tag, user data, bits per pixel, frame rate, height, format of video, width and current time needs to be extracted which are required by further processing.
3) *Frame Acquisition:* A video is a combination of number of frames and image modification process is applied on each frame separately. Hence in the frame acquisition step, video is divided into number of frames for obtaining the different frames of video. Number of frames of video is counted.
4) *Pre-processing:* Pre-processing has three parts Re-sizing, De-blurring and De-noising. In Resizing, Image is resizes, so that it will be available in the size required by the further processing. In De-blurring, blurriness present in the underwater image is removed using Wiener Filter. In De-noising, noises present in the image are removed. We are using median filter for noise removal.
5) *Image Restoration:* Image restoration is carried out using DCP (Dark Channel Prior) and it is based on IFM (Image Formation Model). The simplified Image Formation Model is given as:

$$I^c(x) = J^c(x)t^c(x) + B^c\big(1 - t^c(x)\big), c \in \{r, g, b\} \quad \text{--------(1)}$$

Where, $I^c(x)$ is the observed intensity in color channel c of the input image at pixel x, $J^c$ is the scene radiance, $B^c$ is the BL(Background Light), $t^c$ is the TM(Transmission Map), c is one of the red, green, and blue channels. TM describes the portion of the light that is not scattered and reaches the camera. The goal of haze removal is to recover $J^c$, $B^c$, and $t^c$ from $I^c$. Using DCP, we have obtained the following equations

Background Light Estimation

$$\widetilde{B^c} = I^c\left(\arg\max_{x \in p_{0.1\%}} \sum_{c \in \{r,g,b\}} I^c(x)\right). \quad \text{--------(2)}$$

Transmission Map Estimation

$$\tilde{t}(x) = 1 - \min_{y \in \Omega(x)} \left\{ \min_{c \in \{r,g,b\}} \frac{I^c(y)}{B^c} \right\}, \quad \text{--------(3)}$$

Scene Radiance Recovery

$$\widetilde{J^c}(x) = \frac{I^c(x) - \widetilde{B^c}}{\max\left(\widetilde{t^c}(x), t_0\right)} + \widetilde{B^c}, \quad \text{--------(4)}$$

In this image restoration step, we will get color restored haze free image.

6) *Image Enhancement:* For the image enhancement HSV-CLAHE method is used in which HSV is the color space which has three channels these are Hue (H), Saturation (S) and Value (V) and CLAHE stand for contrast-limited adaptive histogram equalization algorithm. In in this method RGB image is converted into the HSV image then apply CLAHE on H and S component of image. After that HSV image is converted back to the RGB image.

CHAHE is a local contrast enhancement technique. Through CLAHE, the input image is partitioned into some non-overlapping regions and histogram equalization is applied on each of them. Then every histogram is clipped by a clip limit which is based on the desired contrast expansion and the size of the neighbouring region. After that, bilinear interpolation is applied to eliminate the region boundaries making them look smoother like as if no boundaries are there. This results in a limit on the local contrast enhancement to the desired extent. For this a Binary Search Based CLAHE (BSB-CLAHE) algorithm is used to determine the points at which the clipping should be done and redistribute the clipped pixels.

7) *Enhanced and Restored Image:* In this way we get the enhanced and restored image, which is the final output in case of underwater image as an input.

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8) *Reconstruction of Vide:* In this step, video is reconstructed by collecting the frames of video. It is applied only if the input data is an underwater video.
9) *Enhanced and Restored video:* Finally we get the enhanced and restored video, which is the final output in case of underwater video as an input.

## IV. RESULTS AND DISCUSSION

We have tested performance of our proposed system on Matlab version R2016a, Windows 10 platform and processor used is Intel® core™i3.

### A. *Examples*

Table I: Examples of underwater image analysis by the proposed method

| | Image 1 | Image 2 | Image 3 | Image 4 | Image 5 |
|---|---|---|---|---|---|
| Input Image | | | | | |
| Output Image | | | | | |

Table II: Examples of underwater video analysis by the proposed method showing the frame number 20 of videos

| | Video 1 | Video 2 |
|---|---|---|
| Input Video Frame | | |
| Output Video Frame | | |

### B. *Comparative Analysis of Performance Parameters*

1) *MSE:* The Mean Square Error(MSE) represents the cumulative squared error between the output and the original

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image. MSE is calculated using the following equation

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M * N}$$

Where, M and N are the number of rows and columns in the input image, respectively.

*2) SNR:* Signal-to-noise ratio is defined as the ratio of the power of a signal (meaningful information) and the power of background noise (unwanted signal):

$$\mathbf{SNR_{dB} = 10 \log_{10}\left(\frac{P_{signal}}{P_{noise}}\right)}$$

*3) Entropy:* Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image.

Entropy = -sum(p.*log2(p))

Where, p contains the histogram counts.

Table II: Comparative Analysis of Performance Parameters

| Parameters / Methods | | [13] | [16] | [17] | Proposed Method |
|---|---|---|---|---|---|
| MSE | | - | 280.53 | 46.50 | 31.89 |
| RMSE | | 715.98 | - | - | 2.11 |
| PSNR | | 20.09 | - | 38.97 | 36.01 |
| Correlation | | - | - | - | 0.96 |
| SNR | | - | - | - | 2.21 |
| Entropy | Input | 7.56 | - | - | 7.02 |
| | Output | 7.83 | - | - | 7.57 |
| SSIM | | 0.62 | - | - | 0.74 |

## V. CONCLUSION AND FUTURE SCOPE

Underwater scene usually contain different types of degradations. In this paper, a method is presented to improve underwater scene by combining image restoration and image enhancement technologies. We are using DCP (Dark Channel Prior) method for image restoration and enhance it using HSV-CLAHE (Hue Saturation Value - Contrast Limited Adaptive Histogram Equalization) for obtaining real and synthesized underwater images and video. We carry out some pre-processing on underwater images to remove blurriness and noises present in it. Comparative analysis of performance parameters of image is also performed showing the betterment of our proposed method. Large videos will take larger time for processing but we can reduce processing time of videos using separate GPU unit. Our work can be further improved by taking marine snow into the consideration, as it could also be the reason for distortion in captured underwater scene.

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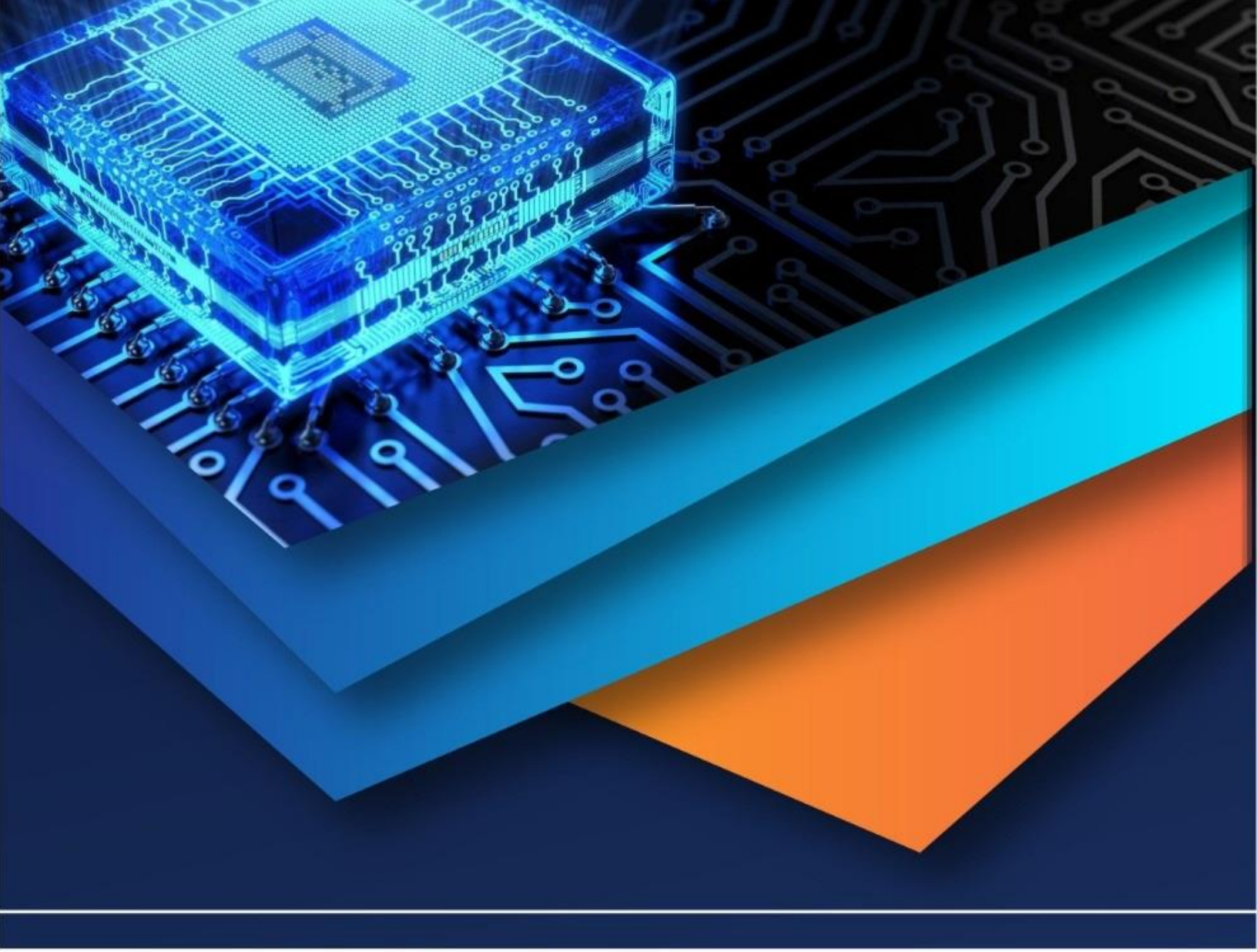

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