Underwater Imaging to Detect Objects and Perform Specific Tasks Using Autonomous Underwater Vehicle

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***Abstract*—Image Processing is an essential feature of Autonomous Underwater Vehicle (AUV). There are many constraints in performing underwater imaging as the turbidity of the water changes as one goes deep in the water. It mostly suffers scattering, limited range, low contrast and most important blur in images. This study proposes the framework of underwater image processing in exploring the deep water world and how one can enhance the underwater image quality. On the basis of the results of image processing, the AUV can be designed to perform underwater tasks.**

I. Introduction

Scientist have shown a lot of interest to explore underwater world in recent years. It is not easy to explore underwater world without the help of special designed devices for oceanography and deep water world. Autonomous underwater vehicles are nowadays mostly used for this purpose. An autonomous underwater vehicle (AUV) is a manmade robot which is being used for deep water exploration. A number of concepts are being used in designing AUV which includes image processing technique for analysing the objects data and allowing AUV to perform specific actions on the basis of the results obtained during the process. Underwater image processing is not a simple task as compared to the processing of image on land. A number of challenges like scattering in images and noise have to overcome while doing underwater image processing. A lot of research is in process to improve the techniques in order to obtain clear images to explore the underwater world in a better way. The goal is to improve the design of AUV to perform the assigned task with more efficiency along with improving the image processing techniques to obtain clear and high quality images and videos. This paper presents overview of image processing problems like de-scattering, colour restoration and underwater image quality assessments [1]. Moreover it also explains the challenges and techniques used in present scenario to overcome these challenges while analysing the underworld data through image processing techniques.

II. Previous Work

A. Underwater Image Processing

Image processing is basically a method used to enhance the image by applying different algorithms or filters. An autonomous vehicle is completely based on image processing technique. The idea is to scan the object and perform any task on the basis of data obtained. The designing of AUV is a complicated process as a number of issues arises while performing underwater work. First and main important concept in AUV designing is image processing to detect the objects. The image processing on land as compared to underwater is easier as there are not many constraints. The underwater imaging is difficult as it suffers scatter due to transportation characteristics of water along with the noise in the background. The numerous constraints include blurring effect which arises due to medium, color reduction due to wavelength absorption, electronic noise, non-uniform lighting and flickering effect during sunshine [1]. The research is in process all around the globe to enhance the techniques which helps to obtain clear images and observe an underwater activity with the help of special optical devices designed for this purpose.

A concept map of ocean observing network was proposed by Lu Et Al [2] which is shown in figure 1. In AUV's, the optical sensors and video devices are well integrated by underwater community for short range operations.The video may be blur or of bad quality due to the propagation of light in water. The question arises what makes images blur and video quality bad.

The main reason is light attenuation in processing underwater images which limits the visibility distance at about 20 meters in water. The light attenuation occurs due to absorption and scattering which arises due to water itself which causes difficulty in underwater imaging. The rapid attenuation of light requires an artificial lighting sources to overcome this difficulty which itself causes another problem due to which a blur image is processed containing bright sport and poorly illuminated surrounding. The distance between the scene and camera induces blue and green color. It also encounters with

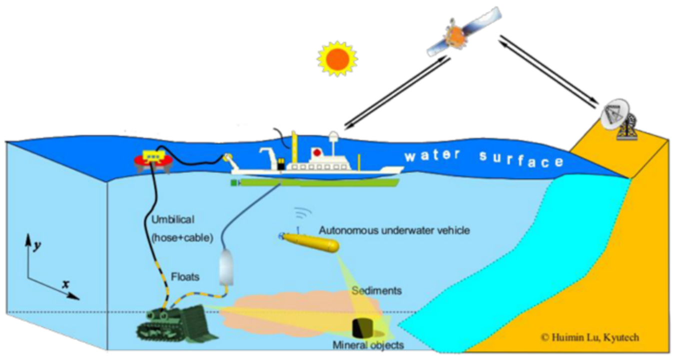

Fig. 1. Ocean Observing Network Model Proposed by Lu Et Al

the variables or species floating underwater which increases absorption and scattering effects. According to [3] image processing can be addressed from image restoration technique or from an image enhancement technique.

(i) Image restoration is a basically a method to obtain an original image from the degraded image by knowing the degraded factors [3]. It usually requires model parameters like attenuation factors and diffusion coeffiicients that characterize the water turbidity [3]. This method is considered to be vigorous as the model parameters are extremely variable and it gets change as the depth increases under the water.

(ii) Image enhancement is a basically a method which uses qualitative subjective criteria to obtain pleasing images. It does not require any parameter models and is considered to be the fastest technique compared to image restoration technique [3].

In underwater image processing, one can encounter two major losses. In order to overcome them, most used two techniques are wavelength compensation (sediment scattering) and color reconstruction (light absorption). There are both physical and non-physical ways to do that. Fattal [4][5] designed color lines method to estimate thickness of haze and then used Markov Random Field model to get clean the image. He [5] used dark channel prior to estimate depth map and then used guides filtering to refine the depth map and get clear image. Chiang [6] proposed wavelength compensation method for underwater imaging, wavelength absorption for underwater imaging was considered first time by Chiang. Lu [1]proposed robust light estimation method to tackle flickers that exist in underwater images. Similarly there are many non-physical methods. Garcia [7] proposed local histogram equalization to tackle haze and non-uniform lightening. Although, it does not work well at dark places. Gibson [8] proposed a method to tackle noise and scattering simultaneously. This method was named as Kernel size de-scattering method. After using this method, some artifacts and halos remains in the image. Lu [3] using depth map refinement proposed single image dehazing method. Bazeiile [9]use YUV color space and enhance images in frequency domain. Iqbal [10]proposed an algorithm using integrated color model to enhance the image, but this method cause color distortion issues.

B. Underwater Object Detection

Due to low light, blurring effect and many other water parameters, it is always being a challenging task to detect object under the water wihtout effort. In past, different methods were used to detect objects from images taken underwater. Many researches were conducted to find an optimal solution of obtaining an original image with all features. Panetta [2] proposed a method which combines colorfulness, contrast and sharpness measure. This method is known as non-reference underwater image quality measure (UIQM). Lu [3] introduced a method to calculate both the visibility of artifacts and overall quality in images. It is a human prediction method which is called High-Dynamic Range Visual Difference Predictor 2. Zuiderveld [4] proposed a model that use histogram technique to focus on a specified region according to interpolation between neighbouring region's histogram. This technique is called contrast limited adaptive histogram equalization (CLAHE). It does not help with non-uniform light as it operate on local regions instead of whole image. Ancuti [5] gave espouse fusion method to combine different images using filtering. Galdren [11] uses red-channel based image restoration method as red channel is not always a minimum channel in RGB color space.

C. Object Detection using Image Processing

Image processing has been used for object detection from images. There are several methods that are being used nowadays to detect objects under the water. According to [1], the corners of an object can be detected by using fourier transform as frequency gets change when color changes in an image. The other method is to take an array of an image and process it to detect objects. Each color has it's own number ranging from 0-255 and each element in array is actually pixel of picture and each pixel has it's own value.

III. Methodology

The main purpose of underwater image processing is to detect specific objects and help AUV to perform specific tasks on the basis of objects recognised. The idea is to perform edge detection method to pass through specific places like edge of a gate underwater is detected and AUV can pass through that gate without hitting its sides or to determine the shape of the objects and detect what they are. Secondly, it is usually use to detect colors underwater in order to observe life of marine creatures and plants. As discussed above that underwater image processing is not as easy as image processing on ground and light rays gets absorb and scatter by sea particles. So first, a smooth and clear image should be obtained by using different techniques in order to proceed futher.

A. Software

Due to availabilty of a large number of softwares and programming packages, it is always difficult for the user to chose to any of the software platform and coding language. For the real word scenarios, OpenCV library is recommended and the coding part usually gets done in C programming language as it is easy to use and the user gets command on C language very quickly.

1) Image Clearification: The first task is to clearify the image from all the haze and blur parts of the image using "Parameter Free Algorithm [9]" This method uses specific steps to clearify the image and remove impurities from it. It basically works on the concept of fourier transform and color channel conversion to simplify the image processing and to increase the speed of processing.

1) Removing Potential Moiré Effect: Moiré effect occurs when one try to see set of lines that are superimposed on another set of lines. Different patterns can be seen when one layer of these lines is being moved on another. It mostly occurs during analog to digital conversion. In underwater image processing, these wavy patterns appear on image taken underwater. It is important to remove them because when we enhance contrast, moiré patterns are also enhanced. These patterns can be removed by using Fourier transform. The peaks in Fourier transforms are removed assuming these peaks are moiré effect [2].
2) Resize Image to Squared Shape: The resizing of image enables to use fast fourier transform and fast wavelet transform algorithms and meanwhile prevents from potential border effects [2].
3) Convert RGB to YCbCr (Luminance Chrominance): This step converts 3 channel RGB into one channel hence speeds up the process as only one channel is being used for work instead of three channels. In YCbCr channel, luminance channel is being processed corresponding to intensity components just like grey scale image. This process speeds up all the following steps as we process only one channel instead of processing each RGB channel each time [2].
4) Homomorphic Filtering: This technique brings uniformity to image and enhances contrast in image. As it is frequency filtering, it does not only correct non-uniform lightening but also sharpens the edges [2].
5) Wavelet Denoising: Gaussian noise is always present in natural images and homomorphic filtering enhances it. So, it becomes important to suppress it. This algorithm of denoising is preferred in many algorithms [3][2].
6) Anisotropic Filtering: This technique improves image segmentation. It smoothens the images in homogenous areas and not only preserve edges but also enhances them. It also deletes small edges amplified by homomorphic filtering, smooth the textures and reduce artifacts [2].
7) Adjusting Image Intensity: In this process, we adjust the intensity value of image at all the places thus increases contrast and suppresses outlier pixels. It then uses whole range of intensity channels and sometimes saturates low or high values if necessary [2].
8) Converting YCbCr to RGB: The luminance channel is converted back to RGB channel to regain colors. After that, symmetry extension part is cut out which was performed in step 2 to recover image of original size [2].
9) Equalizing Color Mean: The underwater image channels are not balanced. This technique suppresses predominant colors by equalizing RGB channels mean. It works better than segmentation technique because segmentation is performed on grey scale and equalization does not affect grey scale image [2].

2) Edge Detection: The main objective of obtaining the clear image under the water is to detect the objects and peform specific tasks on the basis of the data obtained. The edge detection is usually used for the detection of the objects in an image. The edge detection is basically done by using Fourier transform. Once the image becomes clear by using fourier transform, all the frequencies residing in the image are being obtained. The higher frequencies are mostly present at the edges which can be obtained by using low pass filter. After getting know the higher frequencies of the image, the shape of the object can be obtained which helps the AUV to perform the specific task.

3) Color Detection: Every object has its own unique color. After the edge detection procedure, the main goal of the AUV is to detect the colors and distinguish between different colors. As far as color detection is concerned, it can be done by using image array. As described above, an image consists of an array of color. Each pixel represents each element of an array. The colors are represented by numbers in an array. The color of an image can be identified by identifying the range of these digits.

IV. Conclusion

This study throws light on how the image processing is being done underwater considering the turbidity facts of the water and factors which cause bad quality of the image underwater. This study tells about the various algorithms developed in past for underwater imaging and how the image is being processed by applying different techniques. On the basis of the image processed, one can design AUV to perform specific tasks like gate detection, color detection or explore the underwater world in a better way.

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