Multi-Camera View Synthesis for Underwater Video Sequences

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Multi-Camera View Synthesis for Underwater Video Sequences

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***Abstract*—View synthesis is the generation of intermediate views of a scene from a pair of images taken from different position and orientation. View synthesis is a form of interpolation to produce middle view between two adjacent cameras whereby this method is important when there is limited number of cameras that limit capturing of multiple dimensions. Let I_0 be the first original image and I_0 be the second original image from adjacent camera to I_0. Then $I_{0\text{-}1}$ will be the virtually synthesize view. The information from multiple cameras (normally 2) can be combined to predict and therefore generate new viewpoints. In underwater video acquisition, the number of camera being mounted on a structure is limited; therefore, using view synthesis we could reconstruct a better 3D structure. Underwater images have predominant colors, being blue and green, caused by heavy non-uniform light attenuation in the water across the visible spectrum, which eventually shifts the hue in the image towards blue. The low quality underwater images require some pre-processing method such as image reconstruction to recover the image's quality in order for the resultant image be further processed for view synthesis. Preliminary work on acquired videos shows encouraging results.**

Keywords*—*view synthesis; multiple cameras; underwater video acquisition; image reconstruction;

I. Introduction

In terms of visibility, the images taken underwater environment is poor although there is some use of art equipment. With the aid of modern digital cameras, the colours of the tropical that are seen in the beautiful water appeared to be flat and mostly blue. Water has acted as a filter that shifted the colours of the images toward blue, reducing warm reds and yellows [1]. Image processing has two main purposes which are to improve the visual appearance of images to human observer and prepare images for the features and structures measurement which they reveal. Image processing contains the same amount of data but there is some simple rearrangement of data done to an image [2]. The motivation of this project is to obtain missing piece of data or image when no physical camera is placed from that viewpoint for data acquisition. The main objective of the project is to propose using view synthesis to generate in-between view in underwater video sequences. In order to achieve the main objective with better quality, a method to remove predominant blue and green colour that exists in underwater images which is a constraint to an images using OpenCV and Visual Studio.

The rest of the paper is organized as follows: Section II describes and discusses our proposed approach and algorithms. Section III shows the implementation and results. Section IV concludes with future work.

II. Methodology

The analysis was run on a PC platform, using selected video sequences from a research excursion around Pangkor Island, carried out during daylight time for about 4 hour. Further details on equipments and set-up can be found in later section. Figure 1 shows the framework for multi-camera view synthesis for underwater set-up.

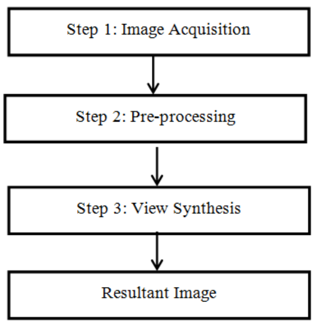


Fig. 1. Framework for Multi-Camera View Synthesis

A. Step 1: Image Acquisition

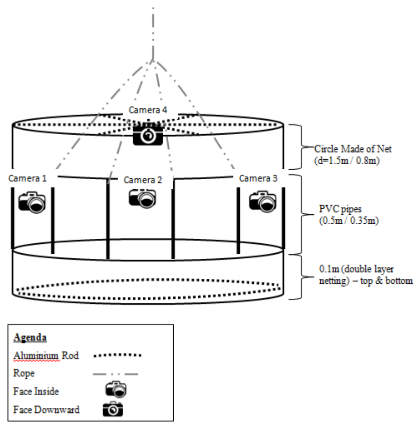
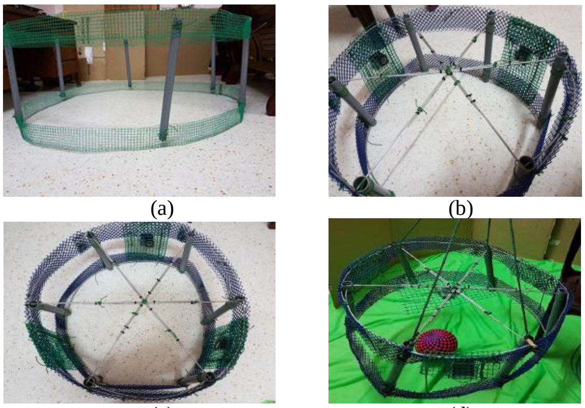


Fig. 2. Model Design of Acquisition Equipment

Three wide angle underwater cameras and 1 normal lens underwater camera are mounted on the structure designed – see Figure 2. The cameras could capture images up to 5M pixel lenses. We developed two (2) structures for acquisition, (1) 1.5 in diameter metal net, and (2) 0.8 in diameter plastic net.

The first structure made, as shown in Fig. 3(a), consist of circle netting with 1.5 meter in diameter and 0.5 meter in height. The structures were made using two 5 meter metal net of 0.1 meter height with six 0.5 meter PVC pipes, i.e. the metal net was folded to form a circle and tied to the 6 PVC pipes as support. The design was not strong, being too huge to be controllable, especially for underwater conditions. The wide space between the upper part and lower part of the circle could cause inconsistency, i.e. due to underwater current, during image acquisition.

A second design with smaller diameter and height was built, as shown in Fig. 3(b) and Fig. 3(c). The second design was set up using plastic net of 2.5 meter, being half of the diameter for our first design, with 6 PVC pipes, was shorten to 0.35 meter each. Hard aluminum rods were used to strengthen the design. Fig. 3(d) shows the strengthen model which was hung up and used to take some sample images. Sample of acquisition excursion and acquired image are shown in Figure 4.



(a) (b) (c) (d)

Fig. 3. Samples of Acquisition Equipment

(a) (b)

Fig. 4. Acquisition: (1) Acquisition at Pangkor Island (2) Acquired image

B. Step 2: Image-preprocessing

In this section, the acquired image has to be pre-processed prior view synthesis. Figure 5 show the resultant images after pre-processing using our previously proposed method, i.e., colour correction and enhancement method [3]. The algorithms used include colour balance, histogram equalization and dehazing. The resultant image (and input image) for each camera are shown in Figure 5.

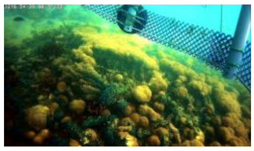
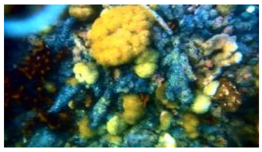
Camera No.	Input	Resultant Image
Camera 1		
Camera 2		
Camera 3		
Camera 4 (Top Centre)		

Fig. 5. Output: Pre-processed Images

C. Step 3: View Synthesis

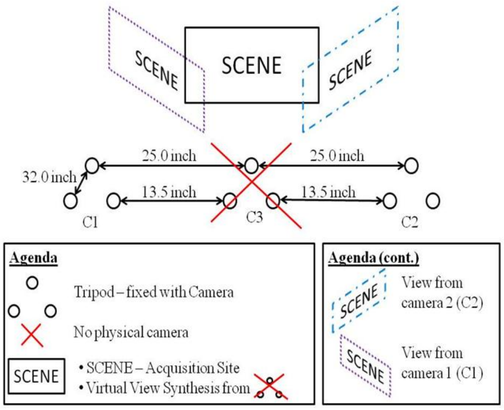


Fig. 6. Layout for Multi-Camera Acquisiton

Virtual View Synthesis is to synthesize a new view at any 3D location from a given set of views. Free viewpoint technology allows user to view a 3D scene by freely changing the angle and view position [4]. With virtual view synthesis, the required view in-between 2 camera position (acquired image) can be obtained, without the existence of physical camera in that particular position. View synthesis could come in handy in some situation where detail imaging is required when there are insufficient devices, i.e. to have a camera from each and every angle surrounding an object due to the cost. Image registration, therefore, will be an important step in view synthesis, where a sets of data (image) is being transform into another coordinate system. That is to say multiple images, i.e. images acquired from multi-camera viewpoints, could be transformed into different images. The step is a necessity as it could enable the integration of data obtained from different measurements (camera).

III. Experimental Results

In this section, we present three (3) sets of experiments. In the first experiment, we test the structure design on air (not underwater) to obtained preliminary data. In the subsequent experiment, we acquired the underwater video using the Structure 1 design. In the final experiment, we acquired the underwater video using the Structure 2 design. The structures designed was brought to Pangkor Island for actual data acquisition from a few spots around Pangkor Island.

A. Preliminary Testing on Structure 2 Designed

The sample images are obtained from all 3 sides of the circle, as well as from the center top of the structure. An object, i.e. a ball, was placed on top of a background, i.e. green clothing, so that chroma key can be applied to segment the background to obtain the object. Figure 7 shows the images taken using the equipment as shown in Figure 3. The image is then processed with chroma key and the resultant image is shown in Figure 8.

Fig. 7. Images Taken using Structure 2

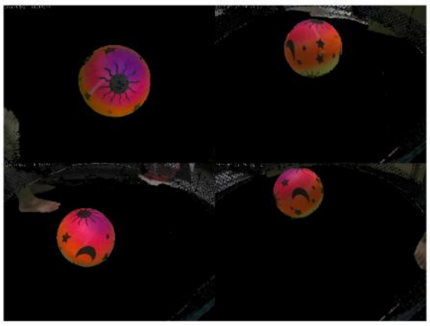


Fig. 8. Resultant Image for Preliminary Testing

B. Actual Implementation on Structure 1 Designed

The design was not too concrete, being too big; it is hard to be controlled, especially for underwater conditions. The wide space between the upper part and lower part of the circle cause inconsistency, i.e. due to underwater current, in image acquisition. The advantage of the design is that a wider area of acquisition (filmed) can be made at once. However, the design is too big to be carried over a motor boat to the sea with clearer water and more Anthozoa (a.k.a. corals). Hence, the acquisition is made near the shoreline, at around Fish House. Figure 9 shows the images taken using Structure 1 Design. Figure 9(a) shows how acquisition is made (from camera 1) while the Figure 9 (b) and (c) are part of the screenshot of the video acquired from camera 2 and 3, respectively. As the diameter is big and the material is not strong enough, centre (suppose to be camera 4) is not used.

(a) (b) (c)

Fig. 9. Underwater: Images Taken using Structure 1

C. Actual Implementation on Structure 2 Designed

Figure 5 images are the screenshot of the third stop in Pangkor Island where there are a lot of Anthozoa (a.k.a. corals) with clearer water. Figure 10 are the images also taken in Pangkor Island. Figure 10 (d) is the position taken frop top and the rest of Figure 10, (a) (b) and (c) are taken from the side of the circle netting.

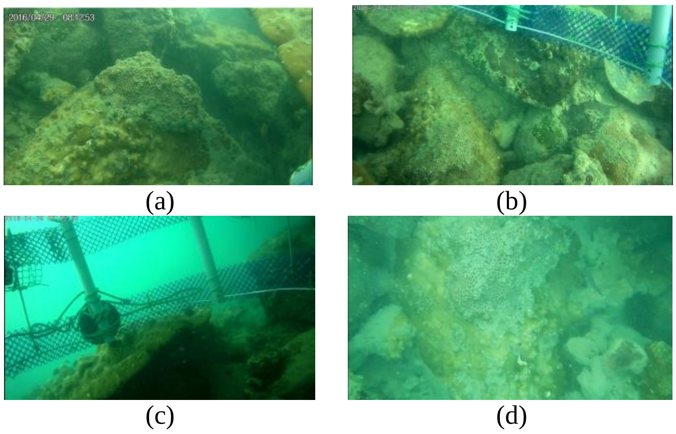


Fig. 10. Underwater: Images Taken using Structure 2

Hence, the Strcuture 2 is better than the Structure 1 in terms of portability and owing to that the acquired images have better visibility as well. However, second design is not without flaws and limitation. To compare Figure 5 and Figure 10, notice that the angle of the view when capturing images varies. This is due to the material used is soft and thus the position can be shifted easily especially by the weight that is attached to the bottom of the equipment.

IV. Conclusion and Future Works

In conclusion, there are 2 designs for image acquisiton for the project; (1) with bigger diameter and (2) smaller diameter. Being big, it allows capturing of wider area of seabed and biodiversity, but restricted it from moving around, i.e., reduced portability. The second structure design being suitable in size and manageable, it allows a camera to be attach to the top centre of the equipment and hence allowing multi-camera video acquisiton from 4 dimensions. The image pre-processing algorithms enlightened that colour correction and enhancement algorithm gives better effect when the water is clear (not cloudy or polluted). Since the image pre-processing method is not generic as it does not guaranteed a good resultant image, improvement to the algorithm is placed as the future work. Apart from that, view synthesis is still under research. View synthesis is to project the depth map from reference view to target, i.e., virtual view location so that middle view between adjacent cameras can be generated. In order to do view synthesis, image registration is an unavoidable method where it should be looked into also.

Acknowledgment

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