Generation of Anaglyph using High Resolution Acoustic Images

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***Abstract*- This paper describes post processing of high resolution acoustic images. A multi-beam acoustic camera with high resolution can be a substitute for typical optical systems as an identification sensor of an unmanned underwater robot in turbid underwater environment. The acoustic images do not allow depth perception, however. Anaglyph method was adopted to generate stereoscopic images and to provide depth perception. There are several ways to generate anaglyph images and, basically, two images are required for each eye. In this paper, how to operate the acoustic camera to get two images are proposed.**

I. Introduction

Performance of conventional optical systems becomes much lower and limited in turbid water environment. In this case, an acoustic camera using multi-beam can be one of substitutes for the optical systems. Especially, for unmanned underwater robots such as AUVs (Autonomous Underwater Vehicle) or ROVs (Remotely Operated Vehicle), the acoustic cameras can be adopted as identification sensors or additional complementary sensors. [1] In KIOST (Korea Institute of Ocean Science & Technology), a bio-inspired underwater walking robot, CR200 has been developed. [2] This robot is supposed to inspect and work in tidal current underwater. The CR200 is equipped with a multi-beam acoustic camera which operates at 3.0MHz frequency and also, optical cameras, a single-beam scanning sonar to retain its visibility.

The acoustic camera projects a wedge shaped volume of acoustic image and returns reflections. The reflection contains intensity and distance constituting 2-dimensional planar image without depth information. During underwater survey or inspection, there are times to perceive depth for more detail.

Anaglyph is one of stereoscopic image generation allowing depth perception. It uses two or more images filtered for each eye, left and right using different colors. Typically, red and cyan are applied. [3] There are two classic ways to generate anaglyph images. The first is to use two images for each eye. In the other words, one image is for left eye and the other is for right eye. Each image is filtered by different colors, typically cyan for right image and red for left image are used. And then, they are superimposed considering parallax. The other way is to adopt one image and its depth map. Depth map contains the height of the surface at points corresponding to each pixel. [4]

In this paper, operation of CR200 and the acoustic camera is described briefly. And then, we introduce features of the acoustic camera and images and propose how to control the acoustic camera to get two images for each eye. Generated sample images are also included.

II. Acoustic camera & images

A. Acoustic camera - ARIS Explorer 3000

We adopted ARIS Explorer 3000 from Sound Metrics. [5] ARIS is shorten for Adaptive Resolution Imaging Sonar. The ARIS operates at 3.0MHz for identification mode and 1.8MHz for detection mode. Maximum downrange resolution is 2.9mm. The camera has a 30^{o} horizontal field of view and 14^{o} vertical field of view. It can image out to 5m and 15m at identification mode and detection mode, respectively. For more convenient operation, a 2-axis actuated rotator is used together with the camera. The rotator we adopted is X2 rotator and it is also from Sound Metrics. Figure 1 shows ARIS and X2 rotator assembled for roll/tilt mode. And installation on CR200 is also shown. Specifications are denoted in Table 1.

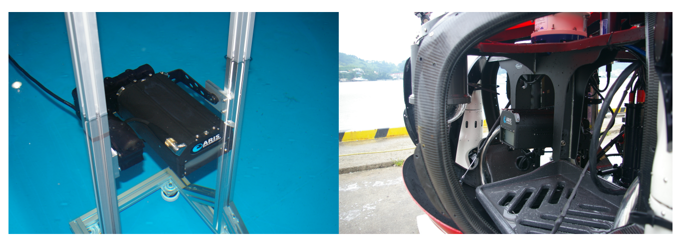

Figure 1 (Left) ARIS with X2 rotator for roll/tilt mode (Right) ARIS and X2 rotator installed on CR200

TABLE I. Specifications of ARIS

	Operating Frequency	Beamwidth	Number of Beams	Range
Identification mode	3.0MHz	0.25	128	5m
Detection mode	1.8MHz	0.42	128 or 64	15m
Frame rate	**Field of view**	**Power consumption**	**Weight @ air**	**Dimension**
30 fps (max.)	30^{o} H, 14^{o} V	15W	5kg	26×16×14 cm

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B. Acoustic image

Acoustic image contains range(or distance) and azimuth(or direction.) Because the acoustic image is displayed according to the distance, there is difference with viewing form of optical image. Figure 2 shows an optical image and an acoustic image for the same target. Corresponding vertices and bars of the target in both images are denoted. Red lines are overlaid with four bars of the target and Alphabet from A to E are marked at five vertices. The point marked by E appears at the lowest of the target in the optical image, on the other hand, the point A appears at the most bottom in the acoustic image. [6] Then, the acoustic camera must be oriented to project acoustic beams with a small grazing angle to the surface or target of interest. [7] That is, perspective view and direction of beams are at 90^{o}.

C. ARIS & CR200

The CR200 is a new type of ROVs having six legs to thrust itself. It is able to walk on the seabed without disturbing sediment or causing fish nearby surprise. In addition, the robot can change its looking direction and attitude quite freely. This ability makes the robot be most valuable as a underwater camera platform. Figure 3 shows the CR200. Overall specifications of the CR200 is detailed in [2]. In Fig. 4, acoustic volume which is projected by the ARIS installed on CR200 is shown. Minimum range is 0.7m and maximum range depends on the operating modes. Three terms relative to the acoustic wedge are denoted: Perspective view, downrange and cross-range. As described above, the perspective view and downrange are perpendicular to each other.

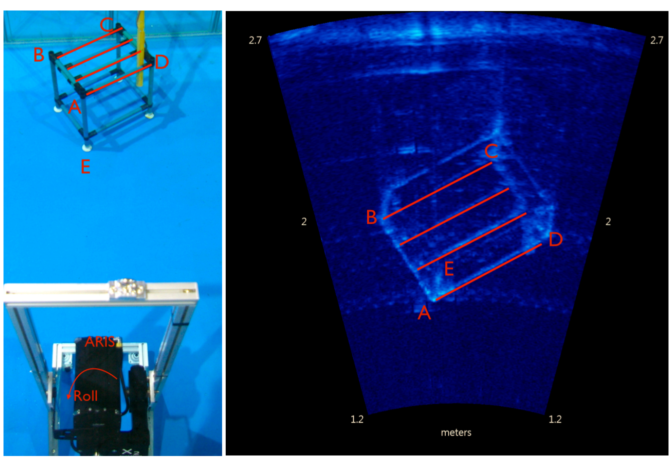

Figure 2. (Left) Optical image, (Right) Acoustic image: Roll axis are depicted.

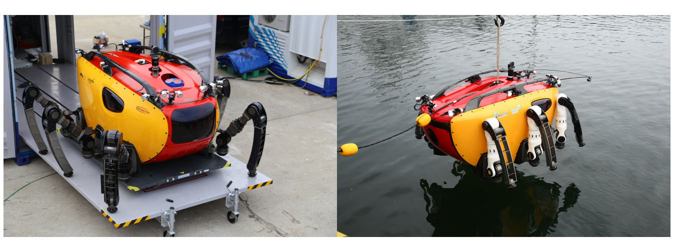

Figure 3. Appearance of CR200: (Left) CR200 on its private hanger, (Right) Launch of CR200 at the pier in SSRI (South Sea Research Institute, KIOST)

III. Anaglyph

A. Introduction

Anaglyph requires two images for each eye. In Fig. 5, how anaglyph to work using the most popular way is shown. [8] In this paper, it is not considered to use depth map.

B. How to operate the acoustic camera

It is common to use a stereo camera or two cameras to get two images for each eye at the same time. Taking two pictures consecutively using one camera with changing its position and orientation properly is also used. It is critical how to arrange the cameras. There are two ways of camera arrangement. One is parallel array and the other is crossing array. (Fig. 6) [9] The symbol of d in Fig. 6 is distance between two cameras and about 65mm is commonly used because it is an average distance between two eyes. The crossing method controls the crossing angle ϕ which is corresponding to vergence by rotating the cameras. We propose to implement the crossing array using one acoustic camera with rotating its roll angle. The crossing method is effective inner 20m at d = 65mm and it is longer than the maximum range of the ARIS, 15m. Figure 7 shows the concept. To change the roll angle of the ARIS in amount of ϕ after taking one acoustic image and to take another acoustic image consecutively shows equivalent effect with the crossing array. Both of perspective view #1 and perspective view #2 lie on the same plane P in Fig. 7. Generation of anaglyph was done using a commercial software 'Anaglyph Workshop' from Sandy Knoll Software, LLC. [10]

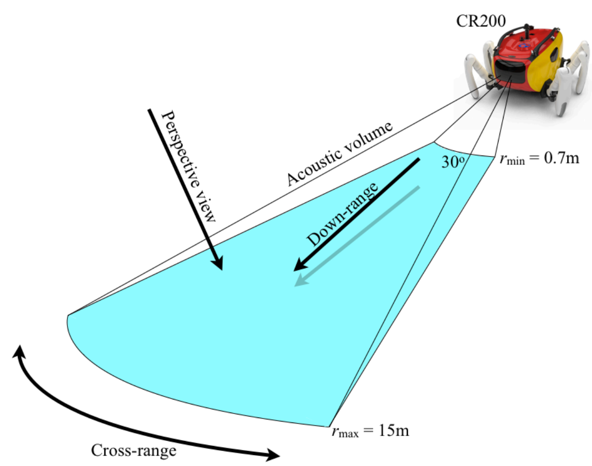

Figure 4. Acoustic volume from the ARIS on CR200

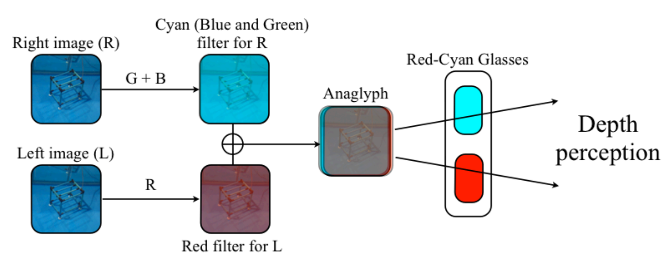

Figure 5. Generation of anaglyph

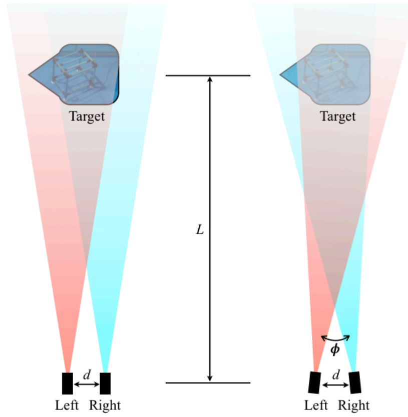

Figure 6. Geometry of two cameras (Left) Parallel array, (Right) Crossing array

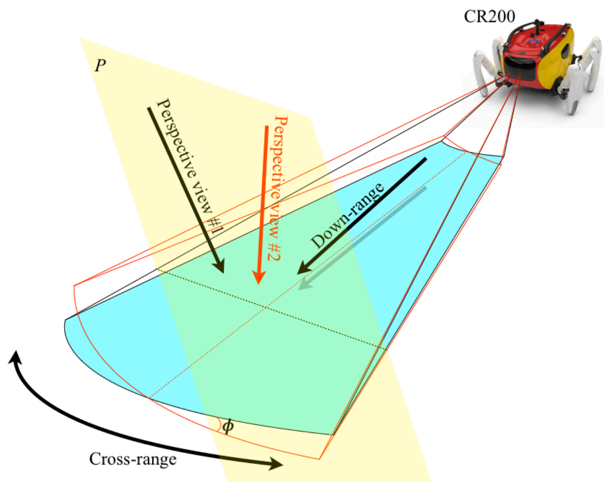

Figure 7. Geometry of the acoustic volumes with different roll angle. As change roll of the ARIS in amount of ϕ, we can implement the crossing array.

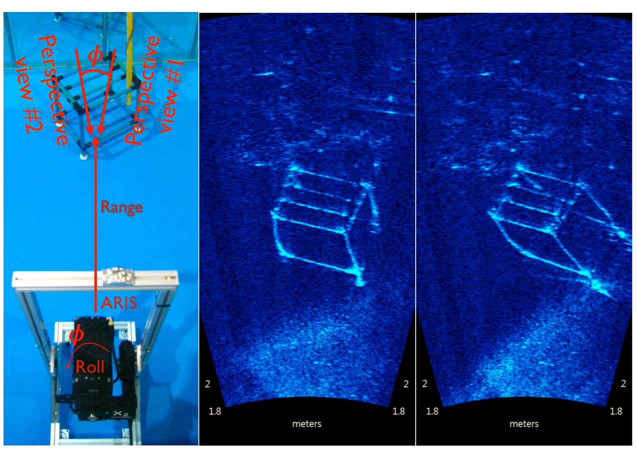

Figure 8. Two perspective views with slight different roll angle. The roll angle has an equivalent role of the vergence. In this figure, the roll angle is exaggerated to help understanding. (Left) Geometry of two perspective views, (Center) Image from perspective view #1 (Right) Image from perspective view #2

Some generated samples are shown in Figures from 9 to 12.

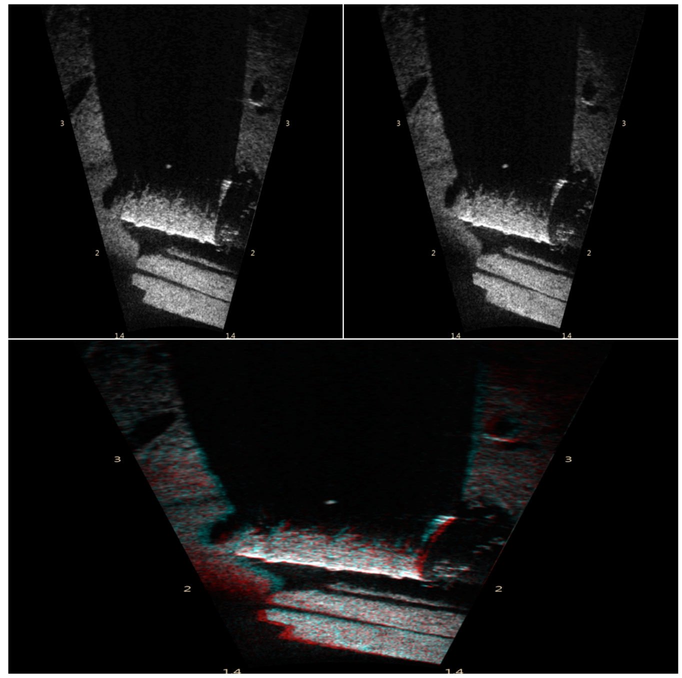

Figure 9. Barrel: (Left Upper) Left image, (Right Upper) Right image, (Center Lower) Anaglyph image (sample raw images from www.soundmetrics.com)

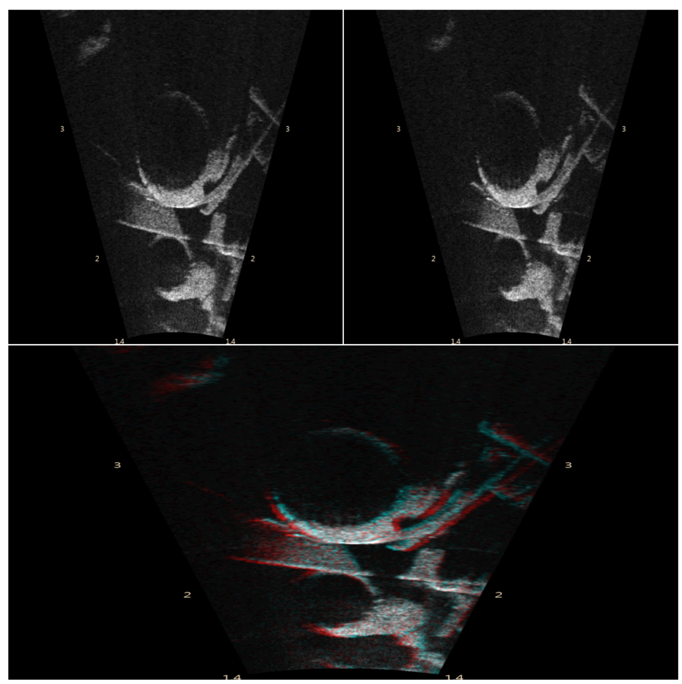

Figure 10. Tires: (Left Upper) Left image, (Right Upper) Right image, (Center Lower) Anaglyph image (sample raw images from www.soundmetrics.com)

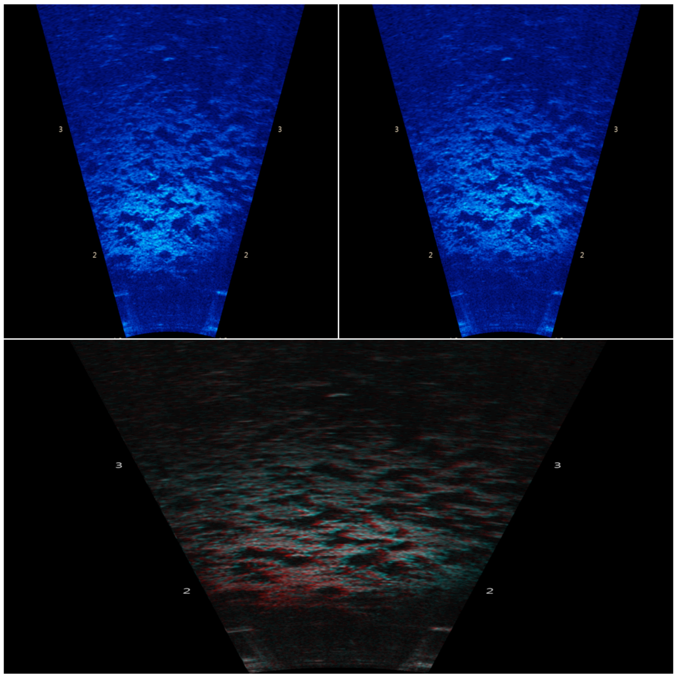

Figure 11. Seabed floor at pier in SSRI: (Left Upper) Left image, (Right Upper) Right image, (Center Lower) Anaglyph image

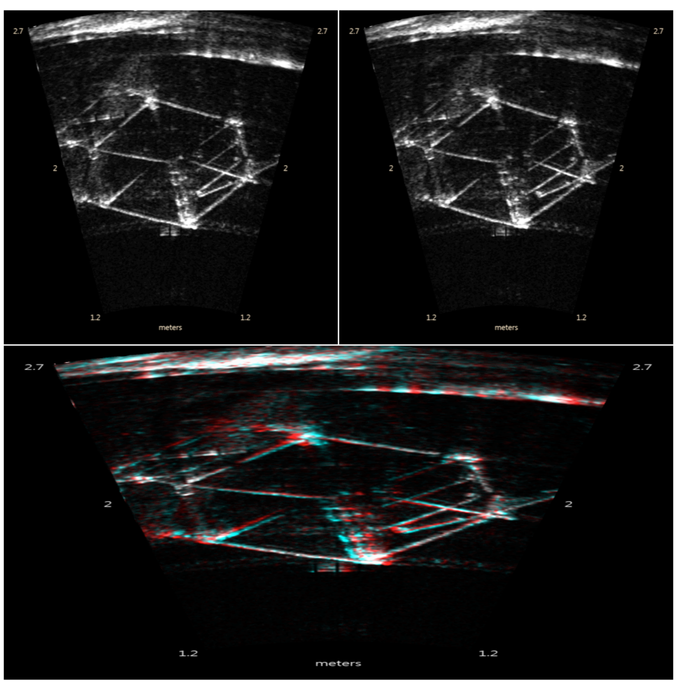

Figure 12. Frame structure in water basin: (Left Upper) Left image, (Right Upper) Right image, (Center Lower) Anaglyph image

V. Conclusion and Future Work

We proposed how to implement the crossing array of single acoustic camera to generate anaglyph images eventually. And sample images were introduced.

Because the CR200 is supposed to work in turbid water, in many cases, operators of CR200 have to control the manipulators using not optical cameras but the acoustic camera. Depth perception will help the operators to recognize targets and subjects and to control manipulators of CR200. And as the CR200 is able to fix itself on the underwater floor like a typical camera tripod, the acoustic camera can take images minimizing shaking caused by external disturbance.

More elaborate theoretical supports will be investigated in the future considering parallax and depth map to get more realistic-looking depth perception. We will carry out research into some methods to evaluate quality of the generated anaglyph images and to improve the quality.

Acknowledgment

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