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# On-Line High-Resolution Sonar Image Recognition Technique for Autonomous Underwater Vehicles

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## ABSTRACT

This paper addresses sonar image's automatic object recognition method for AUVs (Autonomous Underwater Vehicles). The sonar images are severely changed depending on its poses. We propose active sonar image's template updating method. Depending on the pose, a predictor modifies the template for the optimal recognition using the sonar's camera model. This allows reliable recognition at any sonar pose. An experimental vehicle has been constructed to implement the proposed method and evaluate its capability in field.

KEY WORDS: Acoustic; Recognition; AUV; Image; Underwater; Sonar

## INTRODUCTION

In terms of efficiency and safety, risky and repeatable underwater tasks such port surveillance, underwater structures' safety check, require the automation. AUVs (Autonomous Underwater Vehicles) are a strong candidate for the automation (Hover, 2005; Maki, 2006; Yu, 2004). Their excellent mobility and light deck support enables them to automate simple tasks such as wide area data collection. However, their limited object recognition ability restricts them to undertake complicate underwater tasks. The autonomous recognition is one of the most important keys to enhance their applications to variable underwater tasks.

In underwater, sensing methods for the recognition are limited. Optical vision and high-resolution sonar are few available. The former gives relatively long and reliable but the limited visibility encountered in underwater environments restricts working range and reliability (Yu, 2002).

The latter such as DIDSON(Belcher, 2002; DIDSON website; Kim, 2005) can be an alternative. It has the required range and reliability needed for optical recognition combined with the high resolution seen in traditional optical vision systems. However, the sonar images have unique characteristics that hinder its use in autonomous object recognition tasks.

## ACOUSTIC IMAGE ANAYSIS

Compared with an optical image, an acoustic image has a large difference in geometry and characteristics. Figs 1 to 8 show images taken using the DIDSON sonar. In this study, we use DIDSON as the HAC(High resolution Acoustic Camera). for the recognition. It captured various objects on a plain surface at about 1m distance. There are large differences between the produced acoustic images when compared to traditional optical images of the same objects. These differences are due in large part to the acoustic nature. Fig.2 shows a concrete cone. Fig.4 shows its acoustic image. The acoustic image looks like gray scale optical camera images in darkness. They don't have surface information such as texture color. In the acoustic image, the cone is appeared as a diamond shape due to its specific displaying mechanism and acoustic characteristics. This makes the recognition challenging.

Figs.9 and 10 illustrate the differences of displaying mechanism between the optical camera and the acoustic.

As shown in Fig.9, in optical camera's case, the reflected light from the object and background maps into the CCD using the corresponding line which connects the reflection spot and focus point. In this situation there is one to one mapping: at no point do reflections from the object and from the background behind the object overlap on the CCD. This is not the case with the DIDSON acoustic camera.

As shown in Fig.10, the HAC emits acoustic beams (from point DP) and returns two sets of data, the intensity of the return from a point, I, and the distance from the camera, point DP, to the reflection point, D. The difference in images produced by an acoustic and an optical camera occurs when the acoustic return, a function of I and D, gets mapped into an image(Kazuo, 1997). Fig. 10 models the acoustic image produced by simple cylinder, with the upper right image seen in Fig. 10, displaying the full image produced by the HAC. In this image, the top of the cylinder, C0, maps to the bottom of the acoustic image and the side of the cylinder, C1, maps to the middle of it. This