3-D Reconstruction of Underwater Object: Analytical System for Extracting Feature Points Using Two Different Acoustic Views

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This paper presents an analytical system for three-dimensional (3-D) reconstruction of underwater object using acoustic camera. We propose a novel analytical system which enables analysis of multiple acoustic images, leading to 3-D reconstruction of underwater object. The experimental results indicate that the proposed analytical system demonstrates outstanding 3-D measurement results.

1 Introduction

Underwater target recognition plays a great role for rescue missions and various underwater tasks. In recent years, acoustic camera such as DIDSON (*D*ual-Frequency *ID*entification *SON*ar) [1] and ARIS (Adaptive Resolution Imaging Sonar) [2] has become popular with its provision of acoustic images whose resolution is high enough to recognize underwater object. However, unique signal processing of acoustic camera has been preventing establishment of 3-D reconstruction model. Previous research has proposed method to measure 3-D information of underwater environments using multiple acoustic images [3]. However, this study produces no tangible results for 3-D reconstruction of underwater targets. This paper improves and extends previous work on using two different acoustic visions whose poses are known.

2 Methodology

Feature points to be measured are extracted from each acoustic image. While it is impossible to obtain 3-D coordinates of each feature point due to unique signal processing of acoustic camera, candidates for them which are presumably the real coordinates can be described as

$$ {}^{v_1}\mathbf{p}_i = [{}^{v_1}r, {}^{v_1}\theta, {}^{v_1}\phi_i]^{\mathrm{T}}, \tag{1}$$

where ${}^{v_1}\mathbf{p}$ indicates feature point on acoustic image from viewpoint 1. The values for range r and azimuth angle θ are obtainable from pixel coordinate of acoustic image, whereas elevation angle ϕ cannot be acquired. Thus, elevation angle value of candidates is represented by fixing i as the index within the scope of sensing area ϕ_{cam}, assuming

$$ 0 \leq {}^{v_1}\phi_i \leq \phi_{\mathrm{cam}}. \tag{2}$$

After the process above is applied to acoustic image regarding viewpoint 2, 3-D coordinates of feature point $\mathbf{p}$ can be determined. It is because two arcs made of candidate points concerning with each viewpoints intersect at one point.

3 Experimental results

This section describes simulation experimental results. We used cuboid for the underwater object as their multiple vertices allow us to extract highly distinguishable feature points from each acoustic image. The acoustic images of cuboid is shown in Fig. 1. Moreover the acoustic images demonstrate the correspondence of each feature point to be measured.

By the processes described in Section 2, 3-D measurement for each feature point is determined as shown in Fig. 2.

4 Conclusion

This paper proposed a methodology for analytical system to measure 3-D coordinates of feature points, leading to reconstruction of underwater object. Our proposed model dealt successfully with estimating 3-D information of underwater object using multiple acoustic views.

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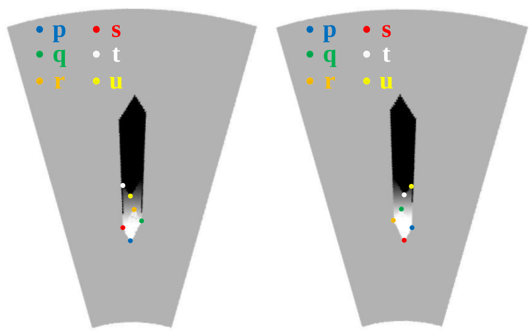

(a) Viewpoint 1 (b) Viewpoint 2

Fig. 1 Acoustic images of cuboid.

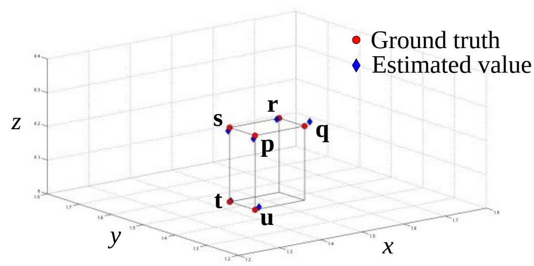

Fig. 2 Experimental results.

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