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A Contour Tracking Method for Underwater Targets Tracking

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1. Introduction

Robust underwater target tracking technique is of great significant, which is a function of underwater vision perception. To supervise the trajectory of underwater objects[1)], as well as their statement, intelligent vision processing of the forward-looking sonar[2)] is necessary. However, satisfied sonar images that clearly describe the underwater targets cannot be easily obtained.[3)] When occlusion happens, it is extremely difficult to distinguish the targets from the impediment.

Using contour describer is a good way to express the underwater targets when partially overlapping happens, and contributes to maintain the estimation to the current state because of its relative steadiness and the insensitiveness of topology changes. Contour tracking is a branch of tracking technique, which utilizes contour describer, with or without association with filtering technique[4)]. Level set function is an effective method of obtaining a contour.

To improve the tracking robustness in fuzziness when the underwater targets are overlapped in forward-looking sonar images, a contour tracking method that use Local Binary Fitting (LBF)[5)] to constrain the evolution of particle filter is discussed for underwater targets tracking in this paper.

2. Methods

Particle filtering[4)] is an implementation of recursive Bayesian filtering by Monte Carlo sampling weights, and it uses a set of weighted particles that represents randomly selected samples to estimate the posterior probability distribution. Particles will undertake a series of process namely, state transition, important sampling, estimation and resampling.

Level set method[5)] transits curve evolution into searching the solution of partial differential equation, by doing which avoid the parameterization and supervision on evolution . As a typical representative of level set method, LBF is insensitive to topology change of close curve which could contribute contour tracking better than conventional methods.

A space prior[4)] is generated from underwater target contour information which is used to restrict the boundary particles in the resampling process of particle filter. The relation between the active contour and moving targets is established, and the space prior is defined according to the distance between particles and the detected contour, which means that the importance weighting is in direct proportion to the likelihood probability density if the prior density was used as the reference distribution. As the number of particle increases, probability density function of particle will approach the optimal Bayesian estimate.

LBF is used to optimize the sampling in order to drive the sampled distribution to higher probability distribution. LBF optimizes the particles by updating their speed and position after state transition. Finally, the optimized particles will be used to set up the posterior probability. The evolution steps are as follows.

Step 1) Initialize parameters of particle filtering.

Step 2) Set up the initial contour and parameters of level set function.

Step 3) Prediction of particle filtering.

Step 4) Compute the LBF energy and evolve the contour .

Step 5) Judge whether the iteration number is reached. If no, go to step 4 for another evolution. If yes, stop evolution and extract the zero level set as the current contour describer.

Step 6) Delete the particles out of the contour, and resample the particles in the contour.

Step 7) Calculate the posterior probability. Judge if the tracking is finished. If no, go to step 2, and record the current estimation result. If yes, output the tracking results.

3. Experimental results

1. Setup

The real sonar images are taken by a dual-frequency identification sonar (DIDSON), which is placed 1 meter under the water surface in a reverberation tank and looking down at a pitch angle of $15°$.

Targets are shown in **Fig. 1**. A steel ring with an outer diameter of 0.22 m, an inner diameter of 0.15 m, and double crossing steel sticks banding on

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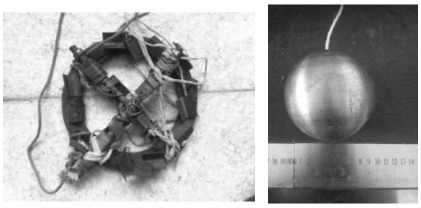
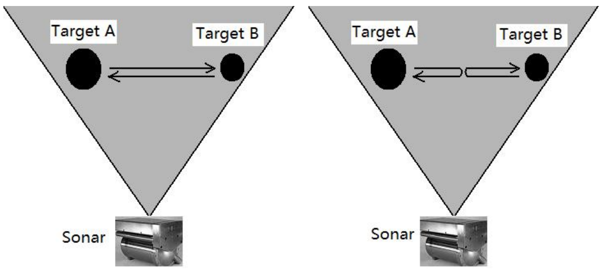
it, as the Target A in our experiments, is hung 1.5 m under the water surface in the tank, inside the field of view of the DIDSON. A solid copper ball, with a diameter of 0.11 m, as the Target B, is hung 1.7 m under the water surface in the tank, inside the field of view of the DIDSON.



(a) (b)

Fig. 1 Targets and their sonar images: (a) Target A, (b) Target B

Two moving patterns of two underwater targets are discussed, as shown in the vertical view of experiments in **Fig. 2**. Target A and Target B both do uniform linear motion with opposite horizontal movement direction, which is defined as Pattern A. On the contrary, the two targets, namely Target A and Target B do the same face-to-face horizontal movement at the beginning, but return after encountering each other, which is defined as Pattern B. Two experiments using different targets are set up. Experiment 1 follows Pattern A and Experiment 2 follows Pattern B.



(a) (b)

Fig. 2 Moving patterns: (a) Pattern A, (b) Pattern B

2. Tracking results

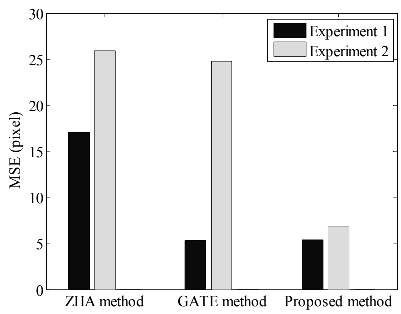


Fig. 3 MSE statistics

MSE statistics are shown in Fig. 3. The proposed method has the lowest MSE value among the three methods in Experiment 2, and has a similar lowest MSE value with the GATE method in Experiment 1.

3. Computational cost

Computational time of the proposed method is also compared with conventional segmentation methods and is shown in **Fig. 4**. Because of using the judging resampling process, the computational time costs more than the other two methods, but they are still at the same level.

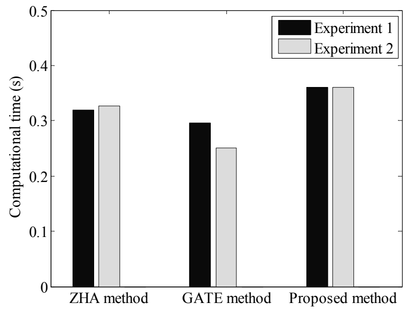


Fig. 4 Computational cost

4. Conclusions

A space prior is generated from underwater target contour information which is used to restrict the boundary particles in the resampling process of particle filter. The relation between the active contour and moving targets is established, and the space prior is defined according to the distance between particles and the detected contour. Experimental results show that LBF-associated contour tracking algorithm has better expression on target contour in comparison with conventional tracking methods.

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