We propose a framework for planning coverage paths for marine habitat mapping using marine robots. The framework combines two existing algorithms with new ideas to provide efficient survey paths. On one hand, our recent algorithm especially targeted for marine environments is used to generate a survey path on a previously unmapped area (off-line). The method has the advantage of minimizing repeated coverage when using a surface vehicle or when surveying at constant depth with an underwater vehicle. On the other hand, only the regions where the marine habitat is present (which often come in the form of widespread "blobs") need to be surveyed in future monitoring missions. However, due to the changing nature of the marine habitats, determining the extent of those regions prior to mission is not possible. Rather than surveying the whole area anew, we propose to use a sensor-based planner that covers the regions of interest (ROIs) on-line. Additional procedures to generate a path that visits all the ROIs are provided. The approach is tested in simulations using a real-world bathymetric dataset and synthetic ROIs. Results show the feasibility of the proposed approach.

Abstract

We propose a framework for planning coverage paths for marine habitat mapping using marine robots. The framework combines two existing algorithms with new ideas to provide efficient survey paths. On one hand, our recent algorithm especially targeted for marine environments is used to generate a survey path on a previously unmapped area (off-line). The method has the advantage of minimizing repeated coverage when using a surface vehicle or when surveying at constant depth with an underwater vehicle. On the other hand, only the regions where the marine habitat is present (which often come in the form of widespread "blobs") need to be surveyed in future monitoring missions. However, due to the changing nature of the marine habitats, determining the extent of those regions prior to mission is not possible. Rather than surveying the whole area anew, we propose to use a sensor-based planner that covers the regions of interest (ROIs) on-line. Additional procedures to generate a path that visits all the ROIs are provided. The approach is tested in simulations using a real-world bathymetric dataset and synthetic ROIs. Results show the feasibility of the proposed approach.

1. Motivation

- Target application: marine habitat mapping for habitat monitoring.
- Objective: pass a marine robot over all points of a marine habitat in successive missions (to compare the collected data).
- Habitats often come in widespread "blobs", so covering the whole zone is not efficient.
- The extent of these blobs is time-varying.
- Proposed procedure:
  1. Map the whole area on the first mission (off-line planning).
  2. On successive missions, cover only the current extent of each blob by using sensors to detect its boundary (on-line planning).

2. First-time mapping (off-line)

Coverage path for the first-time mapping. Generated using the Morse cell decomposition method. Avoids obstacles and minimizes repeated coverage.

Redundant coverage caused by seabed depth changes when navigating at constant depth.

Variable spacing. Avoids repeated coverage, and path is 34% in this example.

Constant spacing. Many zones with repeated coverage (yellow-red).

3. Mapping of regions of interest only (on-line)

An on-line coverage algorithm is applied to the regions of interest (ROIs) corresponding to habitat blobs determined within the initial map.

4. Results and further work

We tested our proposed method on the real-world bathymetric dataset shown throughout the poster and using synthetic ROIs:
- Path length on first-time mapping is 34% shorter than using constant spacing thanks to variable spacing. Repeated coverage is minimized.
- The method successfully covers only the current extent of each ROI in re-mapping missions. Notice the spiral path on the lower-left ROI to search for the region when the robot starts at a non-ROI point.
- The executed simulations show the feasibility of the proposed method.

Further and on-going work:
- Implementation on our torpedo-shaped robot Sparus AUV.
- Application of the proposed method in sea trials to map and monitor real marine habitats.

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