Photomosaic Mapmaking of the Seafloor using SIFT and Differential Lighting

Marcus Hammond
Aerospace Robotics Laboratory
Stanford University
marcus.hammond@stanford.edu

Abstract

This project will address the problem of creating mosaic maps of the seafloor using remotely-operated vehicles (ROV) or autonomous underwater vehicles (AUV) operated by the Monterey Bay Aquarium Research Institute (MBARI). The author believes that a number of shortcomings of the current system could be improved upon through the use of SIFT for image registration. Time permitting, the author would also like to investigate the use of differential lighting and shadow analysis to build up more detailed texture maps of the seafloor.

1. Introduction

MBARI currently performs mosaic mapping of the seafloor by running a remotely operated vehicle in a back-and-forth "lawnmower" path, grabbing frames from a video camera as it goes. The resulting images are correlated using SLOG filtering. This method is not robust to scale or orientation, and can only be done robustly with the high frame rate provided by video input. This is acceptable for performing registration in-line, but breaks down when attempting to perform side-to-side correlation between two swaths. The current system requires offline verification of swath overlap, which is slow, and not robust to scale, orientation and illumination changes.

2. Proposed Improvement

2.1. SIFT-based correlation and registration

SIFT features are robust to large changes in scale and orientation. Also, because each feature has a unique identifier, correlation can be performed between photos taken further apart in time and space. Once feature correlations are established, robust algorithms that reject outliers (like RANSAC) can be used to register the images in the map. All this holds great potential for improving the SLOG system.

2.2. Building texture models with differential lighting

Although they are robust to scale and orientation changes, SIFT features are not robust to illumination changes. Previous attempts to address this have included controlling lighting in a scene and the use of high dynamic range images. Rather than eliminate changes in illumination, the author would like to explore using multiple images taken under different, controlled lighting conditions and extracting depth information about the seafloor features from the observed shadows. In-depth analysis of this technique will likely be beyond the scope of this course project, but the author hopes to begin exploring the idea.

3. Data Access

The ARL has mosaic data from a number of past dive missions that will be used for this project. The data includes imagery and odometry, as recorded by the submersibles' onboard IMU and Doppler Velocity Logger. Ideally, the map registration will help knock out the drift associated with these inertial measurements.

For the differential lighting task, no data exists currently. If the project progresses to the point where this topic may be addressed, the author plans to manually take images using controlled lighting, trying to mimic seafloor conditions as well as possible. Looking to the future, it is likely that MBARI missions will be able to take this type of data.

4. Project Context and Statement of Authorship

The idea of using SIFTs for mosaicking is not the author's, originally, but all work toward implementing the solution is and will be the author's alone. The shadow analysis is related to lunar landing PhD research being done by Eleanor Crane, also in the ARL. However, the idea of intentionally creating shadows through differential lighting and using them to gain additional texture information while mosaicking the seafloor is the author's innovation.