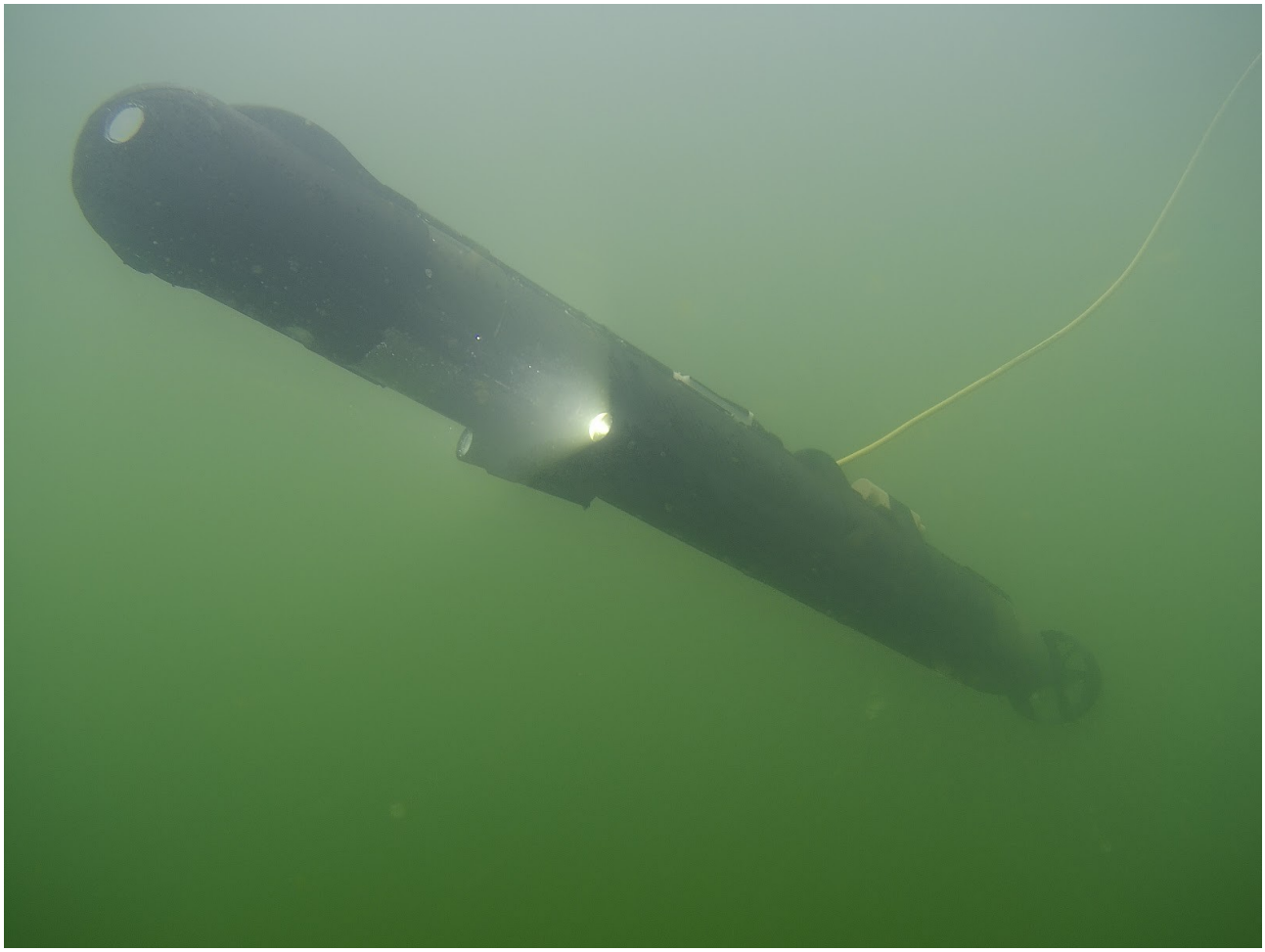
Underwater Robot Master Thesis Projects in SMaRC



Background

Within the Swedish Maritime Robotics Center, SMaRC, we have developed both a small AUV, SAM, and a larger AUV, LOLO, with unique capabilities and sensors. One of the partners researches around cultivation of algae, SEAFARM. Those algae farms are one of the testbeds for our AUV technology. If inspection of the algae cultivation could be automated it would allow much larger and more efficient production.

The SAM AUV is currently equipped with Doppler Velocity Log (DVL), three cameras, sonar, depth and attitude sensors. The dead-reckoning and waypoint following system has been tested in field tests and demos. A model predictive controller has been developed. The vehicle has several innovative actuation features. For example, it can vary its buoyancy and center of gravity to adjust pitch roll and depth. Lolo is much larger and can carry a variety

of sensors such as cameras and sonar.

Besides the AUVs themselves we have much data collected from More advanced AUVs such as the Kongsberg Hugin, as well as underwater data from industrial survey ships/ROVs. All this data can be used for testing of perception and navigation algorithms.

Simulators are an important tool for testing and evaluation. We have several simulation environments each with strengths targeting a specific research area, such as modeling dynamics, cameras or sonars. WE can load environments based on real bathymetric data and simulate collection of new data with our AUVs.

Industrial partners include Ocean Infinity, SAAB Dynamics and SAAB Kokums.

Possible Projects

1. Outlier rejection (MBES denoising):Multibeam echo sounder (MBES) is a type of sonar that produces relatively narrowbeams of sound that can be used to build up a point cloud as the AUV moves. Thisis the preferred sensor for most industrial surveys. A major task currently carriedout by humans is to clean-up that data and remove the ‘bad’ points. This consumes many man-hours at for example Ocean Infinity, OI. This project will use modern AI and deep learning to automate that task. We expect to be able to get some real data from OI and can simulate as much as is needed for this project. We believe that diffusion models might be one way to proceed.
2. Diffusion models for increased MBES resolution (completion) Although the amount of very high resolution MBES bathymetry point cloud (e.g. those collected by AUVs) is limited, there is an abundance of low resolution bathymetry data collected by e.g. surface vessels. Some of these data are made public by GEBCO. This project would investigate whether it is possible to do superresolution of low resolution bathymetric data, and would likely involve deep learning based approaches such as GAN or diffusion models. The data used for this project can come from GEBCO, simulation or some real AUV bathymetric surveys.
3. Automatic sea-/eel-grass detection from multi-spectral MBES bathymetry and/or monocular vision:
    1. The gist of the project is to use multi-spectral MBES data to detect the presence and (to some extent) quantify the volume of specific vegetation on the seafloor. Additionally, monocular or stereo vision could be used (in conjunction or instead of MBES data) to develop the detection solution.
    2. This is an interdisciplinary project that not only requires knowledge on core robotics subjects, but will require some fundamental understanding regarding underwater acoustic and optical measurements.
    3. Depending on the scope and motivation of the student, this project can also involve hardware integration and field experiments with our in-house built autonomous surface vehicles.
    4. Responsible: Aldo Terán Espinoza
4. AUV Pose Estimation for Docking is described here: Thesis Description
5. Automatic pattern recognition and fish described here.
6. More underwater projects with sonar, control, planning, ...

Merits for these projects include an interest in robotics, control and estimation. Proficiency in programming and deep learning can be beneficial. The student will be part of a dynamic team at SMaRC, and will receive support in the form of regular meetings with supervisors and colleagues.

Some key people in the group for this project are Contact:

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