Master's Thesis Project

Sampling-Based Safe Return for Autonomous Underwater Vehicles

This Could Be You, Chelsea Sidrane

Introduction

One of the major concerns in the operation of autonomous underwater vehicles (AUVs) is that they will get lost and run out of battery, rendering them unrecoverable. In response to this concern, this project will explore `safe return` path planning; where the vehicle always plans a path to return to its origin point within battery limits, while also pursuing other objectives. In this case, the vehicle will have an exploration objective. We propose to solve this problem using sampling-based motion planning as it is fast enough to use in real-time. If successful, we would like to test the method onboard the SAM AUV (pictured at right).

Sampling-based motion planning typically builds graphs or trees [1, 2] but the safe return problem necessitates that the first initial path is a cycle and subsequent paths return to the goal/origin point. Existing work on planning graph cycles for persistent monitoring exists [3], but needs to be adapted to the finite horizon case and combined with existing online methods [1] to construct subsequent trajectories that return to the origin [4], all while considering an exploration objective [2].

Goal

You will produce a novel algorithm, theoretical guarantees for the algorithm, a clean open-source implementation of the algorithm working in the SMARC simulator, and if time permits, demonstrate the performance on the SAM hardware platform (pictured above).

Prerequisites

Prerequisites include an interest in robotic motion planning and information gathering, strong programming skills in any high-level language (Python, Julia, C++, etc.), basic graph theory, basic knowledge of statistics, some exposure to formal proofs, basic knowledge of ROS[1]. Desirable skills include knowledge of differential equations or dynamical systems, knowledge of / experience with robotic planning algorithms, optimizing code for speed and parallelism, and experience with robotic hardware.

Contact

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References

[1] Naderi, Kourosh, Joose Rajamäki, and Perttu Hämäläinen. "RT-RRT* a real-time path planning algorithm based on RRT." In *Proceedings of the 8th ACM SIGGRAPH Conference on Motion in Games*, pp. 113-118. 2015.

[2] Hollinger, Geoffrey A., and Gaurav S. Sukhatme. "Sampling-based robotic information gathering algorithms." *The International Journal of Robotics Research* 33, no. 9 (2014): 1271-1287.

[3] Lan, Xiaodong, and Mac Schwager. "Planning periodic persistent monitoring trajectories for sensing robots in gaussian random fields." In *2013 IEEE international conference on robotics and automation*, pp. 2415-2420. IEEE, 2013.

[4] Xin, Peng, Xiaomin Wang, Xiaoli Liu, Yanhui Wang, Zhibo Zhai, and Xiqing Ma. "Improved bidirectional RRT* algorithm for robot path planning." *Sensors* 23, no. 2 (2023): 1041.

[1] Some missing prerequisites can be fulfilled through completion of provided reading material or coursework in the semester preceding the project.