Master's Course Project
FLIPP: Fast Lightweight Informative Path Planning

This Could Be You, Matti Vahs, Dr. Chelsea Sidrane, Dr. Ignacio Torroba

I. Introduction

Informative path planning is the task of intelligently choosing waypoints online during planning to maximize information gain and other objectives. Typically, a distribution over an unknown field such as a Gaussian process is maintained and updated in a Bayesian fashion using measurements taken along the chosen path. The most difficult part of informative path planning is accurately accounting for the value of future information. As each data point is collected, it changes the value of information that future observations can provide. While some approaches use greedy/myopic planning to select the next waypoint [1], state of the art approaches tend to use multistep planning horizons [2]. When using a long planning horizon, one must then condition the value of information gain for each potential new observation in the trajectory on the information gained by previous potential measurements in the planned trajectory. While there are many methods to approximate the Bayesian update [3], most still involve costly computation, limiting the length of the planning horizon.

Fig. 1. SAM autonomous underwater vehicle (AUV) from the SMARC center

II. Goal

We propose combining a lightweight Gaussian process posterior approximation that we have developed with a fast sampling-based online planning algorithm, RT-RRT*, to perform fast, online, long-horizon conditional planning for information gathering. We will compare our algorithm to other recent multistep conditional planners on the task of bathymetric mapping for AUVs and drones navigating an obstacle course. We hypothesize that our algorithm will gather information more quickly leading to accurate surrogate models of the unknown field in less time/distance travelled. We also expect our algorithm will enable longer planning horizons and/or have faster execution time than more computationally heavy methods. We will evaluate the algorithm both in simulation and on real hardware. If there is time, the project may explore extending from 2D to 3D planning.

III. 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, 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.

IV. Note

This is not intended as a master's thesis project but could evolve into one in future terms if the work goes well. We do expect to publish the results of this work.

V. Contact

vahs@kth.se, chelse@kth.se

References

[1] R. Marchant and F. Ramos, "Bayesian optimisation for informative continuous path planning," in *2014 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE, 2014, pp. 6136–6143.

[2] P. Morere, R. Marchant, and F. Ramos, "Continuous state-action-observation pomdps for trajectory planning with bayesian optimisation," in *2018 IEEE/RSJ international conference on intelligent robots and systems (IROS)*. IEEE, 2018, pp. 8779–8786.

[3] I. Torroba, M. Cella, A. Terán, N. Rolleberg, and J. Folkesson, "Online stochastic variational gaussian process mapping for large-scale bathymetric slam in real time," *IEEE Robotics and Automation Letters*, vol. 8, no. 6, pp. 3150–3157, 2023.

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