Autonomous Vehicle Path Planning

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Robots need to go to a destination from its current position. Despite decades of research in path planning, there are challenges because of the complex missions. We work on multi-objective planning for autonomous boats that considers the influence of wind and currents, variable water level, and shorelines. These objectives make the solution space so large that classical planning algorithms are simply too slow. We have considerable experience applying metaheuristic algorithms like Genetic Algorithm and Particle Swarm Optimization. These approaches sacrifice a guaranteed optimal solution, but with huge speed improvements.

Student opportunity ideas

Multi-object boat path planning to maximize sampling reward

We have a boat path planner that considers distance, time, and energy costs. In addition, it considers the reward of deviating from that path to collect data. We combine all criteria into a single optimization value so that each candidate path has one score. Instead, we could treat it as a true multi-objective optimization to make a more informed solution selection. For example, by selecting a set of energy efficient paths and choosing the one with highest sampling reward that is within a specified percentage of allowed deviation from the most energy efficient option.

Incorporate dynamic water level into planner

Our planning objectives include dynamic forces that act upon the vehicle such as wind and currents. Another important dynamic is that the shorelines change depending on the water level. The boat has a depth requirement, and we need to incorporate predictions of the water level to ensure safe passage.

Automatic high-res map generation

Using high-resolution near infrared imagery, we can automatically segment water from land. However, bridges are detected as non-water (obstacles). One idea is to add roadmap data to automatically remove bridges from the map to make a useful shoreline map for vehicles that need to get very close to the shoreline for data collection tasks.

Update our system for Laguna Madre autonomous missions

Our water currents data for energy efficient planning comes from ocean model outputs. Recently, NGOFS2 was launched that includes high resolution current forecasts for the Laguna Madre. A student could work with this data to incorporate it into our planner so that field experiments could be performed to validate our system.

Related publications & resources

Krell, E., King, S. A., & Carrillo, L. R. G. (2022). Autonomous Surface Vehicle energy-efficient and reward-based path planning using Particle Swarm Optimization and Visibility Graphs. *Applied Ocean Research*, *122*, 103125.

Code repo: https://github.com/ekrell/conch

Krell, E., King, S. A., & Carrillo, L. R. G. (2020, July). Autonomous Water Surface Vehicle Metaheuristic Mission Planning using Self-generated Goals and Environmental Forecasts. In *2020 American Control Conference (ACC)* (pp. 2502-2507). IEEE.

Presentation: https://youtu.be/y94cxkz6EZs

Krell, E., Carrillo, L. R. G., King, S. A., & Hespanha, J. P. (2020, July). Game Theoretic Potential Field for Autonomous Water Surface Vehicle Navigation Using Weather Forecasts. In *2020 American Control Conference (ACC)* (pp. 2112-2117). IEEE.

Code repo: https://github.com/ekrell/fujin

Presentation: https://youtu.be/NjIyf1SfgP0

Krell, E., Sheta, A., Balasubramanian, A. P. R., & King, S. A. (2019). Collision-free autonomous robot navigation in unknown environments utilizing PSO for path planning. *Journal of Artificial Intelligence and Soft Computing Research*, *9*.

Code repo: https://github.com/ekrell/RobotPathPlanningPSO

Gunasekaran, K. U., Krell, E., Sheta, A., & King, S. A. (2018, July). Map generation and path planning for autonomous mobile robot in static environments using GA. In *2018 8th International Conference on Computer Science and Information Technology (CSIT)* (pp. 91-96). IEEE.