Science of Autonomy: Optimal Path Planning

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Science of Autonomy: Optimal path planning optimizes maritime navigation by analyzing environmental factors such as ocean currents to determine time-optimal routes in the ocean. I hypothesized this wasn't feasible given how vast the ocean and variables were. Using the Hamilton-Jacobi-Bellman (HJB) partial differential equation, reachability sets and fronts were calculated to find the furthest points a vessel can travel given ocean conditions. Simulations between Lisbon, Funchal, and Ponta Delgada were created to explore how vessel speed, direction, and currents affect efficiency. Results showed that higher current magnitudes aid propulsion while high-vorticity areas challenge navigation. Faster speeds reduce travel time but increase energy use, while slower speeds improve fuel efficiency by using favorable currents. This study shows the importance of adaptive path planning with real-time data to enhance navigation efficiency and safety. However, while I conducted this research in Portugal, my goal as a Pacific Islander was to apply this knowledge to my home island of American Samoa. In response to the lack of data in the South Pacific, I built an underwater remotely operated vehicle (ROV) using repurposed materials to collect oceanographic data. The ROV was designed to measure water quality, temperature, and salinity, and it provided information that I plan on integrating into the path-planning algorithms. This research project has the potential to revolutionize maritime navigation, provide more efficient routes, empower local communities, and advance the field of ocean science.

Awards Won: