Trajectory Planning and Control of an Autonomous Underwater Vehicle

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Abstract

The Earth's surface is predominantly covered by the ocean, accounting for more than 70% of its total area. Within this vast expanse lie a plethora of resources, diverse ecosystems, and yet-to-be-discovered mysteries. However, despite its significance, the underwater environment remains largely unexplored, primarily due to the formidable challenges associated with operating in such a harsh and often unpredictable domain. The immense pressure, extreme temperatures, and limited visibility underwater make exploration and research particularly challenging. Traditional methods of underwater exploration have been labour-intensive, time-consuming, and often limited in scope. In recent years, there has been a notable shift in focus towards the development of autonomous underwater vehicles (AUVs) which are equipped with advanced navigation systems, sensors, and communication tools, allowing them to navigate the depths with unprecedented precision and efficiency.

AUVs play a pivotal role in exploring and monitoring the underwater environment, facilitating scientific research, conservation efforts, and a wide range of industrial applications. From conducting geological surveys and marine biology research to supporting offshore oil and gas exploration, these AUVs are revolutionizing our understanding of the ocean and its vast potential. The study aims to address the trajectory planning and control of an AUV by adopting an optimal trajectory planning algorithm Minimum Snap Trajectory and a PD controller to follow the trajectory under the given constraints. The Minimum Snap Trajectory generation involves finding a polynomial trajectory through the specified waypoints given to the system while reducing the jerk with an aim to generate smooth and efficient motion for AUVs in a 3D environment. The PD controller is tuned and implemented to follow the generated trajectory to reduce the position and velocity error along the 3D motion. Simulation studies are conducted in a MATLAB environment to verify the effectiveness of the proposed approach.

Keywords: Autonomous Underwater Vehicle, Mathematical Modelling, Trajectory Planning, PID Controller.