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Author: Mr. Ayush Ranjan
Indian Institute of Technology Kanpur, India, ayranjan@iitk.ac.in

Mr. Vishrant Dave
Indian Institute of Technology Kanpur, India, vishrant@iitk.ac.in
Mr. Prateesh Awasthi
Indian Institute of Technology Kanpur, India, prateesh@iitk.ac.in
Dr. Dipak Kumar Giri
Indian Institute of Technology Kanpur, India, judipakkumar@gmail.com

TRAJECTORY PLANNING AND EXECUTION IN A HYPER REDUNDANT CONTINUUM MANIPULATOR FOR SATELLITE DOCKING

Abstract

This research paper presents a novel approach for trajectory planning and execution in hyper redundant continuum manipulators. The planner integrates Deep Deterministic Policy Gradient (DDPG) based reinforcement learning with Single Object Tracking to enhance the sampling efficiency for planning. The proposed model takes into account the high degree of freedom and non-linearities inherent in such systems, making it suitable for learning and optimizing control policies in real-time. The model successfully learns the dynamics of the system and outputs the required angular velocities of the motors which finally control the end effector kinematics of the robot. The high sample complexity of the reinforcement learning model is tackled by providing guidance using target tracking. The targets chosen in our case are non-stabilized cubic satellites.

We choose to deploy a target tracking system in non stationary background using CNNs with multiple dominant plane segmentation by optical-flow clustering which is capable of predicting the motion of satellites in real-time based on visual data. This perception module is trained on several benchmark datasets and then fine tuned in our specific environment. The DDPG model is trained in Gazebo Physics Engine in a dynamic environment including obstacles, visual occlusions and lightning changes. The final deployment and testing is performed on a 7 link continuum manipulator with the goal of successfully docking a satellite model by continuous detection and navigation towards the docking port and effectively avoiding obstacles like flat plane solar panels. The experimental results successfully highlight the effectiveness of using deep reinforcement learning for the control and trajectory execution of the manipulators, achieving higher speed, precision and stability compared to conventional methods. This paper opens up new avenues for further research in the control of hyper redundant systems. This motion controller has the potential to be integrated into satellite capture systems, enhancing their efficiency and accuracy.