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CONTROL DESIGN FOR TRANSFER OF PAYLOAD BETWEEN REUSABLE ROCKET AND LOWER END OF THE SKYHOOK

Abstract

The future of space transportation is fast evolving, and we must transition to a sustainable form of technology. Skyhook presents itself with the most efficient and eco-friendly space technology and will be a crucial step towards space for all. A skyhook is a long cable that orbits the Earth with the main spacecraft body at the upper end and a docking port at the lower end. This paper considers a spinning skyhook that exploits momentum transfer for transferring payload from the Earth's atmosphere to orbit. The considered skyhook uses electrodynamic tether propulsion to maintain the skyhook's orbit and provide propellantless propulsion. The feasibility of using tether electrodynamic propulsion for the skyhook has already been investigated. However, the main hindrance in using the proposed transportation technology is that a spinning skyhook requires a very accurate and time-bounded control system for docking the payload to the lower end of the skyhook due to the short optimal docking period. To tackle this problem, the lower end of the skyhook consists of a robotic manipulator coupled to a drone, which is connected to the lower end's main docking port via a long cable.

The docking control design consists of two parts: force control design for the robotic manipulator and drone combination and thrust control of the rocket. Controlling both systems using a single control design will make the overall control very complex. Hence, both the control systems are treated independently, and the controls are integrated using reinforcement learning to offer the ideal docking combination. The reusable rocket will launch the payload from the Earth's surface to reach the docking port at the required position and time. Initially, the control is focused on the thrust control of the rocket so that it reaches the desired position and orientation. However, gradually the focus of the control shifts to force control of the robotic manipulator. With the use of reinforcement learning, a cooperative control architecture is built between these two distinct control systems. When the docking of the payload is confirmed, the rocket will release the payload. Since the initial condition for rocket re-entry will be different for each case, an adaptable thrust control system is used for the rocket re-entry system. The drone will be pulled back to the main docking section with the help of the cable. Numerical simulations will be carried out to demonstrate the efficacy of the proposed concept.