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TOWARDS AN AUTONOMOUS FREE-FLYING ROBOT FLEET FOR INTRA-VEHICULAR TRANSPORTATION OF LOADS IN UNMANNED SPACE STATIONS

Abstract

The prospect of the Deep Space Gateway space station deployment in late 2020s, designed to support lunar and beyond Earth-moon missions, raises new challenges to the space robotics community. In particular, given the expectation for this space station not to be permanently manned, logistics operations, such as inspection and handling of material to and from automated cargo spacecraft have to be handled autonomously by robots. This paper starts by discussing the requirements of such robots to perform loading and unloading operations to and from a cargo spacecraft docked to the station. The limited available space inside the station limits the size and power of these robots, thus cooperative transportation methods are proposed to cope with large and heavy loads in an efficient way. The development and prototyping of these robots in a relevant environment requires microgravity. Parabolic flights are a possibility, but the short duration of the time intervals under microgravity limits significantly what can be tested. However, the presence of research platforms aboard the ISS, such as the NASA SPHERES, on station since 2006, and the NASA Astrobee, to be commissioned in late 2018, opens the door to validate and evaluate load transportation methods in microgravity, for significantly longer periods of time when compared with parabolic flights. In addition, being these robots fully autonomous, little crew time for experiment support is expected to be needed, in particular for the case of NASA Astrobee. The paper proceeds by proposing an architecture to perform load transportation tasks by one or more robots, followed by an update on the current research being carried out at the Institute for Systems and Robotics on this problem. In this context, we will first review the design of Space CoBot, a free-flyer robot for intra-vehicular operations, designed to outperform both SPHERES and Astrobee in terms of thrust. Then, we will present initial work on the problem of object tracking and capture using convergent controllers. And finally, our current work on load inertial parameter estimation using excitatory trajectories will be presented. Both object tracking and capture, and the load inertial parameter estimation work are platform agnostic. In particular, we aim at validating it on free-flying robots on station (SPHERES and/or Astrobee), while targeting its deployment in Space CoBot in the long run. We expect this work to produce concrete steps towards the autonomous operation of mobile robots inside space stations.