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A ROS/GAZEBO-BASED FRAMEWORK FOR SIMULATION AND CONTROL OF ON-ORBIT ROBOTIC SYSTEMS

Abstract

Future and under-development missions will require extensive use of robots for active debris removal, on-orbit servicing, assembling and manufacturing applications. The development and testing of such systems often require an iterative approach that, together with the technical difficulties of reproducing space conditions in ground-based test facilities and the high costs associated with these tests, discourage the utilization of hardware-based approaches in the earlier stages of the design. Using simulation tools such as ROS/Gazebo is currently common practice for testing and developing control algorithms for typical ground-based robotic systems but still is not commonly accepted within the space community. One of the reasons for this is that this kind of development environment does not allow for a complete and realistic simulation of the space conditions, such as micro-gravity and frictionless conditions. Numerous studies in this field use ad-hoc built, but not standardized, not open-source, and, sometimes, not verified tools that complicate, rather than promote, the development and realization of versatile robotic systems and algorithms for space robotics.

Keeping in mind this panorama, the solution proposed in this paper moves towards developing a unified open-source tool for space-robotic simulations. The adopted framework is based on Robotic Operating System (ROS), an open-source meta operative system to develop robot applications, combined with Gazebo, a tool to simulate populations of robots in customized environments. Such tools were modified to include and reproduce the principal environmental conditions that eventual space robots and manipulators could experience in an On-Orbit Servicing (OOS) scenarios. This solution allows for the simulation of complex space robotic systems and at the same time takes advantage of the number of packages already developed in ROS for control, vision, teleoperation and modelling tools. In this way, it is possible to simulate robotic operation for OOS, without the need of ad-hoc coded simulation tools but relying on a well validated tool, following the ROS principle of "Don't reinvent the wheel".

The paper presents a description of the architecture of the different software modules. It shows the key features of the developed tool, with a particular focus on the customization of the simulations and eventual possibilities of further expansion of the tool. Validation of the simulator suite is also presented, focusing on the authenticity of the results in space conditions. This is obtained by comparing the simulations against published flight mission data from some experiments carried on by NASDA in the frame of the ETS-VII mission.