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ARCHITECTURE AND DEVELOPMENT OF A MISSION COMPLIANT ROBOTIC SAMPLE PICKUP ARM SYSTEM FOR MARS SAMPLE RETURN CAMPAIGN

Abstract

The acquisition of samples from extraterrestrial bodies is a crucial task to better scientifically study

these environments. With the existing constraints in cost and safety to send humans to locations such as Mars, the use of robots still plays a critical role in carrying out these operations. However, the environmental and mass restrictions of sending scientific installations and equipment to analyse samples, makes the idea of bringing samples back to Earth a promising alternative. This is the main idea of the Mars Sample Return (MSR) campaign, where samples placed inside tubes by the NASA rover called Perseverance would be brought back to Earth. The Sample Fetch Rover (SFR) was conceived to facilitate a mobile manipulator that would autonomously fetch each of these Returnable Sample Tube Assemblies (RSTAs), but this concept was eventually discarded. Yet, it served to promote the development of technologies that would validate operations such as the mentioned sample acquisition. In this context, ESA tasked Airbus with the implementation of the RSTA Acquisition System (RAS). A proof of concept of this system was tested in 2023 in an outdoors environment, mounted at the front of a four-wheeled rover named Codi.

This paper describes the evolution and testing of the RAS to adapt to a variety of challenging scenarios involving the pickup of RSTAs. RAS hardware includes a 6 DoF robotic arm with a gripper as well as cameras for tube detection and assemblies that help the manoeuvrability of the system and the storage of the RSTAs. The majority of improvements have been made on the software side, with the design and implementation of a ROS2 based architecture. Within this architecture sits a management layer designed to robustly and repeatably exercise the autonomous tasks of which the RSTA pickup sequence is composed, as well as a node graph based implementation of the arm stances/motions and gripper positions that facilitates commanding of the hardware in a controlled manner when interacting with elements in the physical environment. The RAS software is supported by the MoveIt library, used to plan and control the motion of the arm while avoiding any collision with the hardware, the RSTA or the terrain. A Vision Based Detection System (VBDS) uses the images taken by the cameras to locate the RSTA with respect to the rover in preparation for the grasp sequence. Finally, a motion capture system provides the ground truth localisation of the arm.