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ASTROBEE: MAPPING THE INTERNATIONAL SPACE STATION'S JEM IN SUPPORT OF JAXA'S KIBO ROBOT PROGRAMMING CHALLENGE

**Abstract**

This paper summarizes the objectives and successful and unexpected items during the NASA/JAXA joint collaborative activities towards the 1st JAXA Kibo Robot Programming Challenge (RPC). Special attention is given to activities, lessons learned, and proposed improvements related to the mapping made by the Astrobees free-flying robot of the Japanese Experimental Module (JEM) where the competition took place.

The 1st JAXA Kibo RPC invited students from several countries in Asia to participate by solving programming challenges that JAXA developed. After a round of elimination, the finalists were selected and they were invited to upload their code to solve a challenge onboard the JEM at the International Space Station (ISS) using the Astrobees robots. In this challenge, students created Android Packages (APK) that can be loaded onto Astrobees High Level Processor (HLP), an Android-based computer. It enabled an Astrobees free-flyer to visit three different locations inside the JEM to obtain data that would instruct the robot to complete a final task with the participation of an ISS crew member.

During this effort several "firsts" were accomplished, namely: the operation of an Astrobees free-flying robot without crew present in preparation for the main event, autonomous image acquisition towards creation and update of the map used by the Astrobees to navigate autonomously the JEM, non-NASA code running on the robot (both JAXA and students), two heterogeneous free-flying robots from two different space agencies working together (Int-Ball Astrobees) during the final event, the first payload (student competition) using Astrobees, and having Astrobees controlled from a non-NASA location (Tsukuba Space Center).

The paper describes the overall objectives of the challenge, gives a brief summary of the timeline of activities, and reports on what went according to plan and what did not. It describes how the Astrobees Team approached and solved these unexpected items, and the analysis and results obtained. Additionally, considerations, strategies, analysis, results, and proposed enhancements on Astrobees mapping of the JEM are presented. We also mention recent localization changes that reduce localization drift by using graph-based optimization in place of the extended Kalman filter localizer. Finally, steps towards improving upcoming ISS activities are provided.