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MULTI-AGENT 3D MAP RECONSTRUCTION AND CHANGE DETECTION IN MICROGRAVITY WITH FREE-FLYING ROBOTS

Abstract

Assistive free-flyer robots autonomously caring for future crewed outposts–such as NASA's Astrobee robots on the International Space Station (ISS)–must be able to detect day-to-day interior changes to track inventory, detect and diagnose faults, and monitor the status of the outpost. This work presents a framework for microgravity multi-agent cooperative robotic mapping and map change detection to enable robotic maintenance of microgravity outposts. We reconstruct the ISS interior from sequences of images collected by each robot via photogrammetry, producing a colored point cloud visualizing the shape and appearance of the interior in 3D. We demonstrate the operation of multi-agent reconstruction in simulation with an arbitrary number of robots and evaluate the increase in total interior coverage and total mapping time. A Gaussian Mixture Model (GMM) clustering approach identifies significant changes between reconstructed maps. Finally, we validate the reconstruction using real image data collected by Astrobee robots on the ISS and note interior changes with the GMM framework. This work outlines the objectives, requirements, and algorithmic modules for the multi-agent reconstruction system, including recommendations for its use aboard future microgravity outposts.