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# CIMON: A VISUAL NAVIGATION SYSTEM FOR FLYING THROUGH THE INTERNATIONAL SPACE STATION

**Abstract**

For the 2018 ISS expedition, it is planned to send the ball-shaped robot CIMON to the space station. CIMON's goal is to act as a flying assistant system for the astronauts, providing work materials, showing locations and offering help and entertainment through a direct speech interface. While the robot offers impressive intelligent assistance functions, it must also manage the core tasks of any autonomous mobile robot: Finding its way and reaching its goal. CIMON can fly through the station using seven propulsion tubes with air fans, giving him full mobility in all directions. The robot is equipped with a full on-board GNC system and uses a sophisticated visual navigation system for continuously estimating its pose. The unusual characteristics of the space station environment, together with a full six degrees of freedom motion system and the restrictions of a small and light-weight robotic body create a special challenge for the navigation system. The paper describes the used visual navigation system in detail, justifies the choices made and gives an overview over the additional functionalities that are needed. As the environment must be regarded as being mostly unknown, the robot uses a full SLAM algorithm for its relative navigation system together with a marker detection algorithm for absolute referencing within the module. To be able to detect and react to the astronauts, a face detection algorithm was integrated into the navigation system. The whole visual navigation system is implemented as on-board software, running in a ROS environment. The system must run on a single mini-pc, making processor load, task timing and communication overhead highly important challenges. CIMON is expected to be flown to space in summer 2018, with experiments scheduled in the latter half of the year. Before the launch, extensive tests were done with the robot, using three different prototype implementations designed for different simulation environments. In spring 2018, a CIMON prototype was tested in a parabolic flight campaign, employing the full GNC and visual navigation system for the first time in a microgravity environment. While the final results of the space experiments are not yet available, the paper includes a discussion about the lessons learnt and the challenges encountered during the test campaign.