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GNC SYSTEM DESIGN FOR THE CREW INTERACTIVE MOBILE COMPANION (CIMON)

Abstract

CIMON is a technology demonstration mission for the ISS scheduled for launch in 2018. Designed as a social companion for astronauts, the flying ball “Cimon” shall perform supporting crew activities like displaying procedures. Furthermore it is designed for social interaction and trained in smalltalk. CIMON consists of two parts: The free flying ball “Cimon” on-board the ISS and the artificial intelligence located on ground. We describe the Guidance, Navigation and Control (GNC) system for Cimon. The GNC is designed in Matlab/Simulink and auto-coded as a node for the Robot Operation System (ROS), which serves as a middleware for communication between the software in orbit and on ground. It runs on Cimon’s on-board computer and provides several operation modes which are triggered by the artificial intelligence. Cimon is designed to navigate autonomously through the Columbus module of the ISS. Vision based navigation is provided by a backwards pointing stereo camera and supported by an inertial measurement unit. Both relative and absolute navigation are supported, allowing Cimon to follow astronaut commands like “Come closer”. For attitude and position control Cimon features 14 small fans arranged in seven tubes that allow an independent control of all six degrees of freedom. Due to safety precautions the thrust is severely restricted varying between 30 and 120 mN in the three main directions of movement. Hence, a major challenge of the GNC system is to provide a level of agility that satisfies a human counterpart despite those restrictions. One approach taken is to concentrate on rotational movements when expressing human-like emotions like nodding in consent. Those allow for a faster, more dynamic response and require less free space around Cimon. The latter being another important factor since space on the station is limited. To avoid obstacles of any kind Cimon is equipped with twelve ultrasonic sensors. Cimon may respond to the astronaut by turning around utilizing its voice tracking and face detection capabilities. If required, it may also approach the astronaut and place and hold itself in a convenient reading and chatting position. For verification different test environments were implemented. A Matlab simulation serves for functional and performance tests. To test with ROS, a 3D environment was designed using Gazebo with Cimon implemented as URDF model. This setup features real-time and processor in the loop capabilities. Additionally, hardware tests with an air bearing and a free movement test on a parabolic flight are performed.