SPACE SYSTEMS SYMPOSIUM (D1)
Cooperative and Robotic Space Systems (6)

Author: Mr. Jan Harder
Technical University of Munich, Germany

Mr. Martin Dziura
Technical University of Munich, Germany
Mr. Stefan Haberl
Germany

FUTURE TECHNOLOGIES FOR OPERATING ROBOTS IN SPACE

Abstract

Future robotic space missions for on-orbit servicing or space debris removal require significantly improved capabilities especially for achieving safe and reliable proximity operations and rendezvous and docking (RvD). Existing technologies for relative navigation and robotic capture are limited in their performance envelope and usually tailored to a narrow set of tasks and compatible to a specific set of cooperative target objects. To enable more flexible and challenging missions multiple aspects of those technologies need to be improved. To tackle this issue by developing and evaluating new technologies, the Technical University of Munich (TUM) established the Real-Time Attitude Control and On-Orbit Navigation Laboratory (RACOON-Lab), a hardware-in-the-loop simulator for proximity operations. The simulation environment provides all mission-relevant elements, such as servicer and target spacecraft, orbit dynamics including perturbations, a movable sun-simulator, relay-communication link as well as a mission control center. The infrastructure is real-time capable and allows custom experimental setups using flexible hardware sensor integration performing docking operations including a human in the control loop. The RACOON-Lab is used for experiments within the two research focus areas of human-robot-interaction and system autonomy. This paper presents most recent results in these two areas evaluating the feasibility of artificial acoustic feedback and demonstrating the capabilities of computer vision technologies. With the predicament of including humans in the control loop for supervising partially autonomous systems, our research focuses on the operational concepts and design multi-modal man-machine interfaces (e.g. support- ing acoustic feedback) for future RvD operations. We present first user study results of an acoustic feedback system augmenting the human operator during critical operations. The goal of such operator augmentation is to increase situational awareness and improve docking safety and success rate. Besides the augmentation of established sensory feedback modes like monoscopic video streams we work on the evaluation of alternative sensor technologies to exceed existing technological limits. The utilization of 3D object reconstruction in orbital proximity operations is one novel technology and has been proposed to improve both human interfaces and autonomous algorithms in terms of situation awareness, docking efficiency and resource consumption. Using different RGB-D sensors and realistic illumination in the RACOON-Lab not only a proof-of-concept but detailed parameter studies could be performed to support this proposal.