Paper ID: 53113
oral

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

Author: Dr. Marco Sabatini
Sapienza University of Rome, Italy, marco.sabatini@uniroma1.it

Mrs. Chiara Marchionne
Sapienza University of Rome, Italy, chiamrc@yahoo.it
Prof. Paolo Gasbarri
Sapienza University of Rome, Italy, paolo.gasbarri@uniroma1.it

GNC ARCHITECTURE SOLUTIONS FOR ROBUST OPERATIONS OF A FREE-FLOATING SPACE MANIPULATOR VIA IMAGE BASED VISUAL SERVOING

Abstract

A class of advanced space activities, including on-orbit servicing and debris removal, often requires the use of robotic arms. Autonomy of these operations is a key asset, since the necessary continuous monitoring of the scenario and real-time control cannot be provided by a ground station. In this framework, the use of optical devices for computing the arm control is a solution, already analyzed in many researches. Image Based Visual Servoing (IBVS) is a control strategy that makes use of images (comparing the acquired image with the reference one) to compute the desired end-effector velocity, without the need of reconstructing the pose of the target object. The final goal is reached when the acquired and reference images coincide, meaning that the end-effector has moved to the correct position. Space manipulators present special features with respect to terrestrial applications. The movement of the robotic arm could lead to an excessive rotation of the platform, since it is unconstrained. Two alternative modifications of IBVS are developed: (a) the movement of the base is not avoided, but its effects are considered by including open loop terms to the commanded velocity and (b) the Reaction Null technique (which modifies the joint velocities so that the resultant reaction on the base is zero) is applied to the IBVS control. Simulations are performed in high-fidelity purposely developed software architecture, in which not only the selected 8 DOF space manipulator is modeled, but also a virtual camera is included in the GNC loop, acquiring images of the target CAD model imported in MATLAB Virtual Reality toolbox. This approach allows to emphasis several problems that would not emerge in simulations with ideal images (made of set of points or primitive shapes, as typically done). Errors on the image feature extraction and possible mismatches between reference and actual features heavily decrease the arm performance, which could be either stacked in a local minimum or even diverge. We have realized that computing the linear and angular velocity of the end-effector within a single computation, as usually performed, increases this undesired behavior. Therefore, a specific GNC architecture is developed, based on finite-state machine logic, in which different IBVS strategies are performed, alternatively commanding only linear or angular velocity of the camera when the “stack” or “divergence” condition is triggered. In this way a stable and robust accomplishment of the tasks is achieved for many configurations and for different target models.