Paper ID: 43511
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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SPACE ROBOT DYNAMIC ANALYSIS OF THE RELATIVE ORBITAL AND ATTITUDE MOTION IN THE CLOSE RANGE RENDEZVOUS PHASE AND GRASPING OF A TARGET SPACE VEHICLE

Abstract

This article deals with the dynamic analysis of the close approach phase of a space robot to a target spacecraft aiming the grasping of a target space vehicle. The chaser robot shall berth by side of the target so as to have it inside its workspace envelop. The grasping operation shall be executed by inverse kinematics. The computer simulation of the equations of the dynamics (relative orbital and attitude equations of motion) yields the grasping conditions and such results are compared with the inverse kinematics grasping operation implemented in a lab experiment. In the experiment it is used two robot manipulators mounted on an air supported platform, constituting a floating robotic system that operates on a glass table. The experiment is wireless and this feature is obtained by using Wifi to implement the communication of the human operator with the robots and a platform containing its own air compressed cylinders. In addition to the Wifi the manipulator platforms include microcontroller, a set of valves to control the compressed air flow, and two compressed air cylinders. The actuators for rotational/translational motion operate on the base of compressed air. A Kinect v2 sensor supported by computational vision is employed externally to the experiment. The use of such sensor aims to measure velocity, perform robot tracking as well as to obtain the X, Y, and Z positions of the manipulators' grippers at run time and 3D video scenes. The information is sent via Wifi, over the UDP protocol, to a computer with MATLAB software, which writes the actual speed and positioning information and compares with the prescribed results (estimated in simulation). The experimental result obtained by inverse kinematics for the capture of the target is compared with the results of the computational simulations, aiming at the validation and improvement of the mathematical model simulated via MATLAB. If the error does not meet the nominal specification the operator commands the robot system to continue the control loop. The compressed air autonomy is about 30 minutes for the platform floating and 1 minute for the grasping operation. The results are presented by using plots of the relative distance and velocity with respect to time, attitude synchronization with respect to time, and the robot-like spacecraft attitude motion during the safety-critical operations of grasping the target spacecraft. The direct kinematics obtained by the computational simulation is compared with the results of the inverse kinematics obtained via experiment.