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DESIGN, REALIZATION AND CHARACTERIZATION OF A FREE-FLOATING PLATFORM FOR FLEXIBLE SATELLITE CONTROL EXPERIMENTS

Abstract

Experimental verification of theory or numerical results is a common practice in all scientific and technological disciplines. Some aspects of space systems are indeed particularly hard to test on ground: a terrestrial mock-up replicating the orbital dynamics should be in a gravity-free environment. One of the most common approaches to (at least partially) realize it, consists in free-floating systems, in which the friction between an experimental platform and the working surface is almost completely removed. The vertical axis is still subject to gravity, and only 3 degrees of freedom (two horizontal translations and one rotation about the vertical axis) replicate the orbital behavior. Our research group had been developing since 2012 a free-floating platform named PINOCCHIO (Platform Integrating Navigation and Orbital Control Capabilities Hosting Intelligent Onboard). This platform was used for rendezvous operations using vision-based autonomous navigation, proximity operations, and lately attitude maneuvers affected by the interaction with elastic dynamics of flexible structures (solar panels or antennas). The need to further investigate this last research field, in the optics of fulfilling the requirements imposed by an ESA project, called for the design, realization and characterization of a new platform to increase of the performance and the capabilities of the test rig. A rigid aluminum chassis bus has been equipped with four appendages fitted with vibration actuators (both patch and stack piezoelectric (PZT) devices) and PZT sensors. A VICON external metrology system has been implemented to obtain online measurements of attitude, position and elastic displacement thanks to a net of optical markers placed on the platform. This paper first describes the main components of the system, including the pressure air system, the attitude and elastic control, the navigation and communication system, and relevant electronics. The characterization of the system is the core of the second part of the paper. The physical (mass, moment of inertia), control (thrusters' torque and force) and IMU characteristics are experimentally measured with the associated uncertainty level. The accuracy of the VICON system in static and dynamic conditions is also characterized, obtaining a 100 micrometers-level resolution for external measurement of rigid and elastic displacements; this information is used as a benchmark to evaluate the accuracy obtained for the onboard PZT sensors, and its fundamental for performing tests of fine pointing control algorithms for flexible and agile satellites. The proposed characterization methodology and associated results could be of interest for university and industry laboratories intended to develop new free-floating platforms.