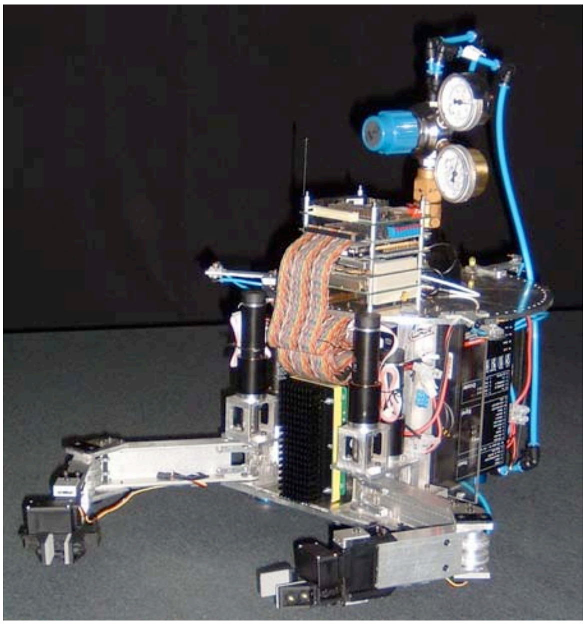
The NTUA Space Robotics Emulator: Design and Experiments

Evangelos Papadopoulos, Iosif Paraskevas and Thaleia Flessa
Departement of Mechanical Engineering
National Technical University of Athens

Autonomous robotic exploration is a key step in space exploration and in the expansion of human presence in space. The importance of space robots in satellite servicing, in EVA assistance and in removing orbital debris is continually growing, driven by space commercialization and exploration efforts. A successful deployment of such robots requires analytical and experimental task validation on Earth. With this aim, we present the planar space robot emulator developed at NTUA.

The emulator provides a low cost, long duration and reconfigurable platform for the analytical and experimental validation of different control, dynamics, and path planning schemes, thus facilitating the transition from theory to application. The emulator consists of a granite table of minimum roughness (less than 5 micron) and a small robot (approx. 15 kg) supported on three air-bearings. The robot hovers over the table on a 10μm CO_2 film and is therefore capable of horizontal frictionless motion, emulating a 2D motion in zero gravity in a laboratory environment. The robot is fully autonomous. Its propulsion autonomy is achieved by an on board CO_2 tank that provides gas to the air bearings and to three couples of on/off thrusters. The robot is also equipped with a reaction wheel to control its angular momentum, in conjunction with the thrusters. Moreover, the robot has two arms, each with two revolute joints; each arm also has a gripper as end-effector.



Computational autonomy is achieved with a PC104 mounted on the robot and power autonomy is achieved with a set of on-board batteries. Three optical sensors mounted at the robot base, and sourced from easily available, low cost commercial mice, provide position feedback. An external top camera also provides absolute position feedback. The position feedback system is validated with a PhaseSpace motion capture system. Using this robot, a number of experiments are possible.

The novelty of this system is that the robot is not only of low mass and completely self-contained but it is also composed of subsystems analogous to those of a space system, therefore making the emulator significantly more realistic. Future implementations will include additional robots for validating tasks such as cooperative manipulation, target-chaser scenarios, formation flying etc.