IAF SPACE SYSTEMS SYMPOSIUM (D1)
Interactive Presentations - IAF SPACE SYSTEMS SYMPOSIUM (IP)

Author: Mr. Alessandro Tringali
Space Mechatronic Systems Technology Laboratory, University of Strathclyde, United Kingdom

Dr. Silvio Cocuzza
The Queen's University of Belfast, United Kingdom

PREDICTIVE CONTROL OF A SPACE MANIPULATOR THROUGH ERROR EXPECTATION AND KINETIC ENERGY EXPECTATION

Abstract

In space robotics missions, both for space servicing or debris capture, the minimization of the robot energy consumption and the minimization of the reactions transferred to the base spacecraft are of crucial importance. Both of these targets are related to a longer system lifetime in orbit: while energy minimization allows longer operations by definition, reactions minimization allows to keep the base spacecraft orientation unchanged, which in turn means fuel savings due to the fact that attitude corrections are not necessary. They are usually both implemented through inverse kinematics algorithms, which however only provide local minima along the end-effector trajectory. Thus, as trajectories increase in length, they fail to follow the lowest energy path in the robot joint space, and tend to be singularity-prone. In this paper, a totally new solution is presented based on a predictive control algorithm that computes the direction of minimum end-effector error and kinetic energy integral over a set of future exploration points. Its performance has been evaluated by kinematic simulations and compared to the classic pseudoinverse solution for a 3-DOF planar manipulator. The above mentioned algorithms have been compared by computing the energy consumption sample trajectories, starting from the robot same initial configuration and, in particular, the robot kinetic energy, kinetic energy integral, and total energy have been discussed and compared. The new algorithm has shown significant energy savings over tested end-effector trajectories, and a greatly enhanced capability to reduce the occurrence of singularities with respect to the traditional solutions.