TIME-DELAYED TELEOPERATION OF SPACE ROBOTS

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The poster is sub-divided into two different posters. One dedicated to present current research into time-delayed teleoperation of space robots and what the future will bring. And the second one dedicated to present the novel techniques developed by NAL in the frame of the ETS-7 project.

TIME-DELAYED TELEOPERATION AND BEYOND

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The existence of time delay in the communication link is one of the most important problems regarding the stability of teleoperation systems. Time delay is specially relevant in ground teleoperation of robots orbiting Earth, with values of round trip delay ranging from 5 to 10 seconds.

The poster firstly presents an overview of techniques to overcome time-delay in telemanipulation. A review of those techniques prone to be employed for ground teleoperation of robot arms is carried-out.

The technology developed for teleoperation of space robot orbiting Earth can be extended to other space applications: new aids for manual rendezvous docking, inspector satellite teleoperation both from ground and space, new manual berthing concepts, very long time-delayed teleoperation of rovers, commanding of ISS robots, etc.

The poster is then oriented to present what we think could be possible uses of the technology for other space applications, This part gives a reasonable view from our experience and perspective of the spin-offs that the developed technology could bring in the future. We consider this part of the paper as the baseline for future research efforts in the area of space teleoperation.

Finally, part of the poster is dedicated to present an open telemanipulation platform based on the client-server architecture available at the Polytechnic University of Madrid. It has been designed to test different telemanipulation architectures, using various input devices (6 DOF hand controller, Phantom, Joysticks with force reflection, etc.) and different types of slaves (PUMA robot arm, tele-robotised excavator, GRIPS manipulator, etc). It allows to study factors such as time-delay, bandwidth, man-machine interfaces and force reflection modes. It also includes a Modular Robot Simulator in which to implement predictive displays.

NAL TELEOPERATION TECHNOLOGIES FOR ETS-7

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The ETS-7 satellite was launched at the end of 1997 by the National Space Development Agency (NASDA) of Japan to demonstrate two major missions: automatic rendezvous docking and space robotics. The National Aerospace Laboratory (NAL) of Japan has participated in the ETS-7 robotics experiments with its own apparatus on the satellite and its own teleoperation facilities located at NASDA's Tsukuba Space Center. Its objective has been to establish the basic technologies for on-orbit truss assembly and construction by ground teleoperation of a space arm.

Experiments were conducted using a variety of technologies. Special emphasis was put on effective support systems to be able to carry-out complex tasks through time-delay limitations. Predictive displays, visual aids and force reflection has been the key players in the research.

The poster presents the concepts, implementations and experience gained through the different ETS-7 experiments. The different technologies developed (visual aids, force reflection, ground training, predictive displays) are presented in detail.

The experiments basically included assembling and deploying tasks using the on-board robot arm through different control techniques. Also experiments simulating long-time delay (over 10 s) and experiments to estimate the robot arm distortion were carried-out.

Several papers are already available with the results of these experiments. The objective of the poster is hence to present their content in a systematic and precise way.

To help in this effort, the poster is complemented with videos and photos of the different equipment taken during the experiments.