

Virtual environment technology for space applications

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Abstract

Virtual environment technology is expected to make a big impact on future information processing systems. Virtual environments are simulation systems in which the user, by means of advanced man-machine interface techniques, is to a large extent "immersed" in the apparent environment of a simulated, multi-dimensional reality. Recent advances in areas such as computer generated imagery (CGI), display devices, position/attitude sensors, digital signal processing, physically based modelling, etc., have enabled the implementation of simple virtual environments. However, in order for VE's to be useful in "real-world" applications, many technical problems that currently exist, need to be overcome. Because the field of general virtual environment technology is so broad, focussing on these technical problems alone would merely lead to "solutions in need of a problem". In order to avoid the creation of yet another "technology push", it would be better to examine a number of different applications in a coherent area and see whether an "application pull" can be identified.

Space-related applications can provide a framework to guide an effective research and development programme of basic VE technology. In this paper, a number of space-related applications that could potentially benefit from such VE systems, are discussed. These applications are from very diverse areas, such as remote sensing, scientific visualization, design, and training. Concrete applications that are envisioned, are virtual earth observations, telepresence for planetary exploration, virtual testing facilities, design concept validation, and astronaut mission preparation. In addition to this, several promising technologies, both hardware and software, are identified that need further research and development effort before they can be put to use in practical VE systems.

Conclusions that can be drawn from the development of prototype VE-based training applications at TNO-FEL are that the flexibility, ease-of-use, transportability and greatly reduced development effort makes such systems at least a useful addition, and possibly even an alternative to existing systems.

ON ORBIT EXPERIMENT OF SPACE ROBOTICS

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On-orbit experiment and demonstration of space robotics as well as automatic rendezvous and docking is the primary objective of Japan's Engineering Test Satellite VII (ETS-VII), which is now under development with the schedule to be launched in 1997. This on-orbit experiment aims to evaluate the productivity of robotic function on an actual unmanned spacecraft on orbit.

There arise several critical questions about the possibility of the space robot to practical applications on orbit. Kinematic stability, precision, efficiency, controllability, contingency, ground human operator, communication link, on-board software, sensors, moving parts and structure are all points of interests which are to be evaluated in flight experiments.

ETS-VII, the flying testbed for automatic rendezvous/docking and space robotics experiment will be launched atop the H-2 Rocket as one of the dual launch payloads with TRMM (Tropical Rainfall Measuring Mission) satellite and finally injected into a low earth orbit of 550 km altitude.

A target satellite is separated from the mother chaser satellite to be tracked, chased and captured in autonomous mode.

A single robot arm with 6 degrees of freedom is equipped to the chaser satellite to handle mechanisms on the surface of each satellite. Various ratio of mixture between full autonomous and full teleoperation control will be applied seeking practical control mode and on-orbit evaluation of man-machine relation for robotic maneuver. Dynamic coupling between the motion of satellite and that of the robot arm is to be controlled by onboard control function, which is one of the primary themes of the flight experiment. Teleoperation from the ground via COMETS data relay satellite is also a primary theme of experiment. On board fuel supply and battery exchange are demonstrated by using robot arm.

The experiment on capture and berthing by using robot arm is also planned with the purpose to evaluate the possibility of robotic handling of a large free flying object such as a member of a large structure. Precision and dexterity of robotic arm performance under the condition of limited observation and restricted communication with the ground operator will be evaluated in applying actual tasks on orbit.

SENSORBASED SPACE ROBOTICS -
ROTEX AND ITS TELEROBOTIC FEATURES

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In early 93 the space robot technology experiment ROTEX has flown with space-shuttle COLUMBIA (spacelab mission D2 on flight STS-55 from April 26 to May 6). A multisensory robot on board the space-craft successfully worked in autonomous modes, teleoperated by astronauts, as well as in different telerobotic ground control modes. These include on-line teleoperation and tele-sensor-programming, a task-level oriented programming technique involving "learning by showing" concepts in a virtual environment. The robot's key features were its multisensory gripper and the local sensory feedback schemes which are the basis for shared autonomy. The corresponding man-machine interface concepts using a 6 dof non-force-reflecting control ball and visual feedback to the human operator are explained. Stereographic simulation on ground was used to predict not only the robot's free motion but even the sensor based path refinement on board; prototype tasks performed by this space robot were the assembly of a truss structure, connecting/disconnecting an electrical plug (orbit replaceable unit exchange ORU), and grasping free-floating objects.

The Inertial Upper Stage: Flight Experience and Capabilities

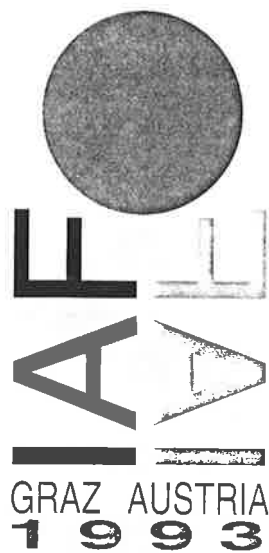
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The Inertial Upper Stage (IUS) program celebrated the tenth anniversary of its first flight in 1992. Over that time it has been used to launch fourteen missions, including five NASA communication, six military, and three interplanetary spacecraft. In 1991, the Boeing IUS Team was awarded the Federation Aeronautique Internationale (FAI) Diplome D'Honneur for Astronautics. The award was given "For the design, development, manufacturing and successful operations achievements of the Inertial Upper Stage..." This paper provides data on: the value of the vehicle's redundant design and past uses of the vehicle's redundant capability to achieve mission success. Payload lift capabilities to various popular orbits using the present IUS boosters, the Space Shuttle, the Titan IV expendable launcher are presented. A resume of injection accuracy history is included.

BOOK OF ABSTRACTS

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