N95-23734

Telerobotics Test Bed for Space Structure Assembly

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KEYWORDS AND PHRASES
Telerobotics, Space robotics, Solar cells, Intelligent monitoring, Test bed

INTRODUCTION
A cooperative research on super long distance space telerobotics is now in progress both in Japan and USA (1).
In this program, several key features will be tested, which can be applicable to the control of space robots as well as to terrestrial robots. local (control) and remote(work) sites will be shared between Electrotechnical Lab.(ETL) of MITI in Japan and Jet Propulsion Lab.(JPL) in USA. The details of a test bed for this international program are discussed in this report.

TASK ANALYSIS

Task Decomposition
A space structure, which is supposed to be a part of a large solar power station, will be assembled with the telerobotics. The assembly work has been decomposed into several tasks, ie,

(1) Deployment of the truss structure.
(2) Installation of an ORU(Orbital Replaceable Unit).
(3) Deployment of a solar cell panel.
(4) Installation of a wire harness.

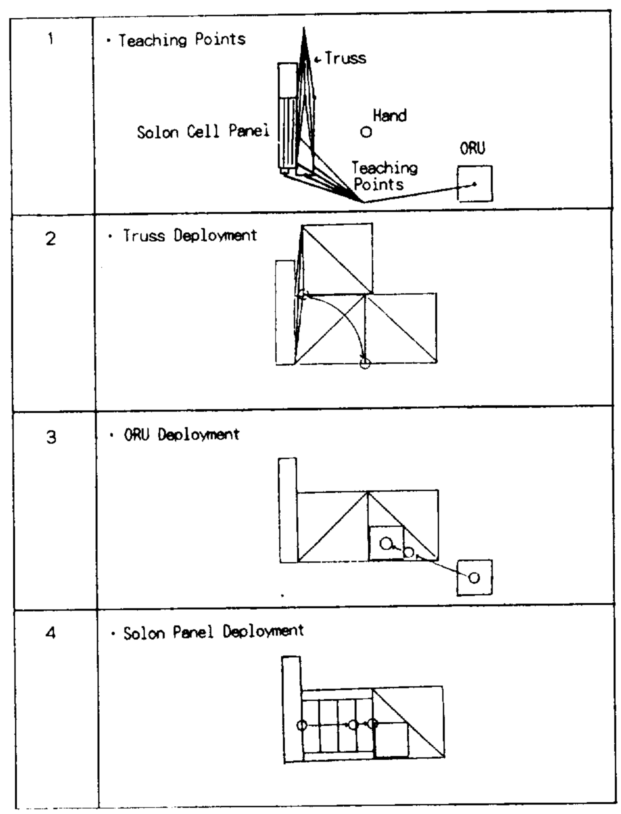

Fig. 1 Task Sequence

Each task is split into small events such as shown is Fig. 1
The time required for each event has been also evaluated.

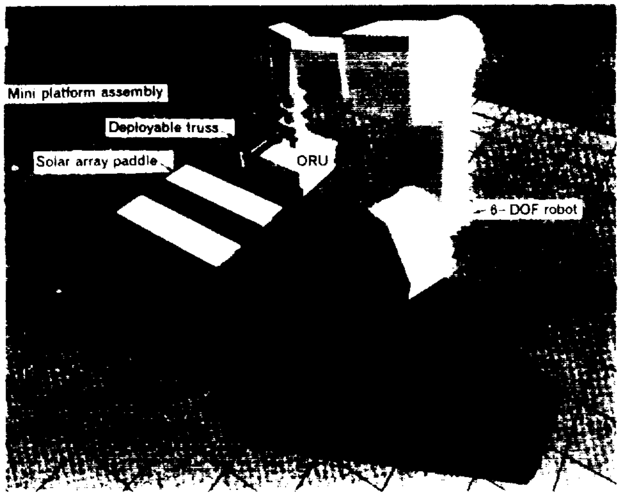

Fig.2 Concept of the Remote Site in Japan

Off-Line Task Validation by the Graphics Simulator

To perform the teleoperation under the constraints of time-delay and limited capacity in a communication line, all the task sequence will be verified using the off-line graphics simulator (Fig. 2), before the execution of the tasks. The simulator will be operated based on a world model of the remote site stored and maintained in the knowledge base.

TELEROBOTIC CONTROL STRATEGY FOR SPACE STRUCTURE ASSEMBLY

The control strategy in the system is embedded in three different blocks of programs, namely,

(1) An intelligent monitoring systtem to control the viewing scheme (2).
(2) A knowledge base as object oriented programs to perform required tasks.
(3) A cooperative control system to cope with the teleoperation of a robot.

The knowledge base is the key element of this system, and the object oriented programs contain data of the work site and define procedures necessary to perform tasks. It accepts task commands described as message to an object model from an operator, and generates motions for both the robot and cameras. Those generated motions can be displayed on the graphics simulator for the confimation of the task.

Generated motion for the robot is sent to the cooperative control system on the remote site. It achieves the servo control of the robot. It also accepts a direct motion control command from the operator, generated by a master-manipulator, a joystick or other commanding devices. The basic flow of the software is shown Fig. 3

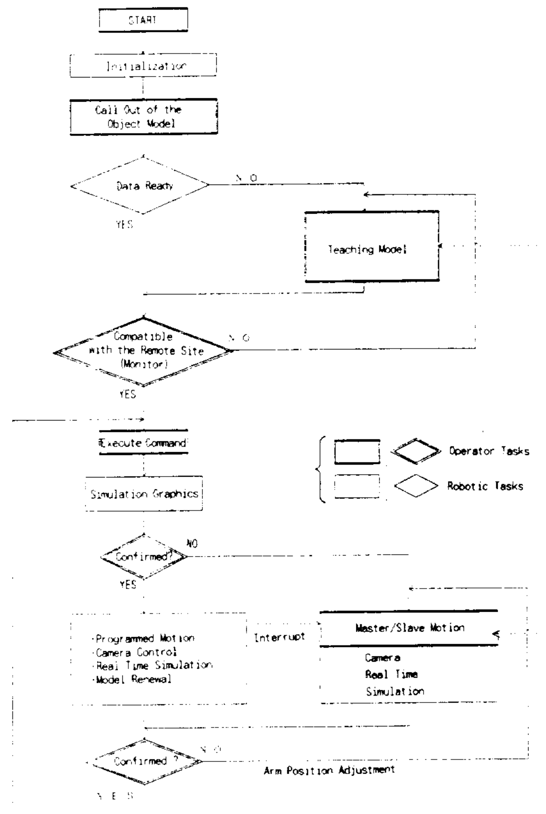

Fig. 3 Software Basic Flow

DESIGN OF TESTBED

System Architecture

A schematic diagram of the system is shown in Fig. 4. The system is split into two parts, one for a remote site which includes the manipulator and the various sensors,and the other for a local site which includes various computers and control software (Fig. 5). Most communication lines are connected through the Ethernet, and the time delay can be introduced in the image and command lines.

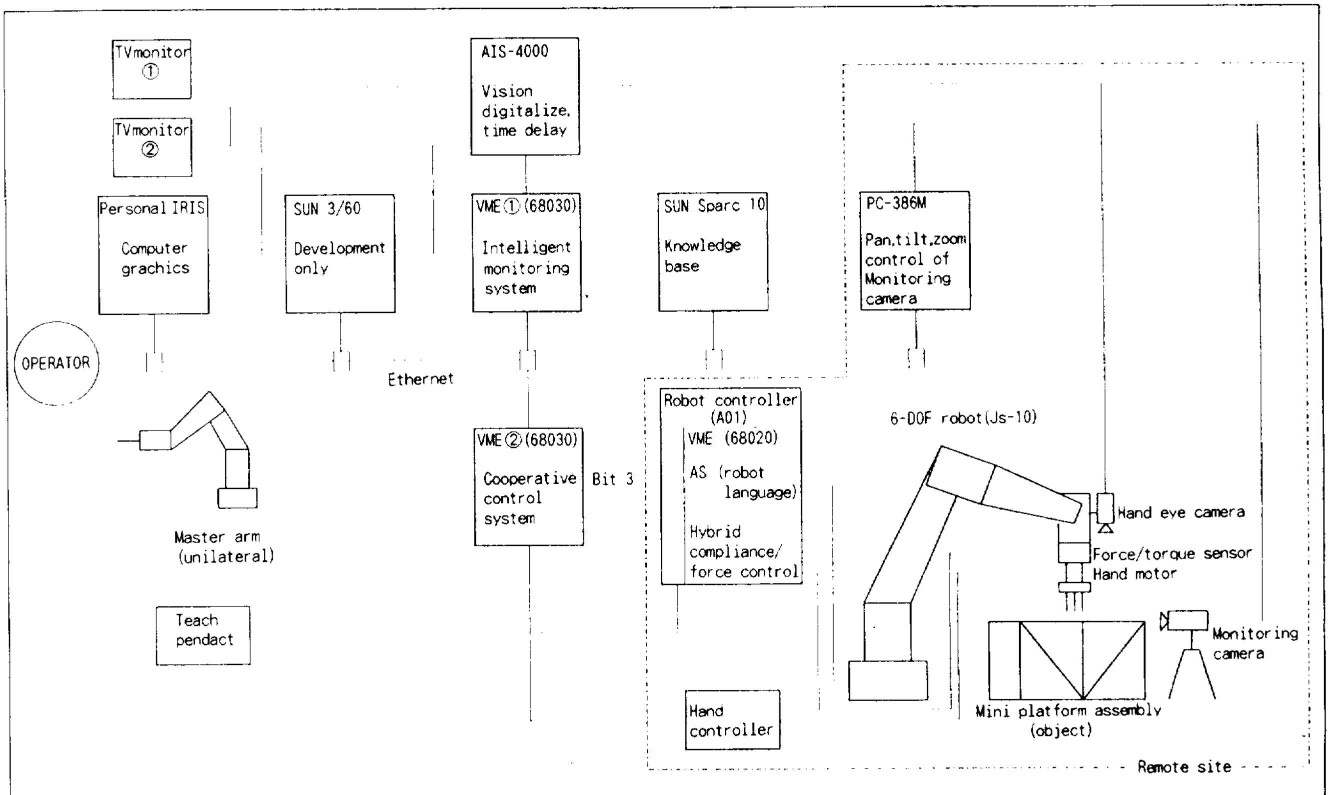

Fig. 4 Ling Distance Space Telerobotics Experiment System

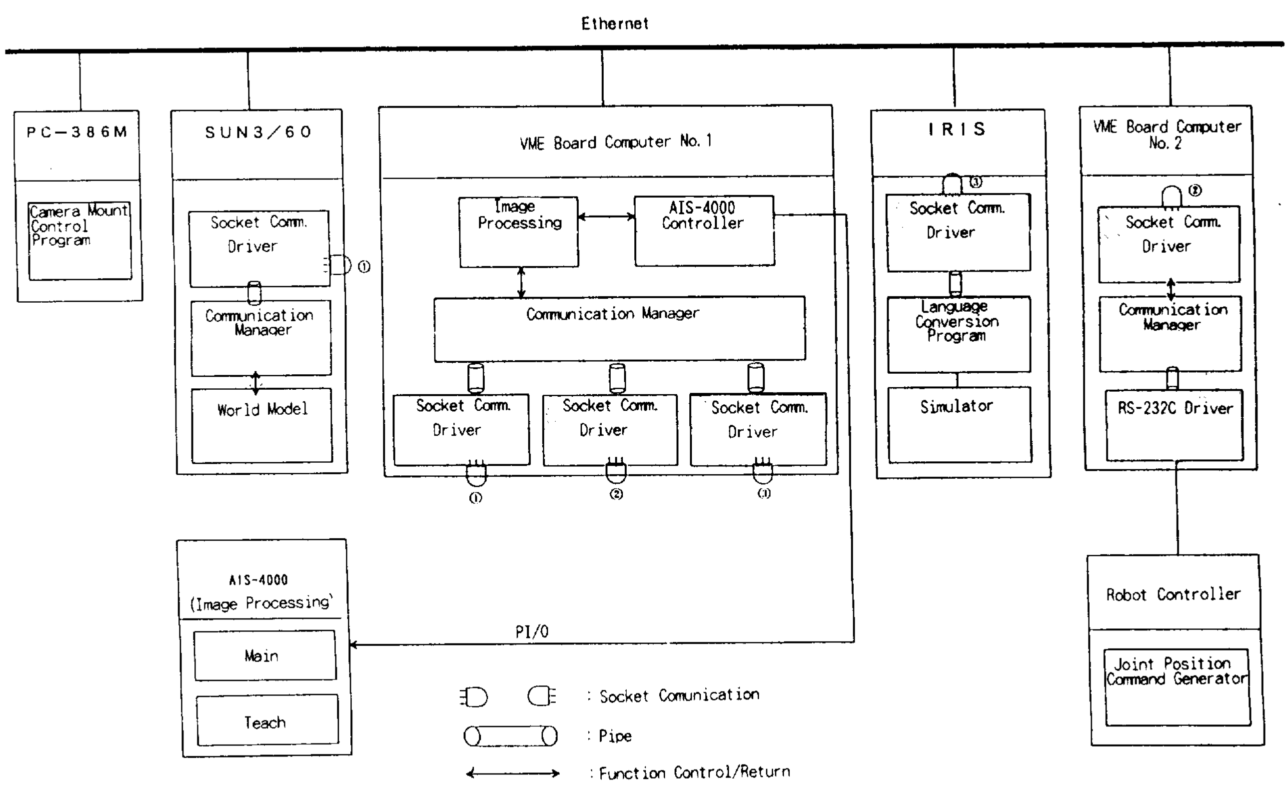

Fig. 5 System Architecture

Robot Friendly Truss Structure

A two-cell truss structure has been designed and manufactured, with a simple and passive latch in each cell. This latch can be easily released by the remotely operated robot, and can be tailored for a robot assembled truss structure. This truss has provisions for the installation of an ORU and the deployment of a solar panel, and is supposed to be a part of the main structure for a solar power generation system.

Description of Hardware

The following hardware other than the truss structure has been manufactured and prepared:

(1) An industrial robot with a hand eye camera, a force-torque sensor and a three-finger hand.
(2) A robot controller with a hybrid compliance-force control capability.
(3) Two TV monitors with image processing capability.
(4) Two workstations with graphics capability.

The prepared testbed for the teleoperation experiment is shown in Fig. 6.

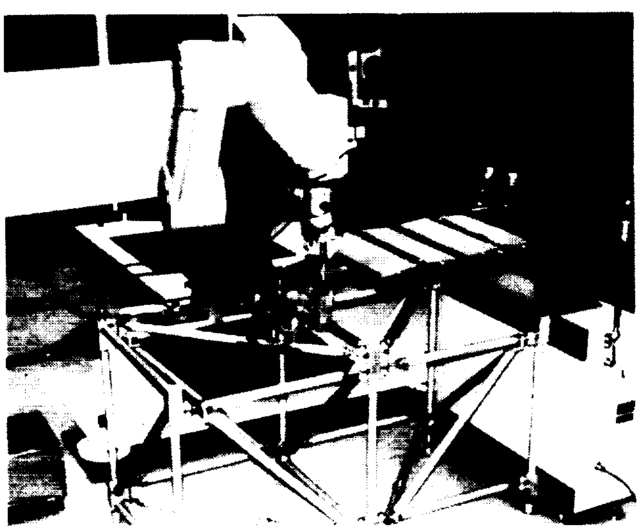

Fig. 6 Testbed for Teleoperation

FUTURE WORKS AND CONCLUSIONS

This telerobotics testbed will be completed by the end of this year, and various robotic tasks will be demonstrated. The first step will be the assembly of a space structure placed in Japan, which will be controlled from the local site in JPL, and the second set of the experiment (3) will be performed in the year after the next.
Once the performance of the system is verified, successive tasks will be planned to prepare for the future application of this technology in space, particularly for the deployment and assembly of a solar power generation system in space.

REFERENCES

(1) Machida, K; Hirai, S and Schenker, P 1993, Study on Long Distance Space Telerobotics: Concept of Interoperation Experiment between Japan and USA. Proceedings of the 37th Space Sciences and Technology Conference, 213-214, Tokyo (In Japanese)
(2) Wakita, Y. Hirai, S and Machida, K 1994, Intelligent Monitoring System Applied to Super Long Distance Telerobotic Task. Proceedings of i-SAIRAS' 94 Los Angeles.
(3) Schenker, P.S and Kim, W.S 1994, Remote Robotic Operations and Graphics-Based Operator Interfaces, Proc. 5th Intl. Symp. on Robotics and Manufacturing, Maui.