1. Title

Fy2000 Ground-based Research Announcement for Space Utilization Research Report

2. Research Term

FY2000〜2002

3. Reserch Field

Space Utilization Technology Develpment

4. Research Categories

Phase IB Research

5. Research Theme

Advanced Operation Methods for Space Robotic Manipulators on International Space Station

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8. Summary of Research

Robot manipulator systems mounted on International Space Station (ISS) are expected to perform fine manipulation for construction and maintenance of ISS, or assistance of experiments. Such manipulator systems are subject to vibrations due to flexibility, which cause degradation of the operational accuracy.

Paying attention to the reaction dynamics, however, it is possible to carry out the manipulation to suppress such vibrations or generate minimum, or zero, vibrations in the system.

The JEMRMS is a manipulator system to be mounted on Japanese Experimental Module (JEM) of ISS, comprising 6 DOF macro part and 6 DOF micro part.

By coordinating macro and micro parts, a control to suppress the vibrations immediately which is referred to as "Maximum Coupled Vibration Suppression," and a manipulation that yields minimum vibrations which is referred to as "Reactionless Manipulation," were developed. The validity of the proposed manipulations was examined by numerical simulations.

Fig.1 shows a graphical simulation model of the JEMRMS. In the simulation, numerical parameters were used that were identified from the ground test of the flight model of the JEMRMS. Fig. 2 depicts an operator interface developed in this research to emulate the operation of the flight model.

Space long-reach manipulators have long been considered as flexible structures because of the low stiffness of the booms, but the ground verification of the flight model tells that the JEMRMS shows flexibility due to the low stiffness of the joints. Fig. 3 (w/o MCVS) illustrates the vibration due to the joint flexibility, after a coarse positioning by the Main Arm, which is a macro part with 10 m long. The amplitude of the vibration is a significant magnitude that degrade the operational performance of the arm. But it is shown that by applying the Maximum Coupled Vibration Suppression (MCVS) the vibrations were damped out quickly.

Fig. 4 (w/o RNS) illustrate the vibrations of the Main Arm that was excited by the reaction of the Small Fine Arm, which is a micro part with 2 m long. But by applying Reactionless Manipulation the vibrations will not be excited on the Main Arm when the Small Fine Arm is operated for handling a payload.

The technologies established in this research will provide a solid basis for advanced operations of space arms in future, for handling massive payloads and assembling huge space structures such as a space solar power plant.

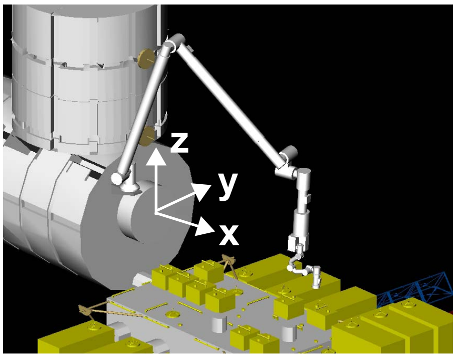

Fig. 1: Graphics simulation model of JEMRMS

Fig. 2: Simulation console of JEMRMS

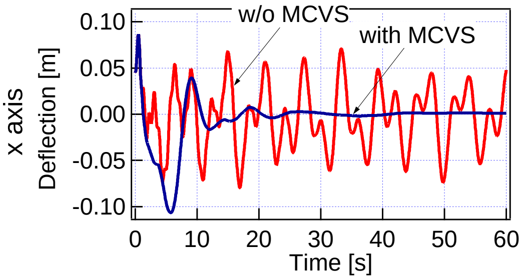

Fig. 3: Motion profile of the end tip after a coarse positioning by the MainArm (w/o MCVS v.s. with MCVS)

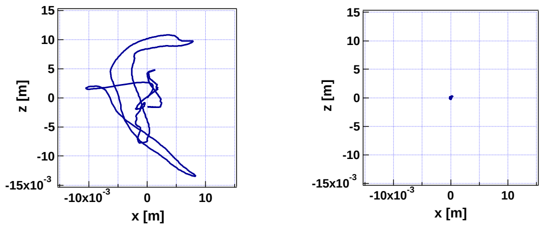

Fig. 4: Vibrations of the Main Arm in Cartesian space (left: without Reactionless Manipulation, right: with Reactionless Manipulation)

9. Publication List

(1) Kazuya Yoshida and Satoko Abiko, " A Proposal for Performance Improvement of JEM-RMS with Reactionless Manipulation ," Proc. of the 23rd International Symposium on Space Technology and Science, vol. 1, pp. 697-702, 2002-d-08, Matsue, Shimane, Japan, May 2002.

(2) Satoko Abiko and Kazuya Yoshida, " An Effective Control Strategy of Japanese Experimental Module Remote Manipulator System (JEMRMS) Using Coupled and Un-Coupled Dynamics ," Proc. of the 7th International Symposium on Artificial Intelligence, Robotics and Automation in Space, AS18, Nara, Japan, May 2003.

10. URL

http://www.astro.mech.tohoku.ac.jp/JEMRMS