1. Title
FY2005 Ground-based Research Program for Space Utilization Research Report

2. Research Term
FY2005〜2006

3. Research Fields
Space Utilization Technology

4. Research Categories
Exploratory Research for Space Utilization

5. Research Theme
Development of Deployment and Retrieval System for a Tethered Space Robot Under Microgravity

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8. Summary of Research
Under current space development, orbital servicing becomes to be important. Spacecraft transportation using tether is effective from the viewpoint of energy consumption and emergency recovery. A tethered space robot, connected to a mother spacecraft through a tether, was proposed in 1995. A tethered space robot can translate by tether tension, and tethered subsystem is multi-body system. Major consequence of the multi-body nature of the subsystem is that its attitude can be controlled under tether tension by its own link motion. This research develops a tethered space robot, which is used on the International Space Station.

Breadboard model of a tethered space robot and deployment system has been developed. Two types of arm link joint of a tethered space robot have been developed: one is deferential gear mechanism; the other is multi-link mechanism. Those are evaluated and vilified in microgravity experiment. From the experimental results, differential gear mechanism has different motion characteristics on direction of arm link motion, and multi-link mechanism moves the arm link at the same characteristics in any direction. However, differential gear mechanism has been adopted for the tethered space robot because of (i) compact mechanism; (ii) few rotational joints; (iii) motion characteristics can be recovered by control. For a tethered space robot operation, the tether is to be extended for a relatively short distance, therefore we do not envision gravity force and/or centrifugal force influencing tether extension. Rather, we will employ tether extension strategy assisted by an initial translation momentum of the subsystem. The developed
deployment system gives an initial translation momentum by springs, which are contracted before tether deployment and extended when tether extension. It is required for those sequences to be performed autonomously.

Based on the results of microgravity experiment for the breadboard model, engineering model of a tethered space robot and deployment system was developed. Engineering model for microgravity experiment can be designed as same scale as flight model. Therefore orbital scale microgravity experiment is possible on the ground. It is noted from microgravity experiment by parabolic flight that deployment and retrieval can be performed successfully. Also, characteristics of attitude control of the tethered space robot, deployment mechanism, tether tension control, and docking mechanism were clarified by microgravity experiment of drop capsule. Engineering model was also evaluated and verified by vacuum and heat test and radiation test. On the other hand, in order to clarify tether motion, basic tether experiments by using only tether (with nothing at its end) were performed.

This research proposes a mission of external inspection of a mother spacecraft (International Space Station) by the tethered space robot. Against to space debris, it is considered that (I) not to appear out debris; (II) to disposal of debris; (III) to recover damage of debris. In order to recover damage of debris, external inspection is effective. Because, it is difficult to take a picture of a spacecraft in space, then a tethered space robot having a camera, whose direction is controlled, is expected.

Future works for orbital experiment of a tethered space robot are: (a) camera selection considering attitude control accuracy and image processing; (b) docking and lock mechanism for the tethered space robot to the deployment system; (c) interface of a spacecraft (International Space Station); launch lock mechanism especially for arm link joint mechanism, tether reel mechanism, deployment mechanism.

9. Publication List

10. URL