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Robotics Technology for Planetary Surface Exploration

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In Japan new lunar or planetary exploration missions including landers and rovers are earnestly under study. Those missions will follow up SELENE (SELenoligical Engineering Explorer), a lunar global remote sensing mission. One of main missions for lunar robotics exploration in post SELENE missions is to demonstrate the technologies for lunar or planetary surface exploration and human activities on the moon in the near future. They will cover pin-point landing technology, reliable landing scheme with obstacle avoidance, safe landing mechanism on rough terrain, exploration rover, tele-science and tele-operation technology, automated construction etc. The following top science will also be conducted in the robotics mission. The working group was also established in 2008 in Japan to study Japanese Mars exploration. In the preliminary study, two orbiters and some landers cooperatively explore Mars. Some explorers, such as surface exploration rovers, wide area exploration by airplanes, subsurface exploration by mole type robots are also under study.

The working group has been conducting the feasibility study of advanced technologies for lunar or planetary robotics exploration. Unmanned mobile robots are expected for the detailed surface exploration of the moon or Mars, because rovers can travel safely over a long distance and observe what to see by some scientific instruments. Therefore the rover R&D group developed innovative test-bed rovers with a new mobility system, lightweight manipulators, and advanced guidance and navigation functions as shown in Fig.1. The developed test-beds have a new suspension system, which consists of a four-wheel drive suspension system and two actives wheels. The proposed system is designed to distribute the load of weight equally to all six wheels whenever the rover climbs up or down, and then provides high degree of mobility for the rover. Smart manipulators with a new end-effector are also developed to perform the in-situ analysis or direct observation on the surface as shown in Fig.2. The developed end-effector has two kinds of functions, gripping and scooping. The experimental results for sample collection show the effectiveness of the developed end-effector. A novel digging robot is also developed as shown in Fig.3. The test-bed rovers install a single camera system, a stereo vision system, an inertial measurement systems, a scan typed laser range finder etc. The rover group developed advanced navigation and guidance methods including a terrain recognition scheme, a path planning algorithm, a self-positioning method, an intelligent tele-driving system.

Firstly, the current roadmap for Japanese solar exploration is introduced in this workshop. Then the author describes planetary robotic exploration scenario by mobile explorers. The author shows the system configuration of the developed test-bed rovers for long traverses and rover-based scientific observation. This also presents the detailed functions and shows the performance of the developed rover test-beds. The effectiveness of the developed smart manipulator is shown by experimental results, sample collection, digging etc. The developed digging robot is presented and experimental results are shown. The developed rover test-bed is used for feasibility study of the future lunar or planetary exploration missions. The exploration scenario or strategy is also verified by the developed rover test-bed through some field tests.

Figure 1: Developed Test-bed Rovers

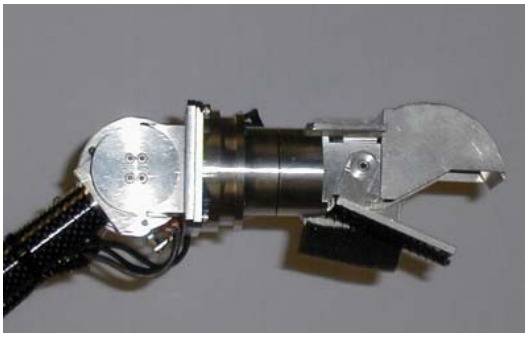

Figure 2: Developed Smart Manipulator

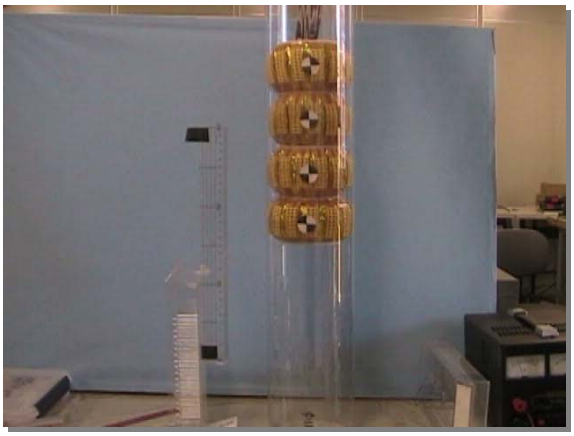

Figure 3: Developed Digging Robot