(Extended Abstract)

Development and Field Testing of MoonRaker, a Four-Wheel Rover in Minimal Design

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Introduction

In the Space Robotics Laboratory, Tohoku University, Japan, we developed a light-weight, four-wheel rover as a research test platform for a low cost lunar exploration that could be conducted commercially near future. The name of the platform is MoonRaker, The purpose of the MoonRaker development is (1) investigate control techniques and physical performance for a lunar rover with minimal size, such as less than 10kg, (2) investigate sensor fusion for accuracy in the rover localization and environment mapping, and (3) investigate software algorithms to increase performance with given limited computing power. In this presentation, the authors describe the design, development and initial field testing results of the MoonRaker project.

Design of MoonRaker

Figure 1 shows the design of the MoonRaker, which has four active wheels. An electric motor is built in each wheel axis. But there is no other motor installed in order to minimize the actuation components. It uses skid-steering and a passive differential suspension system to cope with rough terrain. In the stored (cruise) configuration, the rover fits within the volume of 50 x 40 x 30 cm, however, in the unfold (locomotion) configuration, the size is extended to 55 x 50 x 50 cm. In order to maximize the locomotion performance, we tried to have a larger wheel diameter. In the given configuration design, each wheel has 20 cm in diameter. Total mass is just 10 kg. In order to transform from the stored to the unfold configurations, an external mechanism to pop-up the main body and flip-down the wheel struts is necessary. But this mechanism is not counted in the total mass of the rover.

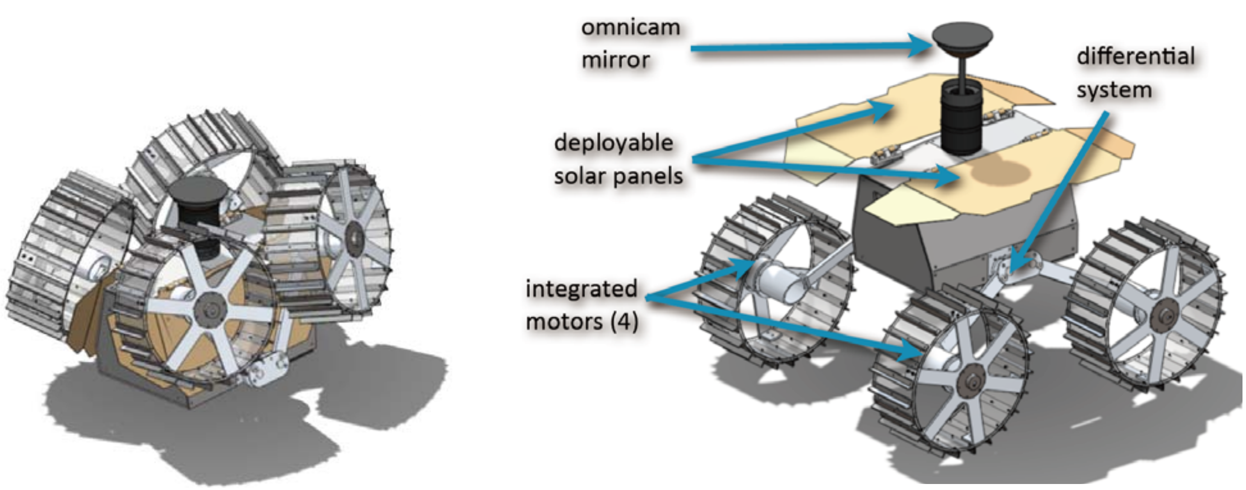

Figure 1: The MoonRaker rover platform in the cruising configuration (left) and the locomotion configuration (right)

Onboard Electronics and Sensors

Figure 2 depicts onboard electronics and sensors.

As for the camera, we adopted an omnicam system with a HDTV quality CMOS sensor with a hyperbolic mirror. Thanks to the omni-directional mirror, we can eliminate the conventional pan-tilt mechanism and actuators, but we can obtain rectangular images in any direction with a normal resolution, just by the mathematical coordinate transformation of the circular image obtained by the omnicam in the HDTV resolution. The omnicam is also useful to extract optical flow data that gives us the information about linear and angular locomotion of the rover.

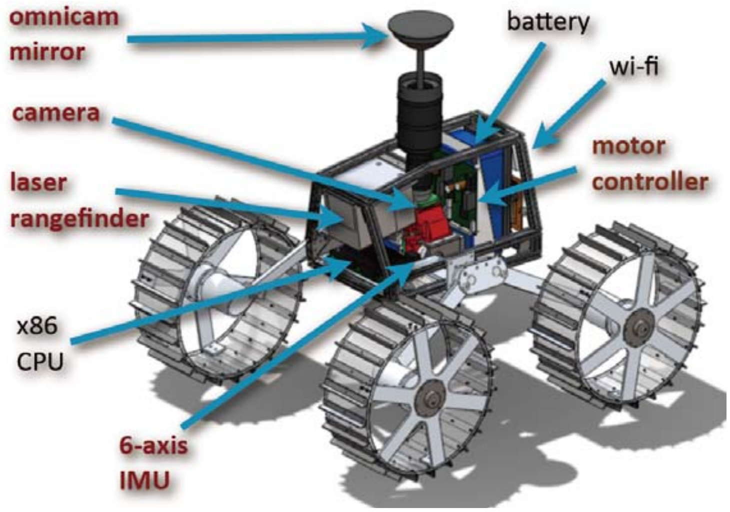

Figure 2: Onboard electronics and sensors of MoonRaker

As for the obstacle detection, a laser rangefinder is installed in the main body. The range sensor developed by Nippon Signal Co. uses a MEMS-processed silicon-wafer-based 2-axis gimbals to scan the laser beam spot. This is another design feature to eliminate conventional rotating motors.

By integrating (fusing and filtering) the data from the laser rangefinder, the omnicam, a 6-axis IMU, and conventional encoder (tachometer) at each wheel, the rover localization and the mapping of surrounding environment can be achieved in a certain accuracy. This is the one of the technical challenge to be achieved by the given limited onboard resources.

Field Testing

Field testing of the MoonRaker platform has been conducted using various volcanic environments in Japan and U.S.A. In Japan, we visited Mt. Mihara in Izu-Oshima island near Tokyo and Mt. Aso in Kyushu island in the south part of Japan. In U.S.A., we visited one of lunar analog test site managed by Pacific International Space Center for Exploration Systems (PISCES) at Mt. Mauna Kea in the Big Island, Hawaii.

Figure 3 is a snapshot image of a fundamental mobility testing in a field with scattered rock obstacles. It was confirmed that the MoonRaker can go smoothly over rock obstacles in the height of half of the wheel diameter (10 cm).

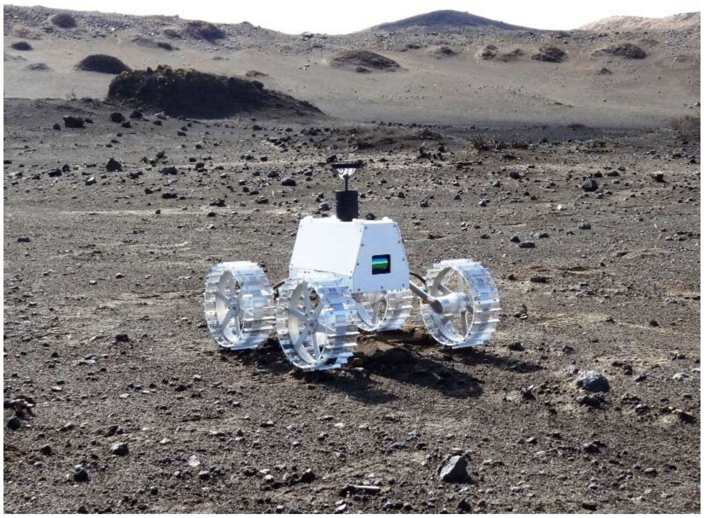
Figure 3: A snapshot image of MoonRaker in Mt. Aso, an active volcano in Kyushu, Japan

Figure 4 shows images taken by the onboard omnicam. The bottom is the original circular image and the top is its expansion (transformation) into a rectangular panorama image of 360 degrees of the surrounding environment. One obvious advantage of the mirror-type omnicam is that self-portraits of the rover itself are always obtained easily.

Figure 5 shows an example of the superimposition of the omnicam image and the laser ranging data.

In the workshop, the results and analyses of our recent field testing will be elaborated.

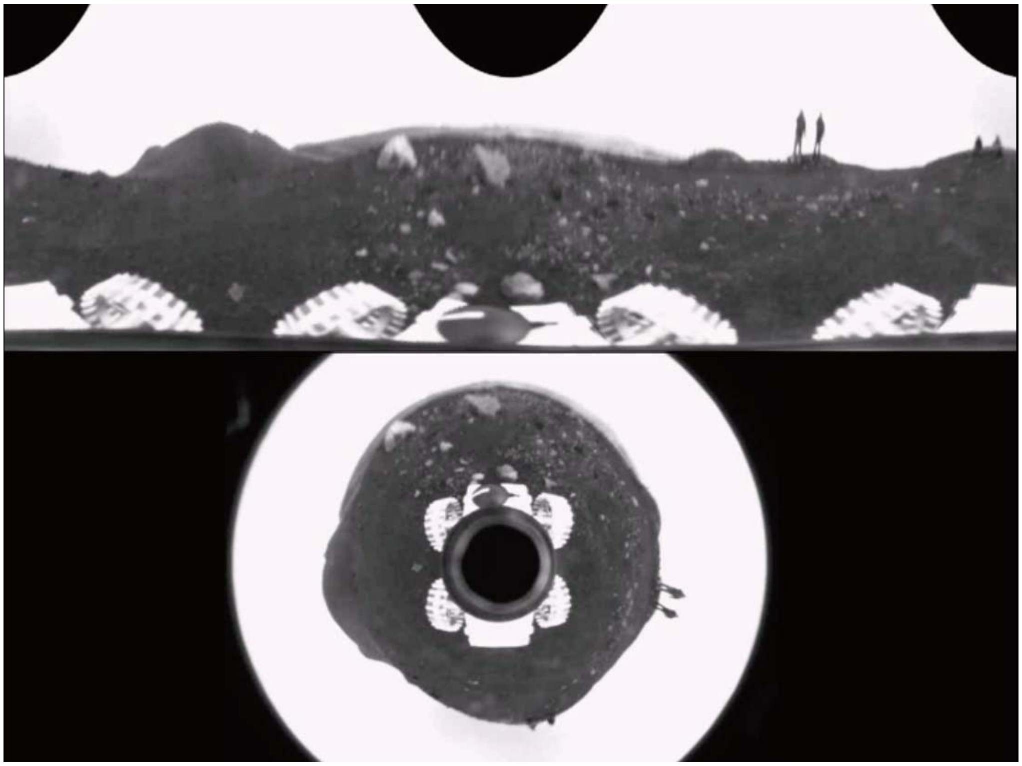

Figure 4: Images from the omnicam: (bottom) original circular image and (top), transformation into a rectangular panorama image.

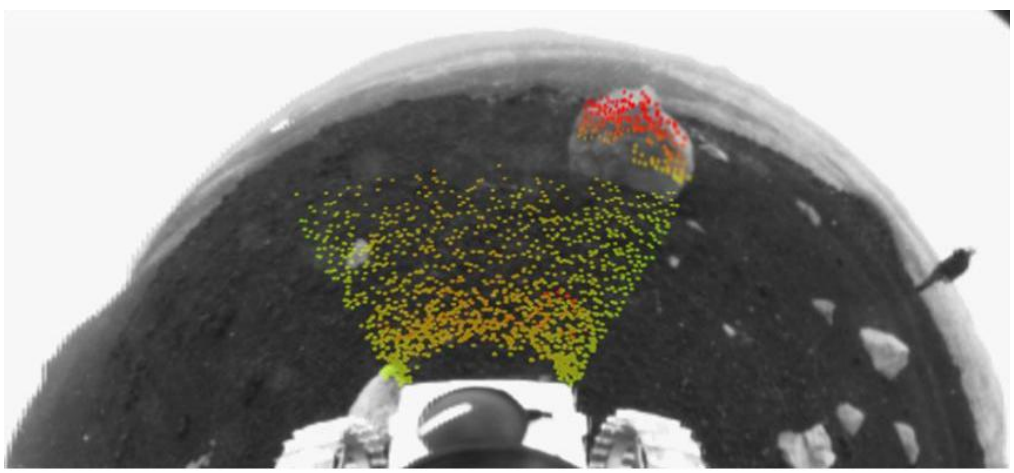

Figure 5: Superimposition of the omnicam image and the laser ranging data (3D point cloud)