Distributed Smart Payload Instrumentation for Planetary Rover Using Mini Rovers

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Abstract: In planetary rovers, between two ground command's duration the rover needs to be stationary in waiting loop to preserve its position of last communicated images to maintain continuity with ground operators. To reduce the low level command delay, the situation demands high level of autonomy in rover operations. Autonomous robotics is still in infant stage and needs space heritage and large volume of past data for Machine Learning algorithms. To overcome the technology gap in implementation of autonomy, a novel concept is proposed in this project. This method involves distributing the task list mechanically using miniature daughter rovers with independent sensor head and minimal backend instrumentation. These daughter rovers will accompany the mother rover with reconfigurable smart sensors, power electronics and IoT devices with high bandwidth connectivity to the mother rover. This concept will involve in splitting the scientific payloads in multiple parts considering minimal (optimal) dependency of control and data. The main objective of the daughter rovers are to execute probable future tasks with all the options using predictive learning and enhance the task execution speed. The other advantage of such daughter rover is to conduct distributed space experiments which are otherwise not possible from single location. Two such proposed experiments are as follows.

- Measurement of surface conductivity between two distant points to predict the inner properties below soil surface using machine learning models.
- Measurement of induced seismic activity between two or more distant points to study the structural properties below soil surface. This can be induced by main rover movement, meteorite fall or safe explosive sounding.

Proposed DDU Seismometer:

We have designed and proposing a simplified version of distributed seismometer. The system will have two opposite pole strong permanent magnets tethered on extreme ends of a tube without touching each other. These suspended magnets will have sensor coil around the tube. Extremely small relative movements will be converted to strong electrical signal. An independent daughter rover will carry and electrically operated hammer and strike it at precise regular interval. Both the rovers will be synchronised through Wi-Fi and work as a synchronous integrator to magnify the shock waves propagated between the rovers. Machine learning algorithm will be used to train and analyse the result to predict sub soil structure. Such training will be conducted in earth on look-alike to the target planet. The on-board machine learning will be conducted based on the data of other experiments. We will correlate the surface conductivity with the induced seismic activity using deep learning network. Such network will be capable of mapping the parameter from one to another and enhance the knowledge on soil property investigation.

Experiments will also conducted similar to Apolo-17 mission[1] to measure DC soil conductivity between tips of 70 m electrical dipole antenna by applying high voltage impulse using two daughter rovers. The daughter rover will be used to lay the antenna (70 m) on planet surface. Experiment will be conducted as Apollo 17 with exception and advantage of using second daughter rover as a moving receiving station. This receiving station will be collecting echo around the dipole. The echo will be analyzed on board using deep learning algorithm developed at DDU.

Reference:

[1] David W. Strangway, NASALunar Surface Electrical Properties Experiment, https://www.lpi.usra.edu/lunar/ALSEP/pdf/31111000673606.pdf