Abstract

With the advancement in wireless technology, smart sensing devices and inquisitiveness; wireless sensors and their networks are sought for space sciences and technologies, either to explore beyond the awareness of human kind or to monitor performances of sophisticated systems. They have potentials for studying lunar and planetary surface sciences, by employing appropriate sensors. Detection of presence of water ice within the planetary regolith is crucial for future manned explorations as well as for understanding geological history of the surface. The search for the presence of lunar water has attracted considerable attention and motivated several recent lunar missions. Though, a few recent lunar missions have detected the water ice, all such results are based on remote observations from the orbiter. To detect the potential water bearing sites and to confirm the remote observations, in-situ measurements of water ice of different geographical locations are essential. The primary focus of the thesis is to address the research issues related to in-situ measurement of water ice on lunar surface using a wireless sensor network.

A lunar wireless model for finding the path loss has been proposed, which is governed by various physical phenomena occurring during the wave propagation on the moon. The RF coverage predictions have been accomplished by the proposed lunar wireless model using the terrain data, measured by a terrain mapping camera on Chandrayaan-1. These form the first thesis contribution.

A technique has been suggested for the prediction of power delay profile and the error rate analysis of lunar wireless link, based on the proposed lunar wireless model. Terrain based analysis of lunar multipath environment has been carried out and link performance parameters like the bit error rate, the packet error rate, the power delay profile and the maximum bit rate for data transmission have been predicted. These works form the second thesis contribution.

The presence of water ice mixed with the regolith can be inferred by measuring permittivity of the regolith. A distinct type of water ice sensor, called wireless impedance sensor node, has been proposed for this purpose. The lab model of the wireless impedance sensor node has been designed, evaluated and developed. To consider the lunar application, the water ice and the lunar soil simulant JSC-1A have been tested using the sensor and the performance of the sensor has been verified by testing the Milli-Q water, whose permittivity is known. These form the third thesis contribution.

A few techniques of sensor deployment on lunar surface have been suggested and compared. Minimum number of sensors needed to cover a given sensing region is derived, assuring wireless connectivity between the nodes. The condition on permissible tolerances in the desired dropping positions of the sensors is derived to address the practical difficulty in achieving exact locations. Moreover, the equations of sensor trajectory parameters have been derived for the moon, as gravity of the moon is different than that of the earth. These works form the final thesis contribution.