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DEM generation and rover landing at the south pole of the Moon

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Abstract

We describe the generation and fusion of digital topographic models (DTMs) derived from LROC NAC image via photogrammetry and LRO Mini-RF images (Stereo) via radargrammetry. Moreover, fast and automatic DTM co-registration with a LOLA DTM is studied for finding the correct and precise planned location for a safe planetary rover landing.

1. Introduction

Radar (radio detection and ranging) is currently one of the important research areas for Earth and moon observation and for helping human beings explore and search for organics on other planetary surfaces and their icy moons, many radar satellites have been or are about to be launched, such as Magellan (1994) radar for Venus, Cassini (1997) radar for Saturn's moons, Mars Reconnaissance Orbiter (2006) Shallow Radar (SHARAD) sounder and Mars Express (2004) Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) for Mars, Lunar Reconnaissance Orbiter (LRO 2009) Miniature Radio Frequency (Mini-RF) for the Earth's moon and in the near future JUICE mission [1] (RIME - Radar for Icy Moons Exploration, SWI - Sub-millimeter Wave Instrument, RPWI - Radio & Plasma Wave Investigation, 3GM radio science package - Gravity & Geophysics of Jupiter and Galilean Moons) for Jupiter's moons. The Magellan multimode S band radar has three modes: SAR, altimetry, and passive radiometry to map almost all of the Venusian surface, whilst the Cassini RADAR instrument transmits and receives Ku-band micro-wave radiation, which operates in both passive (radiometer) and active (altimeter, SAR imaging, scatterometer) modes. Venera 15 and 16 radio occultation experiment data at Venus, Magellan stereo SAR data and Cassini RADAR data and Radio and Plasma Wave Science(RPWS) data are open to the scientific community through the PDS. Moreover, Lunar Reconnaissance Orbiter (LRO) Mini-RF data (S band and X band Raw data, Bistatic Radar data, Level 1 SAR, Level 1 interferometry, Level 2 SAR, Level 3 SAR mosaics, and Level 3 Sandia SAR Stereo data [2]) are available at PDS too, which will greatly advance our understanding of our moon, giving us a first look inside the Moon's coldest, permanently shadowed darkest polar craters with water ice.

2. DTMs generation using photo-grammetry & radargrammetry

For the moon, stereo radar images (LRO Mini-RF) and metadata are first prepared in ISIS. Then a rigorous sensor model (RD model) is developed. After co-registering the radar images as closely as possible to one another, stereo radar images, Bundle adjustment and dense matching is implemented for DTM production. The control points for the Moon are LOLA data. Meanwhile, the DEM is also generated by photogrammetry using LROC NAC stereo images, and then the two DEMs are fused to achieve a better DEM in the permanently shadowed polar region [3].

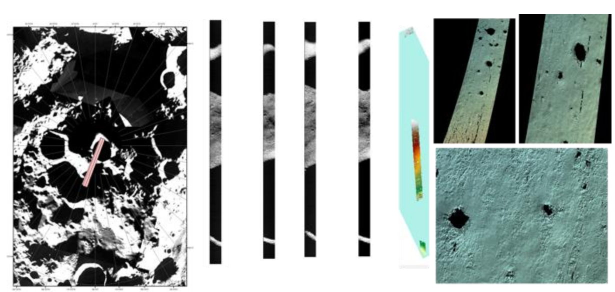

Figure 1: LRO LROC NAC image position, data, DEM result and close-up in DEM with colourmap

3. Fast and automatic DTM co-registration algorithm to improve

precise and safe planetary rover landing on planetary polar region.

DTM co-registration (the TRN algorithm) is studied, whether the DTM is generated by imaging, lidar or radar techniques within the landing equipment, for finding the correct and precise planned landing location for safe planetary rover landing.

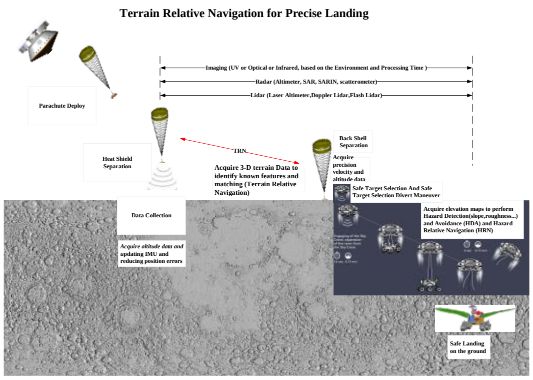

Figure 2: The timeline for a Terrain Relative Navigation for Precise Landing in the atmospheric environment of a celestial body (the red line) (DTM can be made by lidar, radar altimeter, stereo imaging and so on), note: When the landing environment has an atmosphere, like on Mars, a parachute can be used, if landing area has no atmosphere, like the Moon, thrusters are used instead of parachutes.

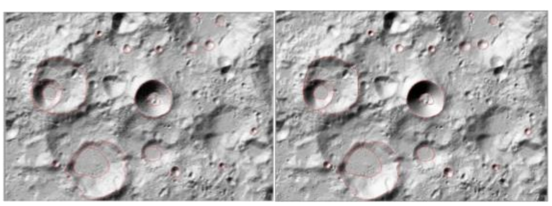

Figure 3: *DTM before and after co-registration at the south pole of the Moon*

4. Summary and Conclusions

In this paper, DEM generation and fusion via photogrammetry and radargrammetry are discussed, and a fast and automatic DTM co-registration algorithm (TRN) is presented, studied and tested for finding the correct landing site and precise and safe planetary rover landing. The Moon experiments demonstrate that the algorithm works very well for rover landing.

Acknowledgements

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References

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