High Resolution DEM Generation from Chandrayaan-2 Orbiter High Resolution Camera Images

Amitabh, Ashutosh Gupta, K Suresh, Ajay K Prashar, Kannan V Iyer, Abdullah Suhail A Z, Shweta Verma, Baharul Islam B, Hemant K Lalwani and T P Srinivasan, High Resolution Data Processing Division, Signal and Image Processing Group, Space Applications Centre (ISRO), Ahmedabad-380058 (India); amitabh@sac.isro.gov.in

Introduction: ISRO launched Chandrayaan-2 mission from Sriharikota, the space port of India, on the 22nd of July 2019. Orbiter High Resolution Camera (OHRC) onboard Chandrayaan-2 Orbiter-craft, is a very high spatial resolution camera operating in visible panchromatic (PAN) band. OHRC measures the solar light reflected from the lunar surface in visible range of electromagnetic spectrum. This camera is designed for imaging in very low sun elevation conditions. OHRC images were extensively used for landing sites characterization to detect the small-scale features particularly smaller boulders on lunar surface. Ground sampling distance (GSD) and swath of OHRC (in nadir view) are 0.25m and 3km respectively, from a 100 km altitude. OHRC has the capability to produce multiview stereo images by spacecraft maneuvering. These stereo pairs can be used to generate the highest resolution Digital elevation model (DEM) so far available for the Lunar surface. This study provides the DEM generation capability from OHRC multiview (Stereo) images of few specific areas of moon surface.

Specifications of OHRC camera: Specifications of OHRC camera is provided in the below table-1.

Table-1: Specifications of OHRC

Parameters	Values
Orbit altitude (km)	100
GSD (m) at nadir	0.25
Swath (km) at nadir	3
Spectral range (nm)	450–800
Telescope diameter (mm)	300
Detector	12 K by 256 TDI (Selectable 64, 128, 192, 265 TDI)
Quantization (bits)	10(electronics) 8 (transmission)
Reference illumination condition	8% Albedo, 5–6° Sun elevation
Reference radiance (mW/cm 2 /sr/µm)	0.5
Saturation radiance (mW/cm 2 /sr/µm)	Min.: 0.8 with 256 TDI, Max.: 3.2 with 64 TDI
SNR@ reference radiance	100 with 256 TDI (140 at saturation)
Stereo views	Fore and Aft in two consecutive orbits by spacecraft maneuvering

Datasets Used:
OHRC multiview Stereo pairs of 8 different regions are used for this study as given in table-2.

Table-2: OHRC Data Products used for Study

Sites (AOI)	Stereo Images		Date of Acquisition
	Image-1 Product ID	Image-2 Product ID	
S1	OHRXXD18CHO0448002 NNNN20239103537349	OHRXXD18CHO0448102 NNNN20239125906064	26-08-2020
S2	OHRXXD18CHO0447002 NNNN20238142712875	OHRXXD18CHO0447102 NNNN20238162415239	26-08-2020
S3	OHRXXD18CHO0448102 NNNN20239115348285	OHRXXD18CHO0448202 NNNN20239135048369	26-08-2020
S4	OHRXXD18CHO0449302 NNNN20240111805567	OHRXXD18CHO0449302 NNNN20240115656269	27-08-2020
S5	OHRXXD18CHO0449502 NNNN20240151148116	OHRXXD18CHO0449502 NNNN20240155037631	27-08-2020
S6	OHRXXD18CHO0449402 NNNN20240131504020	OHRXXD18CHO0449402 NNNN20240135353431	27-08-2020
S7	OHRXXD18CHO0447102 NNNN20238162415240	OHRXXD18CHO0448002 NNNN20239095904709	25-08-2020
S8	OHRXXD18CHO0445602 NNNN20237110847064	OHRXXD18CHO0445602 NNNN20237110847065	24-08-2020

Selene Ortho-images and LOLA DEMs (30m) have been used as reference data source for Lunar Control Point collection for geometrical modeling.

DEM Generation Methodology: The area of interest site observation with two view angles in two consecutive orbits were acquired by spacecraft maneuvering. Two stereo views were obtained at~5° and ~25° about the Pitch axis along with Roll tilts of 23°and 17.6° respectively for side-view. The images obtained by OHRC are from different view angles with a time difference of nearly 2 hours, which provides nearly same illumination of the site. Time taken for imaging the landing site (i.e. 3 km x 12 km strip) is approx. 8 seconds per view in each orbit.

To generate a DEM, an indigenous software called OPTIMUS (*OPTIMal UndulationS)* was used. This is a highly optimized and generic software, which has been developed to generate Digital Elevation Models from the stereo or multi-view satellite images. The software has been designed with performance scalability in mind. This software ingest a level-0 image files, perform a radiometric correction and then identification of lunar control points (LCPs), uses a generic push broom sensor model to relate the image space to ground coordinates by space resection, perform image matching between the two images and finally does the intersection for generation of 3-D irregular points. The irregular 3-D points are then converted into regular DEM by interpolation. Final product

of this software is a DEM at pixel level resolution and corresponding ortho-image.

Results: Figure-1 shows the locations of the area for which DEMs have been generated from OHRC stereo images (Fig.2). The DEMs and Ortho-images are generated at 0.28m pixel size with a vertical resolution of 0.1m (Fig.3 to Fig.5). These DEMs contain finer details of craters and boulders. The crater (>1.2 m) and boulder (>0.28 m) detection becomes very easy with the help of these DEMs and Ortho-images. These DEMs and ortho-images will be utilized for future landing Site selection and characterization.

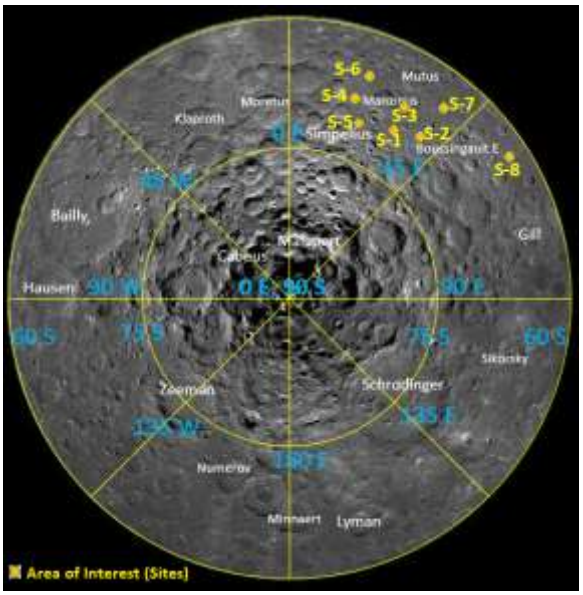

Figure-1. Location of Sites(AOI) in south polar area

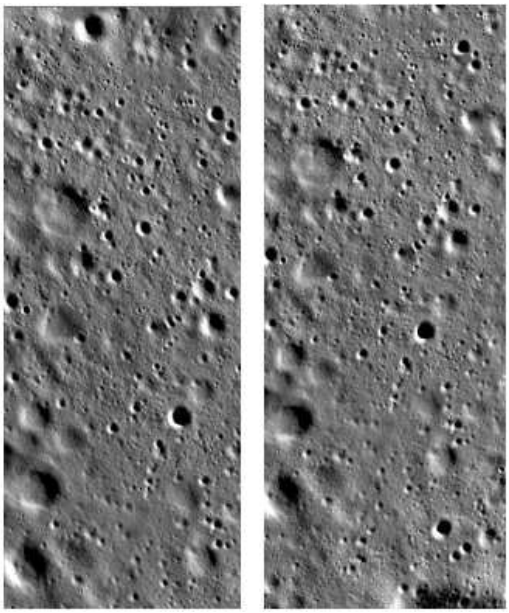
Figure-2. OHRC Stereo Pair of Site-6 (S-6)

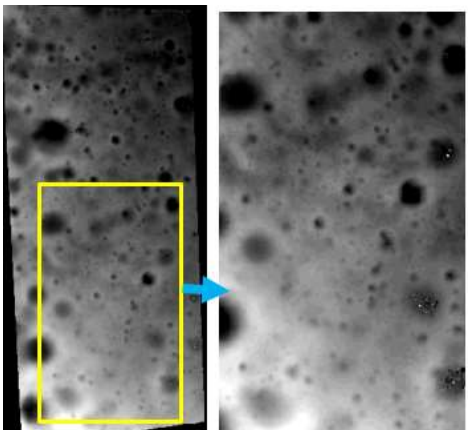
Figure-3. Overview of DEM generated and zoomed view (S-6)

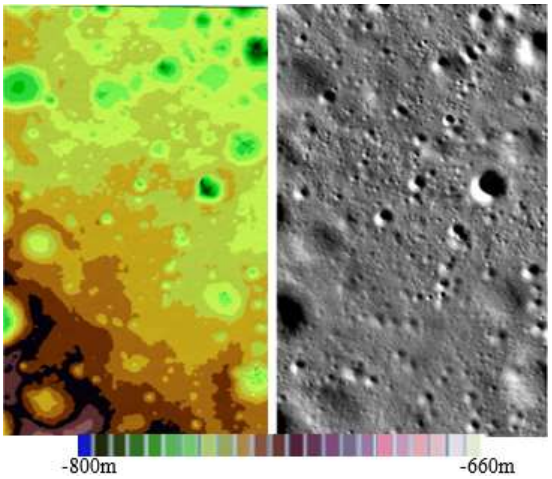

Figure-4. Painted DEM and corresponding Ortho-image (S-6)

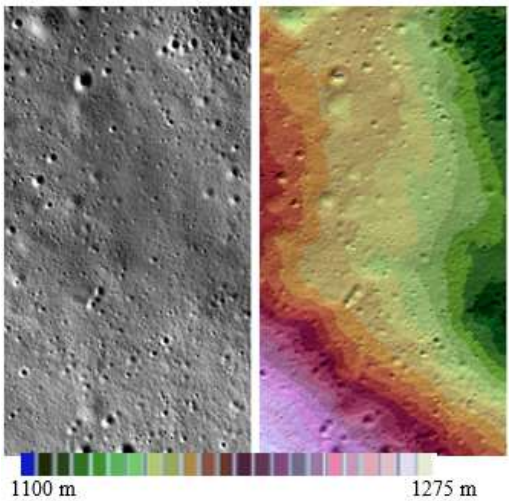

Figure-5. Painted DEM and corresponding Ortho-image (S-3)

References: (1) OHRC onboard Chandrayaan-2 Orbiter, Current Science, Vol.117, No.7, 10 Oct.2019. (2) Orbital Imaging Operations for Characterisation of Chnandrayaan-2 Landing Site, B6:3.5, IAC 2020.