**AUTOMATIC IDENTIFICATION OF LUNAR CONTROL POINTS** V. Nagasubramanian, P. V. Radhadevi, T.KrishnaSumanth, D. Sudheer Reddy, M.V. Jyothi, J. Saibaba, Geeta Varadan, Advanced Data Processing Research Institute, Department of Space, Manovikasnagar P.O., Secunderabad 500 009, India. e-mail: drpvr@adrin.res.in

**Introduction:** In this paper we present a photogrammetric solution for identification of uniformly distributed Lunar control points(LCPs) over long strip images acquired by Terrain Mapping Camera (TMC) of Chandrayaan-1. One major concern for the identification of distributed controls manually is the high difference in resolutions between TMC and the UVVIS ortho mosaic from Clementine which is used as reference. The complications in point identification are also due to different modes of image acquisition of TMC such as payload rotation of 0° or 180° as well as ascending or descending modes. Raw TMC images look very different when compared to the existing lunar control network because of the flipping in both X and/or Y directions. In this paper we present a methodology for automatic identification of Lunar Control Points for processing the TMC images.

**Method:** In this paper, we present a method for automatic identification of Lunar Control Points on TMC camera images of Chandrayaan-1 through a hybrid approach of direct selenocoding and correlation matching. Inhouse developed matching software and the sensor models are used [2, 3, 4]. First, TMC images Fore(F), Nadir(N) and Aft(A) are selenocoded directly at a coarser resolution using the given trajectory. Corresponding portion is cut from the Clementine ortho tile and re-projected in the same projection and resolution in which the selenocodes are generated. This image is matched with selenocode of Nadir image of TMC. Our approach employs a coarse-to-fine hierarchical matching method over selenocodes of TMC images and Clementine ortho image that can provide reliable match points between these images which can be used as control points or check points for further photogrammetric processing. At each level, interest points are identified using Forstner operator. For quality control, an algorithm for blunder weed out is also included.

Matched image point in Clementine is transferred in to the original Clementine ortho tile through a reverse transformation and converted in to latitude and longitude. Conjugate points in the F and A images are identified by matching between N-F and N-A and transferring the points identified in N to F and A. The set of conjugate points from all these cameras are also converted in to raw space through a reverse transformation. For all the points, height is extracted from LOLA DEM (256 pixels/ degree). The major steps involved in this automatic identification of LCPs are: (1) Trajectory fitting. (2) Relative orientation through selenocode generation. (3) Matching. (4) Blunder weeding. (5) Transfer of match points. The processing steps are shown in a flow chart in figure 1.

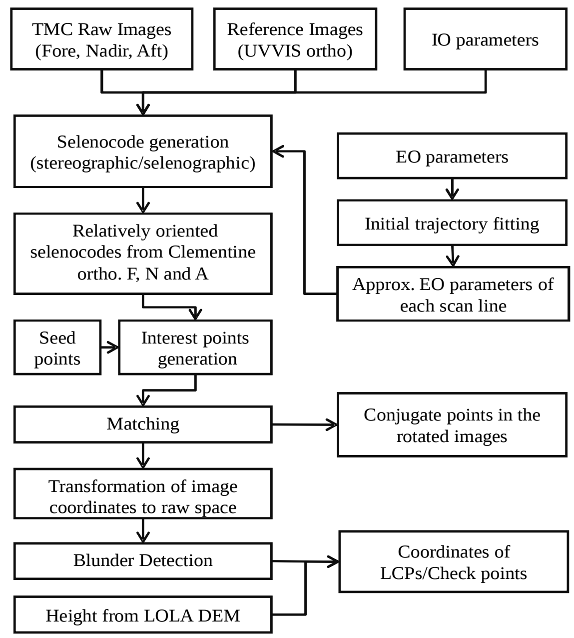


Fig.1. Processing steps in Auto-LCP identification

**Results and Discussion:** It is obvious from Fig.2., that manual identification of control points by comparing raw TMC images and Clementine ortho mosaic is very difficult. Fig.3 shows Clementine ortho and selenocoded TMC images (F, N, A) of Orbit 2011. The area is over equatorial region. The selenocodes are written in selenographic projection and are resampled at the same resolution. Feature comparison and point identification is very easy in these images. Projection becomes very important when we work with long strips extending from polar to the equatorial region. Fig. 4 shows the selenocodes of a long TMC strip over polar region in selenographic projection. Because of the convergence of longitudes at the poles, it is not convenient to compare or match them if we write the selenocodes in selenographic projection, hence, selenocodes in the polar regions are written in stereographic projection which is shape preserving so that shape of features such as craters remains intact. Fig. 5. shows a layout of LCPs identified automatically over a strip (Orbit: 440). Number of points in the middle of the strip is less because of poor matching with Clementine over this area. Thresholds are tightened in such a way that, a point will not be selected unless it is confirmed by different measures. Total number of points required can be decided by the user. Distribution of LCPs and check points over the full strip is ensured by this method of automatic identification of control points.

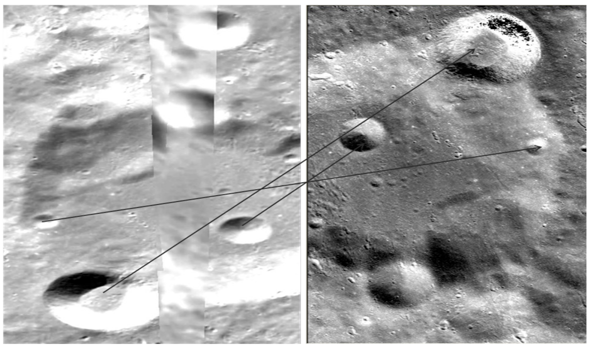

Fig. 2(a) Clementine ortho (b) TMC raw image (Orbit:1181) Flipping in both directions

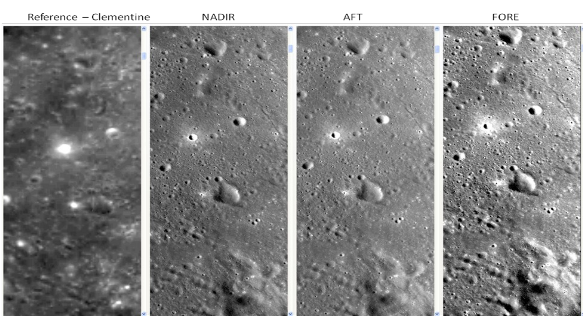


Fig.3(a) Clementine ortho (b) TMC selenocoded image (nadir, aft and fore ) in the same resolution

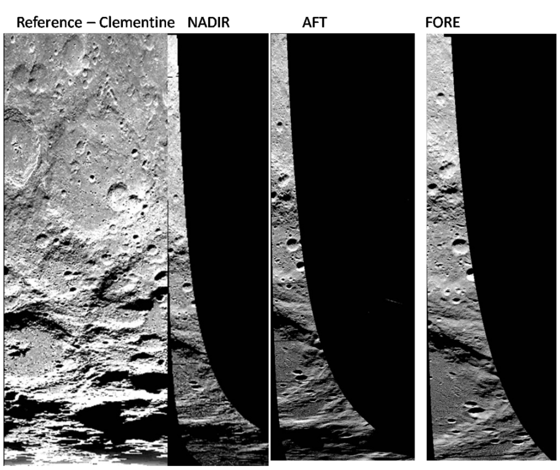


Fig.4(a) Clementine ortho (b) TMC selenocoded image (nadir, aft and fore ) over polar region

**Conclusion:** With different modes of imaging of the TMC camera, identification of distributed Control Points manually with a given coarser reference image like Clementine ortho mosaic is very difficult. An algorithm is described in this paper for addressing these issues and is an integral part of the software package Lunar Mapping System (LMS) for operational generation of TMC data products. Datasets covering different areas over the lunar surface including equatorial and polar region are tested and the results are reported.

**References:**

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[2] P.V.Radhadevi, V. Nagasubramanian, S.S.Solanki, Krishna Sumanth T, J. Saibaba and Geeta Varadan, Rigorous Photogrammetric processing of Chandrayaan-1 Terrain Mapping Camera (TMC) images for Lunar Topographic Mapping. 42nd LPSC Conference, P.No. 1384, 2011.

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Fig.5. Layout of automatically identified control points (Orbit:440) →