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Mars US rover traverse co-registration using multi-resolution Orbital 3D imaging datasets

W. Poole, **J.-P. Muller**
Imaging Group, Mullard Space Science Laboratory, Dept. of Space & Climate Physics, University College London, RH5 6NT, UK (j.muller@ucl.ac.uk)

Abstract

Co-registered 3D Digital terrain Models (DTMs) and orthorectified imaging (ORI) orbital datasets have been produced of all the major US Mars landing sites. These have been sourced from HiRise, HRSC and MOLA. Co-registration was achieved using manual tiepointing within ARCgis v10. These DTM and ORI products were sourced from publicly available datasets or from EU-FP7-PRoViSG partners or generated using internal UCL 3D-RPIF [1] resources. For rover traverses, this results in substantial transformations which implies that all the SPICE kernels will need to be recomputed.

1. Introduction

The EU-FP7-PRoViDE project [2] is attempting to compile into a common geospatial framework all the ground-level and orbital images in order to make available all such data in an unified visualisation framework which can eventually be applied to the ESA ExoMars rover 2018 operations. Significant resources have been focused on ensuring that previous rover traverses (MER and MSL) are self-consistent using look-ahead/behind optical navigation [3]. However, it became obvious when trying to place ground-level rover imagery in context that such traverses did not match with known landmarks visible in the orbital images. After experimenting with different approaches it appears that the use of equirectangular projection and poor co-registration of MOLA profiles with HiRise meant that a different approach had to be undertaken. Shown here are the results of applying manual tiepointing to co-register HiRISE orthorectified imagery (and DTMs) with HRSC whose provenance is well documented [4] with co-registration to MOLA.

2. Methods

HRSC, MOLA and HiRise ORIs and DTMs are loaded into an ARCgis project for each landing/rover site. The sites selected were the final four candidate landing sites for Mars Science Laboratory (MSL), known as *Curiosity*,: Eberswalde Crater, Gale Crater (chosen), Holden Crater and Mawrth Vallis. The selection procedure is described in [5]. The additional areas selected include the past landing sites of Viking Lander (VK) 1 and 2, Mars Exploration Rover (MER) A (*Spirit*) and B (*Opportunity*), and Mars Pathfinder (MPF). Substantial misregistration with HRSC is observed for publicly available HiRise datasets as shown for example in Figure 1 of MER-A (Spirit).

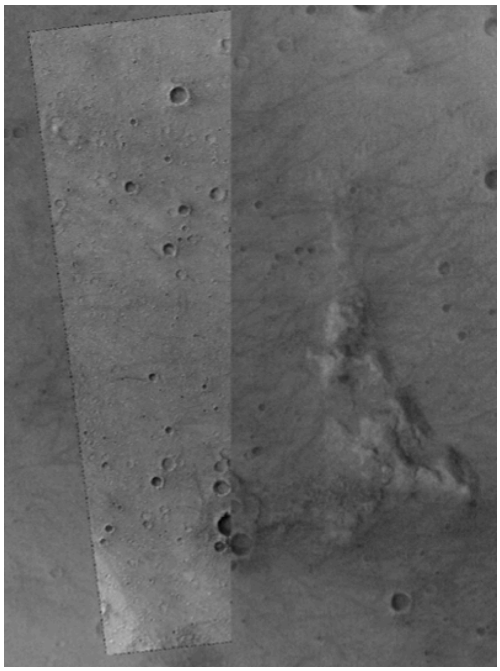

Figure 1. HiRISE image over MER-A overlaid on HRSC showing misregistration between the two.

3. Co-registered results

After selecting homologous tiepoints and applying a second order polynomial (warp) transformation, the misregistration was reduced to pixel-level. Unfortunately this had the unintended consequence that the rover traverse (and the associated SPICE kernel data for each and every rover image acquired in local co-ordinates) no longer matched the landmarks observed in the HiRise image. This is shown in Figure 2 for the same MER-A Spirit scene. A similar but not so pronounced situation was also observed with MER-B (Opportunity). Investigations are currently underway to correct this so that the SPICE kernels may be updated.

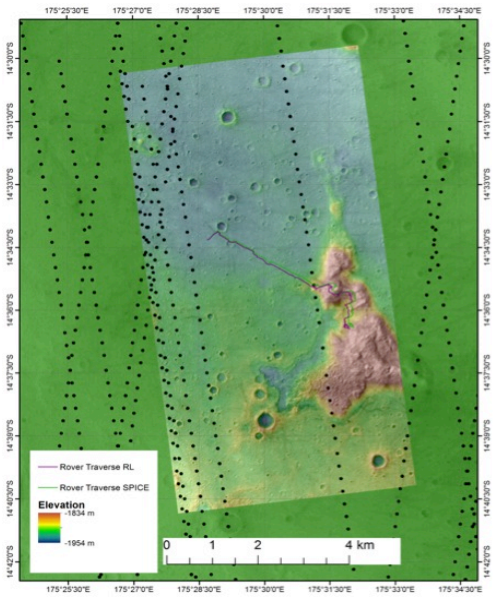

Figure 2. MER-A traverse from optical navigation (labelled RL) and from the original SPICE kernels after co-registration of HiRISE (insert) with HRSC (background). Individual MOLA footprints are shown to highlight the difficulty in finding common MOLA-HiRISE points.

4. Conclusions

Publicly available HiRISE DTMs and ORIs from the NASA HiRISE site [6] over NASA MER rover sites have been shown to include substantial offsets with HRSC and MOLA heights and ORIs. ARCgis v10 was employed to find homologous tiepoints which were then used to derive second order warping transformations. These are shown to have the unintended consequence that the rover traverse is no longer registered with landmarks in the NASA HiRISE images. Further work is required to understand these non-linear errors in order that the SPICE kernels may be properly updated so that traverses fit to observed landmarks.

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