

EU-FP7-iMARS: analysis of Mars multi-resolution images using auto-coregistration, data mining and crowd source techniques: A Mid-term Report

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Abstract

Understanding the role of different solid surface formation processes within our Solar System is one of the fundamental goals of planetary science research. There has been a revolution in planetary surface observations over the last 8 years, especially in 3D imaging of surface shape (down to resolutions of 10s of cms) and subsequent terrain correction of imagery from orbiting spacecraft. This has led to the potential to be able to overlay different epochs back to the mid-1970s. Within iMars, a processing system has been developed to generate 3D Digital Terrain Models (DTMs) and corresponding OrthoRectified Images (ORIs) fully automatically from NASA MRO HiRISE and CTX stereo-pairs which are co-registered to corresponding HRSC ORI/DTMs. In parallel, iMars has developed a fully automated processing chain for co-registering level-1 (EDR) images from all previous NASA orbital missions to these HRSC ORIs and in the case of HiRISE these are further co-registered to previously co-registered CTX-to-HRSC ORIs. Examples will be shown of these multi-resolution ORIs and the application of different data mining algorithms to change detection using these co-registered images. iMars has recently launched a citizen science experiment to evaluate best practices for future citizen scientist validation of such data mining processed results. An example of the iMars website will be shown along with an embedded Version 0 prototype of a webGIS based on OGC standards.

1. Introduction

Since January 2004, the ESA Mars Express has been acquiring global data, especially HRSC stereo (12.5-25m nadir images) with 87% coverage with images $\leq 25\text{m}$ and more than 65% useful for stereo mapping (e.g. atmosphere sufficiently clear). The derived HRSC orthorectified images (ORIs) and corresponding Digital Terrain Models (DTMs) are co-registered to the global MOLA heights and have planimetric accuracy at the subgrid point level ($\approx 9\text{-}25\text{m}$ RMS). This means that non-HRSC can be co-registered to HRSC ORIs to create a time layer stack of all available images of high resolution ($\leq 100\text{m}$ and $\leq 20\text{m}$). DTM/ORIs can also be retrieved for the $\approx 4,000$ stereo-pairs from the NASA CTX and HiRISE instruments ($\approx 1\%$ of total). iMars has built a processing platform which can automatically co-register level-1 (EDR) data from non-HRSC images to the corresponding ORIs/DTMs and examples of

this processing chain will be demonstrated in the meeting. In the second half of the iMars project these processing systems will be exercised “in anger” on all available images above a certain quality threshold to generate a time layer stack for every available image. These co-registered and orthorectified images are being used together with several different data mining approaches to try to locate and identify changes due to previously observed surface change features such as dark streaks, gullies, new impact craters, dune movement, polar pits, RSLs (Recurring Slope Lineae) and avalanches. A quantitative assessment through a workshop at EGU 2014 and a corresponding online questionnaire was made of the scientific interests of European planetary scientists. This survey determined that change detection research was under-developed in Europe. In 2016, it is planned to involve geoscientists in further quantitative studies of automatically determined change features. In parallel to expert user assessments of the automatically determined change detection features, a series of citizen science assessments will be made of these auto-changed features.

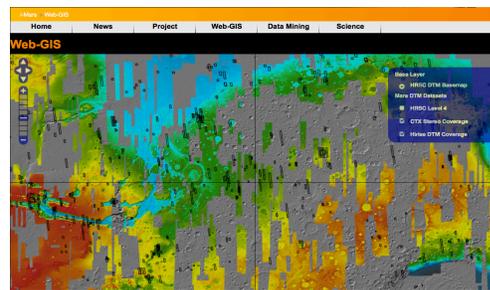


Figure 1. Example of iMars webGIS displaying all HRSC processed DTMs.

The results of the project, including DTMs (see Figure 1) will be disseminated through an OGC-compliant webGIS system based on the PRoGIS described in Giordano et al. (2015). This interface will also be employed within the citizen science assessment.

2. Methods

A number of automated stereo processing chains were assessed in a round-robin exercise within iMars. The two best, NASA Ames stereo pipeline and the

University of Seoul (UoS) were employed in a comparative quantitative assessment. The UoS system was ported by UCL staff [Yershov et al., this conference] onto a linux cluster and in parallel, UoS staff prepared the software for implementing on a parallel system in Korea.

A fully automated co-registration system described elsewhere in this conference (Sidiropoulos & Muller) has been developed to generate level-1b CTX-to-HRSC-ORI, HiRISE-to-CTX and HiRISE-to-HRSC-ORI pairs. The same system can also be applied to older (and future) image pairs from older NASA missions (e.g. MOC-to-HRSC, etc..). An example of the feature selection and auto-co-registration is shown in Figure 3 below.

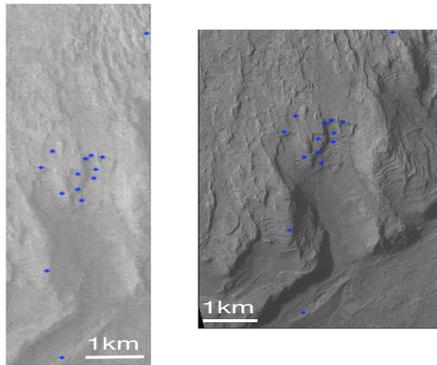


Figure 2. Automated feature points detected from HRSC ORI (left) and CTX level-1.

3. Results

An example of a multi-resolution DTM is shown in Figure 2 from UoS.

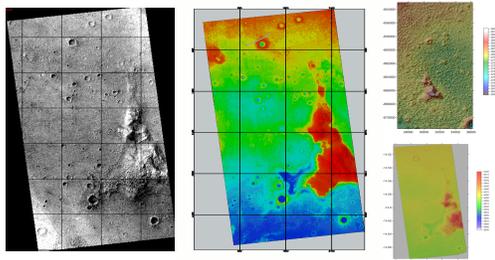


Figure 3. HiRISE ORI and DTM (leftmost panels), CTX-DTM (upper right) and HRSC-DTM of the MER-A Spirit rover site generated using the UoS processing chain.

In the next phase of the project, the DTM and auto-co-registration system will be deployed to process the $\approx 750k$ images that have been acquired to date from orbit of Mars. In addition, the automated data mining will be applied to co-registered sets of ORIs and DTMs and all of the results into the database of the webGIS. These data mining results will be assessed within a citizen science project under the aegis of the Zooniverse project. A sample screen for an initial experiment conducted by the University of Nottingham is shown in Figure 4.

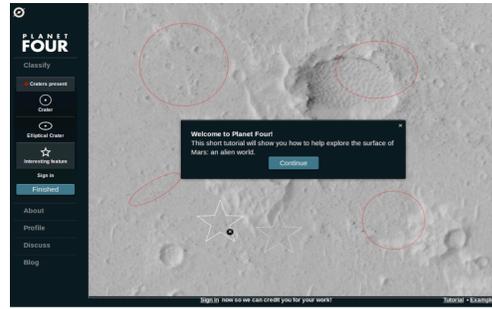


Figure 4. Example screen of a Zooniverse experiment for citizen science for Mars crater detection.

6. Summary and Conclusions

The iMars project is well into the development of the basic processing chains, which will be used in production in the next half of the project to generate a time series of almost 40 years of Mars' observations from orbit. A report will be given on how expert users are being consulted on its evaluation.

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