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A summary report on 3D imaging software, data and their distribution from the EU FP-7 iMars project

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Abstract

In this paper, we summarise the main achievements from the completed EU FP-7 iMars project (http://www.i-mars.eu) including the distribution of open access data products and software.

1. Background and Context

Almost fifty years have elapsed since the NASA Mariner 4 spacecraft first took the pictures of the Martian surface. Over that time, the resolution and quality of these images has improved from tens of kilometres down to 25 cm. Over the intervening $\approx$50 years, many areas on Mars have been repeatedly imaged as each new science team has "re-invented the wheel" and gone back to the same places highlighted by these early images. Historically, the driver for these scientific studies has been the "hunt for water" but more recently, there is an increasing interest in studying different dynamic phenomena associated with the motion of dust and surface-atmospheric interactions. The revolution in planetary surface observations, especially in 3D imaging of surface shape, has led to the ability to be able to overlay different time epochs back to the mid 1970's, to examine time-varying changes, such as the recent discovery on Mars of mass (e.g. boulder) movement, tracking inter-annual seasonal changes and looking for fresh impact craters from meteoritic strikes. As our exploration of surface changes proceeded we determined that the polar regions had some of the most significant surface changes and so a great deal of emphasis was changed to focus on these regions.

Within the iMars project, we wanted to mitigate the deleterious effects of increasing knowledge and accuracy of where the spacecraft was located in its orbit and where the cameras were pointing to allow fully automated computer algorithms to eliminate the impact of these errors and provide co-registered image products so we can playback any area on Mars, which had repeat coverage. Of course, in many cases no change can be observed, however surprisingly the surface is much more dynamic than at first thought particularly with regard to very dynamic phenomena like dust devils. When the technology developed by iMars is rolled out across the planet in future it is very likely that new discoveries will be made. For polar regions, the number of repeat views is significant as well as for regions such as the putative and actual landing sites, Vallis Marineris, the Tharsis volcanic region and other regions repeatedly imaged on the boundary of the so-called dichotomy. Little, if any, information is available on the variability of the Martian surface, although the annual and seasonal changes associated with the polar cap expansion and contraction and the rapid spread of dust storms has been relatively well monitored in the past. However, the Martian surface is undergoing frequent changes from our observations of just 3% of the surface so we do not yet know what we can fully expect to find.

2. Method

The iMars project focused on developing tools and value-added datasets to massively increase the exploitation of space-based data from NASA and ESA Mars mission imaging data and derived 3D data beyond the PI teams. iMars has added significant value by creating more complete and fused 3D models of the surface from multi-resolution co-registered stereo with all 3D imaging products co-registered to a global reference system derived from laser altimetry. iMars has also shown how these 3D models can be employed to create a set of co-registered imaging data through time, permitting a much more comprehensive interpretation of the Martian surface to be made.

Emphasis was placed on the co-registration of multiple datasets from different space agencies and orbiting platforms around Mars and their synergistic use to discover what surface changes have occurred since NASA's Viking Orbiter spacecraft first went into orbit around Mars more than forty years ago.

iMars brought together the best expertise in Europe for the processing of Martian orbital data within a single environment for handling, visualising and interpreting these data. The ESA Mars Express High Resolution Camera (HRSC) provided the 3D mapping products used as base data (for around 50% of the surface), where possible. When CTX stereo products are also available over the same areas as HRSC (for around 20% of the surface) then the CTX products can be co-registered with HRSC and CTX 3D mapping products can then be employed as the base data for higher resolution images such as MOC-NA and HiRISE. A Co-registered Ames Stereo Pipeline using Gotcha Optimization (CASP-GO; *Tao et al, PSS, 2018*) was developed for large-scale production of CTX 3D mapping products and small area production of HiRISE products. Some 5,300 CTX stereo products have been processed using cloud computing provided by Microsoft Azure® covering about 20% of the Martian surface. In iMars, standards were set for the production and dissemination of HRSC mosaiced products, which are easier to utilize for co-registration than individual strips and have better internal geometry. A fully automated Auto-Coregistration and Orthorectification (ACRO; *Sidiropoulos & Muller, 2015, 2017*) system was developed to operate on a linux cluster without any manual intervention. Around 15,000 NASA images (out of the ≈400,000 acquired with resolution of ⩽100m) were processed using the ACRO system covering around 4% of the surface. New HRSC 3D mapping products (Putri, this conference) were produced for the South Polar Residual Cap area and we are working on applying the same approach to the North Polar cap in collaboration with another iMars partner. ACRO products have therefore been processed as well as multi-resolution DTMs from CTX and HiRISE. A large portion of the 3D mapping products have been analysed qualitatively by visual inspection and the ACRO processing includes calculating internal quality metrics, which are used to flag bad products.

An automated data mining algorithm was developed to find scene fragments where single or multiple instances of change are detected. This used supervised classification initially with planetary science labelled inputs but will in the near future employ mass public participation from a shortly-to-be-launched citizen science programme under the auspices of Zooniverse. A great deal of effort was placed on determining the optimum Human Factors for incentivising and motivating such participants. Each additional set of a minimum of 10 identifications and notations will be further employed to improve the classification (standing it is believed at around 50%) and the data mining applied to new areas by non-EU funded students at Masters and PhD level.

3. Results and future work

All of these new products are viewable through an OGC-compliant webGIS developed at FUB which is hosted at MSSL (http://www.i-mars.eu/web-gis; Walter et al., JGR/ESS, 2018). This includes tools for viewing temporal sequences of co-registered ORIs over the same area. This allows experts and members of the public to examine different parts of the planet for changes as well as perform geomorphological and geological research.

In parallel, a citizen science project at Nottingham University has defined training samples for classification of change features and for verification of change. Scientific use cases include new craters & slope streaks.

Distribution of the iMars products will take place through ESA PSA and NASA PDS in PDS4 standards The CASP-GO software will be released through the NASA Ames ASP Github.

The iMars base data can be used by the ESA ExoMars Trace Gas Orbiter 2016 and subsequent ESA missions to provide the necessary inputs for selection of a future landing site for the ESA ExoMars 2020 rover and for any Mars Sample Return missions in the 2020s. It will greatly extend the use of the archived data by providing mapped and co-registered products.

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References

[1] Tao, Y., J-P. Muller, et al., (2018) Planetary and Space Science. Vol. 154, pp.30-58.

[2] Sidiripoulos, P., & J.-P. Muller, IEEE Trans. Geosci. Rem. Sens., doi: 10.1109/TGRS.2017.2734693.

[3] Walter, S.H.G., J.-P. Muller, P. Sidiropoulos, Y. Tao, et al, (2018) The iMars web GIS – an interactive online mapping tool for the spatio-temporal visualization of topography data and dynamic time-series of single image layers. JGR/ESS special issue: Planetary Mapping: Methods, Tools for Scientific Analysis and Exploration.