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The Multi-Temporal Database of High Resolution Stereo Camera (HRSC) and Planetary Images of Mars (MUTED): A Tool to Support the Identification of Surface Changes

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Introduction

Image data transmitted to Earth by Martian spacecraft since the 1970s, for example by Mariner and Viking, Mars Global Surveyor (MGS), Mars Express (MEx) and the Mars Reconnaissance Orbiter (MRO) showed, that the surface of Mars has changed dramatically and actually is continually changing [e.g., 1-8]. The changes are attributed to a large variety of atmospherical, geological and morphological processes, including eolian processes [9,10], mass wasting processes [11], changes of the polar caps [12] and impact cratering processes [13].

The detection of surface changes in planetary image data is closely related to the spatial and temporal availability of images in a specific region. While previews of the images are available at ESA's Planetary Science Archive (PSA), through the NASA Planetary Data System (PDS) and via other less frequently used databases, there is no possibility to quickly and conveniently see the spatial and temporal availability of HRSC images and other planetary image data in a specific region, which is important to detect the surface changes that occurred between two or more images. In addition, it is complicated to get an overview of the image quality and label information for images covering the same area. However, the investigation of surface changes represents a key element in martian research and has implications for the geologic, morphologic and climatic evolution of Mars.

In order to address these issues, we developed the "Multi-Temporal Database of High Resolution Stereo Camera (HRSC) Images" (MUTED), which represents a tool for the identification of the spatial and multi-temporal coverage of planetary image data from Mars. Scientists will be able to identify the location, number, and time range of acquisition of overlapping HRSC images. MUTED also includes images of other planetary image datasets such as those of the Context Camera (CTX), the Mars Orbiter Camera (MOC), the Thermal Emission Imaging System (THEMIS), and the High Resolution Imaging Science Experiment (HiRISE). The database supports the identification and analysis of surface changes and short-lived surface processes on Mars based on fast automatic database queries. From the multi-temporal planetary image database and the multi-temporal observations we will better understand the interactions between the surface of Mars and external forces, including the atmosphere. MUTED will be available for the scientific community via the Institut für Planetologie (IfP) Muenster.

Scientific objectives

Our objectives are (1) to study examples of surface changes based on multi-temporal HRSC ND image data caused by eolian processes, mass wasting and polar processes, as well as impact cratering processes, and (2) to document examples of surface changes through the comparison of multi-temporal HRSC ND image data with other past, current and future missions of Mars exploration, e.g., CTX and MOC, and (3) to investigate the causes of the selected examples of Martian surface changes by seeking correlations between morphologic, geologic and atmospherical processes and surface parameters such as topography, relief, elevation, thermal inertia, rock abundance, surface roughness, geologic properties and wind regimes.

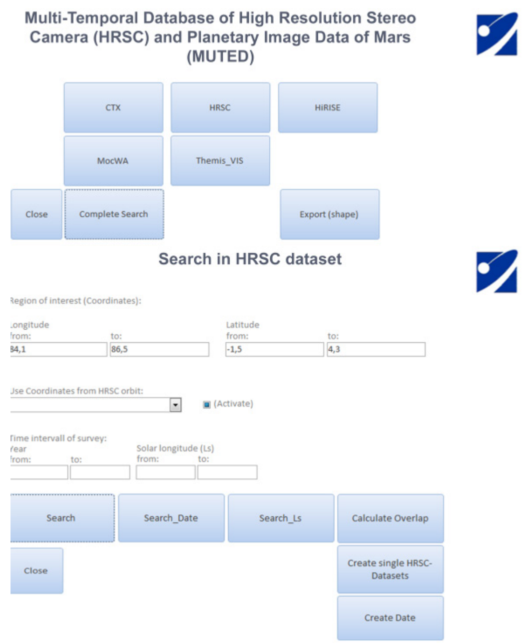

Fig. 1: User interface of the multi-temporal HRSC image database. Calculation of the overlap based on latitude/longitude of region of interest or corner coordinates of selected HRSC orbits.

Multi-temporal HRSC database

We developed an algorithm that automatically creates color-coded polygons to provide information about the location and number of overlapping HRSC ND images. The routine is based on the latitude (Lat) and longitude (Lon) coordinates of the vertices of each HRSC image and the vertices of the 100 sections each HRSC ND image consists of, respectively. In the case of an overlap of two HRSC ND images, the Lat/Lon coordinates of both images will be used to calculate the intersection, which is color-coded in the ranking. The multi-temporal HRSC database is generated by the integration of different planetary image datasets into a Microsoft Access database management system. The calculation of overlapping and the modification of the datasets are done by using VBA and SQL routines.

In the input mask, the parameters for Lat/Lon can be set freely or based on the footprints of a specific image. The compiled tables of overlapping HRSC images appear in a new mask. Additionally to the manual search of images for a requested area, the program automatically calculates overlaps for all images and stores them along with their respective relationships. This summed number of overlapping images enables a color coded ranking.

In order to display the calculated results in GIS, a *.dbf- and *.prn-file is generated. These files are required to create GIS executable shapefiles by using free ShapeLib tools, which are based on Linux. The resulting *.shp- and *.shx-files can then be integrated into GIS. The integration into GIS will contain the development of shapefiles for each color-coded class.

GIS shapefiles

Figures 2A-D show examples of GIS shapefiles created with the multi-temporal database of HRSC images. A global view of all available HRSC images and a color-coded ranking based on the number of overlaps is shown in the GIS shapefile of Figure 2A. There are only a few gaps on the surface left (red), where only one HRSC image is available. Multi-temporal observations based on HRSC images only cannot be performed at these sites. Multi-temporal observations can be done at sites showing HRSC orbits outlined in orange, yellow or green. However, particularly for investigations of recent and short-term processes on the surface of Mars, such as dust devil movement, it is important to identify those sites that have been monitored within days, hours or minutes. This is only possible with additional planetary image data such as from the Context Camera (CTX), which are already included into the database. CTX images cover areas of an extent comparable to HRSC and also have comparable resolution. Together with HRSC, CTX images are best suited for the detection of surface changes. The addition of other planetary datasets such as CTX images will not only improve the spatial coverage of multi-temporal images, but will also extend the time period of observation. Figure 2B shows a global view of all available HRSC and CTX images and a color-coded ranking based on the number of overlaps. Although multi-temporal observations are possible using nearly all orbits, researchers that are searching for short-lived dust devils need to quickly identify those overlaps between HRSC and CTX, that have been acquired within a short time, for example within one day (Fig. 2C) or within 3 hours (Fig 2D). While there are ~60 sites on Mars that have been monitored by HRSC and CTX within one day, there are only 19 locations on Mars that have been monitored by HRSC and CTX within 3 hours. The GIS shapefiles created by the multi-temporal database of HRSC images, in particular those that show images acquired within a short timespan (hours) give researchers the option to conveniently and easily identify those sites on Mars, where investigations of recent and or short-term surface processes are possible.

Integration of additional datasets

We added additional planetary image datasets to our database. Context Camera (CTX) images, Mars Orbiter Camera (MOC) wide-angle (WA) images and Thermal Emission Imaging Instrument (THEMIS) nadir images are already included into the database. Currently we are implementing the High Resolution Imaging Science Experiment (HiRISE) dataset into the database. In particular, CTX images cover areas of an extent comparable to HRSC and also have comparable resolution. Together with HRSC, CTX images are best suited for the detection of surface changes. The addition of planetary datasets such as CTX images will not only improve the spatial coverage of multi-temporal images, but will also extend the time period of observation.

Release of MUTED

The BETA version of the multi-temporal HRSC database including the Access file and calculated shapefiles is currently available upon request via the Institut für Planetologie (IfP) (www.uni-muenster.de/planetology/ifp/). The release version of MUTED will be available via download from the webpage of the IfP. Users will have access to the database including the HRSC, CTX, THEMIS-VIS and MOC-WA datasets. In addition to the visualization of the global datasets in a GIS, users can export GIS shapefiles showing the multi-temporal coverage of images for all datasets available in database.

References: [1] Sagan et al. (1972), Icarus 17, 346-372. [2] Sagan et al. (1973), JGR 78, 4163-4196. [3] Thomas and Veverka (1979), JGR 84, 8131-8146. [4] Chaikin et al. (1981), Icarus 45, 167-178. [5] Zurek and Martin (1993), JGR 98, 3247-3259. [6] Geissler (2005), JGR 110. [7] Raack et al. (2012) Icarus 219, 129-141. [8] Hayward et al. (2014), Icarus 230, 38-46. [9] Bourke et al. (2008), Geomorphology 94, 247-255. [10] Reiss et al. (2011), Icarus 215, 358-369. [11] Quantin et al. (2004), Icarus 172, 555-572. [12] Piqueux and Christensen (2008), JGR 113 E02006. [13] Daubar et al. (2013), Icarus 225, 506-516.

Fig. 2: Examples of GIS shapefiles created with the multi-temporal database of HRSC images. Data gap at Longitude boundary related to Beta version of the database. (A) Global view of all available HRSC images and a color-coded ranking based on the number of overlaps. (B) Global view of all available HRSC images and a color-coded ranking based on the number of overlaps with CTX images. (C) Global view of all available HRSC images and a color-coded ranking based on the number of CTX overlaps acquired within 1 day. (D) Global view of all available HRSC images and a color-coded ranking based on the number of CTX overlaps acquired within 3 hours.