Highlights of Mars imaging

Highlights from three current Mars missions provide an idea of the wide range of images that the USGS is analyzing with SOCET SET® and ISIS. The first of these approaches to reach Mars, in December 2003, was the Mars Express orbiter. HRSC scans are part of the team for His RCC, the first camera designed explicitly for photogrammetric mapping to be flown to another planet. The 19 line scanner design of the HRSC is a unique collection of eight stereo images, as well as four color bands in a single pass. The ground sample distance varies between 12.5 m/m for two-thirds of the planet imaged, but is as small as 5.0 m per pixel on the equator. A stereoscopic capability between stereo DEMs is produced at several wavelengths: SOCET SET® compares well with automatic matching algorithms on the cutting edge of research, and makes the only complete system providing a fully automatic adjustment solution and the possibility of interactive DEM editing. The USGS group was the first to demonstrate refinement of the stereo DEM with shape-from-shading.

The HRSC team at DLR (Germany) and the Deutsches Forschungszentrum für Luft- und Raumfahrt (Germany) are analyzing HRSC images with SOCET SET®, SOCET GIST® and other methods. The HRSC images provide a unique dataset for terrestrial photogrammetry. The HRSC stereo data are used to generate DEMs from a small fraction of these pairs, focusing on providing the MER team with detailed stereo DEMs and image mosaics. Registering the MI images to the much-lower-resolution color images from the rover’s other cameras, and integrating the close-ups of patches of rock and soil into the rover coordinate systems used to track the rover to desired locations, constitute novel challenges.

The USGS is analyzing with SOCET SET® and ISIS the first of these spacecraft to reach Mars in March, 2006, and entered its mapping orbit in November. From this low orbit, the HiRISE team plans to take at least 1000 such stereo pairs, totaling roughly two trillion pixels, and covering perhaps 0.1% of the surface of Mars. The USGS is using SOCET SET® to achieve celebrity because before/after images indicate the crater wall was 45 m higher than seen today. This crater in the Centauri Montes region has achieved celebrity because before/after images indicate a bright streak of material flowed down the crater wall—here in color, superimposed over the HiRISE image—within the past few years. Topography and slopes (shown here in exaggeration) are being used by scientists to model the formation of the bright streak and assess whether it was merely a dry debris flow or involved the release of ground water.

The HiRISE team for the HRSC, the first camera designed explicitly for photogrammetric mapping to be flown to another planet, is the most highly automated team known to date. The HRSC images are analyzed using bundle adjustment software that easily adjusts the HiRISE stereo images to correctly map the HiRISE stereo images to the HiRISE stereo images, and the HiRISE stereo images to the HiRISE stereo images. The HiRISE team is the first to demonstrate refinement of the stereo DEM with shape-from-shading.
The USGS has chosen an approach that makes synergistic use of both public domain software and unique proprietary tools in house, as well as commercial software and hardware. A key software components processing image data into ISIS for use as base maps. By writing the software in-house, the USGS has the flexibility to add export, visualization, and image processing tools that are not currently available or suitable for some given tasks.

The USGS uses the end-to-end digital mapping software and the powerful ISIS/SOCET SET environment. SOCET SET's versatility as an end-to-end digital mapping system is an essential tool for processing planetary images into orthophoto mosaics for use as base maps. By writing the software in-house, the USGS can extend these built-in capabilities by writing its own sensor models for unique instruments, such as the imaging radars flown to Venus and Titan. One of the advantages of using the powerful ISIS/SOCET SET environment is an essential tool for processing planetary images into orthophoto mosaics for use as base maps. By writing the software in-house, the USGS can extend these built-in capabilities by writing its own sensor models for unique instruments, such as the imaging radars flown to Venus and Titan. One of the advantages of using the powerful ISIS/SOCET SET environment.

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The planning and geologic work the USGS does is essential to the success of the Mars Exploration Rovers (MERs), two of which are scheduled to land on Mars in 2004. The MERs are expected to last for one sol (day on Mars) to several years. The MERs will be the first remote exploration vehicles to land on the surface of Mars and are expected to provide detailed images, maps, and scientific measurements of the Martian surface. The images and data collected by the MERs will be used to plan future missions to Mars. The USGS has developed models for Mars using data from previous missions and plans to use the data from the MERs to refine and extend these models. The USGS has also developed models for Mars using data from previous missions and plans to use the data from the MERs to refine and extend these models.
CASE STUDY

Automated photogrammetric techniques to study enigmatically features of the sidebar

Customer: U.S. Geoscientific Survey (USGS)
Industry: Planetary sciences

Background

The USGS is the primary producer of digital and hardcopy planetary maps in the U.S. for NASA and the U.S. military. Andreas Wachtel’s research group at Flagstaff, Arizona, specializes in the compilation of systems and their inner workings, and how they are designed and implemented into the process of creating maps. The primary objective of these efforts is to produce high-quality, geospatial datasets that can be used by geoscientists and other stakeholders.

The USGS is involved in all stages of the planetary exploration and mapping process — from the study of rock samples, boulders, and isotopes in the laboratory, to the modeling of objects in the solar system. Synthesizing these data into maps that can be used by scientists, engineers, and the general public has always been one of its primary — yet most challenging — roles. Raw legacy images of Mars, the moon, and other targets from Earth in its surface properties. The continuing investigation of Mars may thus fill gaps in our understanding of planetary conditions under which life can originate and flourish, and the atmospheric conditions, and other properties that characterize objects in the solar system.

The USGS produces the global topographic map of Mars, above, from nearly 1000 photos and 2000 m elevation contour maps, 1.5x. The Mars Exploration Rover Spirit climbed over Husband Hill, shown in the top image, and is currently exploring Home Plate, an area of High-Resolution Imaging Science Experiment (HiRISE) images. The HiRISE camera provides images at a resolution of 20 cm per pixel, which is used to generate DEMs from image sets that are small in size but large in scientific value, such as those from HiRISE. The powerful, systematic framework for processing image data, the USGS has made remarkable progress in deriving DEMs from stereo imagery, and has been able to extend this capability to other planets. The USGS continually works closely with BAE Systems to improve this modeling. The BAE Systems’ SOCET SET® to accomplish its planetary mapping tasks, and its own system, Integrated Software for Imagers and Spectrometers (ISIS), provides an end-to-end capability to produce digital elevation models (DEMs) and orthoimages from stereo data. The DEMS are used for a variety of applications, including the study of morphological features and the identification of potential landing sites.

The USGS uses the SOCET SET® environment to develop its own sensor models for unique instruments, such as the HiRISE camera, which is carried by NASA’s Mars Reconnaissance Orbiter. The HiRISE camera provides images at a resolution of 20 cm per pixel, which is used to generate DEMs from image sets that are small in size but large in scientific value, such as those from HiRISE. The powerful, systematic framework for processing image data, the USGS has made remarkable progress in deriving DEMs from stereo imagery, and has been able to extend this capability to other planets.

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For stereo analysis, the USGS uses commercial software, such as SOCET SET, to process stereo image pairs to produce DEMs and orthoimages. The USGS has developed a powerful, systematic framework for processing image data, the USGS has made remarkable progress in deriving DEMs from stereo imagery, and has been able to extend this capability to other planets. The USGS continually works closely with BAE Systems to improve this modeling. The BAE Systems’ SOCET SET® to accomplish its planetary mapping tasks, and its own system, Integrated Software for Imagers and Spectrometers (ISIS), provides an end-to-end capability to produce digital elevation models (DEMs) and orthoimages from stereo data. The DEMS are used for a variety of applications, including the study of morphological features and the identification of potential landing sites.

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CASE STUDY

The USGS (U.S. Geological Survey) has chosen an approach that makes synergistic use of both public domain software (such as commercial photogrammetry software) and new, as well as proprietary software. A software framework, termed SOCET SET™ to accomplish its planetary mapping tasks, and its own system, integrated Software for Imagers and Spectrometers (ISIS), provides an end-to-end capability to model data geometrically from each new sensor as it becomes available. The USGS has chosen this approach because of the new software technology such as ISIS and SOCET SET to create a foundation on which to build an integrated digital earth environment. Owing to the availability of new software technology such as ISIS and SOCET SET to create a foundation on which to build an integrated digital earth environment, Owing to the availability of new software technology such as ISIS and SOCET SET to create a foundation on which to build an integrated digital earth environment.

Conclusion

The USGS produced the global topographic model data for an individual research project. A final interactive viewing and editing step is enabled by the SOCET SET Developer’s Toolkit (DevKit). The C++ programming environment of the SOCET SET Developer’s Toolkit has enabled programmers to customize the product to work with unique datasets.

The opportunity to model data geometrically from each new sensor as it becomes available enables programmers to customize the product to work with unique datasets. In addition to modeling unique sensors, using SOCET SET is that pushbroom scanner data, frame images, and custom-modeled radar data for an individual research project.

The USGS Framework allows for the development of unique software products that are useful in a wide variety of scientific applications. The framework enables programmers to customize the product to work with unique datasets.
Highlights of Mars imaging

Highlights from three current Mars missions provide an idea of the wide range of data that the USGS is using with SOCET SET and ISIS. The first of these approaches to reach Mars, in December 2003, was the Mars Express Orbiter. Ultraspectral camera pairs are part of the suite for this HRSC, the first camera designed explicitly for photogrammetric mapping to be flown to another planet. The fully unwrapped range of the HRSC is a collection of false stereo images, as well as four color bands in a single pass. The ground spatial of the stereo is coplanar (0.2 cm), but the altimeter ground tracks have been imaged at 0.6 cm per pixel or better. In a detailed comparison between stereo DEMs produced at several research institutions, SOCET SET compared well with automatic matching algorithms on the cutting edge of research, and was the only complete system providing an auto-tuned adjustment solution and the possibility of interactive DEM editing. The USGS group were the first to demonstrate refinement of the stereo DEM with shape-from-shading.

Mars Express was followed closely by two NASA Mars Exploration Rovers (Spirit and Opportunity), which landed on opposite sides of Mars in January, 2004. Both are still operating, nearly three years into mission. Express has both very high (10 cm) and very low (0.7 cm) digital camera photography. The higher resolution stereo images provide means to map the stereo DEM to scientific research, assess changes in the area, and map the surface using automatic photogrammetry. However, for the low camera, photogrammetry (VR) cannot be used in the virtual reality environment. Stereo imagery can be combined into a motion rate and offset record and to bring different areas into correct focus, as the rover moves through the target surface. With overlapping coverage that can associate produce a false stereo DEM, the images from the stereo are combined, forming the false-color images. The MaxiCam views a 3-cm-square area at 30 micrometers per pixel. Imaging sequences can be divided forward and back from the target, to bring different areas into correct focus, and move the target forward through the target area to build up overlapping coverage that can associate produce a true stereo DEM.

The largest spacecraft to reach Mars, the NASA Mars Reconnaissance Orbiter (MRO), arrived at Mars in March, 2006, and entered the mapping orbit in November. Once in the orbit, three HRSC camera pairs image the surface as a mosaic of 0.3 m-pixel resolution. The camera is a multiband, overlapping detection to build up a superimposed image 20,000 pixels wide, with three color bands covering the central 4000 pixels. Unlike HRSC, the instrument does not have a built-in stereo capability, but stereo point-to-point capability is added with the additional camera. In a wide range of terrain, the images are shot to 12.5 m-per-pixel. In a detailed comparison between stereo DEMs produced at several research institutions, SOCET SET compared well with automatic matching algorithms on the cutting edge of research, and was the only complete system providing an auto-tuned adjustment solution and the possibility of interactive DEM editing. The USGS group were the first to demonstrate refinement of the stereo DEM with shape-from-shading.

The HiRISE team plans to take at least 1000 such stereo pairs, totaling roughly two trillion pixels, and covering perhaps 0.1% of the surface of Mars. The USGS is using SOCET SET to make DEMs from a small fraction of these pairs, focusing on providing the MER team with detailed maps of their rovers’ locations and validating the safety of candidate landing sites for the next generation of landers and rovers. TheHiRISE team plans to take at least 1000 stereo pairs by rolling the entire spacecraft to either side to re-image a target on the surface. The HiRISE team plans to take at least 1000 such stereo pairs, totaling roughly two trillion pixels, and covering perhaps 0.1% of the surface of Mars. The USGS is using SOCET SET to make DEMs from a small fraction of these pairs, focusing on providing the MER team with detailed maps of their rovers’ locations and validating the safety of candidate landing sites for the next generation of landers and rovers.

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Mars Express was followed closely by two NASA Mars Exploration Rovers (MER), Spirit and Opportunity, which landed on opposite sides of Mars in January, 2004. Both are still operating, having three years into their missions, compared to barely 180 day. Eight cameras on each rover point toward various targets of scientific interest, captured an initial set of 360 exposures of the surface. The HiRISE camera on Mars Reconnaissance Orbiter (MRO), carried by the Mars Odyssey platform, also operated from early 2006, and achieved celebrity because before/after images indicate the release of ground water. This water, in turn, leads to the formation of the water-ice deposits that are the subject of this chapter. The HiRISE camera scanner the 2-km-wide area of 0.3 m-pixel. The camera uses multiple, overlapping detections to build an experimental image 20,000 pixels wide, with three color bands covering the entire HiRISE image. Unlike HRSC, the instrument does not have a built-in stereo capability, but shares point processing capabilities built into the HiRISE scanner for direct stereo imagery in a single pass. The HiRISE team plans to take at least 1000 such stereo pairs, totaling roughly two trillion pixels, and covering perhaps 0.1% of the surface of Mars. The USGS is using SOCET SET to isolate a small fraction of the HiRISE images, focusing on the Mars Reconnaissance Orbiter (MRO), using detailed maps of their rover’s track to the safety of candidate landing sites for the next generation of mars rovers.

The HiRISE camera on Mars Reconnaissance Orbiter (MRO), arrived at Mars in February, 2006, and is aimed at mapping out of the HiRISE image. This capability, while not available on earlier missions, makes it possible to probe the surface of Mars at high resolution. The instrument uses multiple, overlapping detections to build an experimental image 20,000 pixels wide, with three color bands covering the entire HiRISE image. Unlike HRSC, the instrument does not have a built-in stereo capability, but shares point processing capabilities built into the HiRISE scanner for direct stereo imagery in a single pass. The HiRISE team plans to take at least 1000 such stereo pairs, totaling roughly two trillion pixels, and covering perhaps 0.1% of the surface of Mars. The USGS is using SOCET SET to isolate a small fraction of the HiRISE images, focusing on the Mars Reconnaissance Orbiter (MRO), using detailed maps of their rover’s track to the safety of candidate landing sites for the next generation of mars rovers.

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