Geophysical Research Abstracts, Vol. 9, 03901, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-03901

Requirements and Solutions for ExoMars Rover Panoramic Camera 3D Vision Processing

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The Pasteur payload on the ESA ExoMars Rover due for launch in 2013 is designed to search for evidence of extant or extinct life either on or down to $\sim$2 m below the surface of Mars. The rover will be equipped with a panoramic imaging system currently under development for visual characterization of the rover's surroundings and (in conjunction with an infrared imaging spectrometer) remote detection of potential sample sites.

The Panoramic Camera stereo imaging system consists of two wide angle multispectral cmareas each with a 65˚ field-of-view (Wide Angle Camera WAC) and a high resolution monoscopic camera (High Resolution Camera, HRC) currently designed to have an 8˚ field-of-view, both mounted on a shared pan-tilt unit. The following scientific objectives drive the requirements for the optical and mechanical layout, and ground processing software:

- Localization of the landing site (mostly by combination of orbiter and ground panoramic images)
- Provision of context information to detect, locate and measure potential scien-

tifically interesting targets

- Geological characterization (using narrow band filters tuned to search for particular geological features) and cartography of the local environments (local Digital Terrain/Elevation Model or DTM).
- Complement to the rover visual navigation system (perception, localization/orientation/tilt within the 3D environment, path planning, 3D/visual odometry)
- Monitoring of rover experiments such as drilling and coring, as well as characterization of the derived rock and soil products
- Studying atmospheric properties and variable phenomena near the Martian surface (e.g. aerosol opacity, water vapour column density, clouds, dust devils, meteors, surface frosts)
- Geodetic studies (observations of Sun, bright stars, Phobos/Deimos).

In this framework, three dimensional (3D) vision processing is a key element of mission planning and scientific data analysis. Besides "standard" processing elements such as digital range and terrain maps, panoramic mosaics, and "virtual" views of the environment, the following techniques will be developed:

- Shape-from shading for refinement of the stereo processing results of the terrain
- Geometrical surface parameters such as surface normal vectors, dip and strike
- Surface characteristics, such as photometric properties and roughness
- Handling of specific local structures such as overhangs and concave shapes
- Flexible selection of viewpoints from different rover locations to obtain large-baseline stereo images for long-range mapping
- Fusion of spaceborne DTMs and orthoimages with PanCam acquired DTMs and images
- Generation of illumination maps and instrument "reachability" maps
- Footprint, accuracy and reliability maps for vision sensor planning and image archive overview

- Specific metrology functions based on the scientific and operational requirements (measure true distances, areas and volumes, 3D morphological parameters, etc.)
- Spatial linking of vision data obtained from different rover locations (DTM fusion, photogrammetric bundle adjustment) by a global mission 3D –data base
- Semi-automatic and automatic segmentation of objects of interest such as rocks, rover wheel tracks and components of the rover
- Fusion of images taken at different times of day
- Multiple resolution map structures to support all levels of detail within a single graphical environment
- Check and correction of the geometric camera system calibration based on images from the surface of Mars

The interfaces to other mission elements such as operations planning, rover navigation system, robotics, public outreach and global Mars mapping are a specific concern of the current development. The 3D vision processing requirements document for the ExoMars Rover Panoramic Camera is currently being finalized. We report on the current status, the proposed solutions, as well as describe what open questions remain to be answered.