EPSC Abstracts,
Vol. 4, EPSC2009-390, 2009
European Planetary Science Congress,

Stereo workstation for Mars Rover image analysis

D. Shin, J-P Muller and the ProVisG (http://www.provisg.eu) Team

Imaging group, Mullard Space Science Laboratory, Department of Space and Climate Physics, University College London, Holmbury St. Mary, Dorking, Surrey, RH5 6NT, UK (ds2@mssl.ucl.ac.uk)

Abstract

This paper describes the development of a stereo workstation and its application at the Imaging group, MSSL, UCL under the EU-FP7 PRoVisG Project. The stereo workstation consists of a planar stereo display driven by a quad-buffer hardware accelerator and a platform independent stereo application, which utilises a state-of-the-art stereo rendering engine developed by JPL. Apart from fundamental stereo rendering capability, the proposed application also includes stereo matching and image processing tools which can help a mission operator and scientist to reconstruct a 3D scene from Mars rover stereo images.

Introduction

Since the twin rovers have been deployed on the red planet through the NASA Mars Exploration Rover (MER) mission [1], they have been continually sending back close range images from the Martian surface, in a quality not available found in previous Mars orbital images. After processing raw packet data using MIPL [xxx], higher level data products (e.g., 3D surface data, solar energy maps, etc.) are computed for a better understanding of the environment around a rover [2]. However, due to the smooth nature of current landing sites (for engineering constraints mainly), MER images often contain regions with homogeneous texture with sparse features. This not only complicates obtaining accurate stereo matching results but also easily prevents to retrieve a dense disparity map unless manual interactions are included.

As a workaround, JPL has been developing a JAVA based stereo rendering engine (called JADIS) and introduced some applications using JADIS [3]. Since this research is still actively ongoing and a stereo matching application on this framework is not yet reported to date, we propose to develop a platform independent stereo application for MER image analysis which in future could be applied to the NASA MSL, or the ESA ExoMars rover. This project is supported as a part of the EU FP7 ProVisG (Planetary Robotics Vision using Ground processing) project, where UCL and JPL are collaborating to implement a stereo application based on the JADIS framework.

The proposed stereo application has inherited the JADIS concept of a platform and graphic hardware independence. In addition, it delivers a complete set of stereo software tools including i) customised stereo image processing tools, ii) scene analysis tools that can monitor associated spacecraft data (e.g., viewing directions of stereo images, exterior calibration data, and rover trajectory from sequences of images) with respect to global coordinates, and iii) stereo matching tools with user interactive parameterisation and visual feedback for 3D model generation. The proposed application is expected to help both mission planning engineers and scientists to analyse close range images from rovers in ongoing and future space missions.

Traditional 3D visualisation and 3D display

Visualising 3D data is not a straightforward process without a full 3D display device. Unfortunately, as this sort of device has not been realised at the time of writing, most traditional algorithms synthesise a 2D perspective view by projecting a 3D model onto a single 2D viewing frame. Thus, a current viewing frame needs to be updated continuously whenever the viewing direction changes. In general, this computationally-intensive visualization process is smoothly executed by means of a buffered rendering strategy. For example, a depth buffer (also known as a z-buffer) is searched to identify the occluded part of a 3D model to reduce the

EPSC Abstracts,
Vol. 4, EPSC2009-390, 2009
European Planetary Science Congress,

computational load. Furthermore, a doubly buffered viewing mechanism is used to update a current scene more efficiently, e.g., the next frame of a scene is temporally drawn to a viewing buffer first and then exchanged with a current viewing frame as it is requested. Consequently, viewers hardly notice the delay

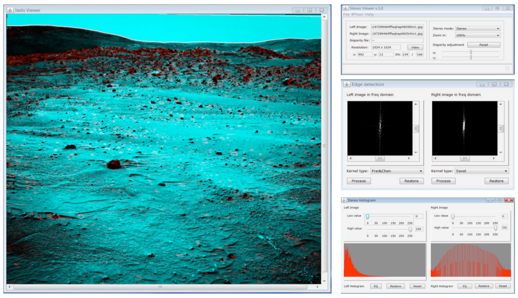

Figure 1 Example for a stereo tool: Two stereo MER images are displayed using anaglyph mode (left); a control window (right top), and two image processing functions

between two viewing frames rather than perceiving this as a continuous motion of a 3D object. However, this rendering method is nothing like a real 3D view and is only possible with a 3D model.

On the other hand, a stereo display has been inspired from biological depth perception, such that if each eye is only stimulated with its own view, the visual cortex subsequently fuses a pair of stereo inputs as if a viewer actually sees a 3D scene. In practice, a stereo display is realised by two display devices for each view with a half-mirror, of which one side is coated by reflective material but the other side has anti-reflective coatings to separate stereo images effectively. Therefore, a stereo display operates in a clone mode to visualise common programme components (e.g. GUI interface) on both displays but an application window accommodating stereo images should display two different views.

When a full 3D model of a scene is available, a stereo display can be exploited to produce a more realistic 3D look-and-feel. For example, each stereo display updates each stereo view when the current viewing direction changes so a viewer can experience a more realistic 3D scene. This viewing strategy is called *3D stereo rendering* and is only available when two double buffers for each view (i.e. a quad-buffer hardware acceleration) are supported.

Stereo tools

The proposed stereo application includes useful tools such as: i) image processing tools (see Fig. 1), ii) scene analysis tool, and iii) stereo matching tools. In particular for the platform independence, this application is wrapped by a JAVA GUI interface and adopts a JAVA 2D rendering engine for simple graphic visualisation. Core algorithms have been implemented using C, C++ and the Intel® OpenCV library to achieve a faster computational time.

Potential applications

The twin rovers of the MER mission include four optical imaging instrument suites [1]. In particular, HazCam captures two pairs of stereo images from front and rear views, and PanCam is able to capture both stereoscopic and panoramic views of Martian the surface. These stereo images can be visualised directly. Also, a wider 3D depth map can be generated by fusing a sequence of NavCam stereo views using the proposed matching tool.

Acknowledgement

This work was supported by the European Community under the Cooperation-Space Work Programme of 7th framework RTD programme.

Disclaimers

This document does not represent the opinion of the EC, and the EC is not responsible for any use that might be made of its content.

References

[1] R. G. Deen and J. J. Lorre. Seeing in three dimensions: correlation and triangulation of Mars Exploration Rover imagery. In IEEE Int. Conf. on Sys. Man and Cyber., Vol 1, pages 911–916, 2005.

[2] D. Alexander and R. G. Deen. MER project: software interface specification. Technical report, Jet Propulsion Laboratory, 2007.

[3] Oleg Pariser and Robert G. Deen. A common interface for stereo viewing in various environments. In Proc. SPIE, volume 7237, 2009