Very high resolution Martian topographic data processing and Its Application for Virtual Reality implementation. Jungrack Kim¹ and Sihyuan Lin², JeongWoo Hong, Dong-In Park, SangYoon Yoon³, YoungHwi Kim⁴Ziin Consulting, Seoul, Korea, kjrr001@gmail.com , ²National Chengchi University, Taipei, Taiwan. lin-tuyuan@googlemail.com, ³Korea Institute of Science and Technology Information, Daejeon, Korea, ⁴Yonsei University, Seoul, Korea

Introduction: The heritage of in-orbit high resolution imaging technology has been implemented in a series of Martian Missions, such as HiRISE (High Resolution Imaging Science Experiment) and CTX (Context Camera) onboard the MRO (Mars Reconnaissance Orbiter). In order to fully utilise the data derived from image systems carried on various Mars orbiters, the generalised algorithms of stereo image processing and photogrammetric Mars DTM extraction have been developed by Kim and Muller (2009) [1]. Due to the successful “from medium to high” control strategy performed during processing, stable horizontal and vertical photogrammetric accuracy of resultant Mars DTM was achievable when compared with MOLA (Mars Obiter Laser Altimeter) DTM. Since the photogrammetric qualities of the stereo topographic products by this approach are verified and the spatial solution can be up to sub-meter scale, they are of great value for Martian Virtual Reality implementation replacing the field trip activities for the geomorphological interpretation. On the other hand, a Virtual Reality (VR) system is also useful to support the scientific research of Martian surface. To these purposes, the DTMs and ortho-rectified imagery obtained from various stereo in-orbital imagery such as HRSC (High Resolution Stereo Camera) of Mars Express, CTX and HiRISE including potential future rovers were processed. Then the topographic data were indigested into a powerful VR system which is provided by Korea Institute of Science and Technology Information (KISTI). As the VR system is established based on high speed parallel processors, high definition 3D display, control pointer and visualisation packages, a full-scale, seamless and real-time visualisation of Mars virtual environment was realised. Therefore, it was proven that the VR scheme implemented in this research will give great opportunities for the scientific researches in geology and geomorphology.

Stereo analysis: The stereo topographic product with the full verified geodetic control is the first essential component for the VR implementation over Martian surface. As the datasets in this research such as MOLA, HRSC, CTX and HiRISE are of various characteristics such as multiple resolution and area coverage, a co-registration of all four sets should be achieved with the first priority. To address this requirement, one of the biggest attractions of HRSC stereo imagery is its positional accuracy as well as co-registration with MOLA with an inherent planimetric accuracy of 25-40 m and a 3D space intersection of up to 6-8m vertical (Speigel, 2007) [2]. This implies that the derived HRSC orthoimage and DTM can be employed as base image data for other much higher resolution optical image’s geometric calibration. Therefore, we have developed a DTM extraction process where HRSC products are first extracted using DLR VICAR photogrammetric routines (see Scholten et al., 2005) [3] and then either CTX followed by HiRISE or HiRISE products alone using the geometric control information from previous products. Then it was combined with two stage stereo image matching scheme which is consist of Zitnick and Kanade (2000) [4]’s algorithms and the Adaptive Least Squares Correlation (ALSC) (Gruen, 1985) [5] to produce the HRSC medium resolution products and CTX, HiRISE high resolution ortho images and DTMs which are composed as the topographic bases of Martian VR. Figure 1 showed the DTM products by this stereo processor over Warrego Valles.

Virtual Reality implementation: The system used for this project is targeted for terabyte scale data visualization from supercomputing. To accommodate varied requirements and provide expected data processing power, the system combines a cluster computer’s architecture with the needs of large scale visualization. Total 90 of InfiniBand connected rendering nodes QuadroFX5600 GPU equipments are main visualization power of the system. For interactive virtual-reality presentation, 16 nodes of 4 core 2 socket Intel Xeon 5450 3.0Ghz system with NVIDIA QuadroFX5600 GPU provides real-time rendering high definition screen. 2 sets of 8 rendering nodes constitute the left and right eye stereo view. 4 of the SONY projectors with 4096 × 2160 resolution
are overlapped to 18% for blending to realize a curvature of the screen, resulting in $7308 \times 2116$ resolution environment in $2 \times 7.2$ meter interactive VR presentation screen. VR navigation has been implemented using RTT DeltaGen (http://www.realtime-technology.com) by realtime-technology AG. The RTT extensively use the cluster computer’s GPU computing power to provide real-time global Illumination and produce a unique visualization environment for typical CAD/CAS based industrial requirements.

To clear the gap between interactive CAD data processing and GeoTiff based topographical image processing, the GeoTiff data from the stereo processor were converted for VR navigation using the Global Mapper. Then the texture mappings were performed using RTT DeltaGen.

**Assessment of VR**: Martian VR implementation is shown in Figure 2. This VR can be evaluated in two aspects 1) the maneuvering of VR, 2) the detailed topography. At first, the 3D maneuvering of Martian surface performed without time lag so that it proved that VR can replace the field trip or simulate the rover movements in the compressed time sequences. In general, the base topographies of VR scene are sufficiently enough for the interpretation of Martian geomorphology. All features which can be interests of the geological interpretation and surface navigation such as meters scale terrace, fractures and small mound are well described. However, if the observer’s point of view come closer to the zero level surface similar to the rover’s stereo camera position, the current resolution of 3D topography is not suitable enough. It means some applications such as the simulation for Martian rover navigation may require higher maximum stereo height point density than current status (<1 point / 1.5m). The visual inspection of rover’s risk elements which may be originated from sub-meter vertical scale features is sometimes not possible with the current stereo heights point density.

The other technical problem is that the commercial S/W of this VR doesn’t accommodate whole topographic data set in one site. In general, the VR commercial S/W manipulates data set as the vector format rather than raster so that it’s only capable of spatial environment implementation up to few square km with HiRISE stereo products which have 1.5 m grid spacing in DTM and 40cm resolution in ortho image. Thus, VRs in this research were established only in the subpart of data extracted by the stereo processor.

the scientific visual technology can be employed to reconstruct virtual Martian surface. There are a lot of 3D visualization products using public domain topographic data sets such as MOLA DTM, HiRISE stereo DTM provided by ASU (Asizona State University). However, it wasn’t implemented over a medium and/or very high resolution topographic products in the geotactically controlled surface that is the essential condition for the quantitative analysis for the scientific research. Therefore, in here we employed a set of geotactically verified topographic products for the VR implantation. Together with the stereo topography, the high speed parallel processors connected with multi beam projectors and 3D pointing devices in our implementation gave the clear merits such as almost realtime movement with a huge topographic input. It is expected that the high speed simulator for the landing site section and rover transversal will be soon constructed over such VR environment after combining close range photogrammetric techniques with the localized rover and lander location.

However, there are currently two unsolved problems in the VR implementation scheme. Firstly, the S/W of VR environment doesn’t support a full set topographic data from the stereo processor. Therefore it has been proposed to employ SEDRIS (Environmental Data Representation & Interchange http://www.sedris.org/) to construct indigenous environment not based on commercial S/W. The merit of the SEDRIS is that all environments such as atmospheric factors, topographic blunders and any other possible situations will be able to synthetically interact with the photogrammetrically constructed topography. Secondly, still the 3D data resolution is not quite enough for some applications. Since the stereo height point density has been reached to the technical limit, it is desired to explore the possibility to employ the multi image shape from shading. The qualities of topographic material are crucial factor for the successful VR application so that we will continuously promote the development of a parallelized and high accuracy topographic processor.

**References**: