Generic stereoscopic tools for planetary topography

Among others, topography is one of the main data that help planetary scientists to decipher alien worlds. Today, the maximum spatial resolution of a Digital Elevation Model (DEM) can only be determined by stereoscopy. For instance, lidar topography is available on Mars at a resolution of 300 m, but stereoscopic DEMs can go up to 50 cm. The typical size of HiRISE data on Mars is ~10 Go per image at full 25 cm resolution. Few numerical software are available (SOCET SET, NASA Ames Stereo Pipeline) but often they are commercial black boxes at very expensive prices, they require manual operation, are very slow on current datasets, and give non optimal results.

The CMLA has acquired over the years a considerable experience in remote sensing, which culminates into the development of the S2P pipeline, which allows to compute a 3D reconstruction from a set of satellite images. The S2P pipeline is well-placed in the small international community of satellite stereo, and rare in its being free software. The program works by cutting the input images into small tiles and feeding these pairs to standard stereo matching algorithms. The final result is obtained by registration and fusion of the all the disparity maps into a single 3D point cloud. This setting allows to test several state-of the art stereo matchers and choose the best one for each situation. One of the most reliable choices turns out to be the “more global matching” algorithm (MGM), developed at CMLA.

The current DEM softwares for planetary science are not up to date and the use of S2P is very promising. Unfortunately it is not possible to use it as is because of the camera models description. On Earth observation spacecrafts, a camera model is provided as a rational function describing the 3D light rays ending in each pixel of the image. S2P relies on these inputs. On planetary observation spacecrafts, the 3D light rays for each pixel must be computed from the spacecraft motion (position, orientation, velocity) as a function of time. The NASA SPICE free software is able to perform this geometry computation. The adaptation of S2P (and also potentially other stereoscopic software) to planetary dataset requires to plug it with SPICE and therefore to remodel completely the S2P chain to work with planetary data.

Team:
Jean-Michel Morel, Professeur, CMLA Centre de mathématique et de leur applications, ENS Cachan (morel@cmla.ens-cachan.fr)
Expertise : Mathematical analysis of image processing

Frédéric Schmidt, Maître de Conférence, GEOPS Géoscience Paris Sud, Université Paris Sud (frederic.schmidt@u-psud.fr)
Expertise: Planetary Science, Mars, Remote Sensing

Carlo de Franchis, post-doctorant, CMLA Centre de mathématique et de leur applications, ENS Cachan (carlo.de-franchis@ens-cachan.fr)
Expertise : Stereoscopy and remote sensing