POLI-MoMA : POtential and LImits of drone imagery to study the MOrpholoy of Martian surface Analogs

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Introduction - Objectives of the mission

Images of analogs of martian surfaces are crucial data (1) to test techniques developed on images acquired by probes around Mars, (2) to test future martian rovers in conditions closest to those possibly encountered on Mars and (3) to study geomorphological features existing both on Mars and on the Earth. (1) Remote sensing techniques are applied on martian images registered by probes in order to map geological features, to detect and measure properties of the surfaces such as roughness and to build Digital Elevation Model from photommetric or photogrammetric methods. (2) Rovers which will operate on Mars are generally tested on the Earth in regions similar to those expected on Mars. Zones where rovers are tested have to be accurately characterized in terms of surface properties (topographic and mechanical) at small scale on areas of some thousands of meters square. (3) Geomorphological feature visible on martian images have to be compared to their terrestrial analogues on images at similar resolution in order to better constrain the surface dynamics and conditions of development. In order to obtain very high resolution images of analogs of martian surface, a campaign of image acquisition has been realized in the desertic South East Morocco by the "Laboratoire de Géologie de Lyon" with the help and under the supervision of the team of the Ibn Battuta Center of the IRSPS from 2 of April 2011 to the 12 of April 2011. This mission was the first experience of DRELIO in arid and dusty conditions.

Material and Methods

The “Laboratoire de Géologie de Lyon” (Université Lyon 1 - ENS Lyon - CNRS) and the “Laboratoire Domaines Océaniques” (Université de Bretagne Occidentale) have built a drone copter for observation of the environment (DRELIO). The copter is a Vario rigidified acrobatic thermic model that rotation speed of blades has been reduced in order to limit vibrations and to increase flight stability. Despite this limitation, the maximum speed reaches 70km.h^{-1}. The total weight of DRELIO is 11 kg. It can transport an additional payload of 6 kg. A professional reflex camera is installed under the copter and is connected to a control station installed on board. The control station pilots the acquisition instruments in terms of starting time and frequency. As it is linked to a GPS, series of specific photographs can be programmed in order to realize multitemporal comparisons from exactly the same point and angle of view. A video camera transfers in real time the images that are acquired. This video is used only to control the swath coverage during the acquisition. A programmable autopilot connected to an atmospheric pressure sensor, an inertial sensor, a geomagnetic direction sensor and a GPS drives and stabilizes the copter during the fly. DRELIO is thus able of fully automatic takeoff, hovering, flight plan following, and landing. DRELIO flight altitude usually ranges from 50 to 200m above the ground. Therefore with 35mm focus lens, pixel size is around 2cm.

In classical conditions, DRELIO flies at 15 km/h at an elevation of 100m above the ground with a period of image acquisition of 2s. Thus, the recovery of successive image is larger than 60% and permits to built Digital Elevation Models (DEM). DEM can be derived using photogrammetric techniques applied on two stereoscopic images. A specific phogrammetric chain has been built, dedicated to the images acquired by DRELIO. This chain uses pairs of stereoscopic images and GPS position of Ground Control Point visible on images to compute high resolution georeferenced DEM. For 2cm resolution images, the average resolution of the DEM is better than 4cm for a planimetric and altimetric precision better than 5 cm. Using the resulting DEM, ortho-images can be computed which are the images corrected from topographic distortion. These DEMS associated to ortho-images enable to calculate topographic properties such as pebble size distributions, roughness etc...

Acquired Data

During the POLI-MoMA mission, 8 flights have been realized on 6 sites for a cumulated fdistance of 19.5 km at an average elevation of 100m. 3800 images have been taken and registered both in JPG format and in Raw format at an average resolution of 3cm. The total surface covered by the images is approximatively of 2km^2. The 8 flight plans have been registered in terms of position and attitude of tea drone. The position of 7 of the flights have been also registered by DGPS. During one flight the DGPS has experienced difficulties and only the GPS signal is readable.

Fight 1 (UTM 30 3360430N 812470E) : The flight 1 has been realized in order to image a debris fan formed by pebbles of various size incised by oueds of metric width and depth. The aim of the flight is to measure the variation of the pebble size on the sedimentary fan.

Flight 2 (UTM 30 3365670N 823730E) : The flight 2 has been realized above a series of connected active oueds which incise decametric hills. These images will be compared to those of Mars.

Flight 3 (UTM 30 3370240N 823730E) : During the flight3, DRELIO has flown above a large oued which bed is occupied by metric pebbles. The velocity of DRELIO has been tested up to 45 km/h.

Flight 4 (UTM 30 3367890N 823816E) : A series of 3 flights with a gap of 1.5 hour between them has been done above a surface covered by peebles of various sizes. The experiment will be used to evaluate the effect of shadows on image analysis.

Fligth 5 (UTM 30 3365810N 823760E) : The aim of this flight is to test the method of photoclinometry. A series of images has been acquired on a hill selected for its albedo homogeneity.

Flight 6 (UTM 30 3408321N 722567E) : The flight has been realized on the area called "Moon 2". The images will be used to test a software able to measure the number of pebbles and blocs.

Preliminary Results

Ten pairs of images have been selected and treated in order to extract the corresponding DEM and the associated orthoimages. The figure 1 shows an example of the DEM of the oueds (flight 2).

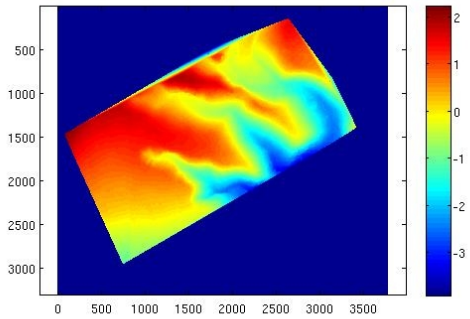

figure 1 : Digital elevation model in relative scale of the head of the Oueds imaged during the flight 2.

Conclusion

During the POLI-MoMA mission, the drone DRELIO has taken more than 3800 images on 6 different areas. We have demonstrated that these images can be used to compute Digital Elevation Models and ortho-images at a resolution better than 4cm. These images will be treated in the next weeks to elaborate a series of geo-referenced DEM and ortho-images.