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Towards photometry of Europa

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Abstract

Exploring the icy satellites of outter planets is a major step in the search for habitability in our Solar System. This work focuses on Jupiter's icy moon Europa and the images captured by the Long-Range Reconnaissance Imager on-board the New Horizons spacecraft. It is aimed at combining images of the satellite in order to derive photometric reflectance models (i.e. angular response of a surface). It will later be extended to the other two icy Jovian satellites, Ganymede and Callisto and larger data sets.

1. Context

Europa is a prime candidate for habitability in our Solar System. The surface of the moon is the youngest of the Jovian icy satellites. It appears to be continiously renewing by an expanding crust [1]. This activity may be driven by a global water ocean [2] for which more and more evidence seems to be advocating, the latest being the observations of possible water plumes with the Hubble Space Telescope [3].

The JUICE (JUpiter ICy moons Explorer) mission from the European Space Agency (ESA) is to be lauched in 2022 and arrive at the Jovian system in 2030 to study Jupiter and its icy moons for three and a half years. The spcacraft is being designed by Airbus Defence & Space in Toulouse, France, with a very innovative navigation system. Any mission to the outter Solar System is challenging considering local radiative and thermal conditions as well as the distance to the Earth. This new way of navigating aims at making spacecrafts more autonomous and is based on extracting navigation data from on-board image processing [4]. For that algorithm to be successful, the spacecraft needs to have very realistic models of its targets - namely Jupiter's icy moons. This work is starting with combining existing images of Europa to make them comparable as a first step towards deriving reflectance models.

2. Data set

This work is focused on the most recent mission to have encountered the Jovian moons - New Horizons. On its way to Pluto, the spacecraft spent three months observing Jupiter and its moons in 2007 with the LORRI (LOng-Range Reconnaissance Imager) camera [5]. Combining all the images captured during the Jupiter phase of the mission, the whole surface of Europa is accounted for.

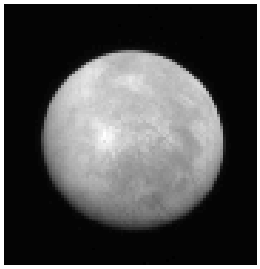

Figure 1: Example of a LORRI observation

By comparing New Horizons images of Europa to simulations based on the available geometry and attitude meta-data from SPICE kernels, it was found that imprecisions in meta-data [4] resulted in considerable errors when associating pixels to their coordinates on the moon. The first step is therefore to improve the meta-data as much as possible to have a coherent data set.

3. Method

Images are compared two by two to ensure that when looking at a common part of the moon, two images are matching. By considering one image as the reference, each pixel of the second image needs to be projected onto the moon to estimate its coordinates (Fig. 2).

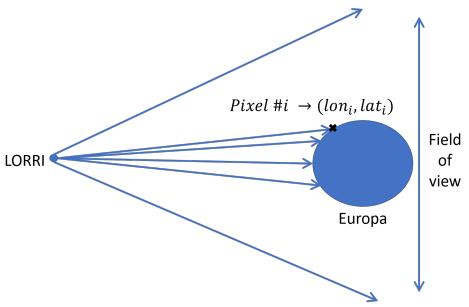

Figure 2: Schematic view of projecting pixels on moon

Step by step the global map of the moon will be reconstructed. Moreover, since all images are taken with different geometries (incidence, emergence and phase angles), it will be possible to determine the photometric behavior of the moon.

4. Conclusion

Next steps will include extracting information from the reflectance variations at the surface and the global photometry. This will also be an opportunity to estimate the structure of the moon's surface - for instance its micro-texture - as it has been done on Mars [6].

In addition, the available data set of past missions is quite rich. Galileo studied the Jovian system for seven years between 1995 and 2002. Cassini also briefly captured images of the icy moons in 2001. We plan to extend our work to these data sets. The same methodology should also be applied to the other two Jovian icy moons: Ganymede and Callisto.

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