PROTOTYPING A GENERALISED SPICE C-KERNEL C-SMITHING METHOD: APOLLO 15 XRFS POINTING FROM IMAGES. A. Escalante[1], M. Costa[2], [1]ESA/ESAC Camino Bajo del Castillo s/n, Ur. Villafranca del Castillo, 28692 Villanueva de la Canada, Madrid, Spain, alfredoescalante95@gmail.com.

Introduction: Precise Spacecraft attitude is often not directly available for planetary missions yet is necessary for some high-precision science applications. A method for systematically reconstructing the attitude of the spacecraft by comparing simulated images generated with SPICE and actual observations is presented. Using the images from the Apollo 15 Mapping camera [1], this method has been used to improve the accuracy of the computed attitude information of the CSM (Command and Service Module) as obtained for the pointing of the XRFS (X-Ray Fluorescence Experiment).

SPICE scenario: SPICE is an information system which uses ancillary data to provide Solar System geometry information in order to analyze scientific observations from space-born instruments [2], [3]. In the presented method, SPICE is the basis on which the tool is built, containing the required mission geometric information as S/C and target body positions; high-precision target body orientation; initial guess of S/C attitude; instruments parameters (FOV, boresight, pixels) and shape model of the target body. SPICE subroutines provide a fast way of manipulating these geometric data, which after configuring the scenario, will be used to generate the simulated images.

Simulated Images generation: Prior generating the simulated images that the tool will use to compare with the actual observations, a few considerations must be taken into account. The first is that either the limb of the target body or features on the surface must appear in the observations, otherwise the tool would have nothing to compare between images. The second one is that the maximum accuracy achievable with this method is given by the pixel size.

In order to generate the simulated images, a grid of vectors is defined, each vector corresponding to one pixel of the instrument sensor. This grid is defined in the reference frame of the instrument. Knowing the pixel size and pixel samples (IK), the grid of vectors is defined in such a way that the origin of all vectors is the focal point of the sensor and the endpoint of each of them are the coordinates of each sensor pixel, with the boresight of the sensor at the center of the grid. Considering that the SPICE scenario knows the relation between involved reference frames (FK), the previous grid of vectors can be expressed with respect to a Moon body fixed frame, the intersection of these vectors with a digital shape model of the surface can be computed with SPICE routines. Finding these intersections and computing the corresponding solar angles from the geometry of the mission, after some processing the simulated image is obtained.

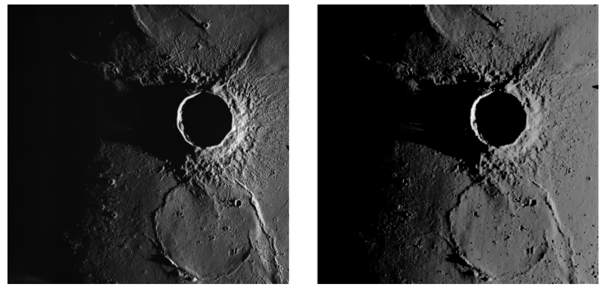

Figure 1: Example of Real (left) and Simulated (right) images

Processing of Images: Ultimately the attitude correction is computed by means of an optimization process, nevertheless, once the simulated images are obtained, both these ones and the actual observations should undergo some pre-processing to facilitate the job of the optimizer. These first manipulation include, filtering by minimum/maximum light values; simplifying both images assigning only binary values to each pixel based on illumination criteria; and initial displacements of the simulated images.

Finally, the optimization process minimizes the cost function, defined as the number of non-zero pixels in the image resulting of subtraction of simulated and real images. The optimization parameters are contained in the displacement vector, composed by columns pixel displacement; rows pixel displacement and rotation about the boresight of the sensor. After optimization, these parameters can be easily transformed to a quaternion of attitude correction. Knowing the fixed angular separation between XRFS and Mapping camera, the pointing of the instrument can be determined with improved accuracy.

Considerations: This technique is still under development. It has already been used providing good results not only for Apollo 15 mission but for Rosetta NAVCAM and OSIRIS images. Still, some improvements are pendant so the tool is able to deal with other types of mission, to mention; target bodies with non-black and white albedo or atmospheric effects.

References: [1] Apollo Image Archive, ASU, http://apollo.sese.asu.edu/index.html. [2] Acton C. (1996)

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