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Robust Detection of Round Shaped Pits Lying on 3D Meshes: Application to Impact Crater Recognition

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Most celestial bodies display impacts of collisions with asteroids and meteoroids. These traces are called craters. The possibility of observing and identifying these craters and their characteristics (radius, depth and morphology) is the only method available to measure the age of different units at the surface of the body, which in turn allows to constrain its conditions of formation.

Interplanetary space probes always carry at least one imaging instrument on board. The visible images of the target are used to reconstruct high-resolution 3D models of its surface as a cloud of points in the case of multi-image dense stereo, or as a triangular mesh in the case of stereo and shape-from-shading.

The goal of this work is to develop a methodology to automatically detect the craters lying on these 3D models. The robust extraction of feature areas on surface objects embedded in 3D, like circular pits, is a challenging problem. Classical approaches generally rely on image processing and template matching on a 2D flat projection of the 3D object (i.e.: a high-resolution photograph). In this work, we propose a full-3D method that mainly relies on curvature analysis. Mean and Gaussian curvatures are estimated on the surface. They are used to label vertices that belong to concave parts corresponding to specific pits on the surface. The surface is thus transformed into binary map distinguishing potential crater features to other types of features. Centers are located in the targeted surface regions, corresponding to potential crater features. Concentric rings are then built around the found centers. They consist in circular closed lines exclusively composed of edges of the initial mesh. The first built ring represents the nearest vertex neighborhood of the found center. The ring is then optimally expanded using a circularity constrain and the curvature values of the ring vertices. This method has been tested on a 3D model of the asteroid Lutetia observed by the ROSETTA (ESA) space probe. The so-obtained results have been compared with a manual detection provided by a planetary scientist expert in the visual identification of craters.