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Extraction of "best fit circles" on 3D meshes based on discrete curvatures: application to impact craters detection

Florian Beguet (1), Sarah Bali (1), Nicole Christoff (1,5), Laurent Jorda (2), Sophie Viseur (3), Sylvain Bouley (4), Agata Manolova (5), and Jean-Luc Mari (1)

(1) Aix-Marseille Université, CNRS, LSIS UMR 7296, Marseille, France (florian.beguet@etu.univ-amu.fr,sakina-sarah.bali@etu.univ-amu.fr, nicole.christoff@univ-amu.fr, jean-luc.mari@univ-amu.fr), (2) Aix-Marseille Université, CNRS, LAM UMR 7326, Marseille, France (laurent.jorda@lam.fr), (3) Aix-Marseille Université, CNRS, IRD, CEREGE UM 34, Marseille, France (viseur@cerege.fr), (4) Université Paris-Sud, CNRS, GEOPS UMR 8148, Orsay, France (sylvain.bouley@u-psud.fr), (5) Technical University of Sofia, Bulgaria (amanolova@tu-sofia.bg)

Impact craters is a typical feature observed at the surface of most bodies in the solar system: terrestrial planets, their satellites, asteroids and even possibly cometary nuclei exhibit impact craters. Their spatial density yields the estimation of the age of the surface, a key parameter required for subsequent geological studies.
With the development of interplanetary missions, a large number of solar system objects have been mapped at a high spatial resolution, emphasizing the need for new automatic methods of crater detection and counting. In this work, we present such a method using a new approach based on the analysis of reconstructed 3D meshes instead of 2D images.
The robust extraction of feature areas on surface objects embedded in 3D, like circular shapes, is a challenging problem. Classical approaches generally rely on image processing and template matching on a 2D flat projection of the 3D object (for instance a high-resolution picture).
In this paper, 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. Centers are located in the targeted surface regions, corresponding to potential crater features. Then "best fit circles" are extracted, based on the rims of the circular shapes. They consist in closed lines exclusively composed of edges of the initial mesh. This approach has been applied to the detection of craters on the asteroid Vesta.

Keywords: geometric modeling, 3D meshes, shape recognition, mesh processing, discrete curvatures, asteroids, crater detection, geology, geomorphology.