

Size and Spatial Distribution of Rock Particles on Small Bodies Revealed with CNN-based Algorithm

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As the number of small body exploration increases, the amount of science data obtained is expanding. Analyses of that data have yielded an unprecedented amount of knowledge about small bodies, and especially unexpected surfaces of small bodies covered by numerous rock particles have been revealed by high-resolution images [e.g., 1]. The size/shape/spatial distribution, sorting, and direction of rock particles have led us to discuss the origins and surface processes of small bodies [2, 3, 4]. Analysis of rock particles is also critical for landing missions to avoid hazardous objects [5], resulting in the growing demand for identifying countless rock particles. In many cases, the identification of particles has been manually conducted by fitting ellipses to the profile of particles. The profiles are generally blurred and difficult to be distinguished from the background due to irregular particle shapes, overlapping particles, image resolution limits, which makes the analysis time-consuming and difficult to be reconducted, leading to the lack of reproducibility. Therefore, a method to analyze a massive amount of rock particles with objectivity and reproducibility has to be established. Here, we develop the computational approach for the automated identifications of rock particles based on the image feature extraction algorithm, the convolutional neural networks (CNNs). We prepare images of the simulated surface of small bodies in a laboratory, and then carefully identified thousands of particles. Using the data of profiles, we trained the model, enabling nearly 90 % of profiles of particles to be correctly traced without the aid of manual analysis. Moreover, by using the model, rock particles on the global surface of asteroid Itokawa are mapped, revealing the size and spatial distribution of particles. The approach of this study can rapidly identify numerous particles, which can be a promising tool for analyzing countless images of the surface of small bodies taken by the current and future small body exploration missions.

References

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