論 文 の 内 容 の 要 旨

論文題目

「Automatic Crater Detection using Segmentation Convolutional Neural Networks
(セグメンテーション畳み込みニューラルネットワークによるクレーター自動検出)」

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Convolutional Neural Networks (CNN) offer promising opportunities to automatically glean scientifically relevant information directly from annotated images, without needing to hand craft features for detection. Crater counting started with hand counting hundreds, thousands, or even millions of craters in order to determine the age of geological units on planetary bodies of the solar system. Automated crater detection algorithms have attempted to speed up this process. Previous research has employed computer vision techniques with hand crafted features such as light and shadow patterns, circle finding, or edge detection. This research continues, but now some researchers use techniques like convolutional neural networks that enable the algorithm to develop its own features. As the field of machine learning undergoes exponential growth in terms of paper count and research methods, the crater counting application can benefit from the new research, especially when conducting joint interdisciplinary projects. Despite these advancements, the crater counting community has not yet adopted standard methods for automating the process despite decades of research. This research enumerates challenges for both planetary geologists and machine learning researchers, looks at the recent automatic crater detection advancements using machine learning techniques (primarily in methods using CNNs), and makes recommendations for the path toward greater automation.

Machine learning segmentation techniques show great promise for automating crater counting. Developing effective segmentation neural networks for this task involves multiple design choices in the network architecture and training set preparation. This research evaluates

two target types, measures the impact of hyperparameters (kernel size, filters), and varies the amount of data used to train the models from using 3 to 15 of the 24 tiles. (Each tile is 30º by 30º and is within ±30º latitude.) The algorithm is trained using annotations of 2-32 km radius Martian craters and THEMIS Daytime Infrared (IR) Global Mosaic tiles. Pixel-based machine learning metrics like loss and accuracy are used during training and validation. In addition, crater count metrics such as recall (match ratio), precision, and F1 score are used to evaluate the performance and for model selection. The results innumerate how incorporating machine learning into the crater counting process is beneficial to planetary geologists: for example, by creating a list of craters in a region or suggesting potential degraded craters for further analysis. A segmentation network using convolutional neural networks is successfully implemented to find 65-76% of craters in common with a human annotated dataset, which is shown to obtain comparable ages of nine diverse regions.