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MARTIAN CRATER CLASSIFICATION USING LIGHTGBM

Abstract

The study of Martian crater morphologies and distribution plays an important part in understanding the solar system's geological history. However, crater classification is a time-consuming process that requires manual labeling of an ever-increasing supply of images from previous and current missions. Recent works have proposed using deep learning-based techniques to automate the classification process. However, deep learning methods must be trained using vast labeled datasets to achieve acceptable accuracy. Furthermore, due to their complex architectures, deep learning methods are slower than other methods, such as gradient-boosting machine learning, which recently emerged as efficient alternatives to deep learning. This work proposes Light Gradient Boosting Machines (LightGBM) combined with Principal Component Analysis (PCA) as a lightweight alternative to deep learning to classify craters from other miscellaneous Martian surface features. The Martian surface images considered in this work were taken by the High-Resolution Imaging Experiment (HiRISE) onboard the Mars Reconnaissance Orbiter. The balanced dataset used for training the LightGBM model consisted of 1,500 manually labeled images, with 750 of them being craters and 750 being other features such as dunes and slope streaks. To optimize the performance of the LightGBM model an exhaustive search was conducted to find the optimal number of principal components and optimal hyperparameters that maximize classification accuracy. As a result, the optimized LightGBM model achieved a classification accuracy of 0.893, an F1-score of 0.891, and an Area Under the Receiver Operating Characteristic Curve (ROC AUC) of 0.893. In the paper, a detailed explanation of the proposed methodology including the experimentation carried out to validate the technique will be provided.