# Evaluation of deep learning for identifying lunar swirls

*鳴澤 将来[1]、加藤 裕明[1]、小川 佳子[1]、平田 成[1]、出村 裕英[1]、林 洋平[2]、大竹 真紀子[3]

*Narusawa Masaki[1], Hiroaki Kato[1], Yoshiko Ogawa[1], Naru Hirata[1], Hirohide Demura[1], Yohei Hayashi[2], Makiko Ohtake[3]

1. 公立大学法人会津大学、2. 国立情報学研究所、3. 宇宙航空研究開発機構 宇宙科学研究本部 固体惑星科学研究系
1. The University of Aizu, 2. National Institute of Informatics, 3. Department of Planetary Science, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

Lunar swirls are sinuous patterns of anomalously high albedo features on the lunar surface. They have irregular shapes, distributions and various spatial scales. More than 10 swirls have been discovered so far. However, the origin of these enigmatic features is still under discussion. We expect there will be yet other swirls and finding of them will contribute to understand their origin.

The lunar swirls are light/shade patterns with no differences in elevation. Therefore, the point to survey lunar swirls is to distinguish them from the features due to topography. In previous studies, lunar swirls were basically specified visually by comparing camera images with digital elevation model (DEM). However, visual inspection takes a long time, and the criteria of identifying lunar swirls could be ambiguous. We search for lunar swirls and try to find them of small-medium size especially. We introduce deep learning to find new swirl candidates, which could not have been recognized at the visual level. The complex characteristics of lunar swirls should be "described" by deep learning and makes it possible to identify them automatically.

The used data are the "combined image" integrating two kinds of information: camera image and DEM, where each data layer is allocated to R and GB bands within a single image, respectively. The Multi-band Imager (MI) data from Kaguya satellite are used as camera data and the data of SLDEM2013 are used as the DEM data.

This study attempts five different ways in preparing training data set so as to make five different leaning models correspondingly. We focus on evaluation of these deep learning models. The basic set of training includes all the representative features of the Moon, such as craters, mountains, rays, graben and swirls. The second dataset of training data are prepared with higher resolution by two times compared with the basic set. The other three data sets of training data are adjusted so that the training data of images from MI and/or SLDEM2013 cover(s) the same dynamic range, respectively. The test area is set in the range of 20°- 50°S, 150° - 180°E around Mare Ingenii on the Moon. The each learning model is evaluated based on the confusion matrix and accuracies and compared to each other.

As results, we found that the accuracy of judging lunar swirls is not so much different between the five models (more than 0.75). However, the accuracy of judging not- swirl features shows diversity ranging 0.15-0.69. The performance of identifying swirls should be the total consideration of the both accuracies. The training set of images with constant dynamic range seems to decrease the learning performance. The models based on such training data may have very strict criteria for non-swirl features. We may need to verify the possibility of over-learning and also try to increase the variety and/or number of training data. At this stage, the training data set of higher resolution images makes better learning model and seems the most useful for identifying lunar swirls.