Automatic detection of lunar sub-km craters via deep learning

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Crater chronology is a method that estimates generated age on surface of a body from size-frequency distribution (SFD) of impact craters. Coordinates and diameter are needed for computing SFD, and measurement accuracy of crater information is factored into the estimation accuracy of crater chronology. So, highly accurate crater information is important for discussing evolution process of the lunar surface. We can sufficiently detect smaller than 1km craters because spatial resolution of lunar observation data is improved, for example, resolution of Terrain Camera (TC) ortho data is 7.4m/pixel to 10.0m/pixel. TC ortho data were generated by SELENE observation data. However, manually detecting sub-km crater take an immense amount of time because number of crater is increase exponentially with decreasing crater diameter. For solving these tasks, automatically crater detection algorithms (CDAs) have been studied. Goal of these studies is to generate high accuracy crater information enough to apply crater chronology. For detecting martian craters from high resolution (12.5m/pixel) panchromatic imagery that was captured by High Resolution Science Camera aboard Mars Express spacecraft, Joseph et al. (2016) proposed a CDA with Convolutional Neural Network (CNN). CNN is part of deep learning methods. By designing the neural network architecture that has more multi layers, deep learning can represent the data more abstract. From supervised data, deep learning can learn optimal features that are needed for feature extraction process and data identification process. Especially, CNN keeps high performance in the field of computer vision (for example, image recognition, sound recognition). Joseph et al., (2016) reported that results of crater detection by using CNN get more high performance than other CDAs (Bandeira et al., 2010; Urbach and Stepinski, 2008).
Purpose of this research is to entertain sub-km CDA by using CNN with TC ortho imagery. By using high resolution imagery, to be able to detect smaller craters than before will be expected. A part of important things for deep learning is to prepare many supervised data. In this research, by detecting craters in manually, we prepared a crater dataset that includes 185 m to 1 km in diameter craters on Mare Imbrium(footprint of a TC ortho image: TCO_MAPm04_N24E333N21E336SC). The TC ortho image was divided into 3 regions (north, center and south). The crater datasets was detected by manually. The center region and the south region were used for learning, and the north region was used for evaluation. Input data for CNN were small patches that were cropped based on each crater diameter, and all patches were scaled 15 x 15 pixel. Positive sample is that craters are included, and negative sample is that craters are not included. In fact, CNN learned classifier task that "are there craters in a patch or not?" In this result, patch based classification accuracy was over 90 %. Additionally, we tried image based classification (crater detection from a part of north area image). In this result, CNN could detect position of craters, but could not detect shape and there were many false detections about object that has similar features to craters.

Keywords: Deep Learning, Crater Detection

