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Automatic Detection of Lunar Craters Based on DEM Data with the Terrain Analysis Method

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Abstract Impact craters are the most obvious tectonic landform unit on the lunar surface and are highly significant in the study of lunar geomorphic features. Currently, the mainstream automatic detection algorithms used to identify lunar impact craters represent the craters as circles, which does not accurately reflect their true shapes, making it difficult to measure characteristics such as circularity and diameter. In this study, morphology of lunar craters were analyzed based on 100m resolution digital elevation models (DEM), and a new crater detection algorithm (CDA) is proposed by extracting higher change rate of slope of aspect (SOA) values at crater rims. Then, the neighborhood mean algorithm and reclassification method are used to obtain the positive terrain, which can filter the noises of non-crater rims. Finally, complete and true impact crater boundaries are obtained using a morphological treatment, and further denoising is simultaneously conducted. The results of experiments in the D'Alembert (lunar highland) and Serenitatis (lunar mare) areas show the following: Compared with the LU60645 crater catalog, the factors for our algorithm were: detection percentage (D) were 89.9% and 89.5%, branching factor (B) were 0.1 and 0.05, and quality percentage (Q) were 82.2% and 85.9%, respectively. Compared with the other algorithms, the Q and the B in the proposed CDA are better than those. It shows that the proposed algorithm maintains a relatively low false detection rate while maintaining a higher correct detection rate. Moreover, the extraction results closely correspond to the natural forms.

Keywords: Lunar crater; DEM; Automatic detection; Terrain analysis method

1. Introduction

The Moon is earth's closest natural satellite and an outpost of humanity's space exploration. China and international lunar exploration projects have made great progress in detecting the lunar surface topography (Araki et al., 2009; Haruyama et al., 2009), analyzing its material composition (Grande et al., 2009; Ohtake et al., 2009), and detecting the spatial environment (Nishino et al., 2009). These achievements have had profound influences on lunar science.

Research concerning lunar geomorphology has always been a core topic of lunar exploration, and craters are the most typical geomorphic unit on the lunar surface. Moreover, the density index of craters can reflect the relative geologic ages of lunar surfaces (Neukum et al., 1975; Van et al., 2016), a crater's morphological characteristics, such as depth, can be used to estimate the lunar regolith thickness (Di et al., 2016; Stopar et al., 2017), and the spatial distribution of craters can be used to accurately approximate the relative order of lunar geologic events (Craddock et al., 1997). Therefore, the study of lunar craters can provide important breakthroughs for the investigations of lunar geomorphology. Researchers have been exploring the important aspects of impact craters for a long time; however, such craters are numerous. Therefore, for works such as that of Salamunićcar, who used laser altimeter data to integrate across the lunar crater catalog

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