Lunar Exploration (2)
Lunar Exploration (1) (1)

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DEEP SEMANTIC CLASSIFICATION OF VISUAL INPUTS FOR HAZARD FREE LUNAR LANDING

Abstract

The vision-based navigation, hazard detection and avoidance are key technologies for a safe landing on planetary surfaces. Conventional approaches dealing with the said problem requires that the digital terrain maps are generated from the high-resolution images of the Moon's surface. From these images, the digital elevation map (DEM) of each geographical viewpoint is derived and this DEM is used to predefine the future landing site. It requires extensive processing and does not guarantee precise landing on unknown terrain. This paper deals with the autonomous lunar landing problem by incorporating deep neural networks for classifying landing areas into hazardous and hazard-free categories. The detection of landing hazards is based on a real-time understanding of underlying terrain using visual inputs from onboard sensors. Hazard detection is achieved in two steps, firstly an input image is segmented to distinguish between different objects in the scene and, secondly the detected objects are classified into hazards if found hazardous by comparing with trained model parameters. In effect, the craters, boulders, and plane area of the scene are separated using semantic segmentation. After that, a binary classifier is used to identify the hazardous components of the terrain. This will guide spacecraft in its descent trajectory planning. A typical guidance trajectory of lunar descent starts at an altitude of around 25 km from the ground. The proposed hazard detection system will be operational below an altitude of around 1 km to study the unknown terrain. In case, any hazard is detected the spacecraft will be retargeted to a potentially safer landing site. Furthermore, the hazardous craters and boulders exhibit different sizes, shapes and hence may or may not be severe for landing. If a hazardous object is found which is not severe, the system may unnecessarily switch to retargeting phase which is a false alarm. To avoid this false retargeting, the level of severity is further quantified using the fuzzy membership function. Fuzzy membership finds the percentage of the severity of the hazards concerning the entire scene. This helps in not only detecting the hazardous areas of the terrain but also in finding the severity of those hazards. Depending upon the severity and the total contribution of hazards in the underlying scene, the magnitude and direction of control guidance commands for further navigation will be decided. Experimental results show that the combined approach for hazard detection outperforms conventional methods with more than 90% accuracy.