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AUTONOMOUS PERCEPTION AND TERRAIN RECONSTRUCTION OF UNSTRUCTURED LUNAR COMPLEX ENVIRONMENT: A REVIEW

Abstract

Lunar surface patrol and exploration is an important way to carry out scientific exploration activities of the extraterrestrial moon. In the lunar exploration programs of various countries, the lunar rover has become an important part of patrol exploration missions. Its functions mainly include: moving scientific instruments, expanding the detection range, and selecting the landing point of the project. However, the unstructured lunar environment brings challenges to the patrol and exploration missions. Due to the continuous impact of meteorites and solar wind radiation on the lunar surface, the lunar surface is soft and complex in shape. Compared with the earth environment, the lunar environment is full of uncertainty, which requires that the lunar rover must have certain functions such as environmental awareness, high-precision positioning, autonomous obstacle avoidance. The lunar rover needs to use autonomous terrain perception and three-dimensional (3D) reconstruction techniques to complete the given missions in the unknown lunar surface environment.

The technology has been developed for decades and researchers also have done lots of work in indoor and outdoor environments. But its application in the large-scale, unstructured, complex lunar surface environment is still in the stage of research and exploration. To this end, this paper summarizes the existing autonomous terrain perception and reconstruction technology in the lunar environment. The works of four sub-techniques of lunar autonomous terrain perception and 3D reconstruction are analyzed firstly, including topographical characteristics perception, obstacles detection and recognition, environmental map representation and 3D terrain reconstruction. Then, this paper introduces the problems and challenges of the existing technology applied to the lunar surface environment, such as unstructured lunar environment, uncertainty of perceived information, complexity of data processing algorithm and immature sensor technology. Finally, the article also points out the future development trends and efforts of autonomous terrain perception and reconstruction technology: multi-robot collaboration, multi-sensor fusion, dynamic simultaneous localization and mapping (SLAM) method and combining with artificial intelligence.