IAF SPACE EXPLORATION SYMPOSIUM (A3)
Virtual Presentations - IAF SPACE EXPLORATION SYMPOSIUM (VP)

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MOTION PLANNING FOR QUADRUPED ROBOT WALKING ON LUNAR ROUGH TERRAIN

Abstract

Lunar exploration robots are utilized to conduct landing area inspection, resource detection and other tasks. As there are diverse specific terrains on the moon, such as moon sea and craters, how the robots move efficiently on the lunar rough terrain is worth to be first studied.

This paper focuses on the motion planning for a quadruped robot walking on the lunar rough terrain. Firstly, the detailed terrain data of the detection area acquired by the navigation camera is filtered, and afterwards the terrain is triangular meshed. Then, the reinforcement learning method is used to plan the path in the grid-based environment and therefore determining the detection route of the robot. Finally, gait planning is carried out to make the robot legs actuate in a certain order.

Terrain features are firstly extracted by selecting the data points that satisfy the curvature threshold conditions. Thus, the general fluctuations are approximately reflected by less scattered points. Then adjacent equilateral triangles for terrain segmentation and interpolation are plotted with optimal shape preservation. In particular, the difference between the interpolated height and actual height of the data points is characterized as the roughness of the terrain.

In the triangular grid-based environment, autonomous intelligent path planning of the robot is performed with Q-learning. This method uses the degree of terrain fluctuations and roughness as rewards, and substitutes them to the Q-learning algorithm as feedback schemes for Q-value iteration. The robot selects the directions of movement to maximize Q-values, and an optimal safe and low-fluctuated path can be eventually generated.

The quadruped robot walks along the planned path using a crawling gait. Each leg switches between the one-leg swing phase and the three-leg support phase. For the swing leg, the foot-end trajectory is planned based on the polynomial method and local obstacle avoidance optimization. Meanwhile, other

legs are actuated to adjust the posture of the trunk to fit in the terrain fluctuations and route changes. Every joint angle of the robot is derived by inverse kinematics.

Numerical simulations illustrate the walking process of the quadruped robot, where the lunar rough terrain is reconstructed as a simplified triangular grid model with terrain features retained. The result shows that the robot can learn the optimal path with less trunk undulations. The gait is continuous and stable, which proves that the motion planning method can effectively improve the mobile stability and adaptability of the robot walking on the lunar surface.