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A MULTI-ROBOT LUNAR AREA COVERAGE METHOD BASED ON REINFORCEMENT LEARNING

Abstract

With the continuous exploration of the universe, the application of multi-robot systems in space missions has become increasingly common. When exploring celestial bodies such as the Moon, area coverage is a key task that requires multiple robots to cover as much area as possible on the lunar surface. However, the complex terrain and environmental uncertainty of the lunar surface make traditional area coverage methods difficult to achieve effective coverage. Therefore, this paper proposes a reinforcement learning-based multi-robot lunar surface area coverage method. The method is based on the Q-learning algorithm and uses a reinforcement learning-based multi-agent system to train robots in simulation environment to achieve lunar surface area coverage.

The proposed method includes two phases: a training phase and an execution phase. In the training phase, robots learn a policy to maximize the lunar surface area coverage and use the Q-learning algorithm for reinforcement learning. Specifically, we use the state information of each robot, such as position, direction, and speed, as the state space, and define a set of actions, including moving forward, left, right, and staying still. Each robot's strategy is continuously optimized during the training process to maximize coverage and avoid collisions.

In the execution phase, robots execute movements based on the learned policy and current state to achieve lunar surface area coverage. Based on the ROS (Robot Operating System) and Gazebo platform, the simulation environment for the execution phase includes the lunar surface terrain, communication, and collision detection between robots. Robots move in the simulation environment and obtain surrounding environmental information through sensors. Communication between robots can transmit state and control information to collaborate in completing tasks. When robots encounter obstacles, they will automatically bypass them to continue moving to adapt to environmental changes.

To evaluate proposed method, we used different numbers and configurations of robots in the experiments, and took the coverage rate and collision frequency as evaluation metrics. The results show that compared with traditional methods, the method can significantly improve lunar surface area coverage and reduce collisions between robots. In the future, we will further optimize the algorithm to achieve more efficient and intelligent lunar exploration tasks.