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RESEARCH ON THE "MARS ROVER-QUADROTOR" COMBINED DETECTION SYSTEM BASED ON DATA-DRIVEN CONTROL

Abstract

Mars, a planet in the solar system that is relatively close to Earth and shares a similar natural environment, has always been the preferred target for human exploration beyond the Earth-Moon system. Currently, Mars rovers serve as the primary agents for surface exploration on Mars. However, on the Martian surface, far from Earth, rovers may encounter unknown and complex working environments. Additionally, they are constrained by varying conditions such as energy and communication, as well as harsh environmental factors, which limit their mission range and efficiency. Therefore, there is a need to seek a more autonomous and efficient combined exploration solution. In this regard, this study designs a "Mars Rover-Quadcopter" combined exploration system. The quadcopter drones in this system provide various services to the Mars rover, including reconnaissance, auxiliary navigation, and fault diagnosis. Meanwhile, the Mars rover serves as a platform for quadcopter drone recharging, ensuring their endurance. However, the implementation of this system must address the challenge of safe landing of quadcopter drones on the Mars rover platform. This involves predicting key factors such as the landing location, velocity, and pitch angle of the quadcopter drone during the rover's movement, as well as achieving high-precision control of its own motion. Firstly, to address the former, this study introduces a long short-term memory recurrent neural network into the combined exploration system to predict the required key parameters. The predicted values are then used as the expected values for the drone's tracking control, ensuring automatic and safe landing. Secondly, considering the inaccuracies in system modeling and unknown environmental disturbances, this study leverages the unique advantages of model-free adaptive control (MFAC) based on data-driven control. It combines MFAC with the hyperbolic tangent sliding mode control algorithm (HTSMC) to design the MFAC-HTSMC controller, achieving accurate control of the quadcopter by complementing each other's strengths. Finally, simulations are conducted using the predicted values as the expected values for tracking control. The results demonstrate the capability to achieve safe and precise landing control of quadcopter drones on the Mars rover platform. Furthermore, after comparing with HTSMC and PID-HTSMC algorithms, it is concluded that the proposed control algorithm in this study, while ensuring system stability, facilitates convenient adjustment of parameters in the combined system, enhances system accuracy and robustness, and improves controller tracking performance. The proposed "Mars Rover-Quadcopter" combined exploration system significantly enhances space exploration efficiency and provides a feasible solution for Mars exploration.