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Author: Dr. mahya ramezani
University of Luxembourg, Luxembourg

Dr. Mohammad ali Amiri Atashgah
University of Tehran, Iran
Dr. Alireza Rezaee
University of Tehran, Iran
Prof. Holger Voos
University of Luxembourg, Luxembourg

ENHANCED MADDPG WITH ENERGY AWARENESS FOR COOPERATIVE PATH PLANNING OF UAV AND UGV ON MARS

Abstract

In this study, we investigate the synergistic application of Unmanned Aerial Vehicles (UAVs) and Unmanned Ground Vehicles (UGVs) for the exploration of Mars' surface. Our primary aim is to devise an efficient path planning strategy to reach predetermined targets amidst the planet's challenging conditions, characterized by rugged terrain, extreme weather, and dynamic environmental elements, such as pervasive dust storms. These factors significantly elevate the operational risks, especially for UAVs, which play a critical role in mitigating perceptual limitations imposed by Mars' landscape. A key consideration in our approach is the sustainability of UAV operations, focusing on battery life and energy consumption to ensure their long-term functionality, emergency management capabilities in case of dust storm in mars. To address these challenges, we have developed an autonomous path planning algorithm that optimizes the collaborative exploration and task execution of both UAV and UGV. The innovation lies in a decision-making algorithm tailored for the UAV, ensuring their safe navigation and task performance obstacles avoidance and dust storms and the necessity for frequent recharging. This algorithm also enhances UGV navigation through UAV-guided obstacle detection, significantly reducing collision risks. At the core of our methodology is the utilization of a Multi-Agent Deep Deterministic Policy Gradient (MADDPG) algorithm, enhanced with a priority-based encoder for decision prioritizing. This modification improves sample efficiency, resulting in an algorithm with a high success rate and faster convergence. Furthermore, our approach emphasizes the resilience of the UAV against Martian weather by employing machine learning models. These models, trained on satellite imagery and environmental simulations, endow the UAV with predictive analytics to foresee and tactically respond to storm formations, including seeking refuge on the UGV. Our algorithm enhances the resilience and sustainability of Martian exploration missions, concurrently optimizing their efficiency and extending their geographical reach.