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MACHINE LEARNING-BASED AUTONOMOUS NAVIGATION FOR ROVERS IN EXTRATERRESTRIAL ENVIRONMENTS

Abstract

Autonomous navigation of rovers in extraterrestrial environments is a critical component of space exploration, particularly for missions to planets such as Mars or the Moon. This paper proposes a machine learning-based approach to enable autonomous rovers to detect and navigate obstacles, ensuring efficient and safe movement across challenging planetary surfaces. The primary objective is to utilize supervised learning techniques to classify safe paths from obstacles using sensor data, such as LIDAR or camera inputs.

The approach begins with the collection of sensor data from simulated or real rover environments. This data includes images and distance measurements that represent the terrain and potential obstacles encountered by the rover. Preprocessing steps, such as normalizing image and distance values, ensure the data is in a format suitable for machine learning algorithms.

A key aspect of this research is the application of supervised learning models, such as Decision Trees, K-Nearest Neighbors (KNN), or Support Vector Machines (SVM), to classify the terrain into navigable paths and obstacle regions. These models are trained on a labeled dataset, where the safe paths and obstacles are identified, allowing the rover to learn the distinctions through examples.

Once the model is trained, it is deployed in a test environment where new, unseen data is used to assess the rover's ability to make real-time navigation decisions. The model's accuracy in predicting safe paths and avoiding obstacles is evaluated through performance metrics such as precision, recall, and overall accuracy.

This work aims to demonstrate that machine learning, specifically supervised learning algorithms, can be effectively used to enhance the autonomy of rovers in planetary exploration. The results of this study have the potential to significantly improve the efficiency and reliability of autonomous navigation systems, reducing the need for human intervention and enabling rovers to explore more distant and hazardous regions of planetary bodies. Ultimately, the successful application of these techniques could play a crucial role in future space exploration missions, contributing to the advancement of autonomous systems for planetary surface operations.