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Author: Ms. Akshayanivasini Ramasamy Saravanaraj
Politecnico di Milano, Italy

Dr. Mauro Massari
Politecnico di Milano, Italy
Mr. DINENDRA ARCOT VISWANATH
Politecnico di Milano, Italy

# ENHANCING AUTONOMOUS OBSTACLE AVOIDANCE IN MARS-LIKE CONDITIONS USING MONTE CARLO LOCALIZATION WITH DOPPLER SENSOR INTEGRATION

**Abstract**

This research investigates the effectiveness of Monte Carlo Localization (MCL) using particle filters enhanced with Doppler sensor data in a simulated 3D environment. The problem addressed is the accurate localization of autonomous agents in environments with significant obstacles and noisy sensor data, a critical challenge for planetary exploration rovers, such as those deployed on Mars, where dust storms impair traditional sensing techniques like lidar. A grid-based map was employed, featuring randomized obstacles in a 3D occupancy grid. The Monte Carlo Localization technique was used to estimate the robot's position based on particle distributions, utilizing Doppler sensor data to refine predictions of movement and obstacle detection.

The simulation incorporated 2D and 3D grid visualizations to illustrate the dynamic positioning of the agent within the environment. A total of 1000 particles were used to represent possible locations of the agent, and the Doppler sensor readings were integrated into the particle weight updates to improve localization accuracy. The noisy Doppler sensor was simulated using Gaussian noise to mimic real-world conditions.

The results confirm the algorithm's robustness in accurately navigating the robot through the grid while avoiding obstacles. The Doppler-based approach demonstrated its advantages over lidar, especially in scenarios simulating poor visibility such as Martian dust storms. The conclusions drawn from this research suggest that Doppler-based sensors offer a viable alternative or complement to lidar in harsh environments, with the potential for real-world applications in extraterrestrial navigation where conventional sensors may fail.