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Author: Mr. Akif Mohiuddin
BRAC University, Bangladesh

Mr. Tazwar Ahmed
BRAC University, Bangladesh
Mr. Md. Shaeak Ibna Salim
BRAC University, Bangladesh
Mr. Abdulla Hil Kafi
Kyushu Institue of Technology, Japan

HAZARD AVOIDANCE AND SYSTEMATIC AUTONOMOUS LANDING FOR SPACECRAFT ON MARS USING COMPUTER VISION

Abstract

Ensuring a safe and precise landing is a crucial challenge in planetary exploration. Diverse environmental features (such as air density per km altitude, diverse topographical features, differences in gravitational pull, etc.) are always a big challenge for a spacecraft to maneuver and find an appropriate landing spot after mission completion. To solve this problem, we are introducing an improved autonomous landing system based on the YOLO machine learning model for precise and real-time hazard detection and guiding the spacecraft for safe landing landmarks. The system continuously scans the landing zone for rock and slope detection using Convolutional Neural Networks (CNNs). Furthermore, Semantic Segmentation distinguishes between hazardous and safe landing locations. The system will classify surface items such as rocks, craters, and slopes, enabling the dynamic adjustment of decent trajectories. After the identification and dynamic creation of waypoints, the system will use deep reinforcement learning (DRL) to sequence a series of predicted waypoints toward a safe landing site. The overall accuracy of the Yolo ML model is the main component for precision, about 90%. By optimizing and pruning the dataset of the Yolo ML model, the accuracy was enhanced up to 95% for anomaly detection. These outcomes can enable systems to land autonomously on the target surface with minimal error and maximum safety. This model can be further utilized with more sophisticated sensor systems such as the fusion of 3D Image Flash, Doppler, and Laser Lidar incorporated with high-resolution cameras that can ensure landing precision up to 98%. We validate our system using a virtual environment comprising Mars conditions. This paper synthesizes the detailed design process, measured parameters(e.g., altitude, velocity, surface topography), and Mars data classification for the CNN model representing the impact of AI integration in spacecraft landing systems.