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SPACE QUALIFIED VPU BENCHMARKING OF CRATER MATCHING ODTS SOLUTIONS BASED ON CONVOLUTIONAL NEURAL NETWORKS

Abstract

The moon is gaining back attractiveness in terms of human exploration for scientific purposes, resources exploitation and as a baseline for Mars exploration. Traditional Lunar Space applications require knowledge of the satellite orbit position which is usually achieved by employing ground segment equipment. Ground support is currently required for a number of functions, including data processing, telemetry and remote control.
Satellites capable of autonomously locating themselves with high accuracy, availability and reliability could reduce the complexity of ground system equipment without sacrificing services requiring spacecraft positioning and enable missions in contexts where ground-control monitoring is not yet available or with time-limited service window. The development of neural networks, and in particular Convolutional Neural Networks (CNN), have been used in various applications in space including autonomous navigation and control, image processing, and fault detection and isolation, opening new possibilities in the satellite orbit determination systems framework, namely vision-based navigation algorithms. AI-based vision navigation algorithms have been widely implemented to extract salient features also with non-nominal illumination conditions and environmental uncertainties due to the great generalization capability and flexibility of neural networks.

The paper presents an Orbit Determination algorithm using Terrain Relative Navigation (TRRN) based on CNN, jointly with measurements coming from standalone sensors (e.g Altimeters, GNSS pseudo-range and pseudo-range-rate, ...). The TRRN technique adopted in this work uses a sensor to acquire a stream of images of the Lunar surface and tries to determine its position depending on the set of detected craters, with the whole set of measurements aggregated using an extended Kalman filter approach. The system has been implemented in a simulation platform that includes the Orbit propagation around the Moon, the Data generation from the sensors, the CNN training and inference steps and the Orbit Determination Algorithm. The Simulated system has been finally being benchmarked over a Space Qualified processing unit, including a dedicated VPU configured to compute the inference steps of the TRRN Neural network.

Results on the performances achievable and on the technical feasibility of an autonomous Orbit determination system orbiting around the Moon are finally presented.