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Author: Dr. Laura Sopegno
Università degli Studi di Palermo, Italy

Dr. Simone Martini
University of Denver, United States
Prof. Kimon Valavanis
University of Denver, United States
Prof. Patrizia Livreri
Università degli Studi di Palermo, Italy

HARDWARE IN THE LOOP IMPLEMENTATION, VERIFICATION AND VALIDATION FOR AN AUTONOMOUS MARTIAN HEXACOPTER

Abstract

Autonomous exploration of the Martian environment is an important and crucial component of current space mission strategies. Unmanned Aerial Vehicles (UAVs) offer viable platform alternatives for a wide range of diverse applications as they improve performance and reliability, and as such, they are considered for future mission scenarios concerning the Moon and Mars exploration. Indeed, recent investigation has demonstrated how UAV deployment contributes to obtaining key results related to optimizing different in-situ tasks such as sample collection, autonomous mapping, and exploration of areas otherwise inaccessible to ground rovers. Completed research from the authors has considered a Martian Hexacopter (MHex) design and Software in the Loop (SIL) validation and verification (VV) on ROS and Gazebo, to highlight autonomous exploration and 3D mapping capabilities of a crater in the Martian Jezero region (doi: 10.1109/TAES.2024.3365667). The aforementioned simulation environment aims to reproduce, with high fidelity, flight conditions on Mars considering the air composition and terrain features based on real/observed data collected from the High-Resolution Imaging Experiment (HiRISE) database. Given a waypoint trajectory sent by a simulated Ground Station (GS), emphasis is given to the autonomous exploration of the Martian site along with Simultaneous Localization and Mapping (SLAM), through 3D Lidar, tracking camera and altimeter sensor fusion, and onboard control techniques. Building on the obtained results, this research focuses on Hardware in the Loop (HIL) implementation, testing, and VV of the MHex architecture for autonomous flight simulations according to the adopted GNC algorithm and mission strategies. In the HIL simulated experiments, the mission is carried on in the Gazebo simulation environment, while the deployed navigation and control algorithms run on RaspberryPi and Pixhawk flight controller unit (FCU), respectively. This methodology allows to test and validate real-time capabilities of the MHex autonomous flight in a GPS-denied environment and builds the foundation for the further realization of a final, scientific prototype to be tested in a terrestrial analog Martian scenario.