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SEMI-AUTONOMOUS GUIDANCE, NAVIGATION AND CONTROL SYSTEM FOR PLANETARY ROVERS

Abstract

The future space robotic missions will involve autonomous assets to explore the remote regions in the Solar System (*e.g.*, Martian polar caps) in safety and with limited assistance from the ground operators. Although rovers' activities are still mainly scheduled and planned from Earth, current research trends are focused on increasing rovers' capabilities to autonomously make decisions based on their perception of the surroundings. To enhance the efficiency of future robotic assets, we are developing a guidance, navigation and control (GNC) system to enable safe operations on unprepared terrains. The software accounts for an accurate modeling of the rover's dynamical equations to simulate traverses across different terrains and slope conditions. Moreover, by processing the visual input from the left- and right-eye cameras, local 3D maps of the rover's neighborhoods are built to support the path planning activities, and to enhance localization accuracies through Visual Odometry (VO) techniques. VO methods are widely employed to provide accurate updates of the rover's position and attitude during the motion by detecting and tracking image-keypoints through successive pairs of stereo images. Moreover, VO algorithms enable higher localization accuracies compared to dead-reckoning methods based on Wheel Odometry (WO) data, which are prone to overestimate the travelled distance due to wheel's slippage. To assess the localization performances of our GNC system, we employed VO techniques to process the images acquired by the NASA Mars2020 *Perseverance* rover. *Perseverance* represents the state-of-the-art in planetary surface exploration, with dedicated hardware to perform demanding computer vision tasks, and it is currently exploring the Martian Jezero crater, setting records on the furthest distance travelled in a single Martian day. We present here the methods we used to reconstruct *Perseverance*'s position and attitude along different traverses that the vehicle performed during the first year of the mission. We retrieved the rover's pose by processing the high-resolution images captured by the navigation cameras in a 3D-to-3D VO framework that also accounts for an accurate modeling of the nonlinear effects characterizing the camera optics. The VO-based estimate of the rover's attitude is fully in line with the orientation provided by the accurate Inertial Measurements Units (IMU) data. The discrepancies between the reconstructed and the telemetered rover's position across the site map suggest errors in the WO measurements, which are compensated by our VO estimate.