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Safe Navigation and Visual Odometry-based Localization for Planetary Exploration Rovers

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The future robotic exploration of planetary surfaces will require autonomous and safe operations to accomplish outstanding scientific objectives. The main goal of space robotic systems consists in expanding our access capability to harsh environments in the solar system (*e.g.*, Martian polar caps, icy moons). However, the operations of systems onboard landers and rovers are still mainly commanded and controlled by ground operators. To enhance the efficiency of future rovers, we are developing a robust guidance, navigation and control system that enables safe mobility on different terrain and slopes conditions, including the presence of obstacles.

High slippery terrains, such as sandy-loose soils, could prevent the rover locomotion, affecting its safety. Furthermore, the presence of these demanding terrains may impact on the rover navigation, leading to inaccuracies in the Wheel Odometry (WO) measurements because of wheels' loss of traction. Therefore, we implemented a navigation algorithm based on Visual Odometry (VO) that is the technique based on the processing of stereo-camera images captured at successive times during the vehicle's motion. This method is fundamental to help WO during operations that require fast responses and high-accurate positioning. We also adopted a LIDAR sensor to improve the position estimate accuracy by processing measurements associated with well-known terrain features.

We present here numerical simulations of rover navigation across different terrain conditions by using accurate dynamical models, including the deformability of both wheel and terrain. VO and LIDAR data are simulated and processed to determine the positioning accuracies that enable safe navigation. The results are in full agreement with the existing (*i.e.*, Mars Exploration Rovers (MER)) and future (*i.e.*, ExoMars) rover performances. Our algorithm allows reconstructing the rover trajectory with higher accuracies compared to the localization system requirement of the NASA MER rovers (*i.e.*, 10% error over 100 meters traverse).