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Estimation of the NASA Mars2020 Perseverance rover path through Visual Odometry

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The future space exploration missions will require autonomous robotic systems capable to safely move across the operational environment and reach sites of scientific interest with limited commands from the ground operators.

The NASA Mars2020 Perseverance rover is the most advanced robotic vehicle ever sent on the planet Mars and is currently exploring the Jezero crater searching for signs of ancient life and investigating the geological history of the planet. The increased computational resources of the Perseverance's onboard computer enable the navigation software to continuously adjust the path, by processing visual inputs through the navigation cameras. The stereo images with the left and right rover cameras are analyzed to build local 3D maps of the surrounding terrain to identify hazardous areas (*e.g.*, steep slopes) that could affect the rover's safety.

We use Visual Odometry (VO) methods to accurately update the rover's position and attitude (*i.e.*, pose), by detecting and tracking the image-locations of landmarks (*e.g.*, the sharp edge of a rock) through successive stereo pairs. VO is a fundamental technique to enhance the localization accuracies of wheeled vehicles in planetary environments where Global Navigation Satellite Systems (GNSS) are not available.

We present here the reconstructed position and attitude of the Perseverance rover that we retrieved by processing images acquired by the navigation cameras during sols 65, 66, 72, and 120. 3D-to-3D algorithms were applied accounting for the nonlinear optical effects that affect the raw images. The estimated rover's orientation is fully in line with the accurate measurements provided by the onboard Inertial Measurement Units (IMUs). The displacements between the telemetered and the reconstructed rover's location suggest errors in the WO measurements, which are compensated by our VO estimate.