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TOWARDS IN-SITU CHARACTERISATION OF PLANETARY TERRAIN USING A HYBRID WHEEL-LEG

Abstract

Planetary exploration rover missions to Mars face significant constraints in terms of power availability, communication bottlenecks and computational capabilities. These limitations have a strong influence on the way these missions are operated, leading to a critical trade-off between speed and safety during rover navigation. The challenging nature of the Martian terrain and the high cost of these missions motivate the frequent use of cautious driving modes that check for wheel slippage and terrain hazards to avoid immobilization. This renders the rover's traversal speed slow and hinders the scientific return of the mission. To mitigate this drawback blind drives are used whenever the rover traverses apparently safe terrain, raising the overall speed of the rover with the risk of inadvertently becoming trapped in hidden non-geometric hazards as experienced by the Spirit rover during the MER mission.

In future missions, avoiding such situations whilst increasing the average traversal speed will be of high priority for the optimisation of the scientific return and the achievement of the planned goals. The FP7 FASTER project proposes a co-operative mission concept where a lightweight Scout rover performs in-situ sensing of the terrain ahead of the mission's Primary rover. The Scout rover is equipped with two wheel-legs, a hybrid concept that combines the mechanical and control simplicity of traditional wheels with the enhanced mobility of legs. This allows the Scout to negotiate irregular and soft terrain that would pose a serious threat to the Primary rover's mobility. The novel work presented in this paper contributes to such a mission concept through the design and implementation of an efficient soil sensor system that enables the Scout rover to characterise the terrain and to detect non-geometric hazards with minimal impact in terms of mass, power and traversal speed.

The operating principle of the proposed sensor system is based on the analysis of the interaction of the hybrid wheel-leg concept with dry granular soils in order to produce an on-line terrain trafficability assessment combining proprioceptive and exteroceptive sensor measurements. The methodology applied combines mathematical modelling of the wheel-leg's kinematics and dynamics with experimental testing using Martian soil simulants to develop wheel-leg sinkage and slippage detection algorithms and empirically correlate their output with the trafficability of the terrain. Initial results prove the capability of the designed soil sensor system to detect slip and sinkage and reveal the sensitivity of these phenomena to different soil configurations and operating conditions.