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JOINT EFFORT OF DLR AND JPL TOWARDS MODEL-BASED PREDICTION OF ROVER LOCOMOTION PERFORMANCE FOR OPERATION PURPOSES

Abstract

A key task in exploration rover operations is the selection of a safe vehicle path, mainly based on camera images and corresponding terrain surface classifications. The traverse of sandy terrain classes is usually considered as highly risky in terms of getting stuck. However, alternative routes via regions of rocky and bedrock terrain are very burdensome for the mechanical parts of the locomotion system, in particular for the wheel rims. Therefore, reliable tools shall support operators to make well-founded trade-offs including all available path options.

In a joint effort DLR and NASA/JPL are focusing on the development of models and simulation tools for precise prediction of rover locomotion performance in loose soil. The collaboration partners bring together their respective expertise and software code for surface-oriented soil contact modeling (SCM, DLR) and for volumetric discrete element modeling (GRAMS, JPL). The variety of models facilitates locomotion analyses ranging from "very precise" on single wheel level to "adequately precise" on system level within multi-body (M3TK, JPL) and multi-physics simulations (Modelica Rover Simulation Toolkit,

DLR).

In order to make the tools applicable for operations and day-by-day mission planning, they must have reached an accepted level of validation. For the team, the results of a comprehensive single wheel test campaign of JPL, conducted by Carnegie Mellon University, are used as reference for their validation effort. The test plan considered variations of wheel parameters (width, diameter, rim profile, etc.) as well as wheel load and constrained slippage. The reference criteria for wheel performance assessment were the wheel sinkage and the drawbar pull which is the produced net force of the locomotion system. The validation campaign was kicked off during a collocation workshop at JPL followed by regular update meetings. In the campaign, for each model a unique set of model parameters has to be identified such that it provides best match of test and simulation results in all variation cases. Observed discrepancies provide then guidelines for model adaptations to be verified within the next parameter identification loop. In case of SCM, soil and model parameters are searched using optimization techniques. For the discrete element model parameters particle shape, size, mass, and friction are iteratively tuned.

In the paper the model validation activities will be presented in detail. The achieved capabilities in capturing selected features of the wheel-soil interaction dynamics will be discussed, taking single wheel and system level aspects into account.