Real-time modeling of tool and wheel interactions with soil for mining applications

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Modeling of the interaction between soil cutting tools and planetary soil, including terrain deformations, in the context of a full multibody dynamics simulation is crucial in estimating the efficiency of soil moving during mining operations, which has applications in the design of efficient high-level control algorithms for planetary resource gathering and site shaping, mission planning and scenario analysis, as well as operator training.

We present a set of new algorithms for modeling the interaction between soil cutting tools and planetary soil which allow for modeling of excavation on steep surfaces, as well as latest methods for wheel–soil interaction, all of which are integrated in the same simulation.

In these methods, we combine physics models from terramechanics and soil mechanics to model a rover or other vehicle with a mounted tool, in tasks where soil interaction is an important component, such as excavation tasks. For excavation, we represent the soil using a deformable mesh model based on level sets or height fields.
We consider the impact of both wheel–soil and tool–soil interactions on the vehicle motion by creating a fully coupled simulation of the dynamics of the vehicle and its environment.

We show recent progress on large mining equipment simulation as well as a mission planning tool developed in collaboration with the Canadian Space Agency which employs some of the techniques presented here.