University of Stuttgart

Institute for Nonlinear Mechanics

Master's thesis

Simulation of debris flow and its interaction with protection nets

Topic Areas:	nonsmooth mechanics, mechanical modeling
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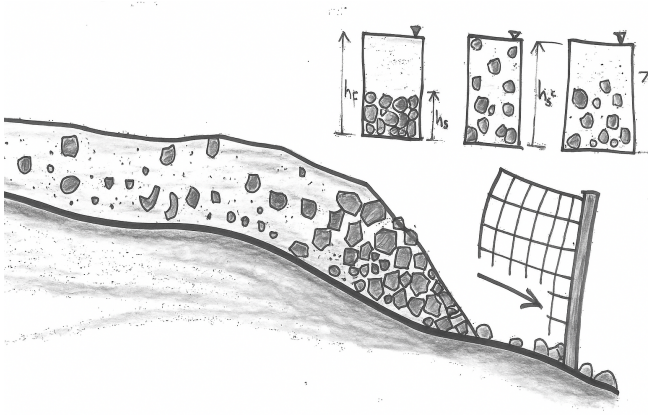
Prerequisites/Prior Knowledge:	Nonsmooth Dynamics

Debris flows are fast-moving mixtures of water, soil, and large rocks that pose significant hazards in mountainous regions. They often occur suddenly and with great destructive power, endangering infrastructure and human life. To mitigate these risks, protective structures such as flexible rockfall protection nets are commonly installed in vulnerable areas. Understanding how debris flows interact with these nets is essential for designing safer and more efficient protective systems.



Sketch of a debris flow with protection net.

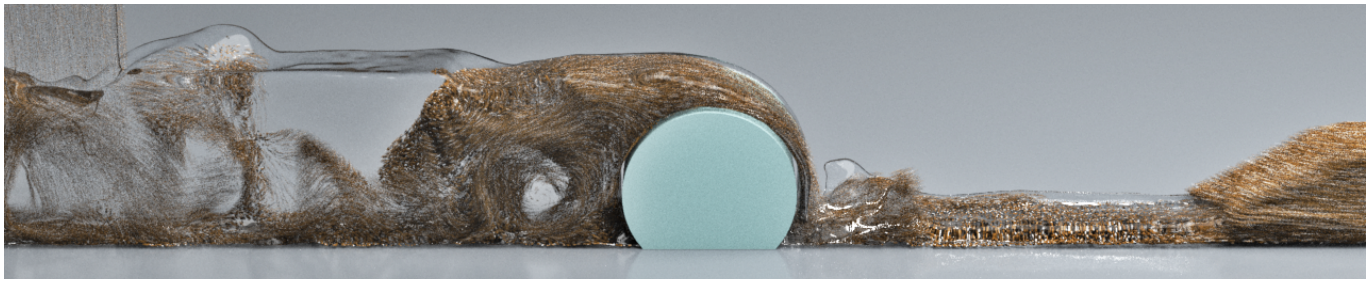
However, simulating such interactions is challenging [1]. Debris flows are multiphase systems involving complex fluid-solid interactions, evolving interfaces, and highly nonlinear material behavior. The flow typically includes fine granular material, water, and large boulders or rock chunks, all moving at high velocity and undergoing strong impacts. Additionally, the contact and interaction with flexible protective nets involves friction, deformation, and sometimes plastic deformations or rupture—phenomena that are inherently nonsmooth and difficult to model.

The goal of this thesis is to conduct a preliminary study within this broad and complex research field. To this end, a two-dimensional debris flow model will be developed, along with its interaction with a single rigid body. Depending on the progress, the model may be extended to account for multiple rigid bodies and their interaction with simplified representations of protective nets.

References

[1] M. G. Trujillo-Vela *et al.*, "An overview of debris-flow mathematical modelling," 2022.

[2] M. Gao *et al.*, "Animating fluid sediment mixture in particle-laden flows," 2018.



Simulation of a debris flow [2].