University of Stuttgart

Institute for Nonlinear Mechanics

Master's thesis
Bachelor's thesis
Term paper

Elastoplastic rod model for rockfall net simulation

Topic Areas:	Multibody simulation, rods, plasticity
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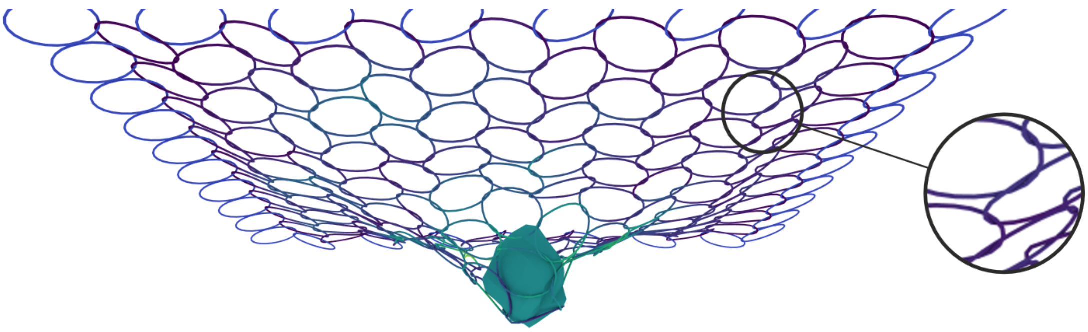
Prerequisites/Prior Knowledge:	Technische Mechanik I-III, Dynamik mechanischer Systeme (ideally)

Rockfalls pose a significant threat to infrastructure, human lives, and transportation routes in mountainous regions worldwide. Protective structures, such as rockfall nets, are widely employed to mitigate these risks by intercepting falling rocks and dissipating their energy. Accurate simulation of rockfall-net interaction is therefore essential for the design and optimization of these safety measures. Existing simulation approaches often rely on simplified models or computationally expensive fully 3D representations. This thesis addresses the need for a computationally efficient yet accurate modeling technique, focusing on the specific challenges presented by the highly deformable and potentially plastic behavior of rockfall nets under impact.
The goal of this work is to develop and implement an elastoplastic rod model for simulating the behavior of rockfall protective nets. Net elements will be modeled as rods, leveraging an existing contact library (e.g., COAL [1]) for efficient contact computation. The primary focus will be the investigation and implementation of suitable plasticity models for rods.

This includes a comprehensive literature review of plasticity models applicable to rods, compare e.g. [2], analysis of existing frameworks and their implementation of plasticity in rods (e.g., the 4C framework[3]), and exploration of rate formulations for plasticity. Further tasks involve assessing the benefits of decoupled stress/strain quantities and investigating second-order cone formulations.

The implementation will be conducted within a C++ framework, with a strong emphasis on understanding and building upon existing formulations.



[1] J. Pan, S. Chitta, D. Manocha, F. Lamiraux, J. Mirabel, J. Carpentier, L. Montaut and others *Coal: an extension of the Flexible Collision Library*, https://github.com/coal-library/coal, 2015–2024

[2] J. C. Simo and T. J. R. Hughes *Computational inelasticity*, Interdisciplinary Applied Mathematics Mechanics and Materials, no. 7. New York Heidelberg Berlin: Springer, 2000

[3] 4C *A Comprehensive Multiphysics Simulation Framework*, https://www.4c-multiphysics.org/