University of Colorado at Boulder
Department of Applied Mathematics

Comprehensive Examination

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Presenter

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Title

Mathematical Modelling and Analysis of Several Flow Driven Problems

In this proposal, we explore several problems related to mathematical models of flow. The first problem deals with random walk particle tracking (RWPT) methods for use in modeling contaminant dispersal through fracture networks. Our contribution is developing an upscaled method to augment standard particle tracking techniques that reduces the computational costs by several orders of magnitude when tracking particle movements along straight cracks. The second problem is concerned with modeling the flow of glacial ice, which is traditionally treated as a shear thinning non-Newtonian fluid. A well known issue with numerically modeling ice flow comes from the power law model used in the constitutive relationship between stress and strain rate, which allows for the effective viscosity of the fluid to grow unboundedly in regions of low strain rate. Our contribution comes from re-examining the data sets used in developing the original flow model and fitting an alternative functional form to the collected data points. This alternative model fits the data points with comparable accuracy to the original flow law, but avoids the problematic viscosity blow up. The third and final problem we examine is community detection in networks. We study the geometry of the network by analyzing a diffusion process propagating on it, and propose a novel approximate clique percolation algorithm to detect communities that scales linearly with the network size.