Simulation of Fiber Dynamics

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In the field of technical textiles like nonwovens and glass wool, fibers and filaments of different materials are produced and processed. During the production, these fibers are subject to forces determining their dynamics. In order to simulate such processes, the dynamics of the fibers needs to be modeled.

The state of the art approaches in simulating fiber dynamics are based on the theory of Cosserat Rods. This theory models the fiber and all its relevant physical fields (e.g. position, torsion, tension, ...) as a one dimensional continuum subject to different outer forces. Numerical implementations of this approach currently exist for specific material properties (elastic, viscous, etc.).

This dissertation aims at building a simulation tool that can realize a broad set of different fiber models and discretization strategies. The basic idea is to semi-discretize the different models in time, thus representing them as Boundary Value Problems (BVP) in space. The discretization strategy for solving these BVPs can then be chosen with relatively few constraints.

Important challenges for the simulation of technical processes include the interaction of fibers with air flow (exerting stochastic forces), machine parts (constraining forces) and other fibers (coupled constraining forces). The machine part interaction requires detection of collisions between the fibers and the given geometry of the machines. When a collision of a fiber with the geometry is detected, its dynamics equation has to be expanded by geometric constraints to prevent penetration. The time step is then recomputed including appropriate contact forces resulting from the geometric constraints. Likewise, the interaction between fibers requires efficient detection and handling of collisions.

The resulting modular tool will provide the basis for simulating a broad field of possible tasks in differenct production processes, like spinning processes and production of nonwovens. The high variability with regard to the material behavior will lend to a greater quality of the simulation of fiber dynamics.