Simulation techniques for fiber-like objects and application of hair simulation in virtual reality

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Abstract: This thesis presents a comprehensive study on the simulation of fibrous objects, with a specific focus on real-time hair simulation for virtual reality (VR) applications. Given the complex physical behavior of hair, including collision, friction, and bending, achieving both visual realism and computational efficiency remains a significant challenge. This research proposes a novel hybrid simulation framework that combines continuum-based rod models with mass-spring systems to balance accuracy and performance. To address the stringent real-time requirements of VR, a parallelized solver leveraging GPU computing is developed, enabling interactive frame rates even for high-fidelity hairstyles. Furthermore, a robust collision handling algorithm is introduced to manage self-interactions and interactions with avatars without compromising stability. The system is integrated into a VR environment, where user studies demonstrate a significant improvement in perceived realism and immersion compared to traditional simulation methods. The findings validate the proposed technique as an effective solution for dynamic hair simulation in interactive virtual worlds, with potential extensions to other fibrous materials such as ropes and fur.

Keywords: Fiber simulation, Hair simulation, Virtual reality, Physics-based animation