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Computational Mathematics Seminar Series

Repulsive Curves and Surfaces

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Digital Media Center 1034
March 26, 2024 - 03:30 pm

Abstract:

Repulsive energies were originally constructed to simplify knots in $\mathbb{R}^3$. The driving idea was to design energies that blow up to infinity when a time-dependent family of knots develops a self-intersection. Thus, downward gradient flows should simplify a given knot without escaping its knot class.

In this talk I will focus on a particular energy, the so-called \emph{tangent-point energy}. It can be defined for curves as well as for surfaces. After outlining its geometric motivation and some of the theoretical results (existence, regularity), I will discuss several hardships that one has to face if one attempts to numerically optimize this energy, in particular in the surface case. As we will see, a suitable choice of Riemannian metric on the infinite-dimensional space of embeddings can greatly help to deal with the ill-conditioning that arises in high-dimensional discretizations. I will also sketch briefly how techniques like the Barnes-Hut method can help to reduce the algorithmic complexity to an extent that allows for running nontrivial numerical experiments on consumer hardware.

Finally (and most importantly), I will present a couple of videos that employ the gradient flows of the tangent-point energy to visualize some stunning facts from the field of topology.

Although some high tier technicalities will be mentioned (e.g., fractional Sobolev spaces and fractional differential operators), the talk should be broadly accessible, also to undergrad students of mathematics and related fields .

Speaker's Bio:

Graduated (German equivalent of Master's Degree) in 2010 at Goettingen University

PhD in 2014 at Goettingen University with Max Wardetzky

Postdoc positions at

- Hamburg University
- RWTH Aachen University
- Leipzig University
- Chemnitz University of Technology

Current position

- Limited Term Assistent Professor at University of Georgia

Fields of interest:

- differential geometry
- numerical analysis
- calculus of variation
- numerical optimization for curves and surfaces
- geometry processing and computer graphics
- computational challenges in geometric knot theory