Geometric Algorithms

COMPSCI 634 • Spring 2016

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Administration

Instructor: Pankaj K. Agarwal
**TA:** TBD
Time: TuTh 4:40-5:55
Location: LSRC D106

Overview

The field of **Geometric Algorithms** studies the design, analysis, and implementation of algorithms and data structures for geometric problems. These problems arise in a wide range of areas, including robotics, computer graphics, molecular biology, GIS, spatial databases, sensor networks, and machine learning. In addition to the tools developed in computer science, the study of geometric algorithms also requires ideas from various mathematical disciplines, e.g., combinatorics, topology, algebra, and differential geometry.

The goal of this course is to provide an overview of the techniques developed in geometric algorithms as well as some of its application areas. The topics covered in the course will include:

1. **Geometric Fundamentals:** Motivation, models of computation, geometric primitives, geometric transforms
2. **Convex hulls:** Planar convex hulls, higher dimensional convex hulls, output-sensitive and dynamic algorithms
3. **Intersection detection:** Segment intersection, line sweep, polyhedra intersection
4. **Geometric searching:** Segment, interval, and priority-search trees,
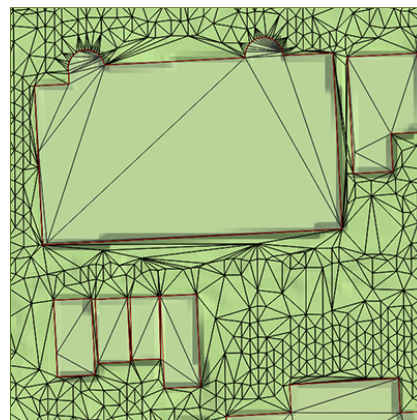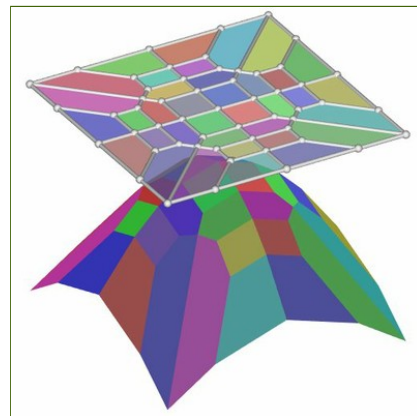
point location, persistent data structure, fractional cascading, range searching, nearest-neighbor searching

5. **Proximity problems:** Closest pair, Voronoi diagram, Delaunay triangulation and their subgraphs, spanners, well separated pair decomposition

6. **Arrangements:** Arrangements of lines and hyperplanes, sweep-line and incremental algorithms, lower envelopes, levels, and zones, applications

7. **Geometric sampling:** Random sampling and e-nets, e-approximation and discrepancy, linear sketches, cuttings, coresets

8. **Geometric optimization:** Linear programming, geometric set cover, shape matching. Euclidean TSP

9. **Embeddings:** Bourgain's theorem, random-projection, low-distortion embeddings, locality sensitive hashing
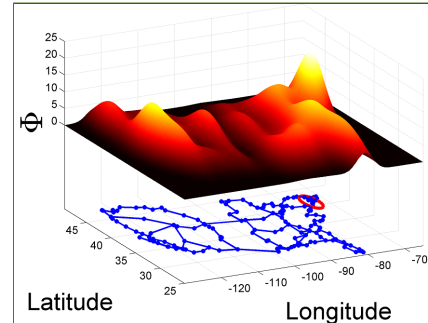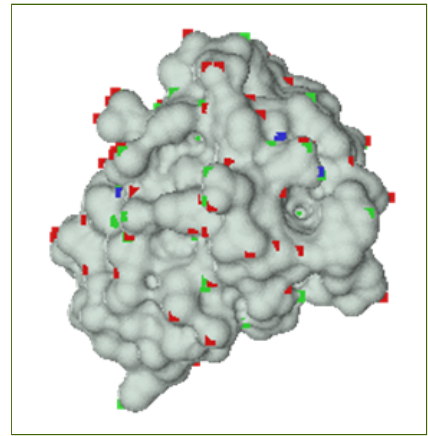
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Textbook

The main textbook for this course:
M. de Berg, O. Cheong, M. van Kreveld, and M. Overmars, Computational Geometry: Algorithms and Applications. Springer-Verlag, 3rd ed., 2008.

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Grading

Assignments: 40% weight
Four assignments will be given during the semester, which each student has to complete individually without searching the material online.

Lecture Scribe: 10% weight
Each student will scribe one lecture.

Research Project: 50% weight
Intended to produce a work of publishable quality, the project should consist of a comprehensive survey on a topic plus new research work. Due on May 2, 2016.

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