



دانشگاه یزد

Yazd Univ.

Computational
Geometry

Course Outline

Textbook

Prerequisites

Introduction

What is CG?

Research on CG

Journals

Conferences

Computational Geometry

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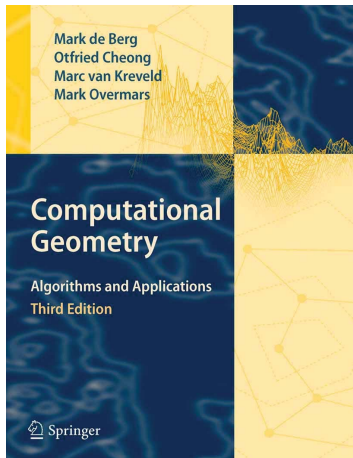
<http://cs.yazd.ac.ir/cgalg/>

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Textbook:

Mark de Berg, Otfried Cheong, Marc van Kreveld, Mark Overmars, **Computational Geometry Algorithms and Applications**, 3rd Edition, Springer-Verlag Berlin Heidelberg, 2008.



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CG on Web:

- **Course Webpage:**
cs.yazd.ac.ir/farshi/Teaching/CG3931/CG.html
- **(Jeff Erickson)**
compgeom.cs.uiuc.edu/~jeffe/compgeom/courses.html
- **(David Eppstein)** www.ics.uci.edu/~eppstein/geom.html
- **(Godfried Toussaint)**
www-cgri.cs.mcgill.ca/~godfried/teaching/cg-web.html
- **Computational Geometry Pages**
www.computational-geometry.org
- and much more ...



What you need to know:

- **Basic Algorithms and Algorithm Analysis:** $\mathcal{O}$, Θ notations, sorting, searching.
- **Basic Data Structures:** Priority Queue (Heap), Binary Search Tree, ... and their analysis.
- **Basic Probability theory:** Expected value, ...
- **Not needed:** Application of CG, programming, knowledge in Geometry.

Prerequisites:



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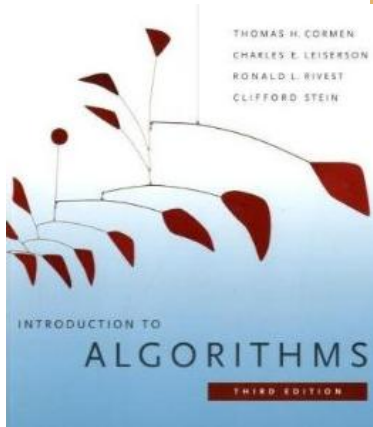
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Computational Geometry

- is a branch of computer science devoted to the study of algorithms which can be stated in terms of geometry.
- is a subfield of the Design and Analysis of Algorithms
- deals with efficient data structures and algorithms for geometric problems
- is only about 30 years old
- started out by developing solid theoretical foundations, but became more and more applied over the last years



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Applications

- Computer graphics,
- Computer-aided design and manufacturing (CAD/CAM),
- Robotics (motion planning and visibility problems),
- Geographic Information Systems (GIS) (geometrical location and search, route planning),
- Integrated Circuit design (IC geometry design and verification),
- and so on.



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The main branches of computational geometry are:

- **Combinatorial computational geometry**, also called **algorithmic geometry**, which deals with geometric objects as discrete entities. A groundlaying book in the subject by Preparata and Shamos dates the first use of the term "computational geometry" in this sense by 1975.
- **Numerical computational geometry**, also called **machine geometry**, computer-aided geometric design (CAGD), or geometric modeling, which deals primarily with representing real-world objects in forms suitable for computer computations in CAD/CAM systems. This branch may be seen as a further development of descriptive geometry and is often considered a branch of computer graphics or CAD.

What is CG?

Combinatorial computational geometry

- The primary goal is to develop *efficient algorithms* and *data structures* for *solving problems* stated in terms of basic geometrical objects: points, line segments, polygons, polyhedra, etc.
- Example: **The closest pair problem**: Given n points in the plane, find the two with the smallest distance from each other. The brute-force algorithm takes $\mathcal{O}(n^2)$ time. A classic result: an algorithm that takes $\mathcal{O}(n \log n)$ time. Also randomized algorithms that take $\mathcal{O}(n)$ expected time, as well as a deterministic algorithm that takes $\mathcal{O}(n \log \log n)$ time.
- Computational geometry focuses heavily on *computational complexity* since the algorithms are meant to be used on very large data sets containing tens or hundreds of millions of points.



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Problem classes

- Static problems
 - 1 **Convex hull:** Given a set of points, find the smallest convex polyhedron/polygon containing all the points.
 - 2 **Line segment intersection:** Find the intersections between a given set of line segments.
 - 3 **Voronoi diagram:** Given a set of points, partition the space according to which point is closest.
 - 4 **Closest pair of points:** Given a set of points, find the two with the smallest distance from each other.
 - 5 **Euclidean shortest path:** Connect two points in a Euclidean space (with polyhedral obstacles) by a shortest path.
 - 6 **Polygon triangulation:** Given a polygon, partition its interior into triangles

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Problem classes

- Geometric query problems

- 1 **Range searching:** Preprocess a set of points, in order to efficiently count the number of points inside a query region.
- 2 **Point location:** Given a partitioning of the space into cells, produce a data structure that efficiently tells in which cell a query point is located.
- 3 **Nearest neighbor:** Preprocess a set of points, in order to efficiently find which point is closest to a query point.
- 4 **Ray tracing:** Given a set of objects in space, produce a data structure that efficiently tells which object a query ray intersects first.

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Problem classes

- Dynamic problems
 - Variations
 - Point in polygon: Decide whether a point is inside or outside a given polygon.



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Journals

- 1 Computational Geometry: Theory and Applications (CGTA)
- 2 Discrete & Computational Geometry (DCG)
- 3 International Journal of Computational Geometry and Applications (IJCGA)
- 4 Journal of Computational Geometry (NEW)
- 5 Other algorithmic journals



Conferences

- 1 ACM Symposium on Computational Geometry (SOCG)
- 2 Canadian Conference on Computational Geometry (CCCG)
- 3 European Workshop on Computational Geometry (EWCG)
- 4 International Conference on Computational Geometry and Computer Vision
- 5 Others, like SODA, STOC, ESA.



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