CSE 5319-001 (Computational Geometry) SYLLABUS

Spring 2012: TR 11:00-12:20, ERB 129

Instructor: Bob Weems, Associate Professor, http://ranger.uta.edu/~weems
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Hours: TR 12:30-1:50 PM and by appointment (please email by 8:30 AM)

Prerequisite: Advanced Algorithms (CSE 5311)

Objective: Ability to apply and expand geometric techniques in computing.

Outcomes:
1. Exposure to algorithms and data structures for geometric problems.
2. Exposure to techniques for addressing degenerate cases.
3. Exposure to randomization as a tool for developing geometric algorithms.
4. Experience using CGAL with C++/STL.

Textbooks: M. de Berg et.al., *Computational Geometry: Algorithms and Applications, 3rd ed.*, Springer-Verlag, 2000.
https://libproxy.uta.edu/login?url=http://www.springerlink.com/content/k18243

S.L. Devadoss and J. O'Rourke, *Discrete and Computational Geometry*, Princeton University Press, 2011.

References: Adobe Systems Inc., *PostScript Language Tutorial and Cookbook*, Addison-Wesley, 1985. (http://Www-cdf.fnal.gov/offline/PostScript/BLUEBOOK.PDF)

B. Casselman, *Mathematical Illustrations: A Manual of Geometry and PostScript*, Springer-Verlag, 2005. (http://www.math.ubc.ca/~cass/graphics/manual)

CGAL User and Reference Manual (http://www.cgal.org/Manual)

T. Cormen, et.al., *Introduction to Algorithms*, *3rd ed.*, MIT Press, 2009.

E.D. Demaine and J. O'Rourke, *Geometric Folding Algorithms: Linkages, Origami, Polyhedra*, Cambridge University Press, 2007. (occasionally)

J. O'Rourke, *Art Gallery Theorems and Algorithms*, Oxford Univ. Press, 1987. (http://maven.smith.edu/~orourke/books/ArtGalleryTheorems/art.html, occasionally)

J. O'Rourke, *Computational Geometry in C, 2nd ed.*, Cambridge Univ. Press, 1998. (definitely)

K. Mehlhorn and S. Näher, *The LEDA Platform of Combinatorial and Geometric Computing*, Cambridge University Press, 1999. (http://www.mpi-inf.mpg.de/~mehlhorn/LEDAbook.html, definitely)

R. Motwani and P. Raghavan, *Randomized Algorithms,* Cambridge Univ. Press, 1995.

K. Mulmuley, *Computational Geometry: An Introduction Through Randomized Algorithms*, Prentice Hall, 1994. (occasionally)

F.P. Preparata and M.I. Shamos, *Computational Geometry: An Introduction*, Springer-Verlag, 1985. (occasionally)

Conferences: STOC, FOCS, ACM Symp. on CG, Canadian Conf. on CG, and European Workshop on CG

Grade: Based on the following weights:

40% Homework Presentations (slides and 5-15 minute talk)

40% Participation in Software Development Exercises - usually involving CGAL

≤ 20% "Discretionary" Quizzes (2-5% each) and Exams (10-20% each)

Policies:

1. Attendance is not required, but is highly encouraged. Consult me in advance if you must miss class for a good reason.

2. CHEATING - YOU ARE EXPECTED TO KNOW UNIVERSITY POLICIES. All cases of plagiarism will be processed through University channels outside the CSE department.

3. Any request for special consideration must be appropriately documented **in advance**. (Special consideration does not include giving a higher grade than has been earned.)

Course Outline

Wk	Devadoss & O'Rourke	de Berg et.al.	CGAL Manual
1	2 CONVEX HULLS 2.1 Convexity 2.2 The Incremental Algorithm 2.3 Analysis of Algorithms 2.4 Gift Wrapping and Graham Scan 2.5 Lower Bound 2.6 Divide-and-Conquer	1 Computational Geometry - Introduction 1.1 An Example: Convex Hulls *Graham Scan* 1.2 Degeneracies and Robustness 1.3 Application Domains	1 Introduction 15 2D hulls 18 Polygons

2		2 Line Segment Intersection 2.1 Line Segment Intersection *Bentley-Ottman Plane Sweep* 2.2 The Doubly-Connected Edge List *Planar Subdivisions* 2.3 Computing the Overlay of Two Subdivisions 2.4 Boolean Operations	19 Set operations 26 Halfedge data structs 32 Set of segments ∩
3	1 POLYGONS 1.1 Diagonals and Triangulations *Tetrahedralizations* 1.2 Basic Combinatorics 1.3 The Art Gallery Theorem 1.4 Scissors Congruence in 2D 1.5 Scissors Congruence in 3D	3 Polygon Triangulation 3.1 Guarding and Triangulations 3.2 Partitioning a Polygon into Monotone Pieces 3.3 Triangulating a Monotone Polygon	22 Polygon partitioning
4	3 TRIANGULATIONS *Point Sets* 3.1 Basic Constructions 3.2 The Flip Graph *of the set of triangulations* 3.3 The Associahedron *like 3.2, but without interior points (convex position)* 3.4 Delaunay Triangulations 3.5 Special Triangulations *MWT, compatible, pseudo-*	9 Delaunay Triangulations 9.1 Triangulations of Planar Point Sets 9.2 The Delaunay Triangulation 9.3 Computing the Delaunay Triangulation 9.4 The Analysis	36 Triangulations 37 Tri. data structs
5	2.7 Convex Hull in 3D	11 Convex Hulls 11.1 The Complexity of Convex Hulls in 3-Space 11.2 Computing Convex Hulls in 3-Space 11.3 The Analysis	16 3D hulls
7	4 VORONOI DIAGRAMS 4.1 Voronoi Geometry 4.2 Algorithms to Construct the Diagram *incremental* 4.3 Duality and the Delaunay Triangulation *incremental*	7 Voronoi Diagrams - The Post Office Problem 7.1 Definition and Basic Properties 7.2 Computing the Voronoi Diagram *Fortune* 7.3 Voronoi Diagrams of Line Segments 7.4 Farthest-Point Voronoi Diagrams	36 Triangulations 43 Seg. Delaunay graphs 44 Apollonius graphs 45 Voronoi adaptor
8	4.4 Convex Hull Revisited	8 Arrangements and Duality - *motivate w/O'Rourke CG in C, chap 6* 8.2 Duality 8.3 Arrangements of Lines *construction* 11.4 Convex Hulls and Half-Space Intersection 11.5 Voronoi Diagrams Revisited	31 2D arrangements
9		6 Point Location 6.1 Point Location and Trapezoidal Maps 6.2 A Randomized Incremental Algorithm 6.3 Dealing with Degenerate Cases	31.3.1 PL queries
10	5 CURVES 5.1 Medial Axis 5.2 Straight Skeleton		23 Straight skeleton
12	6 POLYHEDRA 6.1 Platonic Solids 6.2 Euler's Polyhedral Formula 6.3 The Gauss-Bonnet Theorem 6.4 Cauchy Rigidity		Boost for shortest paths?

	6.5 Shortest Paths 6.6 Geodesics		
13	5.3 Minkowski Sums *Wein's convolution method* 5.4 Convolution of Curves *winding number* 7 CONFIGURATION SPACES 7.1 Motion Planning *cell decomposition*	13 Robot Motion Planning - *collision avoidance* 13.1 Work Space and Configuration Space 13.2 A Point Robot *trapezoidal map, road map* 13.3 Minkowski Sums *convex case, triangulation for non-convex* 13.4 Translational Motion Planning 13.5 Motion Planning with Rotations *slices*	24 2D Mink. sums 30 3D Mink. sums
14		15 Visibility Graphs 15.1 Shortest Paths for a Point Robot 15.2 Computing the Visibility Graph *rotational plane sweep* 15.3 Shortest Paths for a Translating Polygonal Robot	
15	7.2 Polygonal Chains 7.3 Rulers and Locked Chains 7.4 Polygon Spaces		