CSC 437/537 - Geometric Algorithms

Instructor: Joshua A. Levine
Office: 754 Gould-Simpson
Meets: M/W 2:00-3:15pm, 222 Social Sciences
Office Hours: M 3:30-4:30pm, T 4:30-5:30pm (GS 754), or by appointment

TA: Alex Koltz, akoltz@email.arizona.edu
TA Office Hours: M 1:00-2:00pm (GS 938)
TA: Justin Crum, jcrum@math.arizona.edu
TA Office Hours: F 10:00am-11:00am (GS 938)

Course Syllabus
D2L (for 437)
D2L (for 537)
Piazza

Final project info for 537 students
Proposals Due: Feb 22

Homework 1 - Chs. 1-2
Assigned: Jan 23
Due: Feb 06 01:59:59 PM
Graded: Feb 13

Homework 2 - Chs. 3-5
Assigned: Feb 06
Due: Feb 20 01:59:59 PM
Graded: Feb 27

Homework 3 - Chs. 6-7
Assigned: Feb 20
Due: Mar 13 01:59:59 PM
Graded: Mar 30

Homework 4 - Chs. 8-9
Assigned: Mar 13
Due: Mar 27 01:59:59 PM
Graded: Apr 03

Homework 5 - Chs. 10-12
Assigned: Mar 27
Due: Apr 10 01:59:59 PM
Graded: Apr 17

Homework 6 - Chs. 13-15
Assigned: Apr 10
Due: Apr 24 01:59:59

Course Calendar

All topics on this page are tentative and subject to change!
All required readings are intended to be read **before** class begins

Week	Date	Monday	Date	Wednesday
1	Jan 07	-- No Class --	Jan 09	Introduction
2	Jan 14	2D Convex Hulls	Jan 16	Line Segment Intersection
3	Jan 21	-- MLK Day --	Jan 23	Overlay of Subdivisions
4	Jan 28	Polygon Triangulation	Jan 30	low-D Incremental LP
5	Feb 04	low-D Randomized LP	Feb 06	Range Trees
6	Feb 11	Trapezoidal Maps	Feb 13	Point Location
7	Feb 18	Voronoi Diagrams	Feb 20	Variations on Voronoi
8	Feb	Point-Line Duality	Feb	Midterm Exam

		25		27	
9	Mar 04	-- Spring Break --	Mar 06	-- Spring Break --	
10	Mar 11	Delaunay Triangulations	Mar 13	More Delaunay	
11	Mar 18	Alpha Hulls	Mar 20	Segment Trees	
12	Mar 25	3D Convex Hulls	Mar 27	Binary Space Partitions	
13	Apr 01	Motion Planning	Apr 03	Quadtrees	
14	Apr 08	Visibility Graphs	Apr 10	Grad Presentations	
15	Apr 15	Grad Presentations	Apr 17	Grad Presentations	
16	Apr 22	Grad Presentations	Apr 24	Grad Presentations	
17	Apr 29	Grad Presentations	May 01	Final Exam Review	

PM
Graded: May 01

Final Exam: Fri., May 3, 1-3pm, 222 Social Sciences

Highlighted dates have a homework assignment **due** immediately before class begins on that day.
Boxed dates correspond to *the day before* the deadlines for the dropping (without a W) and the withdraw deadlines for this semester.
See Spring 2019 Undergraduate Dates and Deadlines and Spring 2019 Graduate Dates and Deadlines.

Link to Google drive folder with all lecture slides

Lecture 01 - Introduction (slides)
Date: January 09, 2019

Required Reading:
- Course Syllabus

Lecture 02 - 2D Convex Hulls (slides)
Date: January 14, 2019

Required Reading:
- BCKO, Sections 1.0-1.4

Optional Reading:
- Mount, Lectures 1,3 (pg. 2-6,11-16)

- Jarvis, R. A. (1973). On the identification of the convex hull of a finite set of points in the plane. Information processing letters, 2, 18-21.
- Graham, R. L. (1972). An efficient algorithm for determining the convex hull of a finite planar set. Info. Pro. Lett., 1, 132-133.
- Chan, T. M. (1996). Optimal output-sensitive convex hull algorithms in two and three dimensions. Discrete & Computational Geometry, 16(4), 361-368.
- Many variants referenced in BCKO, Section 1.5

Lecture 03 - Line Segment Intersection (slides)
Date: January 16, 2019

Required Reading:

- BCKO, Sections 2.1

Optional Reading:

- Mount, Lecture 5 (pg. 25-32)
- Bentley, J. L. & Ottmann, T. A. (1979). Algorithms for reporting and counting geometric intersections. IEEE Transactions on computers, (9), 643-647.
- Chazelle, B. & Edelsbrunner, H. (1992). An optimal algorithm for intersecting line segments in the plane. Journal of the ACM (JACM), 39(1), 1-54.

Lecture 04 - Overlay of Subdivisions (slides)
Date: January 23, 2019

Required Reading:

- BCKO, 2.2-2.3

Optional Reading:

- Mount, Lecture 23 (pg. 134-137)
- Paper that first suggested the DCEL: Muller, D. E., & Preparata, F. P. (1978). Finding the intersection of two convex polyhedra. Theoretical Computer Science, 7(2), 217-236.
- Winged-edge data structure: Baumgart, B. G. (1975, May). A polyhedron representation for computer vision. In Proceedings of the May 19-22, 1975, national computer conference and exposition (pp. 589-596). ACM.

Lecture 05 - Polygon Triangulation (slides)
Date: January 28, 2019

Required Reading:

- BCKO, 3.1-3.3

Optional Reading:

- Mount, Lecture 6 (pg. 32-38)
- Garey, M. R., Johnson, D. S., Preparata, F. P., & Tarjan, R. E. (1978). Triangulating a simple polygon. Inform. Process. Lett., 7, 175-179.
- Lee, D. T., & Preparata, F. P. (1977). Location of a point in a planar subdivision and its applications. SIAM Journal on computing, 6(3), 594-606.
- A particularly famous solution: Chazelle, B. (1991). Triangulating a simple polygon in linear time. Discrete & Computational Geometry, 6(3), 485-524.

Lecture 06 - low-D Incremental LP (slides)
Date: January 30, 2019

Required Reading:

- BCKO, 2.4,4.2-4.3

Optional Reading:

- Mount, Lecture 7 (pg. 39-42 -- skip the section on point-line duality for now)

Lecture 07 - low-D Randomized LP (slides)
Date: February 04, 2019

Required Reading:

- BCKO, 4.3-4.4

Optional Reading:

- Mount, Lecture 8 (pg. 45-53)
- Seidel, R. (1991). Small-dimensional linear programming and convex hulls made easy. Discrete & Computational Geometry, 6(3), 423-434.

Lecture 08 - Range Trees (slides)
Date: February 06, 2019

Required Reading:

- BCKO, 5.1-5.5

Optional Reading:

- Mount, Lectures 31,32 (pg. 163-174)
- Bentley, J. L. (1975). Multidimensional binary search trees used for associative searching. Communications of the ACM, 18(9), 509-517.

- Chazelle, B., & Guibas, L. J. (1986). Fractional cascading: I. A data structuring technique. Algorithmica, 1(1-4), 133-162.
- Chazelle, B., & Guibas, L. J. (1986). Fractional cascading: II. applications. Algorithmica, 1(1-4), 163-191.

Lecture 09 - Trapezoidal Maps (slides)
Date: February 11, 2019

Required Reading:
- BCKO, 6.1

Optional Reading:
- Mount, Lecture 9,10 (pg. 53-57)
- Kirkpatrick, D. (1983). Optimal search in planar subdivisions. SIAM Journal on Computing, 12(1), 28-35.

Lecture 10 - Point Location (slides)
Date: February 13, 2019

Required Reading:
- BCKO, 6.2-6.3

Optional Reading:
- Mount, Lecture 10 (pg. 57-62)
- Snoeyink, J. S. (2017). Point location. In Handbook of Discrete and Computational Geometry, Third Edition (pp. 1005-1028). CRC Press.
- Sarnak, N., & Tarjan, R. E. (1986). Planar point location using persistent search trees. Communications of the ACM, 29(7), 669-679.

Lecture 11 - Voronoi Diagrams
Date: February 18, 2019

Required Reading:
- BCKO, 7.1-7.2,7.5

Optional Reading:
- Mount, Lecture 11 (pg. 63-70)
- Fortune, S. (1987). A sweepline algorithm for Voronoi diagrams. Algorithmica, 2(1-4), 153.
- Guibas, L., & Stolfi, J. (1985). Primitives for the manipulation of general subdivisions and the computation of Voronoi Diagrams. ACM transactions on graphics (TOG), 4(2), 74-123.

Lecture 12 - Variations on Voronoi
Date: February 20, 2019

Required Reading:

- BCKO, 7.3-7.4

Optional Reading:

- Mount, Lecture 30 (pg. 160-163)
- Chew, L. Paul. (1990). Building Voronoi diagrams for convex polygons in linear expected time. Technical Report PCS-TR90-147, Dept. Math. Comput. Sci., Dartmouth College, Hanover, NH.
- Aggarwal, A., Guibas, L. J., Saxe, J., & Shor, P. W. (1989). A linear-time algorithm for computing the Voronoi diagram of a convex polygon. Discrete & Computational Geometry, 4(6), 591-604.

Lecture 13 - Point-Line Duality (tentative)
Date: February 25, 2019

Required Reading:

- BCKO, 8.1-8.4

Optional Reading:

- Mount, Lecture 7 (particular the parts on duality on pg. 41-44)
- Mount, Lecture 14 (pg. 80-83)
- Edelsbrunner, H., Seidel, R., & Sharir, M. (1993). On the zone theorem for hyperplane arrangements. SIAM Journal on Computing, 22(2), 418-429.
- Edelsbrunner, H., & Guibas, L. J. (1989). Topologically sweeping an arrangement. Journal of Computer and system sciences, 38(1), 165-194.

Lecture 15 - Delaunay Triangulations (tentative)
Date: March 11, 2019

Required Reading:

- BCKO, 9.1-9.2

Optional Reading:

- Mount, Lecture 12 (pg. 70-74)
- Chapter 2 (Available from Shewchuk's website) of Shewchuk, J., Dey, T. K., & Cheng, S. W. (2016). Delaunay mesh generation. Chapman and Hall/CRC.

Lecture 16 - More Delaunay (tentative)

Date: March 13, 2019

Required Reading:

- BCKO, 9.3-9.4

Optional Reading:

- Mount, Lecture 13 (pg. 74-79)
- Guibas, L. J., Knuth, D. E., & Sharir, M. (1992). Randomized incremental construction of Delaunay and Voronoi diagrams. Algorithmica, 7(1-6), 381-413.

Lecture 17 - Alpha Hulls (tentative)
Date: March 18, 2019

Required Reading:

- Edelsbrunner, H., Kirkpatrick, D., & Seidel, R. (1983). On the shape of a set of points in the plane. IEEE Transactions on information theory, 29(4), 551-559.

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