EECS 395/495 – Computational Geometry

Fall 2014

Instructor: Goce Trajcevski

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Class meets: Mon./Wed. 4:00-5:20PM, Tech LG66

Office hours: Mon./Wed. 3:00-4:00 (or, by appointment)

I. **Course description**: The main goal of this course is to expose the students to the fundamentals of the field of Computational Geometry (CG), particularly focusing on the combinatorial aspects of the inherent geometric properties that can contribute towards efficient algorithmic solutions of the problems of interest in different application domains. Towards that end, most of the topics introduced will be tied with particular application, highlighting the impact of the recognition of the geometric properties, before the actual data structures and algorithms are discussed. The main rationale behind this is the fact that in addition to the tools developed by "traditional" computer science, deriving efficient geometric algorithms relies upon ideas from various mathematical disciplines (algebra, combinatorics, topology, affine and differential geometry, etc.).

The course will attempt to strike a balance between the two fundamental aspects of studying any field: – *depth*, as for the most part, we will focus on in-depth studying of several important abstractions, considered "canonical"; and – *breadth*, illustrating certain concepts in an overview-manner, as well as the diversity of the application domains in which the use of efficient algorithmic solutions based on geometric concepts is a paramount (the last part of the course will introduce a few "potpourri"-like topics).

II. **Required text: "***Computational Geometry, Algorithms and Applications*", by M. de Berg, M. van Kreveld, M. Overmars and O. Schwazkopf, published by Springer.

III. **Reference text and/or other materials:**
   a. "*Computational Geometry in C*", by Joseph O' Rourke";
   b. Handouts that will be provided as part of the course.

IV. **Required Prerequisites**: An elementary background in Data Structures and Algorithms is assumed (equivalent to EECS 311).

V. **Course Outcomes:** After finishing the course, the students should be comfortable with reading and understanding of the vast body or research literature that is founded on certain computational geometry results. They will also be able to not only recognize the geometric features of the problem at hand in the domain(s) of interest, but also reason about inherent trade-offs when selecting particular data structures representing those features, and be able to develop their own implementations of the algorithmic solutions, while capitalizing on the existing libraries.

VI. **Tentative Course Outline**

Week1	- Introduction/Motivation/Applications; Elementary computations (areas/volumes) and the impact of the numerical (im)precision. - Convex Hull: Applications and Implementation;
Week2	- Maps and Line Segments Intersection; - Polygon Triangulation (start – Art Gallery problem) *Homework #1 Assigned; Project #1 handed out (in-class discussion)*
	- Polygon Triangulation (cont.)

Week 3	Applications (visibility) - Introduction to Linear Programming (2D; applications) *Homework #1 due;*
Week4	- Linear Programming (cont.) - Range Searching (start) *Project #1 due*
Week5	- Range Searching (cont.) - Fractional cascading *Midterm;* *Term-Project = Project #2 posted (see below for details)*
Week 6	- Point Location - Voronoi Diagrams (start) *Presentation topics posted (see below for details)*
Week 7	- Voronoi diagrams (cont. + Higher Order Voronoi diagrams) *Homework #2 posted*
Week 8	- Arrangements and Duality - Tree-based structures (kd-Trees and Quadtrees) *Homework #2 due*
Week 9	- Potpourri: Medial Axis and Straight Skeletons (Sensor Networks) Minkowski Sum (Motion Planning)
Week 10	- Porpourri (cont.): DS-Sequences (Upper/Lower Envelopes) *Start of in-class presentations (cf. topics selected in Week #6)*
Week 11	*Cont. in-class presentation (cf. topics selected in Week #6)*
Week 12	- Finals Week: NOTE: there will be no Final Exam for this course – term projects due

VII. Grading

Your grades will be based on:

- Two homeworks (15%)
- Project 1 (15%)
- Midterm (25%)
- Project 2 (25%)
- Presentation (15%)

Few important notes: The first project will be common for the entire class, involving an implementation of some "canonical" algorithm. However, the 2nd project ("term-project") will be something that the students can choose (work in teams is also possible, depending on the selection) from among the following:

- **Research**: you are expected to address a research problem that has some "geometric flavor" (and, of course, provide as efficient solution as possible). In addition to the choices provided by the instructor, you are at a complete liberty (especially so for graduate students) to have something related, or of interest, to your thesis/dissertation work, however, in that case you must obtain a joint approval by the instructor and your academic advisor.
- **Implementation**: provide an implementation for algorithmic solution, preferably to be used as a platform for generating experimental/comparative observation (e.g., as part of a simulation tool). Once again, the students are at liberty of doing something related to their own research and/or senior design project, however, an approval by both the instructor and an advisor is required.

- **Survey**: present an overview of a collection of articles addressing a particular problem-category. Certain topics will be offered by the instructor, but students are welcome to propose other topics too.

Depending on the enrollment, it may also be the case that the in-class presentations during the last week++ of classes (cf. topics presented during Week #6 of the quarter), may be done in teams of two.

Closing Remarks (Awareness and Academic Responsibilities): Please be advised that it is each student's individual responsibility to keep him/herself up-to-date with the announcements made in class, distributed via email, or otherwise posted. As indicated, some of the assignments could be done in teams, however, if a particular assignment is indicated as an individual one – although you are encouraged to always discuss class-related issued with your classmates – it is your responsibility to ensure that the work is done individually. The policies for cheating are well-defined by the University regulations. In addition, notwithstanding our willingness to be understanding for the students' commitments and time-constraints, please do not attempt to obtain an incomplete grade for the course based solely on your poor performance – it is against the rules.

Welcome and good luck!!!