Birla Institute of Technology and Science, Pilani
Second Semester 2019-2020
Course Handout Part II

Date: 06/01/2020

In addition to the Part-I (General Handout) for all courses appended to the timetable, this portion gives further specific details regarding the course.

Course No. **: CS F402**
Course Title **: Computational Geometry**
Instructor-in-Charge: Dr. Manjanna B

1. Scope and Objective:

The objective of this course is to introduce each individual student to computational geometry – a branch of theory of algorithms that aims at solving problems involving geometric objects, and its application areas.

- learn various algorithmic approaches, and assess their strong and weak points in a particular context, thus gaining an ability to choose appropriate approach for a given concrete problem.
- engage in design, analysis, and implementation of algorithms and data structures for geometric problems;
- these geometric problems arise in a wide variety of application areas such as computer graphics, computer-aided design, geographical information systems, robotics, spatial databases, sensor networks, and to a lesser extent, computer vision and machine learning.

The scope of this course includes a number of computational geometry topics such as testing point inclusion in a polygon, computing convex hulls, intersection detection, geometric searching, proximity problems, arrangements, triangulations, geometric sampling, and geometric optimization.

2. Text Book:

T1: M. de Berg, M. van Kreveld, M. Overmars, and O. Schwarzkopf. Computational Geometry: Algorithms and Applications. Springer-Verlag, 3nd edition, 2008

3. Reference Books:

R1. Geometric Approximation Algorithms, Sariel Har-Peled, AMS Series in Mathematical Surveys and Monographs
R2: David Mount's lecture notes, Fall 2016
R3. Computational Geometry: An introduction, Franco P. Preparata and Michael Ian Shamos, Springer-Verlag, 1985
R4. Computational Geometry in C, Cambridge University Press, 1988
R5. Introduction to Algorithms, Cormen et al.
AR. Additional reading assigned by the Instructor

4. Course Plan

No. of Lectures	Learning objectives	Topics to be covered	Chapter in the Text Book
1-3	Preliminaries	Mathematical and geometric review. mathematical models of computation, representation of basic geometric objects, convexity, polytopes, testing point inclusion in a polygon	T1: Ch 1 R1: Ch 1
4– 8	Convex hulls	Planar convex hulls, higher dimensional convex hulls, randomized, output-sensitive, and dynamic algorithms, applications of convex hull	T1: Ch 1
9– 12	Intersection detection	Segment intersection, line sweep, map overlay, halfspace intersection , polyhedral intersection	T1: Ch 2
13-16	Geometric Searching	segment, interval, and priority-search trees, point location, persistent data structure, BSPs, Quad trees, fractional cascading, range searching, nearest-neighbor searching	T1-Ch 5, Ch 6, Ch 10, 12, 14 Ch 16 R1: Ch 2
17-19	Proximity Problems	Closest pair, Voronoi diagram, Delaunay triangulation and their subgraphs, spanners, well separated pair decomposition	T1-Ch 7 R1: Ch 3
20-22	Arrangements	Arrangements of lines and hyperplanes, sweep-line and incremental algorithms, lower envelopes, levels, and zones, applications of arrangements	T1 – Ch 8
23-25	Triangulations	Monotone and simple polygon triangulations, point-set triangulations, optimization criteria, Steiner triangulation, Delaunay refinement	T1 – Ch 3, Ch 9
26-29	Geometric sampling	Computing Cuttings by random sampling, epsilon-nets and approximations, VC dimensions and applications to geometric optimization,	R1-Ch 4, 5, 6, 7
30-33	Geometric Optimization	LP-type problems, parametric searching, approximation techniques	T1: Ch 4 R1: Ch 15, 16
34-38	Visibility and motion planning	Visibility graphs, Art gallery problem, shortest paths, ray shooting.	T1 - Ch 13, Ch 15
39-42	Worst-case lower bounds	Algebraic computation-tree, reductions for various problems, a few 3SUM-hard geometric problems	

5. Evaluation Scheme:

Sr. No.	Component	Duration	Weightage (%)	Date & Time	Nature of Component
1.	Quiz 1	60 min.	10%		OB
2.	Quiz 2	60 min.	10%		OB
3.	Research Project		30 %		
3	Midterm Exam	1.5 hrs	20%	6/3 9.00 - 10.30AM	CB
4.	Comprehensive Exam	3 hrs.	30%	12/05 FN	CB

Research Project Details: There will be one research project to be completed by every student either individually or in a group of two or three people. The aim of this component is for the project work to be of publishable or nearly publishable quality or you might as well get something substantive out of the experience. Each student is encouraged to develop their own projects, but a number of topics will be discussed in the class or one can come and discuss with the instructor in his chamber. You should start thinking about the project as soon as possible, and get it approved by the instructor. The evaluation of the project will consist of two parts. The first part, which will be due immediately after one month once the semester has started, will require each student or a group to submit a proposal, literature survey, and initial work to support the proposed research. The second part of the evaluation, due in the last month of the semester, will be based on the following two deliverables:

(i) A well-written paper for submission to the instructor (the primary measure of assessment will be the quality of the methods, analysis, and results in the paper; however, the paper should also be well-written and express you results lucidly).

(ii) A short presentation to the class highlighting the major contributions of the paper (the primary measure of assessment will be the clarity with which you present your ideas and your ability to effectively communicate your results to your peers, and to the instructor.

6. Chamber Consultation hours: To be announced in the class.

7. Make-up Policy:
Prior Permission of the Instructor-in-Charge is usually required to take a make-up for a test.
A make-up test shall be granted only in genuine cases on justifiable grounds.

8. Notices: Notice regarding the course will be displayed on the CMS and CS & IS group notice board.

9. **Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-in-charge
CS F402