Birla Institute of Technology and Science, Pilani
Second Semester 2020-2021
Course Handout Part II

Date: 16/01/2021

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 the course is to introduce each individual student to computational geometry – a branch of the theory of algorithms that aims at solving problems involving geometric objects, and their application areas. In particular, one will

- learn various algorithmic approaches, and assess their strong and weak points in a particular context, thus gaining an ability to choose an 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.
R6. Geometry: Combinatorics and Algorithms Lecture notes, 2018 (https://geometry.inf.ethz.ch/)
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	To understand 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	To learn algorithms for Convex hulls based on various techniques	Planar convex hulls, higher dimensional convex hulls, randomized, output-sensitive, and dynamic algorithms, applications of convex hull	T1: Ch 1
9– 12	To understand Intersection detection in 2D and 3D	Segment intersection, line sweep, map overlay, halfspace intersection , polyhedral intersection	T1: Ch 2
13-16	To learn algorithms and data structures for 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	To solve various Proximity Problems using a variety of techniques	Closest pair, Voronoi diagram, Delaunay triangulation and their subgraphs, spanners, well separated pair decomposition	T1-Ch 7 R1: Ch 3
20-22	To study algorithms for building Arrangements of simple geometric objects	Arrangements of lines and hyperplanes, sweep-line and incremental algorithms, lower envelopes, levels, and zones, applications of arrangements	T1 – Ch 8
23-25	To study algorithms for Triangulations of points and polygons	Monotone and simple polygon triangulations, point-set triangulations, optimization criteria, Steiner triangulation, Delaunay refinement	T1 – Ch 3, Ch 9
26-29	To learn Geometric sampling and study various concepts and algorithms based on that	Computing Cuttings by random sampling, epsilon-nets and approximations, VC dimensions and applications to geometric optimization,	R1-Ch 4, 5, 6, 7
30-33	To study Geometric Optimization	LP-type problems, parametric searching, approximation techniques	T1: Ch 4 R1: Ch 15, 16
34-38	To understand Visibility and motion planning	Visibility graphs, Art gallery problem, shortest paths, ray shooting.	T1 - Ch 13, Ch 15
39-42	To prove some Worst-case lower	Algebraic computation-tree, reductions for various problems, a few 3SUM-hard	

	bounds	geometric problems	

5. Evaluation Scheme:

S. No.	Component	Duration	Weightage (%)	Date & Time	Remarks
1.	Quiz 1	40 min.	10%	As announced by the Instructor	Pre-MIDSEM, Open Book
2.	Research Paper Presentation	---	10 %	As announced by the Instructor	---
3.	Programming Assignment	---	10 %	As announced by the Instructor	Spread across the semester
4.	Midsem Exam	1.5 hrs	30%	03/03 3.30 - 5.00PM	Open Book
5.	Comprehensive Exam	2 hrs.	40%	08/05 FN	Open Book

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.

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.

Dr. Manjanna B.,
Instructor-in-charge
CS F402