UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Course guide
270182 - GEOC - Computational Geometry

Last modified: 13/07/2023

Unit in charge: Barcelona School of Informatics
Teaching unit: 749 - MAT - Department of Mathematics.

Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: RODRIGO IGNACIO SILVEIRA ISOBA

Others: Primer quadrimestre:
RODRIGO IGNACIO SILVEIRA ISOBA - 10

PRIOR SKILLS

- Programming
- Basic knowledge of data structures
- Basic knowledge of algorithmic techniques

This course is recommended for students with knowledge and interest in computation. Students with other specializations of without any specialization are kindly asked to take this into account before enrolling.

Students need to do their presentations in English. This course is not recommend for students with very rudimentary English skills.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Generical:
G3. THIRD LANGUAGE: to know the English language in a correct oral and written level, and accordingly to the needs of the graduates in Informatics Engineering. Capacity to work in a multidisciplinary group and in a multi-language environment and to communicate, orally and in a written way, knowledge, procedures, results and ideas related to the technical informatics engineer profession.

TEACHING METHODOLOGY

Theory classes will set out the contents of the course, oriented to the resolution of examples and applications.

Exercise classes will be centered in the resolution of problems by the instructors as well as by the students. Students will be assigned problems and will have enough time to think about them in advance, so that they will be able to propose their solutions during the class. The problems will be mainly algorithmic.

The purpose of the lab classes is to implement the solutions discussed in the theory and exercices classes, the effective solution of problems being one of the goals of the course. The problems to be solved in the lab classes will start being of elementary complexity, and will end with the resolution of a problem, preferably applied and real.

LEARNING OBJECTIVES OF THE SUBJECT

1.Learn the several kinds of problems in Computational Geometry, as well as their applications.
2.Learn the capacity of combining geometric tools with the appropriated data structures and algorithmic paradigms.
3.See in action several algorithmic paradigms and data structures useful in geometric problems.
4.Apply geometric results to real problems.
5.Ability to solve basic problems that appear in computational geometry.
6.Ability to implement the solutions proposed in the class, as well as those that can be found in the basic references of the course.
7.Ability to recognize the geometric problems behind the applications, and to propose adequate algorithmic tools to solve them.
8.Practice and improve the capability of working in a English speaking professional surrounding

STUDY LOAD

Type	Hours	Percentage
Self study	84,0	62.22
Hours large group	30,0	22.22
Guided activities	6,0	4.44
Hours small group	15,0	11.11

Total learning time: 135 h

CONTENTS

Introduction to Computational Geometry

Description:
The problems studied in Computational Geometry. Applications. Terminology. Basic Tools.

A basic tool

Description:
Oriented area. Left/right. Intersection of two lines. Intersection of two segments. Oriented turn.

Sweep line algorithms

Description:
Bentley-Ottmann algorithm

Basic geometric problems on polygons

Description:
Line/polygon intersection, point location in a polygon, supporting lines to a polygon from a point, etc.

Convex hull

Description:
Algorithms for the construction od the convex hull of 2D point sets.

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Duality. Intersection of halfplanes.

Description:
Geometric duality. The parabola duality. Intersection of halfplanes and convex hulls.

Polygon triangulation

Description:
Triangulation of monotone polygons, decomposition of a polygon into monotone polygons.

Proximity

Description:
Voronoi diagrams and their applications

Triangulations of point sets

Description:
Delaunay triangulation

Line and plane arrangements

Description:
Description, properties, and construction. Levels. Relationship with Voronoi diagrams.

Point location in planar subdivisions

Description:
Variety of strategies. Preprocessing complexity vs query efficiency.

Shape reconstruction

Description:
Alpha-shapes, crust, anti-crust and beta-skeletons.

Students presentations of further subjects

Description:
Extensions of the course contents.

ACTIVITIES

Theory presentations

Description:
Students will be in charge of the final sessions.

Specific objectives:
1, 2, 3, 8

Related competencies :
G3. THIRD LANGUAGE: to know the English language in a correct oral and written level, and accordingly to the needs of the graduates in Informatics Engineering. Capacity to work in a multidisciplinary group and in a multi-language environment and to communicate, orally and in a written way, knowledge, procedures, results and ideas related to the technical informatics engineer profession.

Full-or-part-time: 50h
Theory classes: 30h
Self study: 20h

Solving problems

Description:
Only some of the sessions will be run by the instructor. The remaining ones will consist of presentation and discussion of the solutions of problems, done by the students.

Specific objectives:
5, 7, 8

Related competencies :
G3. THIRD LANGUAGE: to know the English language in a correct oral and written level, and accordingly to the needs of the graduates in Informatics Engineering. Capacity to work in a multidisciplinary group and in a multi-language environment and to communicate, orally and in a written way, knowledge, procedures, results and ideas related to the technical informatics engineer profession.

Full-or-part-time: 41h 30m
Practical classes: 16h 30m
Self study: 25h

Lab

Description:
Implementing geometric algorithms

Specific objectives:
4, 6, 8

Related competencies :
G3. THIRD LANGUAGE: to know the English language in a correct oral and written level, and accordingly to the needs of the graduates in Informatics Engineering. Capacity to work in a multidisciplinary group and in a multi-language environment and to communicate, orally and in a written way, knowledge, procedures, results and ideas related to the technical informatics engineer profession.

Full-or-part-time: 58h 30m
Laboratory classes: 13h 30m
Self study: 45h

Exam

Description:
It consistes of solving some problem(s) and some theory question(s).

Specific objectives:
1, 2, 3, 4, 5, 7

GRADING SYSTEM

The evaluation will be based on the work done by the student along the course. The four components to be considered will be:

Problems presented in class (P)
Final presentation of the chosen subject (T)
Lab exercises (L)
Exam (E)

The final course grade will be calculated as follows:

Final grade = 0.2*P + 0.2*T + 0.35*L + 0.25*E

BIBLIOGRAPHY

Basic:
- Berg, Mark de; [et al.]. Computational geometry: algorithms and applications. 3rd ed. Springer-Verlag, 2008. ISBN 9783540779735.
- O'Rourke, J. Computational geometry in C. 2nd ed. Cambridge University Press, 1998. ISBN 0521640105.
- Preparata, F.P.; Shamos, M.I. Computational geometry: an introduction. Springer-Verlag, 1985. ISBN 3540961313.

Complementary:
- Boissonnat, J.-D.; Yvinec, M. Algorithmic geometry. Cambridge University Press, 1997. ISBN 0521565294.
- Devadoss, S.L.; O'Rourke, J.. Discrete and computational geometry. Princenton University Press, 2011. ISBN 9780691145532.
- Sack, J.-R.; Urrutia, J. Handbook of computational geometry. Elsevier, 2000. ISBN 0444825371.
- Goodman, J.E.; O'Rourke, J. Handbook of discrete and computational geometry. 2nd ed. Chapman & Hall/CRC, 2004. ISBN 1584883014.
- Aurenhammer, F.; Klein, R.; Lee, D.-T. Voronoi diagrams and Delaunay triangulations. World Scientific, 2013. ISBN 9789814447638.

RESOURCES

Hyperlink:
- https://dccg.upc.edu/people/vera/teaching/courses/computational-geometry/