Topological Data Analysis

Code: 104419
ECTS Credits: 6

Degree	Type	Year	Semester
2503740 Computational Mathematics and Data Analytics	OT	4	1

Contact

Name: Joan Porti Pique

Email: joan.porti@uab.cat

Teachers

Martín-Hernán Campos Heredia

Use of Languages

Principal working language: catalan (cat)

Some groups entirely in English: No

Some groups entirely in Catalan: Yes

Some groups entirely in Spanish: No

Prerequisites

Students are required to have followed inear algebra, to have familiarity of the geometric notions of previous years, and to have some knowledge of Python.

Objectives and Contextualisation

The first goal is to introduce the topological features of data (namely, shapes and patterns). We shall learn the methodology do release this information, as well as some applications

Competences

- Apply a critical spirit and rigour for the validation or rejection of your own arguments and those of others.
- Demonstrate a high capacity for abstraction and translation of phenomena and behaviors to mathematical formulations.
- Formulate hypotheses and think up strategies to confirm or refute them.
- Make effective use of bibliographical resources and electronic resources to obtain information.
- Relate new mathematical objects with other known objects and deduce their properties.
- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
- Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
- Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
- Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
- Using criteria of quality, critically evaluate the work carried out.

- Work cooperatively in a multidisciplinary context assuming and respecting the role of the different members of the team.

Learning Outcomes

1. Apply a critical spirit and rigour for the validation or rejection of your own arguments and those of others.
2. Contrast, if possible, the use of calculation with the use of abstraction in solving a problem. Evaluate the advantages and disadvantages of both methods.
3. Describe the concepts and mathematical objects pertaining to the subject.
4. Describe the distinct components of a system and the interactions between them.
5. Make effective use of bibliographical resources and electronic resources to obtain information.
6. Relate these concepts to methods and objects in other areas.
7. Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
8. Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
9. Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
10. Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
11. Understand the basic topological invariants relevant to the analysis of data.
12. Using criteria of quality, critically evaluate the work carried out.
13. Within a problem, distinguish what is important from what is not so as to construct the mathematical model and its resolution.
14. Work cooperatively in a multidisciplinary context, taking on and respecting the role of the distinct members in the team.

Content

1 Introducció a la topologia
2 Complexos simplicials i homologia
3 Homologia persistent
4 Vectoritzacions
5 Una aplicació: periodicitat de sèries temporals
6 UMAP

Methodology

There is a theoretical part (including exercises sessions) and a practical part with computer.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	26	1.04	1, 12, 2, 11, 3, 4, 13, 10, 9, 7, 8, 6, 14, 5
Practices with computer	24	0.96	1, 12, 2, 11, 3, 4, 13, 10, 9, 7, 8, 6, 14, 5
Type: Supervised			

Tutoring and consultations	10	0.4	1, 12, 2, 11, 3, 4, 13, 10, 9, 7, 8, 6, 14, 5
Type: Autonomous			
Independent study and preparation	45	1.8	1, 12, 2, 11, 3, 4, 13, 10, 9, 7, 8, 6, 14, 5
Use of sorftware	30	1.2	1, 12, 2, 11, 3, 4, 13, 10, 9, 7, 8, 6, 14, 5

Assessment

Evaluations is organized as follows:

- Primer parcial de teoria (30%)
- Entregues a pràctiques (40%)
- Presentació final de curs (30%)

- Some of the practical sessions will be evaluated at the end (previously announced). Partial tests and the practical work can be reevaluated, but the contnued evaluation cannot.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Continued evaluation practices	40	10	0.4	1, 12, 2, 11, 3, 4, 13, 10, 9, 7, 8, 6, 14, 5
First partial test theory	30	2.5	0.1	1, 12, 2, 11, 3, 4, 13, 10, 9, 7, 8, 6, 14, 5
Presentació final de curs	30	2.5	0.1	1, 12, 2, 11, 3, 13, 10, 9, 7, 8, 6, 14, 5

Bibliography

- Edelsbrunner, Herbert; Harer, John L. Computational topology. An introduction. American Mathematical Society, Providence, RI, 2010. xii+241 pp. ISBN: 978-0-8218-4925-5.
- G. Carlsson, Topology and data, Bull. Amer. Math. Soc. 46 (2009), 255-308.
- R. Kraft, Illustrations of Data Analysis Using the Mapper Algorithm and Persistent Homology, KTH Master's Thesis, 2016
- Gunnar Carlsson, Mikael Vejdemo-Johansoon, Topological data analysis with applications. 2022
- Tamal Krishna Dey, Yusu Wang, Computational topology for data analysis. 2022
- https://giotto-ai.github.io/gtda-docs/0.3.0/library.html

Software

Compùter practical sessions shall be in Python. We shall use giotto-tda, built on top of scikit-learn