

Title of BIP: Applied topology, topological data analysis

General information

Objectives and Description:

Topological Data Analysis has become an important tool in machine learning and artificial intelligence. The course will provide the needed concepts and methods and tools in homology (persistent homology and persistent diagrams) to have efficient methods to study data clouds and other objects in data analysis

Methods and outcomes:

After the course the student should be acquainted with the basic concepts in topological complexes, homology and persistent homology, and its use in data analysis and other subjects. Specifically, they should be able to approximate data clouds and other geometrical objects by topological complexes and filtrations and, calculate the persistent homology of these objects and the persistent diagrams. After the course the participants should be able to give reliable interpretations of the topological invariants in applications in technology and humanities. Besides, they should be able to use software packages to calculate homology of complexes and persistent diagrams, and to carry out analysis of data with these methods.

Field of Education:

Mathematics and Artificial Intelligence

Target audience / Participants profile:

Last year of mathematics + Msc and Phd of Maths and related areas

No of ECTS issued: 6 ECTS

The evaluation will be twofold: Some of the activities in the physical component will be graded (some theoretical exercises or problems). In the virtual component, the students will read a paper in groups and will need to write a report and make a presentation of the results they find.

Language of instruction and requirements:

English B2

Dates for physical activity:

February 1-10 2027

Location of physical activity:

Zaragoza (Spain)

Dates for virtual component:

February 28th - Early May 2027

Virtual Component Description:

The course will have a virtual classroom where didactical materials (including the recorded on location lectures) will be posted, and where the participants will have digital tests, hand-in exercises and communication channels teacher-student and student-student. We propose meetings via Google Meet. The laborations will be done online.

Organizing Board

Receiving/Host university:

Univeridad de Zaragoza, Spain (Álvaro Lozano alozano@unizar.es)

Sending/Partner universities:

P1. UNED, Spain (Antonio Costa, acosta@mat.uned.es)

P2. Università degli Studi di Modena e Reggio Emilia I, Italy (Paola Cristofori paola.cristofori@unimore.it)

P3. Universitat Autònoma de Barcelona, Spain (Natalia Castellana, Natalia.Castellana@uab.cat)

P4. Universidade Aveiro, Portugal (Tatiana Tchemisova, tatiana@ua.pt)

P5. Université de Pau et des Pays de l'Adour (Vincent Florens, vincent.florens@univ-pau.fr)

P6. Università di Torino (Anna Fino, annamaria.fino@unito.it)

Detailed programme

1. Planned activities during virtual component:

There is no schedule for the virtual teaching.

2. Planned activities during physical component:

The contents of the course will be presented in ten 90 minutes lectures. This is a tentative schedule.

- Day 1. Introduction to Topology. Complexes
- Day 2. Simplicial Complexes and Data Clouds
- Day 3. Simplicial Homology
- Day 4. Persistent Homology I
- Day 5. Persistent Homology II
- Day 6. Discrete Morse Theory
- Day 7. Geometric Structure of Convex Bodies
- Day 8. Morse Homology and The Stability Theorem
- Day 9. The stability Theorem in Zigzag Persistent Homology
- Day 10. Some Examples and Applications

Application procedure

Details about the application procedure can be provided by the local Erasmus office/International office or the local coordinator in each of the universities acting as sending partners.

More information will appear on <https://riemann.unizar.es/biptda/>

Organizational funds:

The University of Zaragoza will cover some meals during the physical mobility. If there are enough funds, the University of Zaragoza may also cover one dinner and some coffee breaks.

Accommodation:

The University of Zaragoza cannot provide accommodation, as students must pay for their own accommodation with

the grant received from their universities. Booking accommodation in advance is highly recommended.

The organizers will provide suggestions of accommodation once students have been selected.

Travelling to Zaragoza:

By plane

You can reach Zaragoza by plane from Milan Bergamo, Roma-Fiumicino, Bucarest-Henri Coandă, Cluj Napoca, London Stansted, and Brussels Charleroi.

Ryanair and Wizz Air are currently the only carriers with international destinations. Please check their websites for details on dates and times of operation.

Otherwise, the airports in Barcelona or Madrid are good options.

By train

Zaragoza is very well-connected to Madrid and Barcelona by high-speed rail. It takes around 1 hour and 30 minutes to get to Madrid Atocha or Barcelona Sants. In Zaragoza, the main station is Zaragoza Delicias.

Trains on the Madrid-Zaragoza-Barcelona line are operated by Renfe, Ouigo and Iryo.

<https://www.renfe.com/es/en>

<https://www.ouigo.com/es/en>

<https://iryo.eu/en/home>

You can check the times of all trains (from different companies) here: <https://www.thetrainline.com/en-us>

RENFE and SNCF operate direct trains from French cities to Barcelona and Zaragoza.

Renfe operates the routes between Marseille and Zaragoza and between Lyon and Barcelona. You can check the current stops and times here: <https://www.renfe.com/es/en/renfe-group/communication/renfe-today/press-room/renfe-presents-ave-high-speed-services-france-two-routes-spain-lyon-marseille>

Information on the routes operated by SNCF (Paris-Barcelona) can be found here: <https://www.sncf-voyageurs.com/en/travel-with-us/in-europe/>

By bus

You may also consider travelling by bus. This can be an interesting option if your flight arrives late or departs early from the Madrid-Barajas airport, as some buses stop directly at the airport (Terminal 4). The journey from Zaragoza to Madrid's airport takes 3 hours and 30/45 minutes. You can check the times on the ALSA website:

<https://www.alsa.com/en/web/bus/home>

deadline:

January 8th, 2027

4/5 students per university are welcome