Allegato 2 - Scheda BIP

Docente proponente e referente **Cognome, Nome** **Email**	Cristofori, Paola paola.cristofori@unimore.it
Local Personale tecnico amministrativo di supporto	Graziella Scalone didattica.fim@unimore.it
Dipartimento	Dipartimento di Scienze Fisiche, Informatiche e Matematiche (FIM)
Corso/i di Studio ammessi a partecipare	Corso di Laurea in Matematica (LT) iscritti al II o III anno; corso di laurea Magistrale in Matematica (LM) tutti gli iscritti
Titolo del BIP	"*Applied topology, topological data analysis"*
Atenei che prendono parte al programma	**Partner Coordinatore** *Universidad de Zaragoza, Spain, E ZARAGOZ01 (Álvaro Lozano alozano@unizar.es)* *Altri Partner:* 1. *UNED, Spain, E MADRID01 (Antonio Costa, acosta@mat.uned.es)* 2. *Universitat Autònoma de Barcelona, Spagna, E BARCELO02 (Natalia Castellana, Natalia.Castellana@uab.cat)* 3. *Universidade Aveiro, Portogallo, P AVEIRO01 (Tatiana Tchemisova, tatiana@ua.pt)* 4. *Université de Pau et des Pays de l'Adour, Francia, F PAU01 (Vincent Florens, vincent.florens@univ-pau.fr)* 5. *Università di Torino, Italia, I TORINO01 (Anna Fino, annamaria.fino@unito.it)* 6. *Linköping University, Svezia, S LINKOPI 01(Milagros Izquierdo, milagros.izquierdo@liu.se)*
BIP ID	*2025-1-ES01-KA131-HED-000312896-5*
Numero di posti disponibili per gli studenti Unimore	3 (eventualmente ampliabili a 4)
Periodo di svolgimento mobilità fisica - attività in presenza: data inizio e data fine	Dall'1 febbraio 2027 al 12 febbraio 2027

Mobilità fisica - attività in presenza:	12 giorni
Periodo di svolgimento componente virtuale – tempistiche rispetto alla componente fisica.	15 febbraio – inizio maggio 2027 dopo la componente fisica
Componente virtuale - durata:	Non ancora definito
Componente virtuale - date e descrizione:	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.
Paese in cui si svolgerà il BIP - mobilità in presenza	Spagna
Città di svolgimento del BIP	Saragozza
Lingua di svolgimento e requisiti linguistici:	No specific certification is required. However, a B2 level of English is strongly recommended to ensure successful participation in the course.
Tipologia di attività didattica prevista	Theoretical Classes (In-person) to introduce the main theoretical concepts ad results. Online laboratories Autonomous Work (on-line): Collaborative project development conducted in groups.
Numero di crediti ECTS previsti dal BIP (minimo 3)	6
Numero di crediti ECTS che verranno riconosciuti	6 Questi crediti saranno riconosciuti: • per gli studenti LT: come *Topologia Algebrica* (se presente nel piano di studi) o crediti liberi • per gli studenti LM: come *Computational Topology* (se presente nel piano di studi) o crediti liberi
Descrizione del programma sia per le attività in presenza che per quelle on-line.	Topological Data Analysis has become an important tool in machine learning and artificial intelligence. The course will provide the needed concepts, methods and tools in homology (persistent homology and persistent diagrams) to have efficient methods to study data clouds and other objects in data analysis. *Planned activities during virtual component:* A calendar will be available as soon as possible

	Planned activities during physical component: The contents of the course will be presented in ten 90 minutes lectures. This is a temptative 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 *Outcomes:* After the course the students 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 mathematical objects and the persistent diagrams. • give reliable interpretations of the topological invariants in applications in technology and humanities. • use software packages to calculate homology of complexes and persistent diagrams, and to carry out analysis data with these methods.
Commissione di selezione/ Docente Referente	Commissione di selezione: Paola Cristofori, (referente), Giuseppe Mazzuoccolo
Criteri di selezione	• Carriera accademica da esse3 e/o autocertificazione • Competenze linguistiche

	• Colloquio A parità di punteggio, la priorità verrà data a chi non ha mai usufruito di una borsa Erasmus + Studio e/o Traineeship e/o Bip, per mobilità di durata lunga e/o breve; limitatamente agli studenti della LT, verrà data priorità agli studenti iscritti al III anno.

Documenti richiesti da allegare in candidatura su Esse3:

- CV *(riportante sia l'attività accademica, sia eventuali altre esperienze, lavorative, di volontariato/associazionismo, come anche altre esperienze all'estero)*
- autocertificazione di eventuali esami superati e non ancora presenti su esse3
- eventuali certificazioni linguistiche *(anche non di lingua inglese)*

Eventuali ulteriori informazioni (*es. alloggio, application*):

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.

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:

Febrary 1-12 2027

Location of physical activity:

Zaragoza (Spain)

Dates for virtual component:

Febrary 15th - 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. Universita 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)

P7. Linköping University (Milagros Izquierdo, milagros.izquierdo@liu.se)

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 temptative 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/

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Accommodation:

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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:

Jaunary 8th, 2027