UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

CONSIGLIO INTERCLASSE IN MATEMATICA

## COURSE OF STUDY — TWO-YEAR MASTER OF SCIENCE PROGRAMME IN MATHEMATICS

## ACADEMIC YEAR — 2023-2024

## ACADEMIC SUBJECT — COMPUTATIONAL GEOMETRY

| **General information** | |
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| Term | First semester (September 25, 2023 – December 22, 2023) |
| European Credit Transfer and Accumulation System credits (ECTS) | 4 |
| SSD | MAT/03 – Geometry |
| Language | Italian |
| Mode of attendance | Not mandatory |

| **Lecturer** | |
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| Name and surname | Amedeo Altavilla |
| E-mail | amedeo.altavilla@uniba.it |
| Telephone | +39 080 544 2663 |
| Department and office | Department of Mathematics, room 14 second floor |
| Virtual meeting room | |
| Web page | https://www.dm.uniba.it/it/members/altavilla |
| Office hours | After lectures or by appointment (email) |

| **Work schedule** | | | | |
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| | Total | Lectures | Hands-on learning | Self-study |
| **Hours** | 100 | 32 | | 68 |
| **ECTS credits** | 4 | 4 | | |

| **Learning objectives** | |
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| | We will discuss the main themes of simplicial homology; we will use these tools for the study of topological properties both in a theoretical and concrete environment; we will introduce the main topological techniques for the analysis of data together with the related tools for computing.<br>At the end of the teaching the student will be able to expose with a suitable language definitions and basic properties regarding simplicial complexes and simplicial homology; the student will be able to apply the content of the teaching to specific situations, to study some properties of topological spaces in order to construct some approximation of them and/or distinguish them. The student will be able to explain the ideas and the fundamental tools of persistent homology and to describe some of its possible application in the context of topological data analysis; the student will learn the main algorithms to compute explicitly some of the tools studied; the student will be able to interpret the results of the analysis produced with the main software packages. |

| **Course prerequisites** | |
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| | Elements of linear algebra, algebra and general topology |

| **Syllabus** | |
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| Course contents | Preliminaries of linear algebra and general topology. Elements of simplicial and singular homology. Persistent homology: barcodes, persistence |

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| | diagrams, metrics on diagrams. Some multivariable persistent homology. Applications. |
| Reference books | Schenck, H. (2022). Algebraic Foundations for Applied Topology and Data Analysis. In Mathematics of Data. Springer International Publishing. https://doi.org/10.1007/978-3-031-06664-1<br>Edelsbrunner, H., & Harer, J. L. (2022). *Computational topology: An introduction*. Providence, RI: American Mathematical Society. |
| Additional course materials | |
| Repository | |

| **Expected learning outcomes** | |
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| Knowledge and understanding | **The student demonstrates knowledge and understanding of algebraic and topological tools that reinforce elementary ones and is able to elaborate and/or apply original ideas to real-world contexts.** |
| Applying knowledge and understanding | **The student is able to apply his/her knowledge and skills in problem solving to new or unfamiliar topics embedded in broader (or interdisciplinary) contexts related to topology or data analysis.** |
| Soft skills | *Making judgements*: The student is able to integrate knowledge from different fields and deal with complexity, and to make judgements on the basis of limited or incomplete information. |
| | *Communication skills*: The student is able to communicate clearly and unambiguously his/her conclusions on topics concerning topological data analysis, as well as the underlying knowledge and rationale, to specialist and non-specialist interlocutors. |
| | *Learning skills*: The student develops learning skills that enable him/her to pursue the study of persistent homology and data analysis independently. |

| **Teaching methods** | |
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| | Lectures and possible workshops. |

| **Assessment** | |
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| Assessment methods | Oral examination and/or opportunity to develop a project. |
| Evaluation criteria | • *Knowledge and understanding*: knowledge of the fundamentals of persistent homology, its prerequisites and its main applications.<br>• *Applying knowledge and understanding*: ability to solve problems and illustrate acquired notions in specific examples.<br>• *Making judgement*: ability to assess the consistency of logical reasoning used in demonstrations and algebraic/geometric constructions, and to compare alternative demonstrations.<br>• *Communication skills*: to present topological and algebraic constructions related to the analysis of data using appropriate language and formalisms.<br>• *Learning skills*: ability to consult advanced texts and scientific articles, also in English. |
| Grading policy | The final grade will be awarded following an oral interview on the course topics and/or one or more in-depth studies agreed upon in advance with the lecturer. In particular, the level of in-depth study of the topics, clarity of presentation and mastery of the subject contribute to the final result, expressed in thirtieths. |

| **Further information** | |
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