

MAT 4930: Special Topics – Topological Data Analysis and Machine Learning

University of Florida, Department of Mathematics
Course Syllabus, Fall 2020

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Class meetings: MWF 4th period (10:40–11:30am), Online

Prerequisites: MAS 4105 with a minimum grade of C, or permission from instructor.

Textbook. A Short Course in Computational Geometry and Topology, by Herbert Edelsbrunner. (The UF library has an eBook copy that you may download.) We will use about half of this book, and about half of what we will cover is in this book.

Additional references. I have links to many resources on my web page. <https://people.clas.ufl.edu/peterbubenik/intro-to-tda/> Wikipedia has articles on some of the topics covered in this course.

Course description. In this course you will learn the basics of computational topology and how they may be used to analyze data. Topological topics will include simplicial complexes, simplicial homology, filtered simplicial complexes, persistent homology, bar codes, persistence diagrams and persistence landscapes. We will learn how to apply these constructions to data by constructing Čech complexes, Vietoris-Rips complexes, Delaunay triangulations and alpha complexes. Once we have learned how to apply the mathematical and computational machinery, we will learn how to combine it with tools from statistics and machine learning. These will include the permutation test, principal component analysis and support vector machines.

Course schedule.

Weeks 1–2	Simplicial complexes and simplicial homology
Weeks 3–4	Filtered simplicial complexes and persistent homology
Weeks 5–6	Feature maps and persistence landscapes
Weeks 7–8	Machine learning
Week 9	More topological data analysis
Weeks 10–13	Work on projects
Weeks 14–15	Presentations

Course Objectives. By the end of this course, you will have learned the basic concepts of computational topology and how they may be combined with machine learning to analyze data. In addition to learning some interesting mathematics, you will learn some important methods in modern data science. You will be able to use the statistical programming language R. You will apply sophisticated mathematics to analyze real data, and be able to present your work in writing and in a presentation. These skills will prepare you for further academic work and for working in technical and quantitative jobs in industry.

Course work and assessment. The grading for the course will be based on homework and homework presentations 50%, a written report on your project 30%, and an oral presentation of your project 20%.

Class Demeanor. This class will be synchronous and interactive. Students are expected to attend classes and to use audio to ask questions and answer questions. Students are expected to share their video and dress as they would in class. Students are expected to arrive to class on time and behave in a manner that is respectful to the instructor and to fellow students. Students are expected to avoid the use of technology for purposes unrelated to class and avoid eating during class time. Other students should be respected in discussion.

Software. We will be using the open source statistical software package R. It is not assumed that you have any prior experience.

Grading scheme. A: 100% – 90%, A-: < 90% – 85%, B+: < 85% – 80%, B: < 80% – 75%, B-: < 75% – 70%, C+: < 70% – 67%, C: < 67% – 64%, C-: < 64% – 60%, D+: < 60% – 57%, D: < 57% – 54%, D-: < 54% – 50%, F: < 50% – 0%.

Homework. The best way to learn mathematics is to do mathematics. The first two assignments will ask you to demonstrate that you have mastered the main mathematical concepts and algorithms. The second two assignments will ask you to demonstrate that you are able to carry out the relevant computations using R. The fifth assignment will help you prepare for your project. You are encouraged to discuss the exercises with your classmates, but you must write up your own solutions. Copying solutions or allowing your solutions to be copied is considered cheating. If you are unable to do any of the homework ask for help as soon as possible.

Class attendance. Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies that can be found at: <https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>.

Disabilities statement. Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the Disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Diversity statement. The Mathematics Department is committed to diversity and inclusion of all students. We acknowledge, respect, and value the diverse nature, background and perspective of students and believe that it furthers academic achievements. It is our intent to present materials and activities that are respectful of diversity: race, color, creed, gender, gender identity, sexual orientation, age, religious status, national origin, ethnicity, disability, socioeconomic status, and any other distinguishing qualities.

Course evaluation. Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

Academic honesty. UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code.” On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor.

Grade points. For current UF grading policies for assigning grade points see <https://catalog.ufl.edu/UGRD/academic-regulations/grades-grading-policies/>.

Campus resources.

Health and wellness.

- U Matter, We Care: If you or a friend is in distress, please contact umatter@ufl.edu or 352-392-1575 so that a team member can reach out to the student.
- Counseling and Wellness Center: <https://www.counseling.ufl.edu>, 352-392-1575.
- Sexual Assault Recovery Services (SARS) Student Health Care Center, 352-392-1161.
- University Police Department, 392-1111 (or 9-1-1 for emergencies). <https://www.police.ufl.edu/>

Academic resources.

- Career Resource Center, Reitz Union, 352-392-1601. Career assistance and counseling. <https://career.ufl.edu/>
- Library Support, <https://uflib.ufl.edu/find/ask/>. Various ways to receive assistance with respect to using the libraries or finding resources.
- Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. <https://teachingcenter.ufl.edu/>
- Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. <https://writing.ufl.edu/writing-studio/>