MTG 7396: Topological Data Analysis and Machine Learning

Advanced Topics in Topology 1
University of Florida, Department of Mathematics
Course Syllabus, Fall 2023

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Class meetings: MWF 7th period (1:55–2:45pm), Little Hall 205

Course description. This course is an introduction to the use of topological tools in data analysis and to combining these tools with methods from statistics and machine learning.

Course Objectives. This course combines pure mathematics, applied mathematics, and data science. Students will learn the theory of topological data analysis (TDA) as well as how to use its computational tools. They will then apply TDA to analyze actual data.

Course schedule.

Weeks 1–4	Persistent Homology
Weeks 5–8	Machine Learning
Weeks 9–10	Statistics
Weeks 11–13	Other TDA methods (time permitting)
Weeks 14–16	Presentations

Course structure. We will start by learning the mathematics of topological data analysis, then learn some of the important tools and ideas in modern statistics and machine learning, and also see how all of these methods may be combined. Along the way we will learn how to use computational tools to apply what we have learned to the analyze both synthetic and real-world data.

Expectations.

- Students will be responsible for using available resources (notes from class, discussions with classmates, internet resources, books, and the mathematical literature) to learn the necessary concepts.
- Students will bring their laptops to class when required (not for the first few classes) to learn how to use computational tools for TDA, and then to apply these tools in their projects.
- Students will be prepared to explain what they've learned.

Course work and assessment. The main part of the course will be a computational project in topological data analysis. The grading for the course will be based on a presentation of this project (40%) and an accompanying written report (40%). The remainder of the grade will be based on smaller homework assignments (20%).

Resources. The following can be downloaded in PDF form from the UF library and/or from the authors' web pages. Our main references will be Part I of Rabadán and Blumberg, and Dey and Wang.

(1) Raúl Rabadán and Andrew Blumberg. Topological Data Analysis for Genomics and Evolution: Topology in Biology. Cambridge University Press, 2019.
(2) Tamal Dey and Yusu Wang. Computational Topology for Data Analysis. Cambridge University Press, 2022.
(3) Steve Oudot. Persistence Theory: From Quiver Representations to Data Analysis. AMS, 2015.
(4) Ingo Steinwart and Andreas Christmann. Support Vector Machines. Springer, 2008.

Grading scheme. A: 90% – 100%, A-: 85% – 89%, B+: 80% – 84%, B: 75% – 79%, B-: 70% – 74%, C+: 65% – 69%, C: 60% – 64%, D+: 57% – 59%, D: 54% – 56%, D-: 50% – 53%, E: 0% – 49%.

Class demeanor. Students are expected to arrive to class on time and behave in a manner that is respectful to the instructor and to fellow students. Please avoid the use of cell phones and restrict eating to outside of the classroom. Other students should be respected in discussion.

Class attendance. Requirements for class attendance 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`.

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/`.

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.

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://sccr.dso.ufl.edu/process/student-conduct-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. More information on UF grading policy may be found at: `https://gradcatalog.ufl.edu/graduate/regulations/`

COVID-19. In response to COVID-19, the following recommendations are in place to maintain your learning environment, to enhance the safety of our in-classroom interactions, and to further the health and safety of ourselves, our neighbors, and our loved ones.

- If you are not vaccinated, get vaccinated. Vaccines are readily available and have been demonstrated to be safe and effective against the COVID-19 virus. Visit one.uf for screening / testing and vaccination opportunities.
- If you are sick, stay home. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 to be evaluated.
- Course materials will be provided to you with an excused absence, and you will be given a reasonable amount of time to make up work.

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: Visit `https://counseling.ufl.edu` or call 352-392-1575 for information on crisis services as well as non-crisis services.
- Student Health Care Center: Call 352-392-1161 for 24/7 information to help you find the care you need, or visit `https://shcc.ufl.edu/`.
- University Police Department: Visit `https://police.ufl.edu/` or call 352-392-1111 (or 9-1-1 for emergencies).
- UF Health Shands Emergency Room / Trauma Center: For immediate medical care call 352-733-0111 or go to the emergency room at 1515 SW Archer Road, Gainesville, FL 32608; `https://ufhealth.org/emergency-room-trauma-center`.
- GatorWell Health Promotion Services: For prevention services focused on optimal well-being, including Wellness Coaching for Academic Success, visit `https://gatorwell.ufsa.ufl.edu/` or call 352-273-4450.

Academic resources.

- E-learning technical support: Contact the UF Computing Help Desk at 352-392-4357 or via e-mail at `helpdesk@ufl.edu`.
- Career Connections Center: Reitz Union Suite 1300, 352-392-1601. Career assistance and counseling services `https://career.ufl.edu/`.
- Library Support: `https://cms.uflib.ufl.edu/ask` various ways to receive assistance with respect to using the libraries or finding resources.
- Academic Resources, 352-392-2010 or to make an appointment 352- 392-6420. General study skills and tutoring. `https://academicresources.clas.ufl.edu/`
- Writing Studio: 2215 Turlington Hall, 352-846-1138. Help brainstorming, formatting, and writing papers. `https://writing.ufl.edu/writing-studio/`
- Student Complaints On-Campus: `https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/`