UCDAVIS MATHEMATICS

Fall Quarter 2016
(version 2016.09.26)

Topology of Data

Course Information

Course Name:	MAT 280 (CRN: 39527)		
Course Webpage:	www.math.ucdavis.edu/∼mtsuruga/teaching/FQ2016_280.html		
Time/Location:	Lectures:	R 2:30-4	MSB 2112
	Discussions:	M 12-1:30	MSB 2112

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Course Description

In this project-based course we will learn about some developments in computer assisted explorations of topology—an area known as Computational Topology. The goal will be to motivate some useful applications of abstract notions from topology. We will starting by analyzing real world data.

Prerequisites

- basic linear algebra
- basic programming (any language)

Grading policy

Each student will be assigned to a group on the first Monday (Sept 26). Group memberships may evolve during the quarter. The groups will choose an article to read together and a publicly available large data set to (attempt to) analyze using the method described in the chosen article.

1. Each group will give a short (5–10 min) progress report on Oct 20 or Oct 24. The presentation order will be chosen randomly by the instructor and announced one week in advance. This will be an opportunity for each group to ask their peers for guidance on the project and also advice to improve their presentation style.

2. During the last two weeks of the quarter, each group will give a 10–15 min beamer presentation of their results. Each group presentation will be evaluated by their peers.

3. Each group will submit one short blog-style report of their results by Dec 2. Draft versions of this report will be reviewed biweekly by the instructor on October 17, October 31, and November 14. These reports will be posted publicly online.

Students who satisfactorily complete all three parts of the group project will receive an A for this course.

Syllabus

The following calendar is a tentative outline for the quarter. The topics may change depending on student interests.

SEP	R	22	Lecture	Intro: Algorithms, Complexity, Topology
	M	26	Workshop	Projects; Software
	R	29	Lecture	Triangulations; Homology computation
OCT	M	3	Workshop	algorithms; Project discussions
	R	6	Lecture	Persistent Homology
	M	10	Workshop	algorithms; Project discussions
	R	13	Lecture	Guest
	M	17	Workshop	algorithms; Project discussions
	R	20		Practice Presentations
	M	24		Practice Presentations
	R	27	Lecture	Persistence “Plus"
	M	31	Workshop	Guest; Project discussions
NOV	R	3	Lecture	Fundamental Groups
	M	7	Workshop	algorithms; Project discussions
	R	10	Lecture	Reeb Graphs; discrete Morse theory
	M	14	Workshop	algorithms; Project discussions
	R	17	Lecture	Bistellar simplification
	M	21		Project presentations
	R	24		NO CLASS
	M	28		Project presentations
DEC	R	1		Project presentations

Software

Math Department Accounts

Students enrolled in this course can create temporary accounts in the mathematics department to use the computers in the computer lab at MSB 2118. Students with accounts will have free access to some mathematical software (such as Maple and Matlab) to be used only in this lab.

Set up your accounts at https://www.math.ucdavis.edu/courses/class-accounts/ . Students are NOT required to set up an account for this course.

Wolfram Mathematica

A special discount is being offered for UC Davis students. Students may purchase a student license for the newly released Wolfram Mathematica v.11 Student Desktop edition for a discounted price of $99 (normally $140).

And if you place your order **before Oct 1**, there will be an additional discount of 15% off of the original price, making it $78!

Instructions:

- Visit https://store.wolfram.com/view/app/mathematica/student .
- Choose a platform.
- Add the product to the Cart.
- Upload a proof of your Student Enrollment (e.g., registration receipt, class schedule)
- Choose an optional Personal License Service, if you want one.
- Enter the promotion code `PD2126` right before checkout.

Students are not required to purchase this software for this course. This license is a perpetual license. The students will be able to use the license as long as they are pursuing a degree.

SageMath

Visit https://cloud.sagemath.com to try SageMath online for free. Sage is easy to learn and has many functionalities similar to Mathematica.
Students are NOT required to use Sage in this course.

RStudio

R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. RStudio is an integrated development environment (IDE) for R. It includes a console, syntax-highlighting editor that supports direct code execution, as well as tools for plotting, history, debugging and workspace management. Other IDEs may exist which work with R, but RStudio is widely used and an environment I am familiar with. Both are free to download.
In particular, there is an R package called TDA which is easy to use and has many persistent homology functions already implemented.
Students are NOT required to use R or RStudio in this course.

Javaplex

Javaplex is a Java software package for computing the persistent homology of filtered simplicial complexes (or more generally, filtered chain complexes), with special emphasis on applications arising in topological data analysis. The above link will take you to a tutorial page which also includes many nice examples.
Students are NOT required to use Javaplex in this course.

Dionysus

Dionysus is a C++ library for computing persistent homology. It also has Python bindings which provide both a simple interface to the low-level C++ functionality as well as high-level auxilliary routines. Their “thinness” is meant to provide the efficiency benefits of C++ together with the simplicity, elegance, and interactivity of Python. Since they mimick the C++ functionality, their documentation may be a helpful resource for the latter.
Students are NOT required to use Dionysus in this course.

Perseus

Perseus computes the persistent homology of many different types of filtered cell complexes after first performing certain homology-preserving Morse theoretic reductions. The program needs a gcc compiler, and the visualizations use Matlab (other software can also be used).
Students are NOT required to use Perseus in this course.