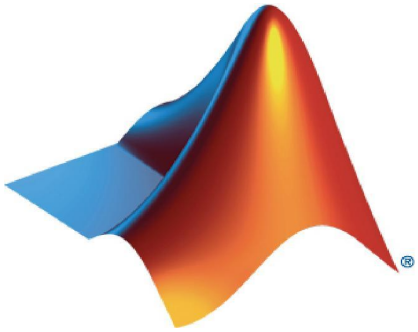
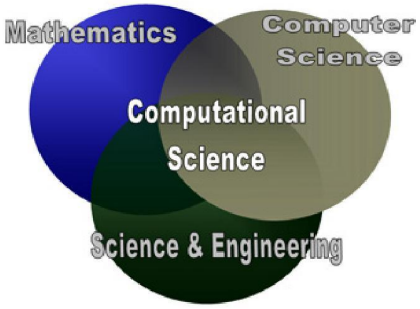
CME 292: Advanced MATLAB for Scientific Computing

Schedule: Winter 2023, Jan 10th-Feb 2nd, Tue/Thur 3:00 - 4:20pm
Room: Huang Engineering Center Rm 203.
Units: 1





Course Description

The goal of this 8-lecture short course is to introduce advanced MATLAB features, syntaxes, and toolboxes not traditionally found in introductory courses. Materials will be reinforced with in-class examples and demos involving various topics from scientific computing and data science, including advanced graphics and animation, data management, machine learning, code optimization, object-oriented programming, and a variety of MATLAB toolboxes. Students should expect to gain exposure to the tools available in the MATLAB software, knowledge of and experience with advanced MATLAB features, and independence as a MATLAB user. Students will be practicing the knowledge learnt through a mini course project, which will be based on either the suggested examples or a topic of their own choice. Successful completion of the course requires completion of this mini project.

Prerequisites

CME 192 (Introduction to MATLAB) or equivalent programming background in other languages is highly recommended prior to taking this course.
Basic knowledge of numerical analysis and numerical linear algebra is recommended.

Course Outline

Lecture	Topic	Date	Dues
1	Course Introduction MATLAB Fundamentals	1/10 Tue	
2	Graphics and Data Visualization	1/12 Thur	
3	File Manipulation Big Data Handling Integration with Other Languages	1/17 Tue	
4	Machine Learning with MATLAB	1/19 Thur	

5	Applied Math with MATLAB	1/24 Tue	Project Statement (1~2 paragraphs) due by Lecture 5
6	Object Oriented Programming Efficient Code Writing	1/26 Thur	
7	Advanced Tools for Image and Signals	1/31 Tue	
8	Project Presentation Wrap-Up & Additional Topics	2/2 Thur	Project Presentation Project Report (2~4 pages) due at the end of Week 4

Instructor

Xiran Liu, Ph.D. Candidate, Institute of Computational and Mathematical Engineering
Email: xiranliu@stanford.edu
Office Hours: by appointment

Mini Project

The goal of the mini project is to let you get involved in some practices of the topics covered in class and get some hands-on experience using advanced MATLAB features. It is not intended to be time-consuming or requiring much prior knowledge of advanced MATLAB. You will work on the project **individually**.

Choice of Topic:
There are two options we provide:

1. We provide a list of suggested topics (attached below). You may pick one from the list. Note that some of the examples involve tools we do not cover in class but may be of interest for people with specific application fields in mind. We provide the link(s) to examples that use advanced MATLAB features and/or tools, and we want you to either
    - apply the similar techniques onto some other data of interest, or
    - go through similar procedures to model a system, build an interface, create a simulation, etc.

    The specific problem chosen should be of similar level of complexity compared to the example problems.
2. If you have some specific tasks of interest that you think can be done by MATLAB, using features and/or tools at or above the level of those we introduce in this class, you may also choose to do your mini project on that. Some examples are:
    - analysis of dataset from your own research
    - modeling a system you are studying

Project Statement:
The project statement is due by Lecture 5. It should contain 1 - 2 paragraphs including the following information:

1. Background: introduce the background of the problem you choose to work with
2. Introduction to Data/Model: briefly describe the dataset you will use, or the system you want to model, or the animation/interactive app you want to build, etc.

Project Report:

The project report should extend the content of your problem statement to include:

3. **Methodology**: explain the method you use to tackle the problem
4. **Results**: show the outcomes of your analysis or modeling, with a few sentences describing your findings. We encourage you to include advanced visualization(s) of your results using MATLAB graphics features. If you work with an animation or interactive app, you may choose to include a few screenshots of your product and demo it live during the presentation.
5. **Discussion/Conclusion**: comment on your work, for example, challenges encountered, interesting findings, limitations, potential future directions, etc.

Each of these can be a few paragraphs, plus the figures and tables. The project report should be at least 2~4 pages including all the five parts mentioned above (including figures). Feel free to have longer reports if you make a lot of progress.

You can write the report either in word, latex, or MATLAB live script, and hand it in as a **pdf file**. Note that we *do not want you to include code* in your main text. You may put the code in the appendix if you want. (If you choose to write in live script, we encourage you to put most of your code in separate files and just call those files from your main script, so that *your main scripts will consist mainly of texts and figures*.)

The *final version* of the report is due at the end of Week 4.

Project Presentation:
The presentation is scheduled at the last lecture. Each person will give a 5 - 8 minute presentation, followed by a few minutes of Q&A. The time is subject to change upon the enrollment of the class. Please prepare a few slides to introduce your project, including the methods and the results. If you work with animations/interactive apps, please include live demos in your presentation.

Attached we provide a list of suggested project ideas, together with the examples.

Suggested topics for the mini project:

	Topic	Example	Link	Project Ideas
1	PageRank	PageRank Algorithm to Rank Websites	www.mathworks.com/help/matlab/math/use-page-rank-algorithm-to-rank-websites.html	Analyze a network dataset of interest using PageRank and provide advanced visualizations.
2	Spatial Data Analysis	Map Creation Using Latitude and Longitude Data	www.mathworks.com/help/matlab/creating_plots/plot-in-geographic-coordinates.html	Perform analysis on some spatial (and temporal) dataset of interest and provide advanced visualizations.
		Density of Cellular Tower Placement	www.mathworks.com/help/matlab/creating_plots/view-density-of-cellular-tower-placement.html	
		Cyclone Track Data in Geographic Density Plot	www.mathworks.com/help/matlab/creating_plots/view-cyclone-track-data-in-geographic-density-plot.html	
		Create Geographic Bubble Chart from Tabular Data	www.mathworks.com/help/matlab/creating_plots/create-geographic-bubble-chart-from-tabular-data.html	
3	Animation	Animation of Graphics Object	www.mathworks.com/help/matlab/creating_plots/animate-graphics-object.html	Create an animation for a system of interest, and possibly include interactive functionality.
		Animating a Surface	www.mathworks.com/help/matlab/creating_plots/animating-a-surface.html	
4	Computati onal	Identifying Differentially Expressed Genes from RNA-Seq Data	www.mathworks.com/help/bioinfo/ug/identifying-differentially-expressed-genes-from-rna-seq-data.html	Choose a biological or biomedical dataset of interest and use
		Exploring Genome-wide Differences in DNA Methylation Profiles	www.mathworks.com/help/bioinfo/ug/exploring-genome-wide-differences-in-dna-methylation-profiles.html	

4	Biology	Gene Expression Profile Analysis	www.mathworks.com/help/bioinfo/ug/gene-expression-profile-analysis.html	interest and use Bioinformatics Toolbox to analyze data.
		Analyzing the Origin of the Human Immunodeficiency Virus	www.mathworks.com/help/bioinfo/ug/analyzing-the-origin-of-the-human-immunodeficiency-virus.html	
5	Classical Machine Learning	Statistical and Machine Learning	www.mathworks.com/help/stats/examples.html?category=index&examplep roduct=all&s_tid=CRUX_lftnav	Work on a problem using Statistical and Machine Learning Toolbox.
6	Deep Learning	Deep Learning	www.mathworks.com/help/deeplearning/examples.html?category=index&examplep roduct=all&s_tid=CRUX_lftnav	Work on a problem using Deep Learning Toolbox.
7	Computer Vision	Computer Vision Examples	www.mathworks.com/help/vision/examples.html?category=index&examplep roduct=all&s_tid=CRUX_lftnav	Perform computer visions tasks on some image or video dataset of interest using Computer Vision Toolbox.
8	Finance	Portfolio Optimization Examples	www.mathworks.com/help/finance/portfolio-optimization-examples.html	Explore portfolio optimization based on market data, potentially using Financial Toolbox.
9	Optimization	Optimization	www.mathworks.com/help/optim/examples.html?category=index&examplep roduct=all&s_tid=CRUX_lftnav	Solve a optimization problem using Optimization Toolbox.
10	PDE	PDE	www.mathworks.com/help/pde/examples.html?category=index&examplep roduct=all&s_tid=CRUX_lftnav	Solve a PDE system of interest using Partial Differential Equation Toolbox.

* If you want to do a data-oriented mini project and do not have any dataset in mind, there are plenty of open-source datasets online (e.g., Kaggle datasets www.kaggle.com/datasets). Feel free to reach out to the instructor if you have trouble finding an interesting dataset.