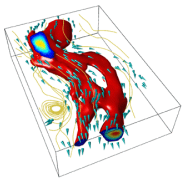
CS 401: Applied Scientific Computing with MATLAB



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Outline

- Course Description
- Details
- Policies
- Intro to CIS Tools Curriculum
- Role of Computing in Science and Engineering
- Basic Concepts

Course Goals

- This course will:
  - Introduce the basic functionality of MATLAB
  - Demonstrate its utility in scientific research
  - Identify interesting concepts and useful techniques in scientific computing

By the end of the course, you should have the skills necessary to apply MATLAB to your research and learn how to extend its capabilities

Syllabus

1. Course Intro and Basic Concepts
2. Intro to Matlab: the workspace
3. Matlab fundamentals: arrays, & simple plots
4. Matlab programming: loops and conditionals
5. Text processing and a survey of Matlab
6. Applied Scientific Computing I: Simulation
7. Applied Scientific Computing II: Data analysis
8. Improving performance: vectorization
9. Intro to numerical methods (more about * and \)
10. Advanced data objects (cell-arrays and structs)
11. 3D plots
12. Loose ends and where to go from here

Course Ungoals

- This course will NOT:
  - Teach you how to program (try CS 100m)
    - You should be comfortable writing programs in some language and be familiar with the following concepts:
      - Programs vs. algorithms
      - Iteration
      - Conditionals and logic
      - Recursion
      - Subroutines, variables, and scope
  - Teach you numerical methods (CS 42X, 62X)
  - Cover everything in MATLAB

Course Business:

- http://www.cs.cornell.edu/Courses/cs401/2001fa
  - Contains syllabus, lecture notes, examples, homework
- Office Hours
  - Tuesday and Wednesday, 11-1 in 3134 Snee (or by appointment)
- Registration:
  - get my signature or CS Undergrad office (303 Upson)
  - S/U only, 1 credit
  - Last day to add/drop: Monday, September 10 !

Requirements

- Reference Text: Hanselman and Littlefield *Mastering Matlab 6*
  - No required reading, but this is a great reference
- Find a computer with MATLAB (v6 preferred, but v5 is OK):
  - Check departmental labs--good site licensing for Cornell machines
  - ACCEL in Carpenter Hall
  - Upson, Carpenter, and Dickson Labs
  - Buy student version

Course Policies

- 4 assignments: 1 per week, due Wednesday, 5PM by e-mail
- If you complete each assignment on time and demonstrate a basic command of the material, you will pass!
- Course policies are strict:
  - A direct consequence of the "mini-course" format
- This course operates as a contract between you and me

The Contract

- I agree to:
  - Begin and end lecture on time
  - Put lecture notes on website by 10PM prior to lecture
  - Be available during office hours
  - Make the assignments of reasonable length (2-4 hours) focusing on material from lectures

The Contract

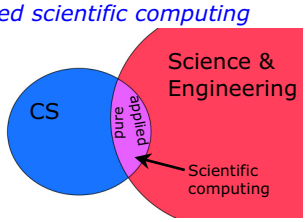
- By registering for the course, you agree to:
  - Arrive on time
  - Participate in the course by asking questions and coming to office hours
  - Turn in your assignments on time
    - Late work will not be accepted and will jeopardize you chance of passing!
    - The only exceptions are for documented, university-sanctioned reasons such as severe illness or by prior arrangement made w/ me 3 days before (includes religious holidays, sports, etc.)

CIS and FCI

- *Cornell University has recognized that computing and information science has emerged as a key enabling discipline vital to nearly all of its scholarly and scientific pursuits.*
- *The Faculty of Computing and Information is founded on the recognition that the ideas and technology of computing and information science are relevant to every academic discipline.*
- *We are united in the need to bring together a core of faculty in this field from across the traditional colleges.*

CIS Tools Curriculum

- CS 401 (should be CIS 401) is the first in a series of courses designed to teach *applied scientific computing*



CIS Tools Curriculum

- "Pure" Scientific Computing
  - Focus is on algorithms for general problems such as optimization, linear systems, differential equations
  - Concerned with accuracy, stability, and efficiency of these algorithms
- "Applied" Scientific Computing
  - How to apply general algorithms to solve scientific problems
  - Algorithms are "black boxes" that we string together to get our work done

CIS Tools Curriculum

- Fall: MATLAB
  - 401: the basics
  - 402: visualization (starts October 15)
- Spring: General tools
  - 403: Developing scientific computer programs (compilers, debuggers, managing large projects)
  - 404: Numerical libraries

Role of Computing in Science and Engineering

- Scientists have been computing for centuries, well before digital computers
- Digital computers allow us to do thing faster, but often the ideas are ancient
- Example: Velocity from pressure data

Geostrophy

- Measuring the velocity of atmosphere and ocean is difficult, but observing pressure is easy
- Fortunately, velocity can be determined from pressure using the *geostrophic* relationship:

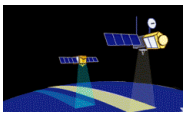
Pressure gradient = Coriolis force (Earth's rotation)

$$1/\rho\nabla p = f \begin{bmatrix} v \\ -u \end{bmatrix}$$

$$f = 2\Omega \sin\phi \qquad \Omega = 7.29\mathrm{e}-5$$

Geostrophy

- An alternative to pressure is sea-surface height
- SSH can be measured by satellites



Geostrophy

- Use hydrostatic equation:

$$p = \rho g Z$$

to introduce SSH (Z) into geostrophic equation:

$$g\nabla Z = f \begin{bmatrix} v \\ -u \end{bmatrix}$$

Geostrophy in MATLAB

- MATLAB allows us to compute the velocity:

$$u = -g/f\frac{\partial Z}{\partial y} \qquad v = g/f\frac{\partial Z}{\partial x}$$

$$f = 2\Omega\sin\phi \qquad \Omega = 7.29\mathrm{e}-5$$

  in only a few lines
- Can examine results graphically

So, what's the point?

- Theme of the FCI is that computing is general
- The geostropic calculations are a specific instance of the general scientific computing process.

Scientific Computing Process

	Data →	Program →	Output
Currents	SSH	Geostropic eq.	U,V,plot
Weather	T,V,M	Finite diff.	T,V,M in future
Bioinfomatics	ATCGCGTA…	Search for genes	Location of genes
Electronics	Signal	FFT	Plot of spectrum

- It is possible to do all of these things in Matlab, and most of them are easier.