Introduction to Computing Using Matlab

CS 1112

Dr. Curran Muhlberger

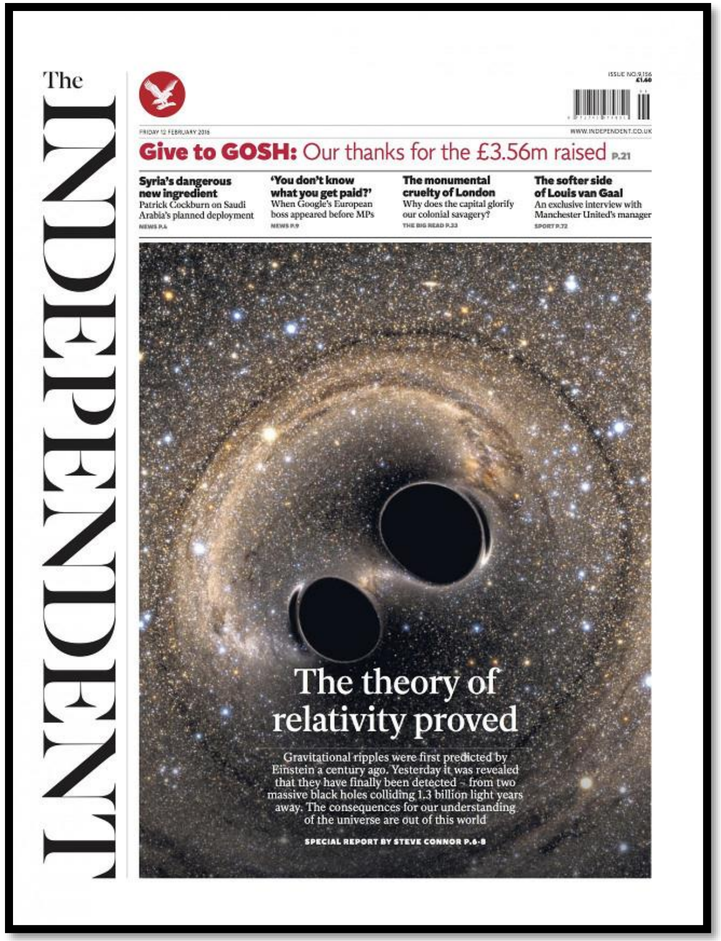
Dr. K.-Y. Daisy Fan

http://www.cs.cornell.edu/courses/cs1112/

Discussion starts *this* week
in Upson 225 lab (not classroom listed in Student Center)

Who is Dr. Muhlberger?

And why should scientists learn to code?



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Give to GOSH: Our thanks for the £3.56m raised P.21

Syria's dangerous new ingredient
Patrick Cockburn on Saudi Arabia's planned deployment
NEWS P.4

'You don't know what you get paid?'
When Google's European boss appeared before MPs
NEWS P.9

The monumental cruelty of London
Why does the capital glorify our colonial savagery?
THE BIG READ P.22

The softer side of Louis van Gaal
An exclusive interview with Manchester United's manager
SPORT P.72

The theory of relativity proved

Gravitational ripples were first predicted by Einstein a century ago. Yesterday it was revealed that they have finally been detected – from two massive black holes colliding 1.3 billion light years away. The consequences for our understanding of the universe are out of this world

SPECIAL REPORT BY STEVE CONNOR P.6-8

NEW YORK POST
Page Six

WEDNESDAY, FEBRUARY 7, 2018 / Snow, 43° / Weather: P. 18 ★ ★ LATE CITY FINAL nypost.com $1.00

Elon sends a Tesla to Mars
(Yes, this is a real picture)

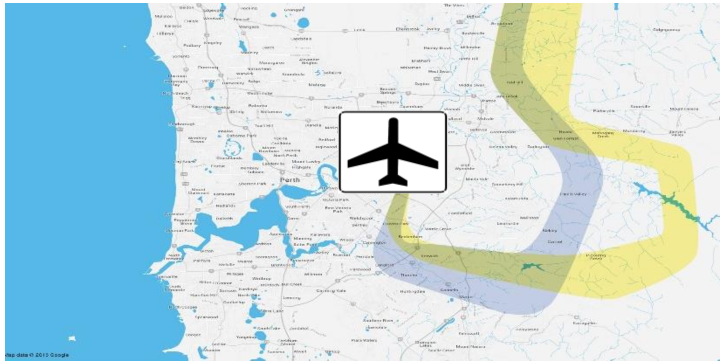
CAR TREK

Elon Musk's SpaceX shot this Tesla into space yesterday with a mannequin named Starman. It will orbit the sun and eventually pass by the Red Planet. PAGE 7

Who is Dr. Daisy Fan?

- Interest in optimization—what is the "best" way to operate a system given constraints and uncertainties?
- Other courses:
  - Intro to computing using Python
  - Optimization with metaheuristics
- Author: *Insight Through Computing: A Matlab Introduction to Computational Science and Engineering* with C. F. Van Loan

Source: energy.gov



Source: airservicesaustralia.com

National Academy of Engineering Frontiers of Engineering Education (2014), Cornell advising award (2016), Engineering teaching award (2011)

About you … in CS1112

- Undergraduates, graduates, researchers, and professionals who want (need) to learn computing
- No prior programming experience needed but some "mathematical maturity"
- You will …
  - Learn programming concepts and good programming habits
  - Practice problem analysis and decomposition
  - Become a code detective—find out "whodunit"
- Develop a "spirit of experimentation"
  - Not thoughtless trial-&-error but purposeful try-then-analyze
- Why should you learn computing?

Today's lecture

- An illuminating problem
- What is computer programming?
- CS1112 philosophies & syllabus
- Choosing between CS1112 & CS1110
- Course logistics/policies (highlights)

Discussion starts *this* week
in Upson 225 lab (not classroom listed in Student Center)

An illuminating problem: computing square roots

- Suppose A > 0

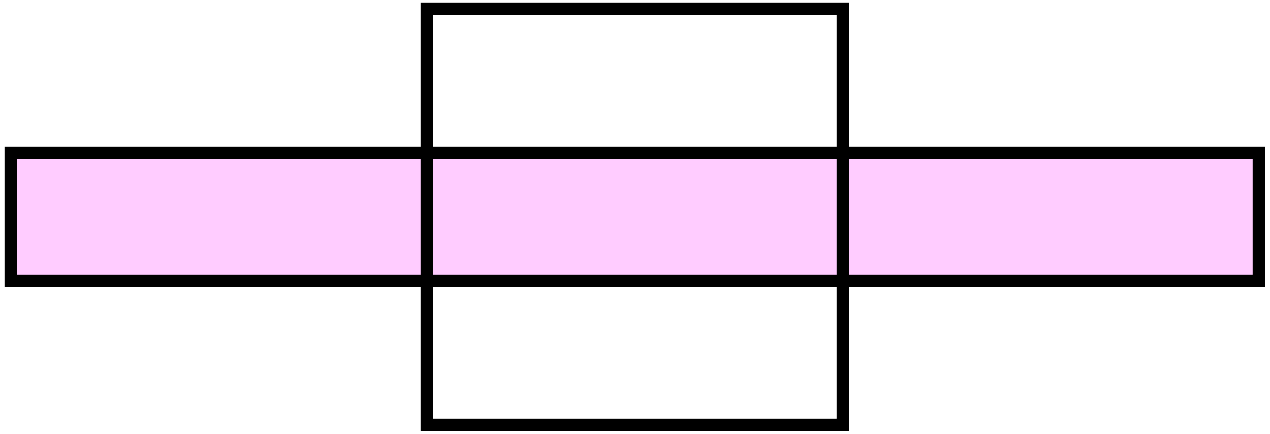
- Observation: If A is the area of a square …
  then I can just measure the side length—that is $\sqrt{A}$

- Solution idea: Make a square with area A

- Real task: Make a sequence of increasingly square rectangles, each with area A

How to make a rectangle “more square”?

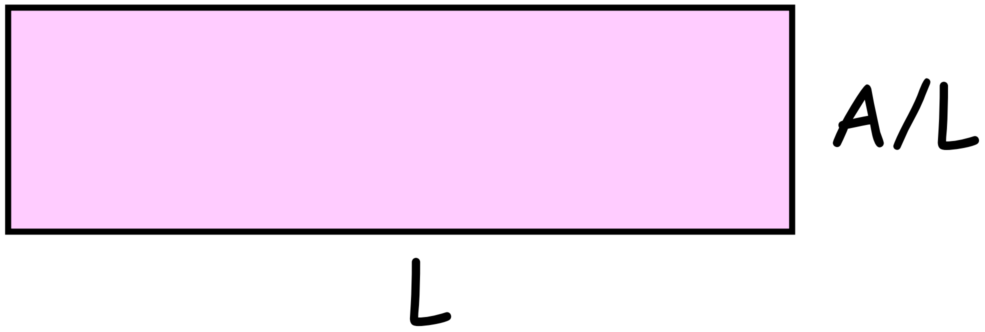
- If a square and a rectangle both have area A …



- then $\sqrt{A}$ is between the length and width of the rectangle

An improvement strategy

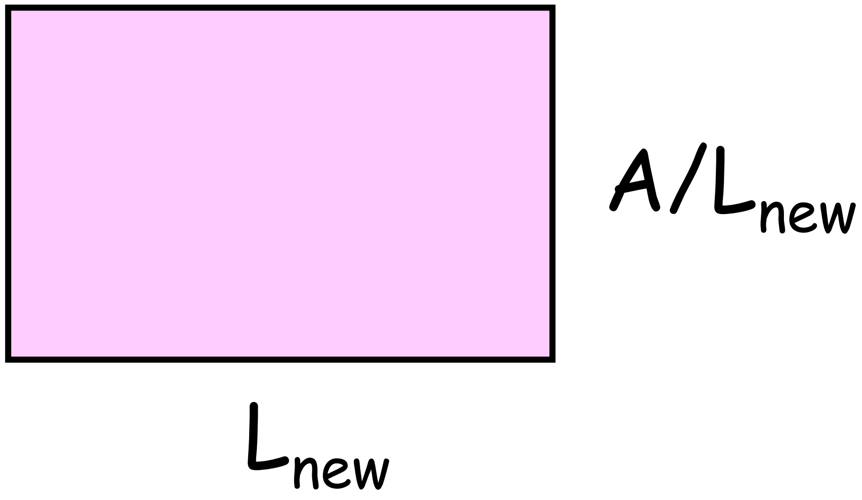
Current:



Recipe: $L_{new} = (L + A/L) / 2$ ←

The average of the length and width.

Next:



A Matlab program to make “increasingly square” rectangles

```
% The first rectangle...
L1 = A;
W1 = 1;
% The second rectangle...
L2 = (L1+W1)/2;
W2 = A/L2;
% The third rectangle...
L3 = (L2+W2)/2;
W3 = A/L3;
% and so on...
```

Demo!

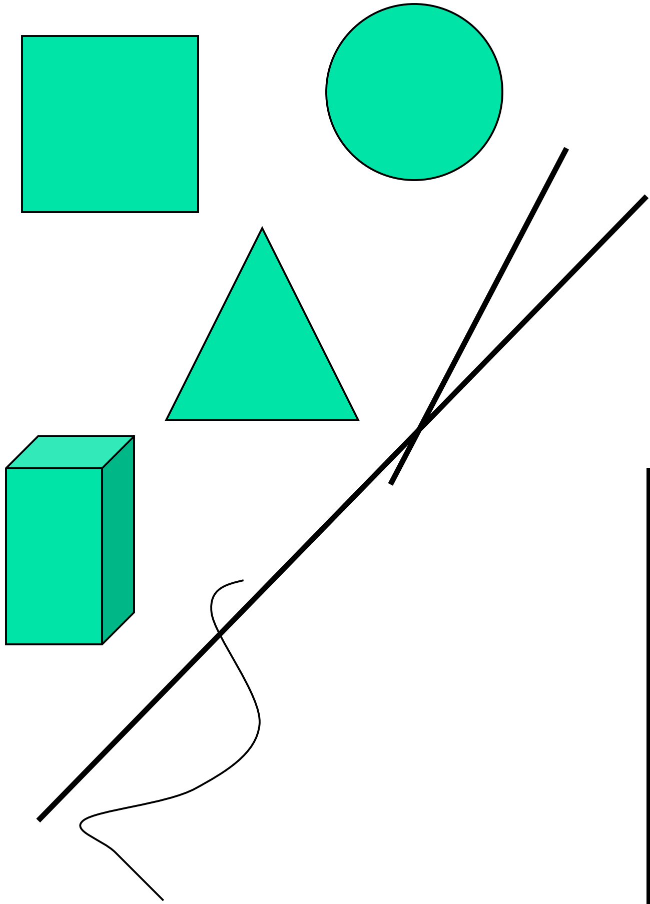
Some conclusions from square root finding problem

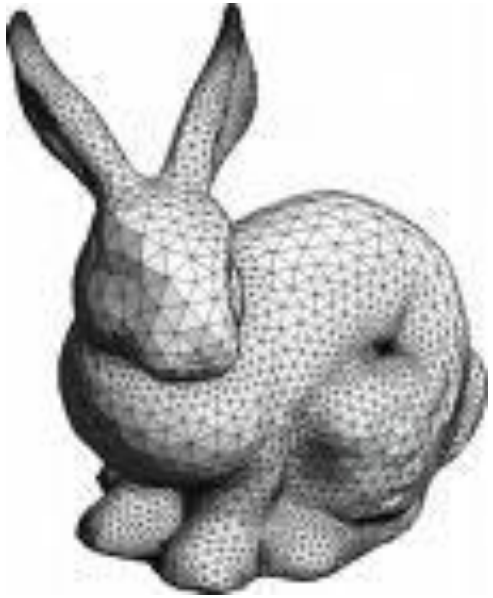
- It paid to have a geometric sense
- A complicated computation was reduced to a sequence of elementary calculations
- A program is like a formula (or sequence of formulas)

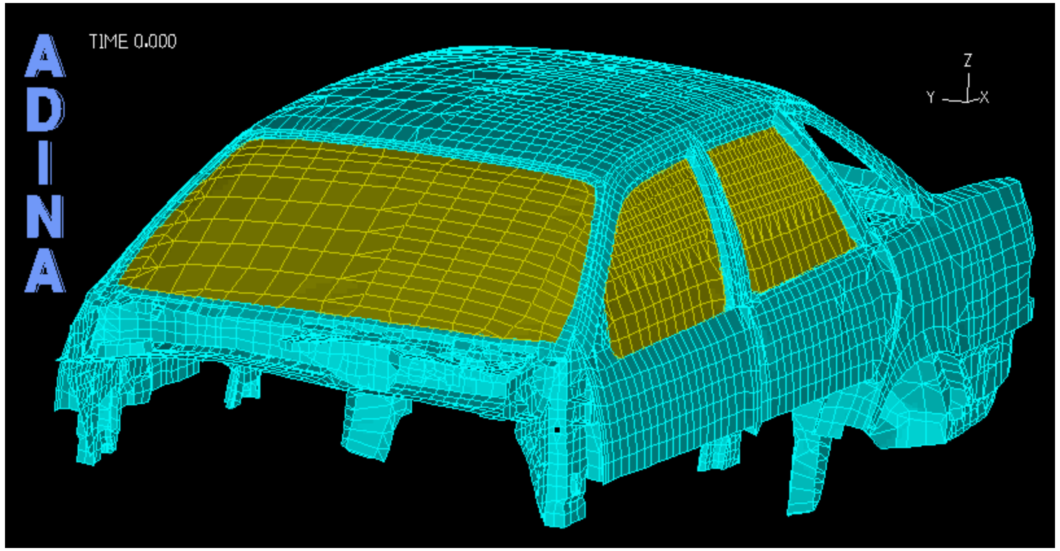
Course Goals

- Develop your "computational senses," senses that you need in computer problem-solving
- Develop a facility with the Matlab programming environment

A sense of geometry







A sense of complexity

Major US Cities
Seattle
Portland
San Francisco
San Jose
Fresno
Los Angeles
San Diego
Salt Lake City
Las Vegas
Phoenix
Denver
Colorado Springs
Albuquerque
Minneapolis/ St. Paul
Kansas City
Wichita
Oklahoma City
Dallas
Austin
Houston
San Antonio
Milwaukee
Chicago
Detroit
Indianapolis
St. Louis
Memphis
Nashville
Louisville
Cincinnati
Columbus
Cleveland
Pittsburgh
Buffalo
Boston
New York City
Philadelphia
Baltimore
Washington D.C.
Norfolk
Charlotte
Atlanta
Birmingham
New Orleans
Jacksonville
Tampa
Miami
Anchorage
Honolulu
N
W
E
S
500 miles
100 miles
500 miles
©EnchantedLearning.com

What is the best itinerary to visit Boston, Miami, LA, Dallas?

3! = 6 possibilities

Add Seattle, NYC Austin, Denver

7! = 5040

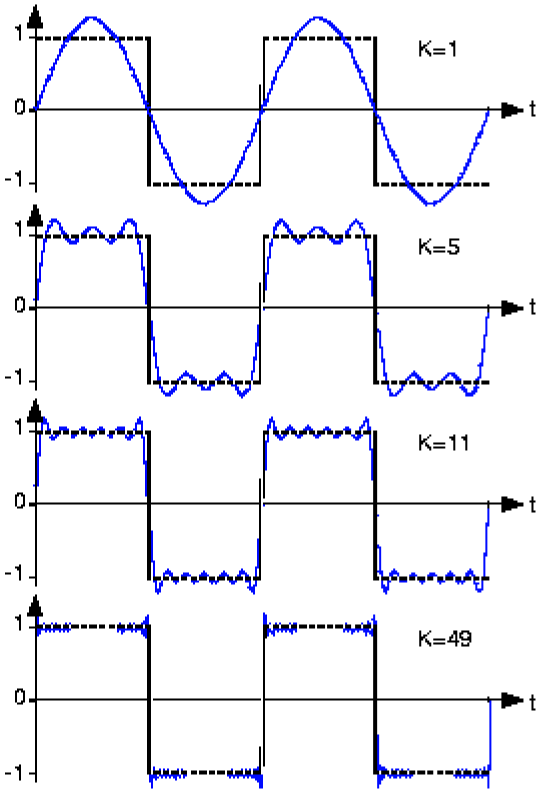
If a computer can process 1 billion itineraries a second, how long does it take to solve a 20-city problem?

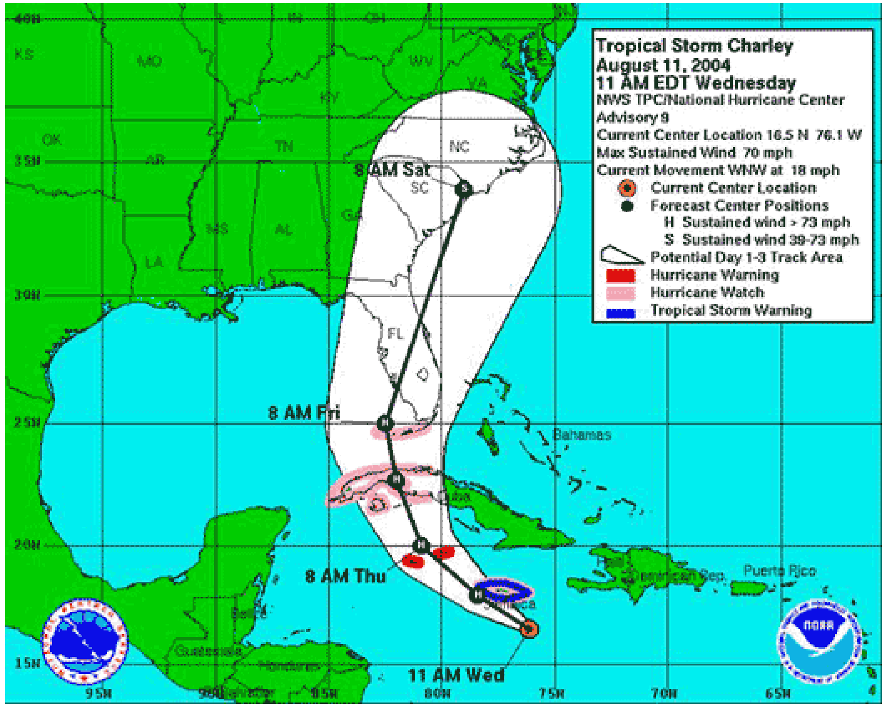
Nearly a century…

A sense of approximation & error

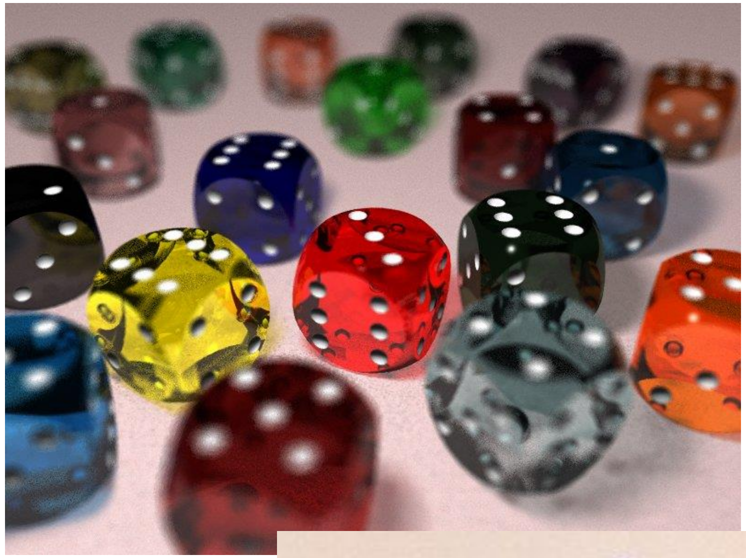
π

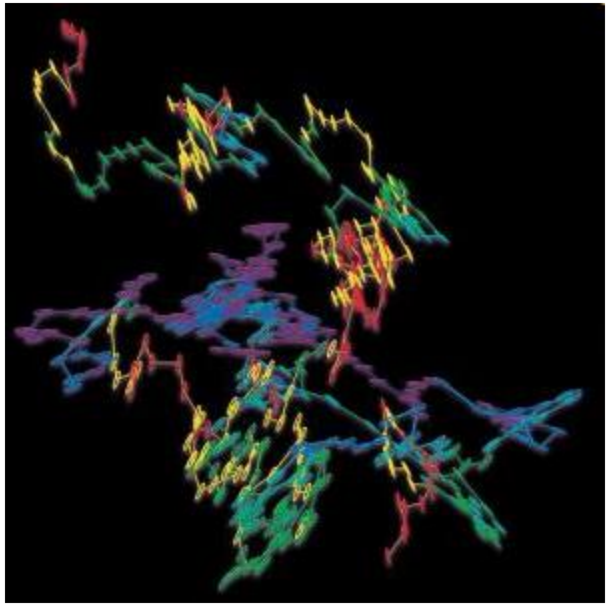
1/3 = .33333...





A sense of randomness and probability





Random walk
Brownian motion in water

Course Goals

- Develop your "computational senses," senses that you need in computer problem-solving

- Develop a facility with the Matlab programming environment

Computer problem-solving

Key: Algorithmic thinking

Algorithm:

A step-by-step procedure that takes you from a prescribed set of inputs to a prescribed set of outputs

Program:

The algorithm expressed in a specific language, e.g., Matlab

Computer problem-solving — Programming

- Developing instructions for the computer to execute (in order to solve some problem)
- The steps must be logical
- Use a particular language *and follow the rules of the language* (grammar/syntax)

Example: *Adding songs from the internet to your music library*

- Find a website with MP3 or other audio files
- Register with the music site, if required for music downloading. (Don’t steal music.)
- Click on the music file to download it onto your computer
- Drag the file to your library

Reference: iTunes

Example: *Adding songs from the internet to your music library*

- Drag the file to your library
- Click on a music file to download it onto your computer
- Find a website with MP3 or other audio files
- Register with the music site, if required for music downloading. (Don't steal music.)

These steps are out of order! Illogical!

Example: *Adding songs from the internet to your music library*

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Example: *Adding songs from the internet to your music library*

- Find a website with MP3 or other audio files
- Register with the music site, if required for music downloading. (Don’t steal music.)
- To download the computer onto your music file click it on
- file Drag your librAry to

Bad grammar (syntax)!

Computer programming is …

- a tool used by computer scientists, engineers, and other professionals
- not all of computer science

- Think about astronomy: Telescope is a tool used by astronomers; astronomy is not about telescopes…

Course Goals

- Develop your "computational senses," senses that you need in computer problem-solving

- Develop a facility with the Matlab programming environment

Matlab is the vehicle we use

With the Matlab environment, you can <u>easily</u>

- Develop programs
- Display results & ideas graphically
- Interact with large data sets (process text, image, and other files)

Matlab has extensive libraries of mathematical, statistical, simulation, and other tools. It is heavily used in engineering & sciences, both in industry and academia.

Demo!

Engineering students take one of these courses:

- CS1112 – this course, Matlab
- CS1110 – Python

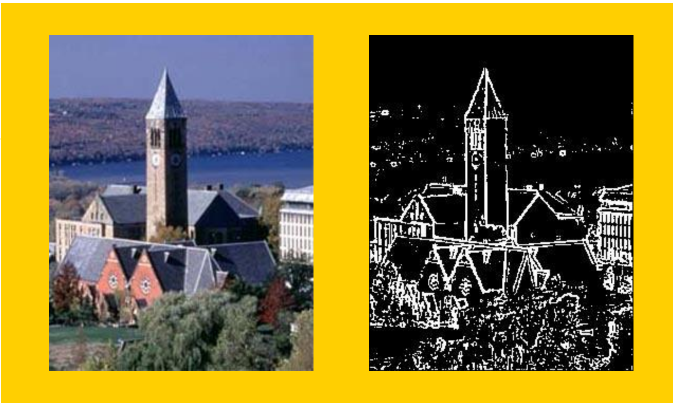
Each course satisfies the Engineering Computing Requirement. In 1112 you *will* learn procedural programming in depth and be introduced to object-oriented programming.

Each course can serve as the prerequisite for CS/ENGRD 2110 Object-Oriented Programming & Data Structure

CS1112 has a focus on *computational science & engineering*

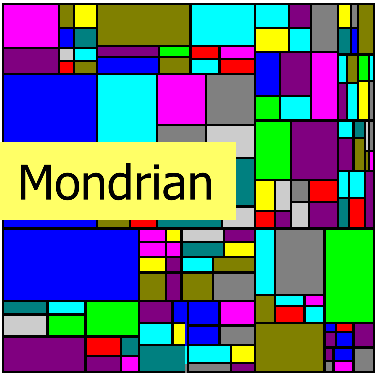
Approximation, randomness,
model building, sensitivity of models

- Lecture examples and homework illustrate above themes
  - Edge detection
  - Ranking web pages
  - Congressional apportionment

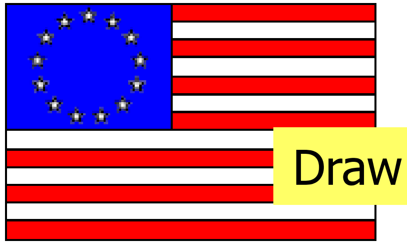


Some past programming assignments

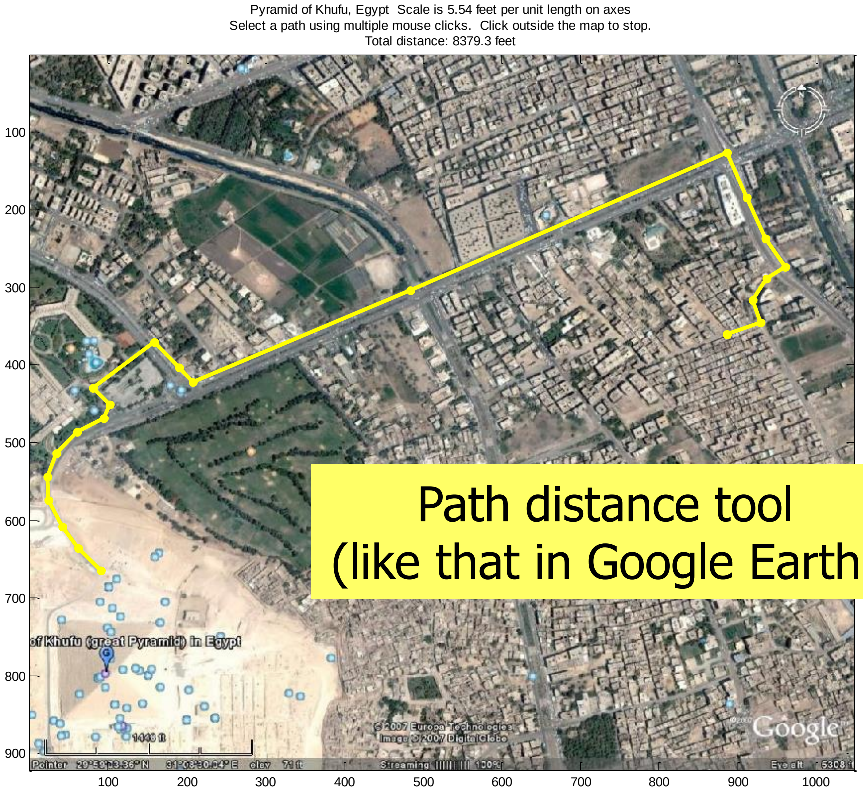
- Find the US population center from census data
- Organize protein data using structure arrays
- Mozart’s musical dice game



Draw the random Mondrian

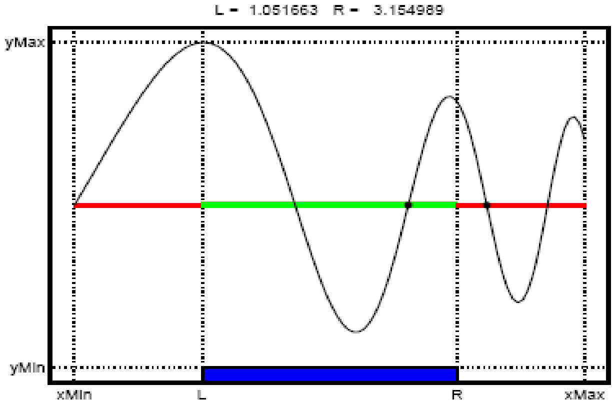


Draw the “Betsy Ross Flag”



Pyramid of Khufu, Egypt Scale is 5.54 feet per unit length on axes
Select a path using multiple mouse clicks. Click outside the map to stop.
Total distance: 8379.3 feet

Path distance tool
(like that in Google Earth)



L = 1.051663   R = 3.154989

Root finding tool

CS1112

- No prior programming experience
- One semester of Calculus
- ***Focus on computational science & engineering***
- Matlab

CS1110

- No prior programming experience
- No Calculus
- ***Focus on software development***
- Python

CS1112 requirements

4 credits → 4x3=12hrs/week

In class: 2hr lec + 1 hr dis = 3 hrs/week

Outside class: 9 hrs/week

- Attend lecture
  - Laptops **not** required – stage-right section is screen-free zone
- Attend discussion—get individual attention/help on weekly exercises!
- Monitor course announcements on website
- Do homework: 6 programming projects
- Take 2 prelims and a final exam at their scheduled times
- Answer in-class quizzes (use your clicker)
- Adhere to the Code of Academic Integrity

Learning and integrity

- Learning is something *you* do; we can only facilitate
- Computers facilitate duplication; duplication does not facilitate learning
  - No value in being a delivery vehicle for the write answer
  - In real engineering, there is no “right answer” to copy
- Respect yourself and others
  - Craft your own programs; build confidence in your own answers

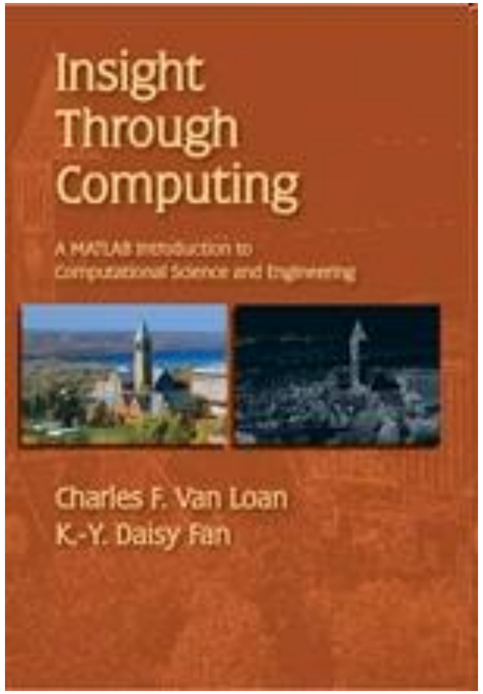
Grading

- Best five* of six projects (25%)
    - Your lowest-scored project is eligible to be dropped only if you scored at least 50% on it
- Discussion exercises (4%)
- In-class polling (1%)
- Prelim 1 (20%)
- Prelim 2 (20%)
- Final exam (30%)

Course Materials

- *Insight Through Computing*

  A Matlab introduction to Computational Science and Engineering



Insight Through Computing

A MATLAB introduction to Computational Science and Engineering

Charles F. Van Loan
K.-Y. Daisy Fan

- An iClicker clicker (or mobile app)

- MATLAB Student Version Download your own copy, use *MATLAB Online* (web browser based), or use public computer labs (Engineering Quad and RPCC)

FREE for students!

What to do now?

- Pick a course

  Take CS1112 or CS1110

  (add/drop: lecture and discussion and optional AEW)
- Check course website
- Start reading (see listing on course website)
- Attend discussion in the lab (Upson 225) today or tomorrow
- Attend the discussion in which you are enrolled!

CS1112 Discussion Sections – start today

Sec #	Time	Room
201	T 12:20-1:10p	UPS 225 lab & HLS 401
202	T 1:25-2:15p	UPS 225 lab & HLS 401
203	T 2:30-3:20p	UPS 225 lab & HLS 401
205	W 10:10-11:00a	UPS 225 lab & HLS 401
206	W 11:15a-12:05p	UPS 225 lab & HLS 401
207	W 12:20-1:10p	UPS 225 lab & HLS 401
208	W 1:25:2:15p	UPS 225 lab & HLS 401
209	W 2:30-3:20p	UPS 225 lab & HLS 401

Discussions are held in UPS (Upson) 225 lab the first two weeks