This is...

Matlab

Course Business:

- http://www.cs.cornell.edu/Courses/cs401/2003fa
  - Contains syllabus, lecture notes, examples, homework
- Office Hours
  - Tuesday & Wednesday, 3-4 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 8 !

Outline

- Homework I
- Tutorial 1
- Getting started: the Desktop & Workspace
- Matlab as calculator
- Variables
- Arrays
- Array Operations

Homework I

- Download from web page
- Use a text editor (e-mailer?) to insert answers
- E-mail to me
  - memo is "CIS 401 Homework 1"
- Please turn of HTML formatting on your e-mail program. It is much easier for me to manage if you send as text.
- If you can't turn HTML off, then attach a text (.txt) file (NOT MS Word!)

Tutorial 1

- Download from web page
- Work through on your own
- Covers simple array manipulation through command window

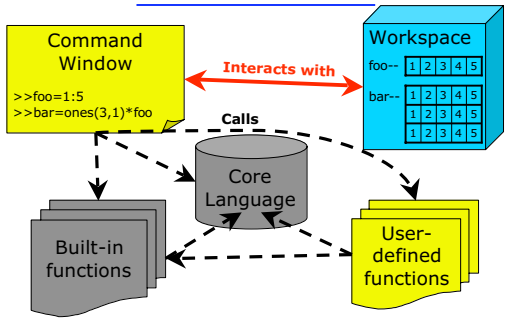
Starting Up

- On Windows:
  - Launch from START, or find matlab.exe & double click
- On UNIX/Linux/MacOS X
  - Open a terminal, type "matlab &"
  - Problems:
    - "Command not found"--check your path
    - Splash window of 6.X hangs--try "matlab -nojvm"

What is Matlab?

- Matlab is an environment for scientific computing
- Essential features:
  - Workspace--contains your data
    - named arrays of numbers
  - Language--a set of basic commands for manipulating data
    - assignment (=), dereferencing (()), arithmetic (+-*/^), logic (&|~), control (for,while, if-else, switch)
  - Functions--more complicated commands built with core language
    - mean, min, max, statistics, signal-processing, graphics,
    - YOUR STUFF!

What is Matlab?



Basic Math

- Matlab is a command-line calculator
  - Simple arithmetic operators
    - + - * / ^
  - Basic functions
    - sin(), log(), log10(), exp(), rem()
  - Constants
    - pi

Big deal, a calculator's $20

- Matlab is a fully-functional programming language
- This means we get variables
  - name = value
    - Name can be anything made of letters, numbers, and a few symbols (_). Must start with a letter
  - End line with ";" to avoid output
    - Can also use ";" to put multiple commands on a line
  - List with who
  - Delete with clear
  - More info with whos

1D Arrays--aka Vectors

- An array is anything you access with a subscript
- 1D arrays are also known as "vectors"
- Everything (nearly) in Matlab is a "double array"
- Create arrays with brackets [ ]
- Separate elements with commas or spaces
- Access with ()'s

Regular arrays

- We can create regularly spaced arrays using ":"
  - A=st:en produces [st, st+1, st+2, … en]
    - A=1 : 5 is [1 2 3 4 5]
    - A=-3.5 : 2 is [-3.5 -2.5 -1.5 0.5 1.5]---note, stops before 2!
    - What happens if en < st ?
  - Can also insert a "step" size: A=st:step:en
    - A=0 : 2 : 6 is [0 2 4 6]
    - A=5 : -2.5 : 0 is [5 -2.5 0];

Accessing vectors

- Matlab arrays start at 1
- In most languages (C, Java, F77) can only access arrays one element at a time:
  - a(1)=1; a(2)=2.5; a(3)=-3; etc.
- In Matlab, can access several elements at a time using an array of integers (aka an *index*)
  - a(1:5) is [a(1),a(2),a(3),a(4),a(5)]
  - a(5:-2:1) is [a(5), a(3), a(1)]

Accessing vectors

- Index vectors can be variables:
  - A=10:10:100; I=[1:2:9]; A(I) gives [10,30,50,70,90]
  - J=[2:2:10];A(J) gives [20,40,60,80,100];
  - What does A(I)=A(J) do?

Column vectors

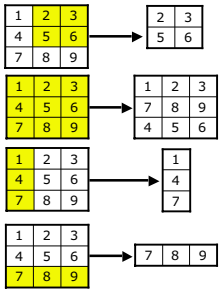
- "row vectors" are 1-by-n
- "column vectors" are n-by-1
- Row/column distinction doesn't exist in most languages, but VERY IMPORTANT in MATLAB
- Create column vectors with semi-colons
  - A=[1; 2; 3]
- Can force to column vector with (:)
  - A=1 : 3 is [1 2 3]
  - A(:) is $\begin{bmatrix}1\\2\\3\end{bmatrix}$

Column vectors

- Convert column-to-row and back with transpose (')
- Can access the same way as row vectors

2D arrays--matrices

- From using commas/spaces and semi-colons
  - A=[1 2 3; 4 5 6; 7 8 9];
  - A(j,k)= j'th row, k'th column
    - A(1:2,2:3)= rows 2 through 3 and columns 1 through 2
    - A([1,3,2], :)= all of rows 1, 3 and 2
    - A(:, 1)= first column
    - A(3,:)= last row



Size matters

- "A is m-by-n" means A has m rows and n columns
- [m,n]=size(A) gets size of A
- length(a) gets length of vectors (max of m and n).
- A(1:3,2)=v, v better have length 3
- A(1:2:5,2:3)=B, B better be 3-by-2

Array Arithmetic

- C=A+B
  - if A and B are the same size, C(j,k)=A(j,k)+B(j,k)
  - If A is a scalar, C(j,k)=A+B(j,k)
- Same for -

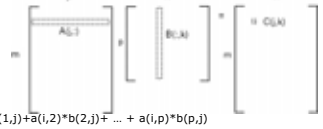
Array Multiplication

- Multiplication is weird in Matlab
  - Inherited from linear algebra
  - To multiply by a scalar, use *
  - To get C(j,k)=A(j,k)*B(j,k) use ".*"
    - Also applies to ".^" and "./"

Matrix Multiplication C=A*B

- A is m-by-p and B is p-by-n then C is m-by-n:

$$C(i,j) = \sum_{k=1}^{p} A(i,k) * B(k,j)$$



  - C(i,j)= a(i,1)*b(1,j)+a(i,2)*b(2,j)+ … + a(i,p)*b(p,j)

Matrix Multiplication

- Another view:
  - C(i,j)=a(i,:)*b(:,j);
    - 1-by-p p-by-1 answer is 1-by-1
    - This is a vector (dot) product

Matrix Multiplication

- Special Cases of A*B

Name	size(A)	size(B)	size(C)
dot product u'*v	1-by-n (row)	n-by-1 (column)	
linear system b=A*x	m-by-n (matrix)	n-by-1 (column)	
outer product X=ones(5,1)*(1:3) Y=(1:5)'*ones(1,3)	m-by-1 (column)	1-by-n (row)	

Matrix Multiplication

- We'll defer matrix division for a while
- matrix multiplication can be useful--even to those who hate LA
  - outer products are very handy
  - Vectorized ops much faster than writing loops

ND arrays

- Until V5, Matlab arrays could only be 2D
- Now has unlimited dimensions:
  - A=ones(2,3,2)
  - A is a 3D array of ones, with 2 rows, 3 columns, and 2 layers
  - A(:,:,1) is a 2-by-3 matrix