Matlab review

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Matlab

• Available at:
  http://www.cmu.edu/computing/software/all/matlab/download.html

• Need to be on either CMU network or VPN
  ▪ Cisco AnyConnect
    http://www.cmu.edu/computing/network/vpn/

• Very helpful for scientific prototyping
  ▪ Many built-in functions
    • Matrix operations, plots, etc.
  ▪ Libraries for signal/image processing
Basics

• Lines starting with % are comments
• Use ; to suppress output
• End lines with ... to wrap

```plaintext
>> ((1+2)*3 - 2^2 - 1)/2
ans: 2
>> ((1+2)*3 - 2^2 - 1)/2;
>> 1 + 2 + 3 + 4 + 5 ...
   + 6 + 7 + 8 + 9
ans: 45
```
Logics and Assignment

- Variable assignment: =
- Logical tests: >, <, >=, <=, ~=
- Logical operators: &, &&, |, ||, ...
Making Arrays

- \( v = [1 \ 2 \ 3 \ 4] \); % row vector
- \( v = [1; \ 2; \ 3; \ 4] \); % column vector
- \( 1:5 \) % row vector \([1,2,3,4,5]\)
- \( 1:3:10 \) % row vector \([1,4,7,10]\)

- Max/min
  
  \([\text{val}, \text{ind}] = \text{max}(\text{array})\)

- sum, prod, median, ....
Making Matrices (1)

• Which one(s) of the followings would make a different matrix?
  - \( m = \begin{bmatrix} 1 & 2 & 3; & 4 & 5 & 6; & 7 & 8 & 9 \end{bmatrix} \)
  - \( m = \begin{bmatrix} 1,2,3; & 4,5,6; & 7,8,9 \end{bmatrix} \)
  - \( m = \begin{bmatrix} [1 & 2; & 4 & 5; & 7 & 8]; & [3; & 6; & 9] \end{bmatrix} \)
  - \( m = \begin{bmatrix} [1 & 2 & 3; & 4 & 5 & 6]; & [7 & 8 & 9] \end{bmatrix} \)
  - \( B = \begin{bmatrix} 1 & 2 & 3; & 4 & 5 & 6 \end{bmatrix}; \ C = \begin{bmatrix} 7 & 8 & 9 \end{bmatrix}; \)
    \( A = [B; C]; \)
Making Matrices(2)

• Creating all ones, zeros, or identity matrices
  ▪ zeros(rows, cols), ones(rows, cols), eye(rows, cols)

• Creating random matrices
  ▪ rand(rows, cols) draws from Unif[0, 1]
  ▪ randn(rows, cols) draws from N(0, 1)

• Getting the size
  ▪ [rows, cols] = size(matrix);
Accessing elements

• Individual elements
  – \( A(r, c) \)
    
    % index starts from 1!
  
  • Accessing n-th row/column
    – \( A(n, :) \) or \( A(:, n) \)

• Other tricks
  – \( A([1,3,5]) \)
  – \( A([1,3], 2:end) \)
  – \( A(1, \text{logical}([1,0,1])) \)
  – \( A(\text{mod}(A, 2)==0) \)
  – \( A(,:)’ \)
    • Access in column-major order
    • \( \text{sum}(A) \)?
Accessing elements

- $X(X>0) = -X(X>0)$

- $X = [3 2 0 4 5]$; $Y = [1 1 1 1 1]$;
  
  $q = \text{zeros}(1, \text{length}(Y))$;
  
  $q(X\sim=0) = Y(X\sim=0) ./ X(X\sim=0)$;
Matrix math

• Transpose: $A'$
• Inverse: $\text{inv}(a)$
• Matrix multiplication vs. Element by Element multiplication
  ▪ $A \times A$
  ▪ $A \times A$
• Same for divisions ($/ \text{ vs } ./$)
Functions

- Operates in a separate workspace
- Function name = filename
- function return_value = function_name (params)

```matlab
my_func.m

function [y,x] = my_func(x)
    y = x^2;
    x = x+3;
end;
```
Scripts vs Functions

my_script.m

```matlab
y = x^2;
x = x+3;
```

```matlab
>> x = 2; my_script;
```

```matlab
>> x
    ans:  5
>> y
    ans:  4
```

my_func.m

```matlab
function [y,x] = my_func(x)
y = x^2;
x = x+3;
end;
```

```matlab
>> x = 2; [y, xp] = my_func(x);
```

```matlab
>> x
    ans:  2
>> y
    ans:  4
>> xp
    ans:  5
```
Anonymous functions

```matlab
>> c = 4;
>> f = @(x) x + c;
>> f(3)
ans: 7
>> c = 5;
>> f(3)
ans: 7
```

- One use case:

  ```matlab
  f = @(x) x.^2 + 3*x + 1;
  quad( f, 0, 1) % integral of f from x=0 to 1
  ```
Cells

• Like arrays, but can have different types
  ▪ \( x = \{\text{‘hello’, 2, 3}\}; \)
  ▪ \( x\{1\} \)
  ▪ \( x\{2\} \)
  ▪ \( x\{5\} = @(x) x + 1 \)
  ▪ \( x\{5\}(2) \)
Plotting

\[ x = 0 : \pi/20 : 4*\pi; \]
\[ \text{plot}(x, \sin(x)) \]

axis on / off
grid on / off
box on / off
whitebg(gcf, [0, 0, 0])
clf
clf reset
xlabel(‘Angle \theta’)
ylabel(‘y = \sin(\theta)’)
title(‘The Sine Function’)

\[ = 0 : \pi/20 : 4*\pi; \]
\[ \text{plot}(x, \sin(x)) \]
Multiple plots?

```matlab
clf
hold on

plot(x, sin(x))
plot(x, cos(x), 'm')
plot(x, x, 'go')

legend('sin', 'cos', 'x')
axis([0, 2*pi, -1, 1])
```

- Colors: r, g, b, w, c, m, y, k
- Symbols: . o x + * s(square) d(diamond) etc.
- Line type: - (solid), -- (dashed), : (dotted), -. (dash-dot)
- [xmin, xmax, ymin, ymax]
Other commands

• List names of variables in the environment
  ▪ whos

• Clear the environment
  ▪ clear

• Edit functions and scripts
  ▪ edit <filename>
ONE COMMAND
YOU SHOULD NEVER FORGET
help
Other things to know

• Useful operators
  >, <, >=, <=, ==, &, |, &&, ||, +, -, /, *, ^, ..., ./, ‘, .* , .^, 

• Useful Functions
  ▪ sum, mean, var, not, min, max, find, exists, clear, clc, pause, exp, sqrt, sin, cos, reshape, sort, sortrows, length, size, length, setdiff, ismember, isempty, intersect, plot, hist, title, xlabel, ylabel, legend, rand, randn, zeros, ones, eye, inv, diag, ind2sub, sub2ind, find, logical, repmat, num2str, disp, ...
Extra materials

• Prof. Touretzky’s tutorial:
  ▪ http://www.cs.cmu.edu/~dst/Tutorials/Matlab/day1.pdf
  ▪ http://www.cs.cmu.edu/~dst/Tutorials/Matlab/day2.pdf

• MIT’s Matlab tutorial