Introduction to Matlab

Patrice Koehl

http://www.cs.ucdavis.edu/~koehl/

koehl@cs.ucdavis.edu
What is MATLAB?

➢ A high-performance language for technical computing (Mathworks, 1998)

➢ The name is derived from MATrix Laboratory

➢ Typical uses of MATLAB
  - Mathematical computations
  - Algorithmic development
  - Model prototyping
  - Data analysis and exploration of data (visualization)
  - Scientific and engineering graphics for presentation
Why Matlab?

➢ Because it simplifies the analysis of mathematical models

➢ It frees you from coding in high-level languages (saves a lot of time - with some computational speed penalties)

➢ Provides an extensible programming/visualization environment

➢ Provides professional looking graphs
Matlab

➢ The Matlab Environment
➢ Variables; operations on variables
➢ Programming
➢ Visualization
The Matlab Environment

Variables; operations on variables

Programming

Visualization
The Matlab Environment

Current folder

Command Window

Workspace

Command history
Help in Matlab

Help Browser
  -> Product Help

Command line:
  >> help <command>

Example:
  >> help sqrt
Matlab

➢ The Matlab Environment

➢ Variables; operations on variables

➢ Programming

➢ Visualization
Scalar variable:
One storage box

Array:
“chest of drawers”
Variables in Matlab

➢ Begin with an alphabetic character: a
➢ Case sensitive: a, A
➢ No data typing: a=10; a=‘OK’; a=2.5
➢ Default output variable: ans
➢ Built-in constants: pi i j Inf
➢ clear removes variables
➢ who lists variables
➢ whos list variables and gives size
➢ Special characters: [ ] ( ) { } ; % : = . ... @
Vectors in Matlab

➢ Row vectors

```matlab
>> R1 = [1 6 3 8 5]
>> R2 = [1 : 5]
>> R3 = [-pi : pi/3 : pi]
```

➢ Column vectors

```matlab
>> C1 = [1; 2; 3; 4; 5]
>> C2 = R2'
```
Matrices in Matlab

➢ Creating a matrix

```matlab
>> A = [1 2.5 5 0; 1 1.3 pi 4]
>> A = [R1; R2]
>> A = zeros(10,5)
>> A = ones(10,5)
>> A = eye(10)
```

➢ Accessing elements

```matlab
>> A(1,1)
>> A(1:2, 2:4)
>> A(:,2)
```
Matrix Operations

➢ Operators + and –

$$\gg \ X = \begin{bmatrix} 1 & 2 & 3 \end{bmatrix}$$

$$\gg \ Y = \begin{bmatrix} 4 & 5 & 6 \end{bmatrix}$$

$$\gg \ A = X + Y$$

$$A = \begin{bmatrix} 5 & 7 & 9 \end{bmatrix}$$

➢ Operators *, /, and ^

$$\gg \ A_{\text{inv}} = A^{-1} \text{ Matrix math is default!}$$
Element wise operations

Operators *, ./, and .^ 

>> Z = [2 3 4]’
>> B = [Z.^2 Z Z.^0]

B=  
   4  2  1
  9  3  1
 16  4  1
Matlab

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M-file programming

➢ **Script M-Files**
  - Automate a series of steps.
  - Share workspace with other scripts and the command line interface.

➢ **Function M-Files**
  - Extend the MATLAB language.
  - Can accept input arguments and return output arguments.
  - Store variables in internal workspace.
M-file programming

➢ Always one script M-File

➢ Uses built-in and user-defined functions

➢ Created in MATLAB Editor

  >> edit model.m

➢ Run from Command Line Window

  >> model
Example: `model.m`

```matlab
% Define input
T = [ 0 : 0.01 : 30]
% Compute model
Y = exp(-T);
% Plot model
plot (T, Y);
```
Example of function

Example: amodel.m

```matlab
function Y = amodel(t, A, B, a, w, p)
% H1 line: AMODEL computes step response.
% Help text: appears when you type
% “help amodel” in command line window.

% Comment: function body is below.
Y = A * exp(-b.*t).*cos(w.*t + p) + B;
```
Input / Output

➢ Get input from command window:

```matlab
>> num = input('What is the altitude :')
>> str = input('Enter name of the planet','s')
```

➢ Display output in command window:

```matlab
String
   >> disp('The answer is:')
String + number:
   >> disp(['The value of x is: ' num2str(x)])
```
Operators

- **Arithmetic**: \( x+y; \ A*B; \ X.*Y; \) etc.

- **Logical**
  - Element-wise AND: \( a \ & \ b \)
  - Element-wise OR: \( a \ | \ b \)

- **Relational**
  \( a == 5; \ a >= b; \ b ~= 6; \)

- **Operator precedence**
  \((()) \ {[]} \) \rightarrow\ Arithmetic \rightarrow Relational \rightarrow Logical
Program flow control: For

Simple program that sums the squares of all the elements of a matrix A:

N = 10;
M = 20;

A = rand(10,20)

Sum = 0;
for i = 1:N
    for j = 1:M
        Sum = Sum + A(i,j)^2;
    end
end

Note that this can be done in one line:
Sum2 = sum(sum(A.*A));
Program flow control: if

Simple program that compares two numbers $a$ and $b$: set $j$ to 1 if $a > b$, -1 if $a < b$, and 0 if $a = b$:

```plaintext
if $a > b$
  $j = 1$;
else if $a < b$
  $j = -1$;
else
  $j = 0$;
end
```
Program flow control: switch

Simple program that reads in an integer number, checks if it is -1, 0, 1, or another number

\[ N = \text{input('Enter an integer number: ')} \]

\[ \text{switch } N \]
\[ \quad \text{case -1} \]
\[ \quad \quad \text{disp('negative one')} \]
\[ \quad \text{case 0} \]
\[ \quad \quad \text{disp('zero')} \]
\[ \quad \text{case 1} \]
\[ \quad \quad \text{disp('positive one')} \]
\[ \quad \text{otherwise} \]
\[ \quad \quad \text{disp('other value')} \]
Other useful commands

➢ **Workspace**
  - `clear`
  - `who`
  - `whos`
  - `close`

➢ **File operations**
  - `ls`
  - `dir`
  - `cd`
  - `pwd`
  - `mkdir`
Matlab

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➢ Visualization
- **Linear plots**

  ```
  >> plot (X, Y)
  ```

  Plotting commands open the **Figure** editor.

- **Multiple datasets on a plot**

  ```
  >> plot(xcurve, ycurve)
  >> hold on
  >> plot(Xpoints, Ypoints)
  >> hold off
  ```

- **Subplots on a figure**

  ```
  >> subplot(1, 2, 1)
  >> plot(time, velocity)
  >> subplot(1, 2, 2)
  >> plot(time, acceleration)
  ```
2D linear plots: `plot`

```
>> plot (X, Y, 'r-')
```

Colors: `b`, `r`, `g`, `y`, `m`, `c`, `k`, `w`
Markers: `o`, `*`, `.`, `+`, `x`, `d`
Line styles: `-`, `--`, `-.`

Annotating graphs

```
>> plot (X, Y, 'ro')
>> legend ('Points')
>> title ('Coordinates')
>> xlabel ('X')
>> ylabel ('Y')
```

Plot Edit mode: icon in Figure Editor
References

Violeta Ivanova, MIT


Experiment with Matlab (Steve Moler):

http://www.mathworks.com/moler/exm/chapters.html

Matlab: Getting started