سیگنال‌ها و سیستم‌ها

کارگاه عملی ۱

آشنایی با متلب

Introduction to MATLAB®

کاظم فولادی قلعه
دانشکده مهندسی، دانشکدگان فارابی
دانشگاه تهران

http://courses.fouladi.ir/sigsys

Introduction to Matlab

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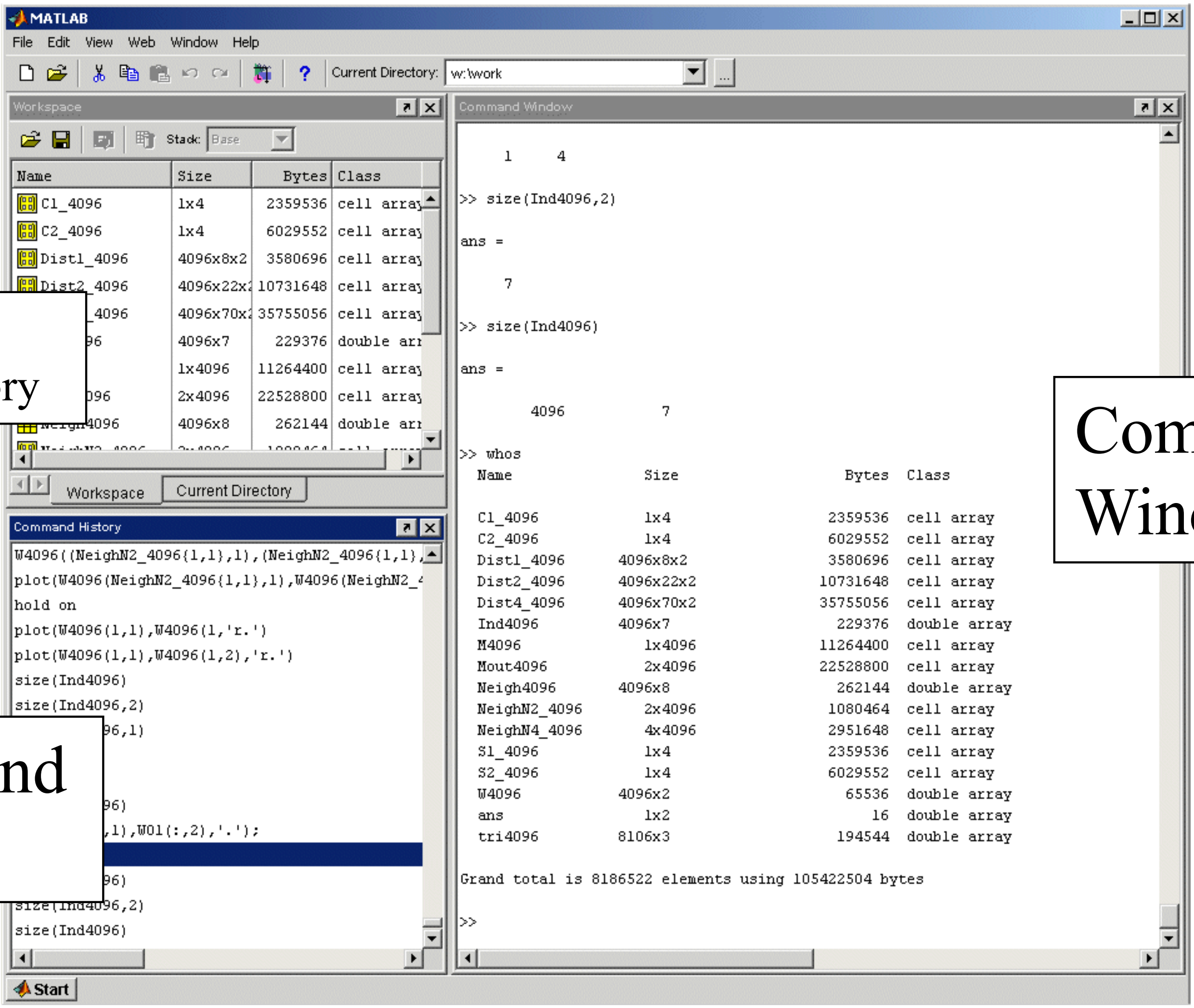
Matlab

- Stands for MATrix LABoratory
- Interpreted language
- Scientific programming environment
- Very good tool for the manipulation of matrices
- Great visualisation capabilities
- Loads of built-in functions
- Easy to learn and simple to use

Matlab Desktop



Name	Size	Bytes	Class
C1_4096	1x4	2359536	cell array
C2_4096	1x4	6029552	cell array
Dist1_4096	4096x8x2	3580696	cell array
Dist2_4096	4096x22x2	10731648	cell array
_4096	4096x70x2	35755056	cell array
96	4096x7	229376	double arr
	1x4096	11264400	cell array
096	2x4096	22528800	cell array
Neigh4096	4096x8	262144	double arr

```
W4096((NeighN2_4096{1,1},1),(NeighN2_4096{1,1},
plot(W4096(NeighN2_4096{1,1},1),W4096(NeighN2_4
hold on
plot(W4096(1,1),W4096(1,'r.')
plot(W4096(1,1),W4096(1,2),'r.')
size(Ind4096)
size(Ind4096,2)
96,1)


96)
,1),W01(:,2),'.');

96)
size(Ind4096,2)
size(Ind4096)
```

```
     1     4

>> size(Ind4096,2)

ans =

     7

>> size(Ind4096)

ans =

        4096           7

>> whos
  Name              Size                    Bytes  Class

  C1_4096           1x4                   2359536  cell array
  C2_4096           1x4                   6029552  cell array
  Dist1_4096     4096x8x2                 3580696  cell array
  Dist2_4096     4096x22x2               10731648  cell array
  Dist4_4096     4096x70x2               35755056  cell array
  Ind4096        4096x7                    229376  double array
  M4096             1x4096               11264400  cell array
  Mout4096          2x4096               22528800  cell array
  Neigh4096      4096x8                    262144  double array
  NeighN2_4096      2x4096                1080464  cell array
  NeighN4_4096      4x4096                2951648  cell array
  S1_4096           1x4                   2359536  cell array
  S2_4096           1x4                   6029552  cell array
  W4096          4096x2                     65536  double array
  ans               1x2                        16  double array
  tri4096        8106x3                    194544  double array

Grand total is 8186522 elements using 105422504 bytes

>>
```

Workspace / Current Directory

Command Window

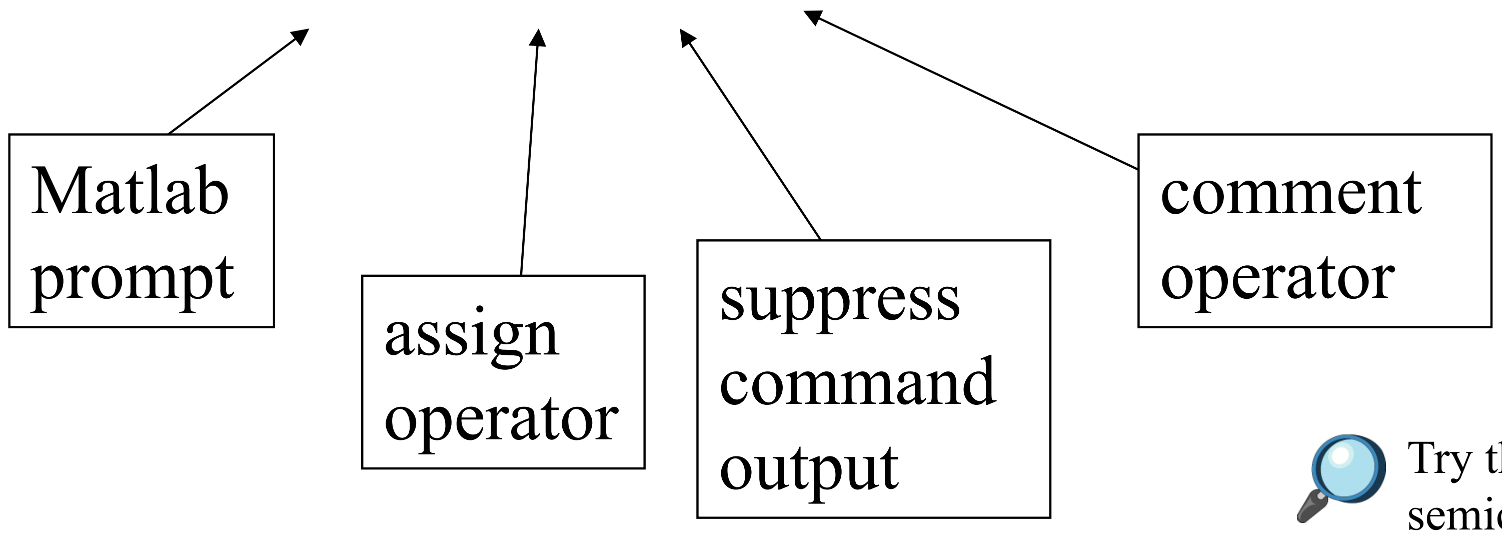
Command History

Explore the Matlab Desktop

Variables

- Don’t have to declare type
- Don’t even have to initialise
- Just assign in command window

```
>>
>> a=12; % variable a is assigned 12
```



Try the same line without the semicolon and comments

Variables (continued …)

- View variable contents by simply typing the variable name at the command prompt

```
>> a
a =
          12
>>
          >> a*2
a =
          24
>>
```

Workspace

- The workspace is Matlab's memory
- Can manipulate variables stored in the workspace

```
>> b=10;
>> c=a+b
c =
    22
>>
```

Workspace (continued …)

- Display contents of workspace

```
>> whos
 Name        Size                   Bytes  Class
  a           1x1                        8   double array
  b           1x1                        8   double array
  c           1x1                        8   double array
Grand total is 3 elements using 24 bytes
>>
```

- Delete variable(s) from workspace

```
>> clear a b; % delete a and b from workspace
>> whos
>> clear all; % delete all variables from workspace
>> whos
```

Matlab help commands

- help

```
>> help whos          % displays documentation for the function whos
>> lookfor convert     % displays functions with convert in the first help line
```

- Start Matlab help documentation

```
>> helpdesk
```

Matrices

- Don’t need to initialise type, or dimensions

```
>>A = [3 2 1; 5 1 0; 2 1 7]
A =
     3     2     1
     5     1     0
     2     1     7
>>
```

square brackets to define matrices

semicolon for next row in matrix

Manipulating Matrices

```
A =

     3     2     1
     5     1     0
     2     1     7
```

- Access elements of a matrix

```
>>A(1,2)
ans=
2
```

indices of matrix element(s)

- Remember Matrix(row,column)
- Naming convention Matrix variables start with a capital letter while vectors or scalar variables start with a simple letter

The : operator

- VERY important operator in Matlab
- Means ‘to’

```
>> 1:10
ans =
     1     2     3     4     5     6     7     8     9    10
>> 1:2:10
ans =
     1     3     5     7     9
```

Try the following

```
>> x=0:pi/12:2*pi;
>> y=sin(x)
```

The : operator and matrices

```
>>A(3,2:3)
ans =
     1     7
>>A(:,2)
ans =
     2
     1
     1
```

```
A =
    3    2    1
    5    1    0
    2    1    7
```

🔍 What'll happen if you type `A(:,:)` ?

Manipulating Matrices

```
A =

     3     2     1
     5     1     0
     2     1     7

B =

     1     3     1
     4     9     5
     2     7     2
```

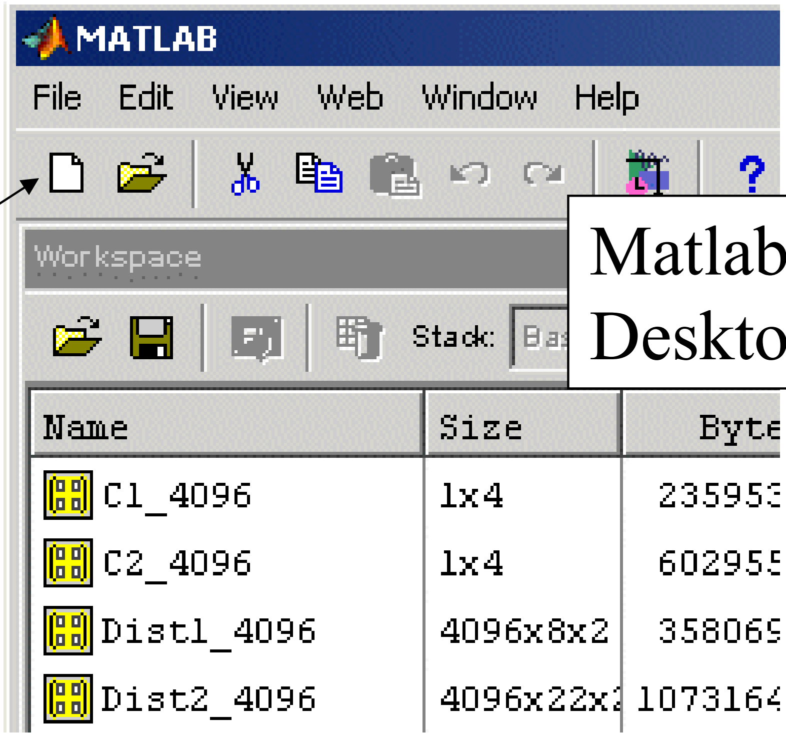
```
>> A '          % transpose
>> B*A % matrix multiplication
>> B.*A         % element by element multiplication
>> B/A % matrix division
>> B./A         % element by element division
>> [B A]        % Join matrices (horizontally)
>> [B; A]       % Join matrices (vertically)
```

Enter matrix B into the Matlab workspace

Create matrices A and B and try out the the matrix operators in this slide

Scripts

- Matlab editor
- Use scripts to execute a series of Matlab commands



Name	Size	Byte
C1_4096	1x4	235953
C2_4096	1x4	602955
Dist1_4096	4096x8x2	358069
Dist2_4096	4096x22x2	1073164

Matlab Desktop

Press to create new m-file in the matlab editor

Scripts (continued)

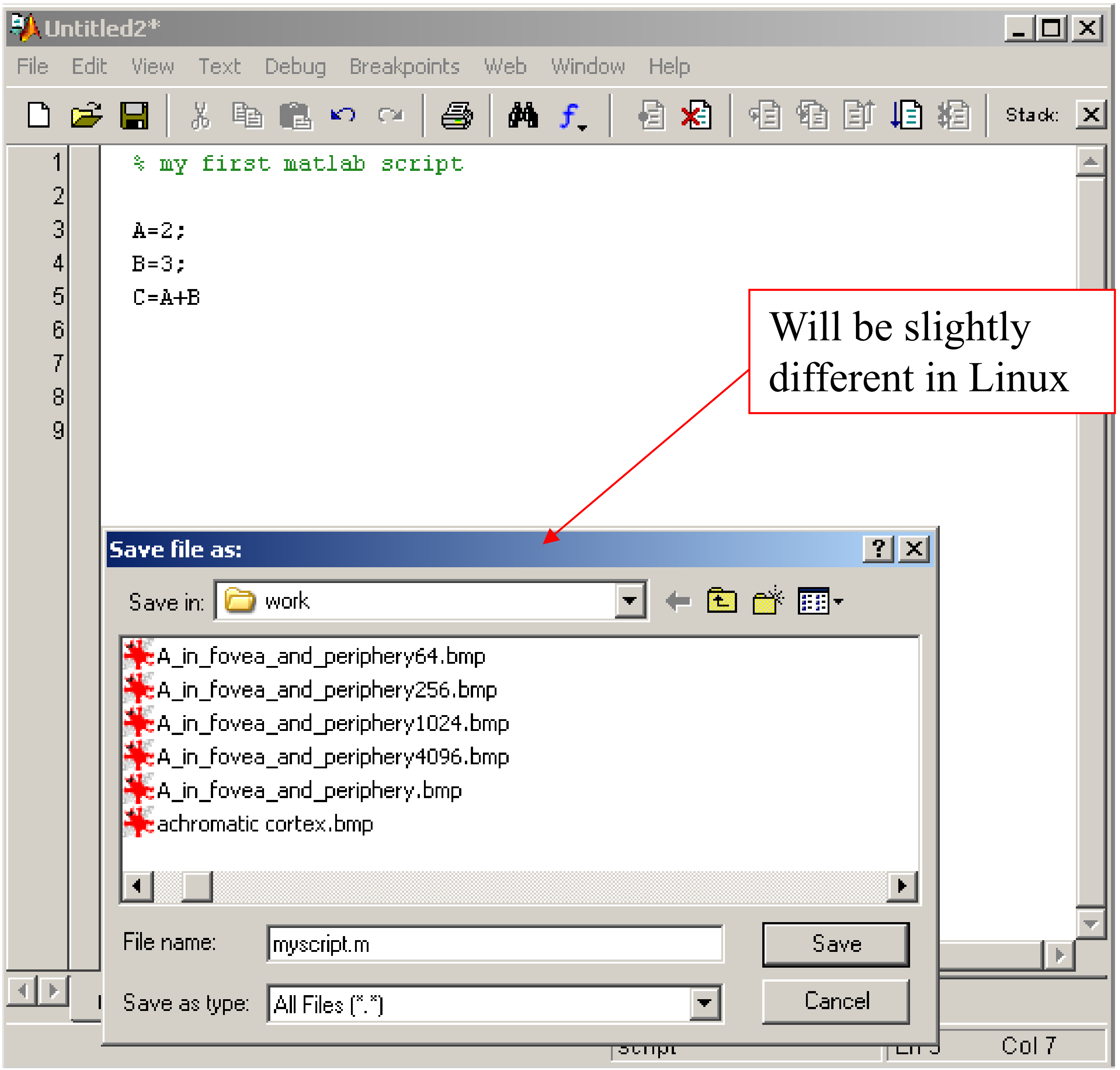
- Scripts will manipulate and store variables and matrices in the Matlab Workspace (memory).
- They can be called from the Matlab command line by typing the (case sensitive!) filename of the script file.

```
>> myscript
```

- Scripts can be opened in the editor by the following

```
>> open myscript
```

Highlight a few lines of your script by left- clicking and dragging the mouse over the lines. Right-click the highlighted lines and select Evaluate Selection.



```
% my first matlab script

A=2;
B=3;
C=A+B
```

Save file as:

Save in: work

A_in_fovea_and_periphery64.bmp
A_in_fovea_and_periphery256.bmp
A_in_fovea_and_periphery1024.bmp
A_in_fovea_and_periphery4096.bmp
A_in_fovea_and_periphery.bmp
achromatic cortex.bmp

File name: myscript.m

Save as type: All Files (*.*)

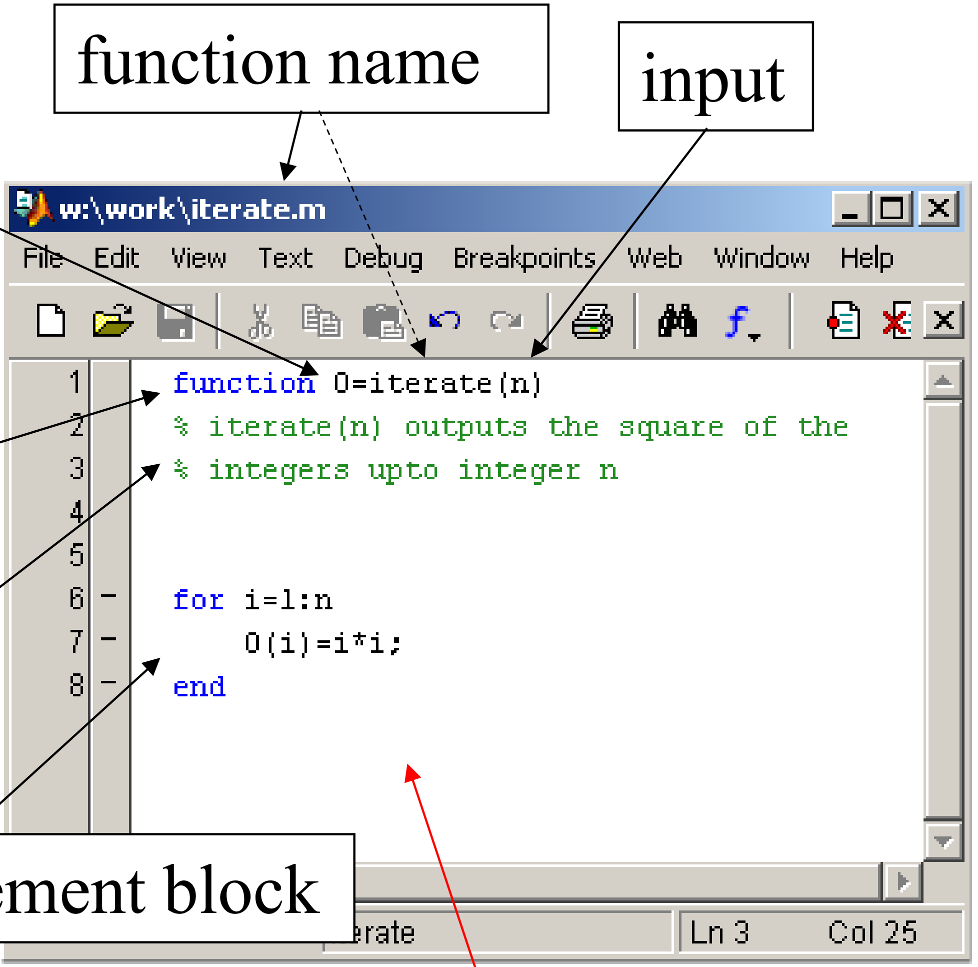
Will be slightly different in Linux

Functions

- Programming in Matlab.
- Users can write functions which can be called from the command line.
- Functions can accept input variable(s)/matrice(s) and will output variable(s)/matrice(s).
- Functions will **not** manipulate variable(s)/matrice(s) in the Matlab Workspace.
- In Matlab functions closely resemble scripts and can be written in the Matlab editor. Matlab functions have the function keyword.
- Remember that the filename of a function will be its calling function name.
- Don't overload any built-in functions by using the same filename for your functions or scripts!
- Functions can be opened for editing using the **open** command. Many built-in Matlab functions can also be viewed using this command.

Functions (continued)

```
>> I=iterate(5)
I =
      1      4      9     16     25
```



```
function O=iterate(n)
% iterate(n) outputs the square of the
% integers upto integer n


for i=1:n
    O(i)=i*i;
end
```

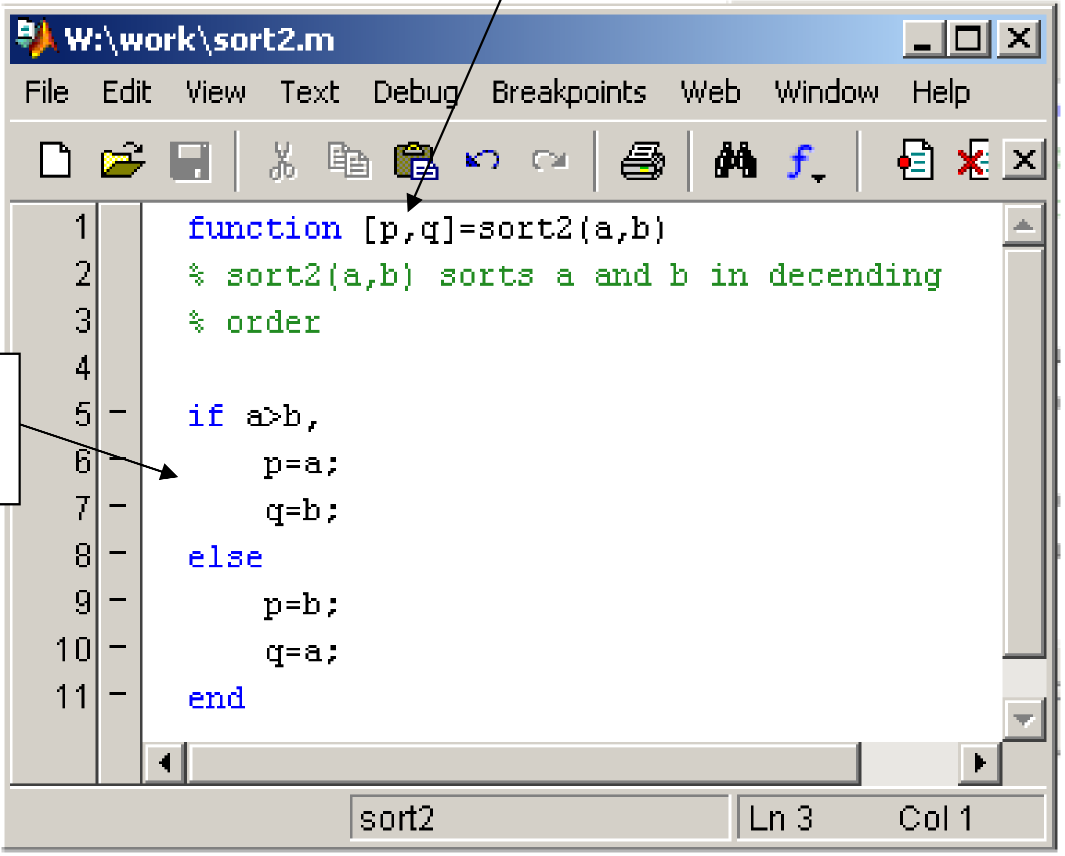
Access the comments of your Matlab functions
>> help iterate

Make sure you save changes to the m-file before you call the function!

Functions (continued)

```
>> [i j]=sort2(2,4)
i =

     4

j =

     2

>>
```

Functions can have many outputs contained in a matrix



```
function [p,q]=sort2(a,b)
% sort2(a,b) sorts a and b in decending
% order

if a>b,
    p=a;
    q=b;
else
    p=b;
    q=a;
end
```

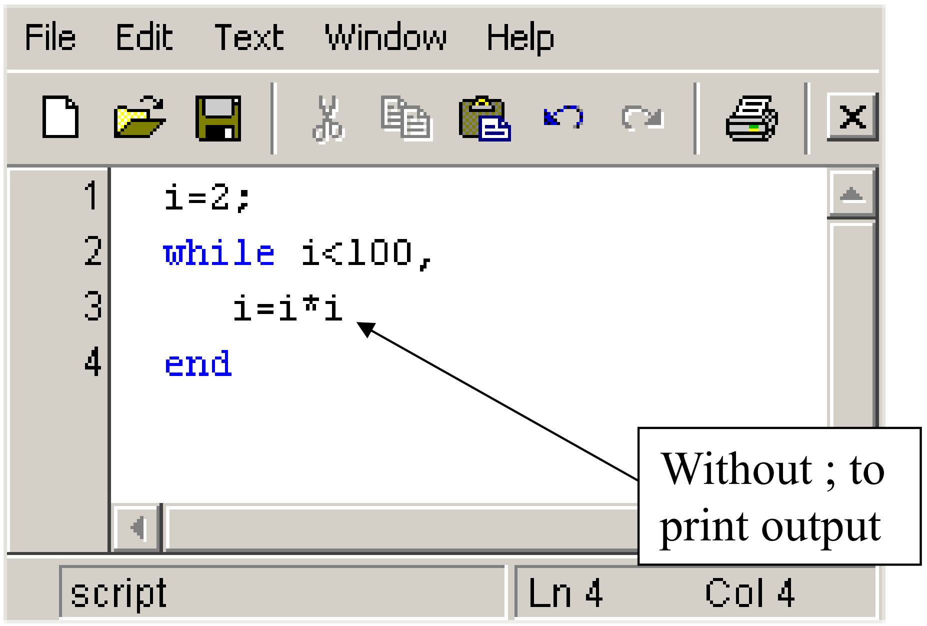
if statement block

Remember to use the Matlab help command for syntax

```
>> help if
```

More flow control

While statement block

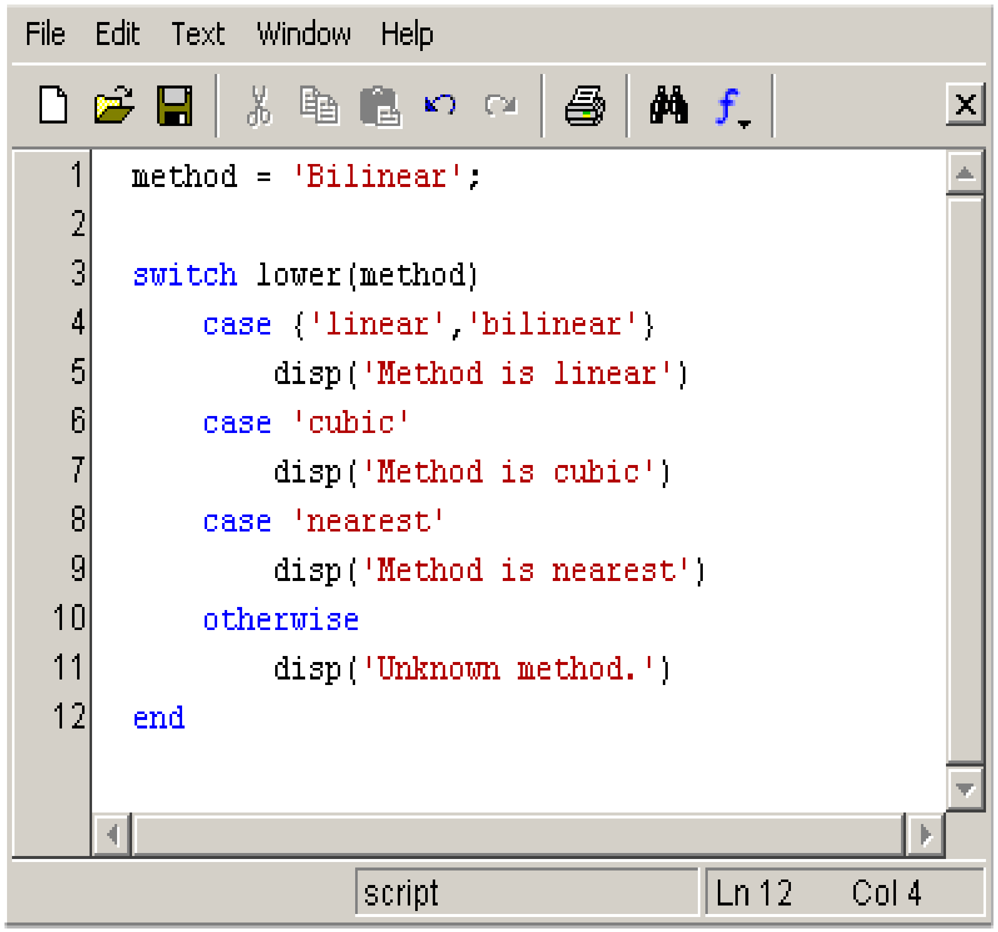


```
i=2;
while i<100,
    i=i*i
end
```

Without ; to print output

```
i =

     4

i =

    16

i =

   256
```

Switch statement block



```
method = 'Bilinear';

switch lower(method)
    case {'linear','bilinear'}
        disp('Method is linear')
    case 'cubic'
        disp('Method is cubic')
    case 'nearest'
        disp('Method is nearest')
    otherwise
        disp('Unknown method.')
end
```

```
Method is linear
>>
```

Debugging

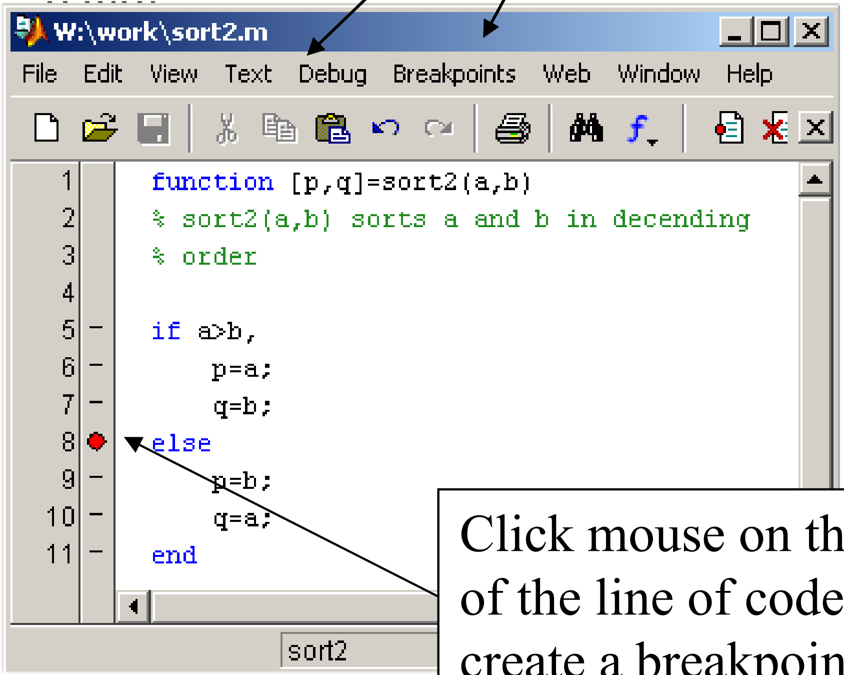
- Set breakpoints to stop the execution of code

```
>> [i j]=sort2(2,4)
K>>
K>> whos
 Name       Size       Bytes  Class
   a          1x1                     8  double array
   b          1x1                     8  double array
Grand total is 2 elements using 16 bytes
K>> a
a =
     2
K>> return
i =

     4
j =
     2
```

local function workspace

exit debug mode

Debug menus



```
function [p,q]=sort2(a,b)
% sort2(a,b) sorts a and b in decending
% order

if a>b,
    p=a;
    q=b;
else
    p=b;
    q=a;
end
```

Click mouse on the left of the line of code to create a breakpoint

Visualisation - plotting data

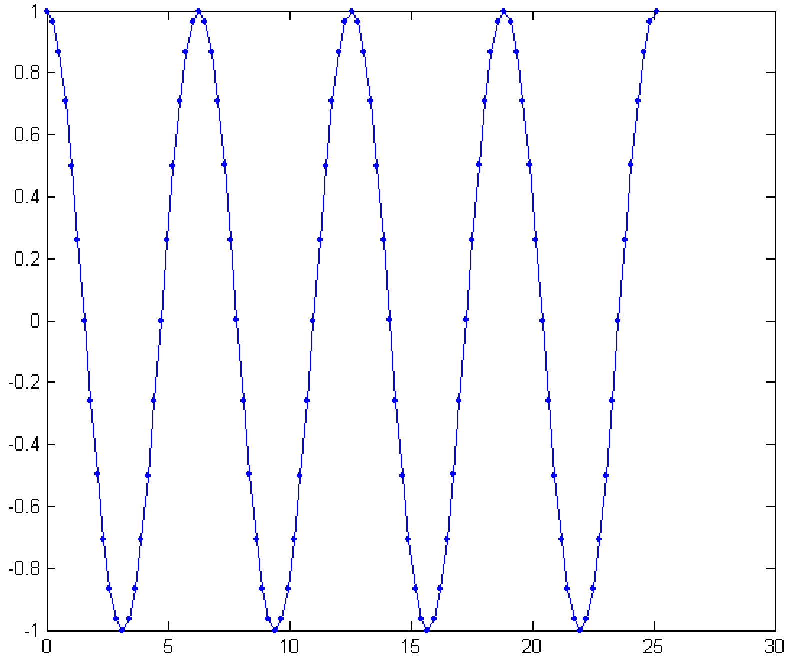
```
>> figure   % create new figure
>> t=0:pi/12:8*pi;
>> y=cos(t);
>> plot(t,y,‘b.-')
```

Plot style

Investigate the function

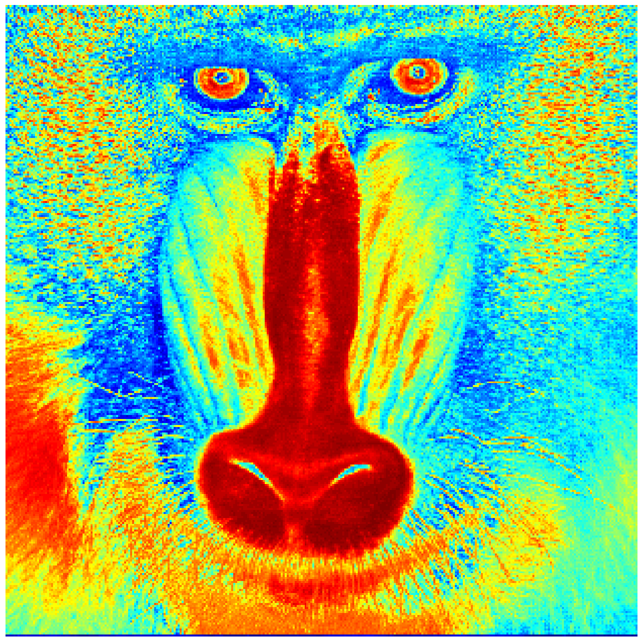
```
>> y=A*cos(w*t+phi);
```

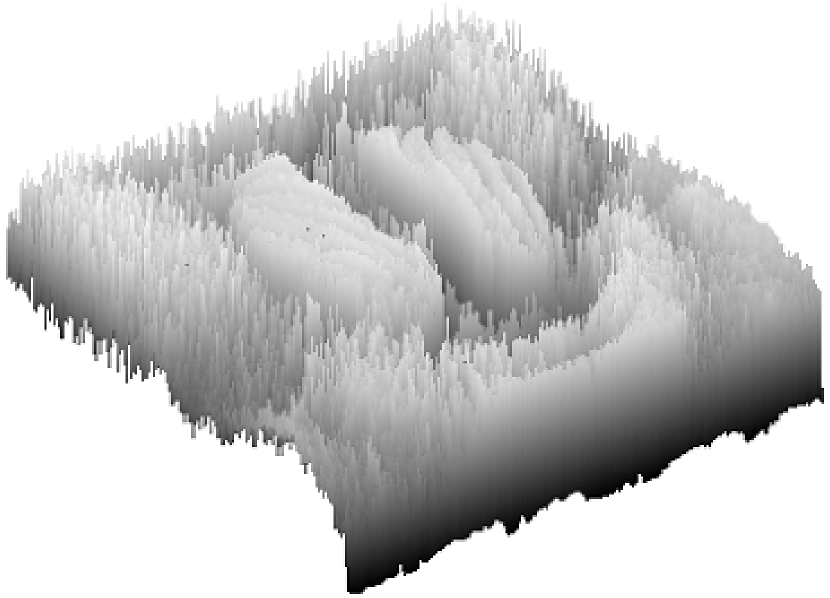
for different values of phi (eg: 0, pi/4, pi/3, pi/2), w (eg: 1, 2, 3, 4) and A (eg: 1, 0.5, 2). Use the **hold on** Matlab command to display your plots in the same figure. Remember to type **hold off** to go back to normal plotting mode. Try using different plot styles (**help plot**)

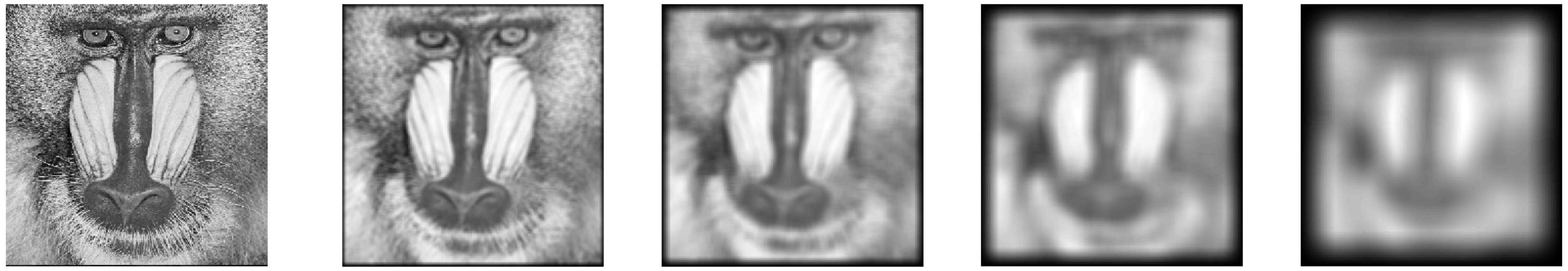


```
A = amplitude
phi = phase
w = angular frequency = 2*pi*frequency
```

Image Processing using Matlab







Useful operators and built-in functions

<	¦	save	!
>	rand	load	⚠ guide
~=	zeros	…	⚠ get
==	min	' '	⚠ set
>=	max	{ }	
<=	repmat	try	
&	axis	catch	

Operating system command

Continue in next line

string

Graphical user interface

cell

error handling

Remember to use the Matlab help command if you get stuck

Tutorial 1

- Login to your workstation, start Matlab and create a working directory
  1) Login to Linux using your username/password
  2) Open a terminal session by right clicking the mouse on the screen and selecting New Terminal
  3) Type the following in the terminal session (do not type the prompt sign >)

```
> matlab
> mkdir work
```

  4) Type the following in Matlab (do not type the prompt sign >>)

```
>> cd work
```

- Explore Matlab! Use the **help** matlab command to understand the built-in Matlab functions
- Type the code in this handout in Matlab and investigate the results.
- Write a Matlab function fibonacci.m to generate the Fibonacci series. This is generated by starting with zero and one and adding the last two numbers of the sequence to generate the next number in the series. Fibonacci series:
  `0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987, ...`
- Create an graph of the Fibonacci series using the built-in **plot** Matlab function. Your graph should resemble figure 1 which contains a plot of the first 20 numbers in the sequence.
- Plot the Fibonacci series in polar coordinates using the built-in Matlab **polar** function. Eccentricity (rho) should be the Fibonacci number and angle (theta) should vary with the Fibonacci number's order in the sequence. Your plot should resemble figure 2 which is a polar plot of the first 10 numbers of the series.
- Exit Matlab by typing quit and logout of Linux.

```
>> quit
```

Figure 1

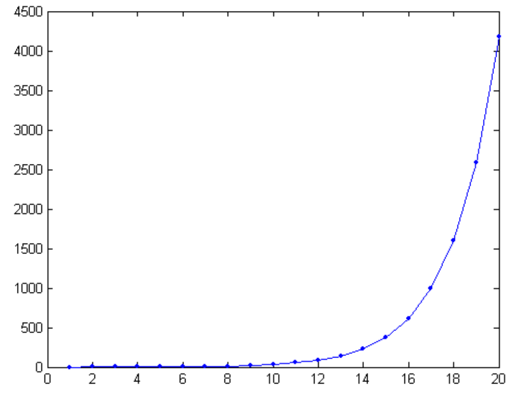
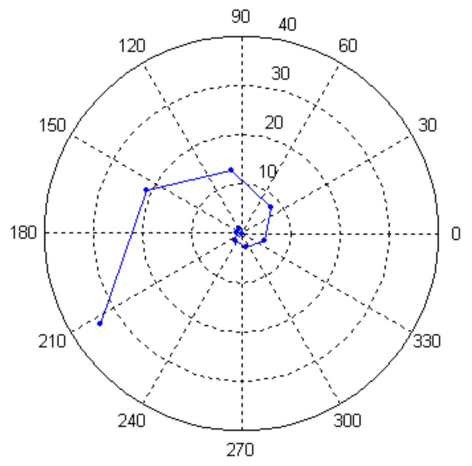


Figure 2


90
40
120
60
30
150
20
30
10
180
0
210
330
240
300
270