Learning MATLAB and its Applications for Signal Processing & Communications

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Learning MATLAB & its Applications — Lecture no. 1

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Overview

References:

[1] Desmond J. Higham and Nicholas J. Higham, MATLAB Guide, 2nd ed. Society for Industrial and Applied Mathematics, 2005.

[2] Amos Gilat, MATLAB An Introduction with Applications. John Wiley & Sons Inc., 2004.

MATLAB Definition

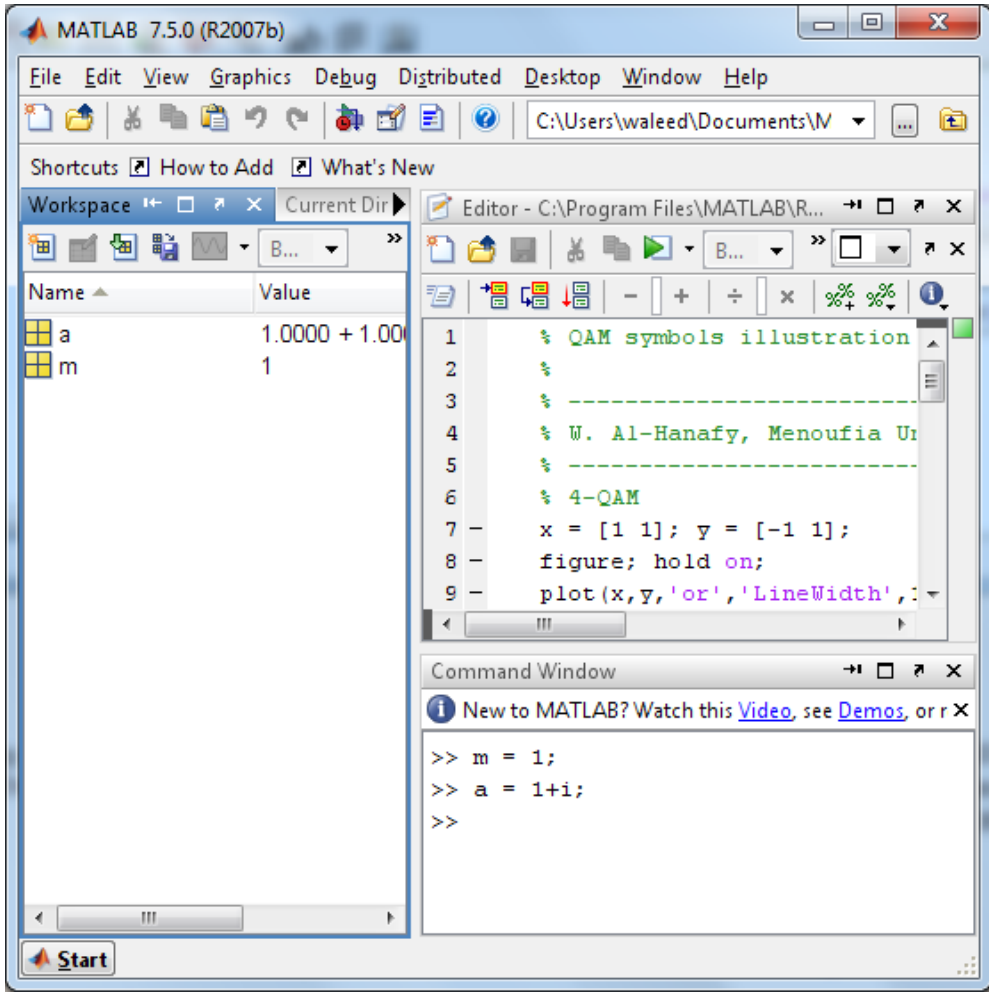
- MATLAB is a powerful language for technical computing.
- The name MATLAB stands for MATrix LABoratory, because its basic data element is a matrix (array).
- MATLAB can be used for math computations, modelling and simulations, data analysis and processing, visualisation and graphics, and algorithm development.
- MATLAB is widely used in universities and colleges in introductory and advanced courses in mathematics, science, and especially in engineering.

MATLAB Definition (cont'd)

- In industry the software is used in research, development and design.
- The standard MATLAB program has tools (functions) that can be used to solve common problems.
- In addition, MATLAB has optional toolboxes that are a collection of specialised programs designed to solve specific types of problems.
- Examples include toolboxes for signal processing, symbolic calculations, and control systems.

MATLAB Windows

Window	Purpose
Command	Main window, enters variables, runs programs
Figure	Contains output from graphic commands
Editor	Creates and debugs scripts and functions
Help	Provides help information
Command History	Logs commands entered in the Command Window
Workspace	Provides information about the variables that are used
Current Dir.	Shows the files in the current directory



Arithmetic Operations

Operation	Symbol
Addition	+
Subtraction	-
Multiplication	*
Division	/
Exponentiation	^

Precedence	Mathematical Operation
First	Parentheses. For nested parentheses, the innermost are executed first
Second	Exponentiation
Third	Multiplication and division
Fourth	Addition and subtraction

Display Formats Commands

Command	**Description**
format short	Scaled fixed point format with 5 digits
format long	Scaled fixed point format with 15 digits for double and 7 digits for single
format short e	Floating point format with 5 digits
format long e	Floating point format with 15 digits for double and 7 digits for single
format bank	Fixed format for dollars and cents
format hex	Hexadecimal format

Elementary Math Built-in Functions

Command	**Description**
sqrt(x)	Square root
exp(x)	Exponential (e^x)
abs(x)	Absolute value
log(x)	Natural logarithm, Base e logarithm (ln)
log10(x)	base 10 logarithm
factorial(x)	The factorial function $x!$, x must be a positive integer
sin(x)	Sine of angle x (x in radians)
cos(x)	Cosine of angle x (x radians)
tan(x)	Tangent of angle x (x radians)
cot(x)	Cotangent of angle x (x radians)

Elementary Math Built-in Functions (cont'd)

Command	**Description**
round(x)	Round to the nearest integer
fix(x)	Round towards zero
ceil(x)	Round towards infinity
floor(x)	Round towards minus infinity
log10(x)	base 10 logarithm
factorial(x)	The factorial function $x!$ x must be a positive integer
rem(x,y)	Returns the remainder after x is divided by y
sign(x)	Signum function. Returns 1 if x $>$ 0, -1 if x $<$ 0, and 0 if x=0

Variables

- **The Assignment Operator:**

Variable_name = A numerical value, or a computable expression

- **Rules About Variable Names:**
  - Can be up to 63 (in MATLAB 6.5) characters long (31 characters in MATLAB 6.0)
  - Can contain letters, digits, and the underscore character
  - Must begin with a letter
  - MATLAB is case sensitive; it distinguishes between uppercase and lowercase letters. For example, AA, Aa, aA, and aa are the names of four different variables
  - Avoid using the names of a built-in function for a variable (i.e. avoid using: cos, sin, exp, sqrt, etc.)
  - Once a function name is used to define a variable, the function cannot be used

Variables (cont'd)

- **Predefined Variables:**

`ans`	A variable that has the value of the last expression that was not assigned to a specific variable. If the user does not assign the value of an expression to a variable, MATLAB automatically stores the result in `ans`
`pi`	The number π
`eps`	The smallest difference between two numbers. Equals to 2^(-52), which is approximately 2.2204e-016
`inf`	Used for infinity
`i`	Defined as $\sqrt{-1}$, which is: $0 + 1.0000i$
`j`	Same as `i`
`NaN`	Stands for Not-a-Number. Used when MATLAB cannot determine a valid numeric value. For example 0/0

Useful Commands for Managing Variables

Command	Outcome
`clear`	Removes all variables from the memory
`clear x, y, z`	Removes only variables x, y, and 7. from the memory
`who`	Displays a list of the variables currently in the memory
`whos`	Displays a list of the variables currently in the memory and their size together with information about their bytes and class.

Simple Examples

Example 1 — Trigonometric identity:

A trigonometric identity is given by

$$\cos^2 \frac{x}{2} = \frac{\tan x + \sin x}{2 \tan x}.$$

Verify that the identity is correct by calculating each side of the equation, substituting $x = \frac{\pi}{5}$

```
>> x = pi/5;                          % Define x

>> LHS = cos(x/2)^2                   % Calculate the left-hand side

LHS =

0.9045

>> RHS = (tan(x)+sin(x))/(2*tan(x))   % Calculate the left-hand side

RHS =

0.9045

>>
```

Simple Examples (cont'd)

Example 2 — Heat transfer:
An object with an initial temperature of T_0 that is placed at time $t = 0$ inside a chamber that has a constant temperature of T_s, will experience a temperature change according to the equation: $T = T_s + (T_0 - T_s)e^{-kt}$ where T is the temperature of the object at time t, and k is a constant. A soda can at a temperature of 120^oF (was left in the car) is placed inside a refrigerator where the temperature is 38^oF. Determine, to the nearest degree, the temperature of the can after three hours. Assume $k = 0.45$. First define all the variables and then calculate the temperature using one MATLAB command.

```
>> Ts = 38; T0 = 120; k = 0.45; t = 3;     % Define variables

>> T = round(Ts + (T0 - Ts)*exp(-k*t))     % Calculate T

T =

59

>>
```

Exercises

Solve the following problems in the Command Window.

1. Calculate:
   (a) $(2+7)^3 + \frac{273^{2/3}}{2} + \frac{55^2}{3}$
   (b) $2^3 + 7^3 + \frac{273^3}{2} + 55^{3/2}$
   (c) $\frac{3^7 \log(76)}{7^3+546} + \sqrt[3]{910}$
   (d) $\cos^2\left(\frac{5\pi}{6}\right) + \sin\left(\frac{7\pi}{8}\right)^2 + \frac{\tan\left(\frac{\pi}{6}\ln 8\right)}{\sqrt{7}}$
2. Define the variables a, b, c, and d as:$a = 15.62$, $b = -7.08$, $c = 62.5$, and $d = 0.5(ab - c)$. Evaluate: (a) $a + \frac{ab(a+d)^2}{c\sqrt{|ab|}}$ and (b) $de^{\left(\frac{d}{2}\right)} + \frac{\frac{ad+cd}{\frac{20}{a}+\frac{30}{b}}}{(a+b+c+d)}$

Vectors

```
Variable_name = [ type vector elements ]
```

Row vector: To create a row vector type the elements with a space or a comma between the elements inside the square brackets

Column vector: To create a column vector type the left square bracket [and then enter the elements with a semicolon between them, or press the Enter key after each element. Type the right square bracket] after the last element

```
Variable_name = linspace(xi, xf, n)
```

Matrices

A two-dimensional array, also called a matrix, has numbers in rows and columns. Matrices can be used to store information like in a table. Matrices play an important role in linear algebra and are used in science and engineering to describe many physical quantities.

Variable_name = [1st row elements; 2nd row elements; ...; last row elements]

Example: >> A = [1 2 3;4 5 6;7 8 9]

Miscellaneous

- **The zeros, ones and eye commands**
- **The transpose operator**
- **Array addressing**
  - **Adding elements to existing variables**
  - **Deleting elements**
- **Built-in functions for handling arrays**
  - **length(v), size(A), reshape(A,m,n), diag(v), diag(A)**

Conclusion

Concluding remarks

- A brief introduction for MATLAB is given
- Elementary operations and some program consideration are also considered.
- Variables examples are defined for scalar, vector, and matrix quantities.
- Some examples and exercises are addressed