National University of Singapore

MA2213, NUMERICAL ANALYSIS I, LABORATORY 1

Introduction to MATLAB

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OUTLINE

INTRODUCTION TO MATLAB

- MATLAB: Matrix Laboratory
- multi-paradigm numerical computing system and proprietary programming language
- Object-oriented programming and procedure languages
- Developed by MathWorks Inc. in USA
- Alternatives: Octave
- Nus student software:

  https://nusit.nus.edu.sg/services/software_and_os/software/software-student/#install-matlab
- Octave:

  https://www.gnu.org/software/octave/

STARTING, 1/2

1. Login with your NUS Net ID:NUSSTU******* and corresponding password
2. Double click the MATLAB icon

Figure: MATLAB Icon

STARTING, 2/2

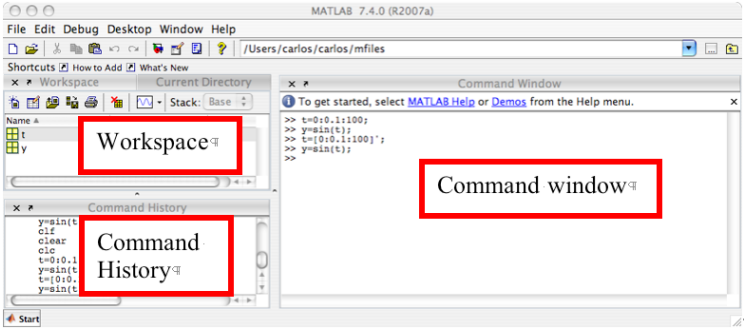

Figure: MATLAB Interface

BASIC STATEMENTS

- Single statements
- assign to a variable
- Usage of semicolon":"
- variable "ans"
- Comments "%"
- Rules for name variable: start by a letter, including letters, numbers and underscore "_". Case sensitive

```
>> 1+2
>> a = 1+2
>> 1+2;
>> a = 1+2;
>> % a = 1+2;
>> A = 1+2;
>> 1A = 1+2;
>> A1 = 1+2;
>> A_1 = 1+2;
```

REAL NUMBER AND COMPLEX NUMBER

→ real number :

Ex

1,1.1,1.1e+1(1.1×10^{1}),1.1e-1(1.1×10^{-1}),pi($\pi = 3.1415...$)

→ Complex number
Default imaginary unit *i* or *j*, which is $\sqrt{-1}$

Ex

1+i,1-i,1+j,1-j,(1+j)'

For operation of complex number: **https://www.mathworks.com/help/matlab/complex-numbers.html**

VECTOR AND MATRIX

- Row vector: a,b
- Column vector: c,d,e
- Matrix: A,B,C (`Vector can be regarded as a special matrix`)
- Special matrix: 0,I,1

Ex

```
a = [1,2,3]; b = [ 1 2 3];
c = [1;2;3];d = a';
e = transpose(b);
A = [1 2;3 4];
B = [1,2,3;4,5,6];
C = B';
O = zeros(4,3);
I = eye(4,4);
one = ones(5,5);
```

SPECIAL VARIABLE

symbol	pi	1	0	true
meaning	$\pi = 3.14\ldots$	default double 1 or "true"	default 0 or "false"	logical 1
symbol	false	inf	-inf	NaN
meaning	logical 0	∞	$-\infty$	non a number: $\frac{0}{0}$

ARITHMETIC OPERATORS

Symbol	+	-	*	/	\	^
Example	1+2	1-2	1*2	1/2	1\ 2	2^ 2
Result	2	-1	2	0.5	2	4

Table: Arithmetic Operators

Refs. **https://www.mathworks.com/help/matlab/matlab_prog/matlab-operators-and-special-characters.html**

RELATION OPERATORS

Symbol	==	~ =	>	>=	<	<=
Example	1==2	1~=2	2>2	2>=2	2<2	2<=2
Result	0	1	0	1	0	1

Table: Relation Operators

Note that here “1” is of the logical type, means “true” and “0” means the logical value“false”.
See the detail of variables by “who var”.

LOGICAL OPERATORS

symbol	|	&	-
meaning	Or	And	Not
Ex	1|0	1& 0	~ 0
Result	1	0	1
Equal exp.	or(1,0)	and(1,0)	not(0)
Another exp.	1||0	1&& 0	~ 0

SOME COMMANDS

cmd:	clc	clear a	clear all	1:3	1:2:3
Result	clear screen	clear variable a	remove all variables	row vector [1,2,3]	row vector [1,3]
cmd:	who a	whos	clf	help cmd	doc cmd
Results:	see detail of variable a	see the details of all variables	clear the graph window	see help information of cmd	see document details of cmd

MATH FUNCTION

abs(*x*) |x|	*sqrt*(*x*) $\sqrt{x}$	sign(x) signum function	sin(x) sin(x)	cos(x) cos(x)	tan(x) tan(x)	cot(x) cotangent of x	sec(x) secant of x	csc(x) The cosecant of x

Table: basic function

asin(*x*)	*acos*(*x*)	atan(x)	acot(x)	asec(x)	acsc(x)
$\sin^{-1}(x)$	$\cos^{-1}(x)$	$\tan^{-1}(x)$	$\cot^{-1}(x)$	$\sec^{-1}(x)$	$\csc^{-1}(x)$

Table: Inverse Trigonometric Functions

syntax	*exp*(*x*)	*log*(*x*)	log2(x)	log10(x)
value	e^x	$\log_e(x)$	$\log_2(x)$	$\log_{10}(x)$

Table: Exponential and Logarithm Functions

COMMAND WINDOW DISPLAY OUTPUT FORMAT

- format short (default): display 4 digits
- format long: display 15 digits
- format short e (format shorte): scientific notation with 4 digits
- format long e: Short scientific notation with 15 digits
- format long g: scientific notation with a total of 15 digits for double values, and 7 digits for single values.
- format rat: Ratio of small integers.
- format compact:Suppress excess blank lines to show more output on a single screen.
- format loose:Add blank lines to make output more readable.

MATRIX OPERATION

- Input matrix: A=[1,2,3;4,5,6]; or A(1,1)=1,. . .A(2,3)=5;
- Get the size: [n1,n2] = size(A); n1:row length, n2: column length. length(A) gets the row length of A.
- Increase the matrix: or A(1,4)=1;A(2,4) = 2;
- Matrix concatenation: row concatenation,A= [B,C] if column length equals. For example, B = [1;2];C=[3;4];
  column concatenation, A= [B;C] if row length equals. For ex. B = [1,2];C = [3,4];

MATRIX INDEXING

A is a matrix of size m×*n*

- A(i,j) : (i,j)-th entry of A
- A(i,:) : i-th row of A
- A(:,j): j-th column of A
- A(end,:): last row of A
- A(:,end-1); second last column of A
- A(a:b,c:d): submatrix of A from a to b row and c to d column.
- A(e,f)(e,f are two vectors): sub matrix of A row indexing in e, column indexing in f.
  For Ex. A = eye(5);e = [1,3,5];f=[3,4];A(e,f)

Note that index should not exceed the size of the matrix. A vector can be regarded as a matrix.

MATIRX COMPUTATION

matrix operation	
A+B	matrix addition
A-B	matrix subtraction
t * A	scalar-matrix,$t \in R, C$
A * B	matrix multiplication
Aˆn	A*A*A..*A, n times
A\ B	inv(A)*B
A/B	B*inv(A)

matrix entrywise operation	
A.+B	wrong expression
A.-B	wrong expression
t. * A	=t*A
A. * B	A(i,j)*B(i,j)
A.ˆn	A(i,j).ˆ n
A.\ B	$\frac{B(i,j)}{A(i,j)}$
A./B	$\frac{A(i,j)}{B(i,j)}$

RELATED OPERATION OF MATRIX

- A: conjugate transpose of A
- A.': transpose of A
- det(A): determinant of a square matrix A
- rank(A): rank of a square matrix A
- eig(A): eigenvalues of a square matrix A
- inv(A):inverse of a square nonsingular matrix A

CONDITIONAL STATEMENTS

If statement

```
a=1;b=2;
if a>b
            y=a;
else
            y=b;
end
```

Find the largest number of {a,b}.

```
a=1;b=2;c=3;%
if a>b
   if a>c
     y=a;
   else
     y=c;
   end
elseif b>c
   y=b;
else
   y=c;
end
```

Find the largest number of {a,b,c}.

switch statement

LOOPS

- While loop:

```
k=0;
y=0;
while k<10
k=k+1;
y=y+k;
end
```

$y = \sum_{i=1}^{10} i$

- for loop

```
y=0;
for  k=1:10
y=y+k;
end
```

$y = \sum_{i=1}^{10} i$

TERMINATION OF LOOPS

→ `break` exits from the innermost loop

```
k=0;
y=0;
while 1
  k=k+1;
  y=y+k;
  if k==10
     break
  end
end
```

$$y = \sum_{i=1}^{10} i$$

```
A= [1,2,3;4,5,6];[n1,n2]=size(A);
y=0;
for i=1:100
  for j=1:100
    y = y+ A(i,j);
    if j==n2
      break
    end
  end
  if i==n1
    break
  end
end
```

$$y = \sum_{i,j}^{n1,n2} A_{ij}$$

TERMINATION OF LOOPS

→ `break` exits from the innermost loop

→ `return` exists the scripts or function

```
y=0;
for  k=1:10
  if mod(k,2)==0 % if k is even
    continue
    %% if condition holds, then pass to
    % next loop without executing the
    % following statements in the loop
  end
    y=y+k;
end
```

The sum of odd numbers from 1 to 10.

```
A = randi(2,10,20)-1;
% create a matrix with 0 or 1
for i=1:10
  for j=1:20
     if A(i,j)==0;
      y=1; disp(A(i,j)); % display this variab
       return
     end
  end
end
```

Check if A has a zero entry.