

# Manufacturing process Digital- Twin-oriented introduction to Octave



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# Purpose

- The purpose of the current presentation is to introduce Octave tool to the ones interested in the concept of digital twin and/or cognitive automation.
- This presentation has been created under the framework EIT Manufacturing Project M-NEST-RIS.
- It is considered as an educational product and its price is equal to 0 Euros.
- Material herein can be reproduced given that the source is mentioned.

# Preparation

- Download Octave
- <https://www.gnu.org/software/octave/download>

Task

*New project*

Octave

File Edit Debug Window Help News

Current Directory: C:\Users\apapa

File Browser

C:/Users/apapa

Name

- > .cache
- > .config
- > .VirtualBox
- > 3D Objects

Command Window

Octave was configured for "x86\_64-w64-mingw32".

Additional information about Octave is available at <https://www.octave.org>.

Please contribute if you find this software useful.  
For more information, visit <https://www.octave.org/get-involved.html>

Read <https://www.octave.org/bugs.html> to learn how to submit bug reports.  
For information about changes from previous versions, type 'news'.

>> *This is the outcome of the code*

Workspace

Name	Class	Dimension	Value	Attribute
<i>This is the list of variables</i>				

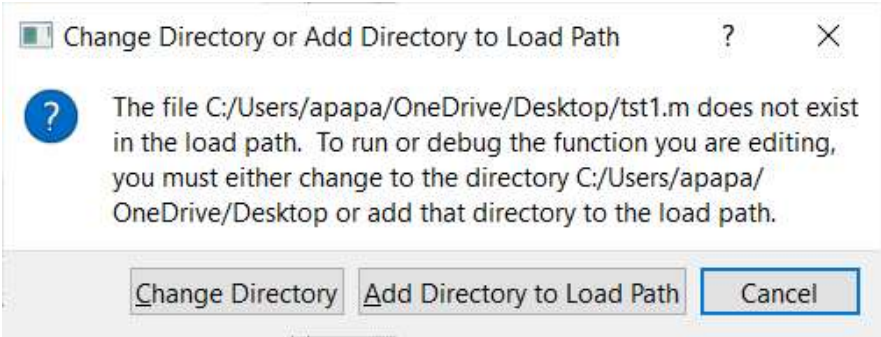
Command History

- tst1
- tst1
- tst1
- # Octave 5.2.0, Mon Dec 21 16:20:27 2020 GMT <unknown@DESKTOP-T1EBL3Q>

Editor Variable Editor

# Writing and executing code

- Procedural coding – one line runs after the other
- First Run requires saving the code file as text



*The path folder refers to a folder in the PC where all the related codes that are required for our code to run exist. One can change this path folder temporarily, or include the folder where they saved their code in the load path, an ensemble of such folders.*

# Types of Variables

- All variables can be considered to be complex matrices

Task

The screenshot shows the Octave software interface. The main window is titled "Octave" and has a menu bar with "File", "Edit", "Debug", "Window", "Help", and "News". The "Current Directory" is set to "C:\Users\apapa\OneDrive\Desktop".

The interface is divided into several panes:

- File Browser:** Shows the current directory structure with folders like "Apps", "demo", "00\_Eap", "EIT", and "ERASMUS".
- Command Window:** Shows the execution of a script. The output is "ans = 2.000000000000000e+00" and the prompt ">>". This pane is circled in red.
- Workspace:** A table showing the current workspace variables. The variable "ans" is of class "double" and dimension "1x1", with a value of "2.00000000...".
- Command History:** Shows a list of executed commands, all labeled "tst".
- Editor:** A script editor window titled "tst1.m" containing the following code:

```
1 clc,clear all
2 format long e
3
4 1+1
5
```

The status bar at the bottom of the editor shows "line: 4 col: 4 encoding: SYSTEM eol: CRLF".



# Task

The screenshot displays the Octave environment with the following components:

- File Browser:** Shows the current directory as `C:\Users\apapa\OneDrive\Desktop` with a tree view of folders including `Apps`, `demo`, `00_Eap`, `EIT`, `ERASMUS`, and `MG_UTRC_DLR`.
- Command Window:** Shows the execution of a script. The prompt `x =` is followed by a 2x3 matrix of complex numbers:

```
1.0000e+00 + 1.0000e+00i 2.0000e+00 + 1.0000e+00i 3.0000e+00 + 1.0000e+00i
1.0000e+00 + 2.0000e+00i 2.0000e+00 + 2.0000e+00i 3.0000e+00 + 2.0000e+00i
```
- Workspace:** A table showing the variable `x` with the following properties:

Name	Class	Dimension	Value	Attribute
x	double	2x3	[1.0000e+00...	complex
- Editor:** Contains a script named `tst1.m` with the following code:

```
1 clc,clear all
2 format short e
3
4 x=[1+i,2+i,3+i;1+2*i,2+2*i,3+2*i];
5
6 x
7
```
- Command History:** Lists the executed command `tst` multiple times.
- Status Bar:** Shows `line: 4 col: 35 encoding: SYSTEM eol: CRLF` and tabs for `Editor` and `Variable Editor`.

# Types of Operations

- All kinds of operations are supported
- For matrices, check operator  $.$ \* against operator \* and  $.$ ^ against ^

# Task

The screenshot shows the Octave environment with a script named `tst1.m` containing the following code:

```
1 clc,clear all
2 format short e
3
4 x=[1+i,2+i,3+i;1+2*i,2+2*i,3+2*i];
5
6 a1=x+x;
7 a2=2*x;
8 a3=x+1;
9 a4=x^2;
10 a5=x.^2;
11
```

The Command Window displays an error message: `error: for x^v, only square matrix arguments are permitted and one argument must be scalar. use . for elementwise power.` The error is circled in red. Below the error, a red note reads: *Caution! There is an error. Why? Below, only a1, a2 and a3 have been created. So, the error is probably at a4 estimation. Also, there is an explanation above.*

The Workspace window shows the following variables:

Name	Class	Dimension	Value	Attribute
a1	double	2x3	[2.0000e+00...	complex
a2	double	2x3	[2.0000e+00...	complex
a3	double	2x3	[2.0000e+00...	complex
x	double	2x3	[1.0000e+00...	complex

The Command History window shows a list of `tst` commands.

# Task

The screenshot shows the Octave software interface. The main editor window displays a script named 'tst1.m' with the following code:

```
1 clc,clear all
2 format short e
3
4 x=[1+i,2+i;1+2*i,2+2*i];
5
6 a4=x.^2;
7 a5=x.^2;
8
```

The Command Window shows the prompt '>>' and no error messages. The Workspace window displays the following table:

Name	Class	Dimension	Value	Attribute
a4	double	2x2	[0.0000e+00...	complex
a5	double	2x2	[0.0000e+00...	complex
x	double	2x2	[1.0000e+00...	complex

The Command History window shows a list of 'tst' commands. The status bar at the bottom indicates 'line: 8 col: 1 encoding: SYSTEM eol: CRLF'.

*No errors this time.*

# Elementary Loops

- The for loop is supported as per below

For start:step:end

- Plotting diagrams is also supported
- Example hereafter refers to plotting a sequence in the complex plane

# Task

The screenshot displays the Octave software interface. The main window is titled 'Octave' and contains several panes:

- File Browser:** Shows the current directory as 'C:\Users\apapa\OneDrive\Desktop'. The file list includes folders like 'Apps', 'demo', '00\_Eap', 'EIT', 'ERASMUS', and 'MG\_UTRC\_DLR'.
- Command Window:** Displays the output of the script execution, showing a sequence of complex numbers for 'x0'.
- Workspace:** A table showing the current workspace variables.
- Command History:** Lists the commands entered in the command window.
- Editor:** Contains a script named 'tst1.m' with the following code:

```
1 clc,clear all
2 format short e
3
4 x0=0.1+i*0.3;
5
6 N=20;
7
8 for n=1:1:N
9     x0=x0^(sqrt(5)/2)*0.9992-0.001-0.05*i
10     figure(1)
11     plot(real(x0),imag(x0),'ro'),hold on
12     pause(0.1)
13 end
14
15 figure(1)
16 hold off
17
```

The status bar at the bottom of the editor shows 'line: 16 col: 9 encoding: SYSTEM eol: CRLF'.

# Conditions & Conditional Loops

- While a statement is true, something is performed continuously
- If – then – else statement as per usual
- Example hereafter refers to estimating pi value up to a desired accuracy

# Task

The screenshot shows the Octave environment with a script named `tst1.m` being executed. The script calculates the sum of a series and checks for convergence. The Command Window shows the output of the script, and the Workspace window shows the variables created during execution.

```
1 clc,clear all
2 format long e
3
4 myerror=1;
5
6 myprecision=1e-3;
7
8 s=0;
9
10 n=-1;
11
12 while abs(myerror)>=myprecision
13     n=n+1;
14     myerror=4*((-1)^n)/(2*n+1);
15     s=s+myerror;
16     if mod(n,150)==1
17         [n,myerror,s]
18     endif
19 endwhile
20
21 s_final_value=s
22
```

Command Window Output:

```
ans =
    1.998010000000000e+05  -1.000993486034890e-05   3.141587648634860e+00
ans =
    1.999510000000000e+05  -1.000242558820514e-05   3.141587652389474e+00
s_final_value =    3.141597653564762e+00
>>
```

Workspace Table:

Name	Class	Dimension	Value	Attribute
ans	double	1x3	[1.99951000...	
myerror	double	1x1	9.99997500...	
myprecision	double	1x1	1.00000000...	
n	double	1x1	2.00000000...	
s	double	1x1	3.14159765...	
s_final_value	double	1x1	3.14159765...	

Command History:

```
tst1
tst1
tst1
tst1
```

*Useful for sequences and series' practical convergence checks*

*Consider changing precision to 1e-6*



# Systemic Approaches

- Transfer functions' definition is supported
- As well as their step responses
- An external package is required to be loaded
- Example hereafter refers to plotting the step response of a first order continuous time system

# Task

The screenshot displays the Octave software interface. The main window is titled "Octave" and contains several panels:

- File Browser:** Shows the current directory as "C:/Users/apapa/OneDrive/Desktop". The file list includes folders like "Apps", "demo", "00\_Eap", "EIT", "ERASMUS", and "MG\_UTRC\_DLR".
- Editor:** Contains a file named "tst1.m" with the following MATLAB code:

```
1 pkg load control ## this is a comment stating that you need to load a package
2 ## you do not have to do it every time though
3 clc,clear all
4 format short e
5
6 s = tf('s');
7
8 g=1/(s+1);
9
10 step(g)
11
```
- Command Window:** Shows the prompt ">> |".
- Workspace:** A table showing variables in the workspace:

Name	Class	Dimension	Value	Attribute
g	tf	1x1	...	
s	tf	1x1	...	
- Command History:** Lists the command "tst" multiple times.
- Status Bar:** Shows "line: 8 col: 11 encoding: SYSTEM eol: CRLF".

# Theoretical modelling

- Numerical solutions for ODEs (and PDEs) can be approximated
- Example hereafter refers to utilizing Runge-Kutta 4-5 method to solve a system of linear differential equations written in its first-order form

# Task

The screenshot shows the Octave software interface. The main window is titled 'Octave' and contains several panes:

- File Browser:** Shows the current directory as 'C:\Users\apapa\OneDrive\Desktop'. It lists folders like 'Apps', 'demo', '00\_Eap', 'EIT', and 'FRAGMLIC'.
- Editor:** Contains a script named 'tst1.m' with the following code:

```
1 clc,clear all
2 format short e
3
4 fvdv = @(T,Y) [Y(2); (1 - Y(1)^2) * Y(2) - Y(1)];
5 [t0,y0] = ode45 (fvdv, [0, 20], [2, 0]);
6
7 figure(1)
8 plot(t0,y0)
9
```
- Workspace:** A table showing variables in the workspace:

Name	Class	Dimension	Value	Attribute
fvdv	function_ha...	1x1	...	
t0	double	51x1	[0.0000e+00...	
y0	double	51x2	[2.0000e+00...	
- Command History:** Shows a list of executed commands, all labeled 'tst1'.

The status bar at the bottom indicates 'line: 8 col: 11 encoding: SYSTEM eol: CRLF'.

# Uncertainty management

- Statistics' tools are supported
- Example hereafter refers to K-S test for uniform probability density function

# Task

The screenshot displays the Octave software interface. The main window is titled 'Octave' and contains several panes:

- File Browser:** Shows the current directory as 'C:\Users\apapa\OneDrive\Desktop'. The file list includes 'Apps', 'demo', '00\_Eap', 'EIT', and 'FRASMLUC'.
- Command Window:** Shows the results of previous commands: 'a = 7.4971e-01' and 'b = 3.1252e-04'. The prompt '>>' is visible.
- Workspace:** A table listing variables in the workspace:

Name	Class	Dimension	Value	Attribute
a	double	1x1	7.4971e-01	
b	double	1x1	3.1252e-04	
x	double	1x50	[8.1686e-01,...	
x1	double	1x30	[0.0000e+00...	
y	double	1x50	[6.6726e-01,...	

- Editor:** Contains a script named 'tst1.m' with the following code:

```
1 clc,clear all
2 format short e
3 pkg load statistics
4
5 x=rand(1,50);
6 y=x.^2;
7
8 a=kolmogorov_smirnov_test(x,"unif", 0,1)
9 b=kolmogorov_smirnov_test(y,"unif", 0,1)
10
11 x1=linspace(0,1,30);
12
13 figure(1)
14 subplot(2,1,1)
15 plot(x1,empirical_cdf (x1, x)),hold on
16 plot(x1,x1),hold on
17 hold off
18 subplot(2,1,2)
19 plot(x1,empirical_cdf (x1, y)),hold on
20 plot(x1,x1),hold on
21 hold off
22
```
- Command History:** Shows a list of executed commands, with 'tst1' repeated.

At the bottom of the editor, the status bar indicates 'line: 9 col: 36 encoding: SYSTEM eol: CRLF'. Below the editor is a 'Variable Editor' pane.

# IoT, metrology and control

- I/O control is supported
- Example hereafter refers to retrieving data (=signal) from microphone, playing them through the speakers and at the same time visualizing a their spectrogram

# Task

The screenshot displays the Octave software interface. The main window is titled "Octave" and contains several panes:

- File Browser:** Shows the current directory as "C:\Users\apapa\OneDrive\Desktop".
- Editor:** Contains a script named "tst1.m" with the following code:

```
1 clc,clear all
2 format short e
3
4 T=3;
5 Fs=50000;
6
7 x = record(T, Fs);
8
9 player=audioplayer (x, Fs);
10
11 play(player)
12
13 pkg load signal
14
15 figure(1)
16 specgram(x,256,Fs)
17
```
- Workspace:** A table showing the current workspace variables:

Name	Class	Dimension	Value	Attribute
Fs	double	1x1	5.0000e+04	
T	double	1x1	3.0000e+00	
player	audioplayer	1x1	...	
x	double	150000x1	[5.4018e-03;...	
- Command Window:** Shows the prompt ">>".
- Command History:** Shows the command "tst1" being executed.

The status bar at the bottom indicates "line: 17 col: 1 encoding: SYSTEM eol: CRLF".



# Extra information

- For further information about the current presentation, the concepts in it, or the project, please contact
  - Dr. Panos Stavropoulos, [pstavr@lms.mech.upatras.gr](mailto:pstavr@lms.mech.upatras.gr)