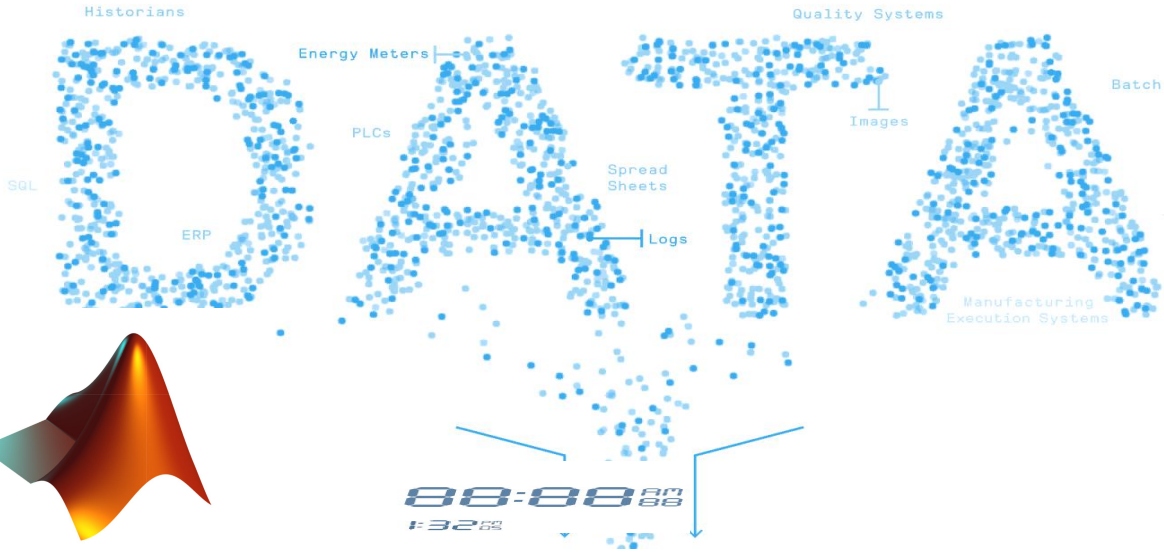
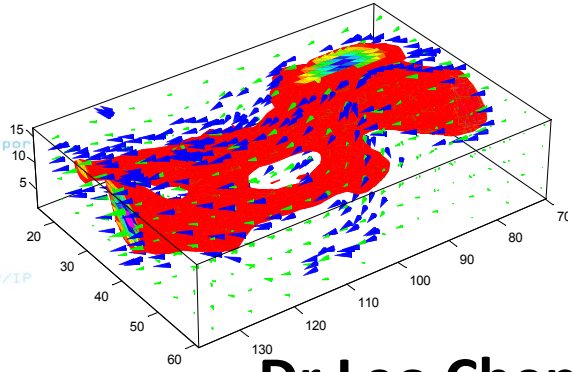
Introduction to Artificial Intelligence - Laboratory Handbook (MATLAB)01





Dr Leo Chen
leo.chen@ieee.org
29/Jan/2022

Module Contents

1. Introduction
2. Evolutionary Computation
3. Artificial Neural Network
4. Fuzzy Logic and Fuzzy Systems
5. More AI Subsets
6. AI and Industry 4.0
7. AI Applications
8. Labs
9. Courseworks

MFE204TC Lab Timetable

Date	Week	Lab	Title	Location	Time Slot
14/03/2022,Monday	4	Lab01	MATLAB + Data Analysis	A - Onsite B - Online	09:00-12:00
14/03/2022,Monday	4				13:00-16:00
17/03/2022,Thursday	4				09:00-12:00
18/03/2022,Friday	4				13:00-16:00
28/03/2022,Monday	6	Lab02	Evolutionary Computing Practices	A: SD319 + B	09:00-12:00
28/03/2022,Monday	6				13:00-16:00
31/03/2022,Thursday	6				09:00-12:00
01/04/2022,Friday	6				13:00-16:00

3hrs/week, 6hrs in 2 weeks, 4 **different** student groups in 1 week

LAB Contents

Lab01 – MATLAB/SIMULINK

Lab02 – Evolutionary Computing

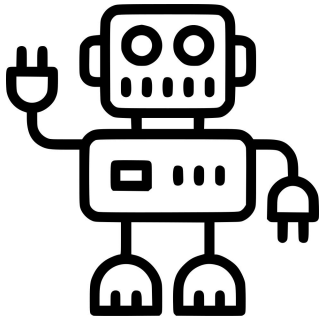
Lab03 – Artificial Neural Network

Lab04 – Fuzzy System

Lab05 – More AI Subsets

Lab06 – AI and I4

Lab07 – AI Applications



Topic01-01

Use a **`while`** *loop to determine how many years it will take to accumulate £900,000 in a bank account if you deposit £10,000 initially and £10,000 at the start of each following year; the account pays 5.3% annual interest at the end of each year. Set a breakpoint inside the while loop to trace every iteration. What is the resulting balance in the account? (Answer: 33 years; £948,458.33).*

Tips: Internal rate of return (IRR)

https://www.mathworks.com/help/finance/irr.html

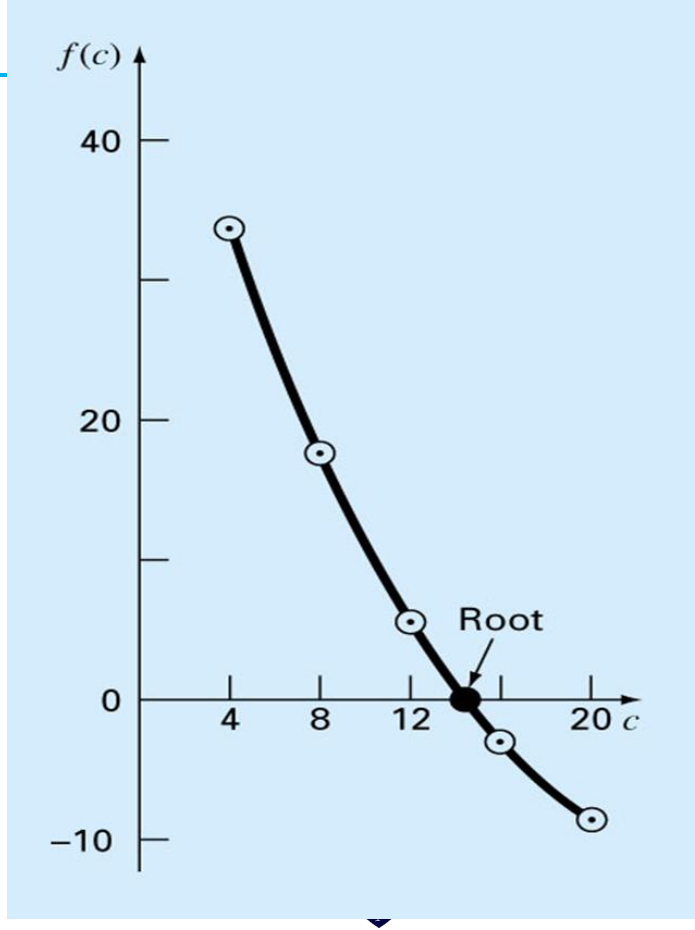
Topic01-02

Solve the following equation using Bisection method, until the approximate error falls below a stopping criterion of ε_s=0.5%.

$$f(c) = \frac{668.06}{c}\left(1 - e^{-0.146843c}\right) - 40$$

Initial values: X_{lower}=12, X_{upper}=16

What if you try a different set of initial guess?



Topic02

01 MATLAB Functions
02 MATLAB Scripts
03 FAQ 3 : Run Plots Demo

Codes for Textbook on IEEE Code Ocean
https://codeocean.com/2018/09/11/computational-intelligence-assisted-design-lpar-ciad-rpar-in-the-era-of-industry-4-0-book-matlab-codes-colon-test-functions/code

01 MATLAB Functions – Case 01

$$Max: f(x) = x\sin(10\pi x) + 2.0 \qquad (-1 \le x \le 2)$$

Step 1: define a function named ‘SGA_FITNESS_function’;

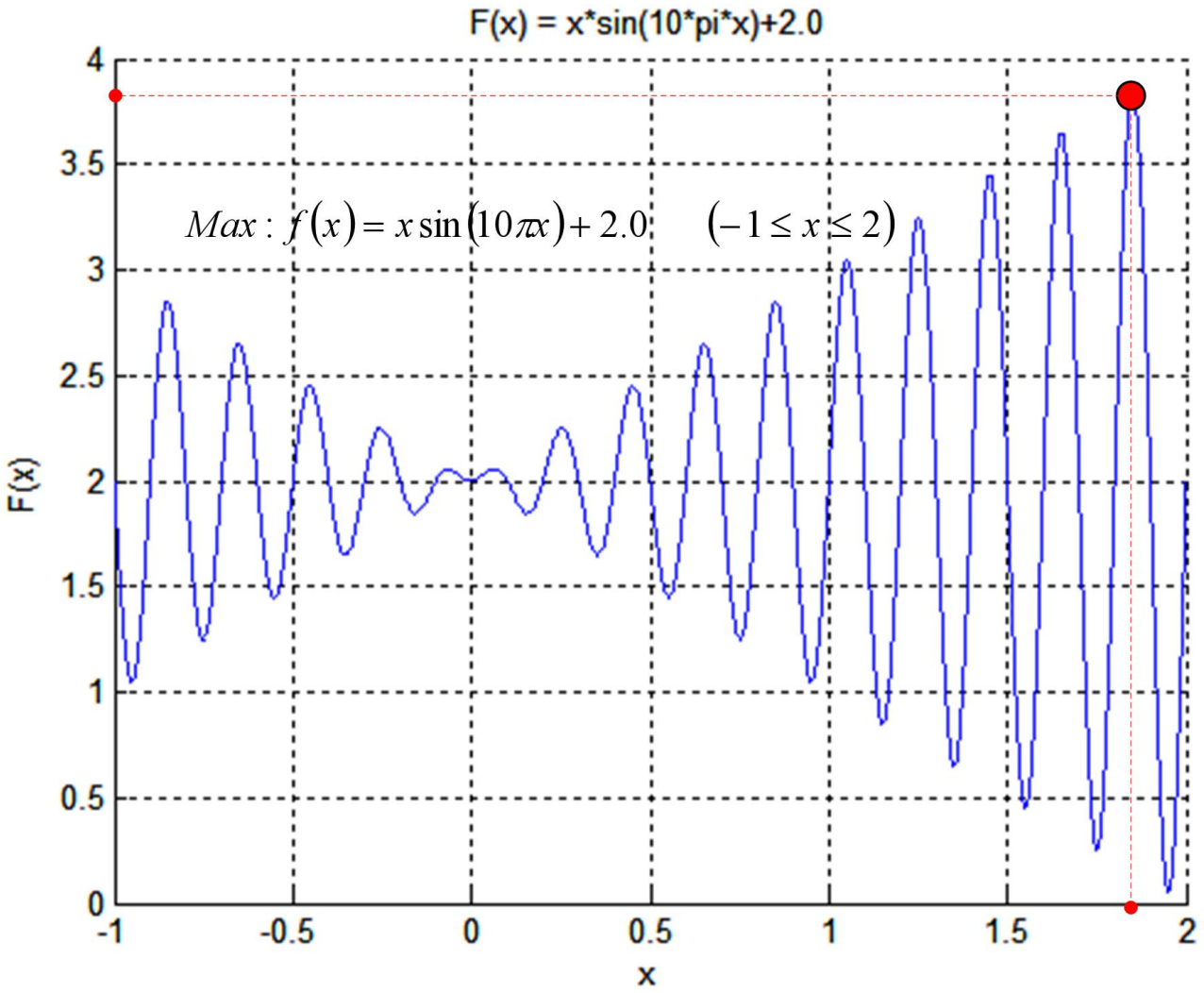
Step 2: plot its curve within [-1, 2];

Step 3: save the figure as, jpg, pdf and eps formats.

01 MATLAB Functions – Case 01

SGA_FITNESS_function.m

```
function [ fitness ] = SGA_FITNESS_function( x )

%SGA_FITNESS_function begin
%User can design their own fitness function here
%as a standard matlab function

  fitness = x*sin(10*pi*x)+2.0;

%SGA_FITNESS_function end
```


F(x) = x*sin(10*pi*x)+2.0
$Max: f(x) = x\sin(10\pi x) + 2.0 \quad (-1 \le x \le 2)$
F(x)
x
4
3.5
3
2.5
2
1.5
1
0.5
0
-1
-0.5
0
0.5
1
1.5
2

01 MATLAB Functions – Case 02

$$Max: f(x,y) = \frac{\sin(x)}{x}\frac{\sin(y)}{y} \qquad (-10 \le x \le 10, -10 \le y \le 10)$$

Step 1: define a function named ‘SGA_FITNESS_function’;

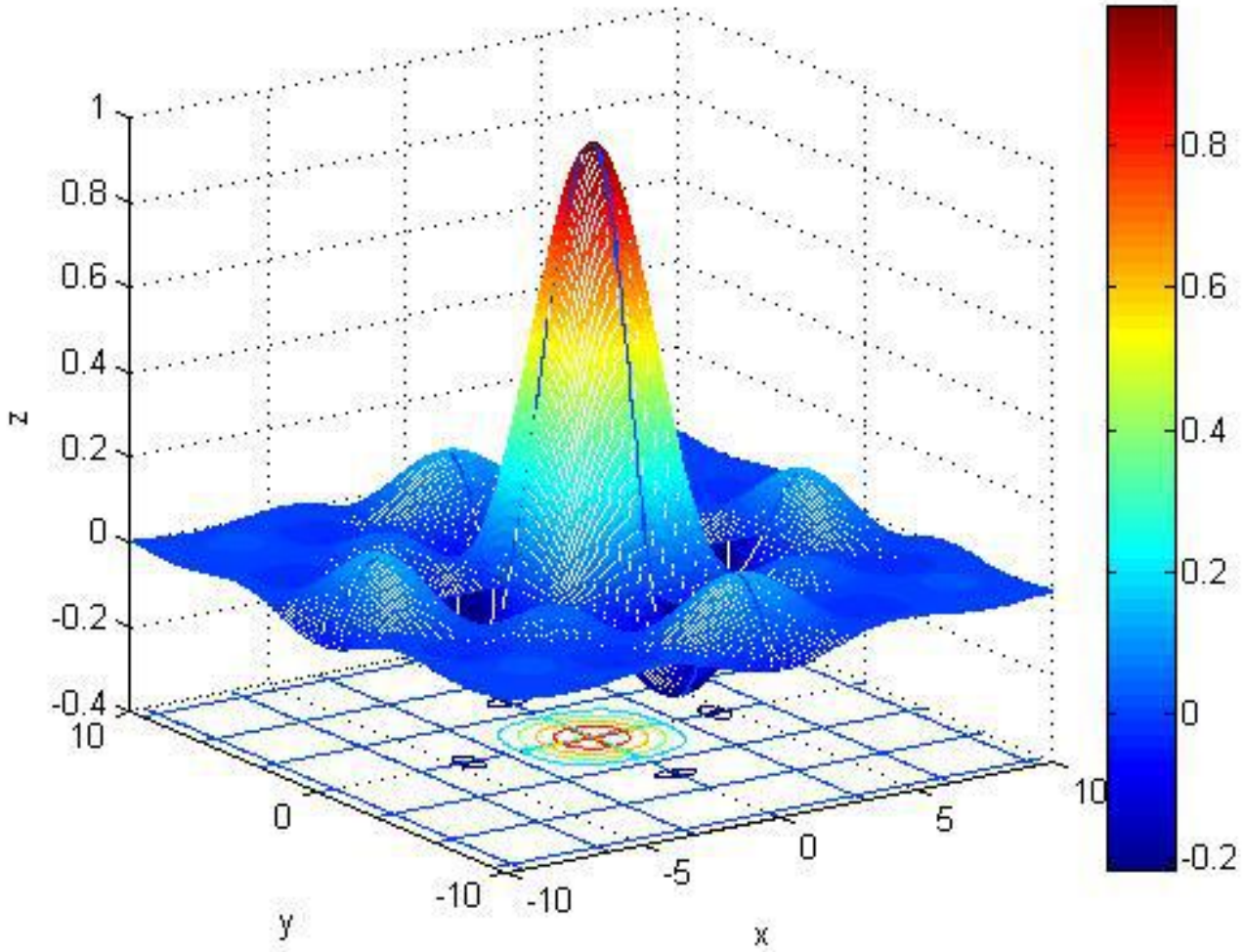
Step 2: plot its curve within x and y \in [-10, 10];

Step 3: save the figure as, jpg, pdf and eps formats.

01 MATLAB Functions – Case 02

SGA_FITNESS_function.m

```
function [ fitness ] = SGA_FITNESS_function( x, y )

%SGA_FITNESS_function begin
%User can design their own fitness function here
%as a standard matlab function

  fitness = (sin(x)./(x+eps)).*(sin(y)./(y+eps));

%SGA_FITNESS_function end
```

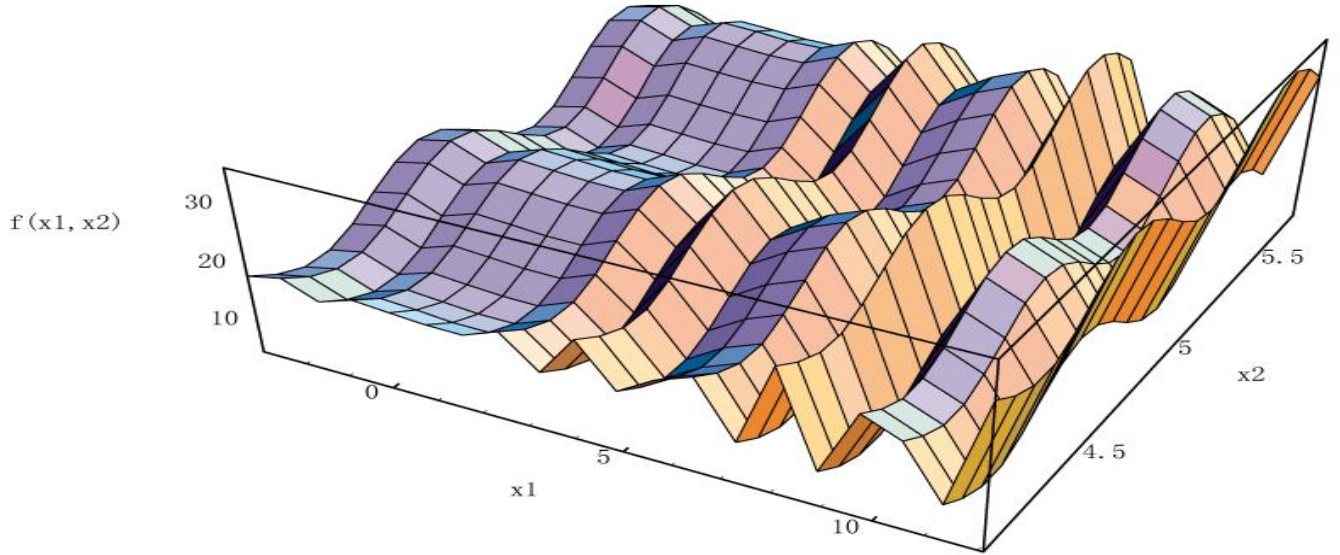

1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
z
10
0
-10
y
-10
-5
0
5
10
x
0.8
0.6
0.4
0.2
0
-0.2

01 MATLAB Functions – Case 03

$$Max: f(x_1, x_2) = 21.5 + x_1 \times \sin(4\pi x_1) + x_2 \times \sin(20\pi x_2)$$

$$(-3.0 \le x_1 \le 12.1)$$

$$(4.1 \le x_2 \le 5.8)$$



01 MATLAB Functions – Case 03

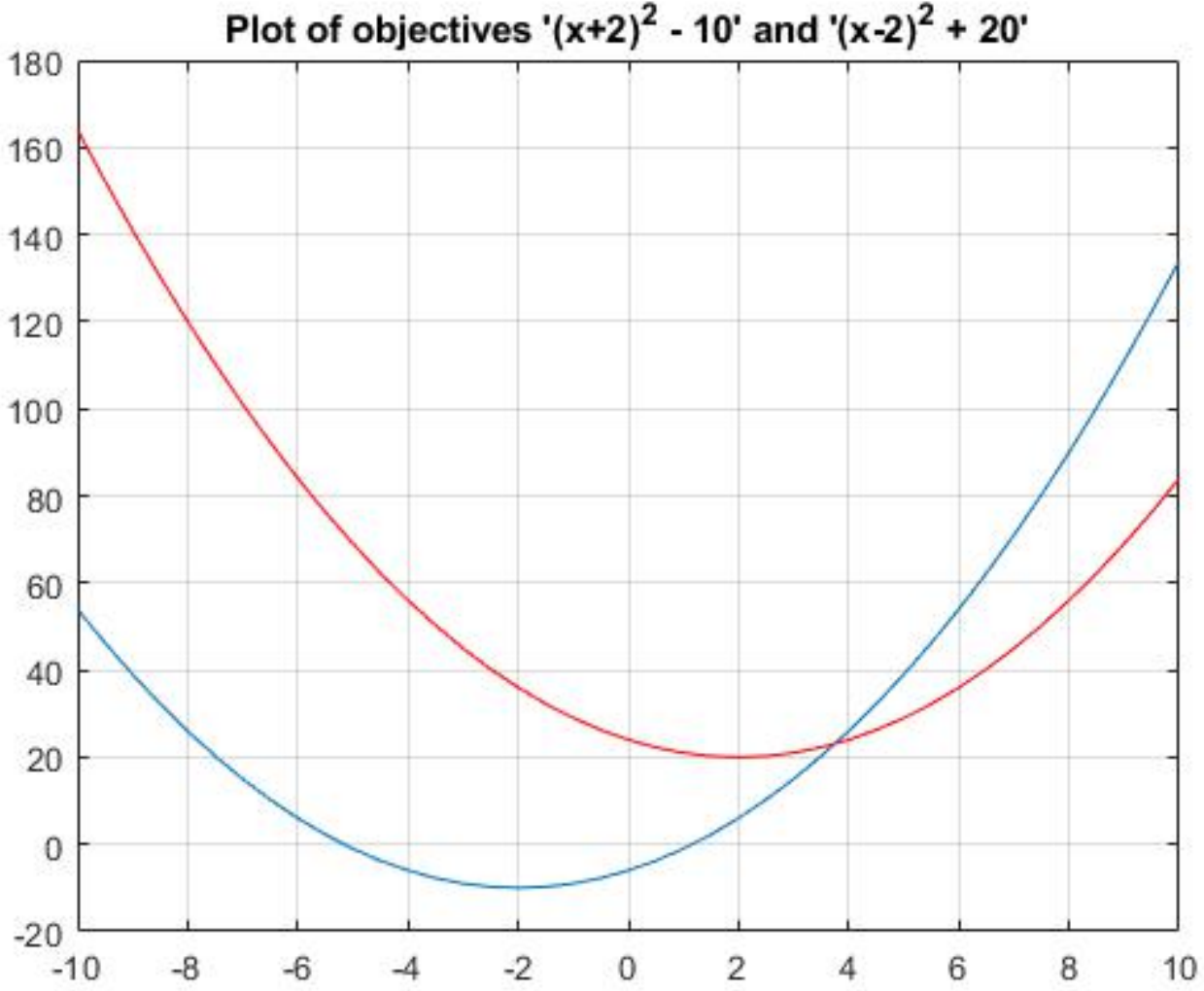
SGA_FITNESS_function.m

```
function [ fitness ] = SGA_FITNESS_function( x1, x2 )

%SGA_FITNESS_function begin
%User can design their own fitness function here
%as a standard matlab function

  fitness = ?

%SGA_FITNESS_function end
```

01 MATLAB Functions – Case 04

- Plot two fitness (objective) functions on the same axis

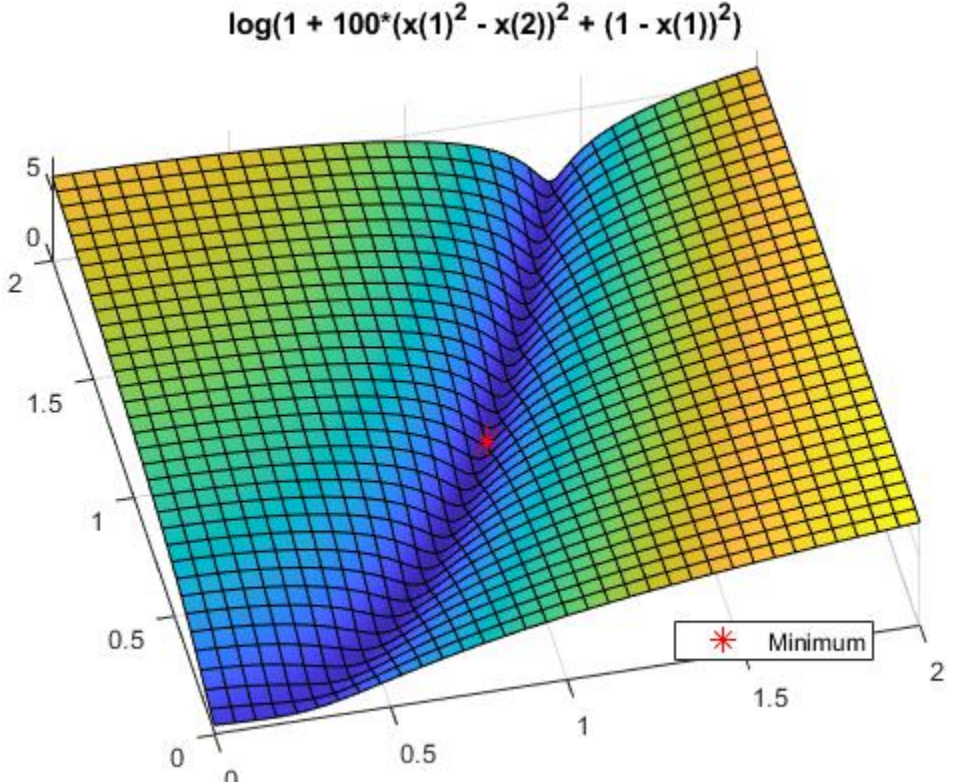
```
y(1) = (x+2)^2 - 10;
y(2) = (x-2)^2 + 20;
% m file
x = -10:0.5:10;
f1 = (x+2).^2 - 10;
f2 = (x-2).^2 + 20;
plot(x,f1); hold on; plot(x,f2,'r'); grid on;
title('Plot of objectives ''(x+2)^2 - 10'' and ''(x-2)^2 + 20''');
```


Plot of objectives '(x+2)^2 - 10' and '(x-2)^2 + 20'
180
160
140
120
100
80
60
40
20
0
-20
-10
-8
-6
-4
-2
0
2
4
6
8
10

01 MATLAB Functions – Case 05

Rosenbrock's function

```
function y = simple_fitness(x)

y = log(1 + 100*(x(1)^2 -
x(2))^2 + (1 - x(1))^2)
```



02 MATLAB Scripts

- Case 01 - Distance
- Case 02 - Matrix
- Case 03 - Calculations
- Case 04 - Questions from Grade 2

Case 01 - Distance

The distance travelled by a ball falling in the air is given by the equation below.

Use MATLAB to calculate the position of the ball at time t = 5s, if x_0 = 10 m, v_0 = 15 m/s, and a = −9.81 m/s^2 .

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

Case 02 - Matrix

$$A = \begin{bmatrix} 3 & -6 & 2 \\ 2 & 8 & 3 \\ 1 & -2 & 5 \end{bmatrix}, B = \begin{bmatrix} 6 & 9 & -1 \\ 7 & 5 & 1 \\ -5 & 9 & 10 \end{bmatrix}, C = \begin{bmatrix} -7 & -5 & 2 \\ 10 & 6 & 1 \\ 3 & -9 & 8 \end{bmatrix}$$

a) Use MATLAB *to find the products* AB *and* BA .

b) Verify the distributive property $(AB)C = A(BC)$.

c) Find A^3.

Case 03 - Calculations

Case 03-01 *Write a* MATLAB *program to evaluate the function* $y(x) = \ln \dfrac{1}{1-x}$. *Test your program for* $x = -2, 0, 1,$ *and* 2.

Case 03-02 *Write a* MATLAB *program* **`funxy.m`** *which evaluates the value of the following function.*

$$f(x,y) = \begin{cases} x + y, & x \geqslant 0 \text{ and } y \geqslant 0, \\ x + y^2, & x \geqslant 0 \text{ and } y < 0, \\ x^2 + y, & x < 0 \text{ and } y \geqslant 0, \\ x^2 + y^2, & x < 0 \text{ and } y < 0. \end{cases}$$

Case 04 - Questions from Grade 1

Case 04-01 There are eight numbers: 11, 22, 33, 44, 55, 66, 77, 88.
To write a script *findA2H.m, which* can find the A,B,C,D,E,F,G and H to satisfy the expressions 1 to 4 below:

Expression 1: (A) - (B) = 11
Expression 2: (C) - (D) = 22
Expression 3: (E) - (F) = 33
Expression 4: (G) - (H) = 44

Answer:

Expression 1: 33 - 22 = 11
Expression 2: 88 - 66 = 22
Expression 3: 77 - 44 = 33
Expression 4: 55 - 11 = 44

That is,

A = 33 B = 22
C = 88 D = 66
E = 77 F = 44
G = 55 H = 11

Case 04 - Questions from Grade 1

Case 04-02

There are eight numbers: 11, 22, 33, 44, 55, 66, 77, 88.
To write a script *findA2L.m, which* can find *possible* solutions of the A,B,C,D,E,F,G,H,I,J,K and L to satisfy the expressions 1 to 4 below:

Expression 1: (A) - (B) = I
Expression 2: (C) - (D) = J
Expression 3: (E) - (F) = K
Expression 4: (G) - (H) = L

Case 04 - Questions from Grade 2

- **Case 04-03**

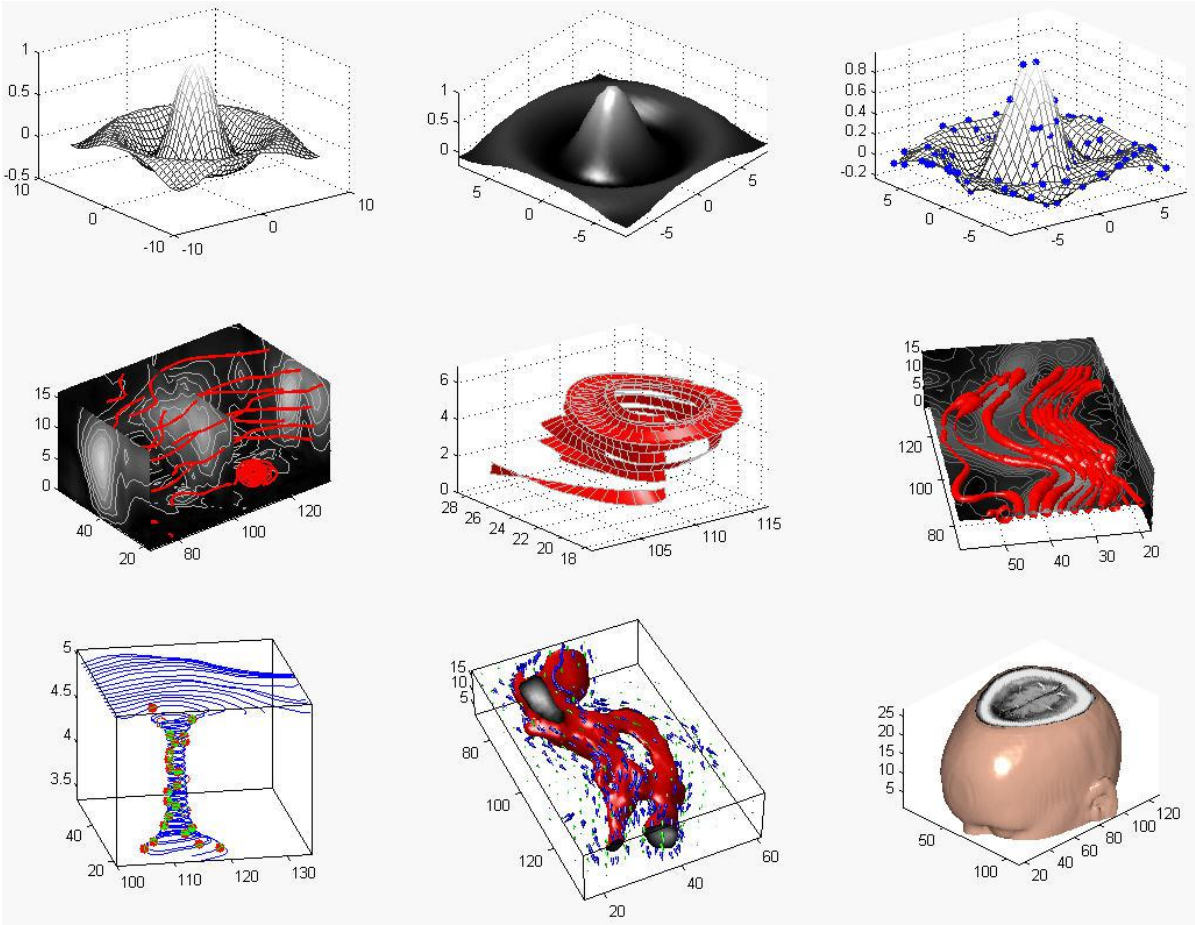
To write a script *findexpn.m with internal functions, which* can find *possible* combinations of the (A1,B1,C1), (A2,B2,C2), (A3,B3,C3),…, (Ai,Bi,Ci),… (An,Bn,Cn) and n to satisfy the given series of numbers:

(11, 22, 33, 44, 55, 66, 77, 88) and (0, 11, 22, 33, 44, 55, 66, 77, 88, 99)

Case 04 - Questions from Grade 2

Expression 1: (A1) - (B1) = C1
Expression 2: (A2) - (B2) = C2
Expression 3: (A3) - (B3) = C3
.
Expression i: (Ai) - (Bi) = Ci
.
Expression n: (An) - (Bn) = Cn

03 Go to FAQ 3 : Run Plots Demo



Topic03 - SIMULINK

- 01 Semi-active Control of Skyhook
- 02 Examples on **MATHWORKS**

01 Semi-active Control of Skyhook[1-3]

Lab Files

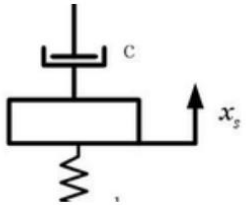
MathWorks® Products Solutions Academia Support Community Events Get MATLAB

File Exchange

Search File Exchange | File Exchange

MATLAB Central | Files | Authors | My File Exchange | Publish | About | Trial software

New Version | Connect this to GitHub | Delete



Semi-active Control of Skyhook for 1/4 Suspension System

version 1.1.0.0 (109 KB) by Leo Chen

Semi-active control of skyhook

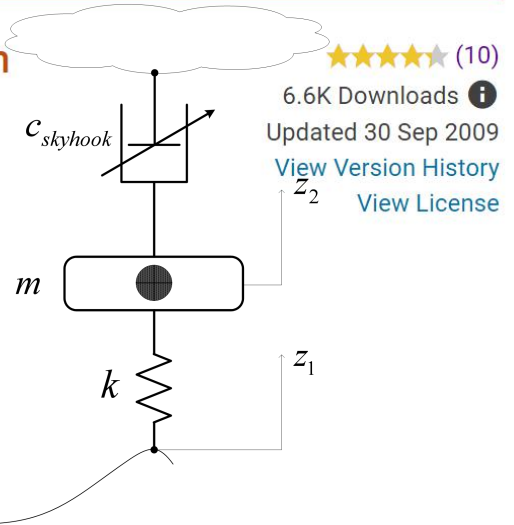
(10)

6.6K Downloads

Updated 30 Sep 2009

View Version History

View License



Reference

[1] Leo Chen (2021). Semi-active Control of Skyhook for 1/4 Suspension System (https://www.mathworks.com/matlabcentral/fileexchange/11118-semi-active-control-of-skyhook-for-1-4-suspension-system), MATLAB Central File Exchange. Retrieved August 29, 2021.

[2] Yi Chen, (2009), Skyhook Surface Sliding Mode Control on Semi-active Vehicle Suspension Systems for Ride Comfort Enhancement, Engineering, Scientific Research Publishing, Volume 1, Number 1, Pages 23-32.

[3] Yi Chen, (2011), Fuzzy Skyhook Surface Control using Micro-Genetic Algorithm for Vehicle Suspension Ride Comfort. In: Mario Koeppen, Gerald Schaefer, Ajith Abraham, Editors. Intelligent Computational Optimization in Engineering: Techniques & Applications, Springer series “Studies in Computational Intelligence”, Vol. 366, Page 357-394, Springer Berlin Heidelberg, July 2011.

02 Examples on MATHWORKS

- **Running Robot Model in Simscape**
  https://ww2.mathworks.cn/matlabcentral/fileexchange/64237-running-robot-model-in-simscape?s_tid=srchtitle

- **Manipulator Algorithm Design — Examples**

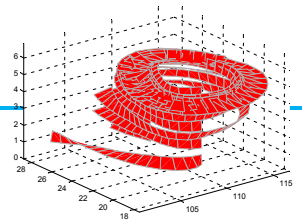
https://ww2.mathworks.cn/help/robotics/examples.html?category=manipulators&s_tid=CRUX_topnav

- **Mobile Robot Algorithm Design — Examples**

https://ww2.mathworks.cn/help/robotics/examples.html?category=ground-vehicle-algorithms&exampleproduct=all&s_tid=CRUX_lftnav

See more:
https://ww2.mathworks.cn/help/index.html?s_tid=CRUX_lftnav

FAQ



FAQ 01 : How to find more demos for MATLAB?

FAQ 02 : How to set MATLAB current work path?

FAQ 03 : Run Plots Demo?

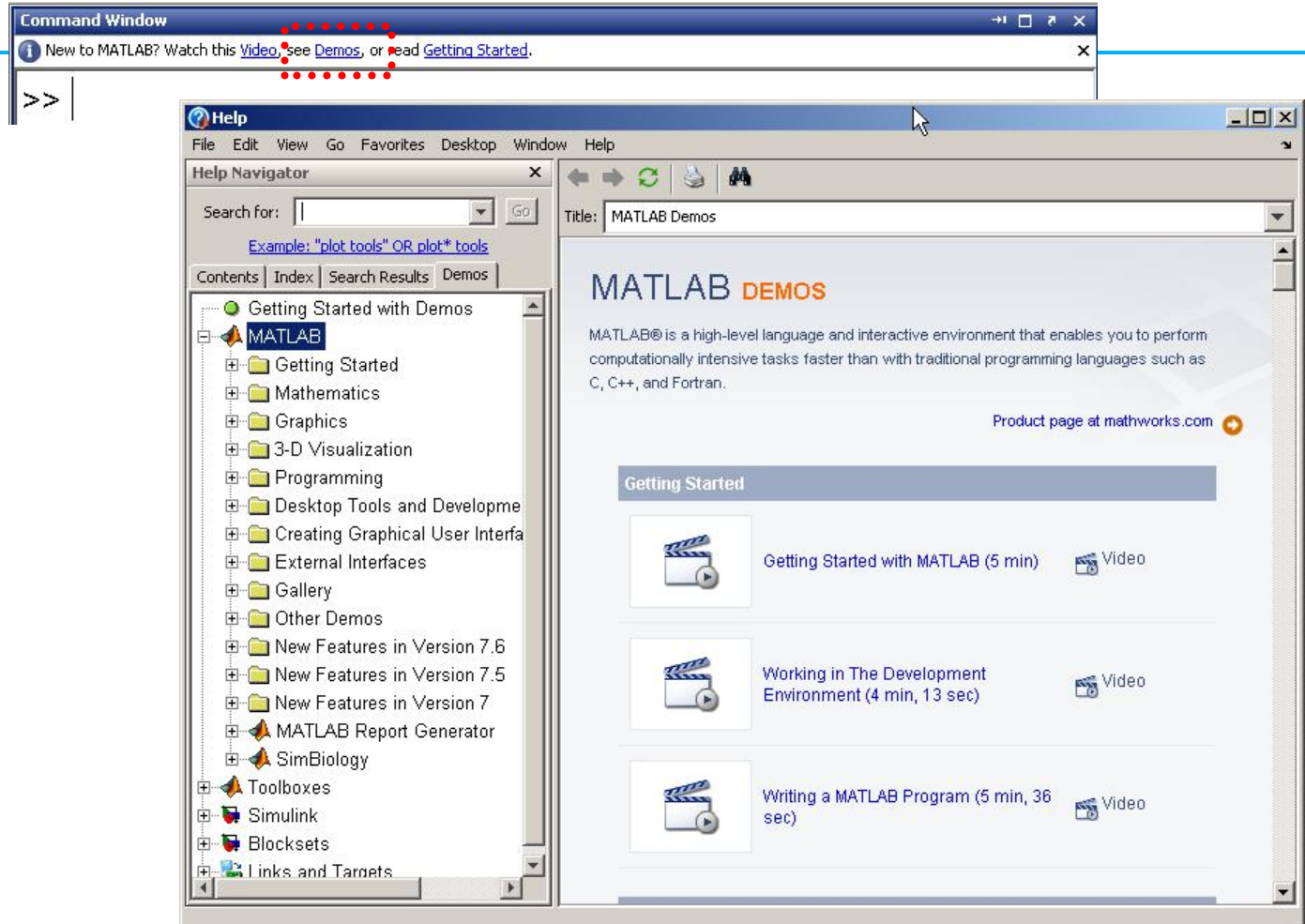
FAQ 04 : Keyboard Shortcuts in the Command Window

FAQ 05: Run your MATLAB codes when in the online LAB

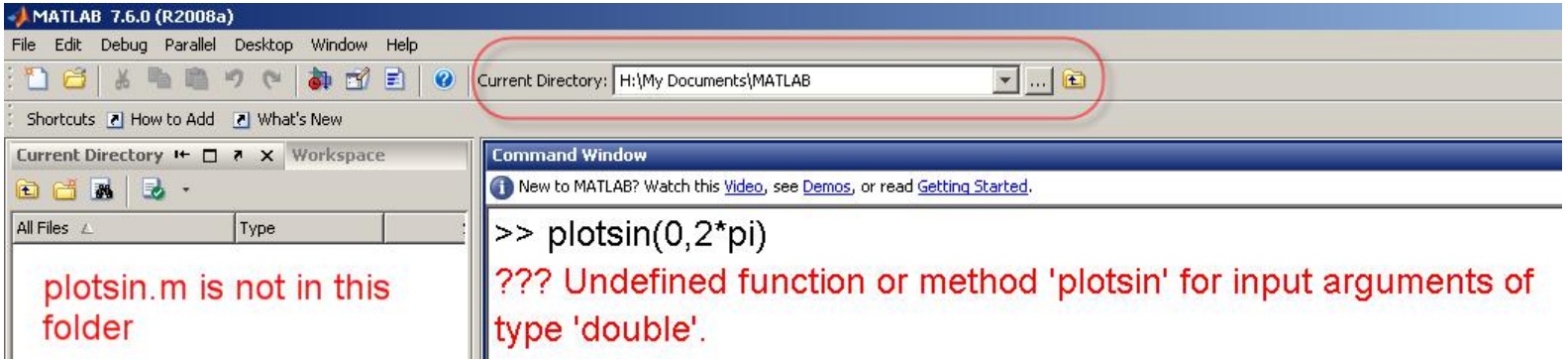
FAQ 06: Cheat Sheets for Using MATLAB with Python

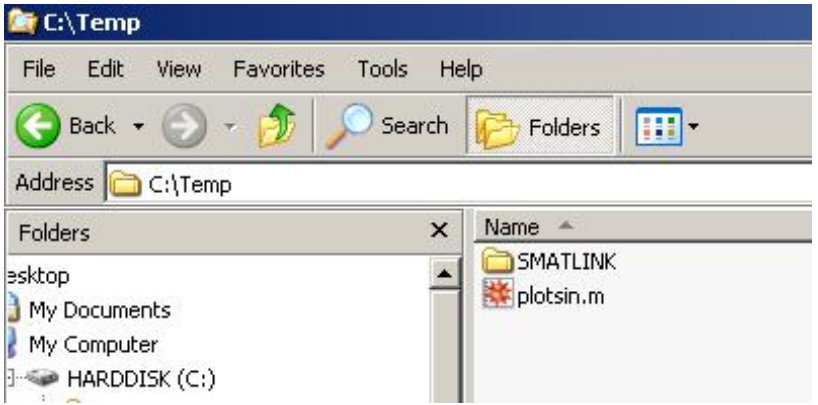
FAQ 07: How to install MATLAB

FAQ 1 : DEMOS

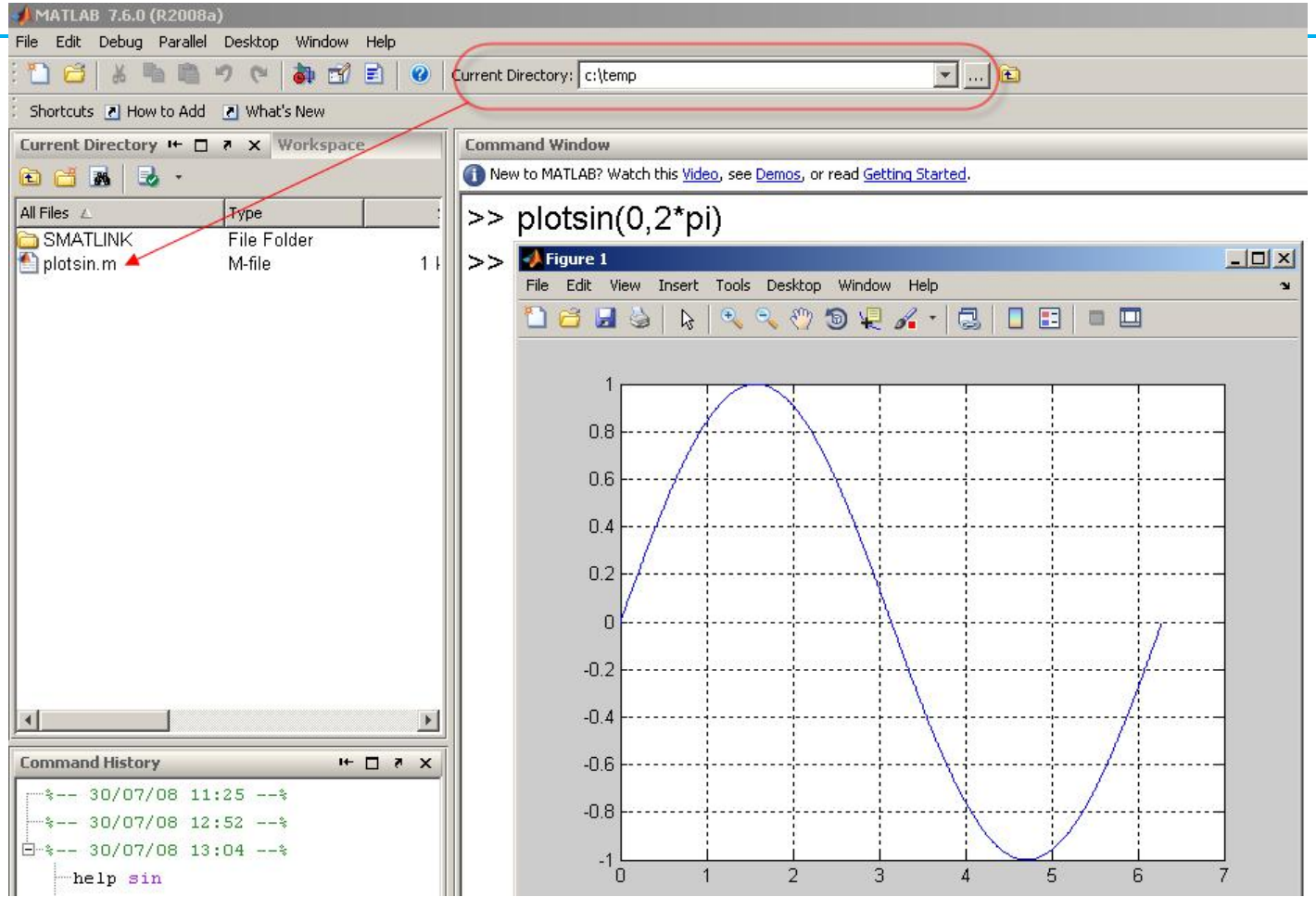

Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
>>
Help
File Edit View Go Favorites Desktop Window Help
Help Navigator
Search for:
Go
Example: "plot tools" OR plot* tools
Contents Index Search Results Demos
Getting Started with Demos
MATLAB
Getting Started
Mathematics
Graphics
3-D Visualization
Programming
Desktop Tools and Developme
Creating Graphical User Interfa
External Interfaces
Gallery
Other Demos
New Features in Version 7.6
New Features in Version 7.5
New Features in Version 7
MATLAB Report Generator
SimBiology
Toolboxes
Simulink
Blocksets
Links and Targets
Title: MATLAB Demos
MATLAB DEMOS
MATLAB® is a high-level language and interactive environment that enables you to perform computationally intensive tasks faster than with traditional programming languages such as C, C++, and Fortran.
Product page at mathworks.com
Getting Started
Getting Started with MATLAB (5 min)
Video
Working in The Development Environment (4 min, 13 sec)
Video
Writing a MATLAB Program (5 min, 36 sec)
Video

FAQ 2 – Set work path - a case





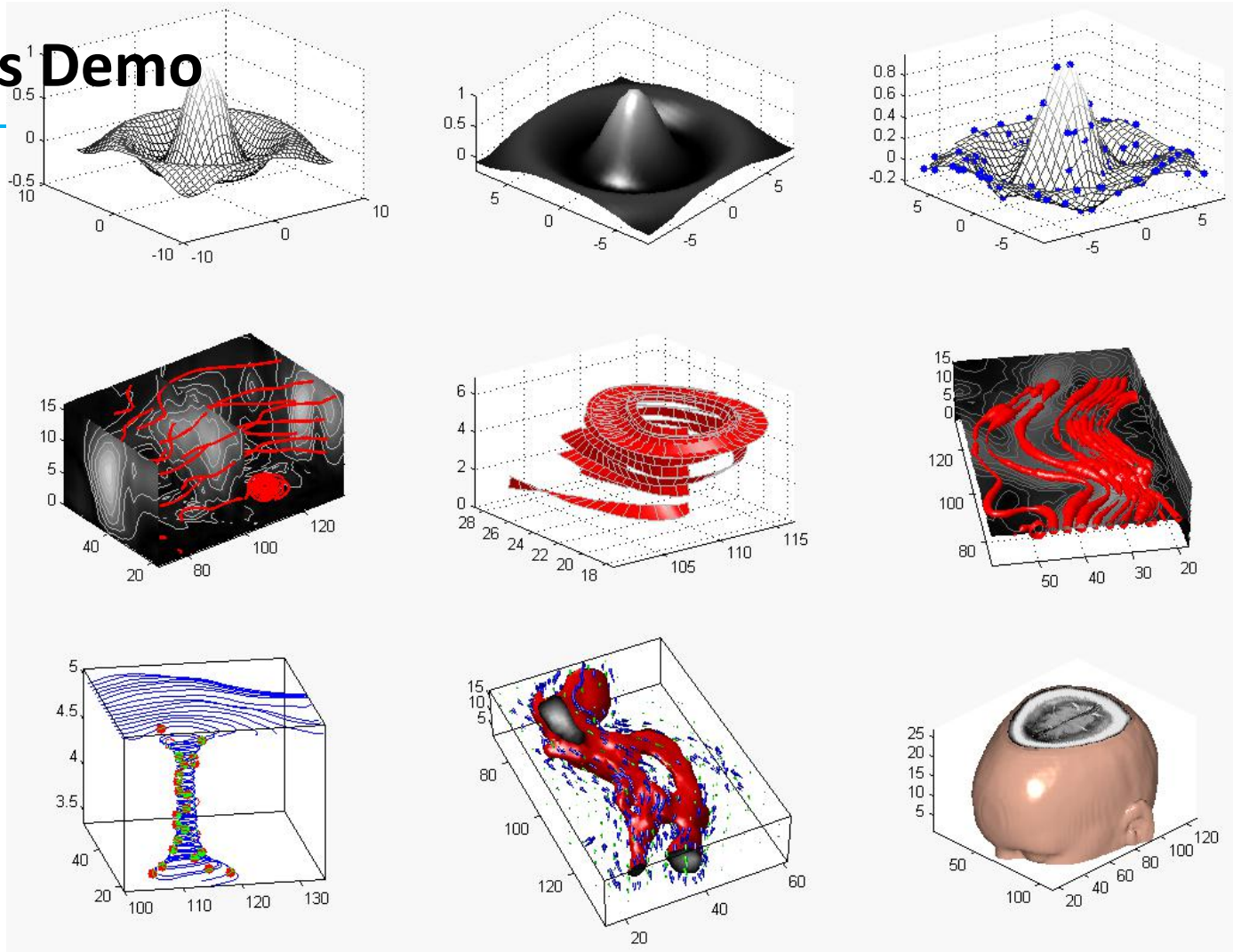
FAQ 2 – Set work path - a case



FAQ 3 : Run Plots Demo

ITTS_case_plots_function.m
ITTS_case_plots_script.m

The file is available here :
https://github.com/LeoYiChen/Global-Teaching-Programme-AI-and-Industry-4.0-/blob/main/FAQ%203-Run%20Plots%20Demo.zip



FAQ 04 : Keyboard Shortcuts in the Command Window

Key or Mouse Action for Windows Preference	Control Key for MATLAB standard (Emacs) Preference	Key or Mouse Action for Macintosh Preference	Operation
↑	**Ctrl+P**	↑	Recall *previous* line — for details, see Recalling Previous Lines. See also Command History Window, which is a log of previously used functions, and Keeping a Session Log. With the **Accessibility** preference selected, moves the cursor up a line when it is above the prompt. In that event, use **Ctrl+** ↑ to recall previous lines for key bindings for MicrosoftWindows and Apple®Macintosh® platforms.
↓	**Ctrl+N**	↓	Recall *next* line — for details, see Recalling Previous Lines. Works only after using the up arrow or **Ctrl+P**. With the **Accessibility** preference selected, moves the cursor down a line when it is above the prompt. In that event, use **Ctrl+** ↓ to recall previous lines for key bindings for Windows and Macintosh platforms.
Ctrl+Home	None	**Home**	Move to top of Command Window.
Ctrl+End	None	**End**	Move to end of Command Window.
None	None	**Cmd+Home**	Move cursor and scroll to top of Command Window.
None	None	**Cmd+End**	Move cursor and scroll to end of Command Window.
None	None	**Shift+Cmd+Home**	Select to top of Command Window.
None	None	**Shift+Cmd+End**	Select to end of Command Window.
←	**Ctrl+B**	←	Move *back* one character.
→	**Ctrl+F**	→	Move *forward* one character.
Ctrl+ ←	None	**Option+** ←	Move *left* one word.
Ctrl+ →	None	**Option+** →	Move *right* one word.
Home	**Ctrl+A**	**Cmd+** ←	Move to beginning of current statement. With key bindings for Macintosh platforms, move to beginning of current line.
End	**Ctrl+E**	**Cmd+** →	Move to *end* of current statement. With key bindings for Macintosh platforms, move to end of current line.
Esc	**Ctrl+U**	**Esc**	Clear the command line when cursor is at the command line. Otherwise, move cursor to command line.

FAQ 05: Run your MATLAB codes when in the online LAB

- **On your local computer**

Install MATLAB on your local computer and run your codes

Check your university IT department for support

- **Online**

See the next two pages

FAQ 05: Run your MATLAB codes when in the online LAB

- **MATLAB Online:**

Use MATLAB and Simulink through your web browser

https://matlab.mathworks.com/
(Login required)

- **Try your codes via live editor**
  https://ww2.mathworks.cn/products/matlab/live-editor.html#

MATLAB Live Editor - MATLAB

MATLAB Login | MATLAB &

https://ww2.mathworks.cn/products/matlab/live-editor.html#

LIVE EDITOR | INSERT | VIEW

Go To | Find | Bookmark — NAVIGATE

Text | Heading 1 | B I U M — TEXT

Code | Control | Task | Refactor — CODE

Run Section | Section Break | Run and Advance | Run to End — SECTION

Integration.mlx

*Use the Live Editor to **edit** and **run** this live script in your browser or download and run it in your MATLAB.*

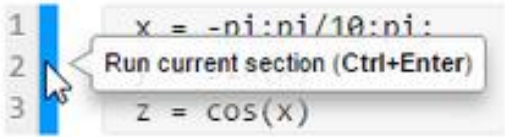
Run the entire script

From the toolstrip

Run an individual section

From the toolstrip

or



From the left margin

Challenge: *Can you find the value of the definite integral* $\int_0^{2\pi} \sin^2(x)\cos^2(x)\,dx$ *? (hint: see line 2)*

FAQ 06: Cheat Sheets for Using MATLAB with Python

- To quickly get started using MATLAB together with Python? whether you're **calling MATLAB from Python** or **calling Python from MATLAB**[1]:
  - Using MATLAB and Python Together
  - MATLAB for Python Users
  - MATLAB Basic Functions Reference
  - Importing and Exporting Data
  - Preprocessing Time Series Data

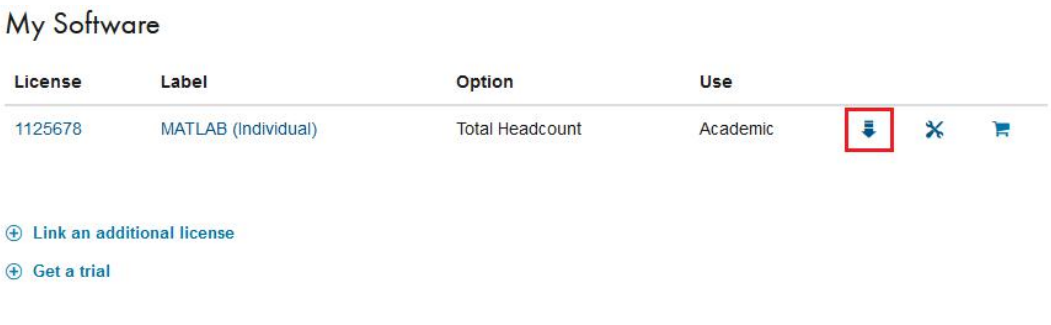
FAQ 06: Cheat Sheets for Using MATLAB with Python

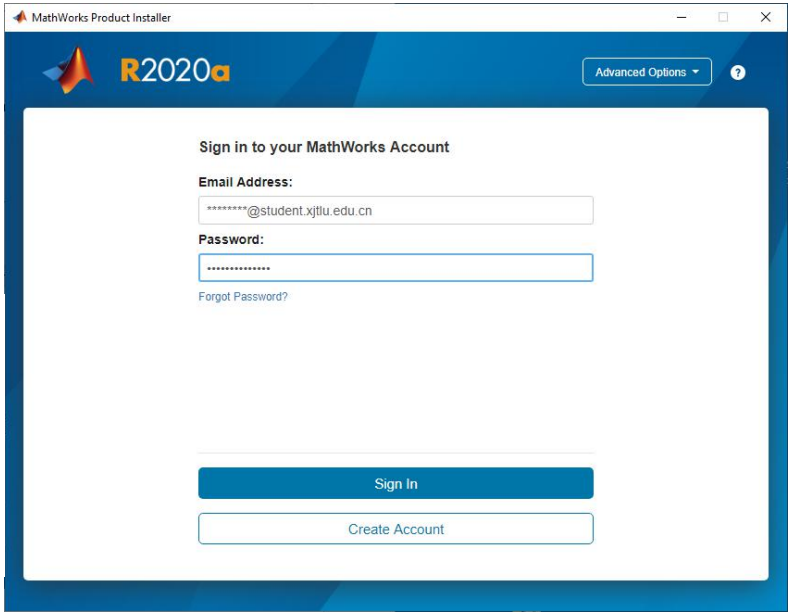
- How to Call MATLAB from Python (5:46) - Video
- How to Call Python from MATLAB (3:04) - Video

FAQ 07 How to install MATLAB

- **MATLAB License Registration and Installation Guide (For student) PDF**

https://guide.xjtlu.edu.cn/how-to-register-and-install-matlab-license-for-student.html





Source Codes of Text Book

- Yi Chen, Yun Li, (2018), Computational Intelligence Assisted Design (In the Era of Industry 4.0), CRC Press (ISBN 978-1-4987-6066-9) https://www.taylorfrancis.com/books/9781498760676

1) IEEE Code Ocean

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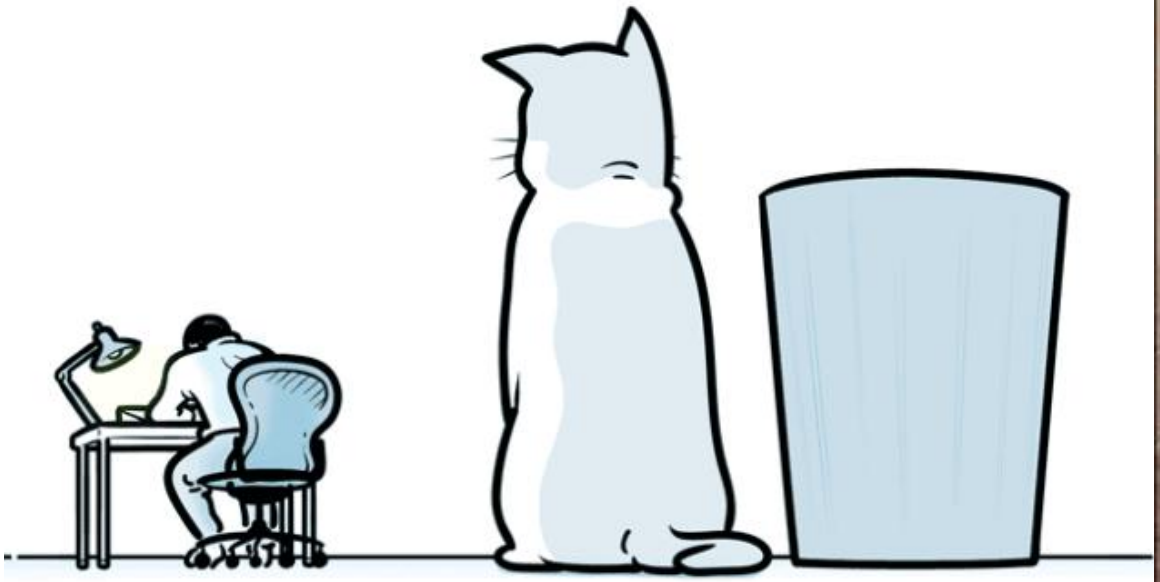
Thanks and Questions



Introduction to Artificial Intelligence - Laboratory Handbook (MATLAB)01

Thanks and Questions

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