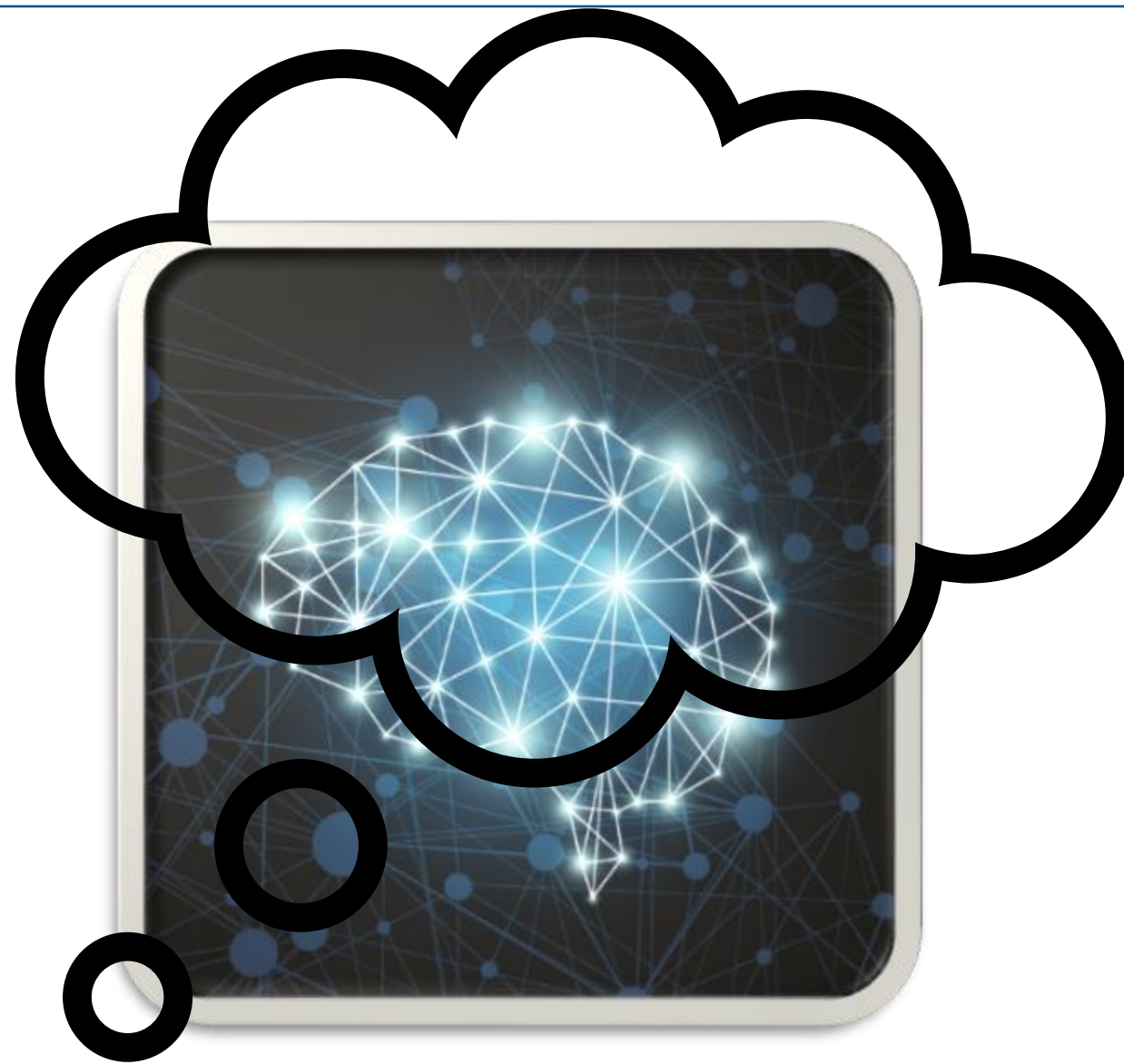


MATLAB EXPO

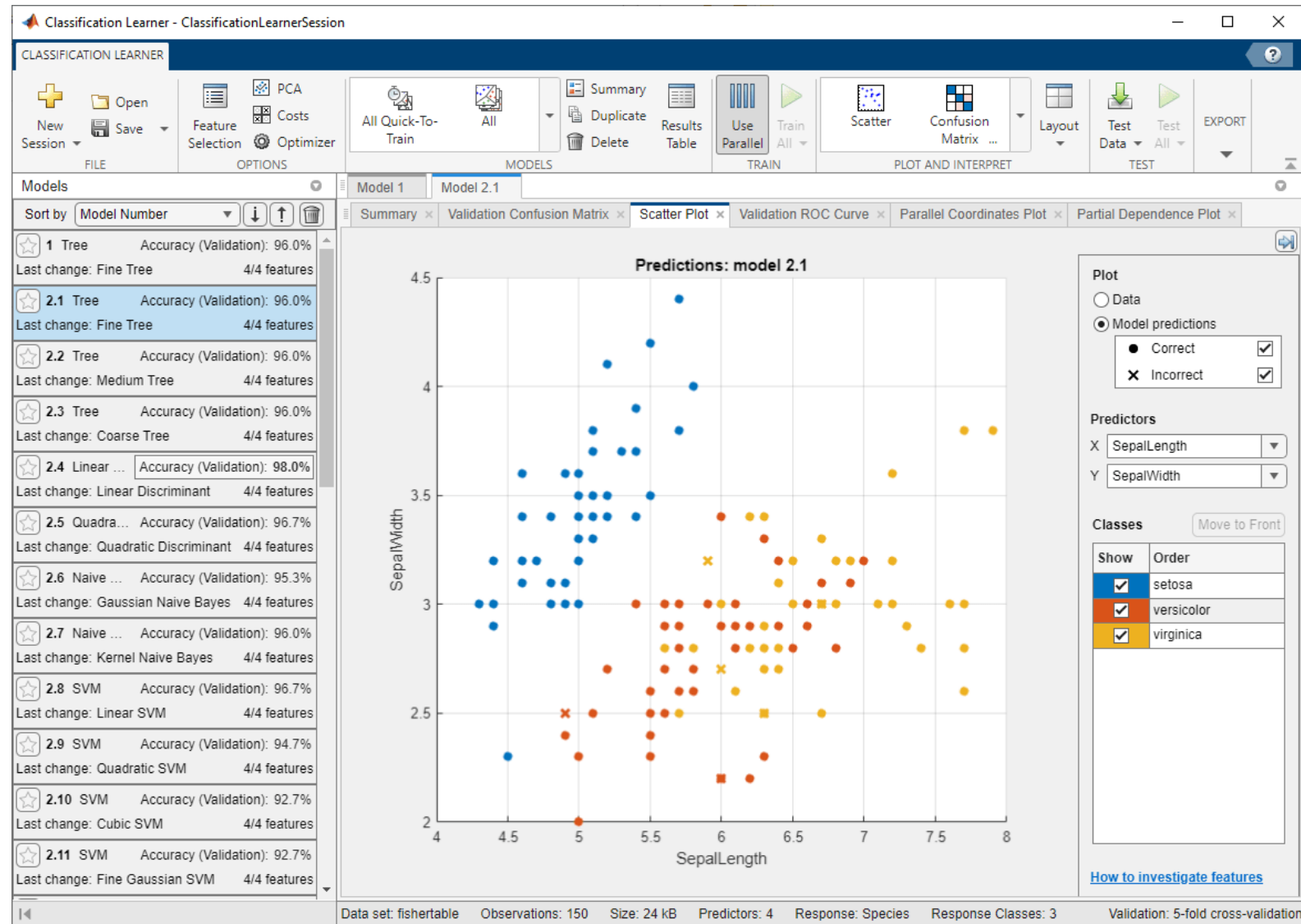
Python과 함께 사용하는 MATLAB 워크샵

박인용 과장, 매스웍스코리아



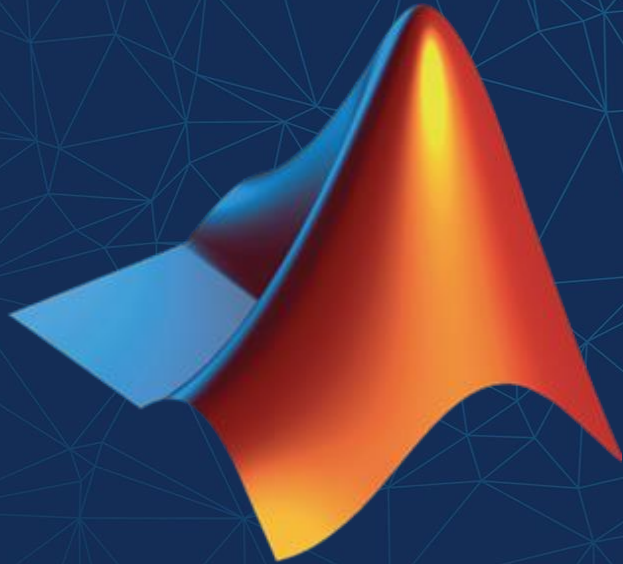


Classification Learner App

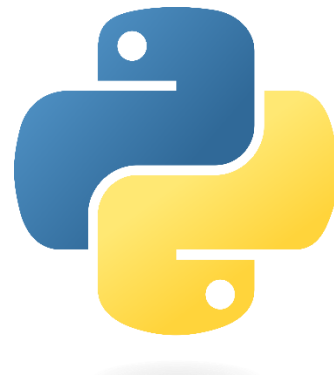
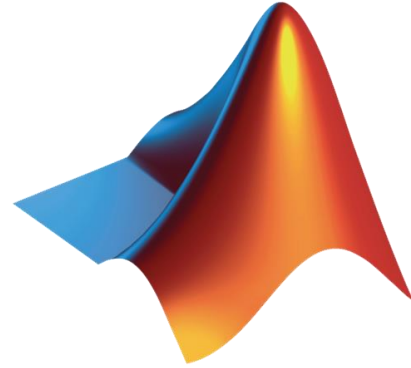


MATLAB with Python

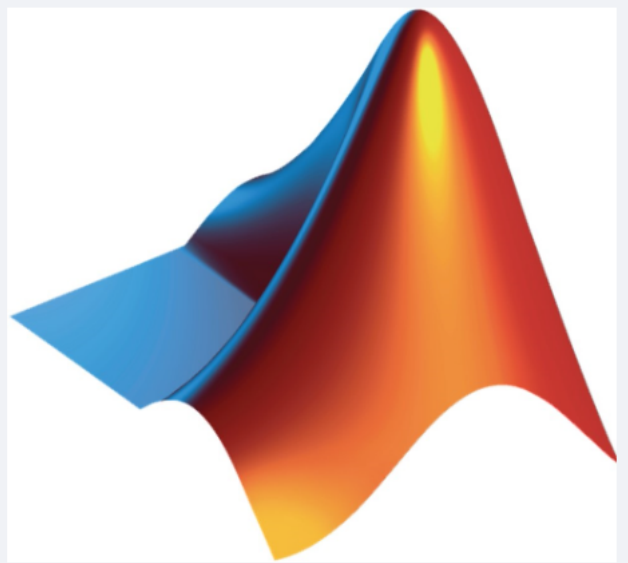
Easier than you think



Demo Workflow





MATLAB



MATLAB or Python

Upload file


 Drag and drop file here
 Limit 200MB per file
 Browse files


sig1.wav 86.2KB
×

▶ 0:01 / 0:01

🔊 ⋮

Preprocess

▶ [...] ...









shape (96, 64)

Predict



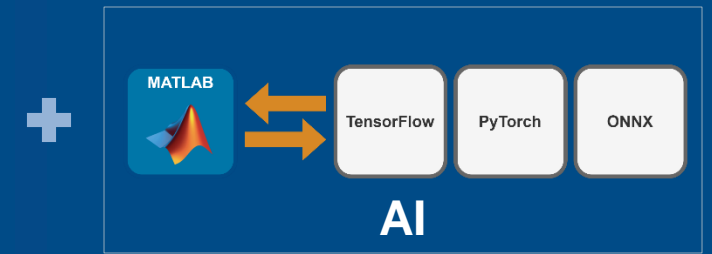
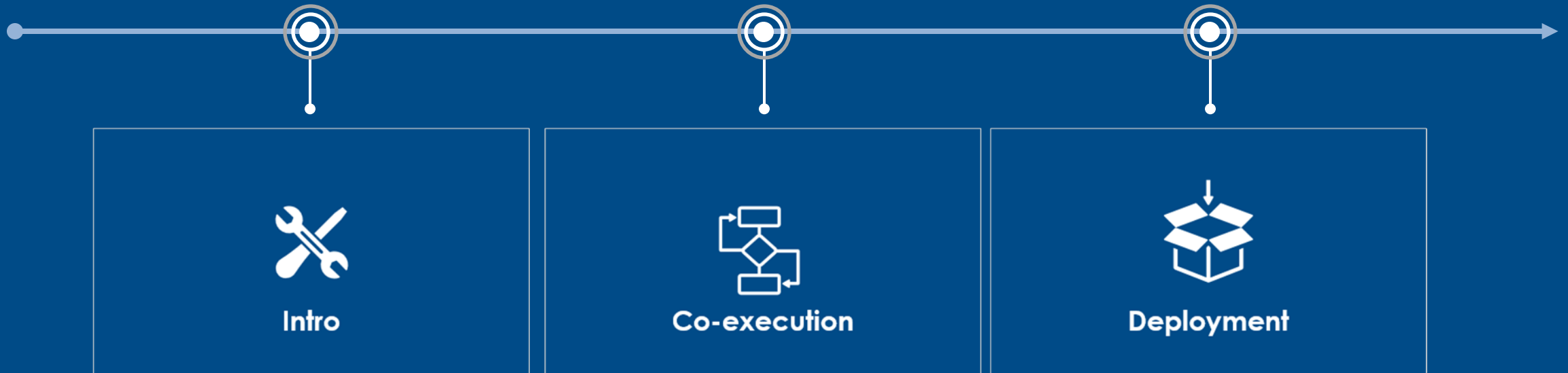
Google

🔍 Google 검색 또는 URL 입력

-  Lightning Exp...
-  MathWorks I...
-  Sign In
-  Learner Home
-  Yann Debray ...
-  https://www...
-  insidelabs
-  https://inside...
-  https://youtu...
-  바로가기 추가

✎ Chrome 맞춤설정

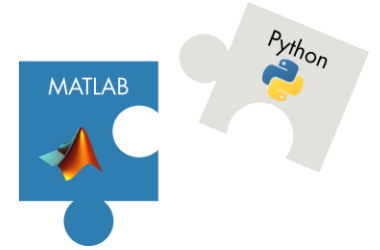
Plan





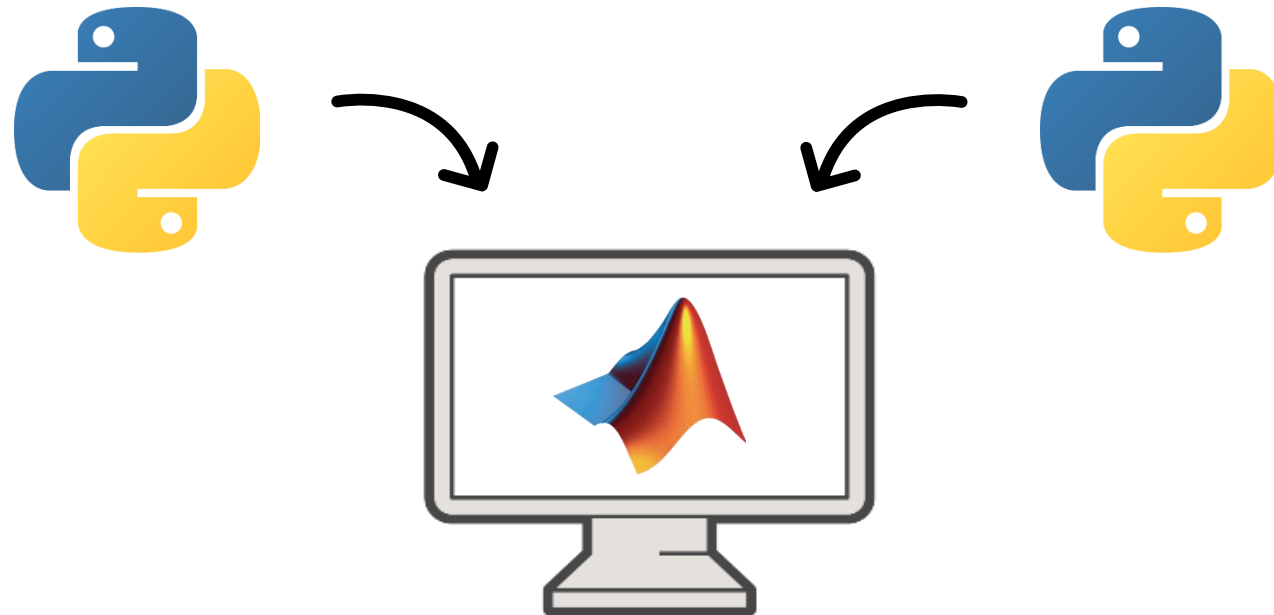
Intro

Why Call Python from MATLAB?

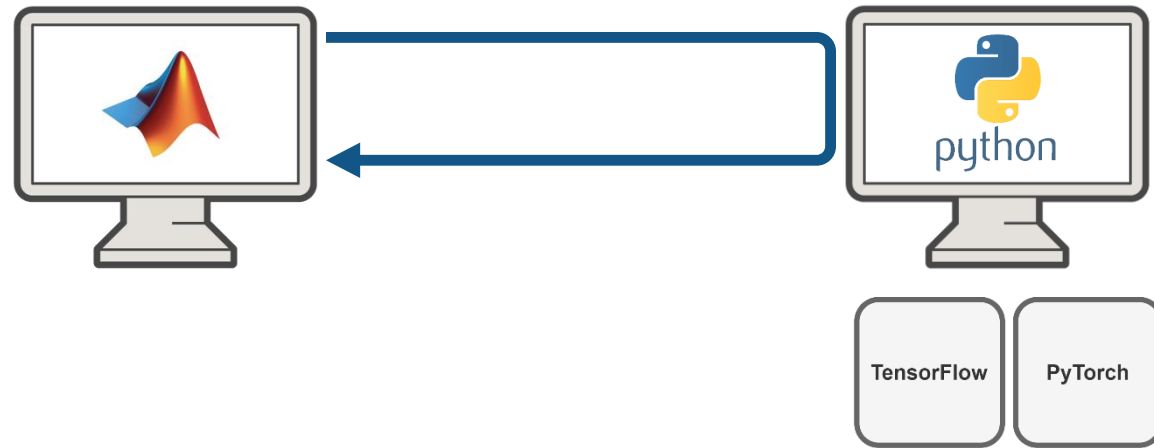
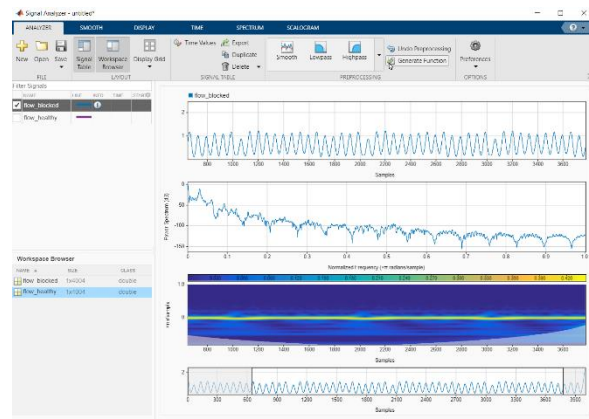
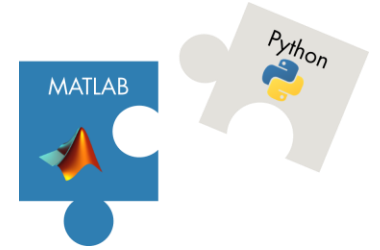


Already working in MATLAB, and:

- Want to reuse existing Python code
- Need functionality that is only available in Python



Call Python from MATLAB

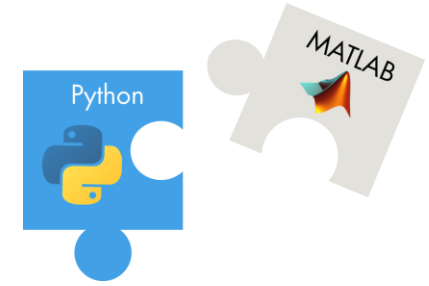


All	70		1	81			2	
Bearing		233	55					
Bearing & Blocking	1	130	135	3	5			
Bearing & Leak	62			108		1	2	
Blocking					259		61	
Leak						201	7	
Leak & Blocking					2	82	99	
None					12		321	
	All	Bearing	Bearing & Blocking	Bearing & Leak	Blocking	Leak	Leak & Blocking	None

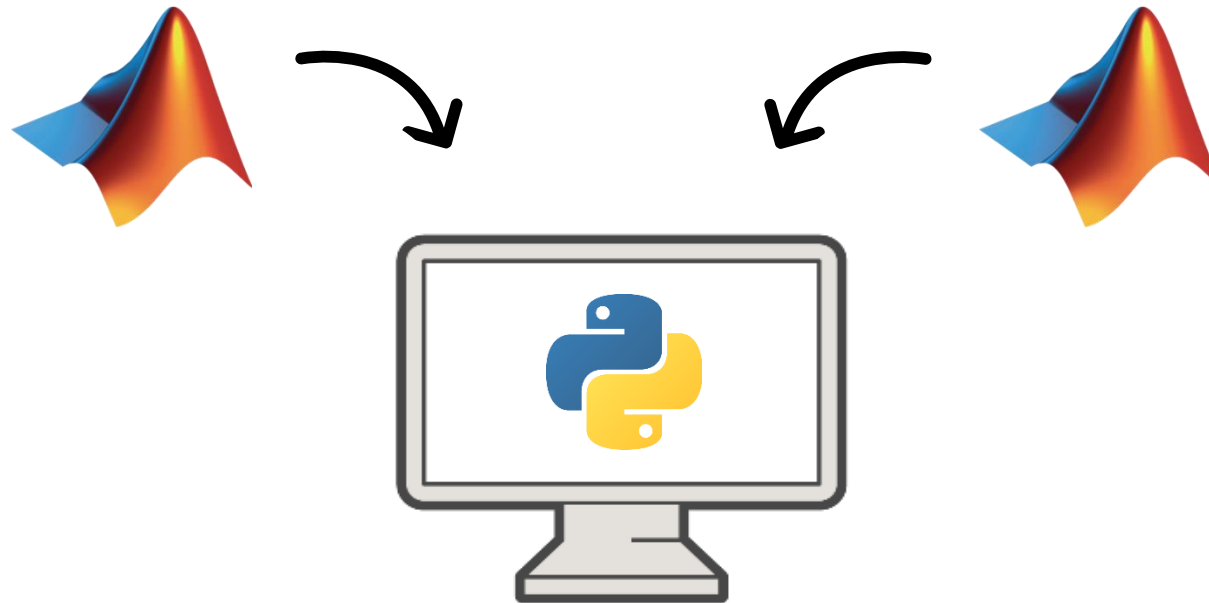
Predicted Class

Ex : [Use a Python Speech Command Recognition System in MATLAB](#)

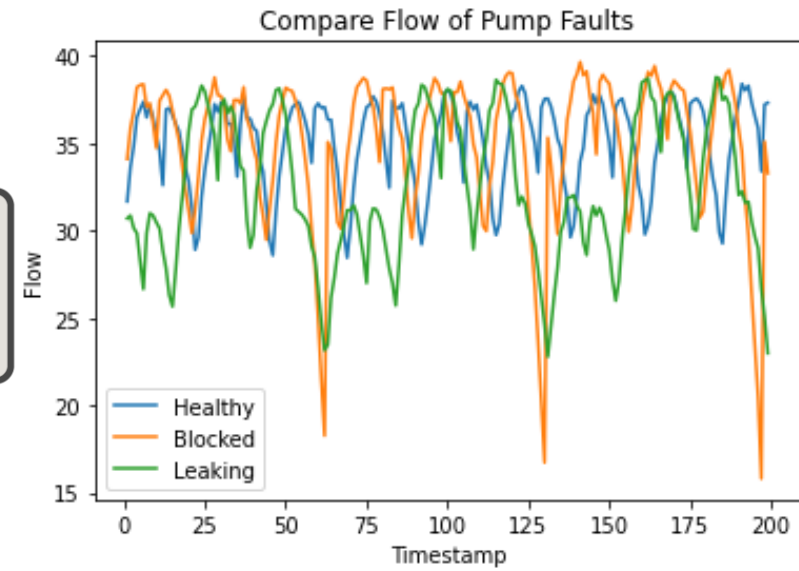
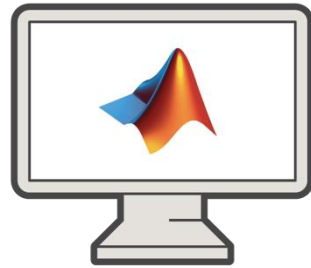
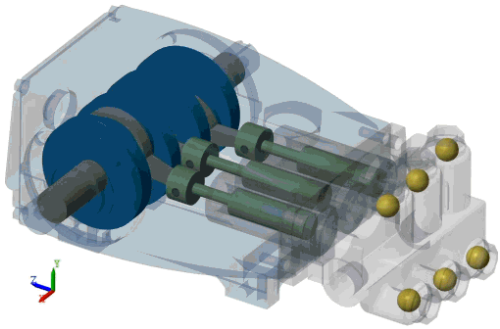
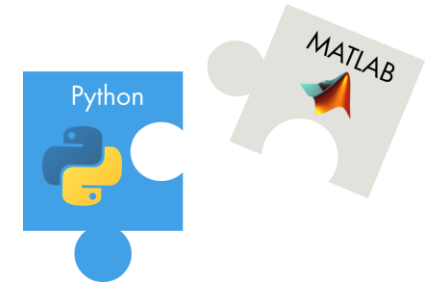
Why Call MATLAB from Python?



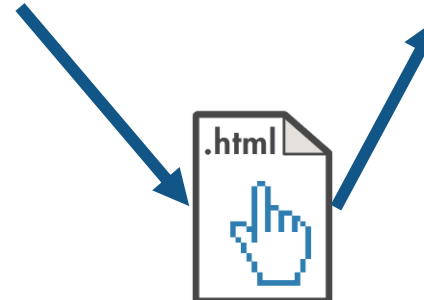
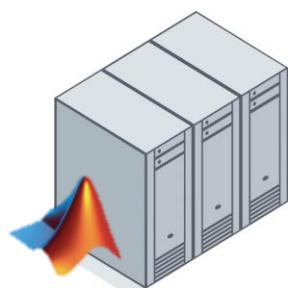
- **Already working in Python, and:**
 - Want to reuse existing MATLAB code
 - Need functionality available in MATLAB
 - Want to collaborate with MATLAB users



Call MATLAB from Python



Deployment WebApps



How do they communicate?

Automatic Data Conversion Chart

Data Type Conversions

Data types will be automatically \geq converted where possible.

MATLAB	Python
double, single	float
complex single complex double	complex
(u)int8, (u)int16, (u)int32, (u)int64	int
NaN	float(nan)
Inf	float(inf)
String, char	str
Logical	bool
Structure	dict
Vectors	array.array()
Cell array	list, tuple

Some MATLAB data types need to be converted.

MATLAB	Conversion Function
categorical	char
string	char
table	table2struct
timetable	timetable2struct
datetime	char

Note: The default numeric type is integer in Python and double in MATLAB when typing **42**

To create a float in Python:

```
>>> x = 42.0
>>> x = float(42)
```

Create integer from MATLAB:

```
>> x = int32(42)
```

https://mathworks.com/help/matlab/matlab_external/passing-data-to-python.html

Data Exchange (Parquet)

```
T = parquetread("data/healthy.parquet")
```

T = 4004x4 table

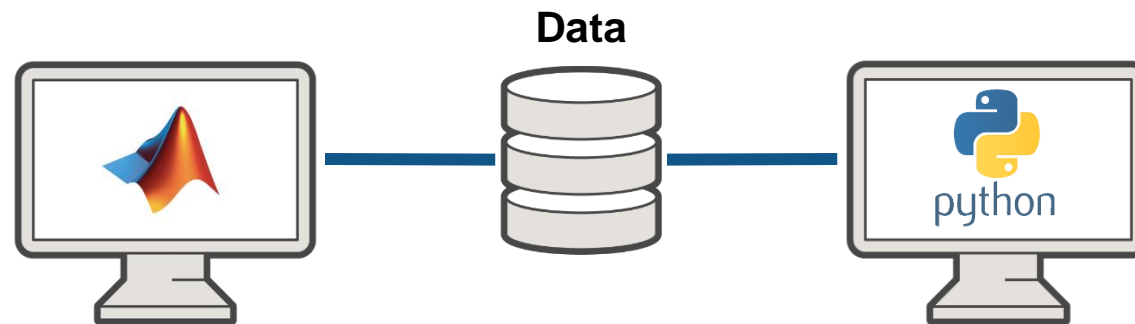
	timestamp	Flow	Pressure	Current
1	27-Jan-2022	30.4092	7.1813	38.1
2	27-Jan-2022	31.6696	7.1952	38.1
3	27-Jan-2022	33.6281	7.2088	38.1
4	27-Jan-2022	34.8138	7.2178	38.1
5	27-Jan-2022	36.4904	7.2300	38.0
6	27-Jan-2022	36.9497	7.2364	38.0
7	27-Jan-2022	37.3693	7.2365	38.0
8	27-Jan-2022	36.4781	7.2432	38.0
9	27-Jan-2022	37.1206	7.2403	37.9

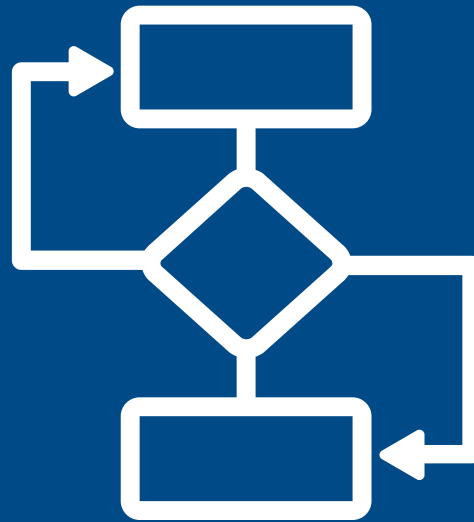
```
df = pd.read_parquet('data/healthy.parquet')  
df.head()
```

✓ 0.1s

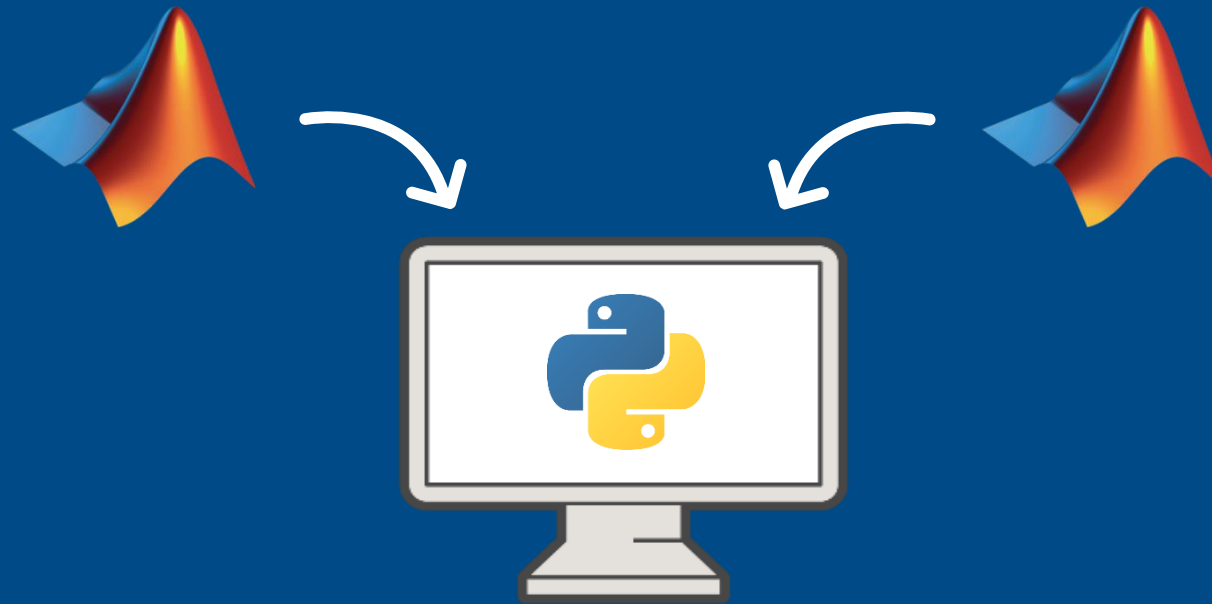
Python

	timestamp	Flow	Pressure	Current
0	2022-01-27	30.409192	7.181319	38.180181
1	2022-01-27	31.669556	7.195158	38.127088
2	2022-01-27	33.628129	7.208793	38.110161
3	2022-01-27	34.813787	7.217771	38.122689
4	2022-01-27	36.490430	7.229957	38.073930





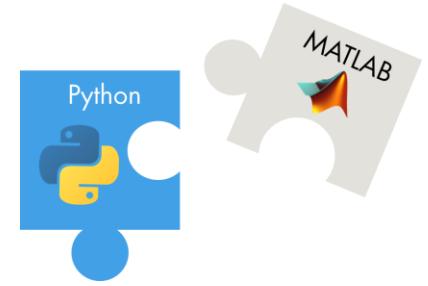
Co-execution



Call MATLAB from Python

Call MATLAB from Python

MATLAB Engine API



1. Installing MATLAB Engine API for Python

For MATLAB 2022b +

```
$ python -m pip install matlabengine
```

For previous MATLAB versions

```
cd "matlabroot\extern\engines\python"  
python setup.py install
```

2. Start a MATLAB process

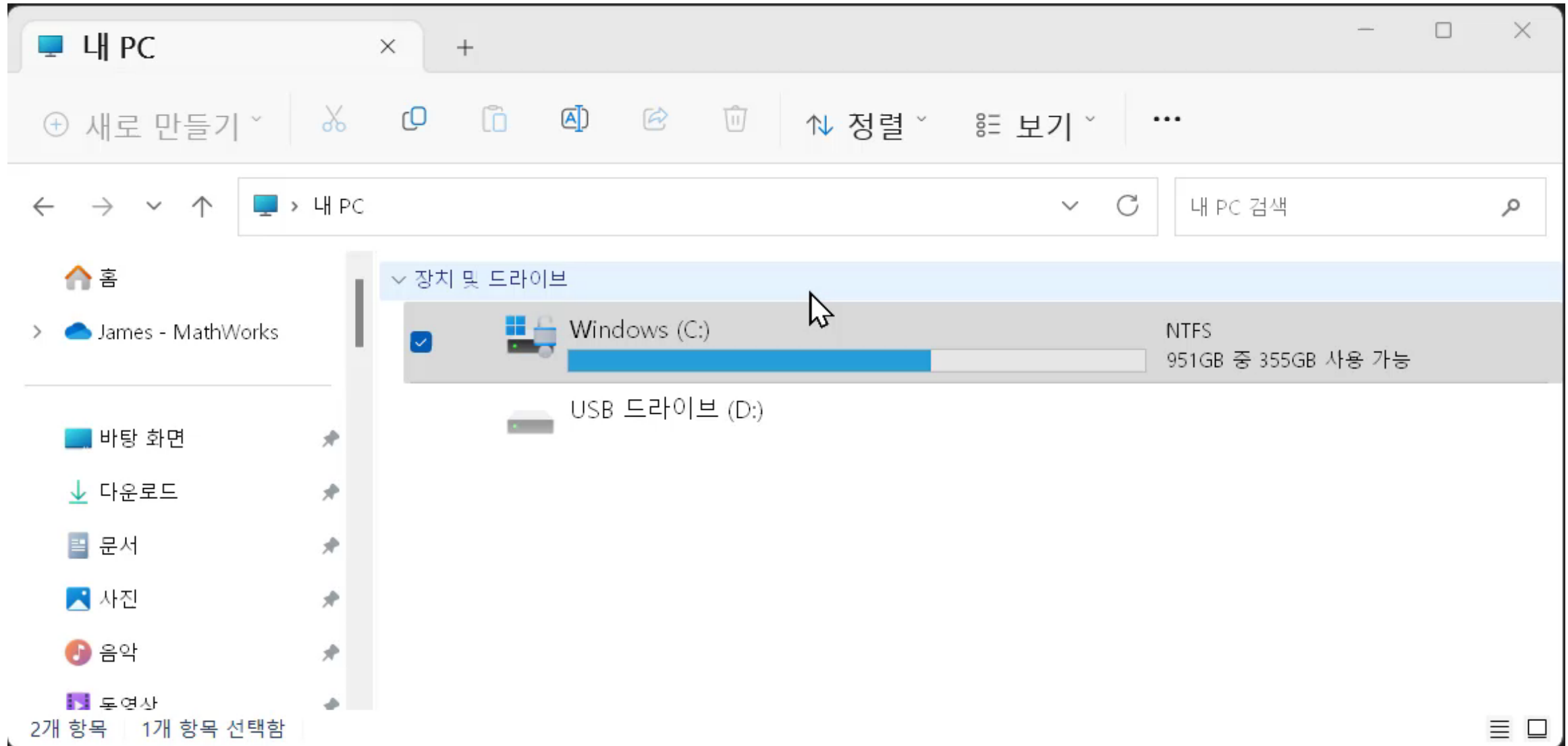
```
>>> import matlab.engine  
>>> m = matlab.engine.start_matlab()
```

3. Call MATLAB functions

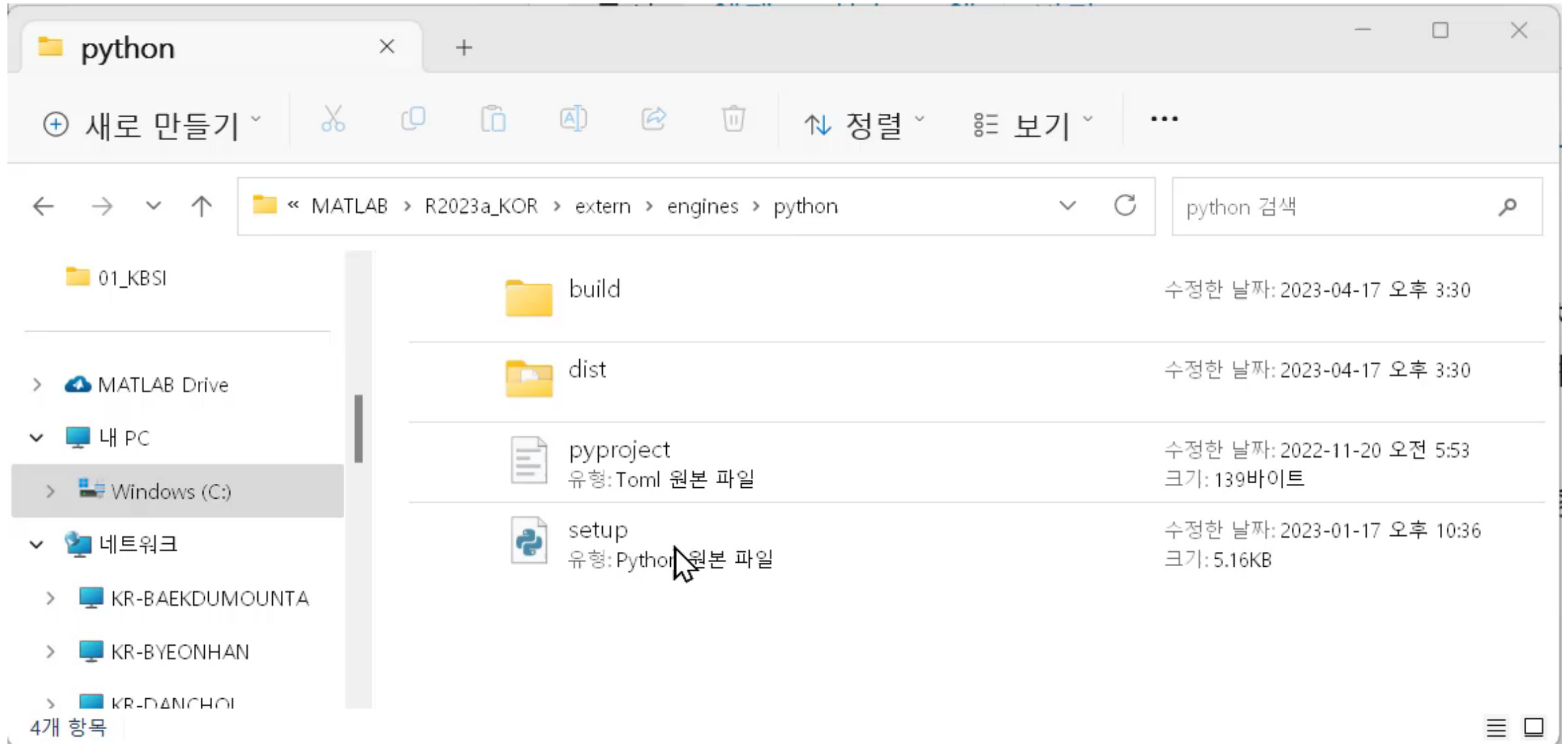
```
>>> x = m.sqrt(float(42))
```

```
명령 프롬프트  
Microsoft Windows [Version 10.0.22621.1555]  
(c) Microsoft Corporation. All rights reserved.  
C:\Users\jpark>python -m pip install matlabengine|
```

Engine Setup - Locating setup.py in MATLAB folder

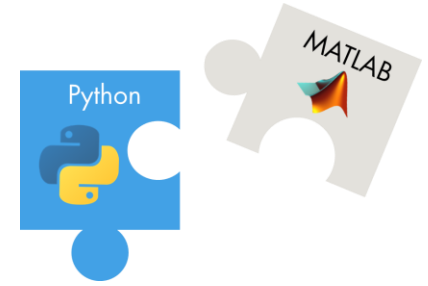


Engine Setup - Installing setup.py



Call MATLAB from Python

MATLAB Engine API



1. Installing MATLAB Engine API for Python

For MATLAB 2022b +

```
$ python -m pip install matlabengine
```

For previous MATLAB versions

```
cd "matlabroot\extern\engines\python"
```

```
python setup.py install
```

2. Start a MATLAB process

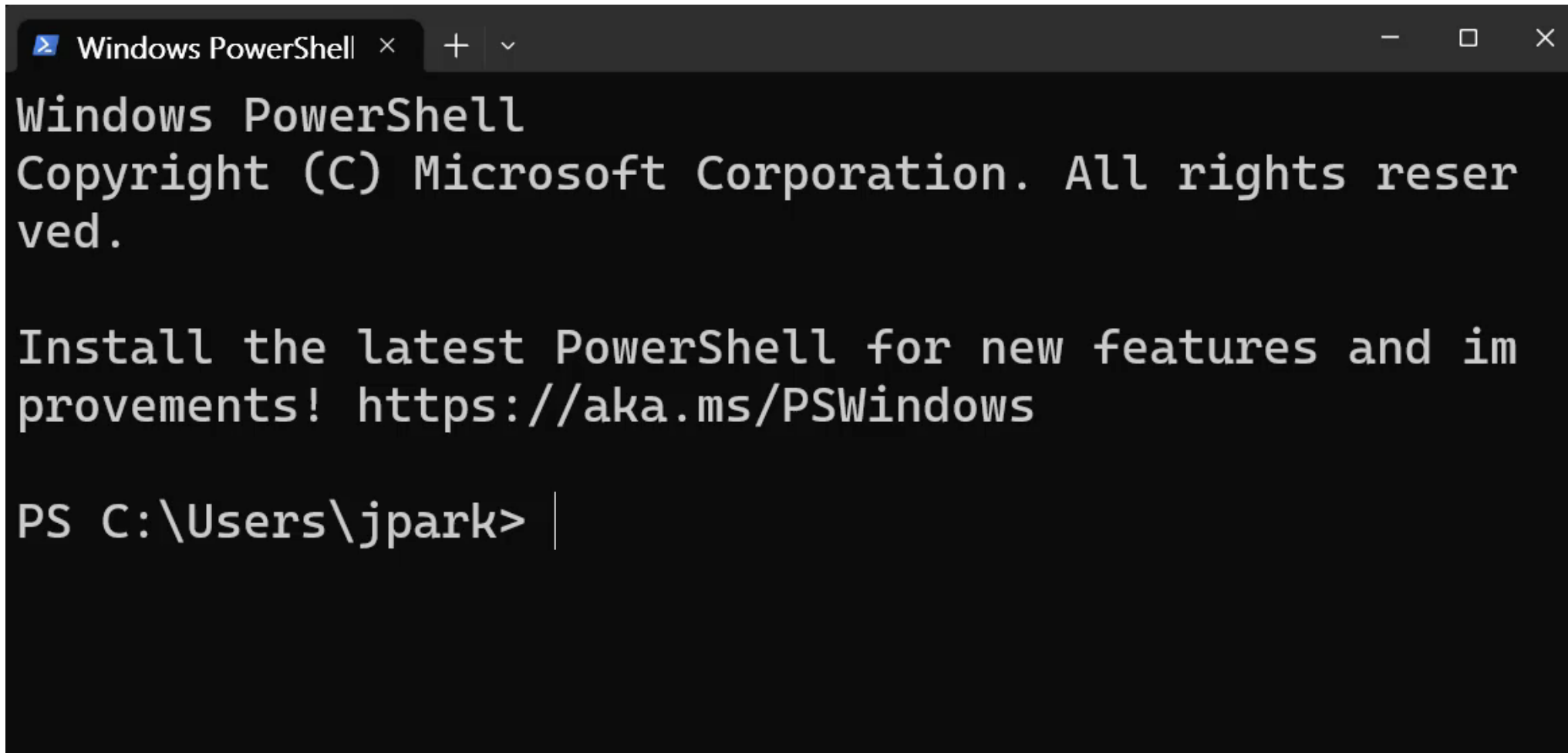
```
>>> import matlab.engine
```

```
>>> eng = matlab.engine.start_matlab()
```

3. Call MATLAB functions

```
>>> x = eng.sqrt(float(42))
```

Running MATLAB in Python

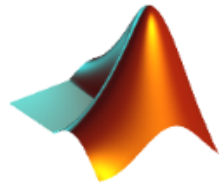
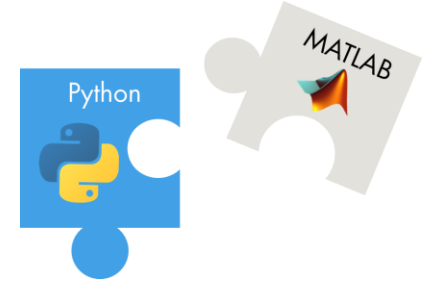
A screenshot of a Windows PowerShell terminal window. The window title bar shows "Windows PowerShell" with a close button, a plus sign, and a dropdown arrow. The terminal content includes the title "Windows PowerShell", a copyright notice for Microsoft Corporation, a message about installing the latest PowerShell, and a command prompt showing the current directory as "C:\Users\jpark>".

```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Install the latest PowerShell for new features and improvements! https://aka.ms/PSWindows

PS C:\Users\jpark> |
```

Syntax Differences When Calling MATLAB from Python



MATLAB

```
>> [s,sidx] = sort(x)
```

```
>> foo(x)
```

```
>> C = A + B
```



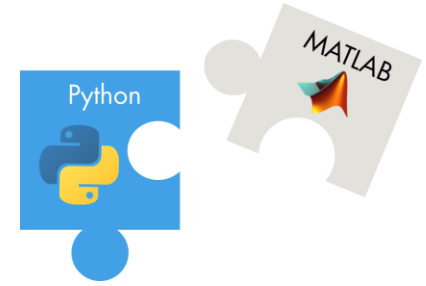
Python

```
>>> s = eng.sort(x,nargout=2)
```

```
>>> eng.foo(x,nargout=0)
```

```
>>> C = eng.plus(A,B)
```


Demo with a Custom MATLAB Function



1. Clean Data



2. Make Function



3. Make Input



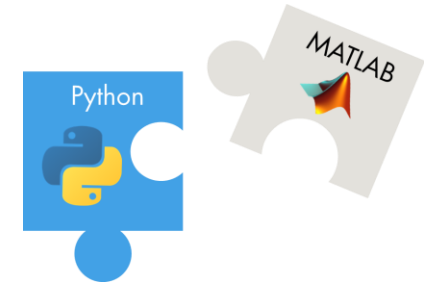
4. Start Engine



5. Call Function



1. Clean Data



The screenshot shows the MATLAB R2023a Live Editor interface. The top menu bar includes HOME, PLOTS, APPS, LIVE EDI..., INSERT, and VIEW. The toolbar contains icons for file operations (New, Open, Save, Print, Export), text formatting (Normal, Bold, Italic, Underline, Monospace), code execution (Run, Step, Stop), and other tools (Code, Control, Task, Refactor). The current file is 'untitled6.mlx' located at 'C:\Git\audio'. The Live Editor window is titled 'Live Editor - untitled6.mlx *' and contains a control panel on the left and a plot on the right.

Specify method

- Cleaning method: Fill missing
- Moving window: Centered
- Max gap to fill: [empty field]

Display results

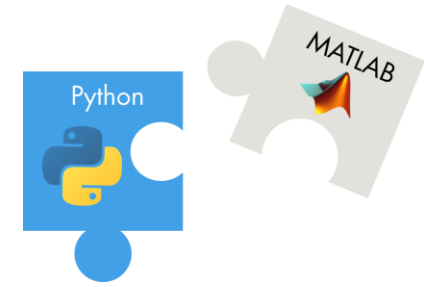
- Cleaned data
- Filled mis

Number of filled missing entries: 2

The plot shows a line graph with two data series: 'Cleaned data' (blue line) and 'Filled missing entries' (red dots). The x-axis ranges from 0 to 8, and the y-axis ranges from 1 to 2. The 'Cleaned data' series has values approximately 1.5 at x=1, 1.0 at x=2, and 2.0 at x=8. The 'Filled missing entries' series has values approximately 1.5 at x=1 and 2.0 at x=8.

Command Window: Zoom: 150% UTF-8 LF script

2. Make Function

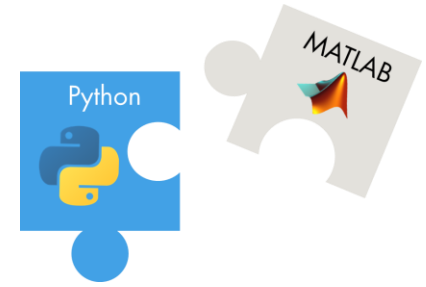
A screenshot of the MATLAB R2023a software interface. The top menu bar includes HOME, PLOTS, APPS, EDITOR, PUBLISH, and VIEW. The Editor window shows a function definition for 'myDataCleaner'. The Command Window at the bottom shows search results for 'missingIndices' and the current cursor position at line 1, column 45.

```
1 function [cleanedData2,nMissing] = myDataCleaner(signal)
2 % Fill missing data
3 [cleanedData2,missingIndices] = fillmissing(signal,"movmean",5);
4
5 % Display results
6 figure
7
8 % Plot cleaned data
9 plot(cleanedData2,"Color",[0 114 189]/255,"Linewidth",1.5,...
10      "DisplayName","Cleaned data")
11 hold on
12
13 % Plot filled missing entries
14 plot(find(missingIndices),cleanedData2(missingIndices),".","MarkerSize",12,...
15      "Color",[217 83 25]/255,"DisplayName","Filled missing entries")
16 title("Number of filled missing entries: " + nnz(missingIndices))
17
```

Command Window

5 usages of "missingIndices" fo... Zoom: 150% UTF-8 CRLF myDataCle Ln 1 Col 45

3. Make Input



```
+ Code + Markdown | ▶ Run All ☰ Clear All Outputs ↺ Restart | ... 📄 Python 3.10.4
```

make random signal

```
▶ import random
import numpy as np

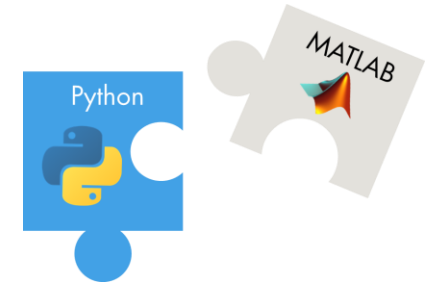
signal = random.choices([np.nan, 1, 2, 3, 4], k=100)
print(signal)
```

[1] ✓ 0.4s Python

```
... [2, 1, 4, 1, 4, 1, 1, 3, 2, 4, 1, 2, 3, 2, 1, nan, 3, nan, 1, 2, 4, 4, 3,
```

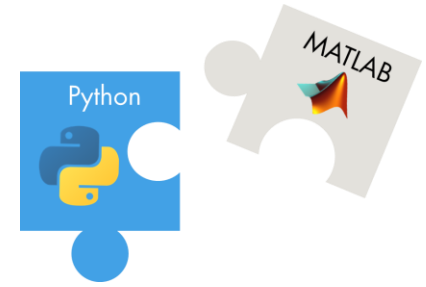
[] Python

4. Start Engine



```
+ Code + Markdown | ▶ Run All ☰ Clear All Outputs ↺ Restart | ... 📄 Python 3.10.4
[1] ✓ 0.4s Python
... [2, 1, 4, 1, 4, 1, 1, 3, 2, 4, 1, 2, 3, 2, 1, nan, 3, nan, 1, 2, 4, 4, 3,
start matlab engine
▶ [ ] Python
import matlab.engine
eng = matlab.engine.start_matlab()
```

5. Call Function



```
+ Code + Markdown | ▶ Run All ≡ Clear All Outputs ↺ Restart | ... Python 3.10.4
[2] ✓ 11.4s Python

run matlab function

▶ # add path
  eng.addpath(eng.genpath("C:/Git/audio"), nargout=0)

# run matlab function
output = eng.myDataCleaner(np.array(signal), nargout=2)

[ ] Python
```


Automatic Data Conversion Chart

Data Type Conversions

Data types will be automatically \geq converted where possible.

MATLAB	Python
double, single	float
complex single complex double	complex
(u)int8, (u)int16, (u)int32, (u)int64	int
NaN	float(nan)
Inf	float(inf)
String, char	str
Logical	bool
Structure	dict
Vectors	array.array()
Cell array	list, tuple

Some MATLAB data types need to be converted.

MATLAB	Conversion Function
categorical	char
string	char
table	table2struct
timetable	timetable2struct
datetime	char

Note: The default numeric type is integer in Python and double in MATLAB when typing **42**

To create a float in Python:

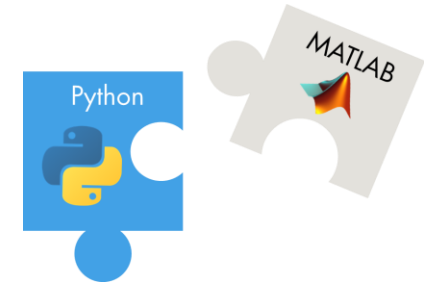
```
>>> x = 42.0
>>> x = float(42)
```

Create integer from MATLAB:

```
>> x = int32(42)
```

https://mathworks.com/help/matlab/matlab_external/passing-data-to-python.html

MATLAB in Visual Studio Code



The screenshot shows the Visual Studio Code interface with the MATLAB extension page open. The left sidebar displays a list of extensions with search results for 'matlab'. The main area shows the details for the 'MATLAB' extension by MathWorks, including a 3D surface plot icon, version 'v1.0.2', and an 'Installing' button. The extension description reads: 'Edit MATLAB code with syntax highlighting, linting, navigation ...'. Below the description are tabs for 'DETAILS', 'FEATURE CONTRIBUTIONS', and 'CHANGELOG'. The main heading reads 'MATLAB extension for Visual Studio Code'. A 'Categories' dropdown menu is open, showing 'Programming Languages'.

EXTENSIONS: MAR...

- MATLAB** 6K ★ 5
Edit MATLAB code with synta...
MathWorks **Installing**
- Matlab Unoffi...** 562K ★ 4.5
MATLAB support for Visual St...
Xavier Hahn **Install**
- matlab-format...** 141K ★ 3.5
format matlab code
AffenWiesel **Install**
- Matlab Code R...** 103K ★ 4.5
Enables code execution in VS

Extension: MATLAB - Visual Studio Code

workingWithMATLAB.ipynb | audioFeatureExtractor.m | Extension: MATLAB X

MATLAB

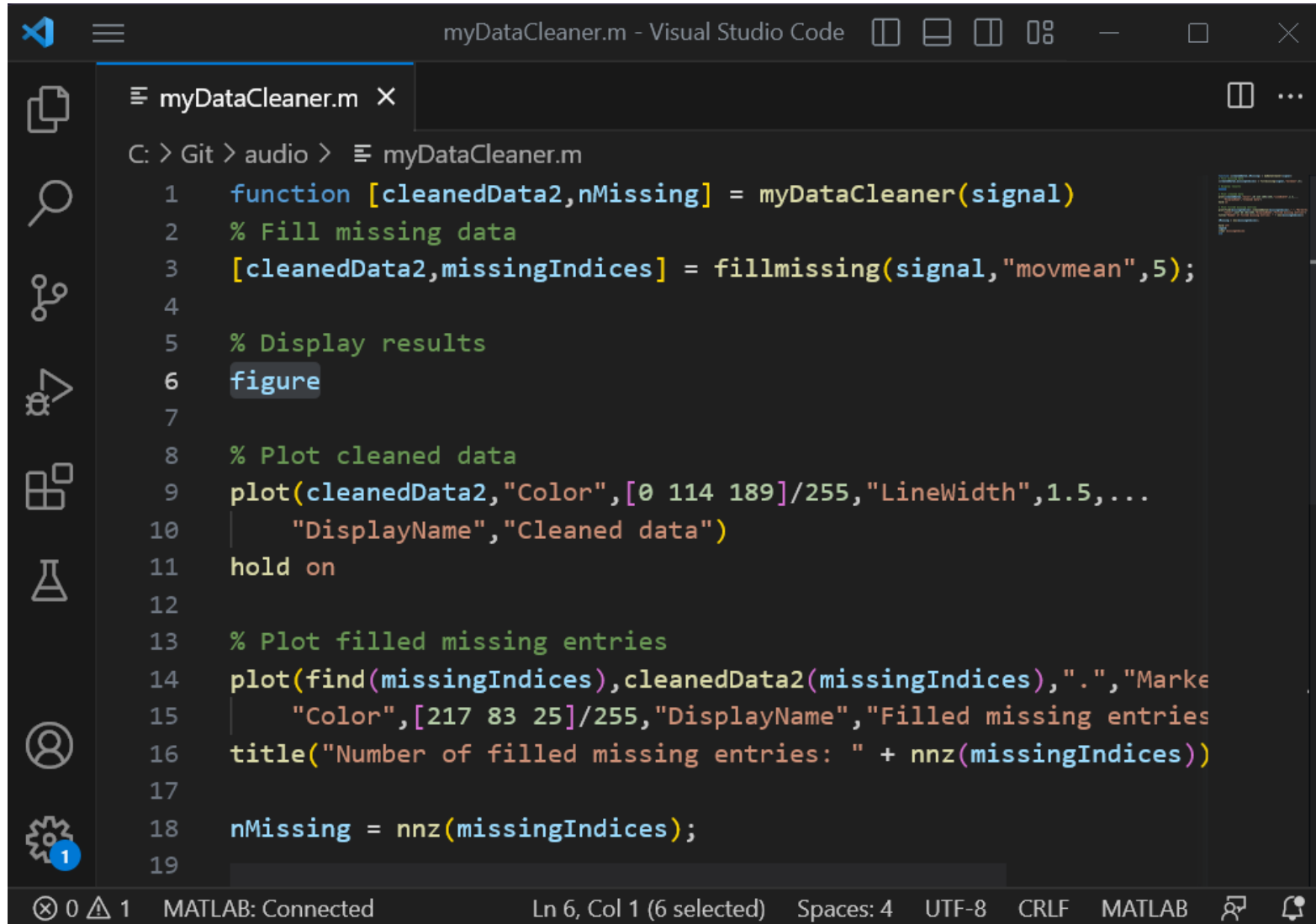
 v1.0.2
MathWorks mathworks.com | 6,611 | ★★★★★ (8)
Edit MATLAB code with syntax highlighting, linting, navigation ...
Installing ⚙️

DETAILS | FEATURE CONTRIBUTIONS | CHANGELOG

MATLAB extension for Visual Studio Code

Categories
Programming Languages

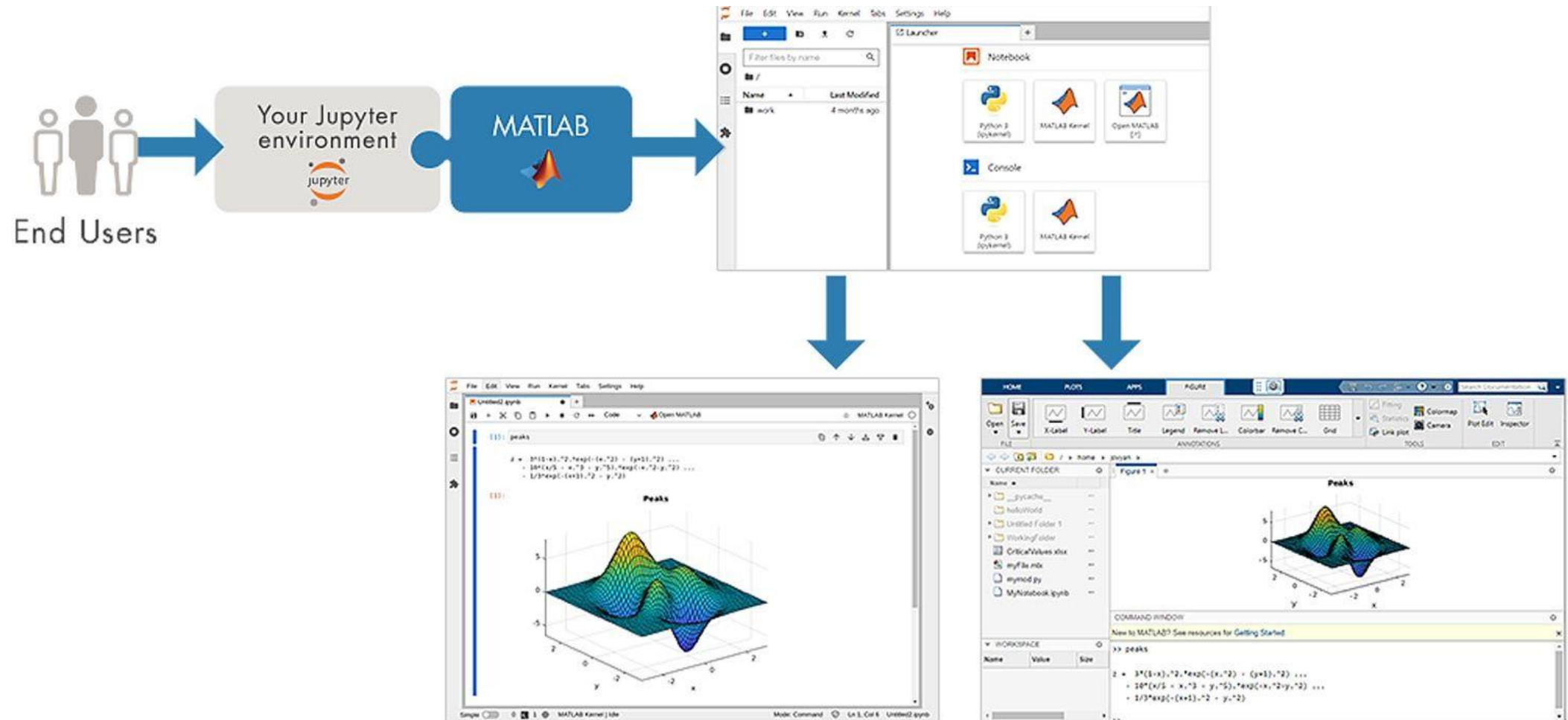
MATLAB in Visual Studio Code



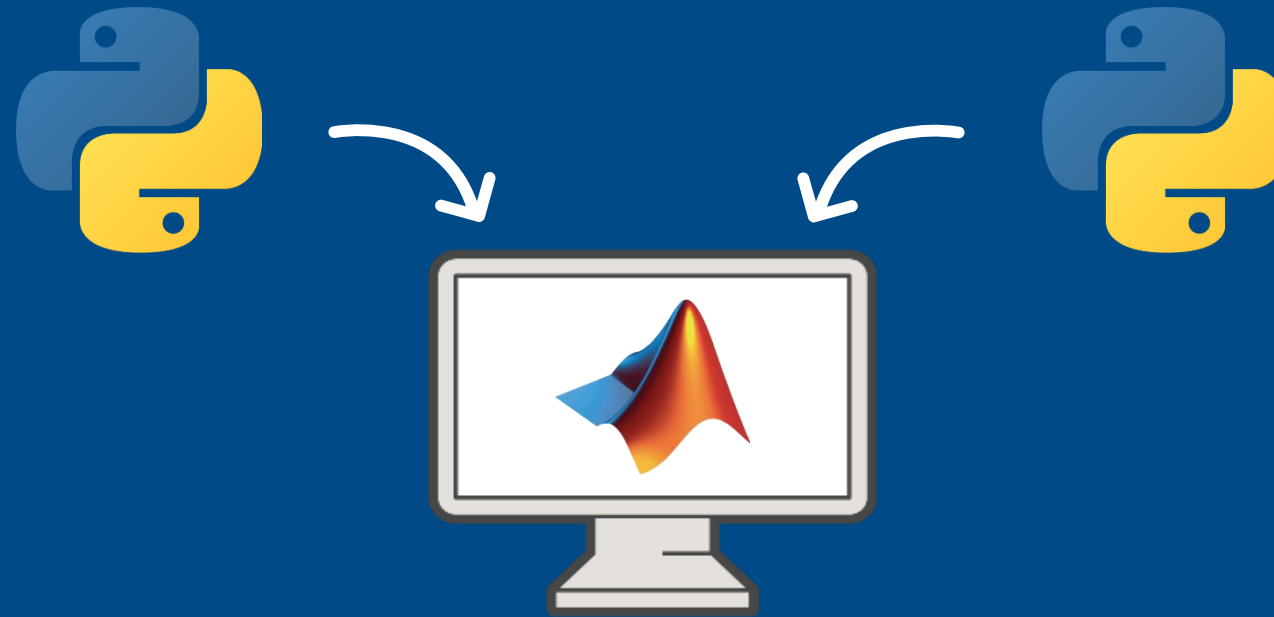
```
myDataCleaner.m - Visual Studio Code
myDataCleaner.m X
C: > Git > audio > myDataCleaner.m
1 function [cleanedData2,nMissing] = myDataCleaner(signal)
2 % Fill missing data
3 [cleanedData2,missingIndices] = fillmissing(signal,"movmean",5);
4
5 % Display results
6 figure
7
8 % Plot cleaned data
9 plot(cleanedData2,"Color",[0 114 189]/255,"LineWidth",1.5,...
10      "DisplayName","Cleaned data")
11 hold on
12
13 % Plot filled missing entries
14 plot(find(missingIndices),cleanedData2(missingIndices),".","Marke
15      "Color",[217 83 25]/255,"DisplayName","Filled missing entries
16      title("Number of filled missing entries: " + nnz(missingIndices))
17
18 nMissing = nnz(missingIndices);
19
```

0 1 MATLAB: Connected Ln 6, Col 1 (6 selected) Spaces: 4 UTF-8 CRLF MATLAB

MATLAB Integration for Jupyter

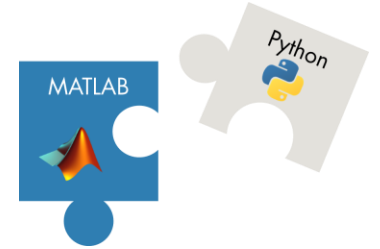


[MATLAB Integration for Jupyter \(mathworks.com\)](https://www.mathworks.com)



Call Python from MATLAB

Setup Instructions

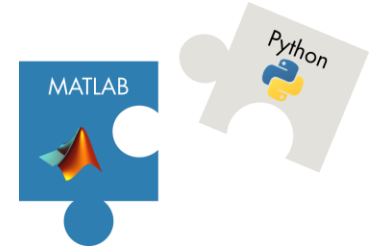


- Pyenv
 - `pyenv("Version", "PATH TO PYTHON")`

```
Command Window
>> pyenv
ans =

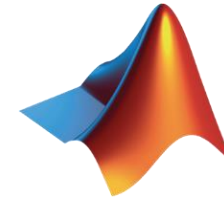
  PythonEnvironment with properties:
    Version: "3.10"
    Executable: "C:\Users\jpark\AppData\Local\WPY64-31040\python-3.10.4.amd64\python.exe"
    Library: "C:\Users\jpark\AppData\Local\WPY64-31040\python-3.10.4.amd64\python310.dll"
    Home: "C:\Users\jpark\AppData\Local\WPY64-31040\python-3.10.4.amd64"
    Status: NotLoaded
    ExecutionMode: InProcess
```

Syntax Differences When Calling Python From MATLAB



Python

```
>>> import math  
>>> math.sqrt(42)
```



MATLAB

```
>> py.math.sqrt(42)
```

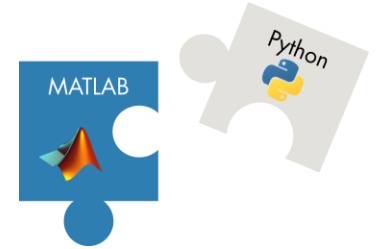
Before R2022a

```
>>> print('hello', 'world', sep=', ')
```



```
>> py.print('hello', 'world', .sep=', ')  
pyargs('sep', ', ')
```

Setup Instructions for Calling Custom Python Class



- Pyenv
 - pyenv("Version", "PATH TO PYTHON")

```

Command Window
>> pyenv
ans =

  PythonEnvironment with properties:

    Version: "3.10"
    Executable: "C:\Users\jpark\AppData\Local\WPY64-31040\python-3.10.4.amd64\python.exe"
    Library: "C:\Users\jpark\AppData\Local\WPY64-31040\python-3.10.4.amd64\python310.dll"
    Home: "C:\Users\jpark\AppData\Local\WPY64-31040\python-3.10.4.amd64"
    Status: NotLoaded
    ExecutionMode: InProcess
  
```




- Add to Python Path using
 - addpath("path-to-pythonFile.py")
 - filePath = fileparts(which("pythonFile.py"))
 - if count(py.sys.path, filePath) == 0
 - insert(py.sys.path, int32(0), filePath);
 - end

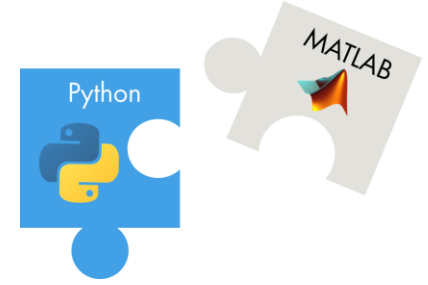
Set up Python and Python path

```

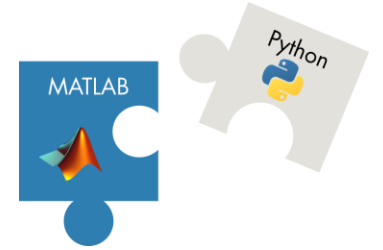
pyversion
pathToSpeech = fileparts(which('mySpeechRecognizer.py'));
if count(py.sys.path, pathToSpeech) == 0
    insert(py.sys.path, int32(0), pathToSpeech);
end
  
```


Demo with a Custom Python Class

1. Make Class 
2. Add Path 
3. Call Method 

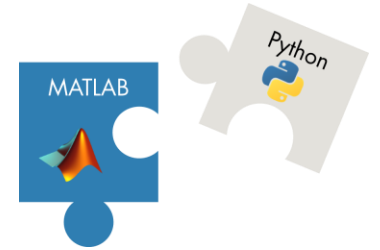


1. Make Class



```
class breakfast: Untitled-1 ●  
1 class breakfast:  
2     def __init__(self, menu):  
3         self.menu = menu  
4     def getBreakfast(self):  
5         return self.menu  
6     def addBreakfast(self, food):  
7         self.menu.append(food)  
8         print(f"{food} added")
```

2. Add Path



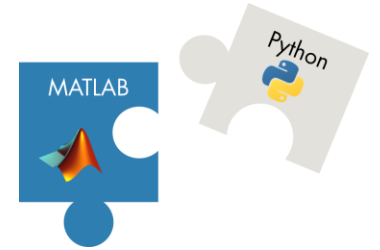
```
Command Window
```

```
>> addpath("C:\Users\jpark\OneDrive - MathWorks\Desktop");  
>> py.sys.path  
  
ans =  
  
Python list with values:  
  
['', 'C:\\Users\\jpark\\AppData\\Local\\WPY64-31040\\python-3.10.4.am  
  
Use string, double or cell function to convert to a MATLAB array.  
  
>> fileparts(which("Breakfast.py"))  
  
ans =  
  
'C:\Users\jpark\OneDrive - MathWorks\Desktop'  
  
fx >> insert(py.sys.path, int32(0), fileparts(which("Breakfast.py")))
```

```
Workspace
```

Name ▲	Value
ans	'C:\#User

3. Call Method



Command Window

```
>> pythonBreakfast = py.breakfast.breakfast(py.list(['bacon'], ['eggs']))
>> pythonBreakfast.menu

ans =

Python list with values:

    ['bacon', 'eggs']

Use string, double or cell function to convert to a MATLAB array.

>> pythonBreakfast.getBreakfast()

ans =

Python list with values:

    ['bacon', 'eggs']

Use string, double or cell function to convert to a MATLAB array.

fx >> |
```

Workspace

Name ▲	Value
ans	1x2 list
pythonBreakfast	1x1 break

Automatic Data Conversion Chart

Data Type Conversions

Data types will be automatically \geq converted where possible.

MATLAB	Python
double, single	float
complex single complex double	complex
(u)int8, (u)int16, (u)int32, (u)int64	int
NaN	float(nan)
Inf	float(inf)
String, char	str
Logical	bool
Structure	dict
Vectors	array.array()
Cell array	list, tuple

Some MATLAB data types need to be converted.

MATLAB	Conversion Function
categorical	char
string	char
table	table2struct
timetable	timetable2struct
datetime	char

Note: The default numeric type is integer in Python and double in MATLAB when typing **42**

To create a float in Python:

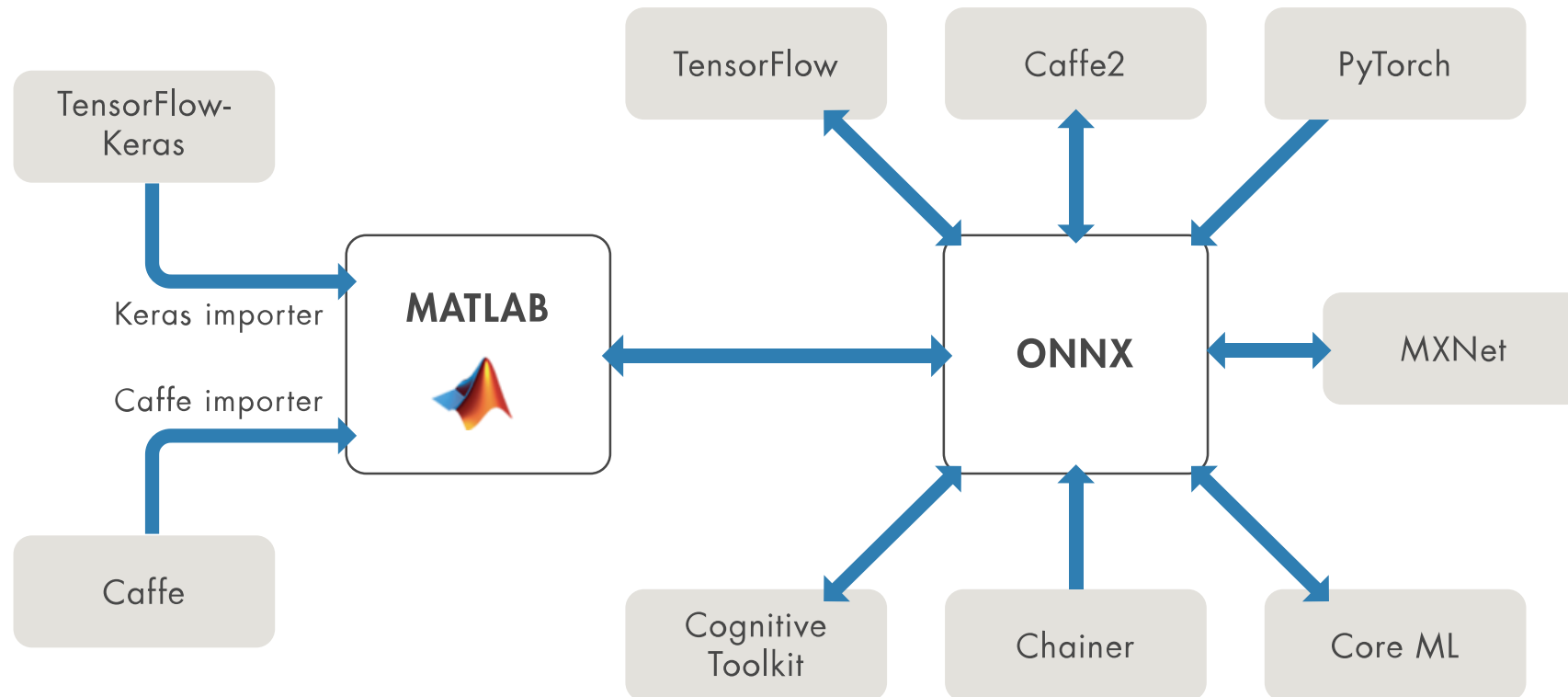
```
>>> x = 42.0
>>> x = float(42)
```

Create integer from MATLAB:

```
>> x = int32(42)
```

https://mathworks.com/help/matlab/matlab_external/passing-data-to-python.html

AI Model Interoperability



<https://www.mathworks.com/solutions/deep-learning/models.html>

Using Open-source with MATLAB Deep Network Designer

```
import torch
model = torch.hub.load('pytorch/vision:v0.10.0', 'alexnet', pretrained=True)
model.eval()
```

[2] ✓ 0.4s Python

... Using cache found in C:\Users\jpark/.cache\torch\hub\pytorch_vision_v0.10.0

```
AlexNet(
  (features): Sequential(
    (0): Conv2d(3, 64, kernel_size=(11, 11), stride=(4, 4), padding=(6, 6))
    (1): ReLU(inplace=True)
    (2): MaxPool2d(kernel_size=3, stride=2, padding=0, dilation=1, ceil_mode=False)
    (3): Conv2d(64, 192, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2))
    (4): ReLU(inplace=True)
    (5): MaxPool2d(kernel_size=3, stride=2, padding=0, dilation=1, ceil_mode=False)
    (6): Conv2d(192, 384, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (7): ReLU(inplace=True)
    (8): Conv2d(384, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
```

Using Open-source with MATLAB Deep Network Designer

The screenshot displays the MATLAB Deep Network Designer software interface. The main workspace shows a neural network diagram with the following components:

- input_1_Batc... VerifyBatchSiz...**: A batch size verification layer.
- imageinput**: An image input layer, currently selected. A tooltip indicates: "입력 크기 정수로 이루어진 행 벡터" (Input size is a row vector of integers).
- Conv_0 convolution2dL...**: A 2D convolution layer.

The **Layer library** on the left includes categories like **INPUT** and **CONVOLUTION AND FULLY C...**. The **Properties** panel on the right shows the configuration for the selected **imageInputLayer**:

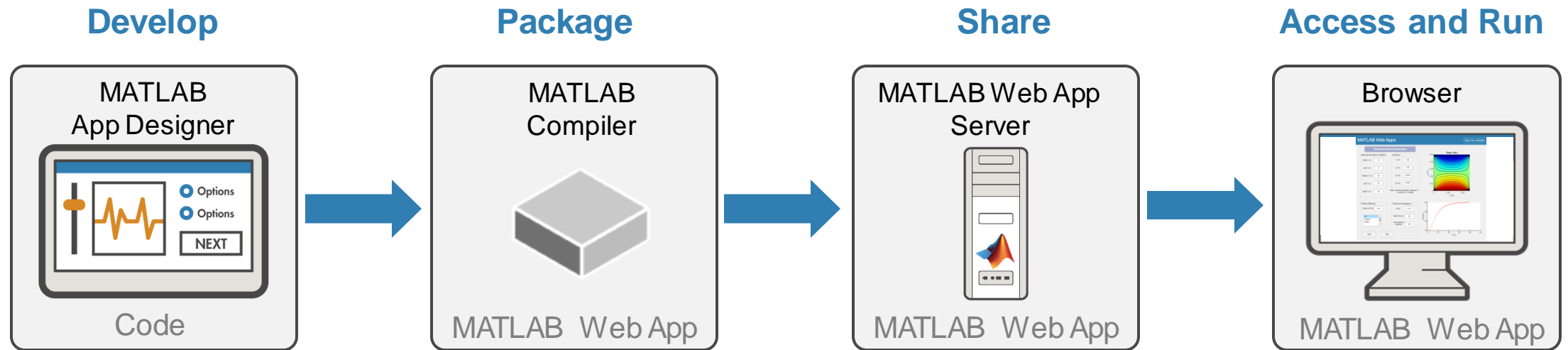
Property	Value
Name	imageinput
InputSize	1920,1080,3
SplitComplexInputs	<input type="checkbox"/>
Normalization	zerocenter
NormalizationDimension	auto
Mean	[]
StandardDeviation	[]
Min	[]

The **Overview** section at the bottom right shows a vertical bar representing the network's architecture.



Deployment

MATLAB Web App Server



MATLAB App Designer

App Development for Non-Programmers

The screenshot displays the MATLAB App Designer interface for an application titled "Air Quality Monitor". The interface is divided into several key areas:

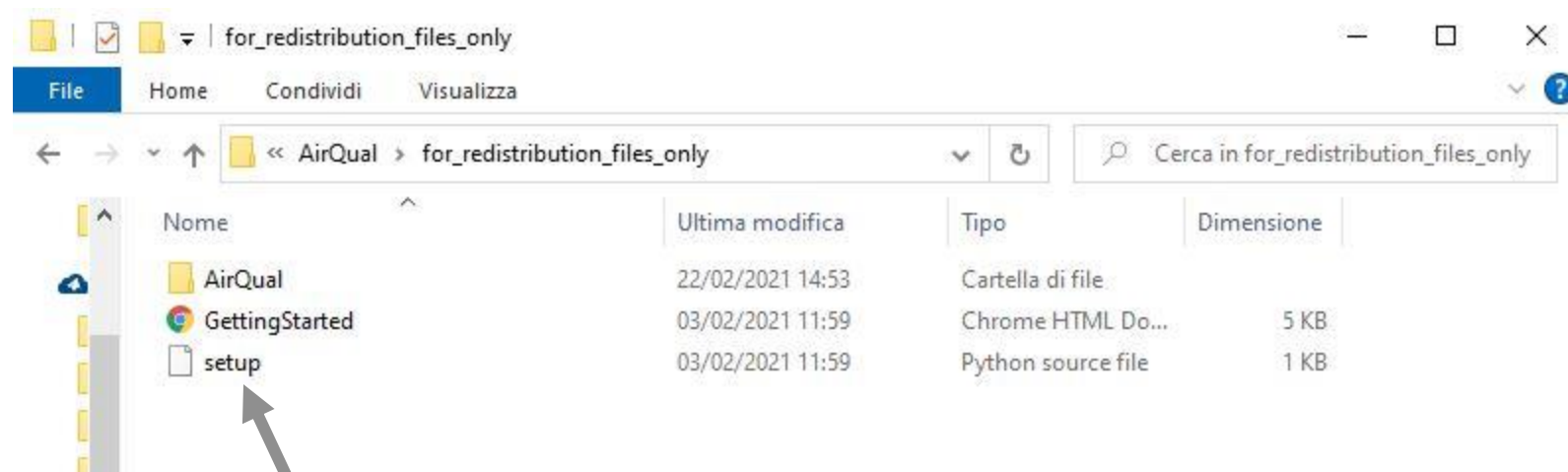
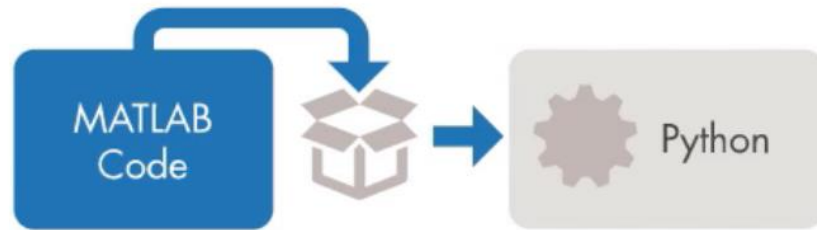
- Top Toolbar:** Includes standard file operations (Save, Copy, Paste, Print, Share), alignment tools (Apply Horizontally, Apply Vertically), and view options (Show grid, Show alignment hints, Snap to grid, Show resizing hints). A "Run" button is also present.
- Component Library (Left):** A panel containing various UI components categorized under "COMMON" and "CONTAINERS". Common components include Axes, Button, Check Box, Date Picker, Drop Down, Edit Field (Numeric), Edit Field (Text), HTML, Image, Label, List Box, Radio Button Group, Slider, Spinner, State Button, Table, Text Area, and Toggle Button Group.
- Design Canvas (Center):** The main workspace where the app is built. It features a title bar "Air Quality Monitor" and a plot area titled "Local Current Conditions". The plot shows a line graph with an x-axis labeled "X" ranging from 0 to 1 and a y-axis ranging from 0 to 1. Below the plot, there are input fields for "Location (US City)", "Temperature", "Pressure", "DewPoint", "RelativeHumidity", "WindDir", and "Wind Spd". An "Update" button is positioned next to the location field. A "Text Area" component is highlighted with a blue border, and an "HTML" component is also visible.
- Component Browser (Right):** A tree view showing the hierarchy of components in the app. The selected component is "app.TextArea", and its properties are displayed in the "Inspector" panel below it.
- Inspector (Right):** A panel for configuring the selected component's properties. It includes sections for "WordWrap DETAILS", "FONT AND COLOR", "CODE OPTIONS", "INTERACTIVITY", "POSITION", "CALLBACK EXECUTION CONTROL", "PARENT / CHILD", and "IDENTIFIERS".

Generate Python Library from MATLAB Functions

The image shows a workflow for generating a Python library from MATLAB functions. It consists of two main windows:

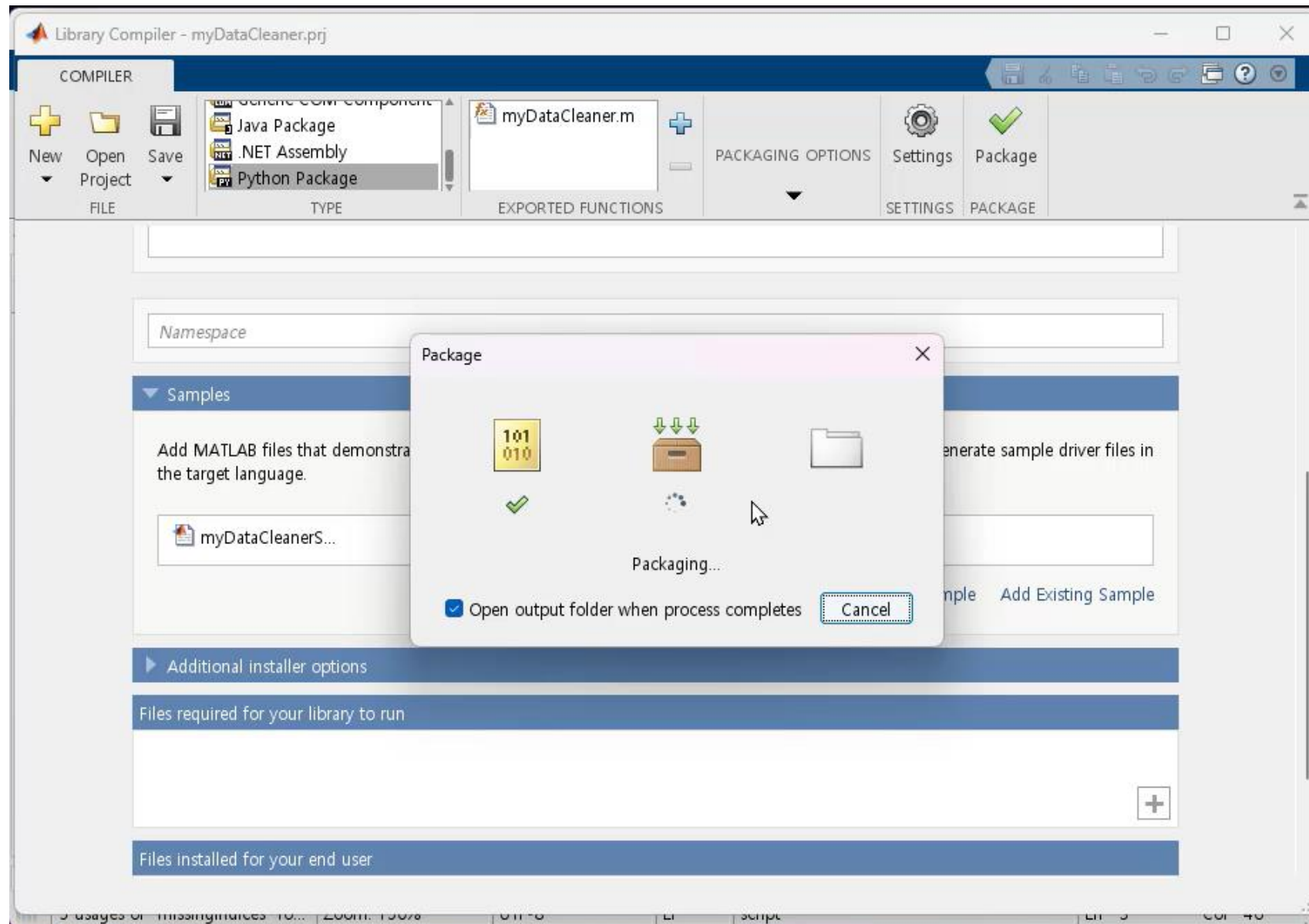
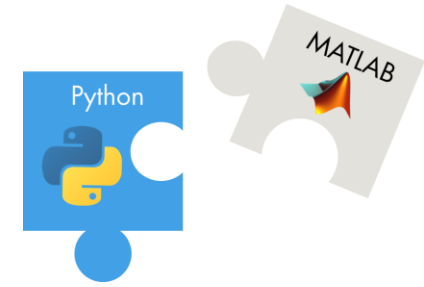
- Visual Studio Code:** The top window displays a Jupyter Notebook titled "CallMATLABfromPython.ipynb". The notebook content includes the heading "Deploy Python package with Compiler SDK" and a paragraph explaining the goal: "Export the SineFit MATLAB function to a Python Package to remove dependency to MATLAB in deployment". A link is provided: https://www.mathworks.com/help/compiler_sdk/python/pass-data-to-matlab-from-python.html. The interface shows standard VS Code controls and a Jupyter toolbar.
- Library Compiler:** The bottom window, titled "Library Compiler - AirQual.prj", shows the configuration for a Python package named "AirQual". The "Library information" section includes fields for "Author Name", "Email", "Company", "Summary", and "Description". The "Files required for your library to run" section lists dependencies: "airQualModel.mat", "backupdata.csv", "backupforecast.csv", "cities.mat", and "prepData.m". The "Files installed for your end user" section shows "AirQual" and "setup.py". A blue arrow points from the Library Compiler window towards the right, indicating the flow of the process.

Generate Python Library from MATLAB Functions



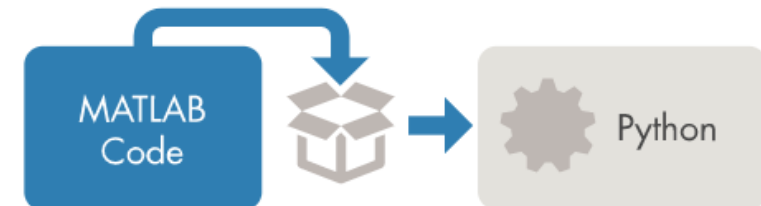
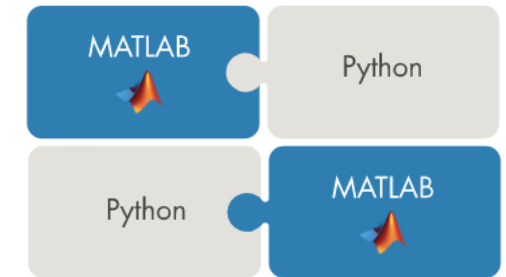
Install library

Running with MATLAB Runtime



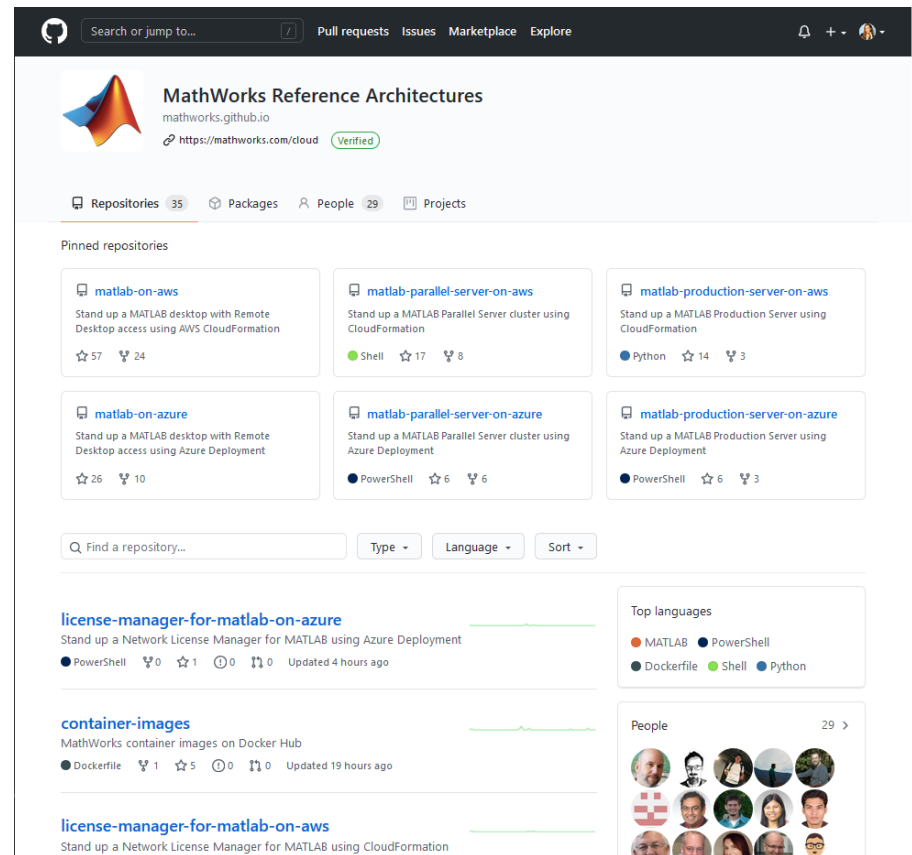
Summary: Using MATLAB with Python

- Data Sharing
 - Parquet
- Interoperability
 - Calling libraries written in Python from MATLAB
 - Calling MATLAB from Python
- AI
 - Great compatibility with Tensorflow, Pytorch, ONNX
- Deploy Apps & Algos
 - App Designer
 - MATLAB Compiler
 - Production API



Use MATLAB Reference Architectures for Easy Cloud Setup, Dockerfiles, and Interfaces to OSS

- <https://github.com/mathworks-ref-arch/matlab-dockerfile>

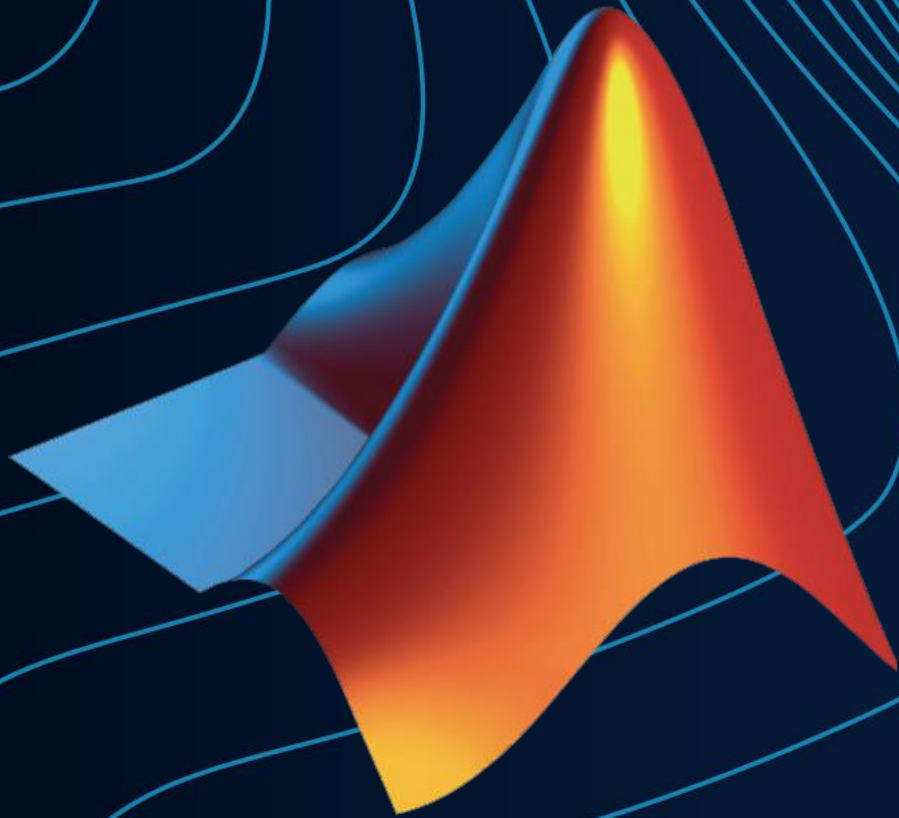


docker

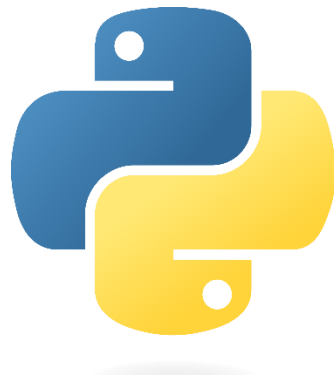
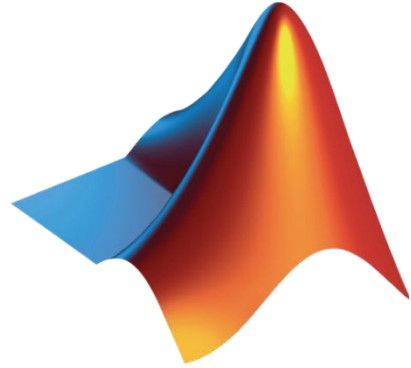
kafka

<https://github.com/mathworks-ref-arch>

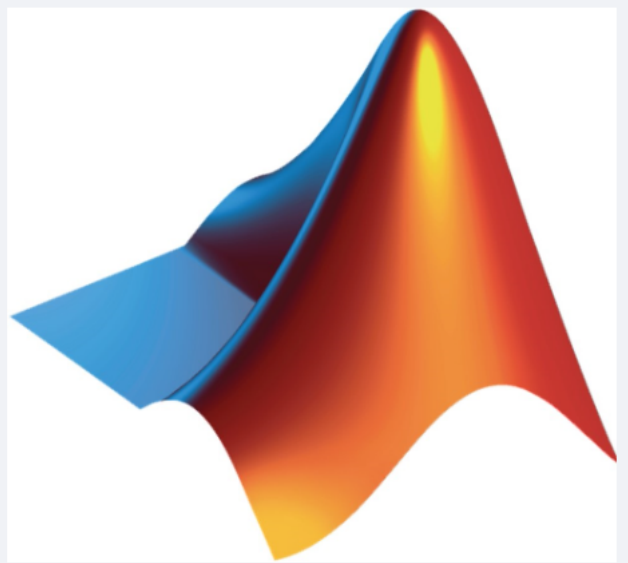
10 minute break



Demo Workflow




MATLAB



MATLAB or Python

Upload file


 Drag and drop file here
 Limit 200MB per file
 Browse files


sig1.wav 86.2KB
×

▶ 0:01 / 0:01

🔊 ⋮

Preprocess

▶ [...] ...

shape (96, 64)

Predict

새 탭

x

Streamlit

x

+



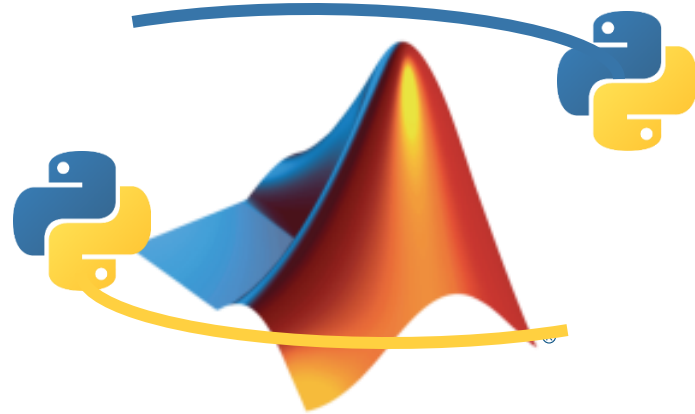
localhost:8502



게스트



Demo workflow

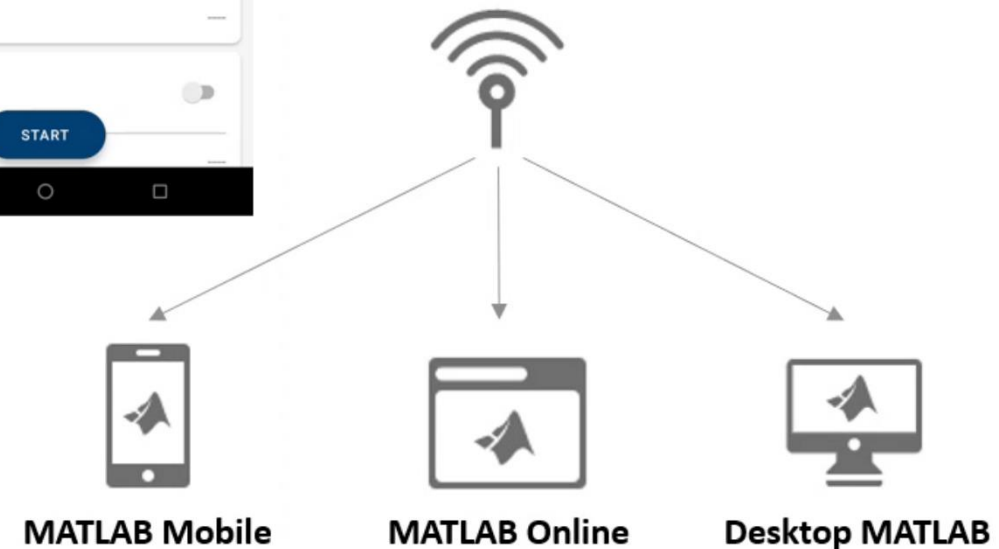
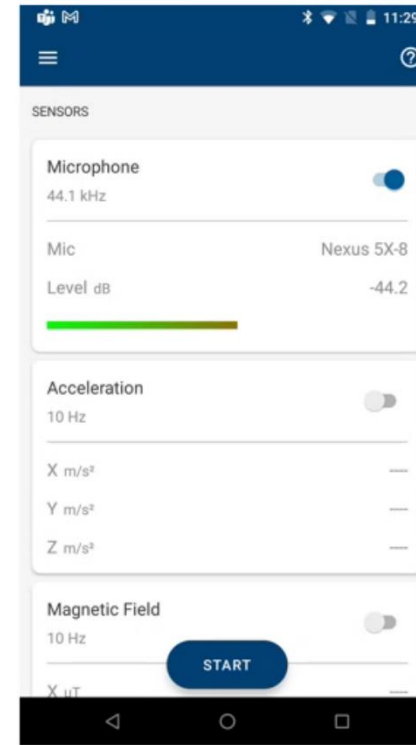


Use Your Mobile Devices to Acquire and Analyze Data



Data
Preparation

- `mobiledev` object to acquire data
 - microphone property
 - GPS
- Send data to MATLAB or MATLAB Online for analysis
- Available both in Android and iOS





 **Data
Preparation**



Data Preparation

MobileSensorData

새로 만들기 | ✂ | 📄 | 📁 | 🗑 | 정렬 | 보기 | ...

← → ↕ ↑ > MATLAB Drive > MobileSensorData MobileSensorData 검색 🔍

이름	수정한 날짜	유형	크기
sensorlog_matlab.m4a	2023-05-15 오후 9:44	WMP11.AssocFile...	78KB
sensorlog_matlab	2023-05-15 오후 9:44	MATLAB Data	1KB
sensorlog_matlab2.m4a	2023-05-15 오후 10:26	WMP11.AssocFile...	98KB
sensorlog_matlab2	2023-05-15 오후 10:26	MATLAB Data	1KB
sensorlog_python.m4a	2023-05-15 오후 9:44	WMP11.AssocFile...	80KB
sensorlog_python	2023-05-15 오후 9:44	MATLAB Data	1KB
sensorlog_python2.m4a	2023-05-15 오후 10:27	WMP11.AssocFile...	92KB
sensorlog_python2	2023-05-15 오후 10:27	MATLAB Data	1KB

8개 항목

Audio Data Preprocessing and Labeling



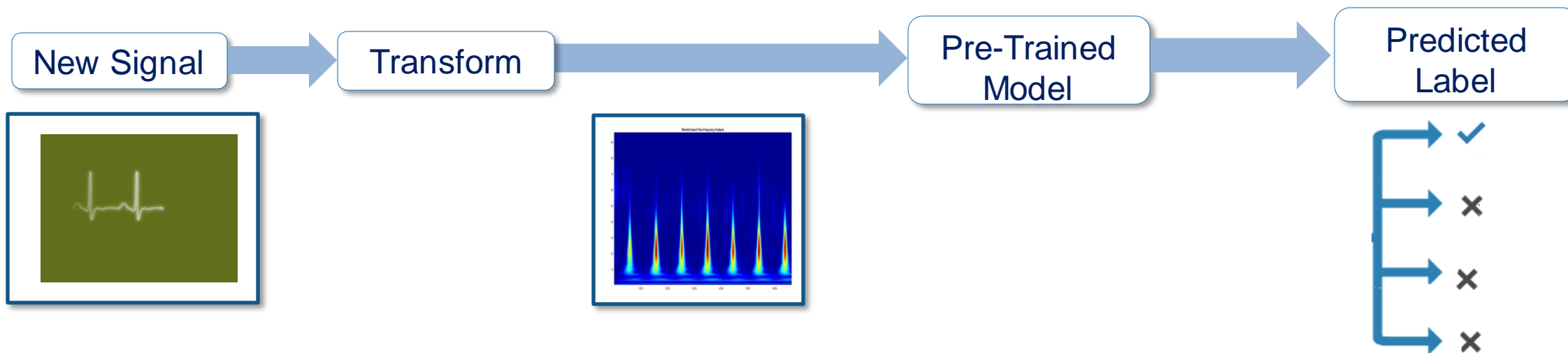
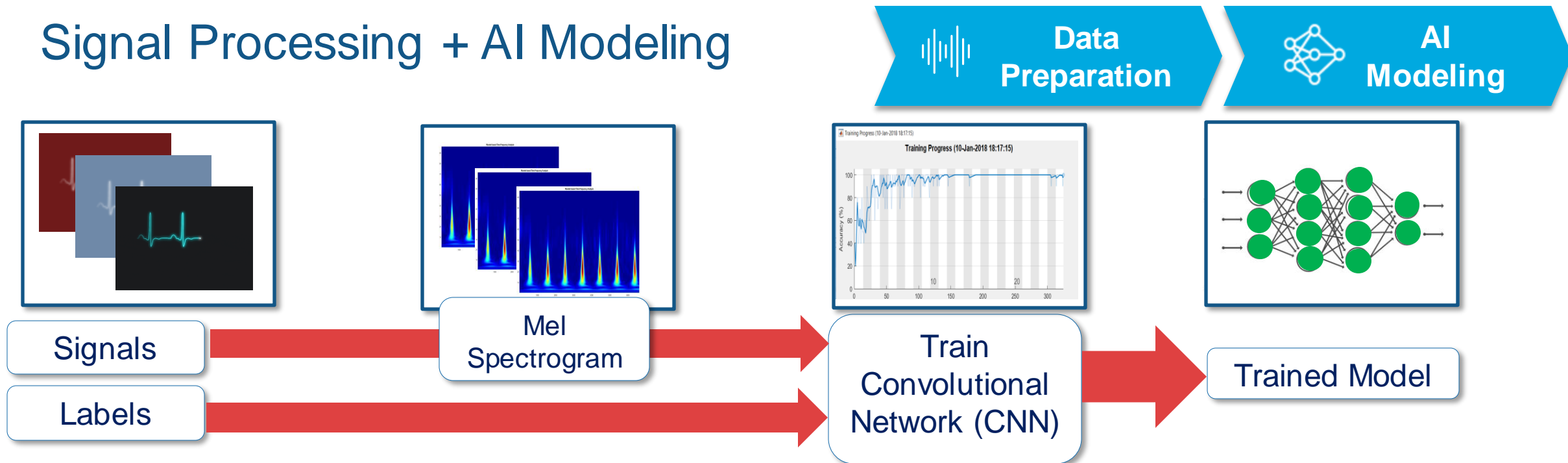
Data
Preparation

The screenshot shows a Windows File Explorer window with the following details:

- Address Bar:** > 내 PC > Windows (C:) > Git > audio
- Search Bar:** audio 검색
- Left Navigation Pane:**
 - 바탕 화면
 - 다운로드
 - 문서
 - 사진
 - 음악
 - 동영상
 - ipark
 - 02_DTE
 - Git
 - EXPO
 - audio
 - mbappe
 - sensorlog
 - MATLAB Drive
 - 내 PC
 - Windows (C:)
 - 네트워크
 - Linux
- Main Content Area (Files and Folders):**

File/Folder Name	Icon	Details
tfmodel	Folder	수정한 날짜: 2023-04-17 오후 2:47
yamnet	Folder	수정한 날짜: 2023-04-16 오후 8:23
.gitattributes	File	수정한 날짜: 2023-04-16 오후 8:23 크기: 507바이트 유형: Git Attributes 원본 파일
.gitignore	File	수정한 날짜: 2023-04-16 오후 8:23 크기: 98바이트 유형: Git Ignore 원본 파일
._audio	File	수정한 날짜: 2023-04-16 오후 8:23 크기: 109바이트 유형: PRJ 파일
a_preprocessing	File	마지막으로 저장한 날짜: 2023-05-15 오후 11:26 크기: 3.44KB
b_trainMATLABmodel	File	마지막으로 저장한 날짜: 2023-05-15 오후 12:35 크기: 500KB
breakfast	File	수정한 날짜: 2023-05-10 오후 6:08 크기: 227바이트 유형: Python 원본 파일
c_simulation	File	마지막으로 저장한 날짜: 2023-04-16 오후 8:23 크기: 27.1KB
c_testTensorFlowModel	File	수정한 날짜: 2023-04-27 오후 2:49 크기: 23.2KB 유형: Jupyter 원본 파일
d_audioApp	File	수정한 날짜: 2023-04-16 오후 8:23 크기: 7.45KB 유형: PRJ 파일
d_deployAudioPipeline	File	수정한 날짜: 2023-05-09 오후 11:12 크기: 262KB 유형: Jupyter 원본 파일
data.wav	File	길이: 00:00:01 크기: 86.1KB
myDataCleaner	File	수정한 날짜: 2023-05-10 오전 11:22

Signal Processing + AI Modeling



Data Preprocessing for Deep Learning



Data
Preparation



AI
Modeling

The screenshot shows a Windows File Explorer window with the following details:

- Address Bar:** 내 PC > Windows (C:) > Git > audio
- Search Bar:** audio 검색
- Files and Folders:**
 - .gitignore (유형: Git Ignore 원본 파일, 크기: 98바이트, 수정일: 2023-04-16 오후 8:23)
 - _audio (유형: PRJ 파일, 크기: 109바이트, 수정일: 2023-04-16 오후 8:23)
 - a_preprocessing (유형: Python 원본 파일, 크기: 3.44KB, 저장일: 2023-05-16 오전 12:31)
 - b_trainMATLABmodel** (유형: Jupyter 원본 파일, 크기: 515KB, 저장일: 2023-05-16 오전 12:34) - Selected
 - breakfast (유형: Python 원본 파일, 크기: 227바이트, 수정일: 2023-05-10 오후 6:08)
 - c_simulation (유형: Jupyter 원본 파일, 크기: 27.1KB, 저장일: 2023-04-16 오후 8:23)
 - c_testTensorFlowModel (유형: Jupyter 원본 파일, 크기: 23.2KB, 수정일: 2023-04-27 오후 2:49)
 - d_audioApp (유형: PRJ 파일, 크기: 7.45KB, 수정일: 2023-04-16 오후 8:23)
 - d_deployAudioPipeline (유형: Jupyter 원본 파일, 크기: 262KB, 수정일: 2023-05-09 오후 11:12)
 - data.wav (길이: 00:00:01, 크기: 86.1KB)
 - myDataCleaner (유형: Objective C 원본 파일, 크기: 633바이트, 수정일: 2023-05-10 오전 11:22)
 - myDataCleaner (유형: PRJ 파일, 크기: 6.69KB, 수정일: 2023-05-10 오후 12:33)
 - myDataCleanerSample2 (유형: Objective C 원본 파일, 크기: 214바이트, 수정일: 2023-05-10 오후 12:33)
 - README (유형: README 파일, 크기: 1.0KB, 수정일: 2023-04-16 오후 8:23)

Importing AI Model



AI Modeling

MATLAB R2023a

HOME PLOTS APPS LIVE EDITOR INSERT VIEW Search Documentation James

FILE NAVIGATE TEXT CODE SECTION RUN

Live Editor - C:\Git\audio#b_trainMATLABmodel.mlx

a_preprocessing.mlx b_trainMATLABmodel.mlx

Select Pretrained Network

Prepare and train the network interactively using [Deep Network Designer](#). To open Deep Network Designer, on the **Apps** tab, under **Machine Learning and Deep Learning**, click the app icon. Alternatively, you can open the app from the command line.

```
deepNetworkDesigner
```

Deep Network Designer provides a selection of pretrained audio classification networks. These models require both Audio Toolbox™ and Deep Learning Toolbox™.

Deep Network Designer Start Page

MATLAB Deep Network Designer

[Getting Started](#) | [Compare Pretrained Networks](#) | [Transfer Learning](#)

Zoom: 150% UTF-8 LF script

Importing Data and Training AI Model



AI Modeling

Deep Network Designer

DESIGNER

NEW BUILD NAVIGATE LAYOUT ANALYSIS EXPORT

Layer library

Filter layers...

- resize2dLayer (for reference input)
- resize3dLayer (for scale)
- resize3dLayer (for output size)
- resize3dLayer (for reference input)

OUTPUT

- softmaxLayer
- sigmoidLayer
- classificationLayer
- regressionLayer
- rpnSoftmaxLayer
- rcnnBoxRegressionLayer
- rpnClassificationLayer
- pixelClassificationLayer
- dicePixelClassificationLayer
- yolov2OutputLayer
- focalLossLayer

Designer Data Training

global_averag...
globalAverage...

fc
fullyConnected...

softmax
softmaxLayer

classoutput
classificationLa...

Properties

Input type	Image
Output type	Classification
Number of layers	86
Number of connections	85

Overview

Testing Trained AI Model in MATLAB



Simulation
and Test

The screenshot shows the MATLAB R2023a interface. The top menu bar includes HOME, PLOTS, APPS, LIVE EDITOR, INSERT, and VIEW. The ribbon contains various toolbars for file operations, navigation, text formatting, code execution, and running sections. The main workspace displays a Live Editor script with the following content:

```
Live Editor - C:\Git\audio\#b_trainMATLABmodel.mlx
a_preprocessing.mlx x b_trainMATLABmodel.mlx x +
training lab, select Export - Generate Code for Training. Examining the MATLAB code to learn how to
programmatically prepare the data for training, create the network architecture, and train the network.

Test Network
Classify the test data using the exported network and the classify function.

11 [audioIn,fs]=audioread('audiofiles/matlab/sig11.wav');
12 info.Label = "matlab";
13 info.SampleRate = fs;
14 [data,info] = audioPreprocess(audioIn,info)
15 classify(trainedNetwork_1,data{1})

16 [audioIn,fs]=audioread('audiofiles/python/sig11.wav');
17 info.Label = "python";
18 info.SampleRate = fs;
19 [data,info] = audioPreprocess(audioIn,info)
20 classify(trainedNetwork_1,data{1})
```

The status bar at the bottom indicates Zoom: 150%, UTF-8, LF, script, Ln 14, Col 44.

Testing Trained AI Model in Python



Simulation
and Test

The screenshot shows a Windows File Explorer window titled 'audio'. The address bar indicates the path: '내 PC > Windows (C:) > Git > audio'. The left sidebar shows the 'James - MathWorks' profile and various folders like '바탕 화면', '다운로드', '문서', '사진', '음악', '동영상', 'jpark', '02_DTE', 'Git', 'EXPO', 'audio', 'sensorlog', and 'data'. The main pane displays a list of files and folders with their details:

File Name	File Type	Last Modified	Size
_audio	PRJ 파일	수정한 날짜: 2023-04-16 오후 8:23	크기: 109바이트
a_preprocessing		마지막으로 저장한 날짜: 2023-05-16 오전 12:31	크기: 3.44KB
b_trainMATLABmodel		마지막으로 저장한 날짜: 2023-05-16 오전 3:58	크기: 524KB
breakfast	Python 원본 파일	수정한 날짜: 2023-05-10 오후 6:08	크기: 227바이트
c_simulation		마지막으로 저장한 날짜: 2023-04-16 오후 8:23	크기: 27.1KB
c_testTensorFlowModel	Jupyter 기본 파일	수정한 날짜: 2023-05-16 오전 4:09	크기: 22.9KB
d_audioApp	PRJ 파일	수정한 날짜: 2023-04-16 오후 8:23	크기: 7.45KB
d_deployAudioPipeline	Jupyter 원본 파일	수정한 날짜: 2023-05-09 오후 11:12	크기: 262KB
data.wav		길이: 00:00:01	크기: 86.1KB
myDataCleaner	Objective C 원본 파일	수정한 날짜: 2023-05-10 오전 11:22	크기: 633바이트
myDataCleaner	PRJ 파일	수정한 날짜: 2023-05-10 오후 12:33	크기: 6.69KB
myDataCleanerSample2	Objective C 원본 파일	수정한 날짜: 2023-05-10 오후 12:33	크기: 214바이트
README	Markdown 원본 파일	수정한 날짜: 2023-04-16 오후 8:23	크기: 3.01KB

The status bar at the bottom shows '28개 항목 1개 항목 선택함 22.9KB'. The taskbar at the very bottom includes 'Zoom: 150%', 'UIF-8', 'CRLF', 'audioPreprocess', and 'Ln 9'.

Testing Trained AI Model in Python with MATLAB



Simulation
and Test

```
c_testTensorFlowModel.ipynb •
C: > Git > audio > c_testTensorFlowModel.ipynb > M+Test TensorFlow Model > M+Use test data > id = np.argmax(Y)
+ Code + Markdown | ▶ Run All ≡ Clear All Outputs ↺ Restart | 📄 Variables ☰ Outline ... Python 3.10.4
```

Use MATLAB Engine

```
[1] import matlab.engine
    m = matlab.engine.connect_matlab()

[2] (audioIn,fs)=m.audioread('audiofiles/matlab/sig11.wav', nargout=2)

[3] info = {"Label" : "matlab","SampleRate" : fs}

[4] m.cd('mlmodel')
```

Deploying as Python Package from MATLAB



Deployment

MATLAB R2023a

HOME PLOTS APPS LIVE EDITOR INSERT VIEW

New Script New Live Script New Open Find Files Import Data Clean Data Variable Save Workspace Clear Workspace Analyze Code Run and Time Clear Commands Simulink Layout Preferences Set Path Add-Ons Help Community Request Support Learn MATLAB

FILE VARIABLE CODE SIMULINK ENVIRONMENT RESOURCES

C:\Git\audio

Live Editor - C:\Git\audio\b_trainMATLABmodel.mlx

a_preprocessing.mlx b_trainMATLABmodel.mlx audioPipeline.m audioPreprocess.m predFcn.m

pretrained network. Each input signal generates multiple spectrograms, so the labels must be duplicated to create a one-to-one correspondence with the spectrograms.

```

33 function [data,info] = audioPreprocess(audioIn,info)
34 class = info.Label;
35 fs = info.SampleRate;
36 features = yamnetPreprocess(audioIn,fs);
37
38 numSpectrograms = size(features,4);
39
40 data = cell(numSpectrograms,2);
41 for index = 1:numSpectrograms
42     data{index,1} = features(:,:,:,index);
43     data{index,2} = class;
44 end
45 end

```

Workspace

Name	Value
accuracy	1
ads	1x1 audioDatastore
adsTest	1x1 audioDatastore
adsTrain	1x1 audioDatastore
adsValidation	1x1 audioDatastore
ans	6x2 cell
audioln	16001x1 double
bacon	6x2 cell
cheese	6x1 string
data	6x2 cell
dataFolder	'audiofiles'
fs	16000
info	1x1 struct
LATTE	4x2 cell
layers_1	86x1 Layer
mellImage	1x2 cell
tdsTest	1x1 TransformedDatastore
tdsTrain	1x1 TransformedDatastore
tdsValidation	1x1 TransformedDatastore
tmp	6x2 cell
tmp_label	1x6 string
trainedNetwork_1	1x1 SeriesNetwork
trainInfoStruct_1	1x1 struct
YPred	6x1 categorical
YTest	1x6 categorical

4 usages of "info" found

Zoom: 150% UTF-8 LF script Ln 32 Col 25

Testing Python Package

**Deployment**

```
d_deployAudioPipeline.ipynb • c_testTensorFlowModel.ipynb •
C: > Git > audio > d_deployAudioPipeline.ipynb > M+Deploy audio pipeline > M+Python Package > import audioApp
+ Code + Markdown | ▶ Run All ☰ Clear All Outputs ↺ Restart | 📄 Variables ☰ Outline ... Python 3.10.4
```

Deploy audio pipeline

Python Package

```
cd audioApp\for_redistribution_files_only
python setup.py install
```

```
[1] import audioApp
    app = audioApp.initialize()
```

```
[2] data = app.audioPipeline('audiofiles/matlab/sig11.wav')
    data[1] # Label field should be empty at this stage
```

Ln 1, Col 16

Deploying Python Package as WebApp



Deployment

The screenshot shows a Windows File Explorer window titled 'audio' with the address bar showing the path '내 PC > Windows (C:) > Git > audio'. The left sidebar shows the navigation pane with 'James - MathWorks' and various folders like '바탕 화면', '다운로드', '문서', '사진', '음악', '동영상', 'jpark', '02_DTE', 'Git', 'audio', 'data', 'mlmodel', and 'Video'. The main pane displays a list of files and folders:

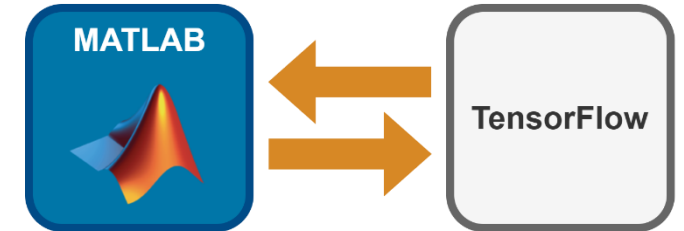
File Name	File Type	Size	Last Modified
breakfast	Python 원본 파일	227바이트	2023-05-10 오후 6:08
c_simulation		27.1KB	2023-04-16 오후 8:23
c_testTensorFlowModel	Jupyter 원본 파일	22.9KB	2023-05-16 오전 4:09
d_audioApp	PRJ 파일	7.35KB	2023-05-16 오전 4:43
d_deployAudioPipeline	Jupyter 원본 파일	262KB	2023-05-16 오전 4:47
data.wav		86.1KB	00:00:01
myDataCleaner	Objective C 원본 파일	633바이트	2023-05-10 오전 11:22
myDataCleaner	PRJ 파일	6.69KB	2023-05-10 오후 12:33
myDataCleanerSample2	Objective C 원본 파일	214바이트	2023-05-10 오후 12:33
README	Markdown 원본 파일	3.01KB	2023-04-16 오후 8:23
streamlit_app	Python 원본 파일	905바이트	2023-05-15 오후 12:26
string(YTest)		17바이트	2023-05-16 오전 3:40
workingWithMATLAB	Jupyter 원본 파일	3.91KB	2023-05-10 오후 5:27

The 'streamlit_app' file is selected, indicated by a blue checkmark in the left margin. The status bar at the bottom shows '28개 항목 17개 항목 선택함 905바이트'.

AI Interoperability - Demos

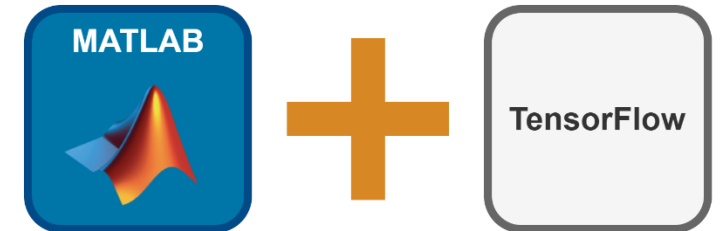
- Converting TensorFlow & PyTorch models into MATLAB

github.com/matlab-deep-learning/Image-Classification-in-MATLAB-Using-Converted-TensorFlow-Model



- Co-executing TensorFlow & PyTorch with MATLAB

github.com/matlab-deep-learning/Image-Classification-in-MATLAB-Using-TensorFlow



AI Interoperability - Examples

- [Hyperparameter Tuning in MATLAB using Experiment Manager & TensorFlow](#)



- [Automate Labeling in Image Labeler using a Pretrained TensorFlow Object Detector](#)



- [Use a Python Speech Command Recognition System in MATLAB](#)

MATLAB EXPO

Thank you



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