Doğukan M. KILINÇ

Yapay Zeka ve Makine Öğrenmesi Mühendisi

Pamukkale Üniversitesi

29.09.2025

MATLAB ile Yapay Zeka

FİGES applied physics & mathematics | MathWorks Authorized Reseller

Agenda

01 Introduction

- What is MATLAB?
- MATLAB for Artificial Intelligence

02 What is Machine Learning?

- Machine Learning Workflow
- Machine Learning vs Deep Learning
- Types of Machine Learning

03 Statistics and Machine Learning Introduction & Toolbox

- Classification Learner App
- Regression Learner App
- Clustering

04 What is Deep Learning?

- Deep Learning Workflow

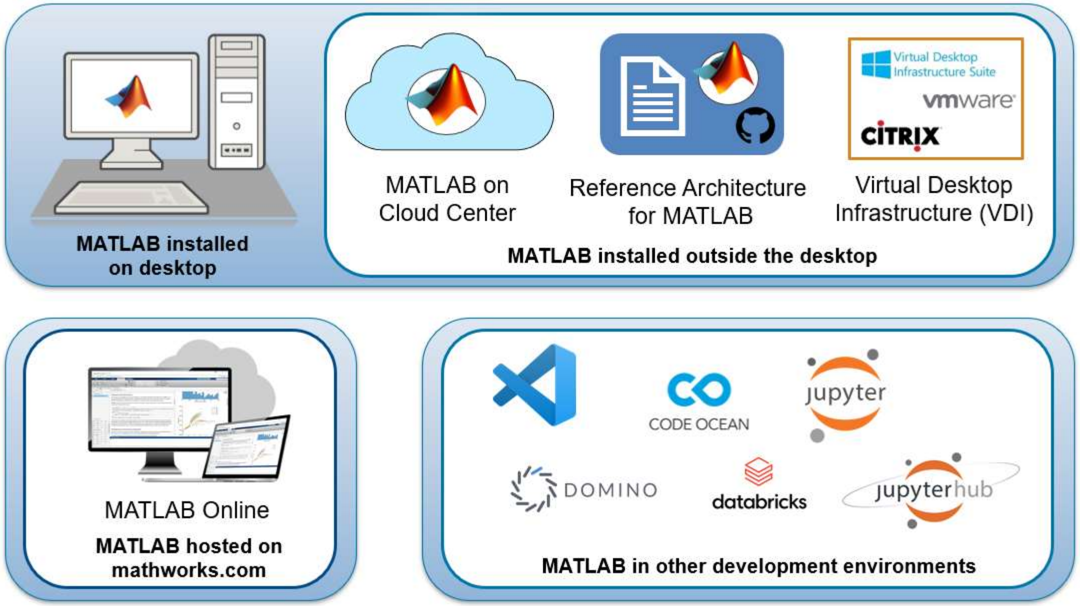
Example: Deployment Algorithm to Microprocessor

Example for PAÜ: Deep Learning for Signals

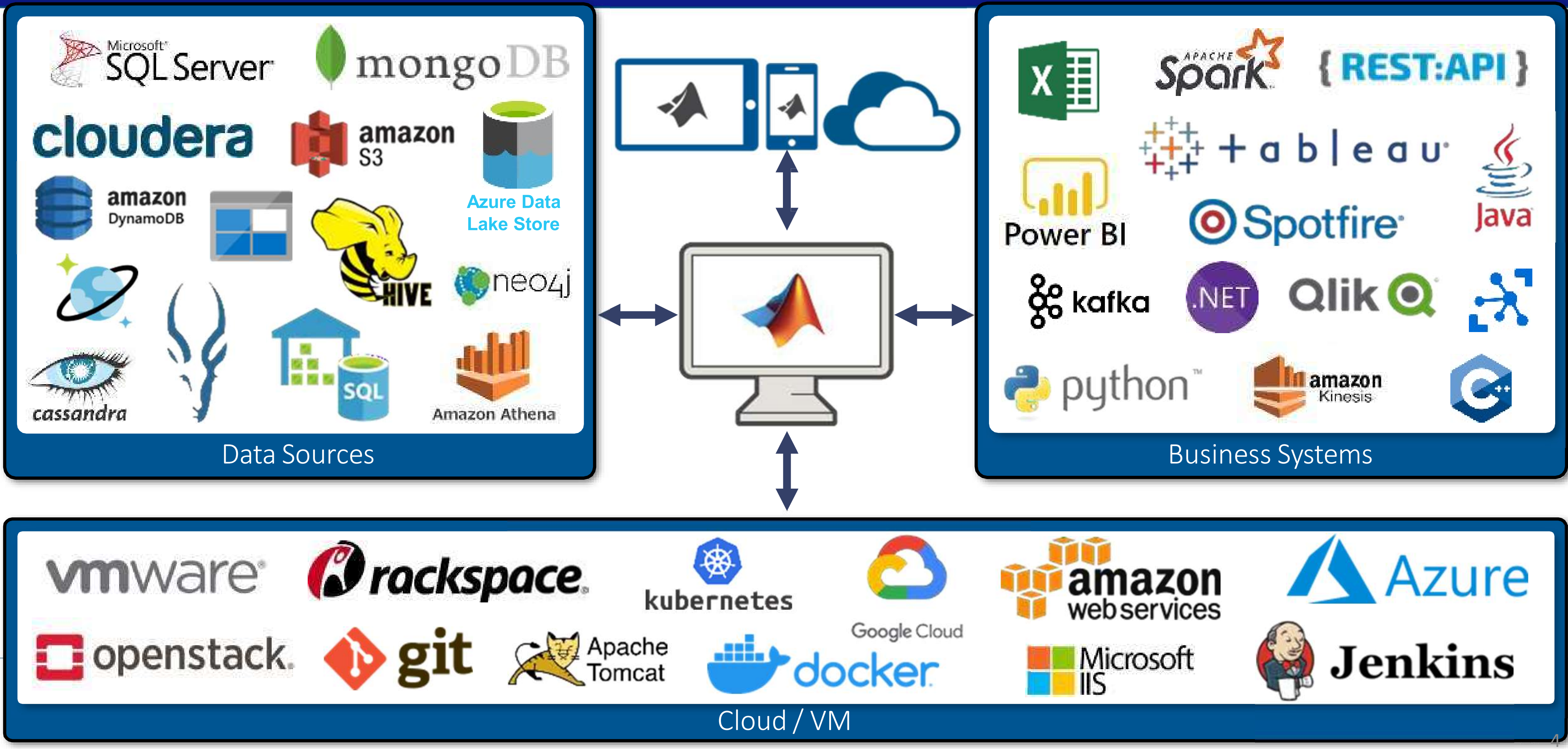
Example for PAÜ: Code Generation for ECG Data Project

What is MATLAB?

➢ Interactive Development Environment

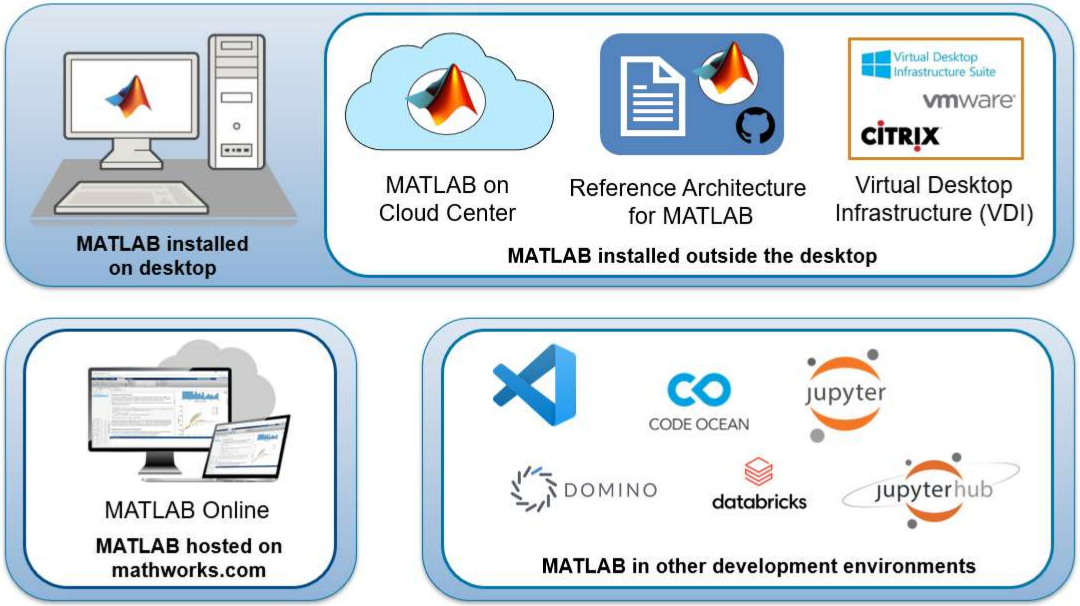


MATLAB and the Analytics Ecosystem



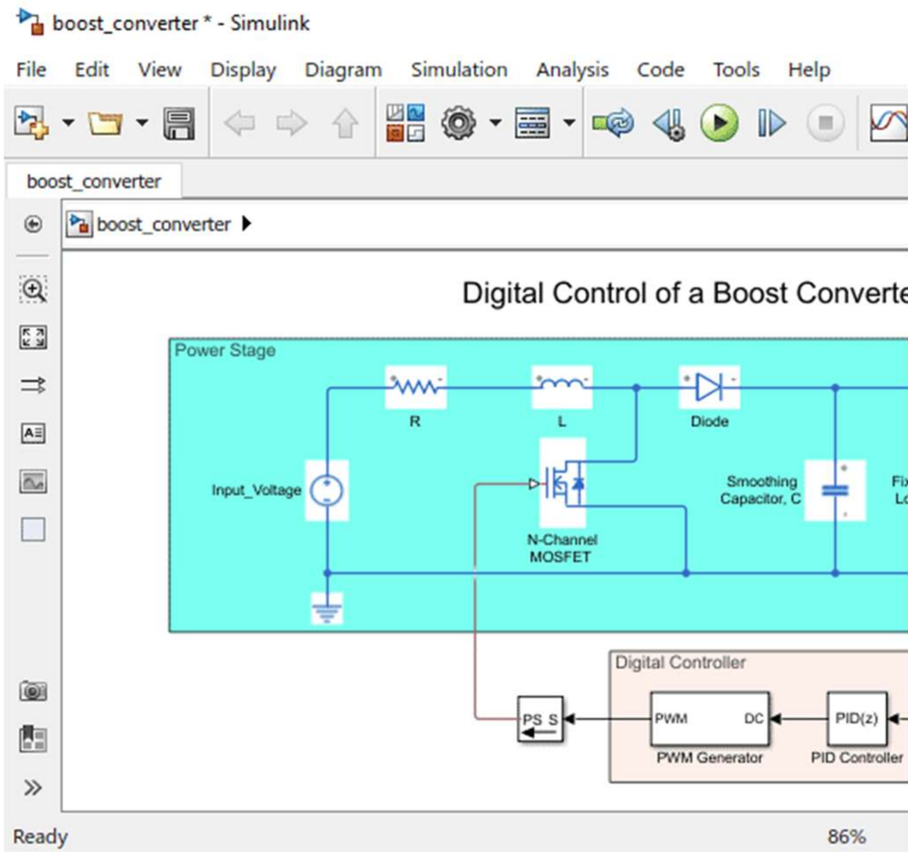
What is MATLAB?

- ➢ Interactive Development Environment
- ➢ Technical Computing Language
- ➢ Data Analysis and Visualization
- ➢ Algorithm Devlopment and Application Development

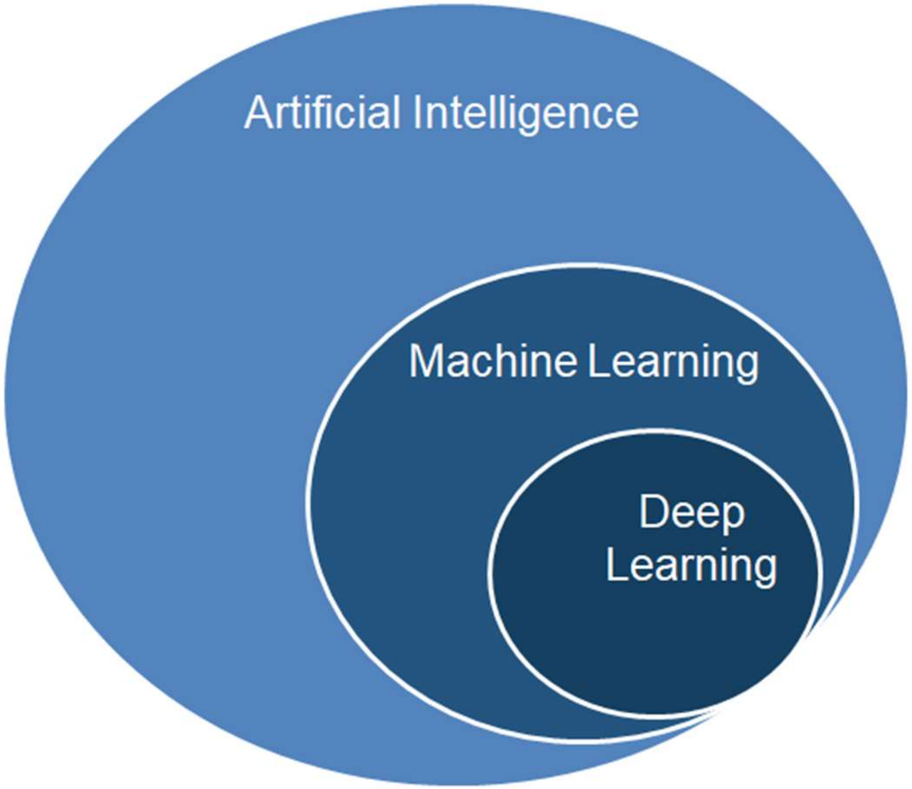


What is Simulink?

- Graphical environment
- Integration with MATLAB
- Multi-domain modelling
- Simulation and validation
- Model-Based Design



MATLAB for Artificial Intelligence



- Machine Learning
- Deep Learning
- Image Processing
- Reinforcement Learning
- Predictive Maintenance
- Data Science / Data Analytics
- Signal Processing
- ...and more

Machine Learning is Everywhere

Solution is too complex for hand written rules or equations

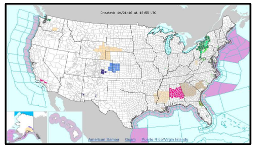
Speech Recognition


Object Recognition


Engine Health Monitoring

learn complex non-linear relationships

Solution needs to adapt with changing data

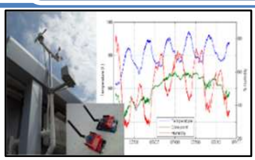

Weather Forecasting


Energy Load Forecasting

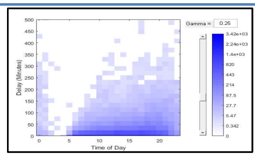

Stock Market Prediction

update as more data becomes available

Solution needs to scale

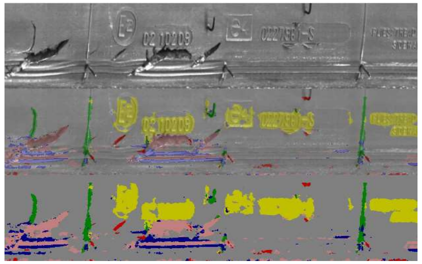

IoT Analytics

Taxi Availability


Airline Flight Delays

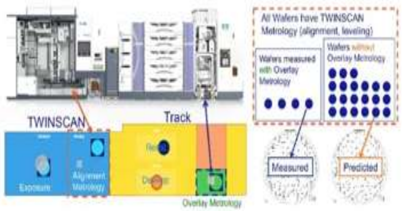
learn efficiently from very large data sets

Machine Learning is Everywhere



Tire Wear

BRIDGESTONE



Overlay metrology improvement

ASML

Telecom customer churn prediction

Cognizant

Forecasting & Risk Analysis

HORIZON WIND POWER

Detect Oversteer

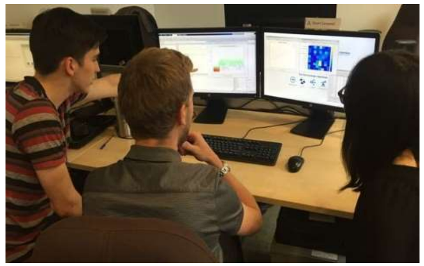
BMW

Monitor Deployed Compressors using Digital Twin

Atlas Copco

Building energy use optimization

BuildingIQ



Portfolio Allocation

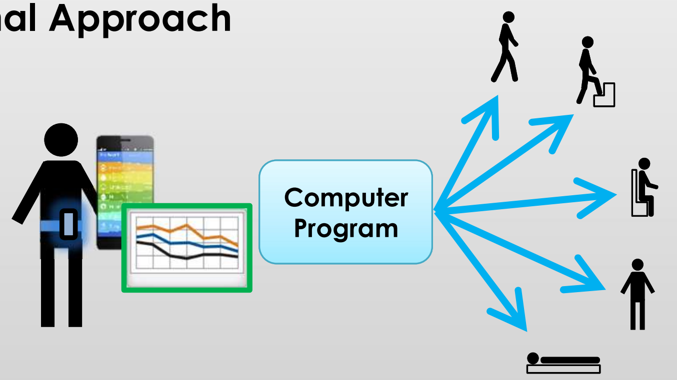
Aberdeen Asset management

What is Machine Learning?

Machine learning uses **data** and produces a **program** to perform a **task**

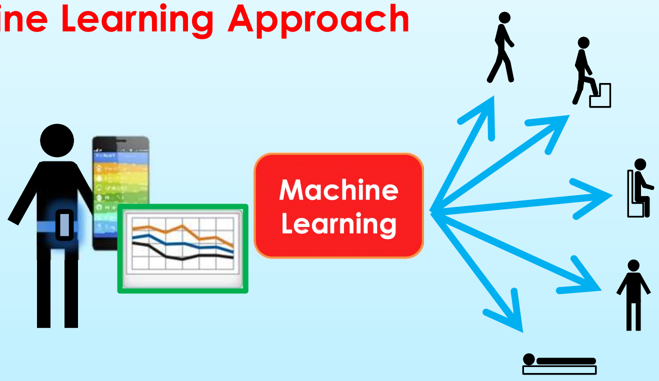
Task: Human Activity Detection

Traditional Approach



Hand Written Program	Formula or Equation
If X_acc > 0.5 then "SITTING" If Y_acc < 4 and Z_acc > 5 then "STANDING" ...	$Y_{activity}$ $= \beta_1 X_{acc} + \beta_2 Y_{acc}$ $+ \beta_3 Z_{acc} +$ ...

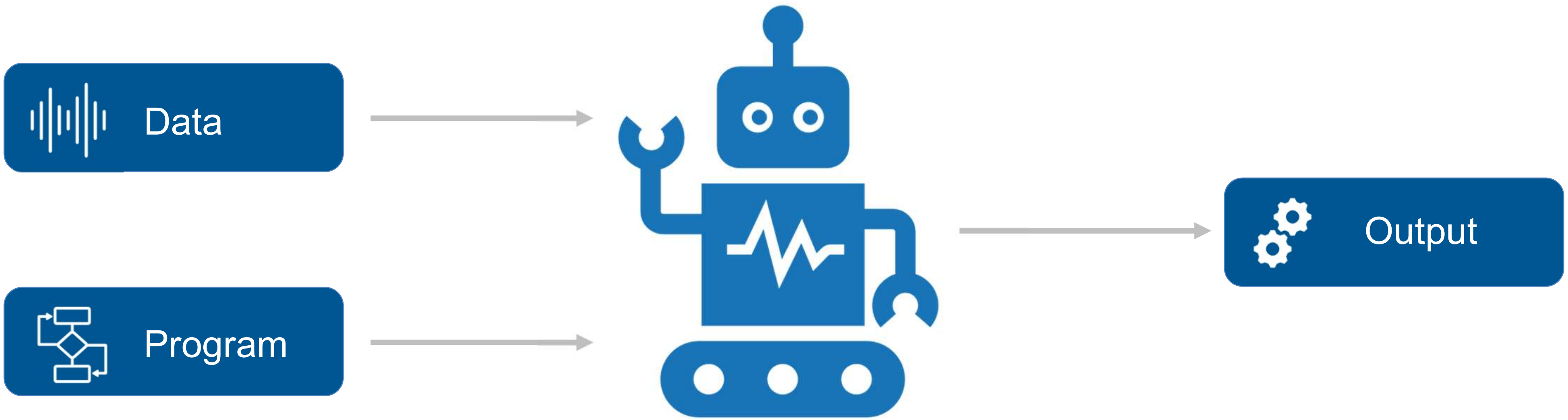
Machine Learning Approach



$$model: \text{Inputs} \rightarrow \text{Outputs}$$

$$model = < \begin{matrix}\text{Machine} \\ \text{Learning} \\ \text{Algorithm}\end{matrix} > (sensor\_data, activity)$$

There are two ways to get a robot to do what you want



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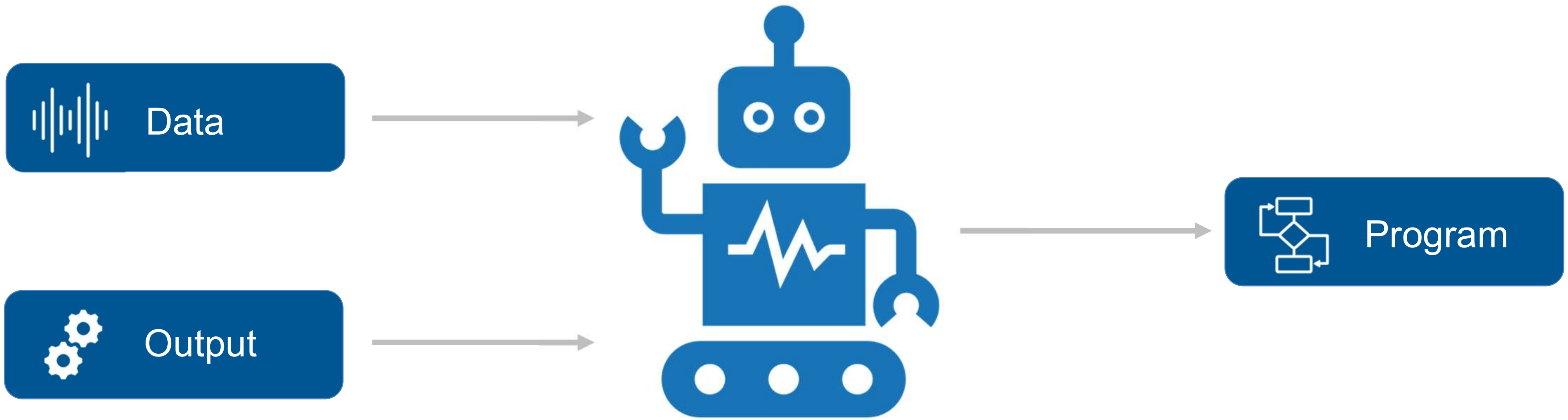

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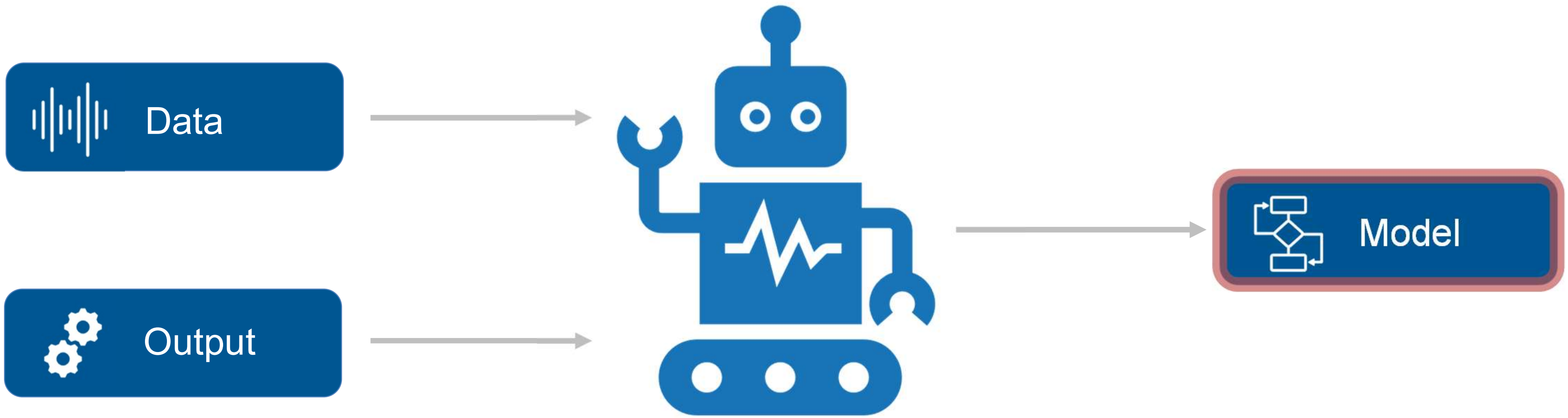

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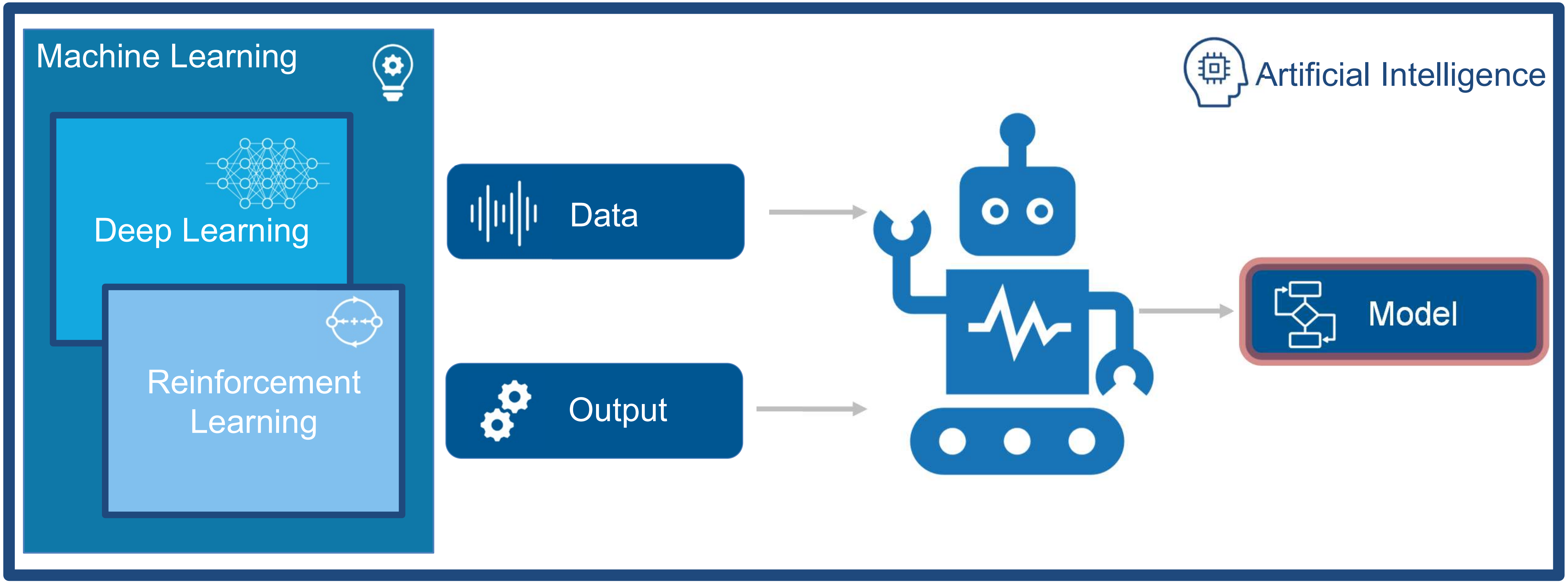
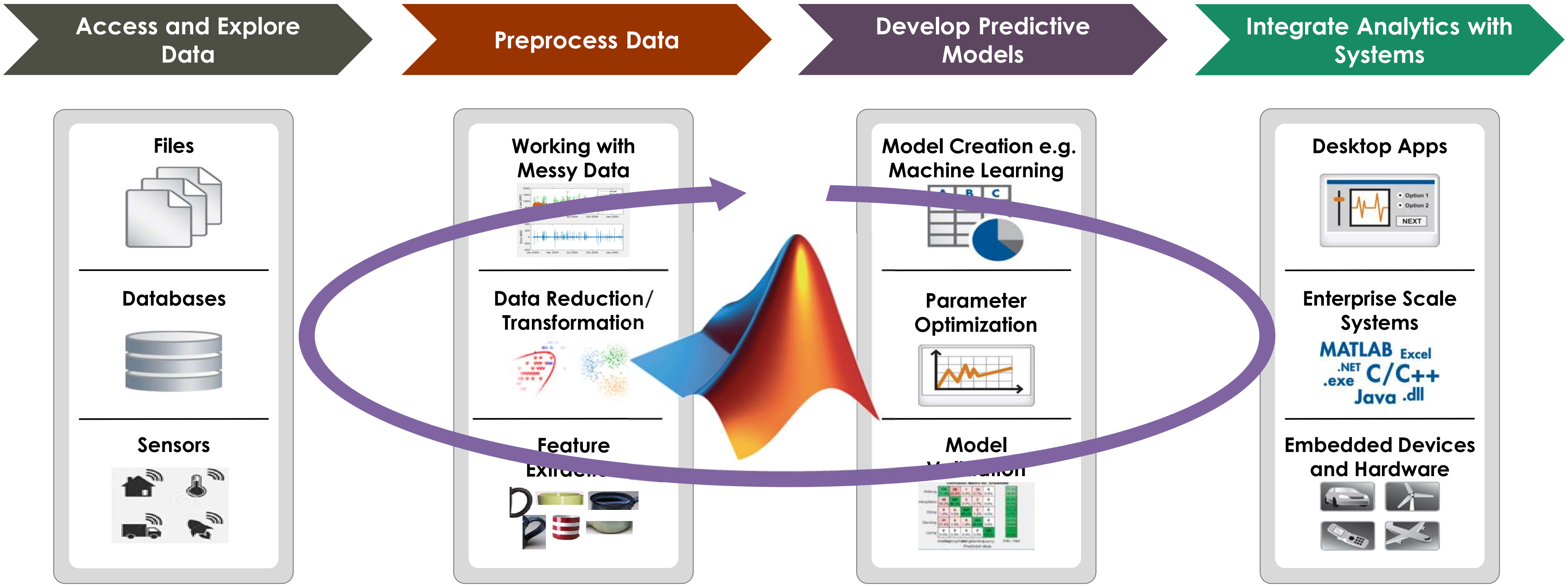


Machine Learning Workflow



Types of Machine Learning

Type of Learning | **Categories of Algorithms**

Machine Learning → **Supervised Learning** → **Regression** / **Classification**

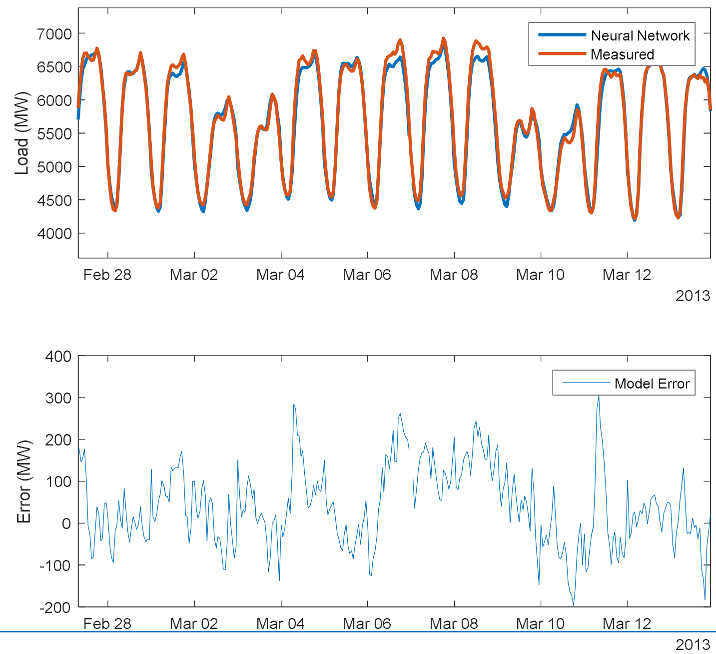
Develop **predictive model** based on both **input and output** data

- Linear Regression, Generalized Linear Regression, Nonlinear Regression, Mixed-Effects, Stepwise, Gaussian Process Regression

- Output is a real number (temperature, stock prices).

Objective:

Easy and accurate computation of day-ahead system load forecast



Types of Machine Learning

Type of Learning | **Categories of Algorithms**

Machine Learning

Supervised Learning

Develop **predictive model** based on both **input and output** data

Regression

Classification

- Decision Trees, Nearest Neighbor, Support Vector Machines, Ensemble Methods, Discriminant Analysis

- Output is a choice between classes
- (True, False) (Red, Blue, Green)

Objective:

Train a classifier to classify human activity from sensor data

Data:

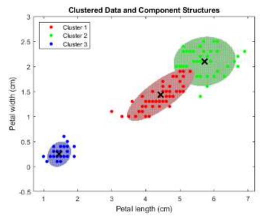
Inputs	3-axial Accelerometer 3-axial Gyroscope 
Outputs	

Types of Machine Learning

Type of Learning | **Categories of Algorithms**

- **Machine Learning**
  - **Supervised Learning** — Develop **predictive model** based on both **input and output** data
    - **Regression**
    - **Classification**
  - **Unsupervised Learning** — Discover an **internal representation** from **input data** only
    - **Clustering**

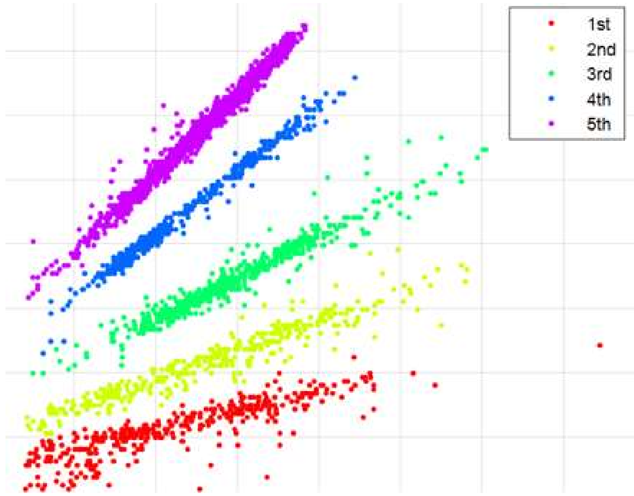
- Hierarchical clustering, k-means clustering, Gaussian micture models, Spectral clustering



Objective:

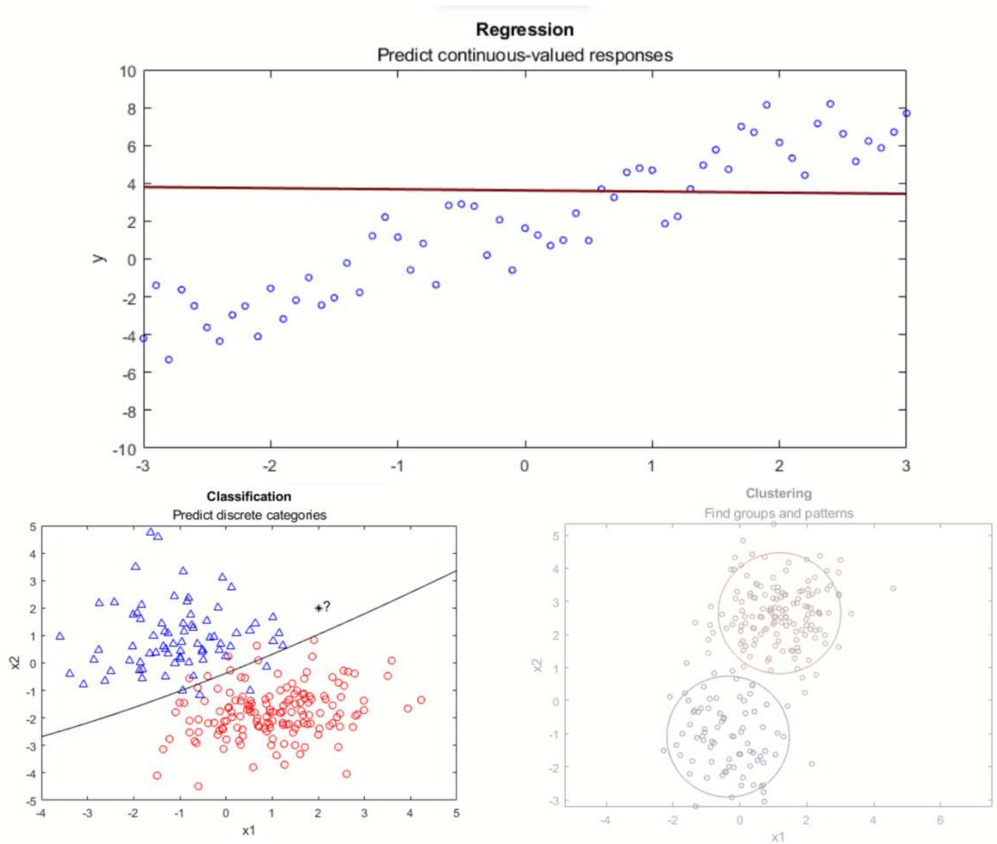
Given data for engine speed and vehicle speed, identify clusters

- Discover a good internal representation
- Learn a low dimensional representation

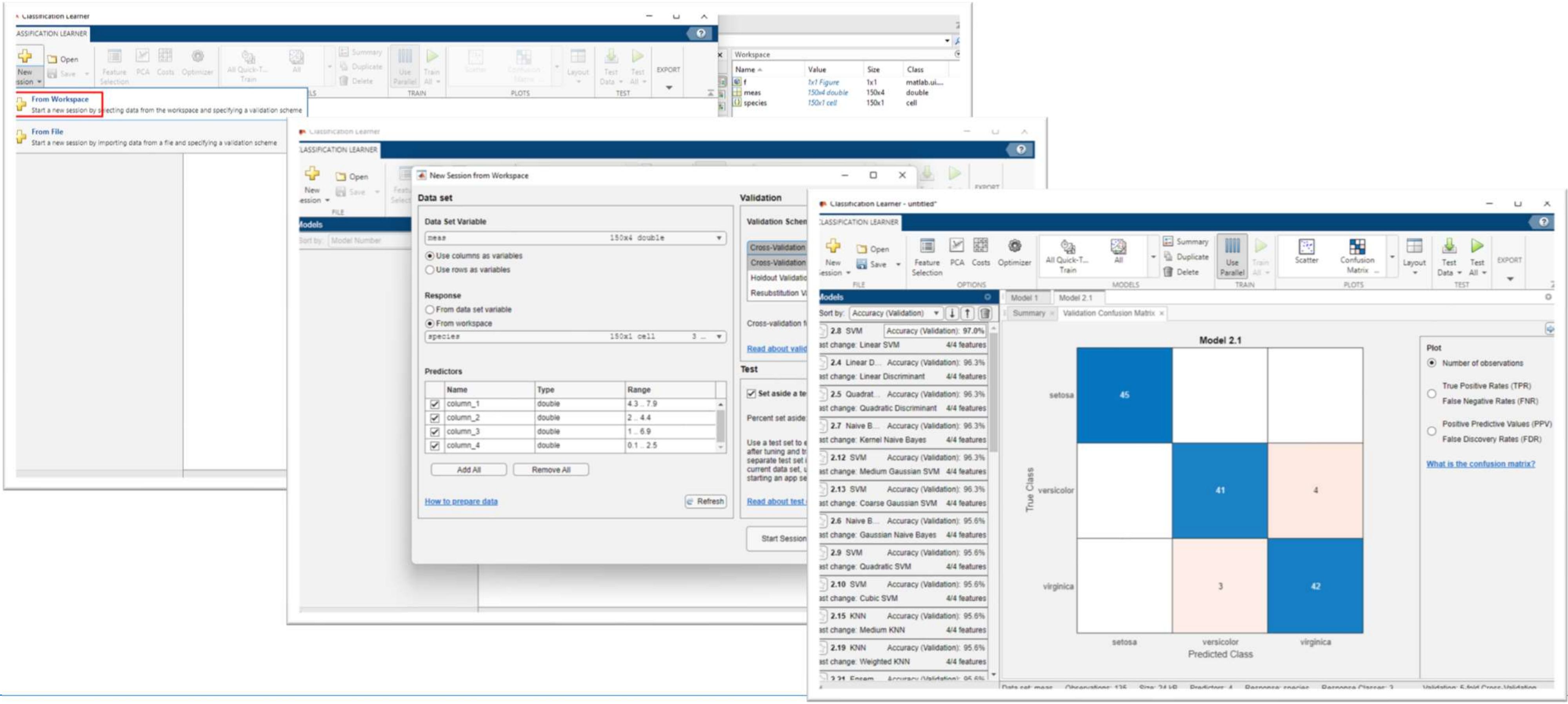


Statistic and Machine Learning Toolbox

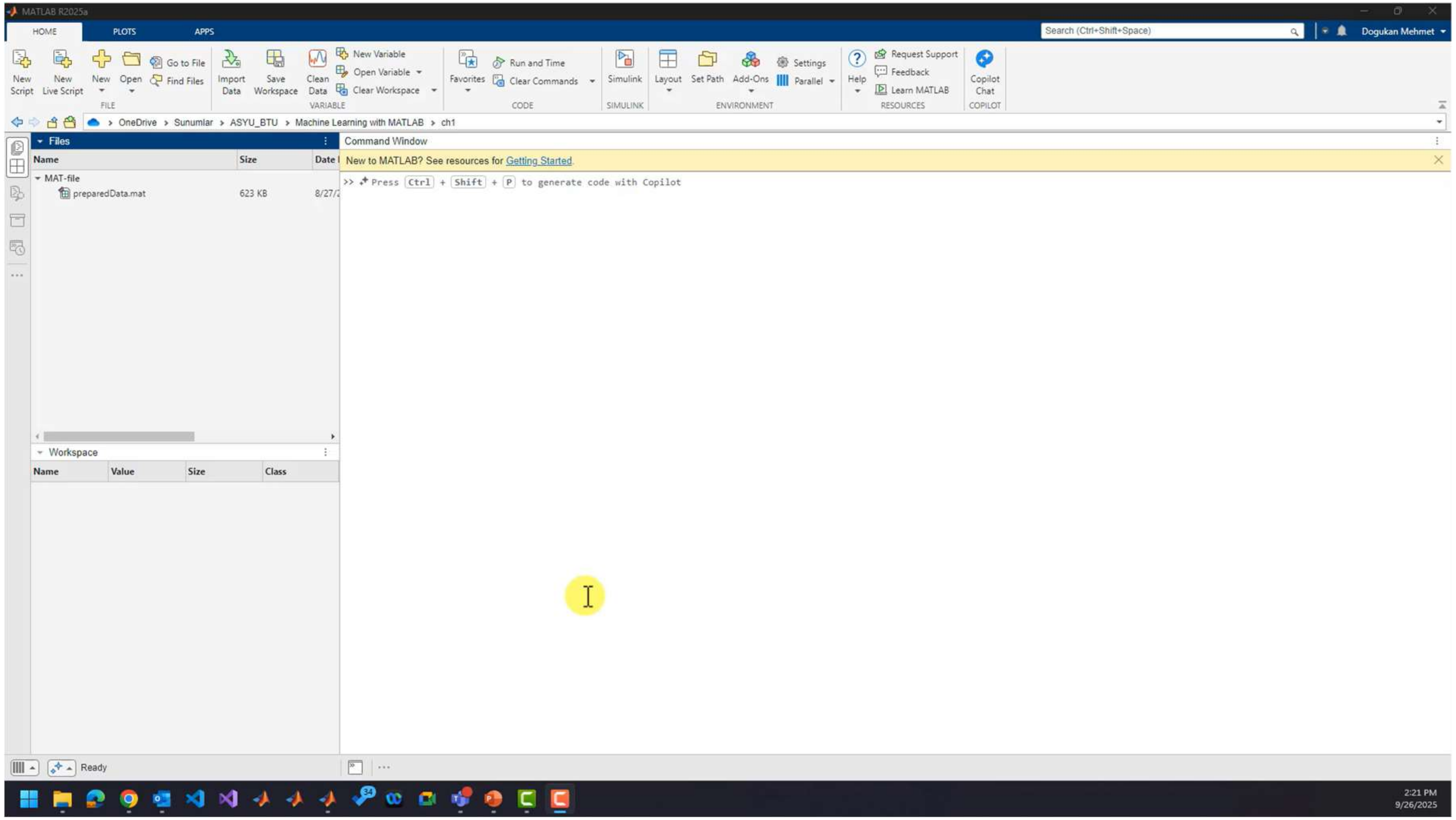
- ✓ Provides functions and apps to describe, analyze, and model data. Use descriptive statistics, visualizations, and clustering for exploratory data analysis; fit probability distributions to data.
- ✓ Regression and classification algorithms let you draw inferences from data and build predictive models either interactively, using the Classification and Regression Learner apps, or programmatically, using AutoML.



Classification Learner App

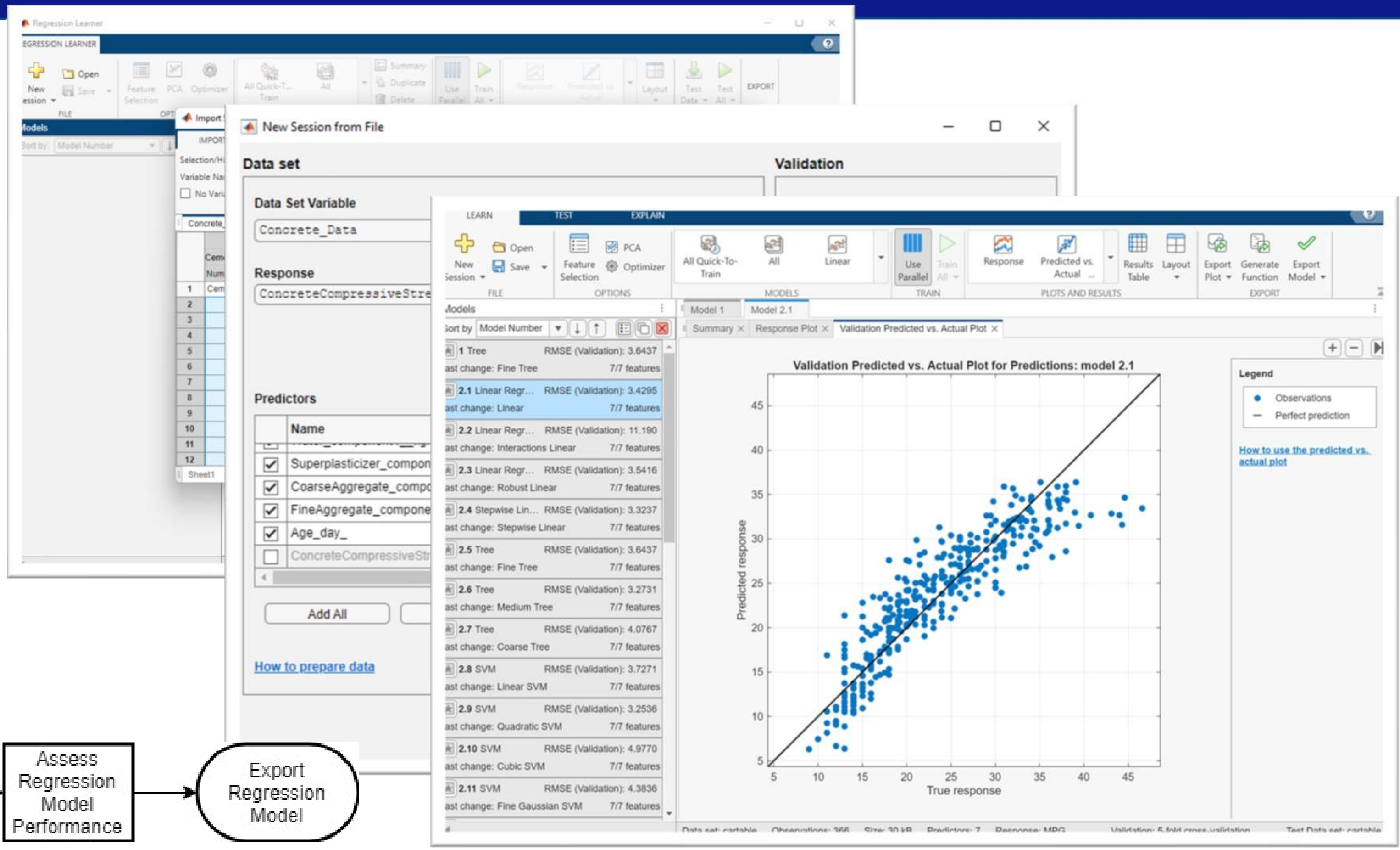


Classification Learner App

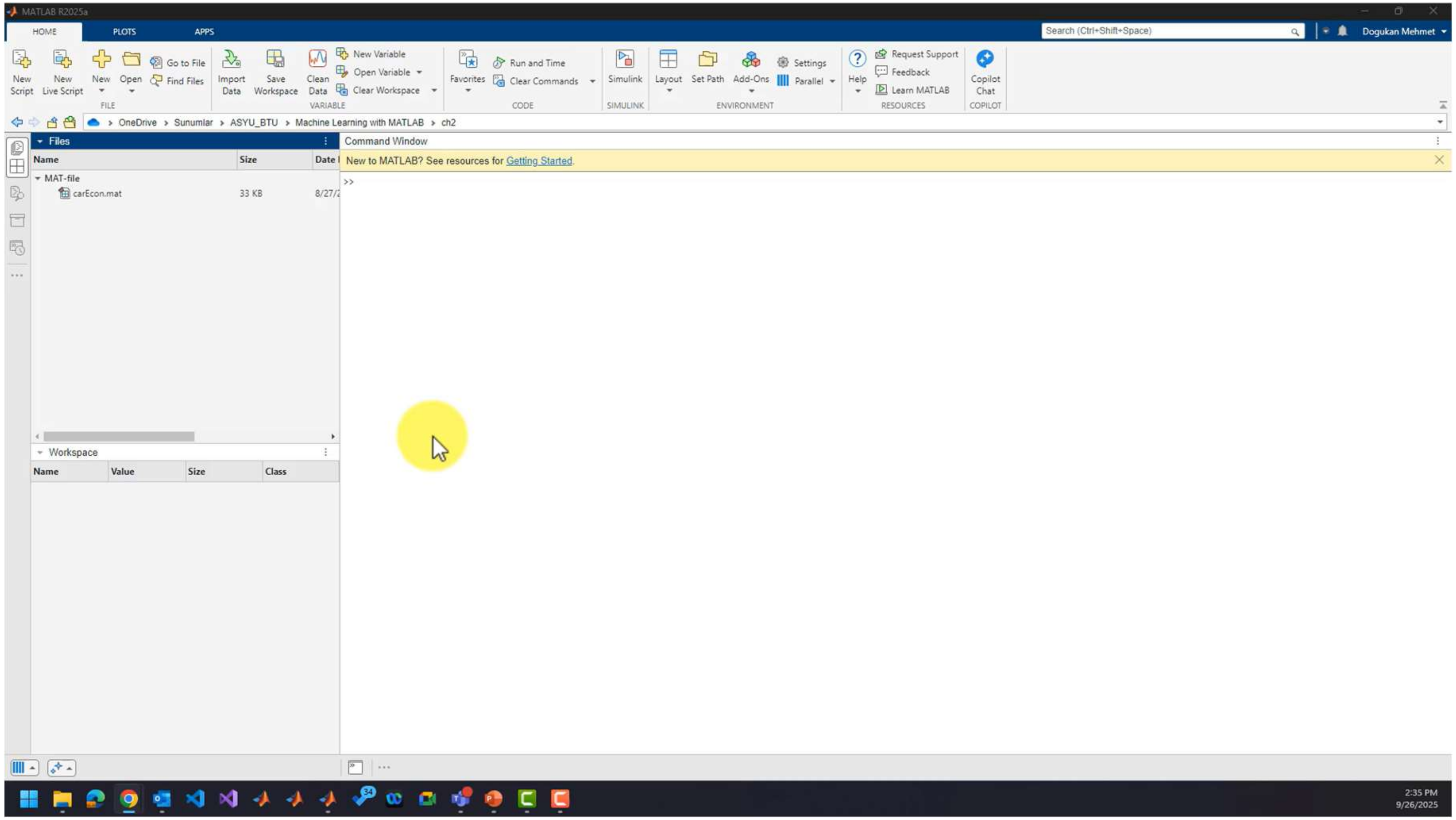


Regression Learner App

Regression models describe the relationship between a response (output) variable, and one or more predictor (input) variables.

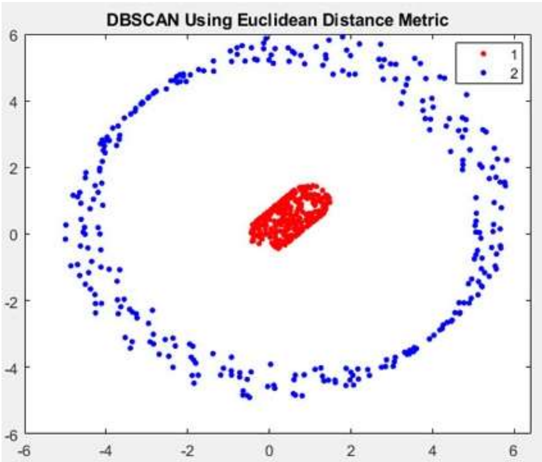


Regression Learner App

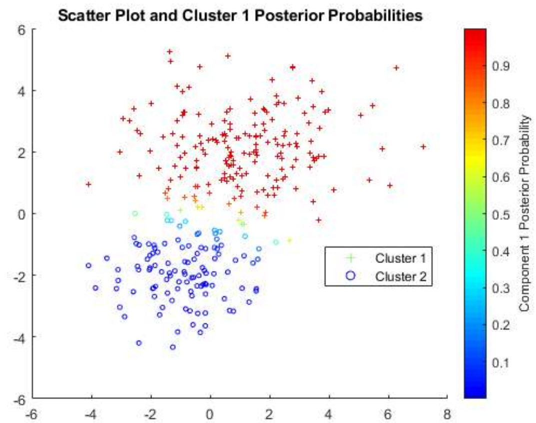


Data Clustering / Unsupervised Learning

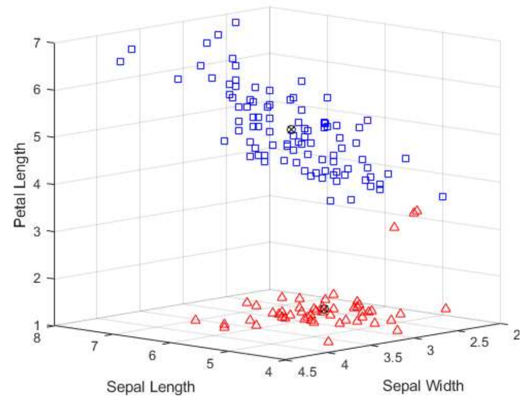
Discover patterns by grouping data using k-means, k-medoids, DBSCAN, hierarchical clustering, and Gaussian mixture and hidden Markov models.



Applying DBSCAN to two concentric groups.



Scatter Plot and Clusters

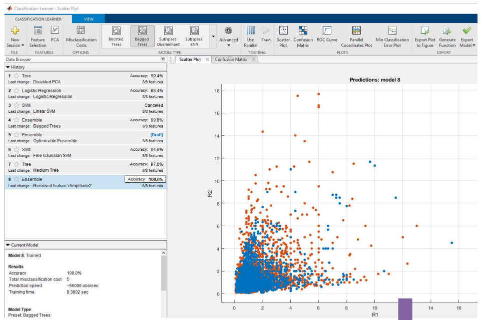


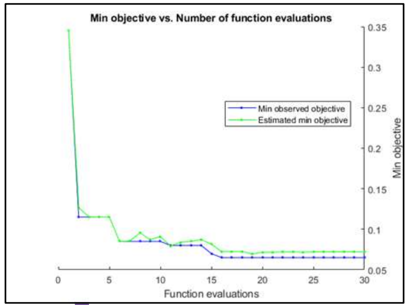
K-means Clustering Results

Machine Learning Wrap-up

Import Data → Preprocess Data → Engineer Features → Build Model → Deploy & Integrate

Interactive Model Training

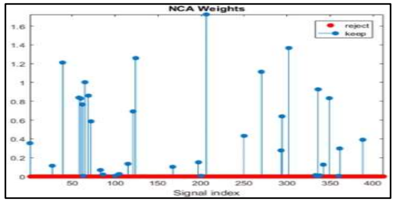




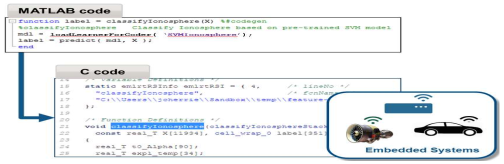
Automated Model Optimization

Clean Messy Raw Data

Feature Selection



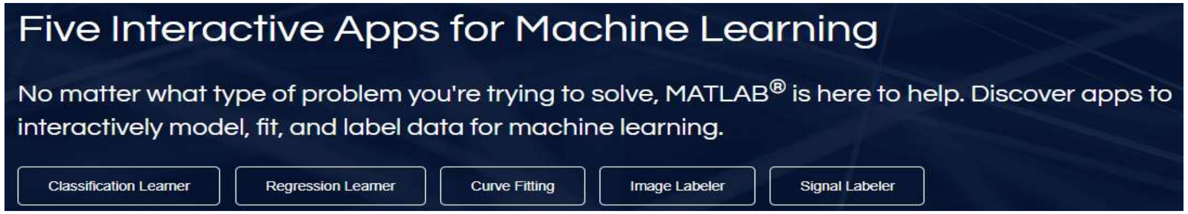
Automated Code Generation



Machine Learning Summary

Machine Learning Onramp (2 hr online introduction)

Practical Data Science with MATLAB (4 course Specialization)



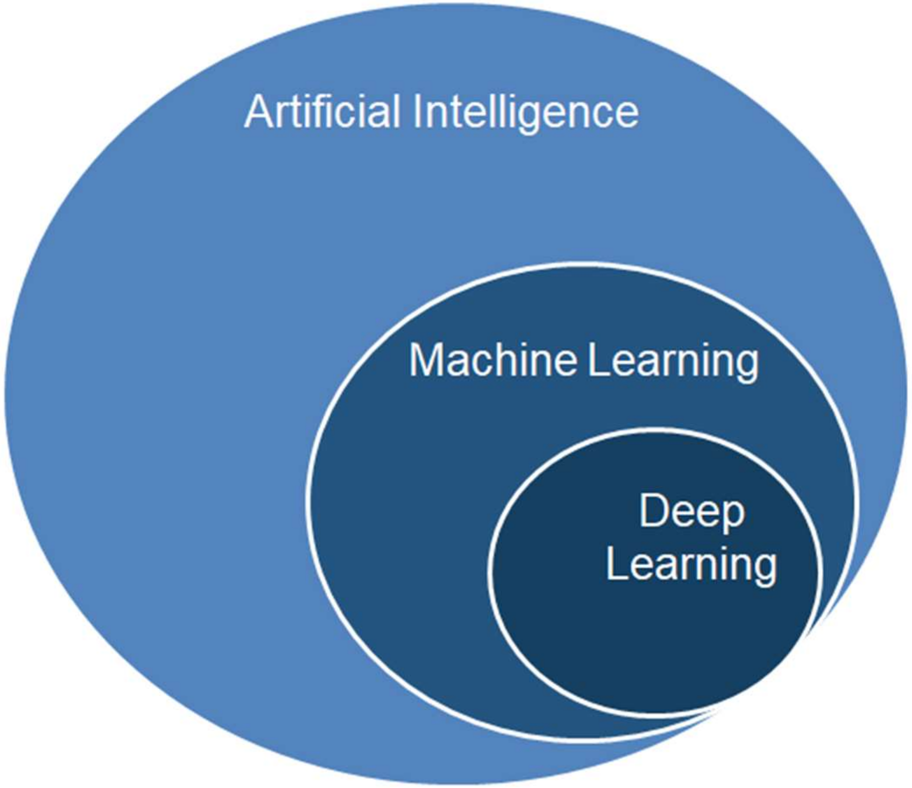
Machine Learning with MATLAB:

- Overview, Cheat sheet
- Machine Learning Intro (Tech talks)
- Machine Learning with MATLAB Introduction (eBook)
- Mastering Machine Learning (eBook)
- Applied Machine Learning (Tech Talk videos)

Machine and Deep Learning

- Deep vs. Machine Learning: Choosing the Best Approach (eBook)
- Deep learning Onramp (2hr online introduction)

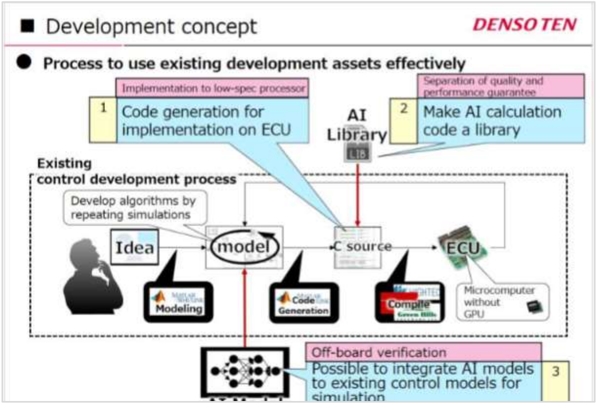
MATLAB for Artificial Intelligence



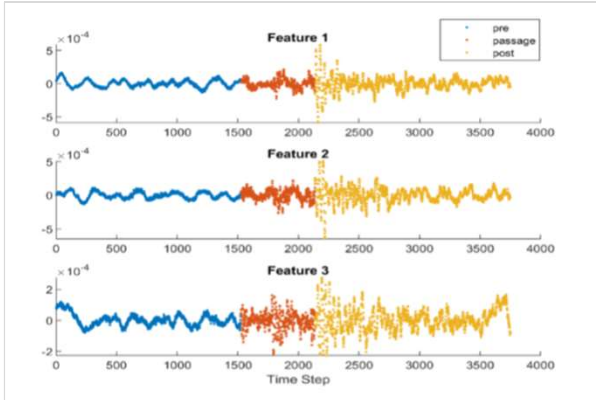
- Machine Learning
- Deep Learning
- Image Processing
- Reinforcement Learning
- Predictive Maintenance
- Data Science / Data Analytics
- Signal Processing
- ...and more

MATLAB Deep Learning used in Industry

Automatic Defect Detection
Airbus



ECU Vehicle Control
Denso

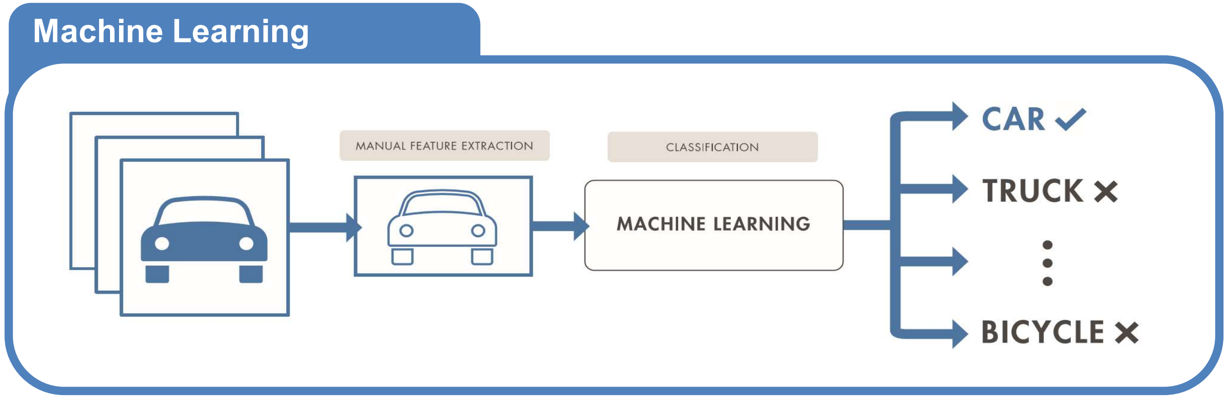


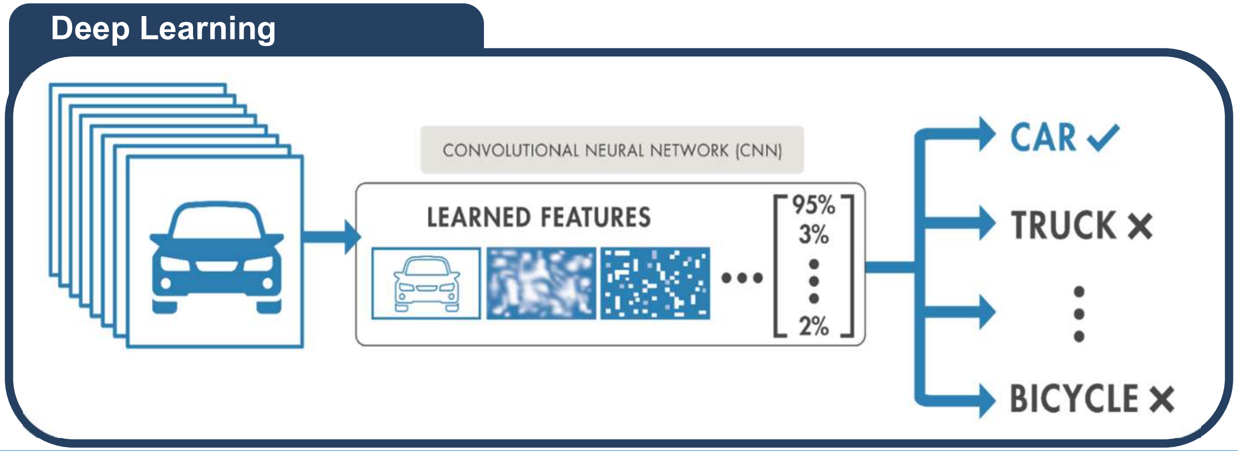
Seismic Event Detection
Shell

What is Deep Learning?

Machine Learning

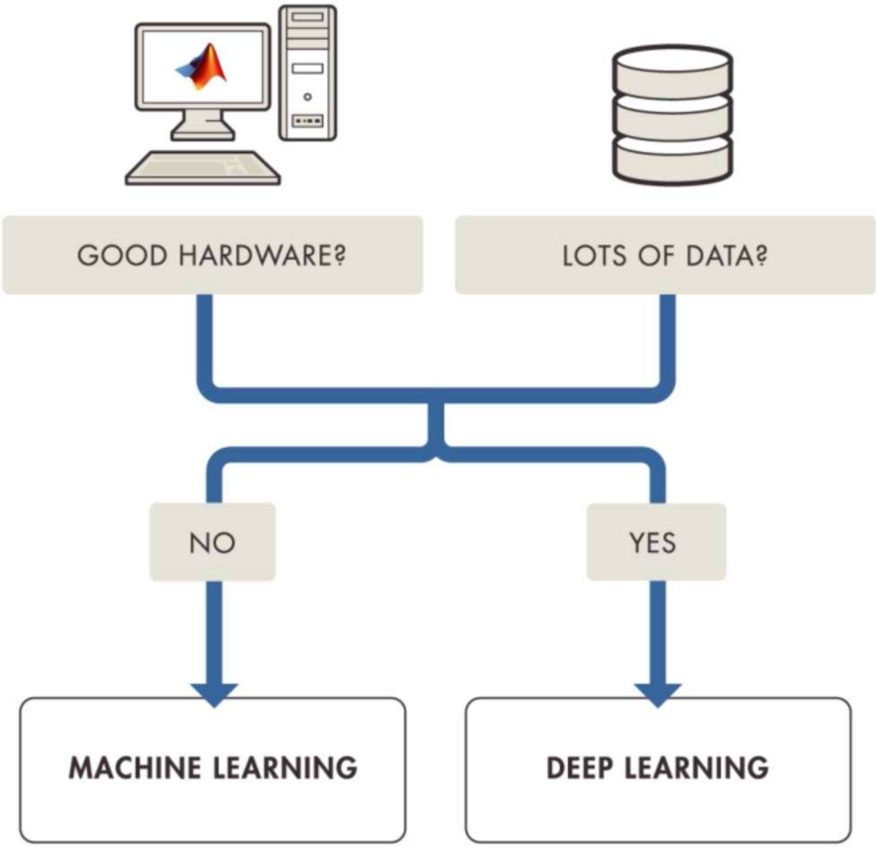
Deep Learning
Neural Networks with many Hidden Layers





- Learns directly from data
- More Data = better model
- Computationally Intensive
- **Not interpretable**

Machine Learning vs Deep Learning



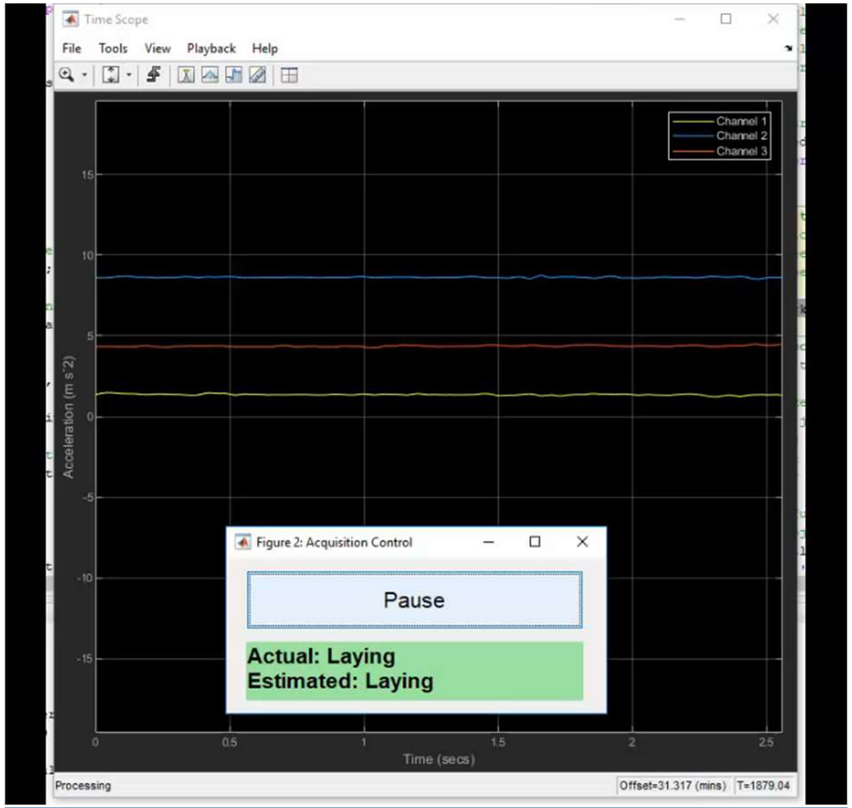
	Machine Learning	Deep Learning
Training dataset	Small	Large
Choose your own features	Yes	No
# of classifiers available	Many	Few
Training time	Short	Long

Applications of deep learning for images and video

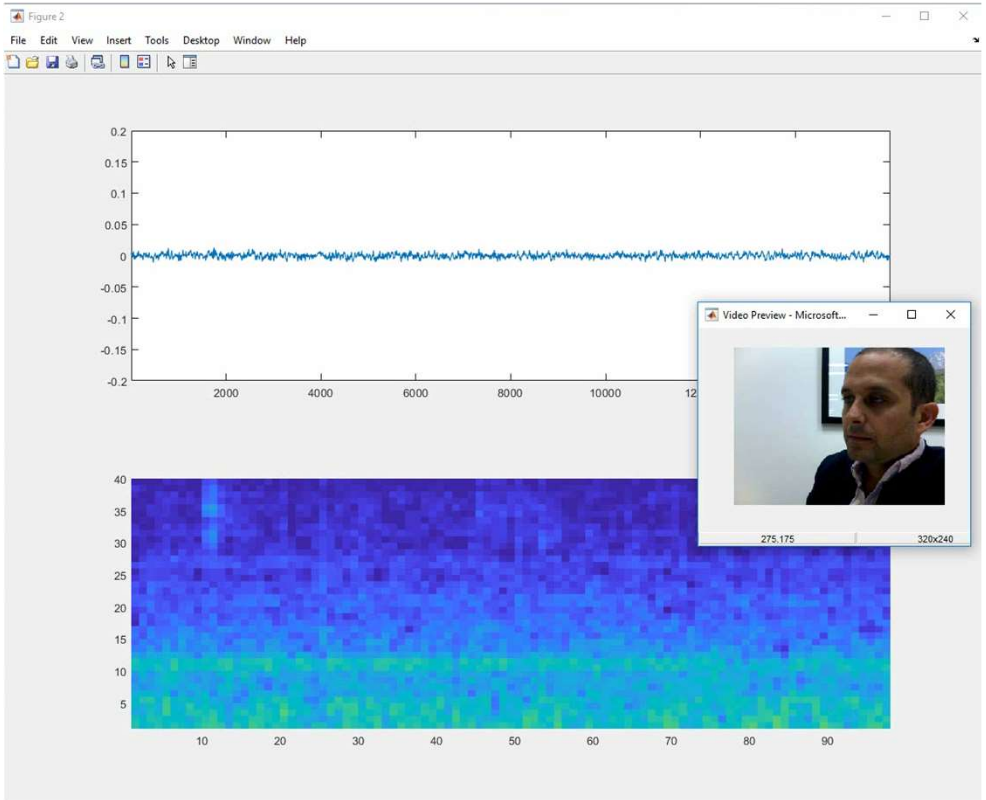
YOLO v2 (You Only Look Once)

Semantic Segmentation using SegNet

Applications of deep learning for signal processing

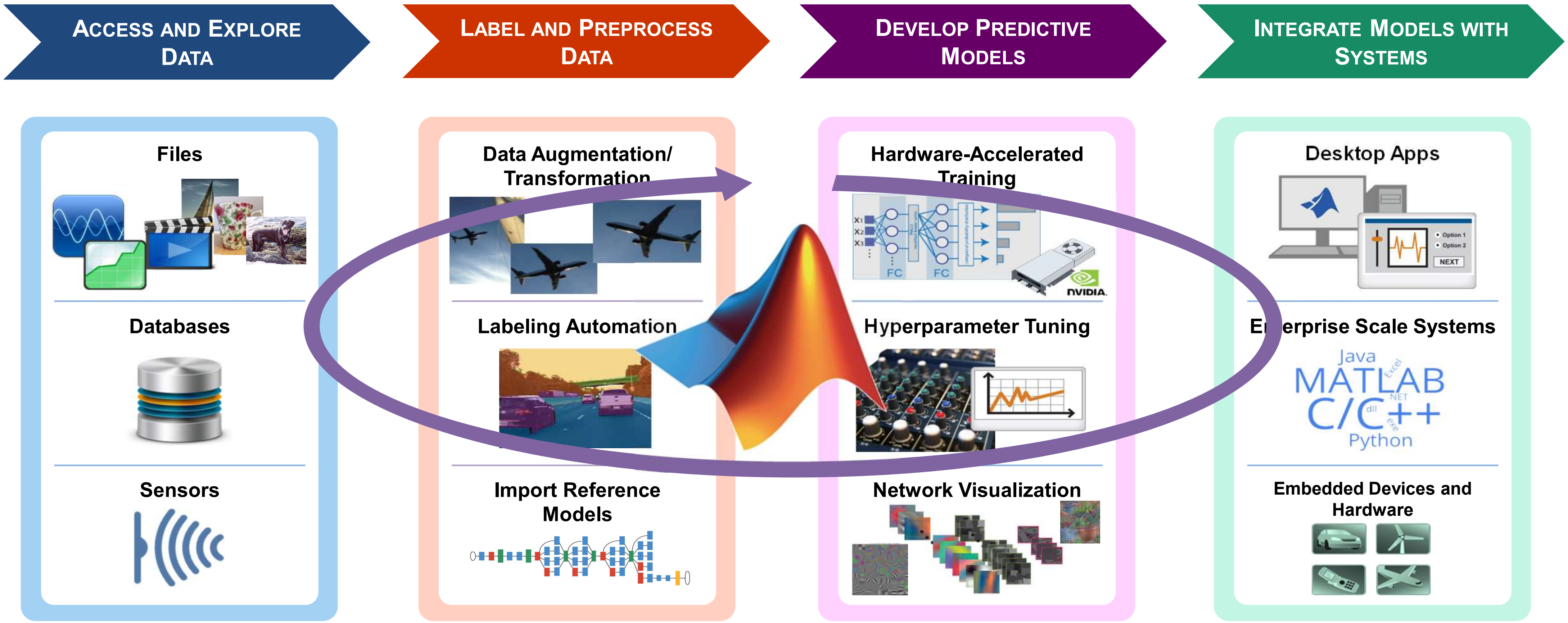


Signal Classification using LSTMs



Speech Recognition using CNNs

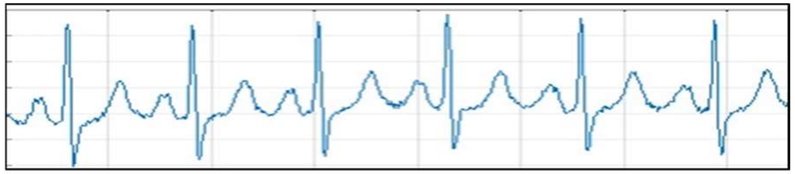
Deep Learning Workflow



Import Data for Deep Learning Networks

199	206	208	201	188	178	165	164	180
202	205	202	188	176	169	178	186	183
203	206	189	178	181	183	182	154	87
203	192	184	186	177	167	153	181	192
191	182	176	166	153	141	136	180	227
166	165	154	154	138	137	169	170	211
158	150	145	183	144	156	158	154	179
143	51	98	144	129	130	143	178	123
107	50	33	95	152	173	192	159	87
104	100	84	120	132	172	131	64	94
119	101	97	81	90	109	87	106	111
127	122	110	97	108	120	133	131	134
111	117	108	119	131	143	146	141	156
126	122	113	119	139	142	155	161	151
129	126	130	111	103	130	149	149	156
138	128	136	144	136	129	134	122	145
154	133	134	141	168	150	126	127	151

Images are a numeric matrix



131	158	185	212	239	266	293	320	347	374	376

Signals are numeric vectors

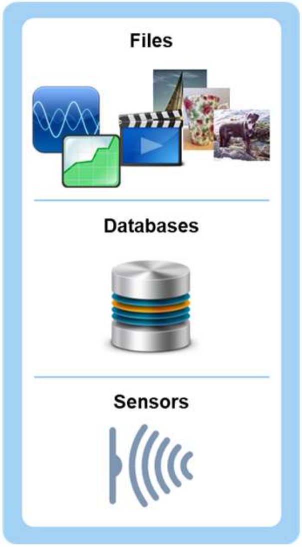
The Bird Flies = [0 13 5 6]

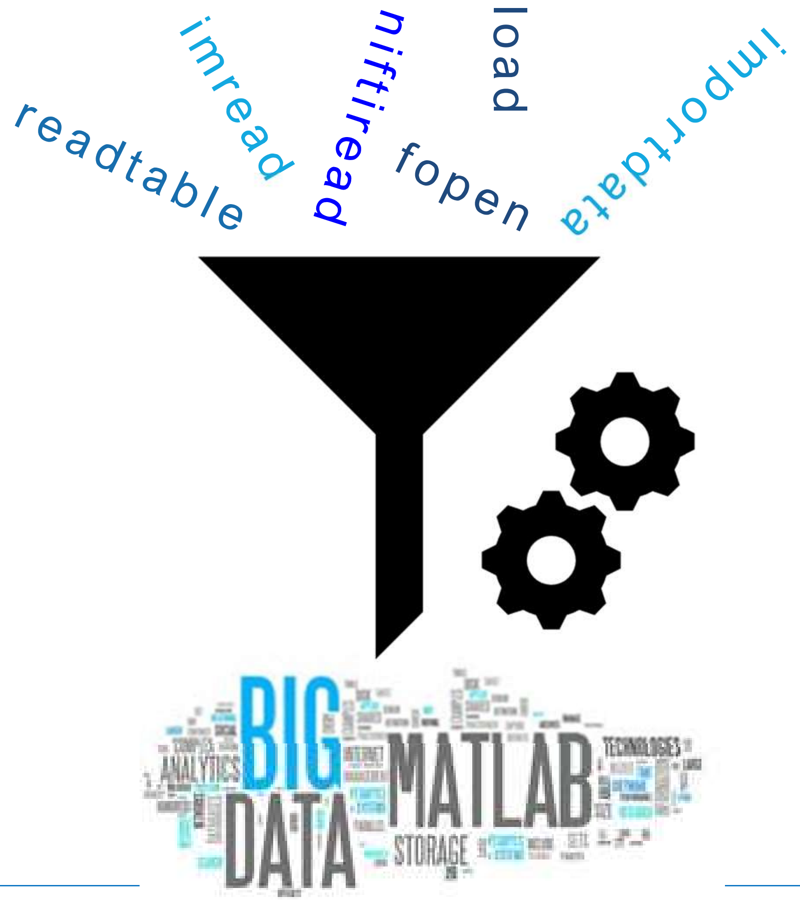
The Leaf Is Brown = [13 3 11 2]

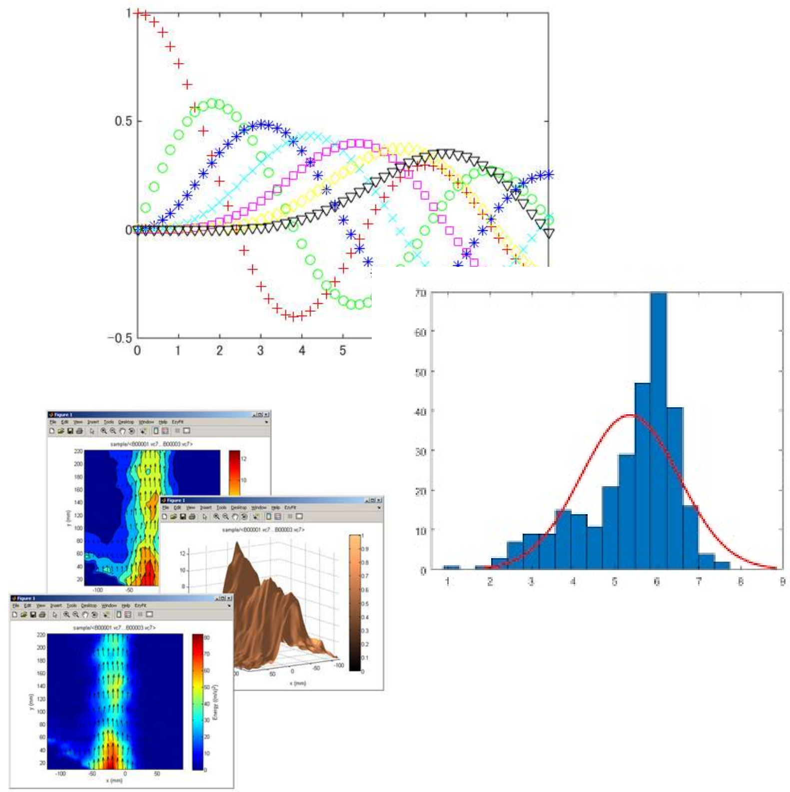
Text is processed as numeric vectors

Deep Learning requires a lot of data

ACCESS AND EXPLORE DATA







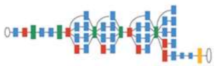
Automated Labeling Apps

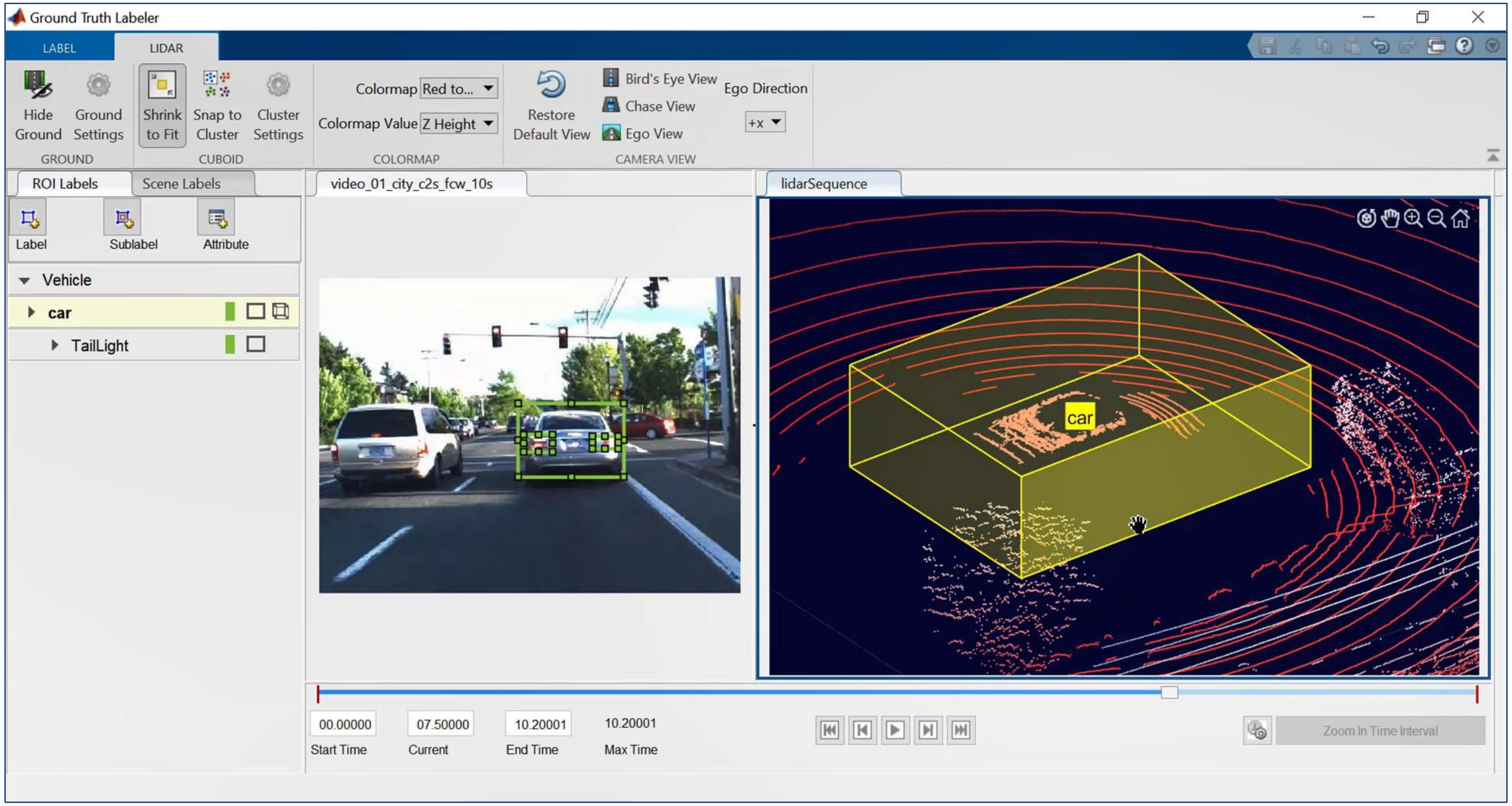
Label and Preprocess Data

Data Augmentation/ Transformation

Labeling Automation

Import Reference Models





BİZİ TAKİP EDİN!

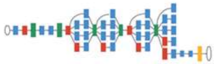
Synthetic Data Generation

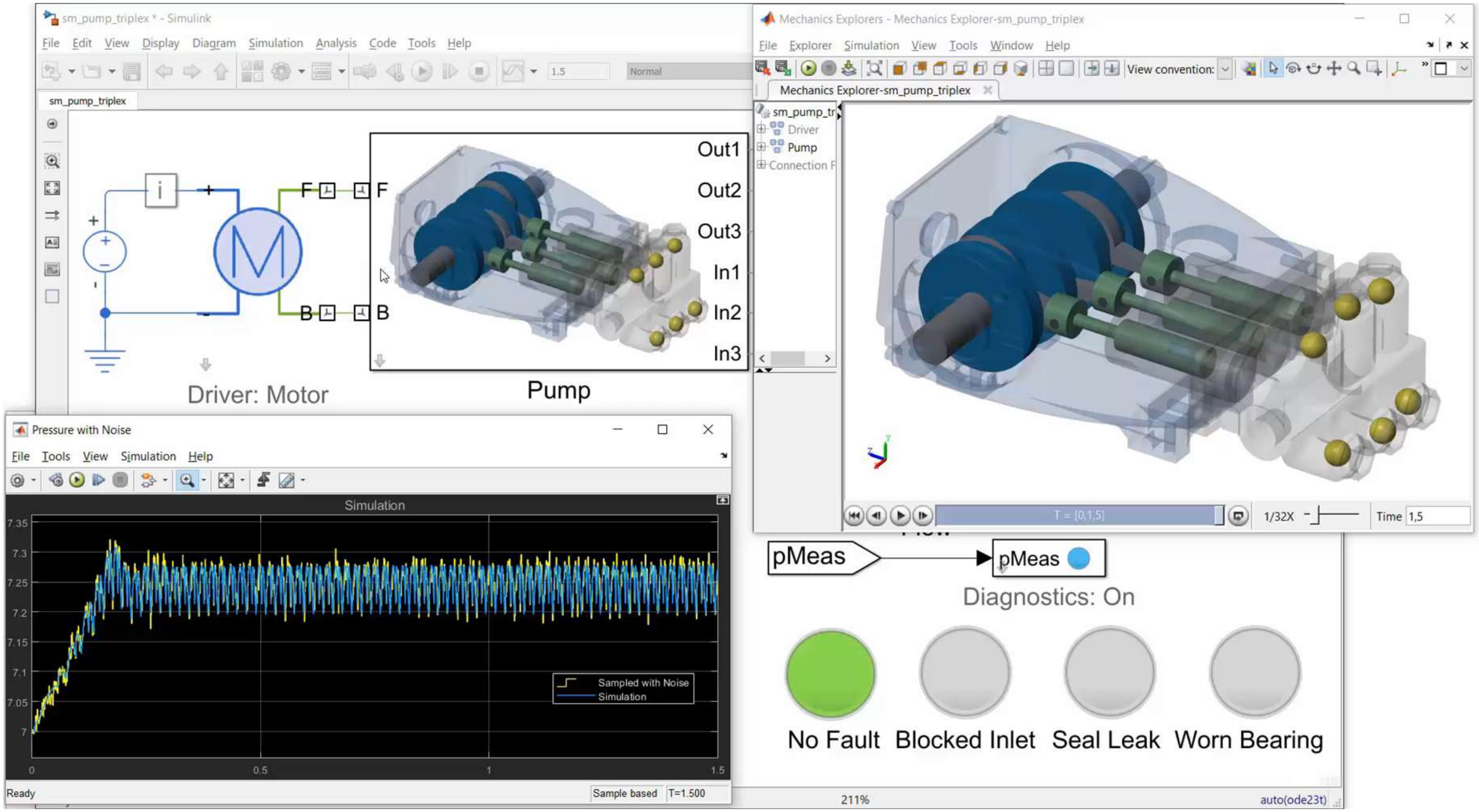
LABEL AND PREPROCESS DATA

Data Augmentation/ Transformation

Labeling Automation

Import Reference Models





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BİZİ TAKİP EDİN!

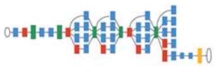
Automated Labeling Apps Save You Weeks to Months

LABEL AND PREPROCESS DATA

Data Augmentation/ Transformation

Labeling Automation

Import Reference Models



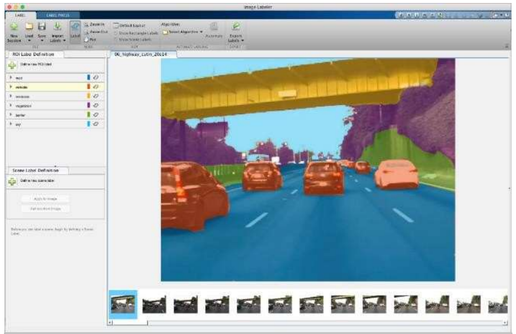
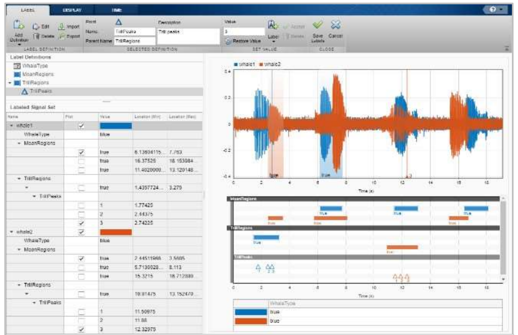


Image Labeler app to label images manually and semi-automatically.



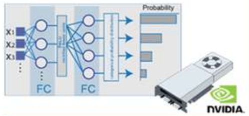
Signal Labeler app to label signals manually and semi-automatically.

Diagnostic Feature Designer to extract time and frequency domain features from signals.

There are 2 training approaches for Deep Learning with Images

DEVELOP PREDICTIVE MODELS

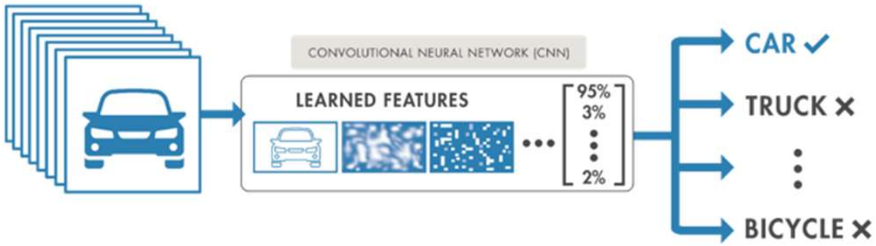
Hardware-Accelerated Training



Hyperparameter Tuning

Network Visualization

Train a deep neural network from scratch



Use a pretrained model

Designing a network from scratch requires some knowledge

DEVELOP PREDICTIVE MODELS

Feature Extraction - Images

- 2D and 3D convolution
- Transposed convolution (…)

Activation Functions

- ReLU
- Tanh (…)

Sequence Data

Signal, Text, Numeric

- LSTM
- BiLSTM
- Word Embedding (…)

Normalization

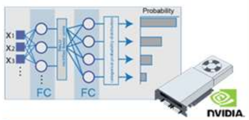
- Dropout
- Batch normalization
- (…)

Research papers and doc examples can provide guidelines for creating architecture.

Start with pre-built models and existing examples

DEVELOP PREDICTIVE MODELS

Hardware-Accelerated Training



Hyperparameter Tuning

Network Visualization

Use pre-built models

Image classification models

AlexNet, GoogLeNet, VGG, SqueezeNet, ShuffleNet, ResNet, DenseNet, Inception…

Reference examples

Object detection

Vehicles, pedestrians, faces…

Semantic segmentation

Roadway detection, land cover classification, tumor detection…

Signal and speech processing

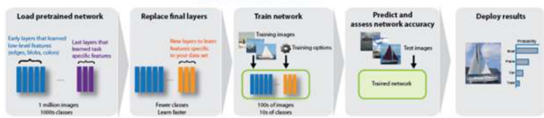
Denoising, music genre recognition, keyword spotting, radar waveform classification…

…and more…

Transfer Learning

Modify and reuse pre-built models

[Get started with Transfer Learning]

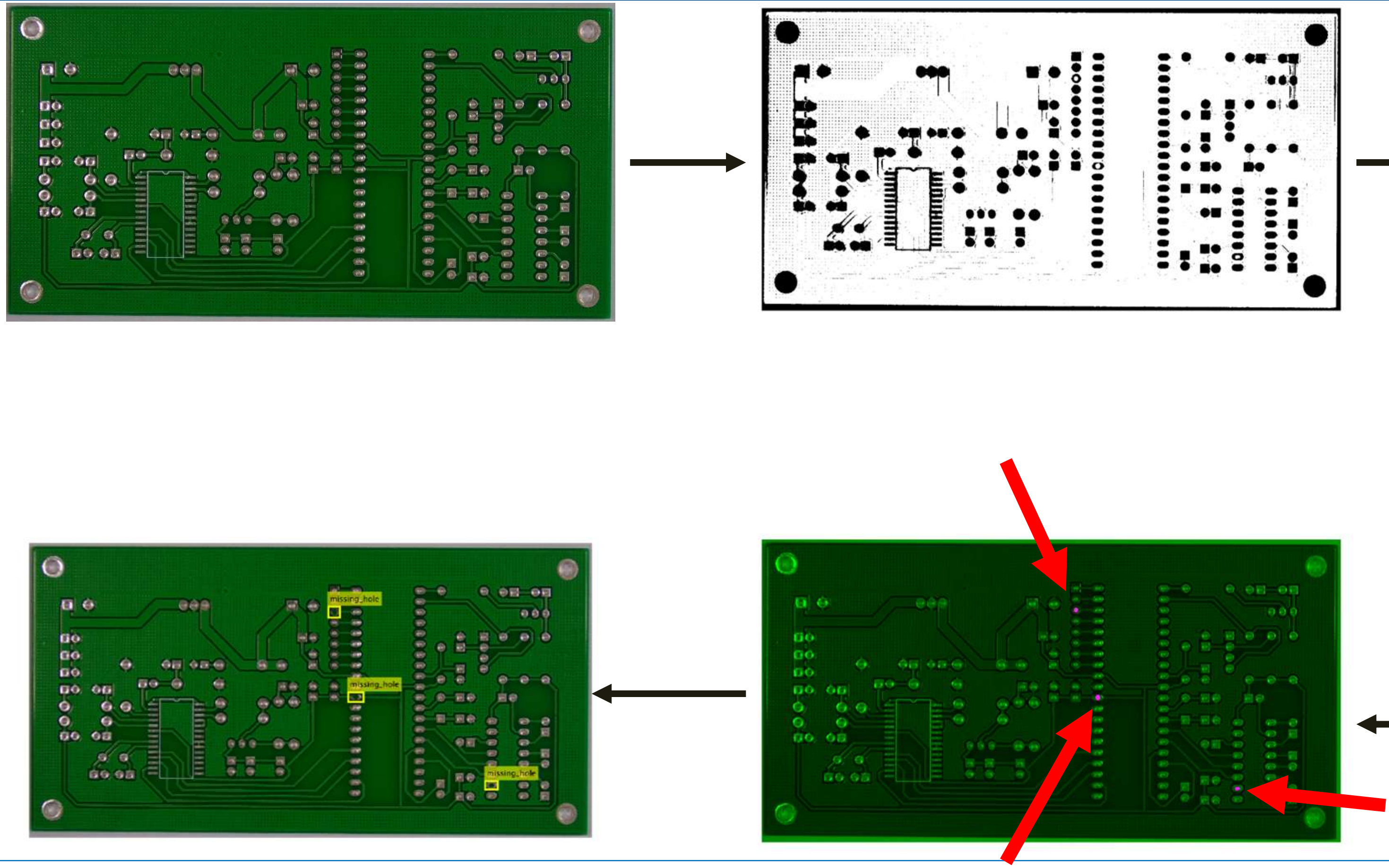


Don't Reinvent

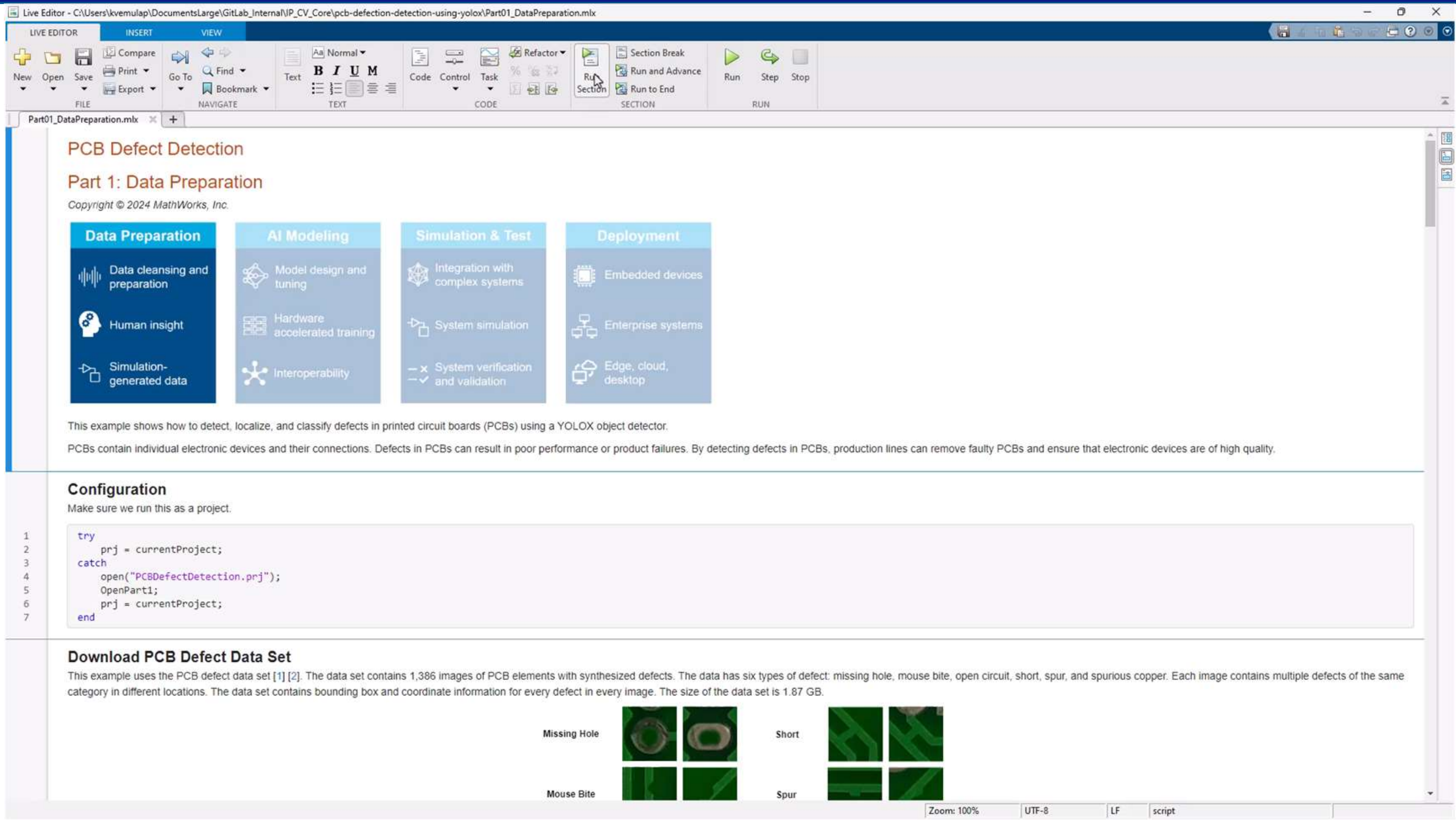
Perfect It

AlexNet, VGG-16, VGG-19, GoogLeNet	ResNet-18, ResNet-101, ResNet-50, Inception-v3, DenseNet-201, Xception	SqueezeNet, MobileNet-v2, ShuffLeNet
Get started with these Models	*Effective for object detection and semantic segmentation workflows*	*Lightweight and computationally efficient*

Data Preparation Demo



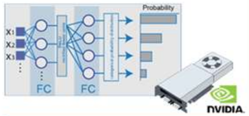
Data Preparation Demo – Pre-recorded Video



AI modeling Apps automate training, tuning, visualization...

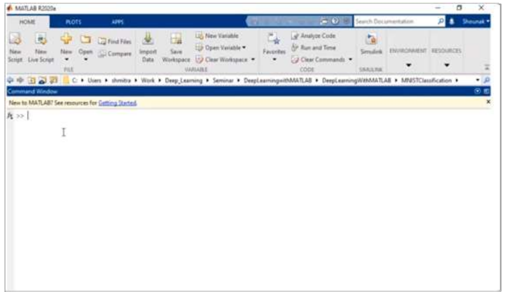
DEVELOP PREDICTIVE MODELS

Hardware-Accelerated Training

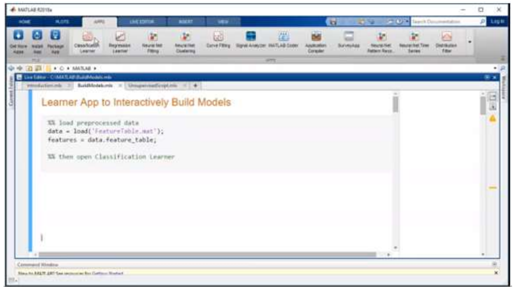


Hyperparameter Tuning

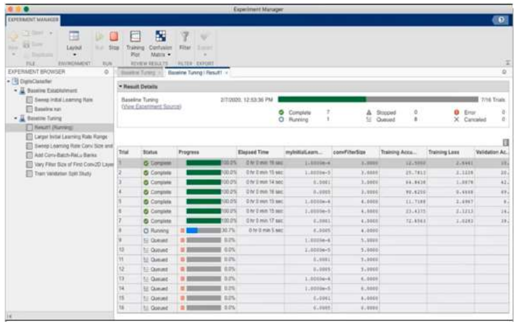
Network Visualization



Deep Network Designer app to build, visualize, and edit deep learning networks.



Learner app to try different classifiers and find the best fit for data sets.



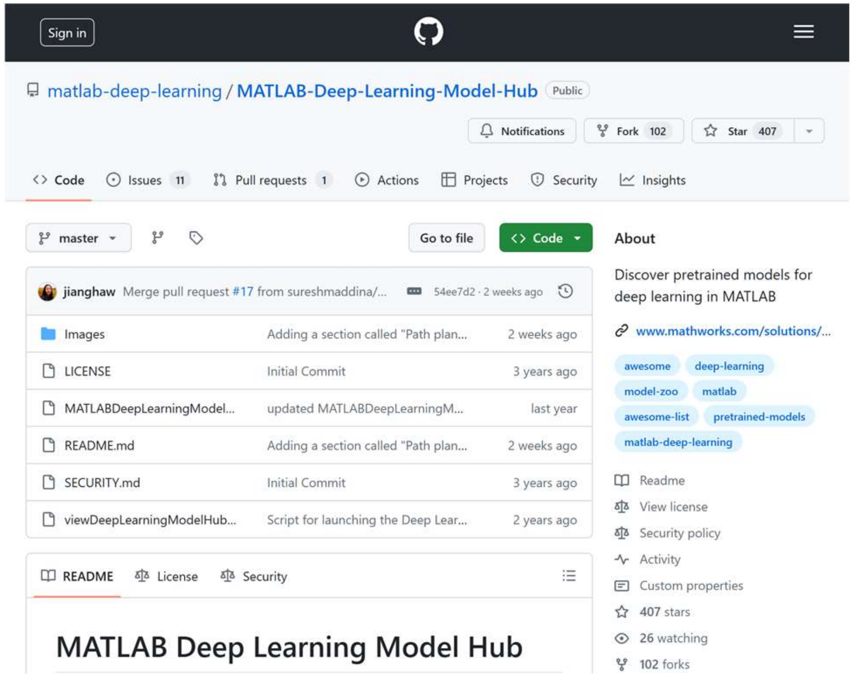
Experiment Manager app to run deep learning experiments to train networks and compare results.

Access pretrained models

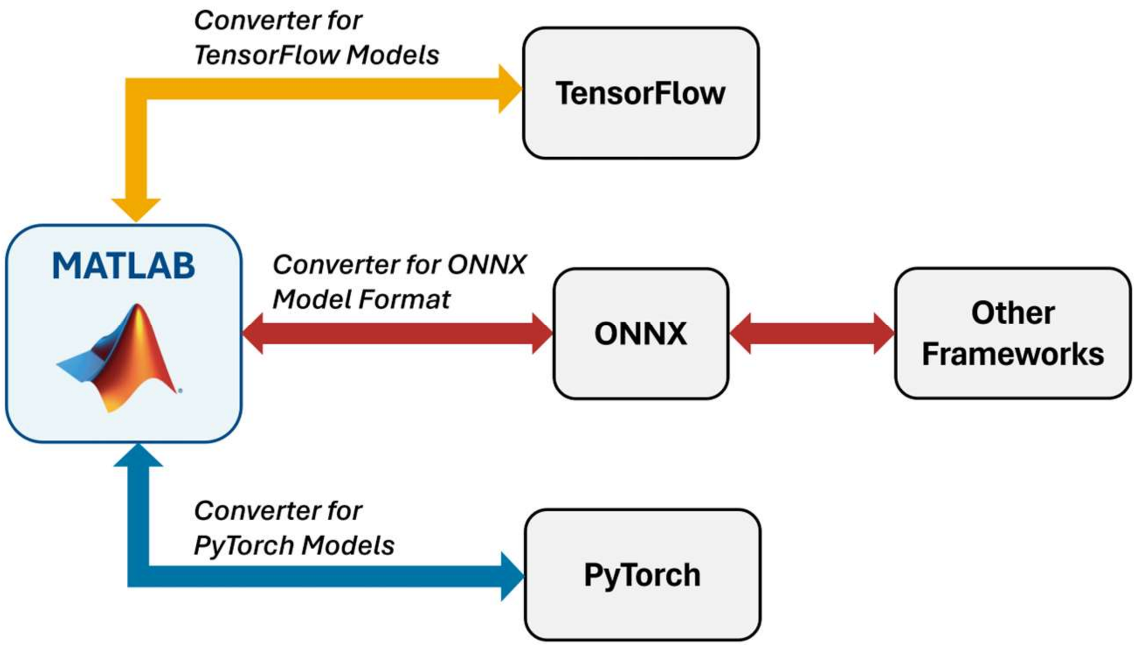
Take advantage of the knowledge provided by pretrained networks to learn new patterns in new data

Find one directly in MATLAB

https://github.com/matlab-deep-learning/MATLAB-Deep-Learning-Model-Hub

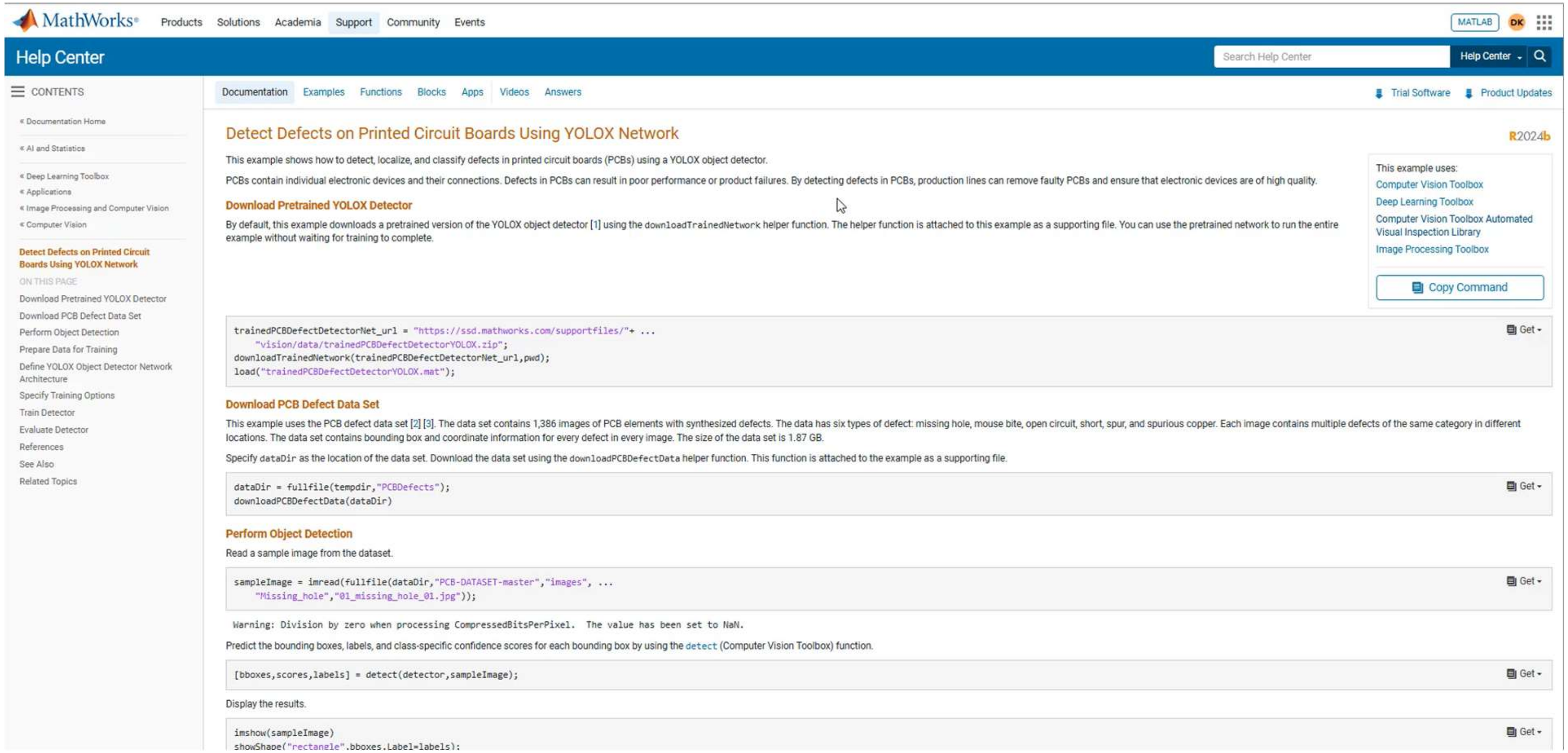


Import it from other platforms



Modeling Demo

[Detect Defects on Printed Circuit Boards Using YOLOX Network]



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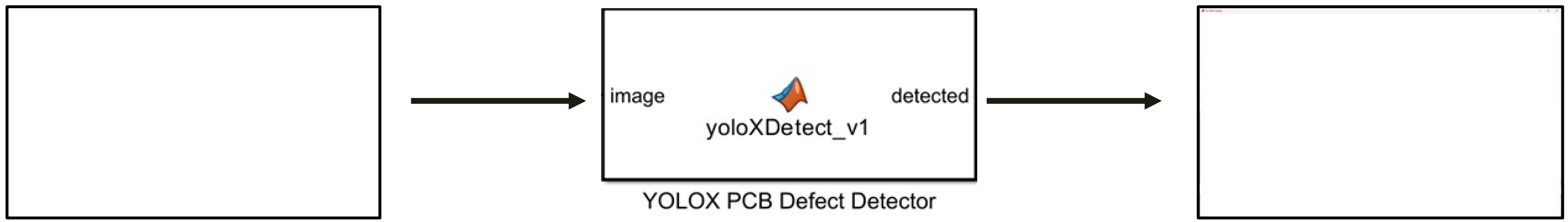
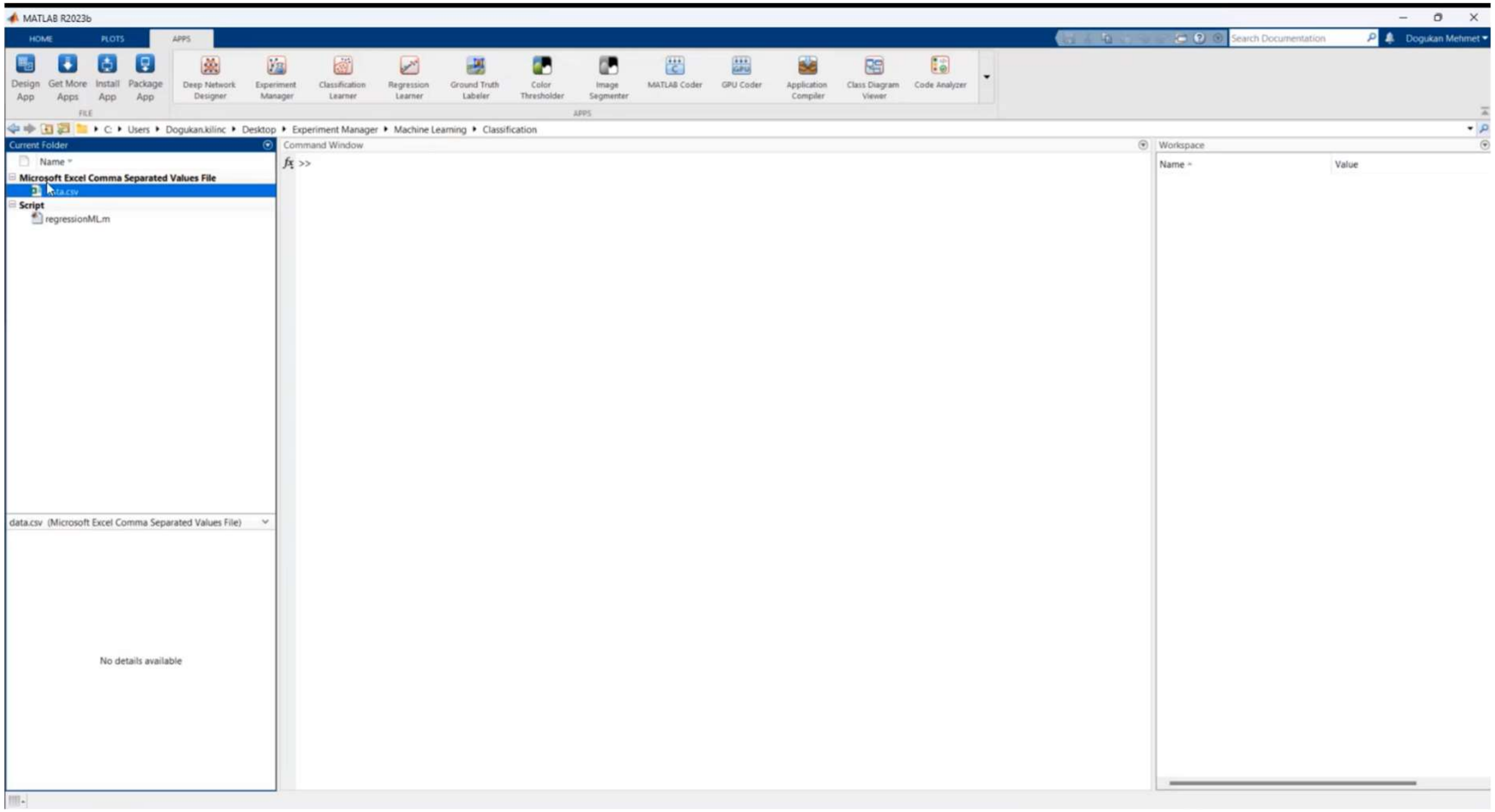
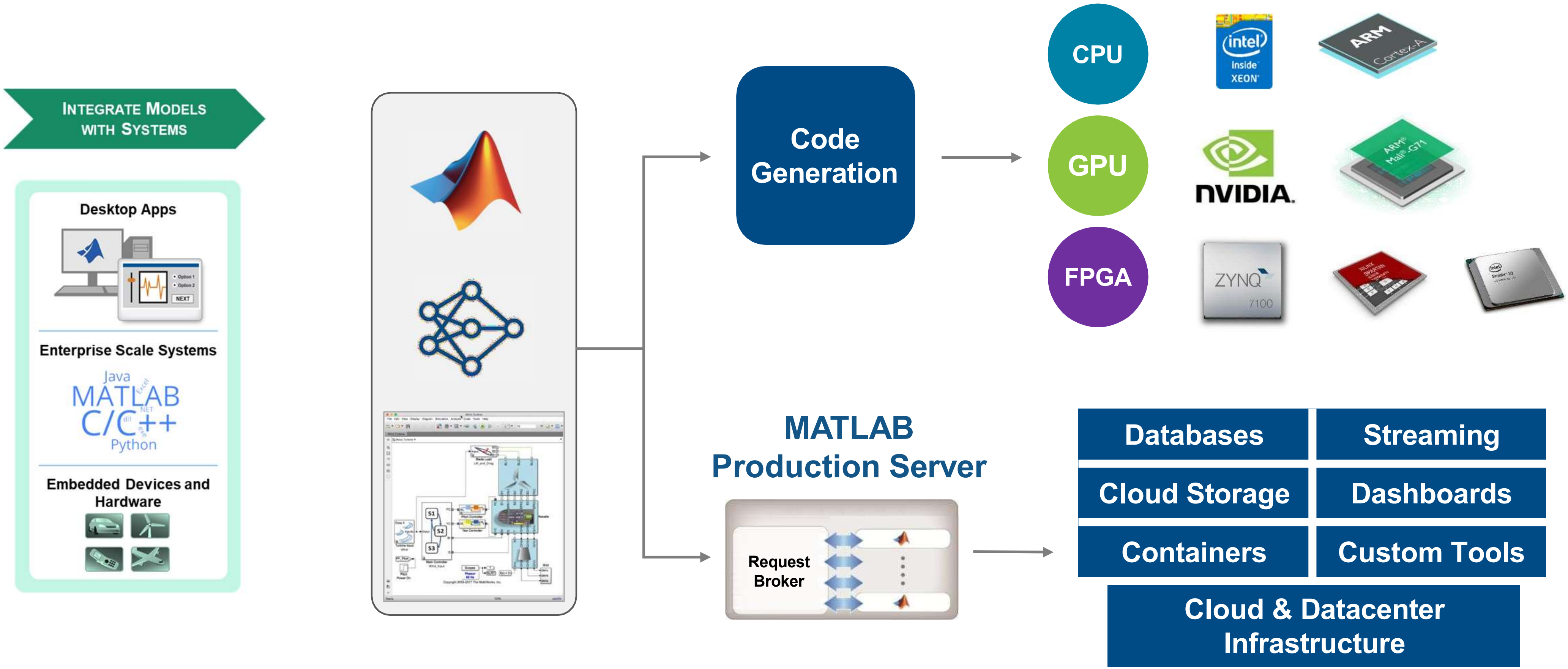
Simulation & Test Demo



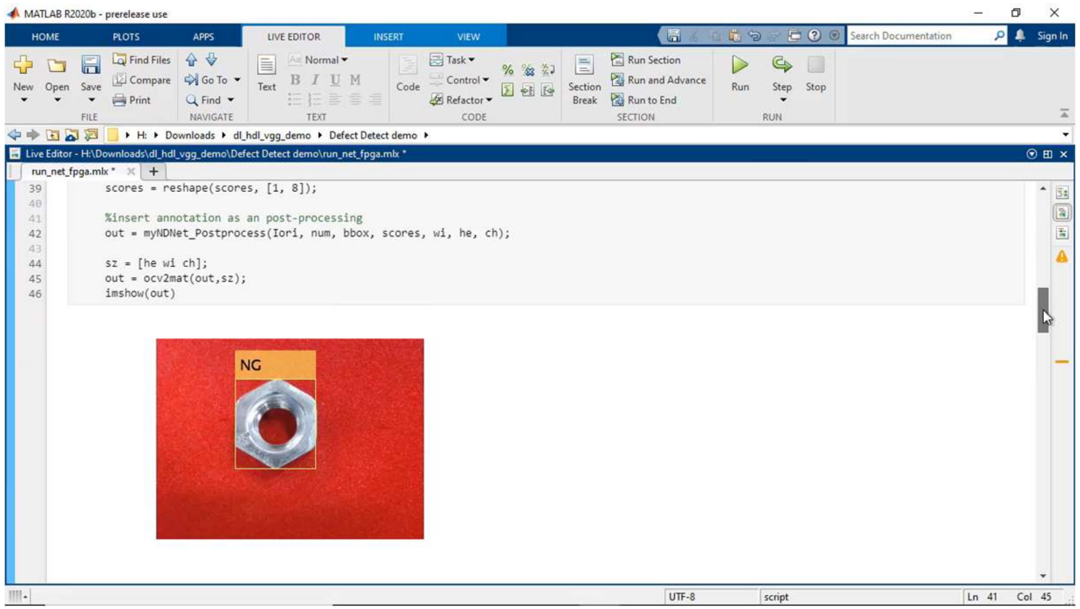
MATLAB Experiment Manager after Deep Learning



Deploy to Any Processor with Best-in-class Performance



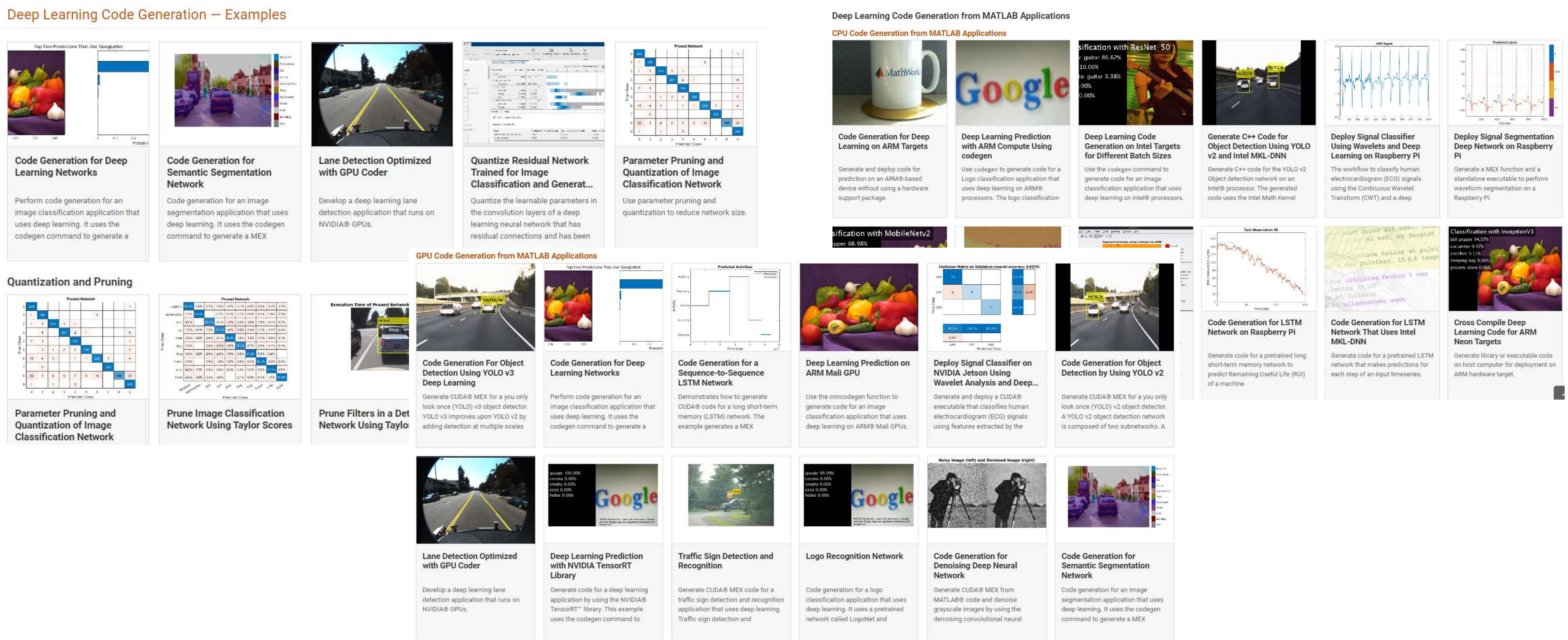
Example: Deployment Algorithm to Microprocessor



Deploy defect detection algorithms from MATLAB to ZCU102 board from Xilinx

Deploy defect detection algorithms from MATLAB to Jetson AGX Xavier

Deep Learning Summary



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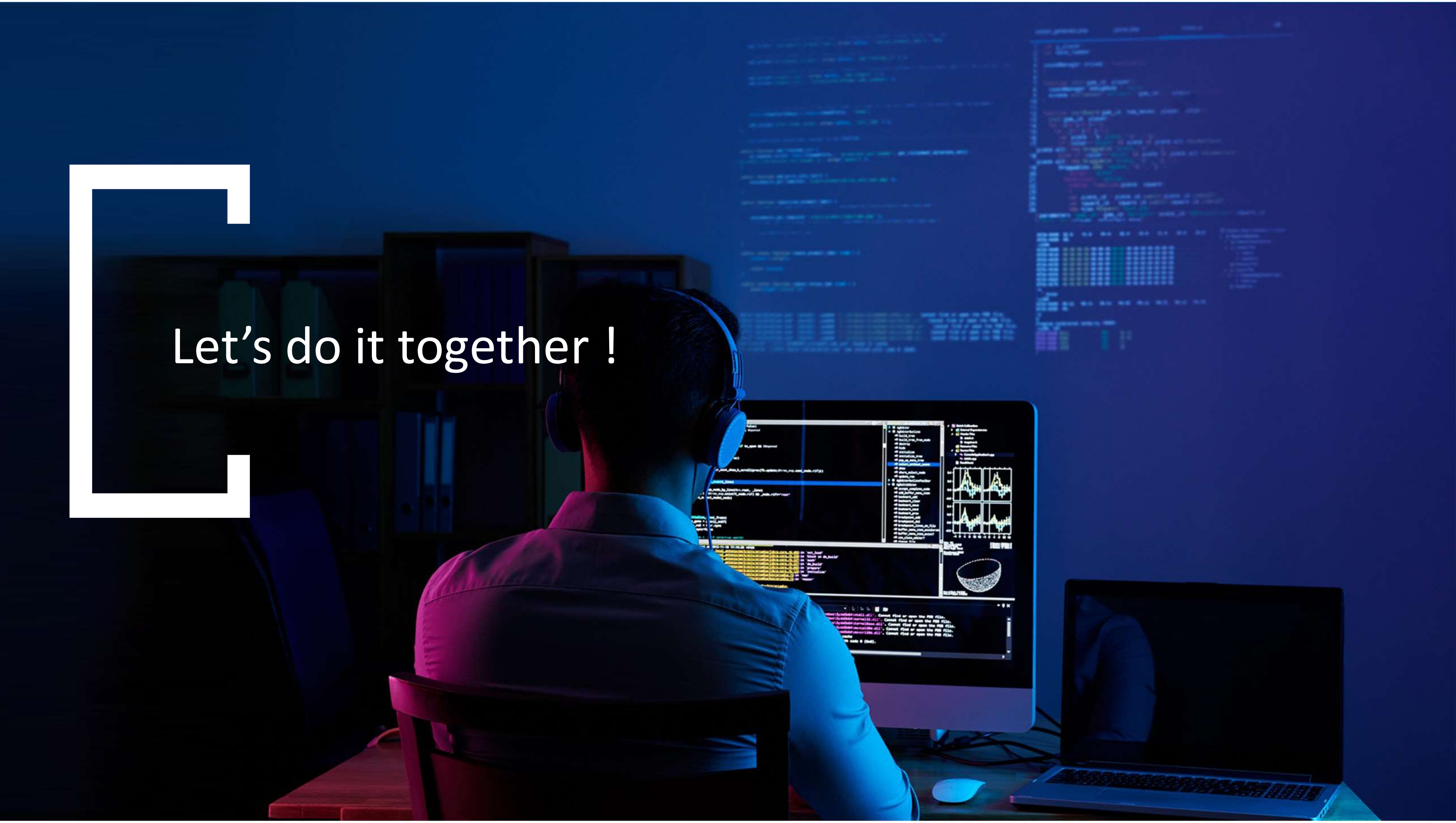
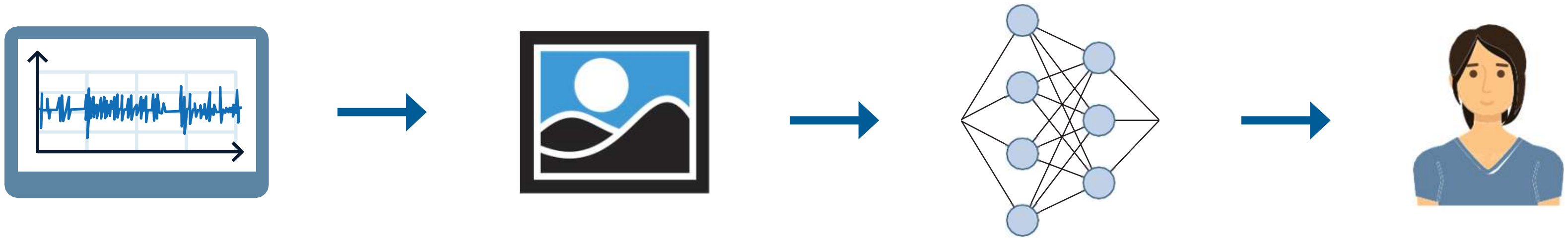


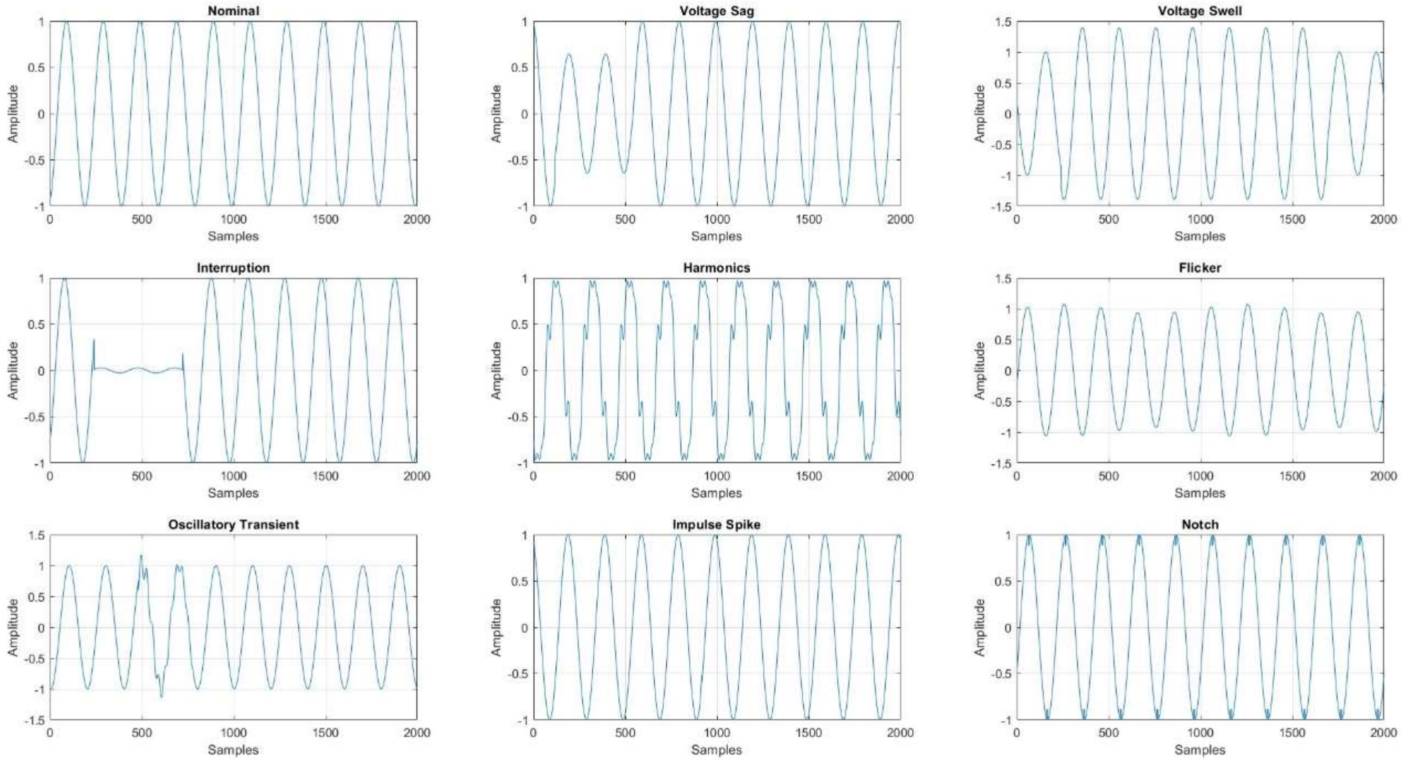
Let’s do it together !

Signal Acquisition

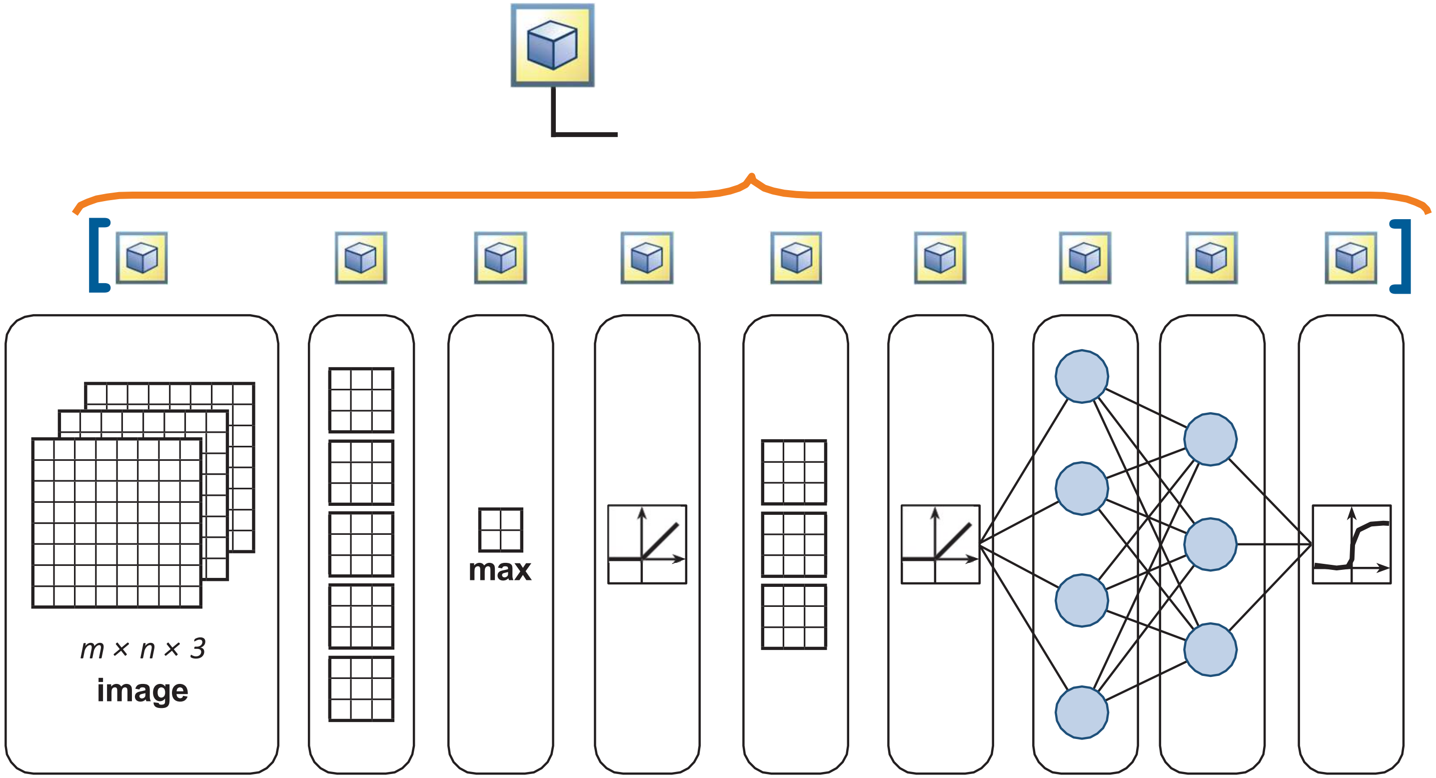


Collect Signals → Time-Frequency Image → Pretrained Network → User ID

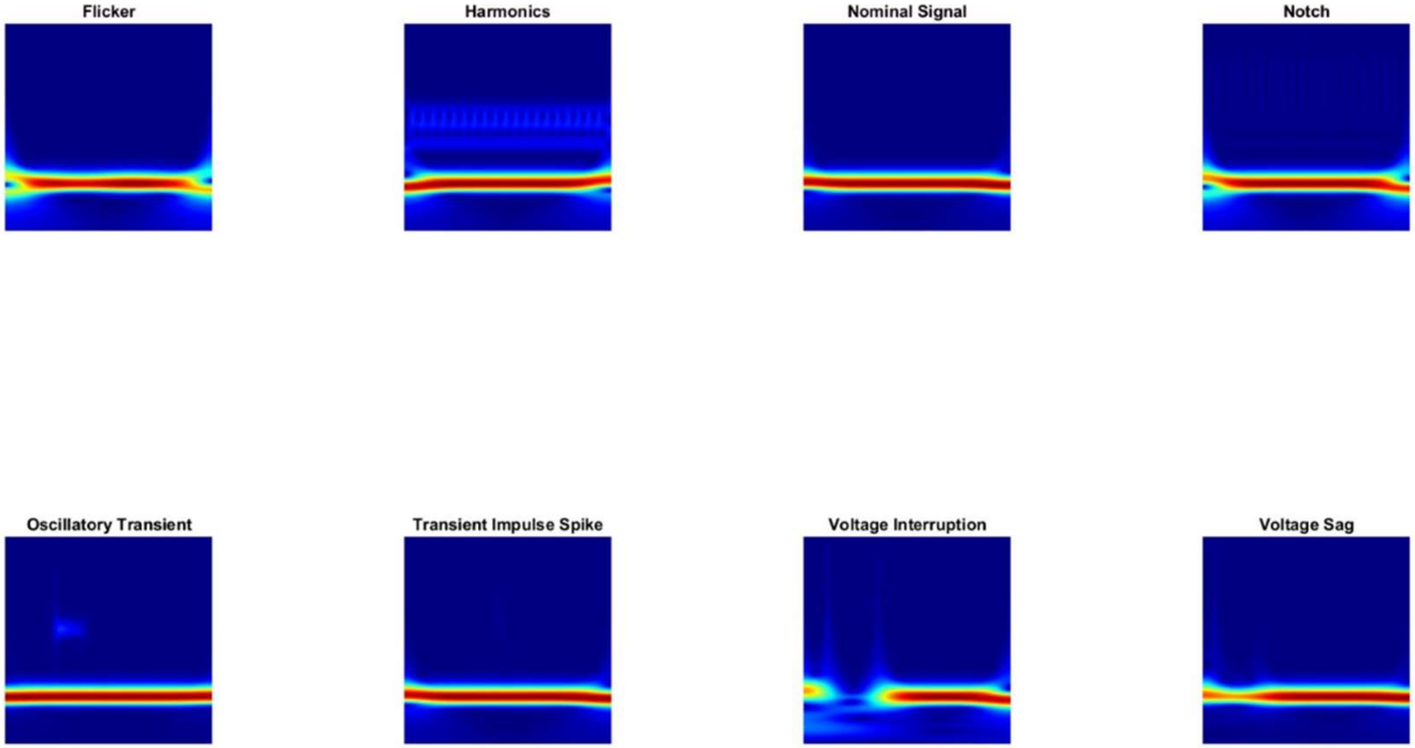
Preprocessing Signals for Classification



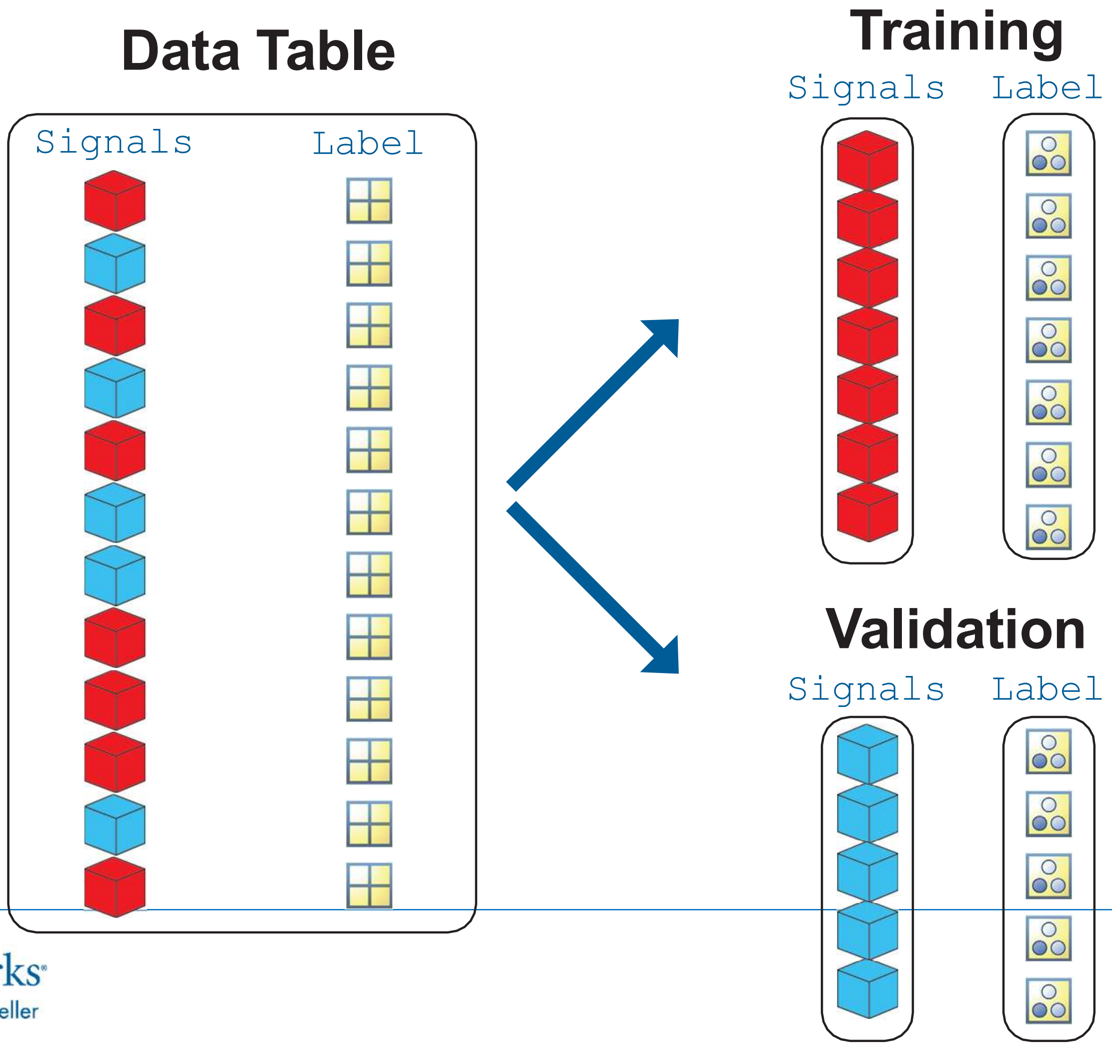
Pretrained Convolutional Neural Networks



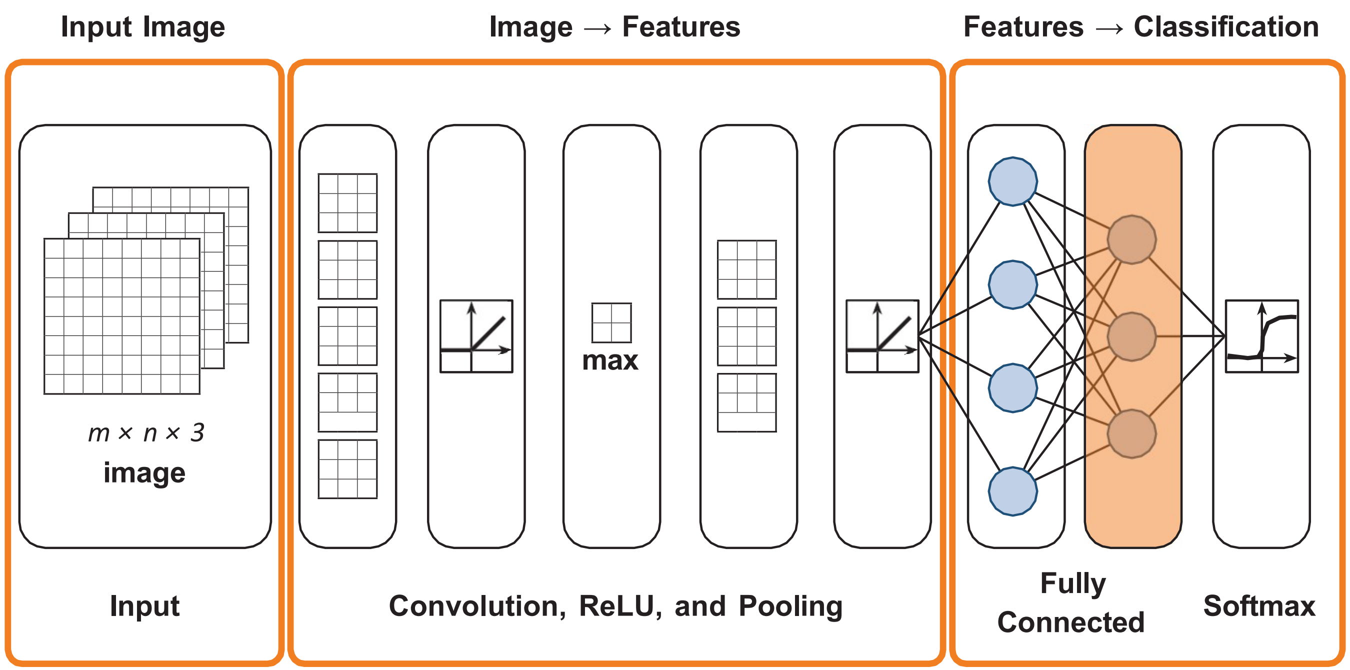
Converting Signals to Images



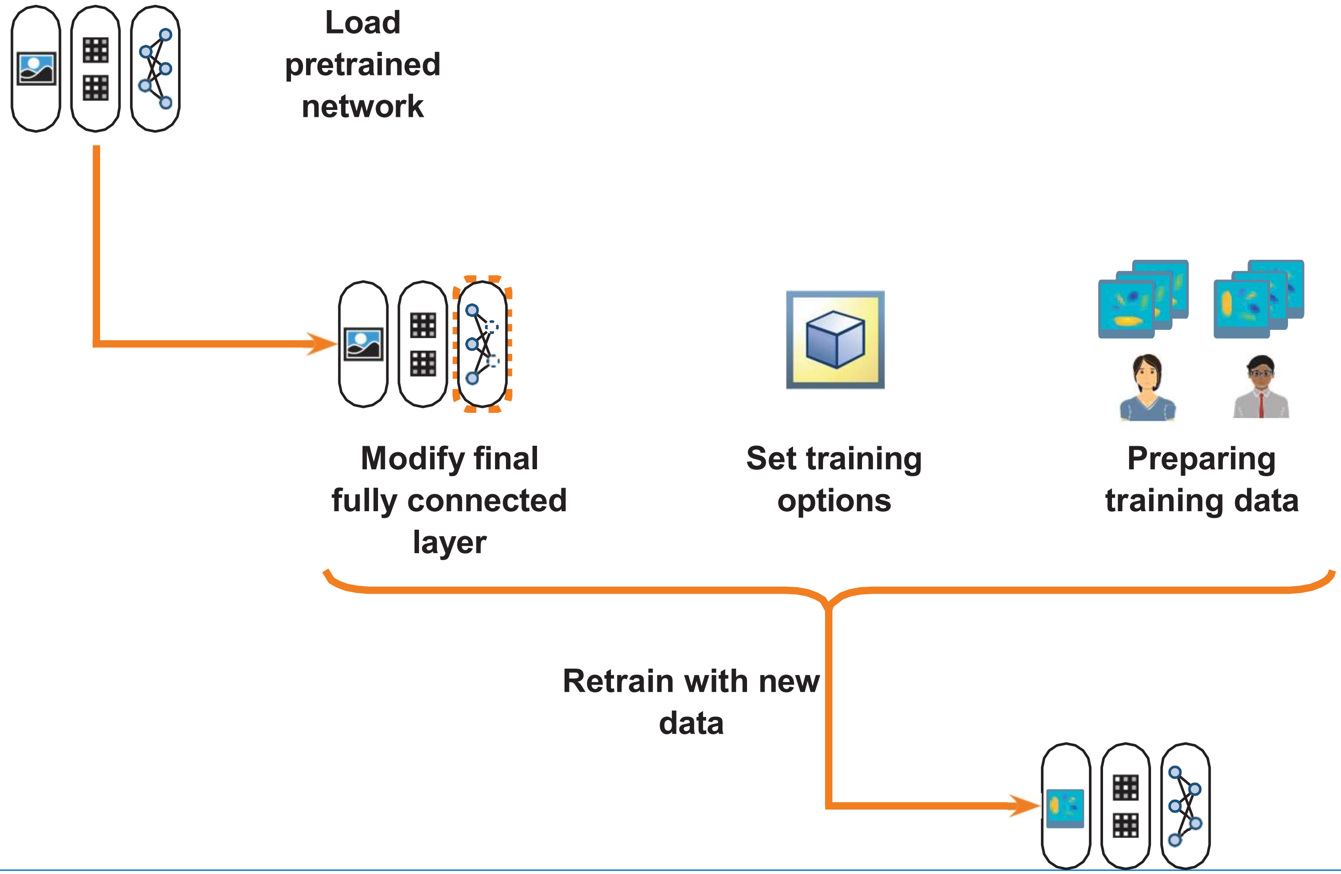
Extracting Training and Validation Data



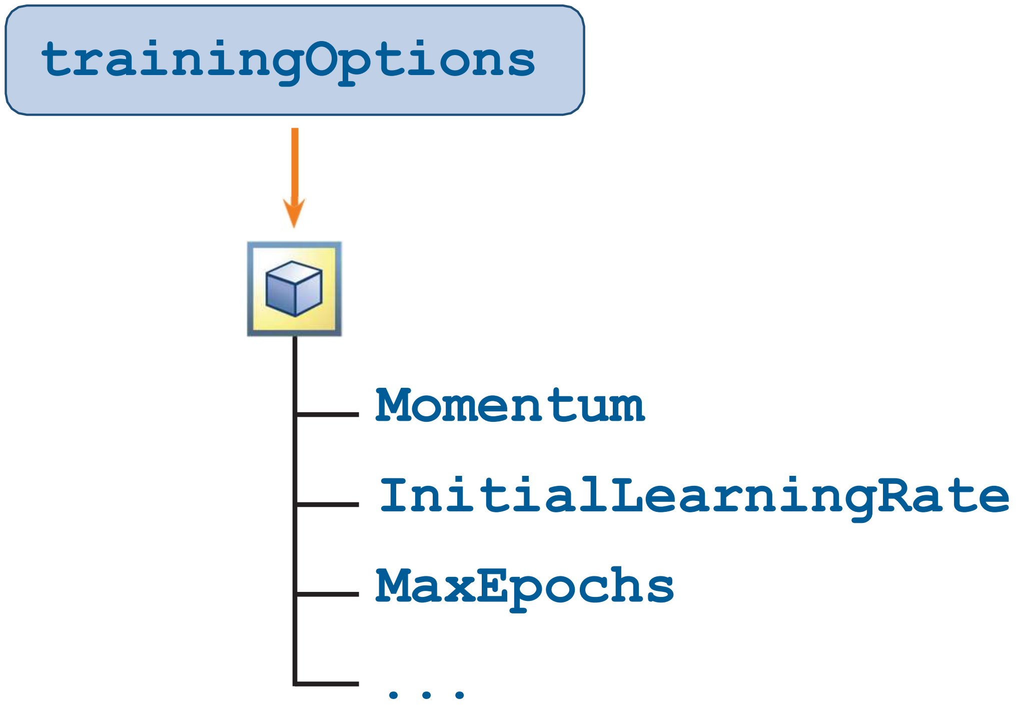
Modifying a Pretrained Network



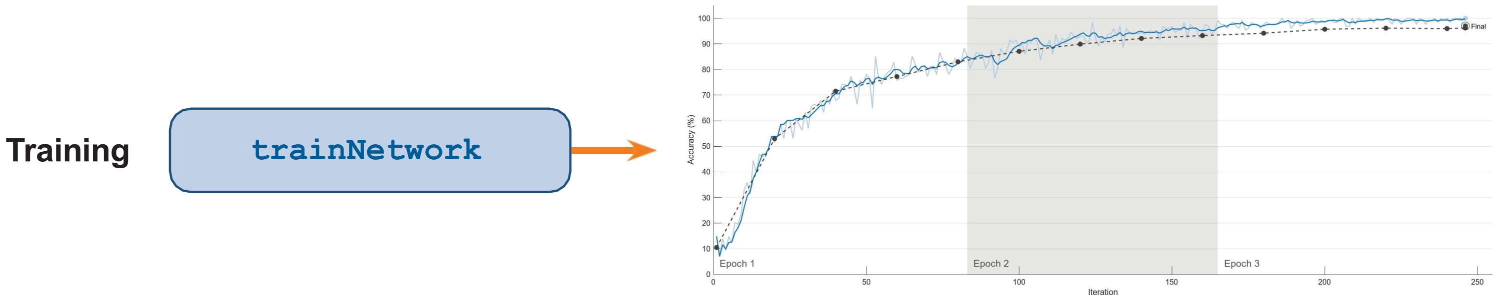
Transfer Learning

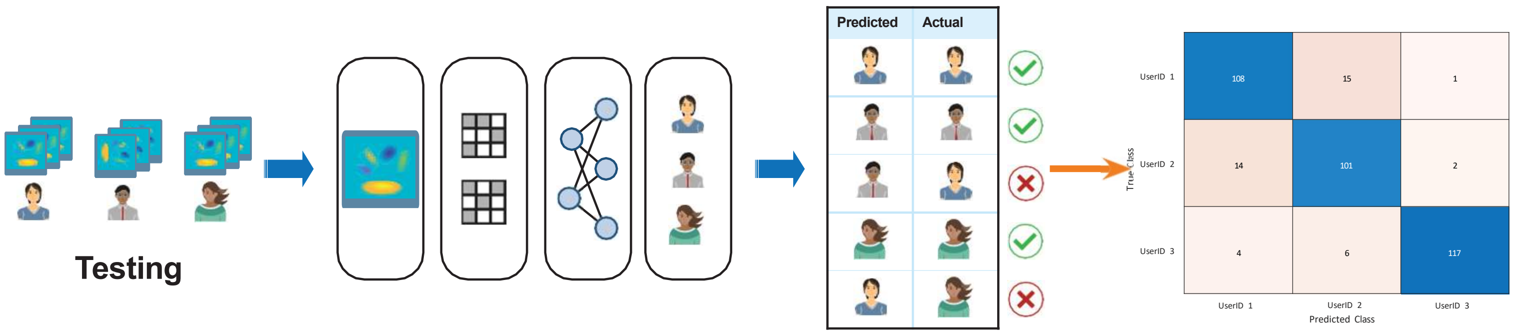


Setting Training Options

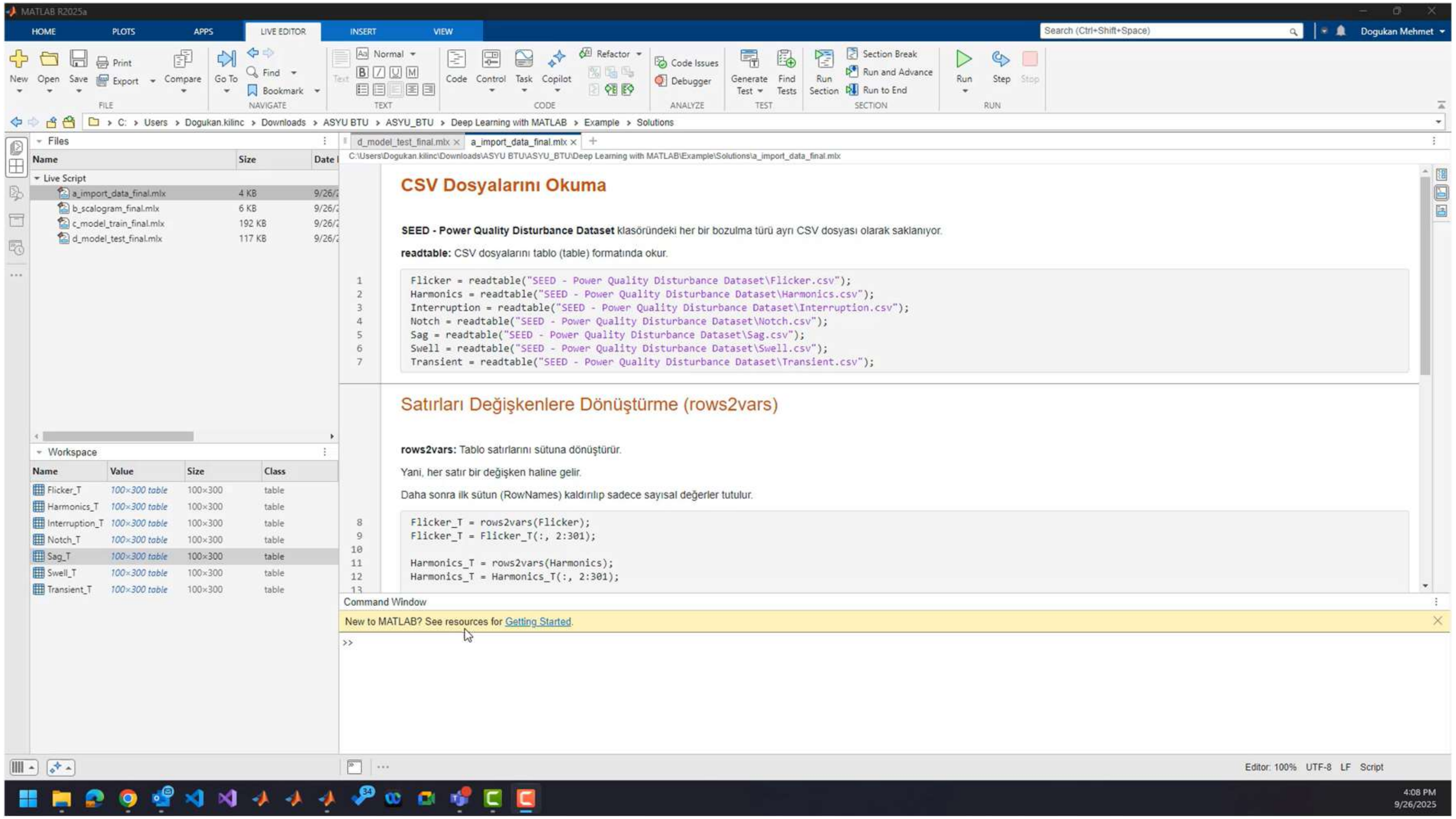


Training and Evaluating the Network





Deep Learning for PQD Signals (← Click with **CTRL + Left Click**)



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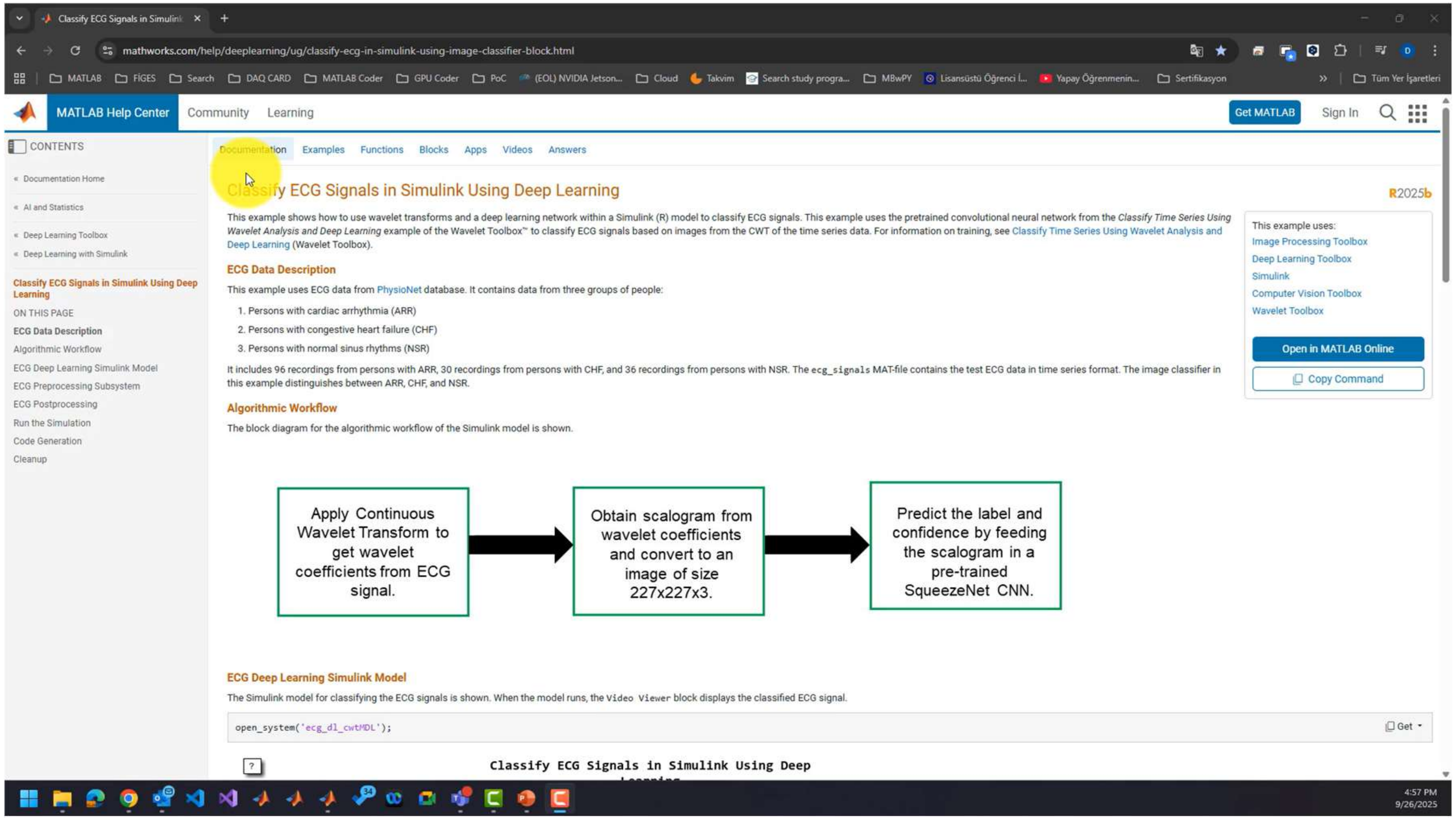
Code Generation for ECG Data Project



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dogukan.kilinc@figes.com.tr