MATLAB EXPO 2021

Getting started with AI in MATLAB

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MathWorks®

In this workshop we will …

Learn the Fundamentals of AI

Learn the Fundamentals of Deep Learning

Use real-world ECG Signals

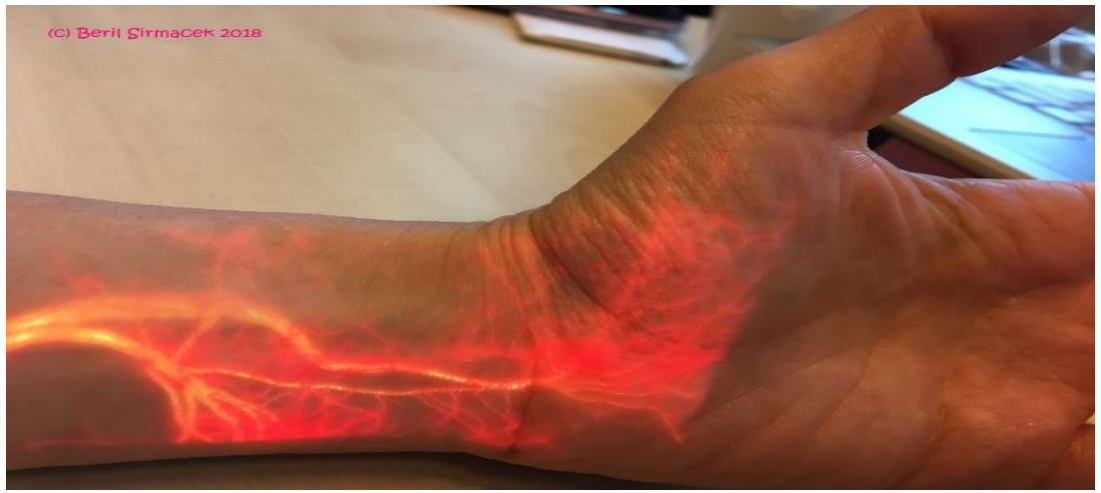
Learn the Fundamentals of Machine Learning

Discuss deployment options

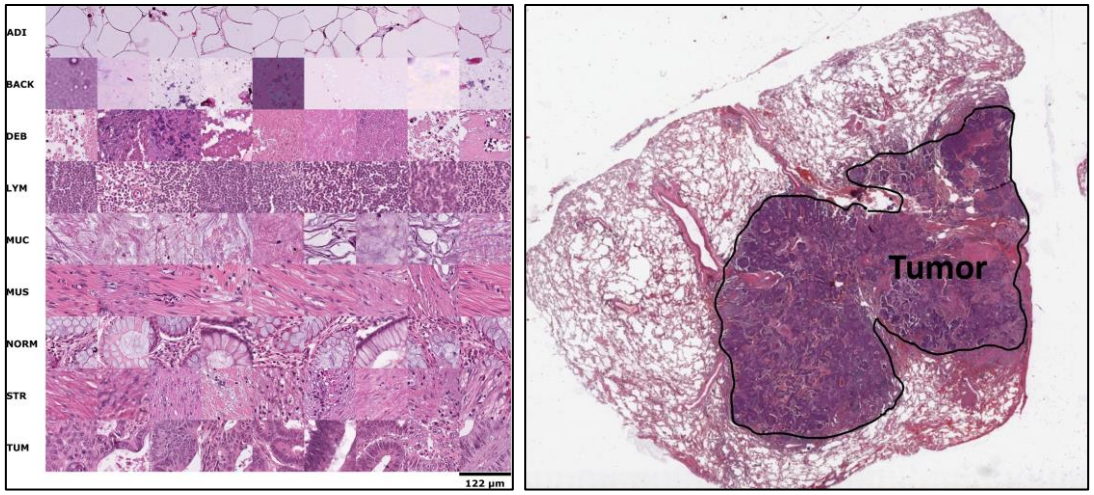
Set-Up Instructions

- Set up a MathWorks account if you don't have one
  - please use **Google Chrome** browser 
  - go to https://www.mathworks.com/mwaccount/
- Copy the materials via the MATLAB Drive
  - go to https://drive.matlab.com/sharing/bac1e750-8f81-411e-bc94-9db1d5195e77
  - Click on Add to my Files/Copy Folder
  - You should see a separate folder saying "Owned By: Me" (on the right-hand side)
- Activate the workshop license and launch MATLAB Online
  - go to https://www.mathworks.com/licensecenter/classroom/MATLAB_EXPO_8726324/
  - click ***Access MATLAB Online***
  - log in using your MathWorks account

AI in Research and Industry



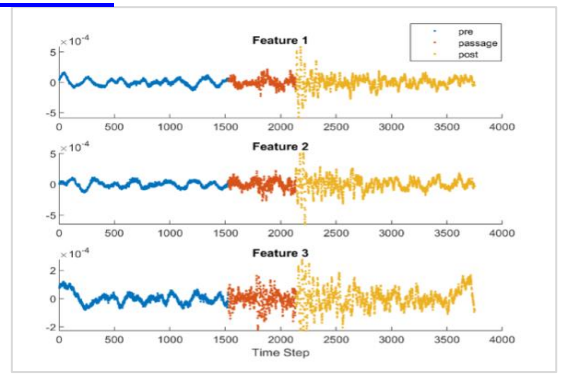
University of Twente: [Augmented Reality of blood flow]



DKFZ Heidelberg: [Deep Learning for Tumor Detection]

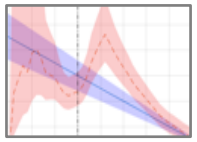
[Automatic Defect Detection] AIRBUS

[Oversteering Detection]



[Seismic Event Detection]

MathWorks Focus on Deep Learning and AI for Engineering and Science



Predictive Maintenance

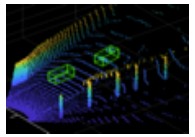
- Bearing Prognosis
- Pump Fault Diagnosis

Predictive Maintenance Toolbox™

Land-Use Classification

- Semantic Segmentation for Multispectral Images

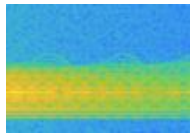
Image Processing Toolbox™



Lidar

- Lidar Point Cloud Semantic Segmentation
- 3-D Object Detection Using PointPillars

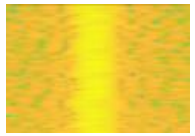
Lidar Toolbox™



Radar

- Radar Waveform Classification
- Pedestrian and Bicyclist Classification

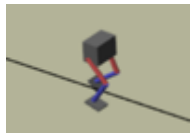
Phased Array System Toolbox™



Wireless Communications

- Modulation Classification
- Detect WLAN Router Impersonation

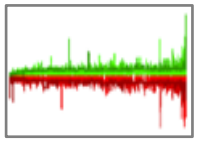
Communications Toolbox™



Reinforcement Learning

- Train Biped Robot to Walk
- PMSM Motor Control

Reinforcement Learning Toolbox™



Computational Finance

- Machine Learning for Statistical Arbitrage

Financial Toolbox™

Robotics

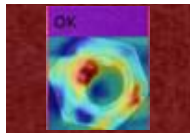
- Avoid Obstacles using Reinforcement Learning

Robotics System Toolbox™

Automated Driving

- Deep Learning Vehicle Detector
- Occupancy Grid with Semantic Segmentation

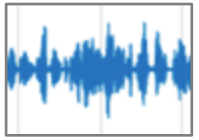
Automated Driving Toolbox™



Visual Inspection

- Manufacturing Defect Detection
- Anomaly Detection for Cloth Manufacturing

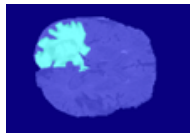
Image Processing Toolbox™



Audio

- Speech Command Recognition
- Cocktail Party Source Separation

Audio Toolbox™



Medical Imaging

- 3-D Brain Tumor Segmentation
- Breast Cancer Tumor Classification

Image Processing Toolbox™

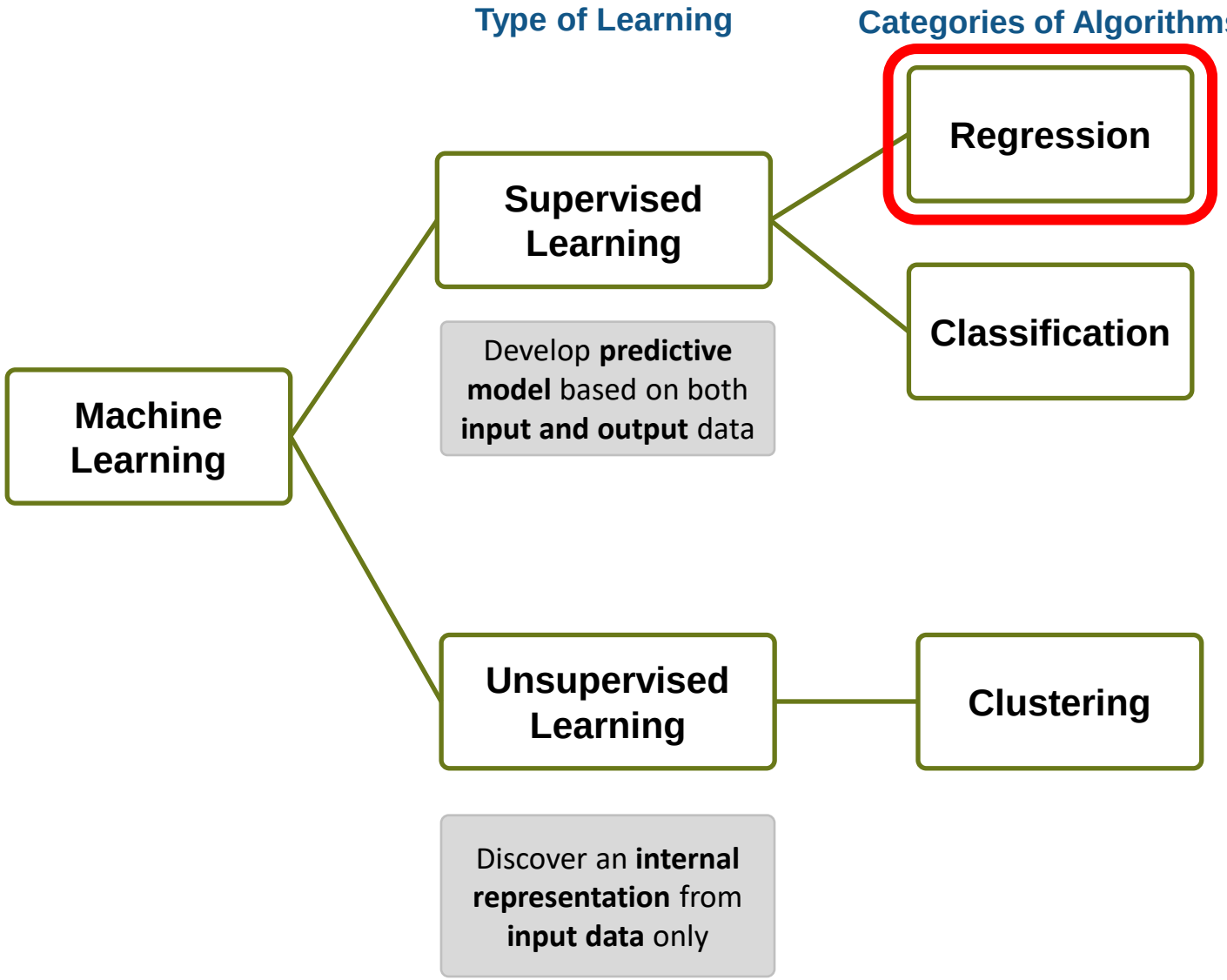
What is AI?

Artificial Intelligence: The ability of a computer to perform tasks commonly associated with intelligent beings like learning or problem-solving.

Machine Learning: Learning a task from data without relying on a predetermined equation. (User may need to provide data features.)

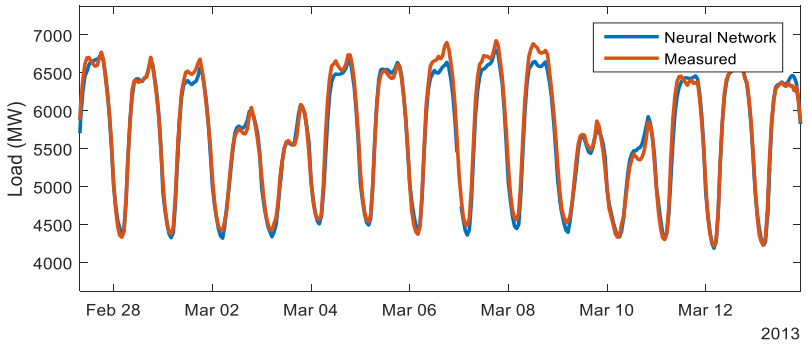
Deep Learning: Learning from raw data without predetermined features using neural networks with many layers

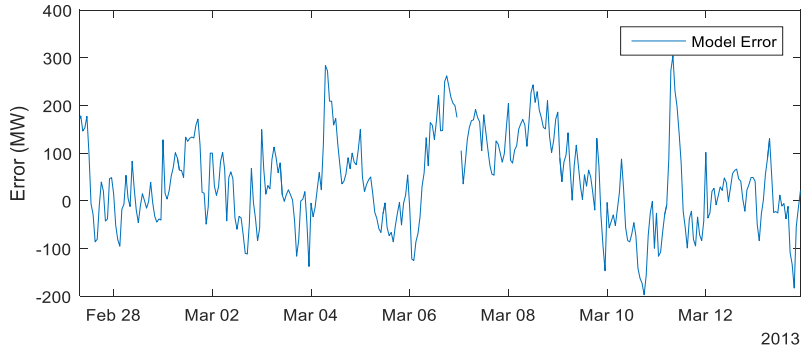
Types of Machine Learning



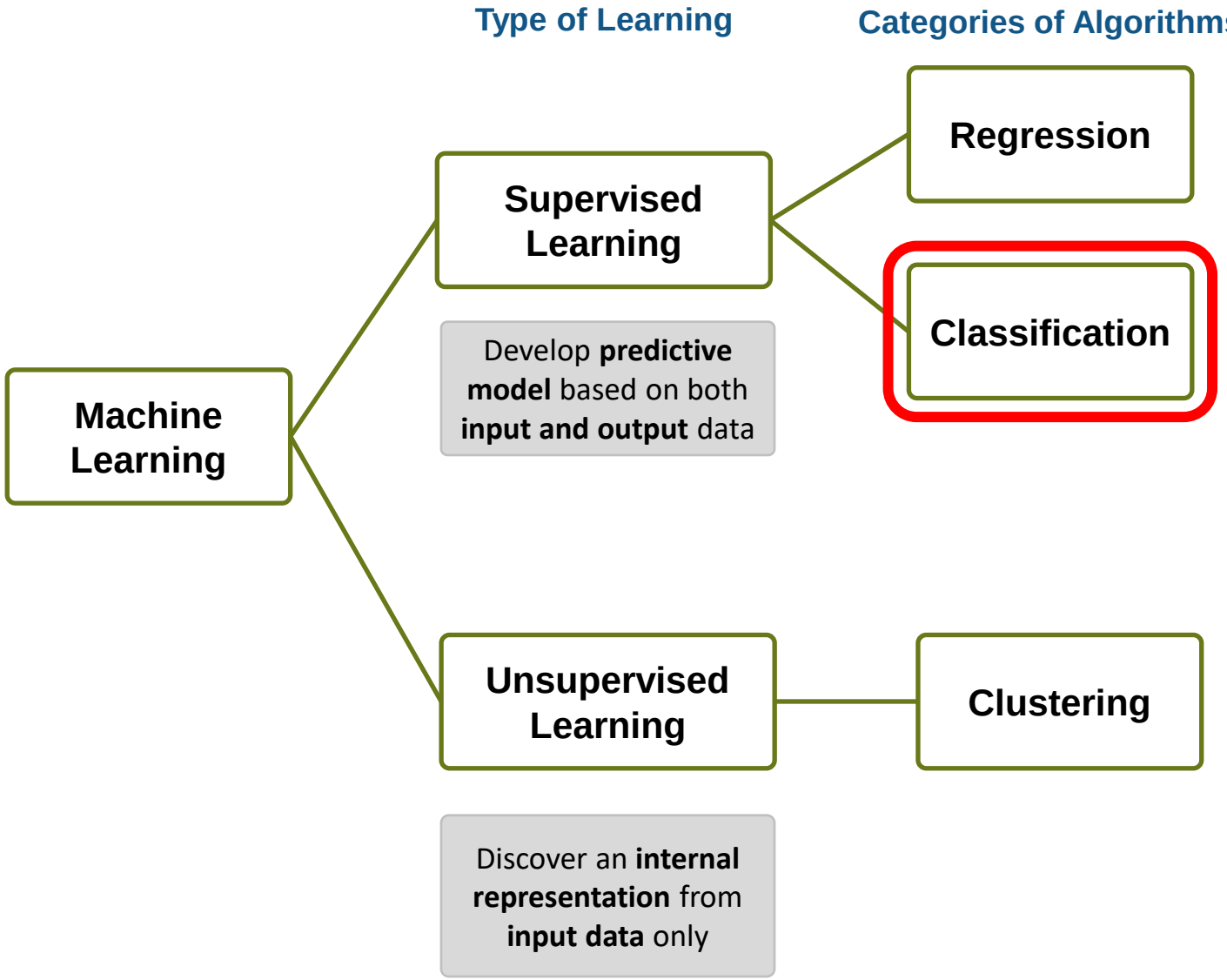
Objective:

Easy and accurate computation of day-ahead system load forecast





Types of Machine Learning



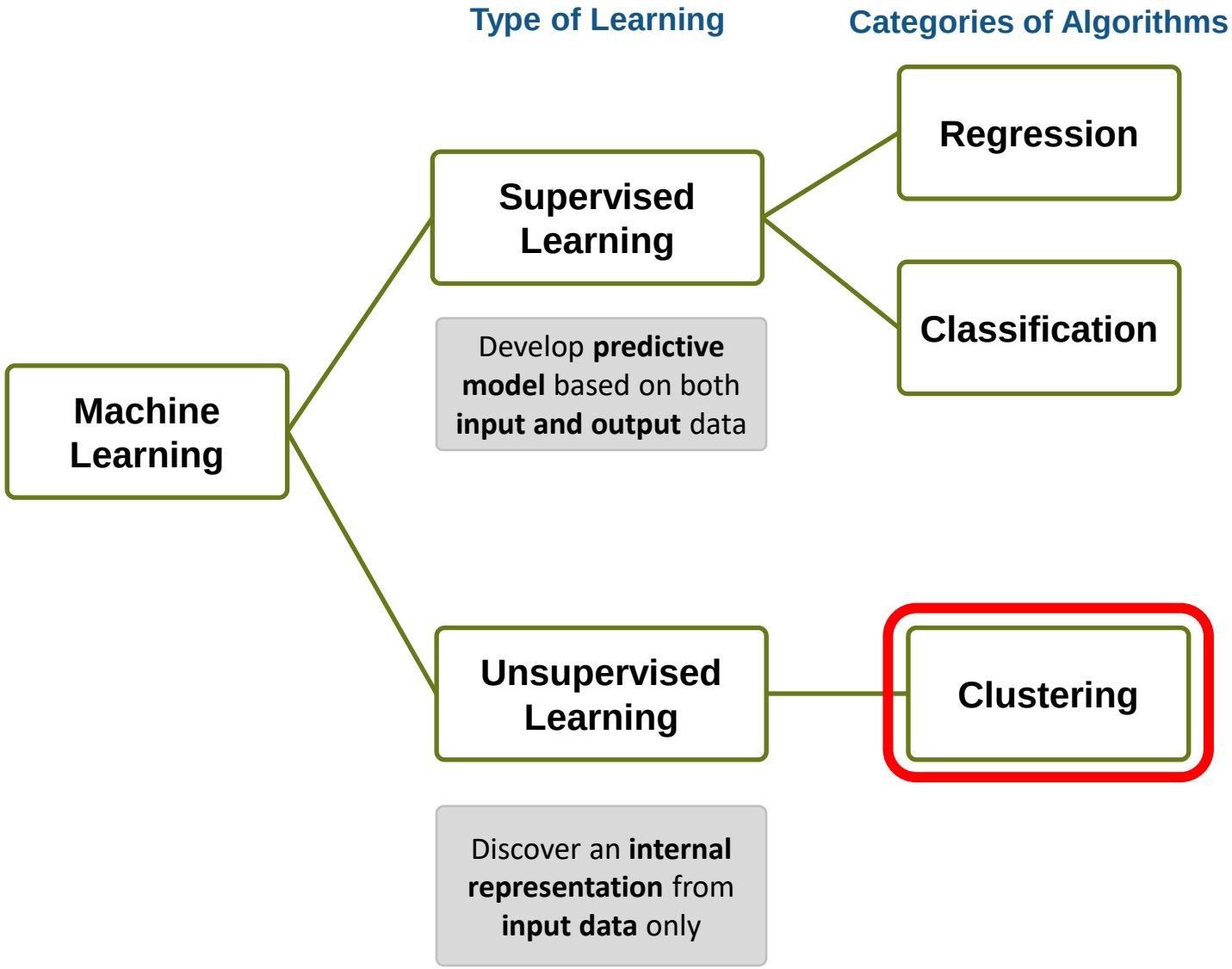
Objective:

Train a classifier to classify human activity from sensor data

Data:

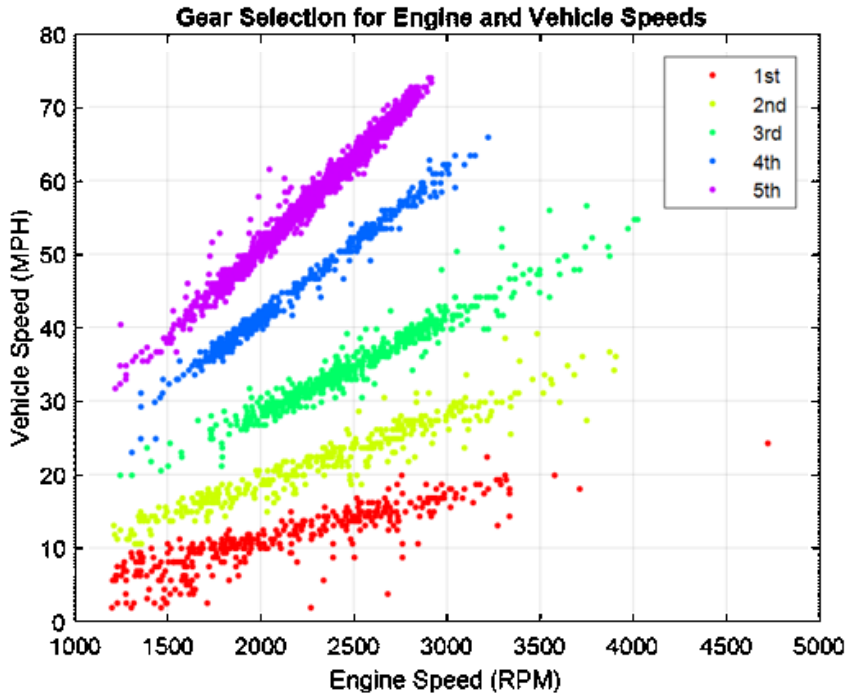
Inputs	3-axial Accelerometer 3-axial Gyroscope 
Outputs	

Types of Machine Learning

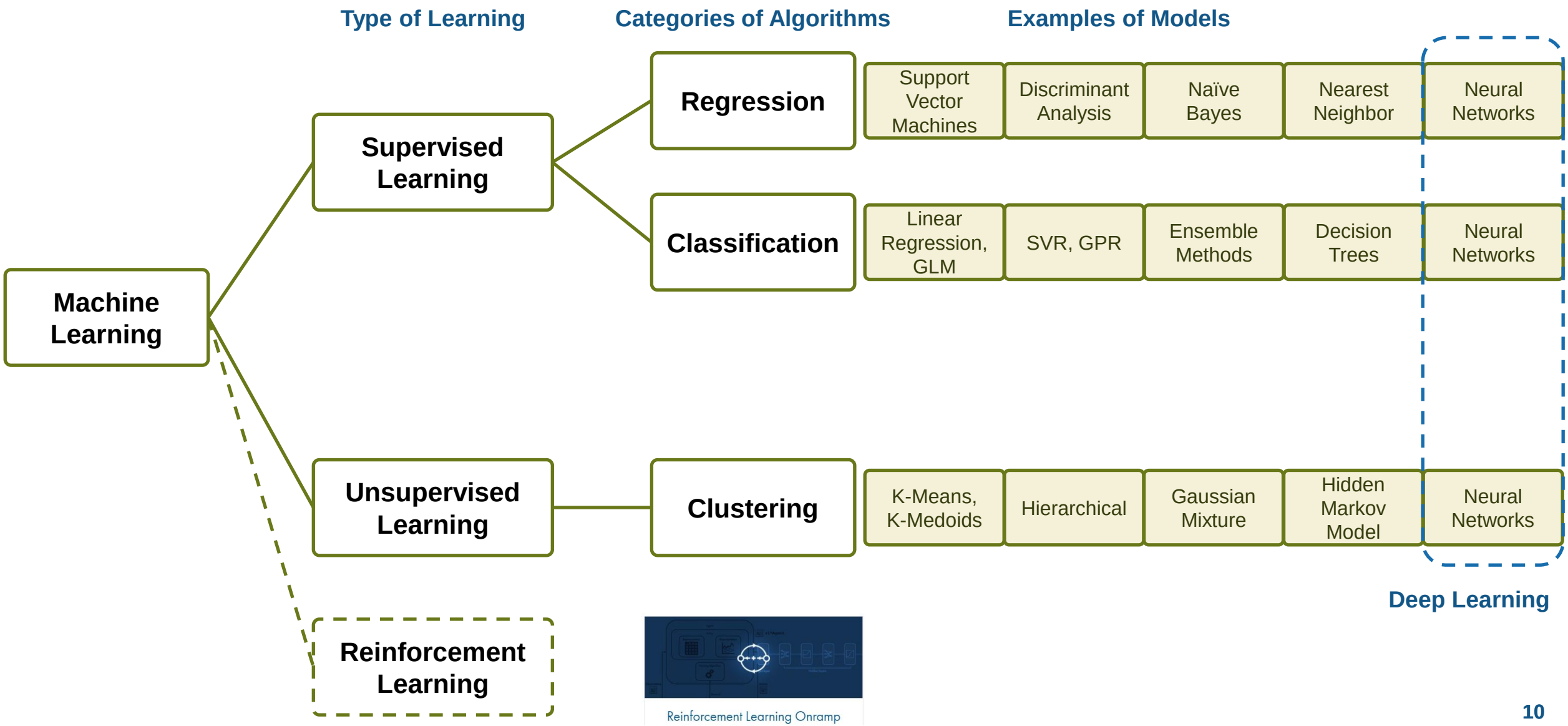


Objective:

Given data for engine speed and vehicle speed, identify clusters

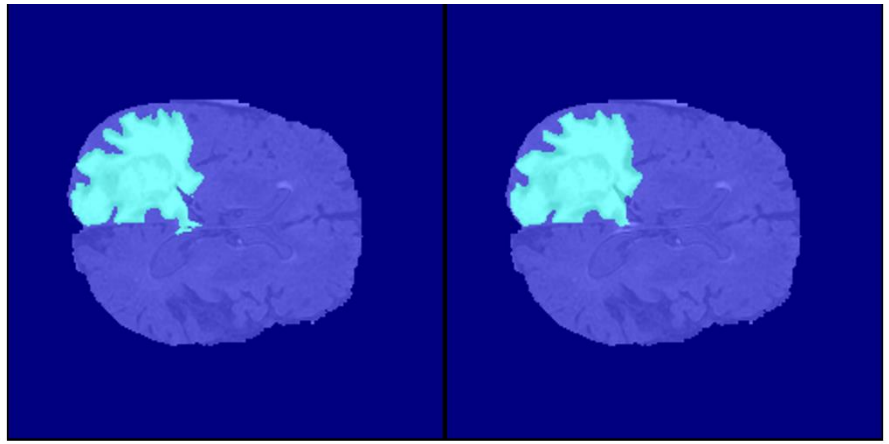


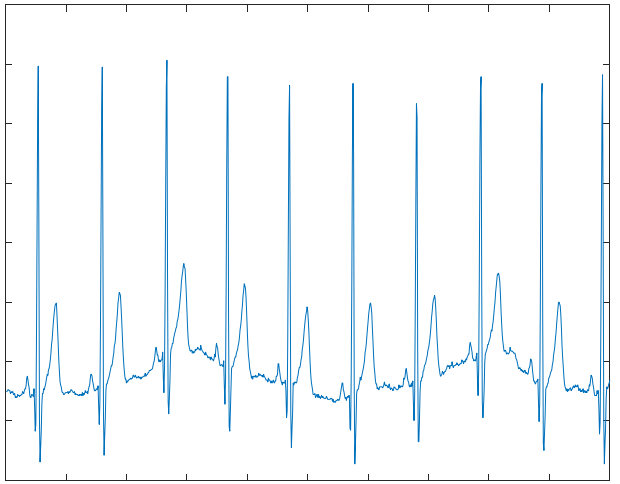
Types of Machine Learning



Machine Learning and Deep Learning Datatypes

Image





Signal

Numeric

AgeCat	WeightQ	GroupCount	mean_BloodPressure	
Under 30	Q1	6	123.17	79.667
Under 30	Q2	3	120.33	79.667
Under 30	Q3	2	127.5	86.5
Under 30	Q4	4	122	78
30-39	Q1	12	121.75	81.75
30-39	Q2	9	119.56	82.556
30-39	Q3	9	121	83.222
30-39	Q4	11	125.55	87.273
Over 40	Q1	7	122.14	84.714
Over 40	Q2	13	123.38	79.385
Over 40	Q3	14	123.07	84.643
Over 40	Q4	10	124.6	85.1

Text

AI Workflow

Data Preparation

- Data cleansing and preparation
- Human insight
- Simulation-generated data

AI Modeling

- Model design and tuning
- Hardware accelerated training
- Interoperability

Simulation & Test

- Integration with complex systems
- System simulation
- System verification and validation

Deployment

- Embedded devices
- Enterprise systems
- Edge, cloud, desktop

Iteration and Refinement

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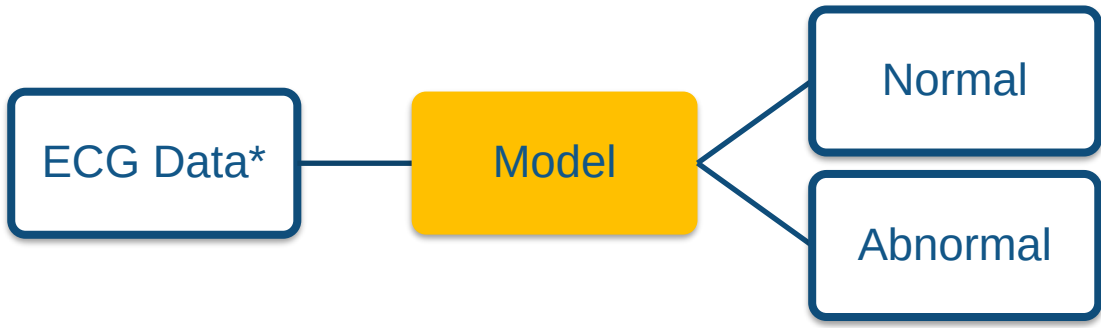
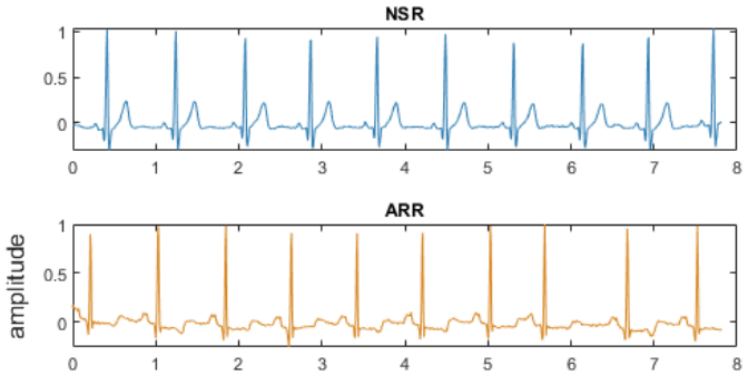
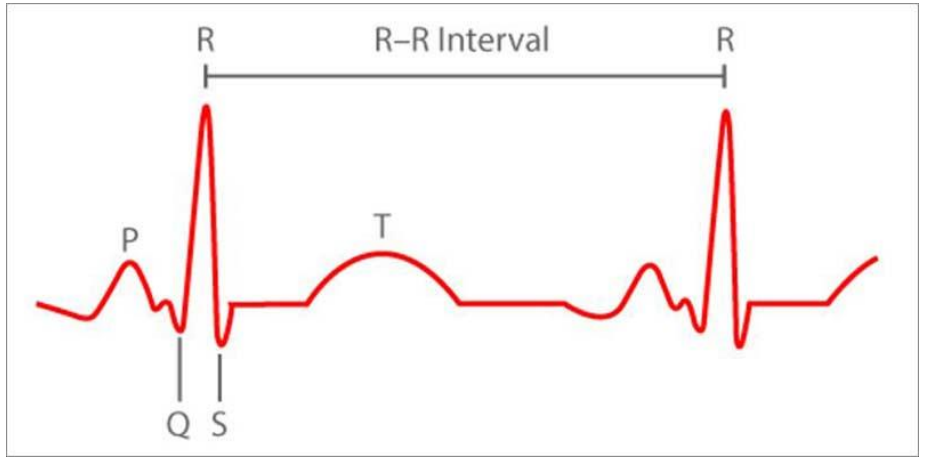
Practical Example: Classify Heart Condition

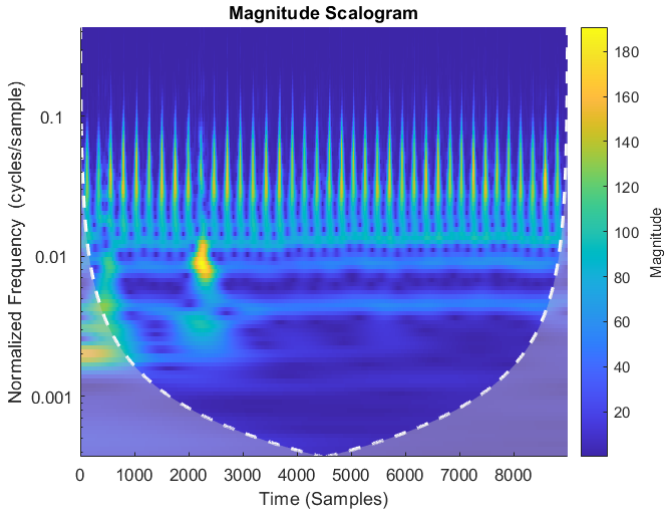




ECG characteristics (for ML):



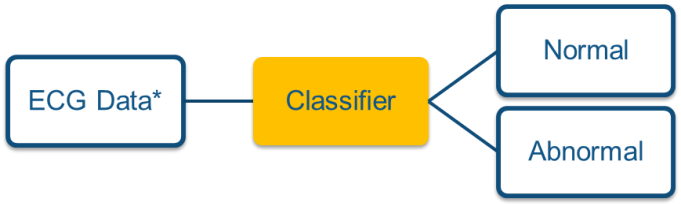
ECG transformation (for DL):

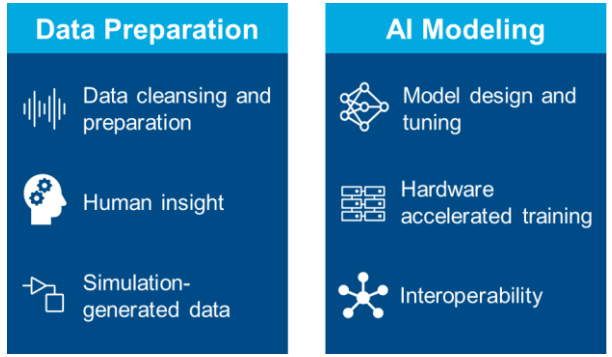


***Dataset was curated for 2017 PhysioNet challenge**: "normal" ECG data was obtained from the MIT-BIH Normal Sinus Rhythm database available at https://physionet.org/content/nsrdb/1.0.0/, and "abnormal" from MIT-BIH Arrythmia database at https://www.physionet.org/content/mitdb/1.0.0/

ML Exercise: Classify Heart Condition

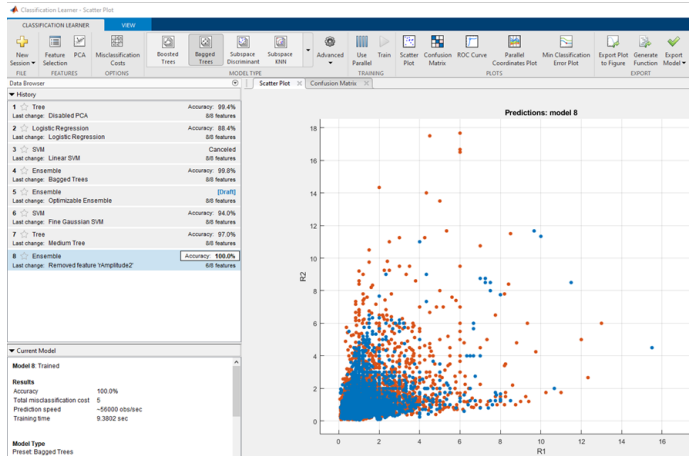
Goal: classify heartbeat signal into normal and abnormal using machine learning





To Do:

- Go to ***Exercises*** folder
- Open ***Ex1_ECG_ML_FeaturesStats.mlx*** and follow along with the instructor

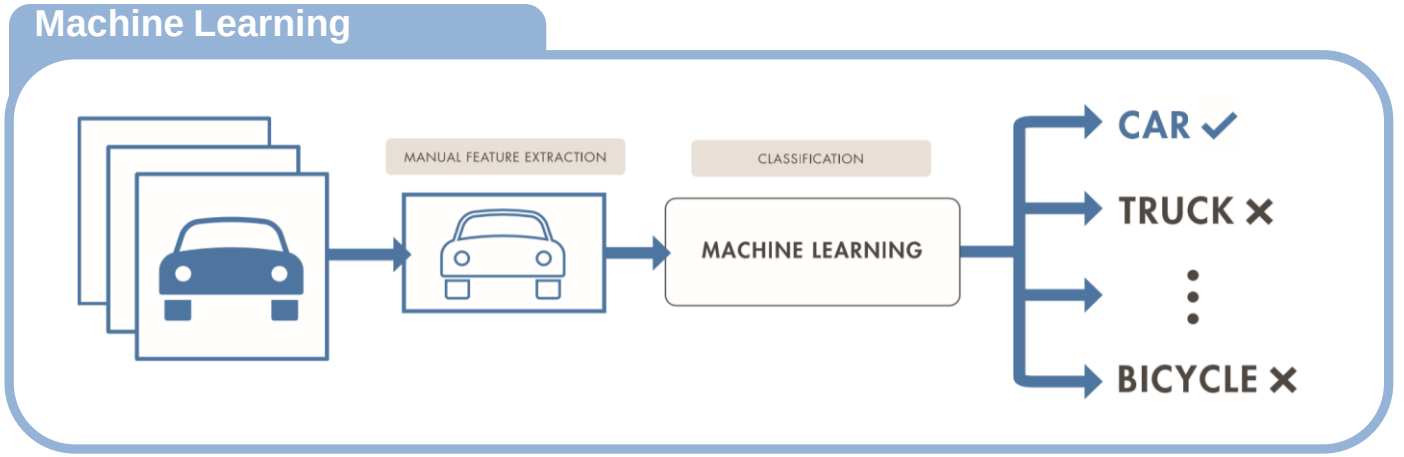


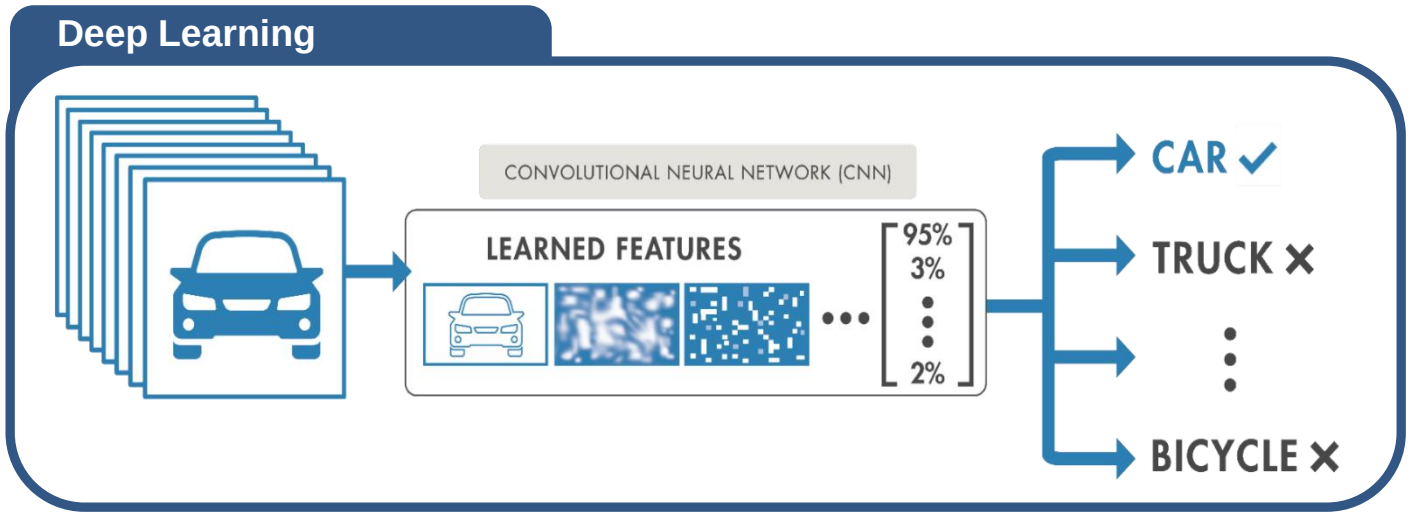
Beyond traditional Machine Learning

Machine Learning

Deep Learning
Neural Networks with many Hidden Layers

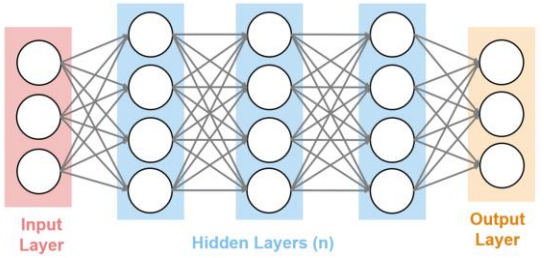
- Learns directly from data
- More Data = better model
- Computationally intensive
- **Not interpretable**

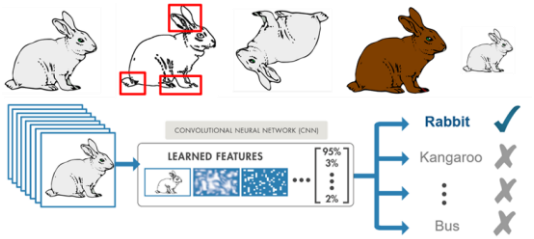


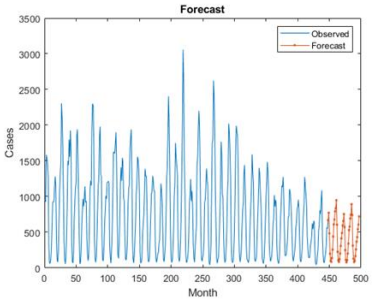


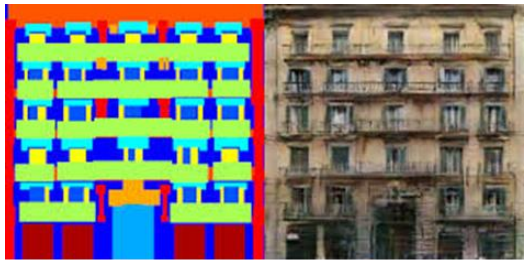
What is Deep Learning?

- DL uses neural networks and was inspired by the human brain
- DL neural networks consist of
  - Neurons arranged in layers
  - Layer combinations
  - Learnable parameters (weights and biases)
  - Hyperparameters (e.g. learning rate, number of epochs, mini batch size, etc.)
- Most commonly, DL is used for:
  - Classification: Output is categorical (or discrete)
  - Regression: Output is numerical (or continuous)
  - (Can also be used to generate things, e.g. GANs)



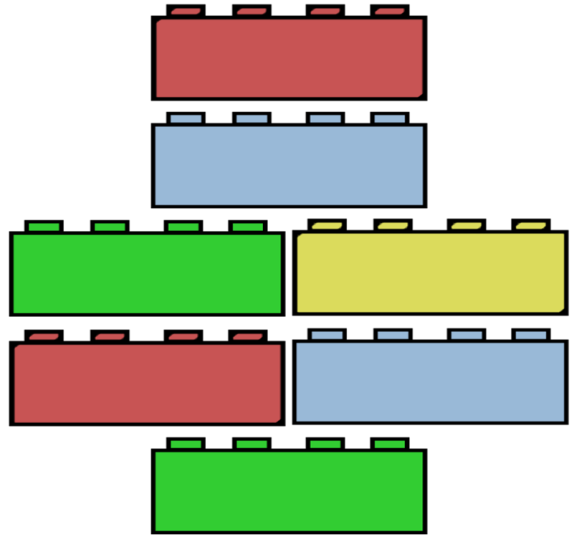


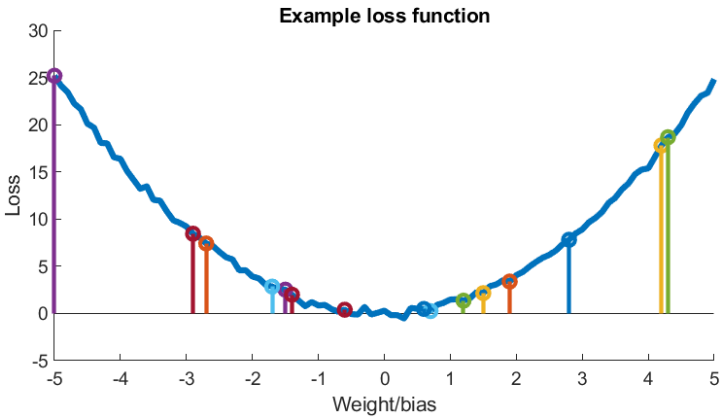




What is Deep Learning?

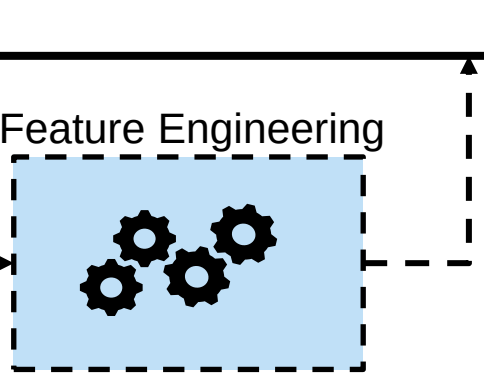
- Layers are like blocks
  - Stack on top of each other
  - Replace one block with a different one
- Information is usually passed in a forward pass (but can also be passed backwards)
- Weights and biases are adjusted in a backward pass (backpropagation) using a gradient descent
- There are different networks for different applications (e.g. CNNs for images, RNNs for sequential data)

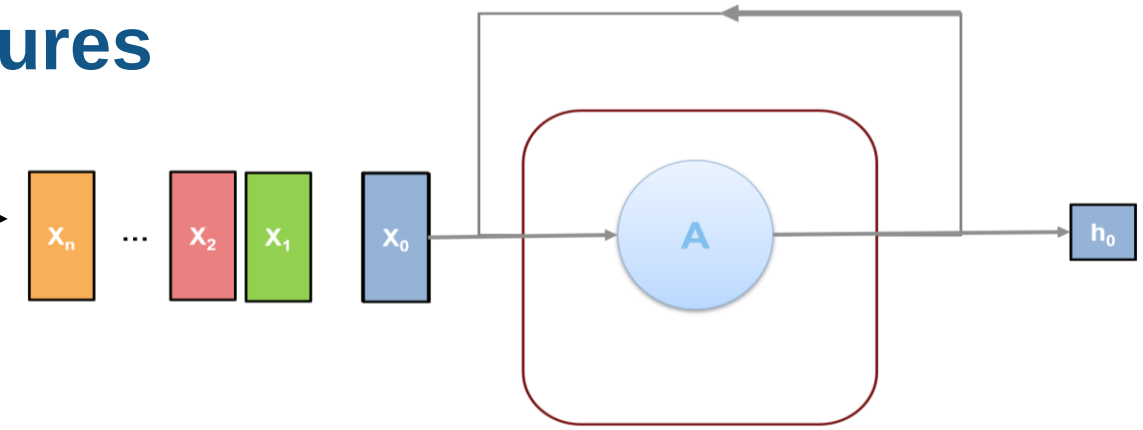




Signal Processing Architectures

Feature Engineering

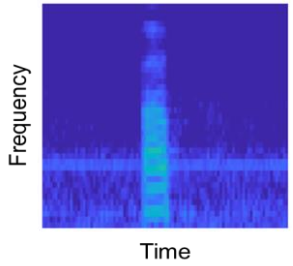




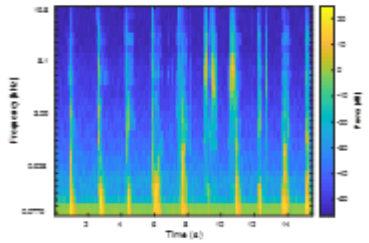
Recurrent Neural Network (**RNN**)

(e.g. Long Short-Term Memory (**LSTM**) Networks)

Spectrogram



OR

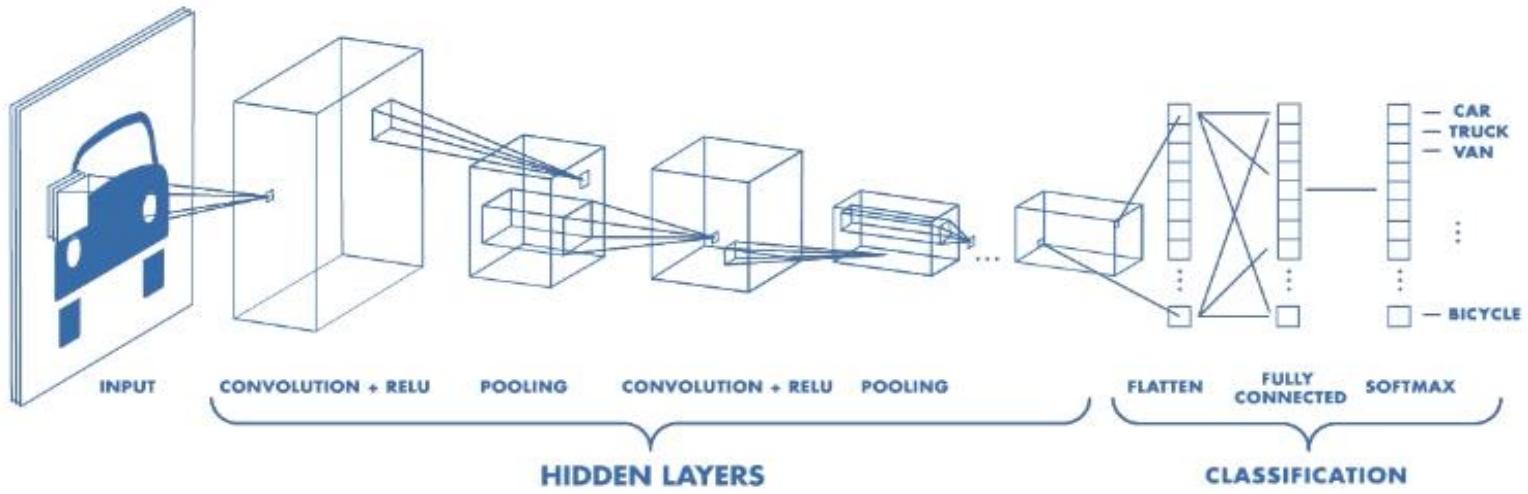


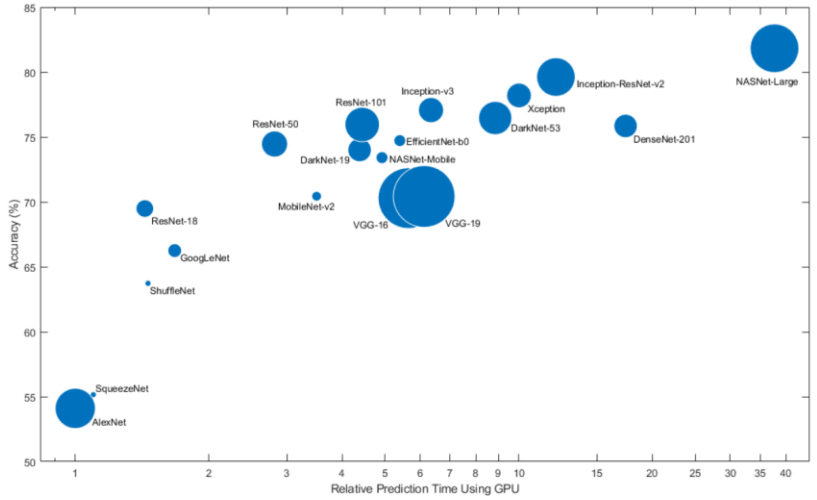
Time-Frequency Transformation

Convolutional Neural Networks (**CNN**)

Quick overview of Convolution Neural Networks

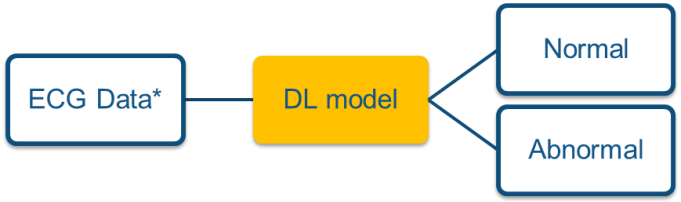
- CNNs are typically used to classify images
- CNNs extract features of different granularities
- A lot of pretrained CNN models exist in MATLAB
- A very good starting point to use with transfer learning

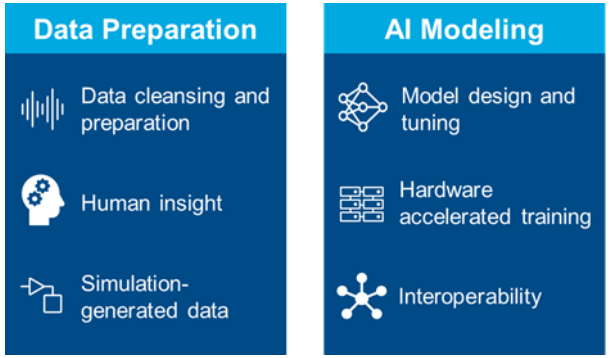




DL Exercise: Classify Heart Condition

Goal: classify heartbeat signal into normal and abnormal using deep learning





To Do:

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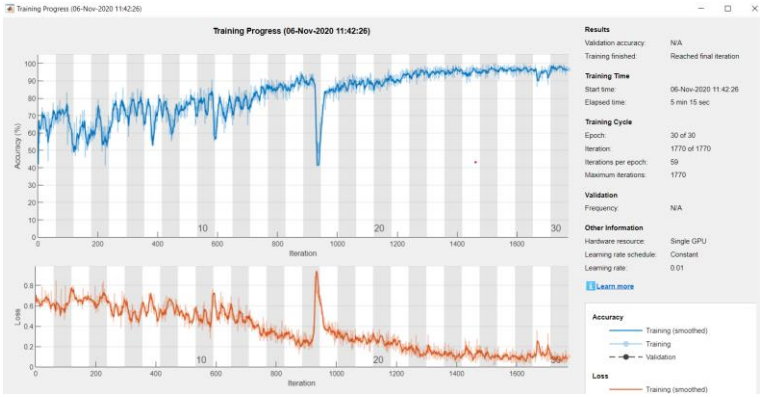

The example using LSTM can be found here.

AI Workflow

Data Preparation

- Data cleansing and preparation
- Human insight
- Simulation-generated data

AI Modeling

- Model design and tuning
- Hardware accelerated training
- Interoperability

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- Integration with complex systems
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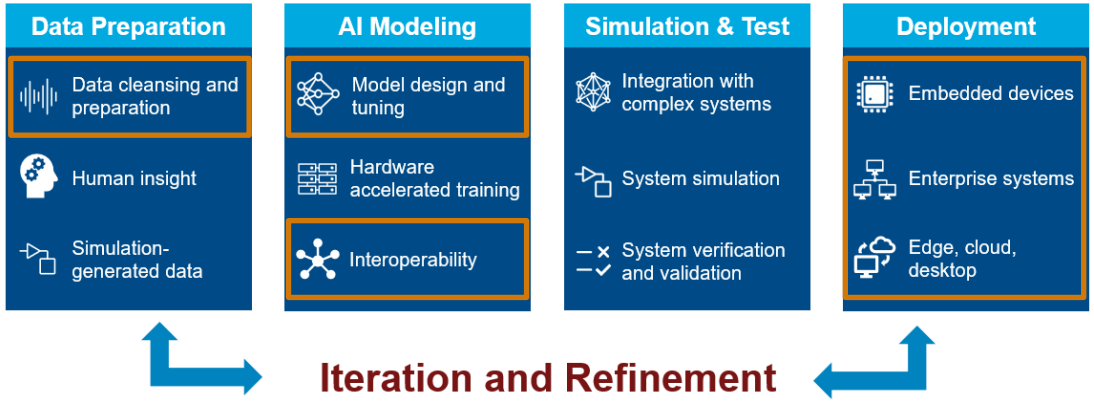
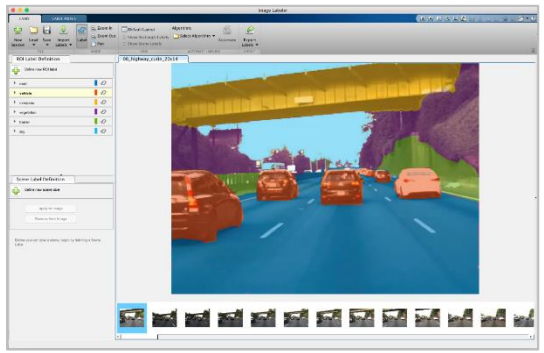
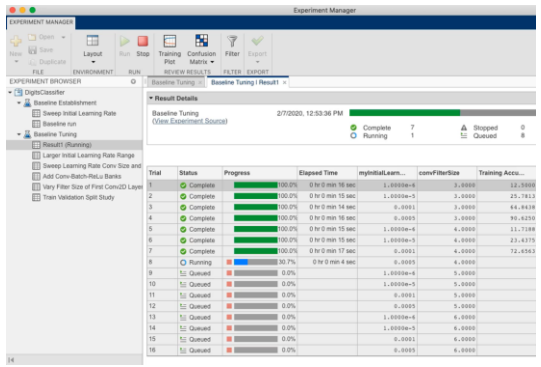
AI Workflow





Signal Labeler
+
Audio Labeler



Experiment Manager

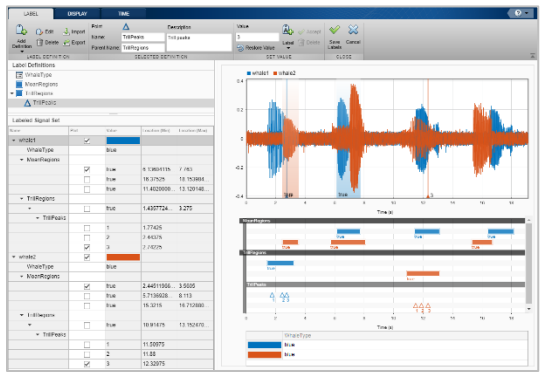
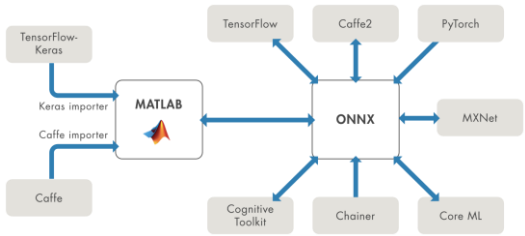
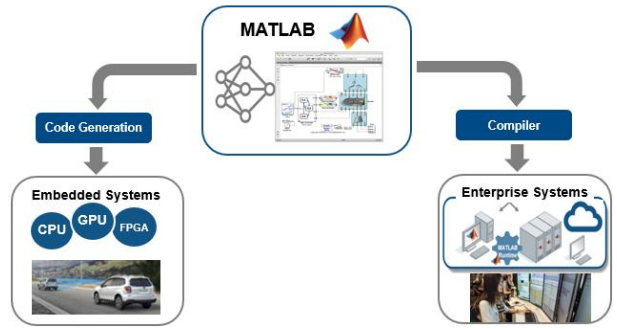


Image Labeler
+
Video Labeler



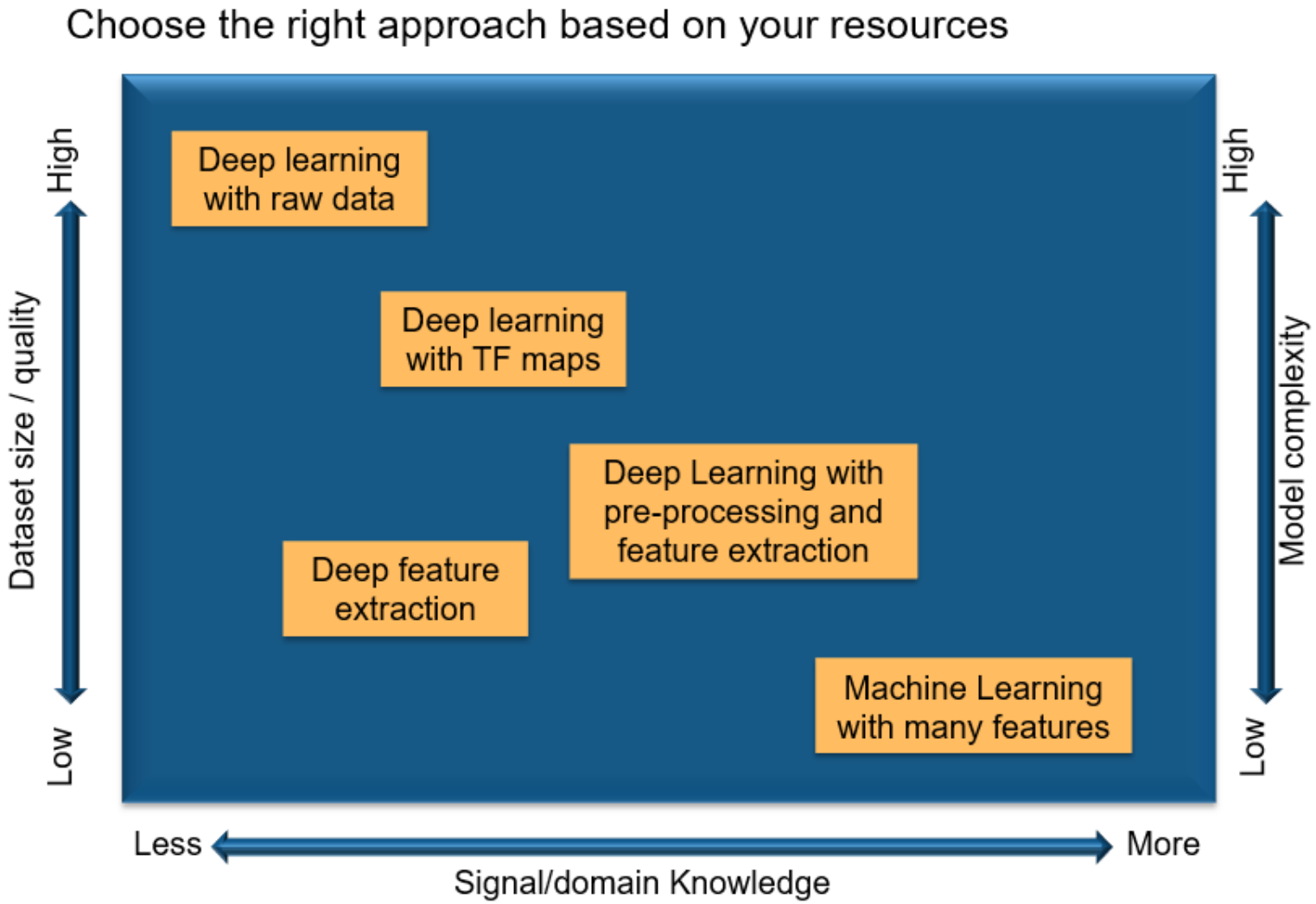
ONNX



EXPO talks:
Deploying AI on PLC (Plenary)

Cloud Data Workflows for Scientists and Engineers (DataBricks & AWS)

Biggest Challenge: Use Machine or Deep Learning?



Resources for Learning

- Get Free Online (hands-on) Training

MATLAB Onramp

Get started quickly with the basics of MATLAB®.

Details and launch

Simulink Onramp

Get started quickly with the basics of Simulink®.

Details and launch

Reinforcement Learning Onramp

An interactive introduction to reinforcement learning methods for control problems.

Details and launch

Deep Learning Onramp

Get started quickly using deep learning methods to perform image recognition.

Details and launch

Control Design Onramp with Simulink

Get started quickly with the basics of feedback control design in Simulink.

Details and launch

Signal Processing Onramp

An interactive introduction to practical signal processing methods for spectral analysis.

Details and launch

Image Processing Onramp

Learn the basics of practical image processing techniques in MATLAB.

Details and launch

Machine Learning Onramp

An interactive introduction to practical machine learning methods for classification problems.

Details and launch

Deep Learning Onramp

Get started quickly using deep learning methods to perform image recognition.

Details and launch

Stateflow Onramp

Learn the basics of creating, editing, and simulating state machines in Stateflow.

Details and launch

Resources for Teaching

- Teach with MATLAB and Simulink
- Teaching Science with MATLAB
- Virtual Labs & Projects
- Online teaching
- Support with developing individual AI courses, please contact us:

jhoerner@mathworks.com or
akamath@mathworks.com

MATLAB EXPO 2021

Thank you