MATLAB EXPO 2019

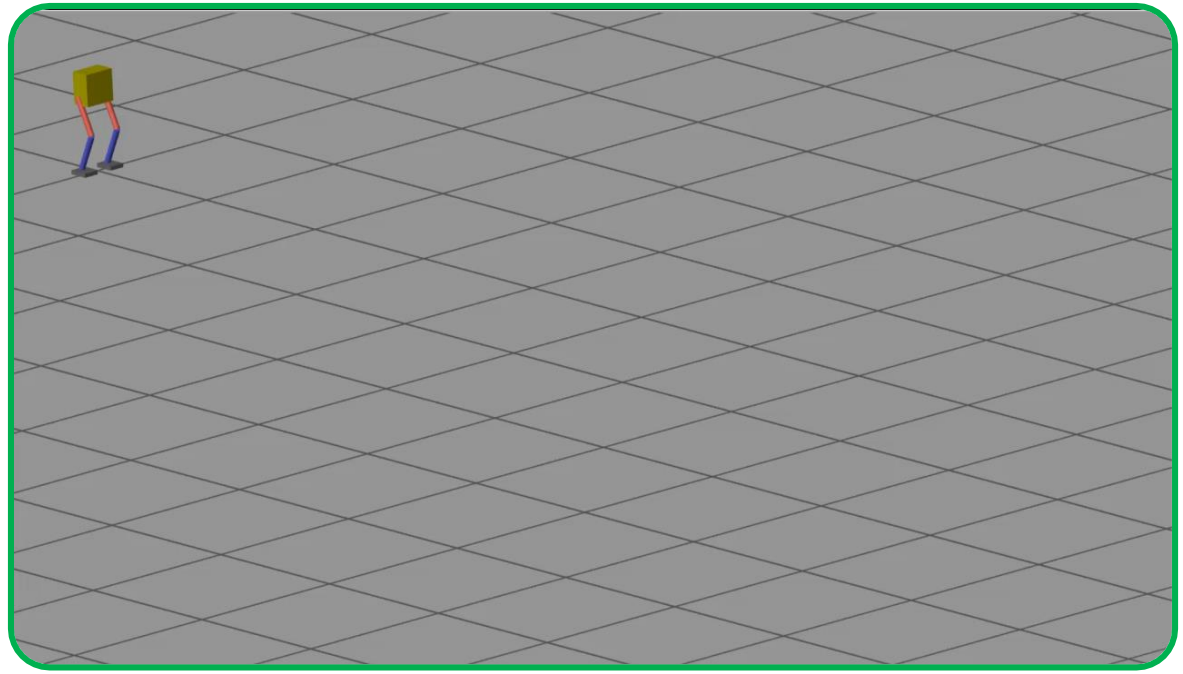
Deep Learning and Reinforcement Learning Workflows in A.I.

Abhijit Bhattacharjee

Why MATLAB for Artificial Intelligence?

Artificial Intelligence

Development of computer systems to perform tasks that normally require human intelligence

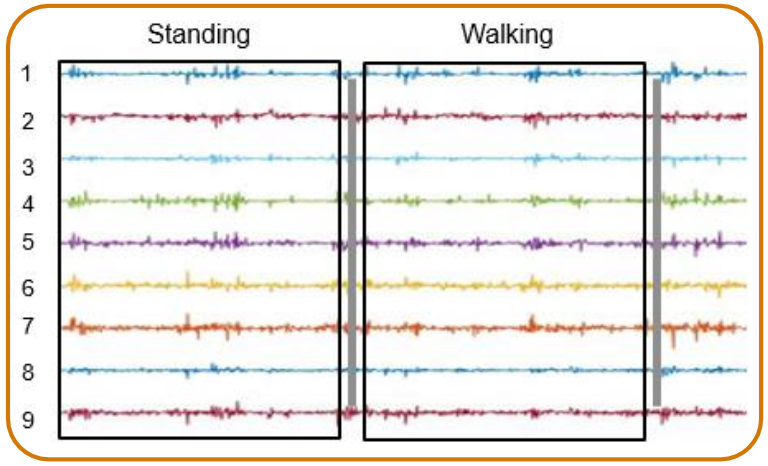


A.I. Applications

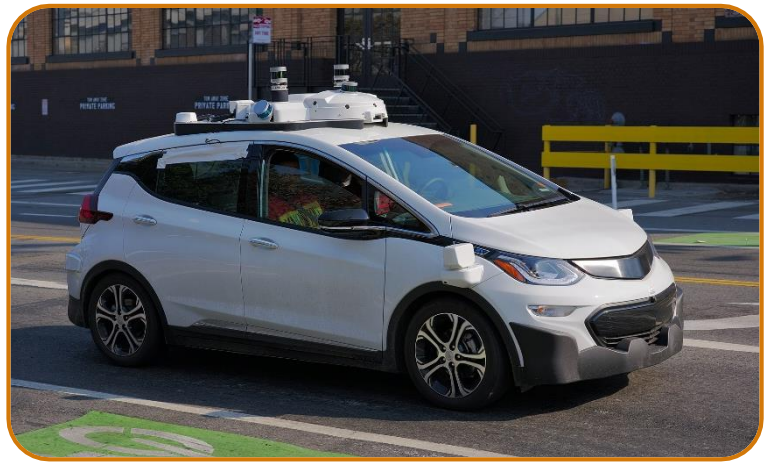
Object Classification

Speech Recognition

Predictive Maintenance



Signal Classification

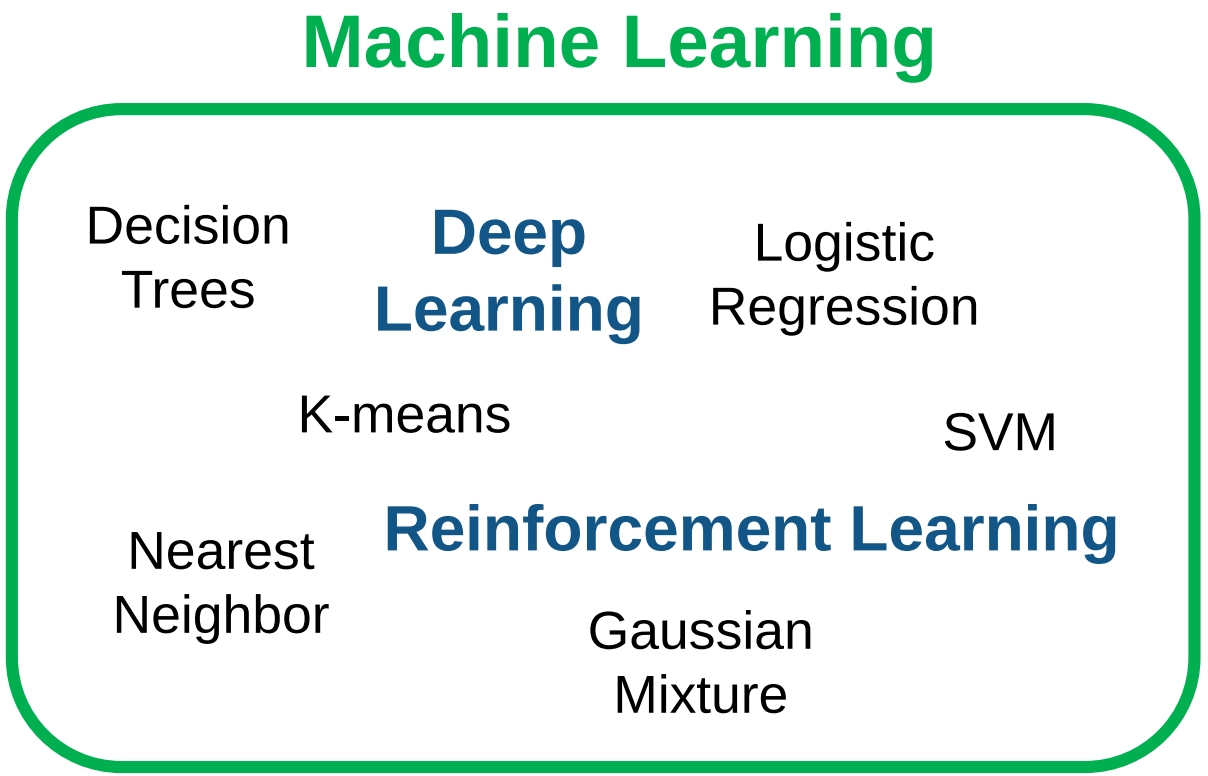


Automated Driving

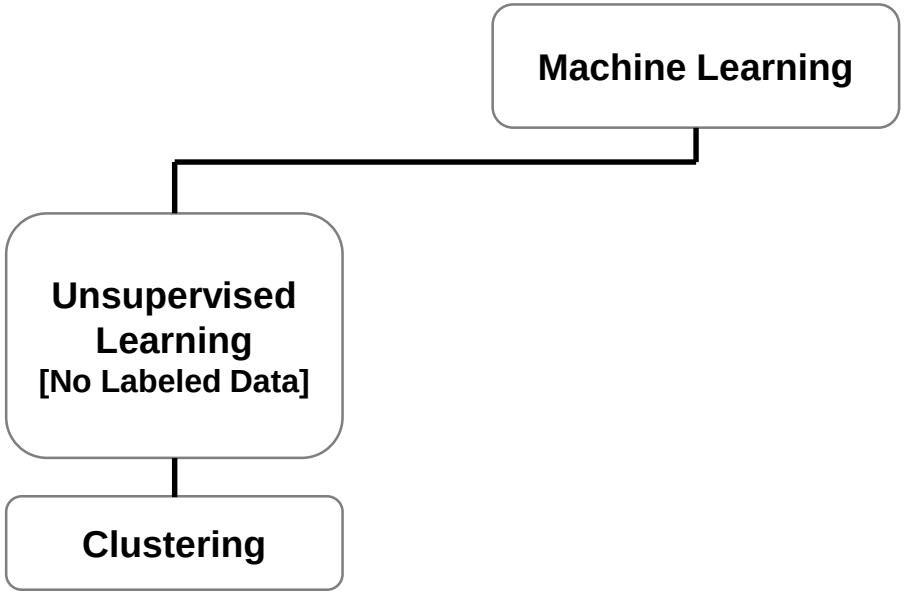
Stock Market Prediction

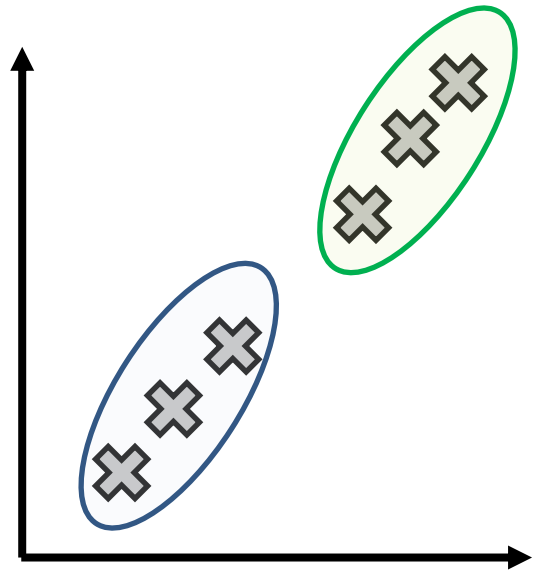
Artificial Intelligence

- Development of computer systems to perform tasks that normally require human intelligence

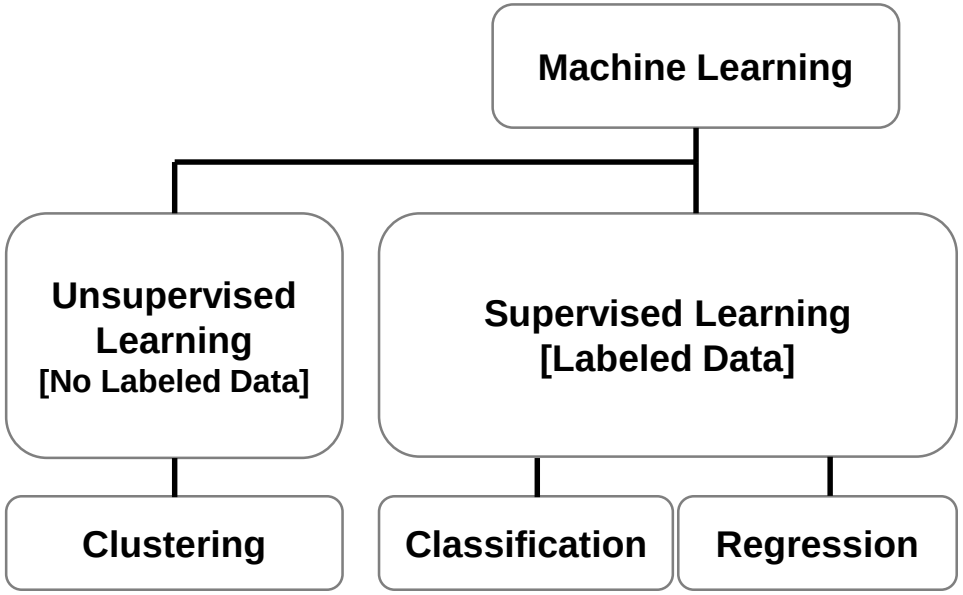


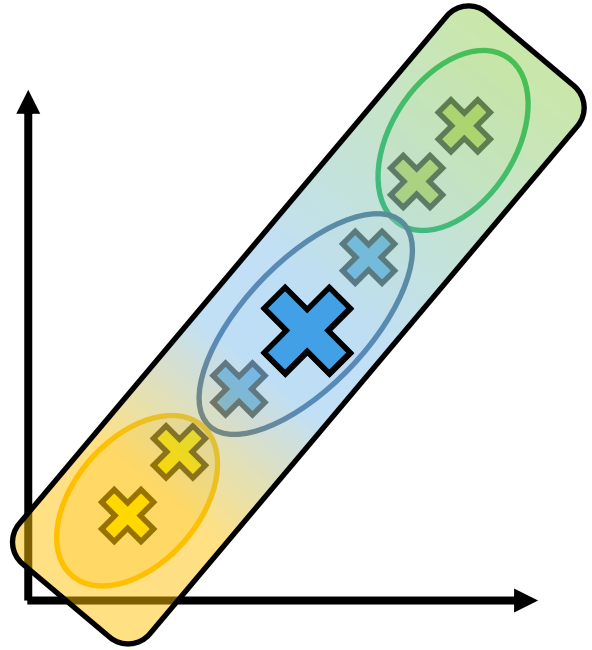
Machine Learning and Deep Learning



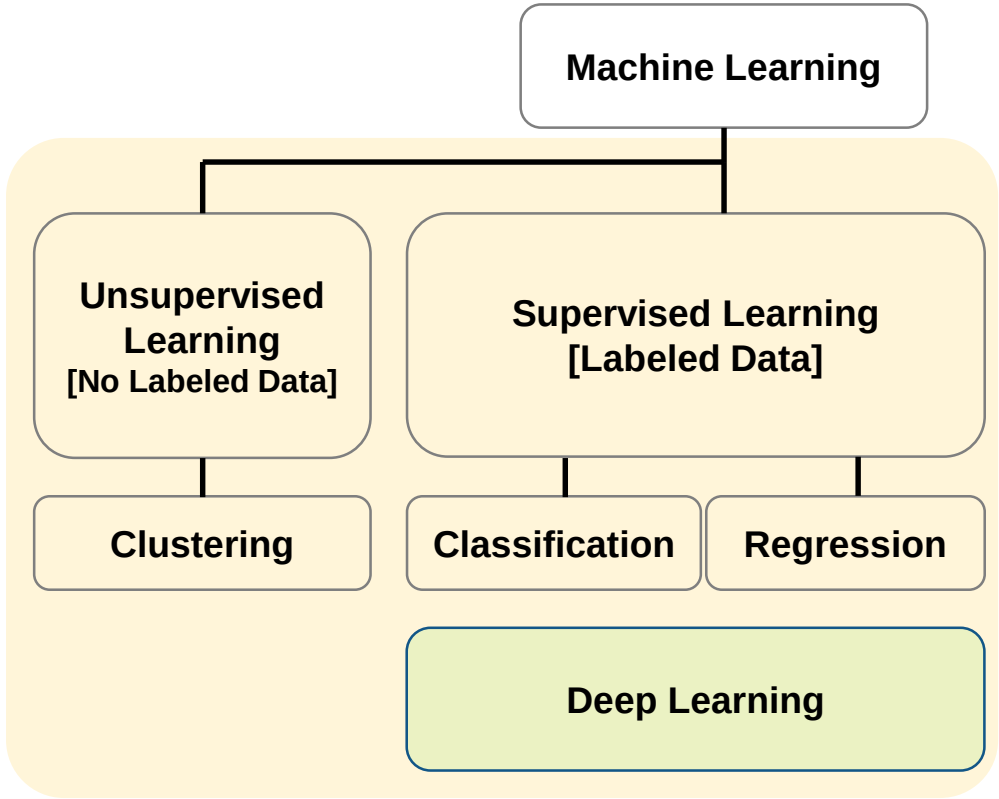


Machine Learning and Deep Learning





Machine Learning and Deep Learning

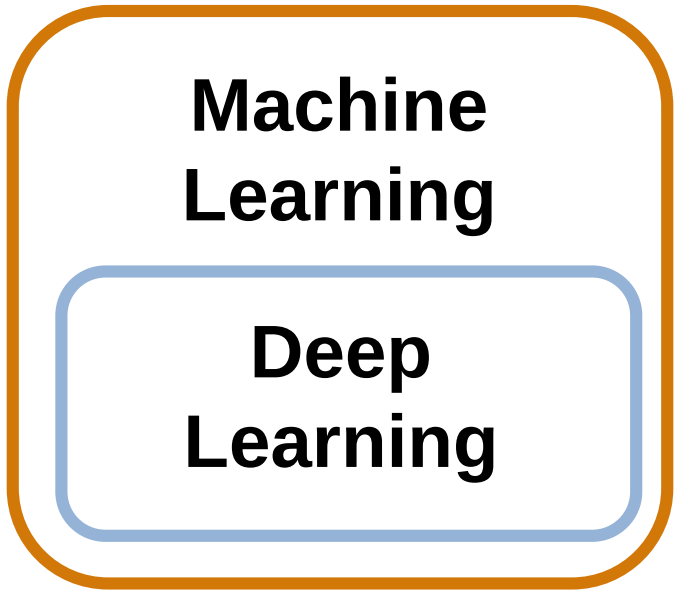


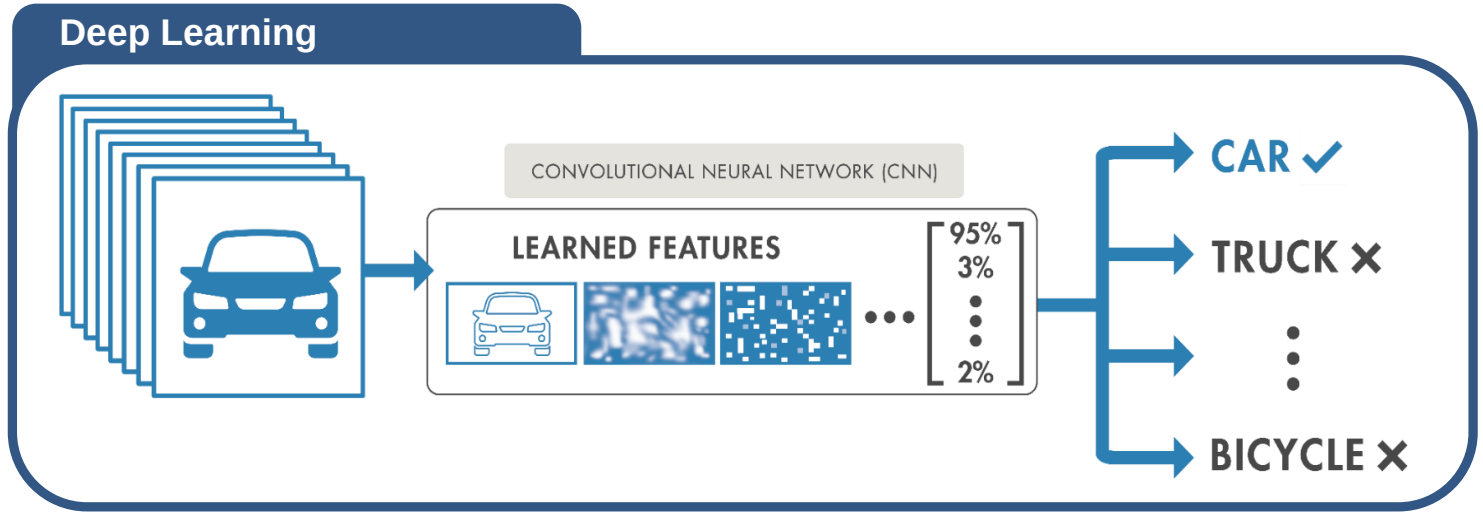
Supervised learning typically involves feature extraction

Deep learning typically does not involve feature extraction

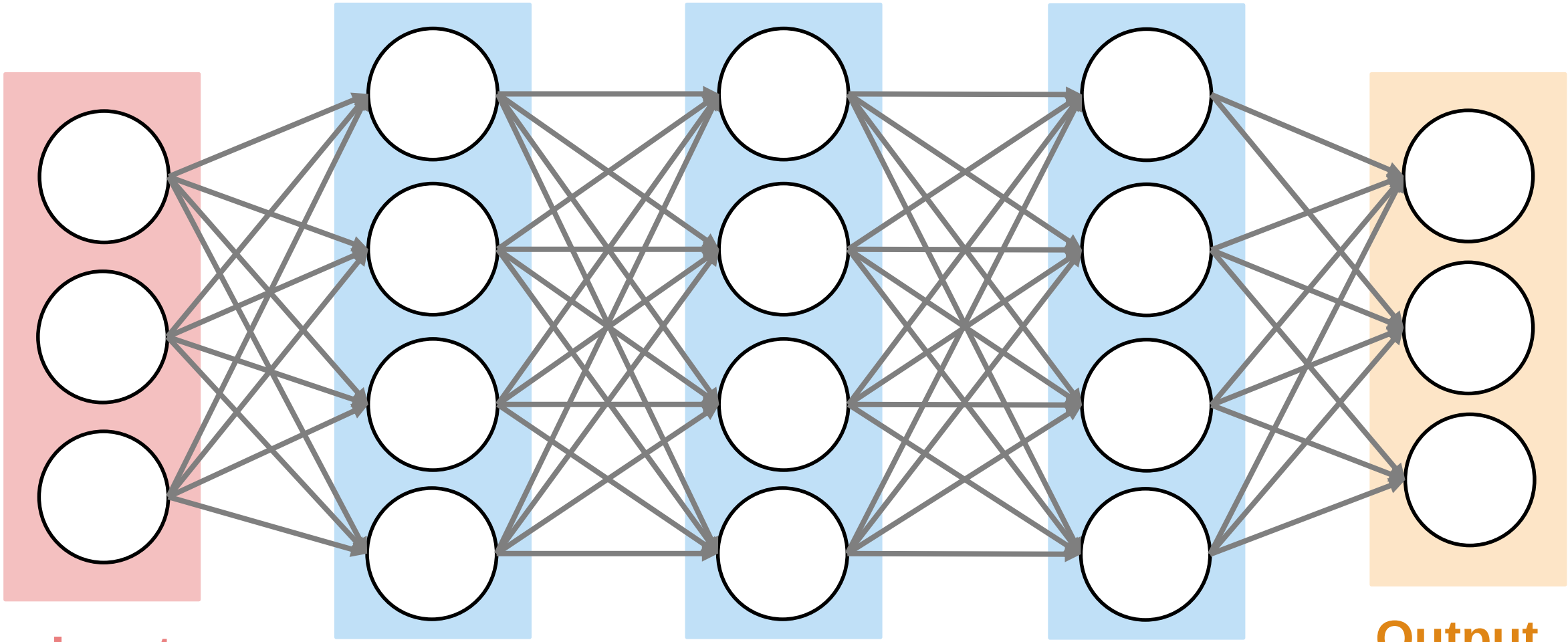
Deep Learning

- Subset of machine learning with automatic feature extraction
  - Learns features and tasks directly from data
  - More Data = better model



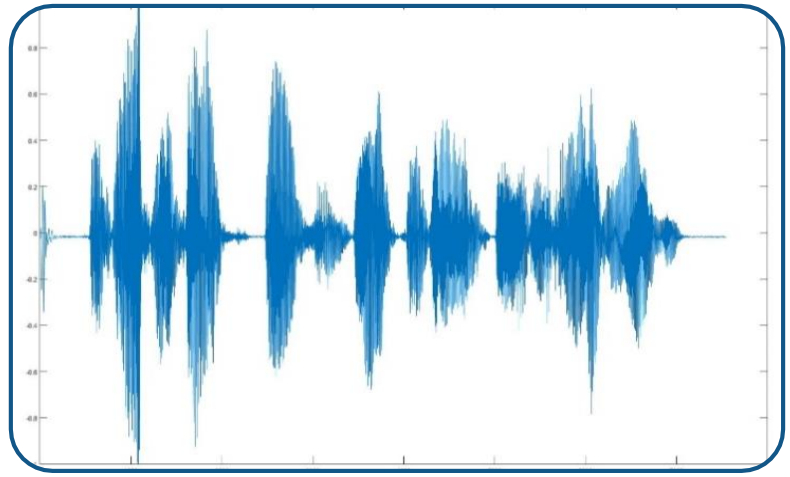


Deep Learning Uses a Neural Network Architecture



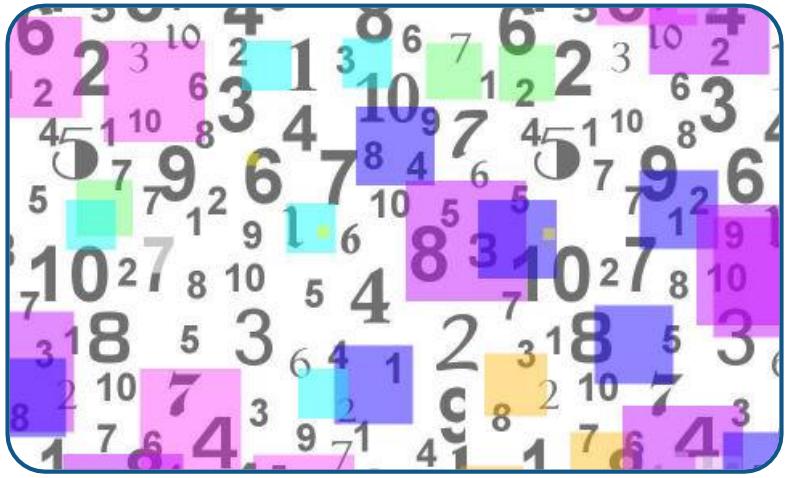
Deep Learning Datatypes

Image



Signal

Numeric



Text

Deep Learning Workflow

Prepare Data

Data access and preprocessing

Ground truth labeling

Train Model

Model design, Hyperparameter tuning

Model exchange across frameworks

Hardware-accelerated training

Deploy

Multiplatform code generation (CPU, GPU)

Edge deployment

Enterprise Deployment

Why MATLAB for A.I. Tasks?

Increased productivity with interactive tools

Generate simulation data for complex models and systems

Ease of deployment and scaling to various platforms

Full A.I. workflows that cannot be easily replicated by other toolchains

Why MATLAB for A.I. Tasks?

Increased productivity with interactive tools

Labeling

Training

Model Exchange

Full A.I. workflows that cannot be easily replicated by other toolchains

“I love to label and preprocess my data”

~ Said no engineer, ever.

Labeling for deep learning is repetitive, tedious, and time-consuming…

but necessary

Image Labeler

LABEL

New Session | Load | Save | Import Labels | Label | Zoom In | Zoom Out | Pan | Default Layout | Show Rectangle Labels | Show Scene Labels | Algorithm: Select Algorithm | Automate | Export Labels

FILE | MODE | VIEW | AUTOMATE LABELING | EXPORT

ROI Label Definition

Define new ROI label

Vehicle

Scene Label Definition

Define new scene label

Apply to Image

Remove from Image

To label a scene, you must first define a scene label.

Car Image 1

Ground Truth Labeler

LABEL

Load | Save | Import Labels — FILE

Label | Zoom In | Zoom Out | Pan — MODE

Layout | Show ROI Labels | Show Scene Labels — VIEW

Algorithm: | Select Algorithm | Configure Automation | Automate — AUTOMATE LABELING

View Label Summary — SUMMARY

Export Labels — EXPORT

ROI Label Definition

Label | Sublabel | Attribute

Lane

Scene Label Definition

Define new scene label

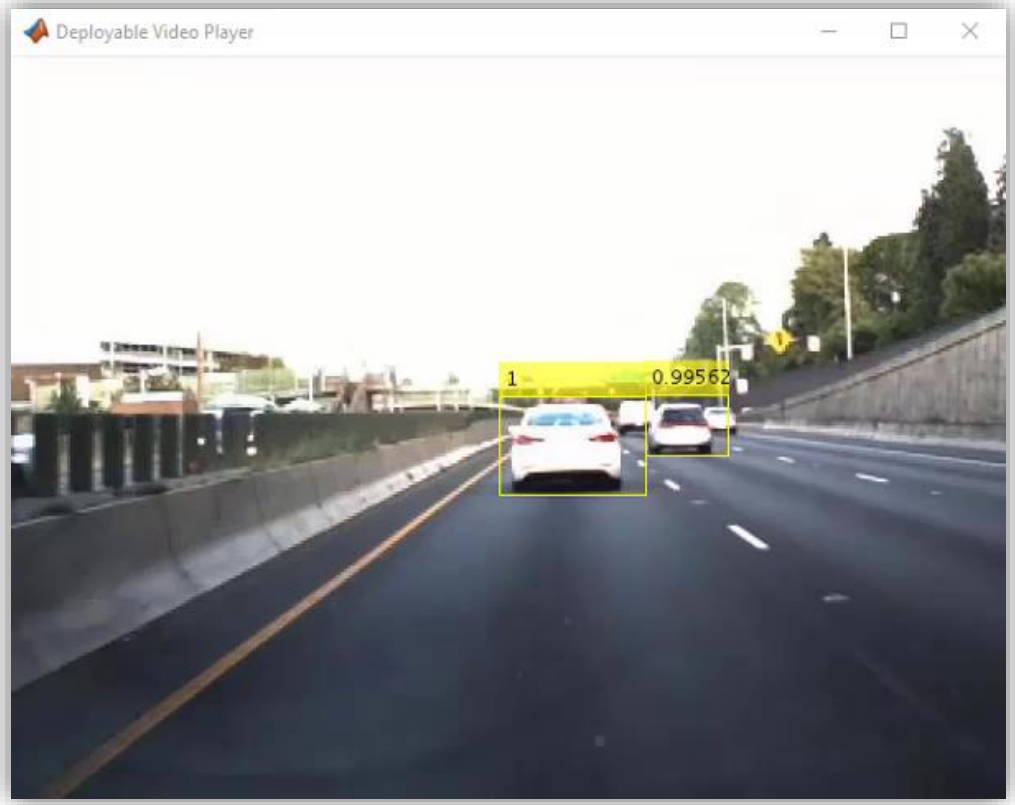
Current Frame | Time Interval | Add Label | Remove Label

To label a scene, you must first define a scene label.

05_highway_lanechange_25s.mp4

Start Time	Current	End Time	Max Time
00.00000	05.80000	25.00000	25.00000

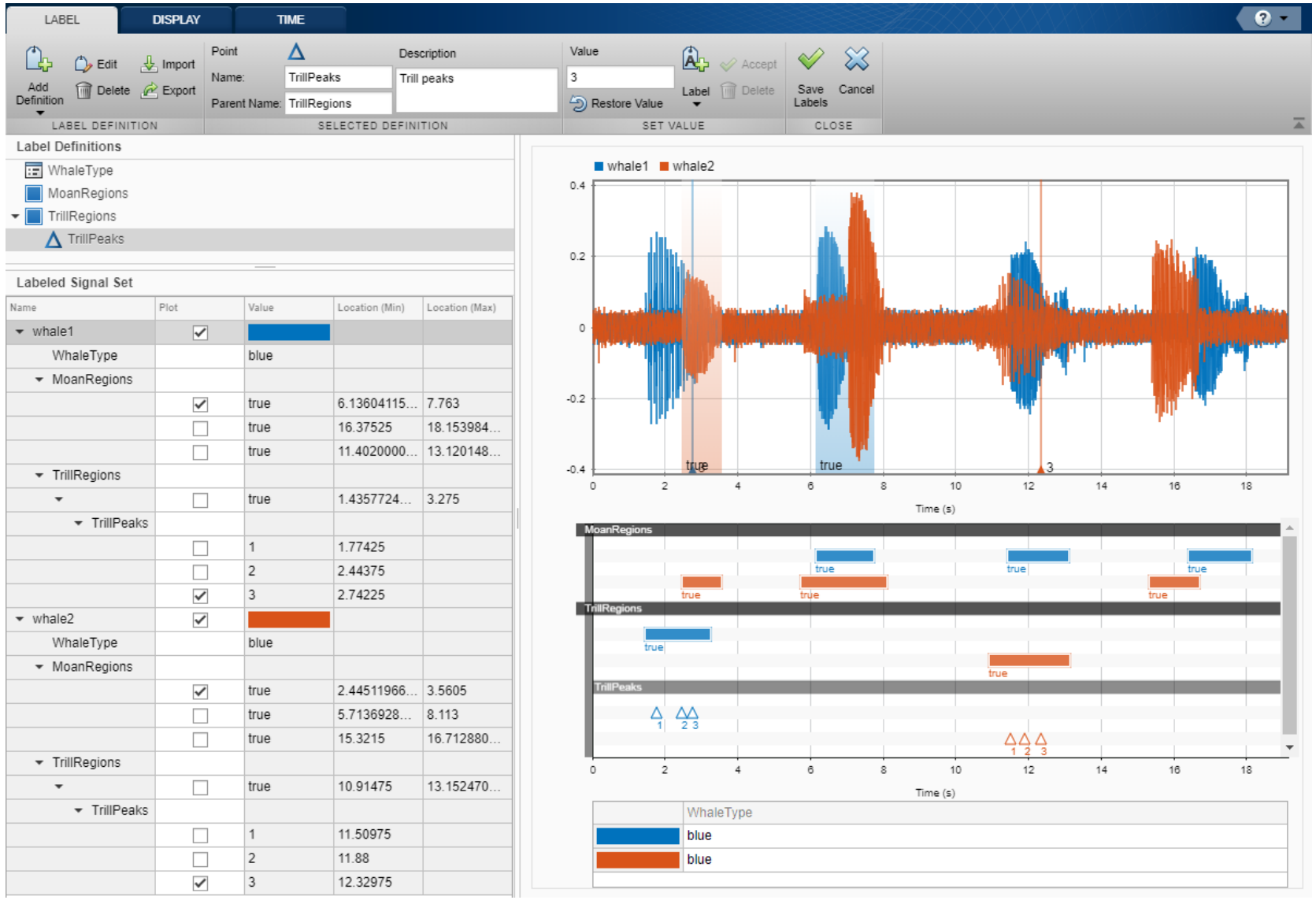
Zoom In Time Interval


Deployable Video Player
1
0.99562

Signal Labeler – annotate signals with labels/sublabels, export to workspace for training

Define Labels

View properties of labels

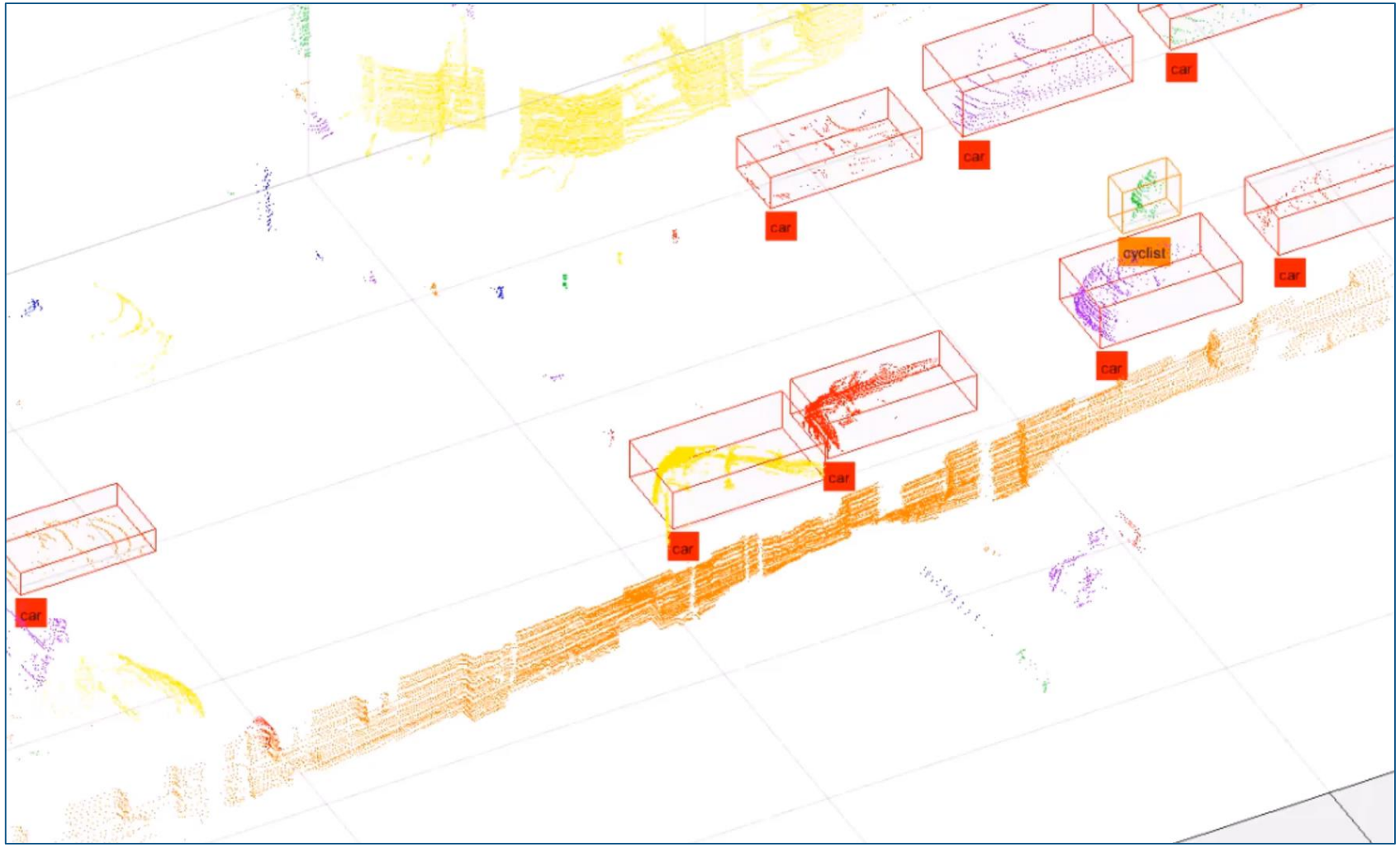


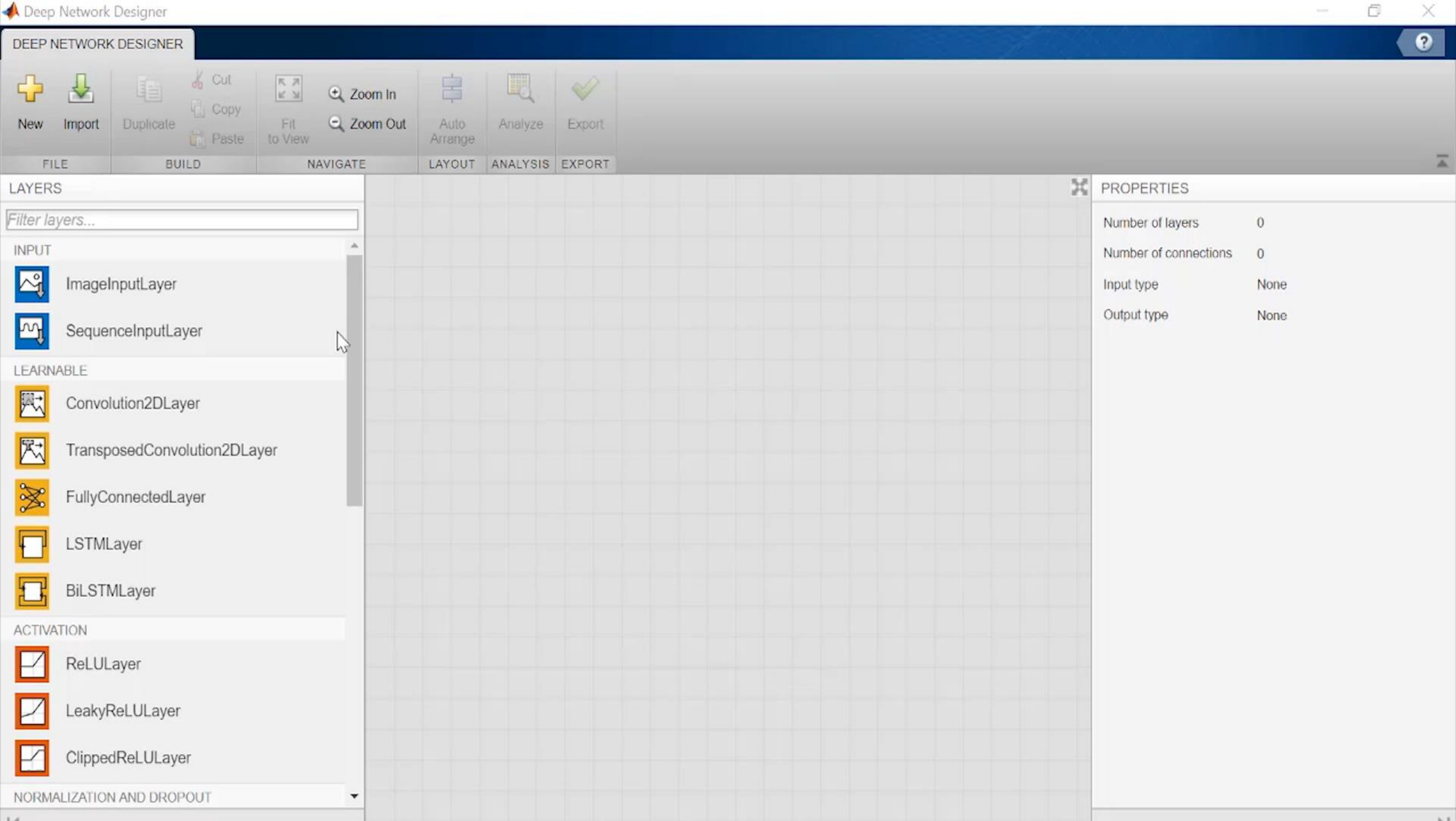
Interactively Label Signals

User Story – Veoneer (Autoliv)

- Automotive
  - Software and hardware for active safety, autonomous driving, occupant protection, and brake control
- Building radar sensor – check accuracy using LiDAR-based verification
- Human analyzes hours of recorded data
- Used MATLAB to semi-automate labeling and tracking of 3D LiDAR point clouds.

Manual Labeling for 25 events took over 20 minutes.
After full automation with MATLAB's tools, it took 5 minutes




Deep Network Designer
DEEP NETWORK DESIGNER
New
Import
Duplicate
Cut
Copy
Paste
Fit to View
Zoom In
Zoom Out
Auto Arrange
Analyze
Export
FILE
BUILD
NAVIGATE
LAYOUT
ANALYSIS
EXPORT
LAYERS
Filter layers...
INPUT
ImageInputLayer
SequenceInputLayer
LEARNABLE
Convolution2DLayer
TransposedConvolution2DLayer
FullyConnectedLayer
LSTMLayer
BiLSTMLayer
ACTIVATION
ReLULayer
LeakyReLULayer
ClippedReLULayer
NORMALIZATION AND DROPOUT
PROPERTIES
Number of layers 0
Number of connections 0
Input type None
Output type None

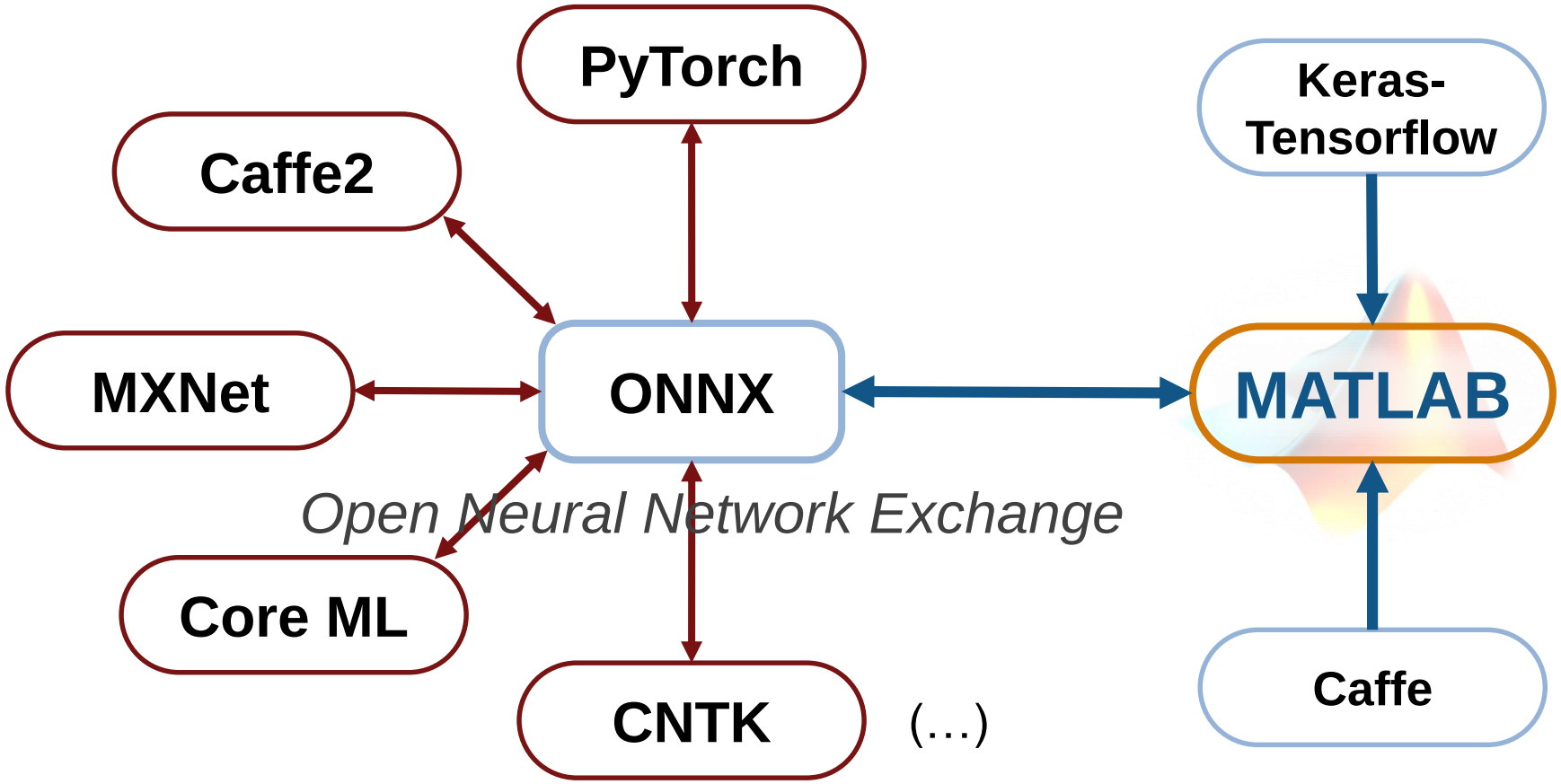
Transfer Learning with Pre-trained Models

- Inception-v3
- ResNet-101
- VGG-16
- Inception-ResNet-v2
- ResNet-18
- GoogLeNet
- DenseNet-201
- VGG-19
- SqueezeNet
- AlexNet
- ResNet-50

Import & Export Models Between Frameworks

- Keras-Tensorflow Importer
- Caffe Model Importer
- ONNX Model Converter

Model Exchange with MATLAB



Why MATLAB for A.I. Tasks?

Increased productivity with interactive tools

Generate simulation data for complex models and systems

Ease of deployment and scaling to various platforms

Full A.I. workflows that cannot be easily replicated by other toolchains

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Reinforcement Learning

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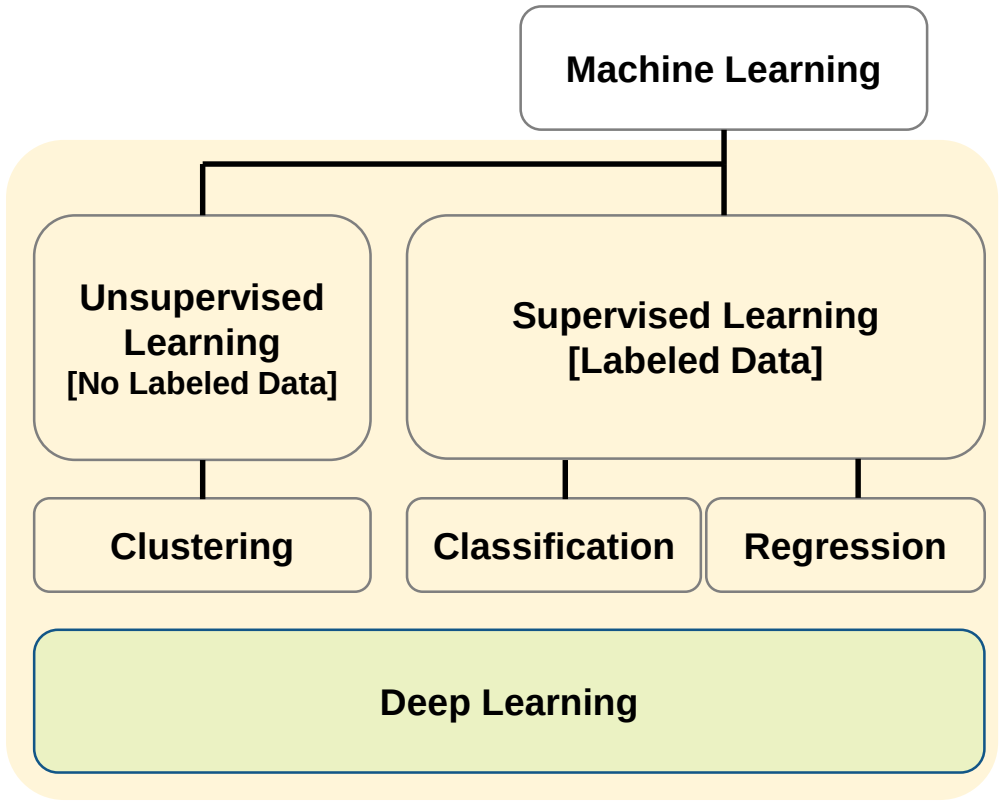
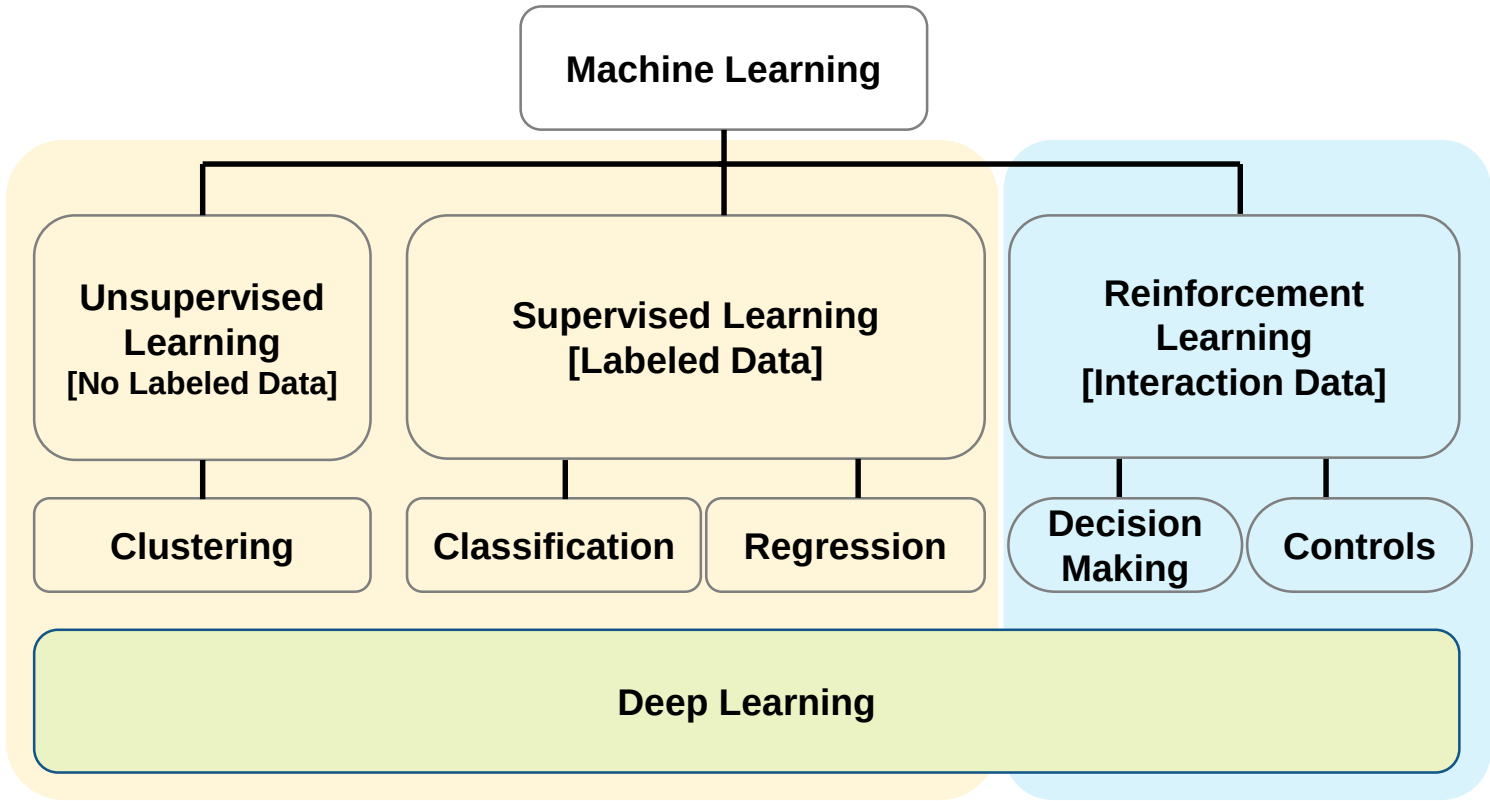
Reinforcement Learning vs Machine Learning vs Deep Learning



Supervised learning typically involves feature extraction

Deep learning typically simplifies feature extraction

Reinforcement Learning vs Machine Learning vs Deep Learning

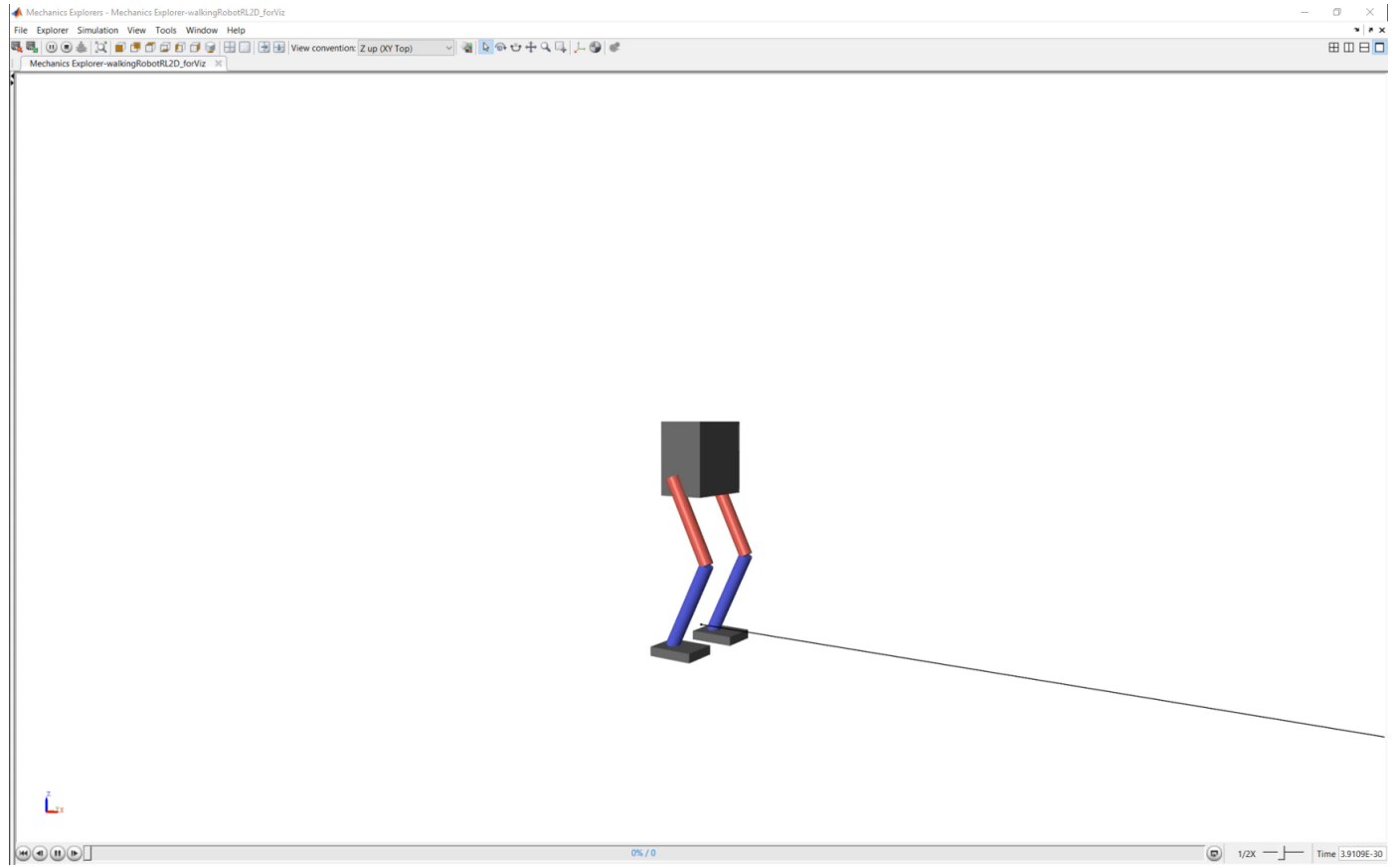


Reinforcement learning:

- Learning through trial & error [*interaction*]
- It's about learning a **behavior** or accomplishing a **task**

What is Reinforcement Learning?

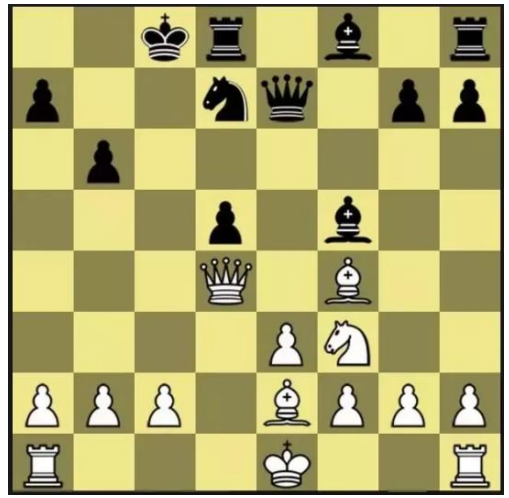
- What is Reinforcement Learning?
  - Type of machine learning that trains an **‘agent’** through repeated interactions with an environment
- How does it work?
  - Through a trial & error process that uses a reward system to maximize success



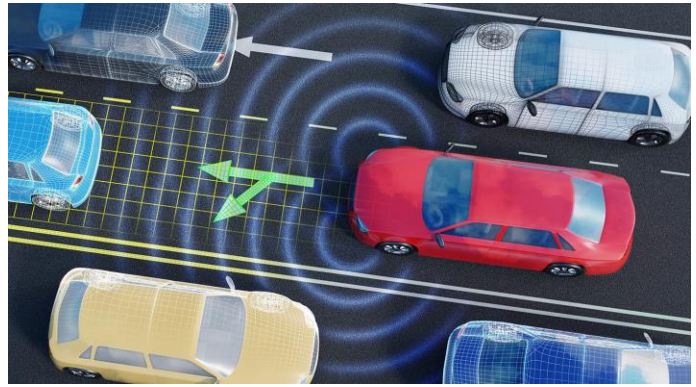
Reinforcement Learning enables the use of Deep Learning for Controls and Decision Making Applications

Controls

Robotics

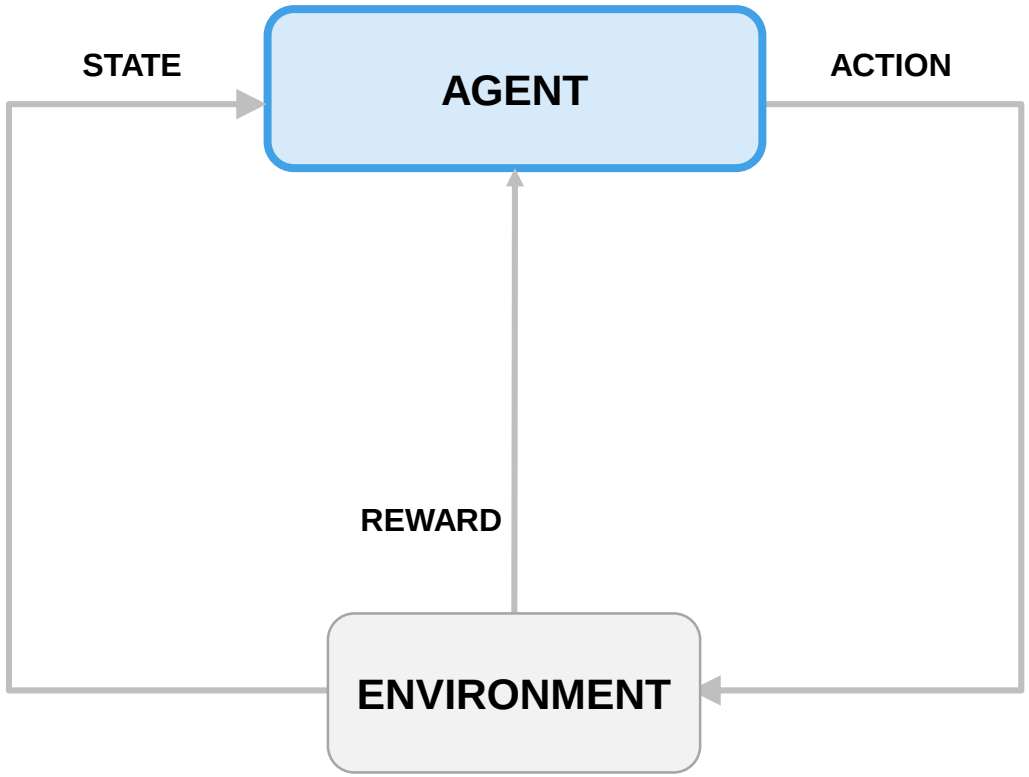


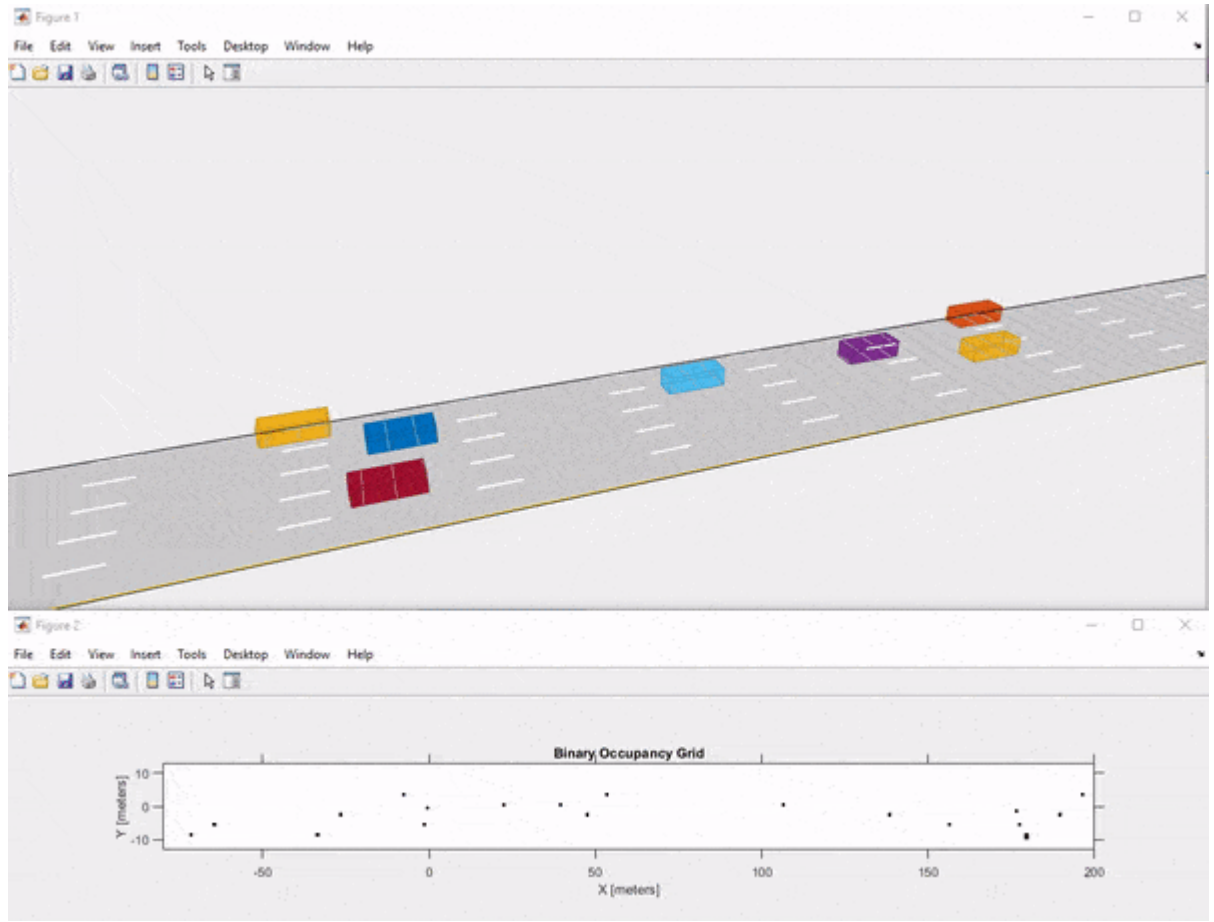
A.I. Gameplay



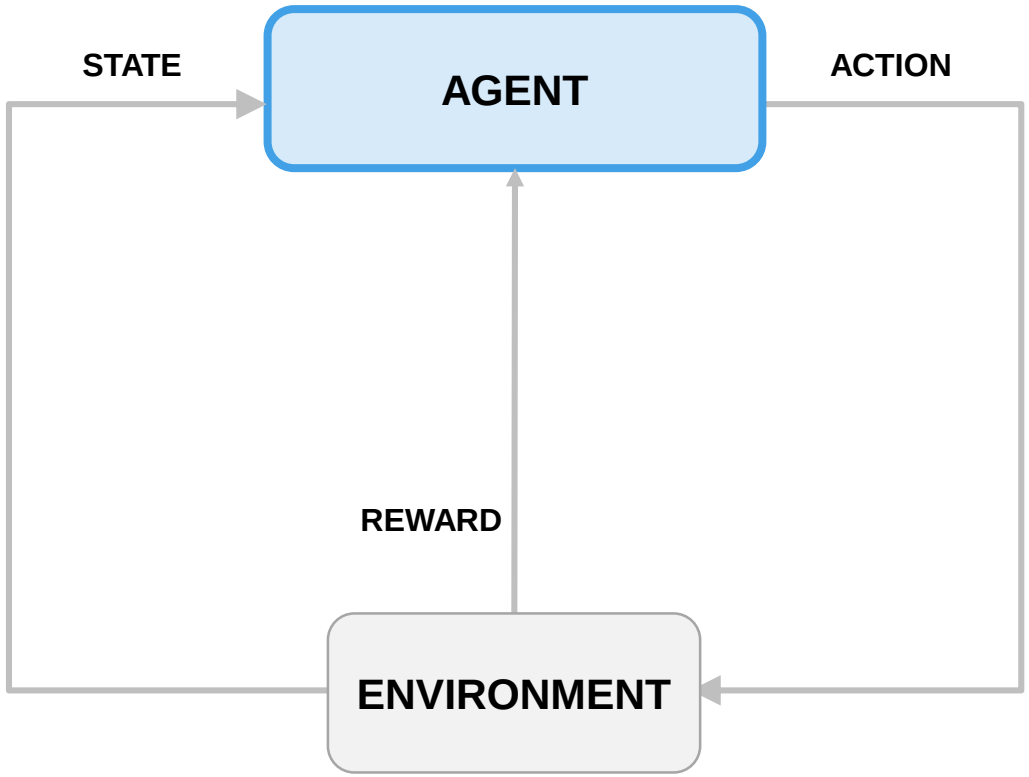
Autonomous driving

How Does Reinforcement Learning Work?





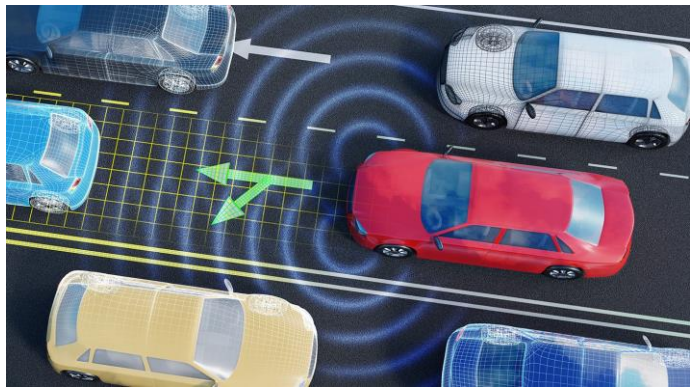
A Practical Example of Reinforcement Learning
Training a Self-Driving Car

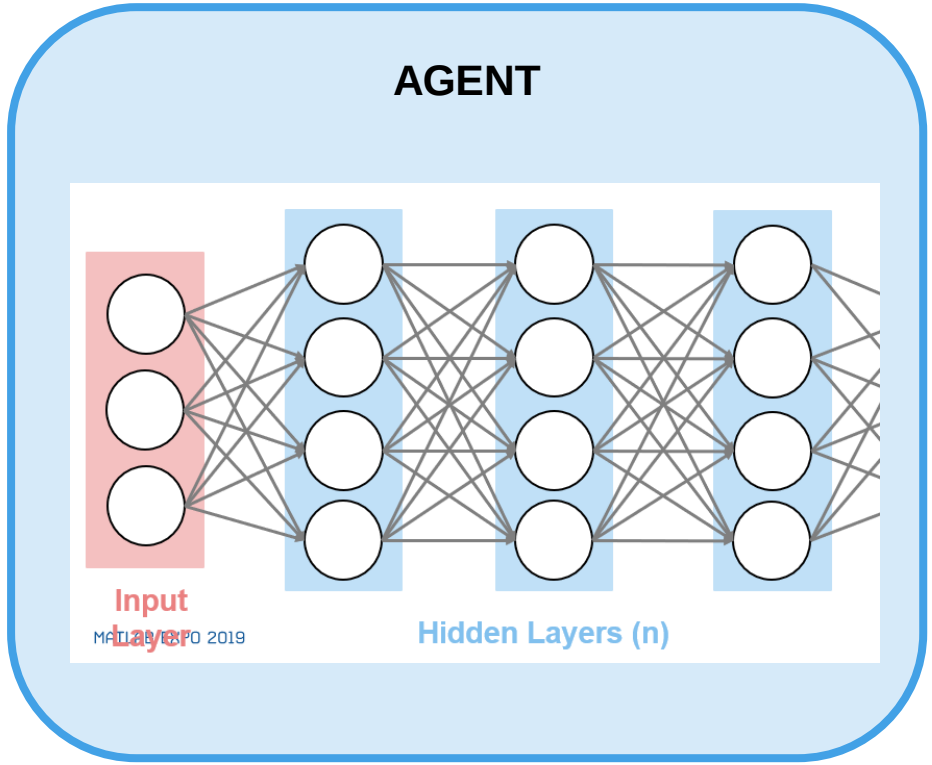


- Vehicle's computer learns how to drive… (**agent**)
- using sensor readings from LIDAR, cameras,… (**state**)
- that represent road conditions, vehicle position,… (**environment**)
- by generating steering, braking, throttle commands,… (**action**)
- to avoid collisions and lane deviation… (**reward**).

The goal of Reinforcement learning is for the agent to find an optimal algorithm for performing a task

Deep Networks are commonly found in the agent, because they can model complex problems.





- Turn left
- Turn right
- Brake
- Accelerate

Reinforcement Learning Workflow

Prepare Data

- Data access and preprocessing
- Ground truth labeling

Simulink – generate data for dynamic systems (planes, cars, robots, etc.)

Train Model

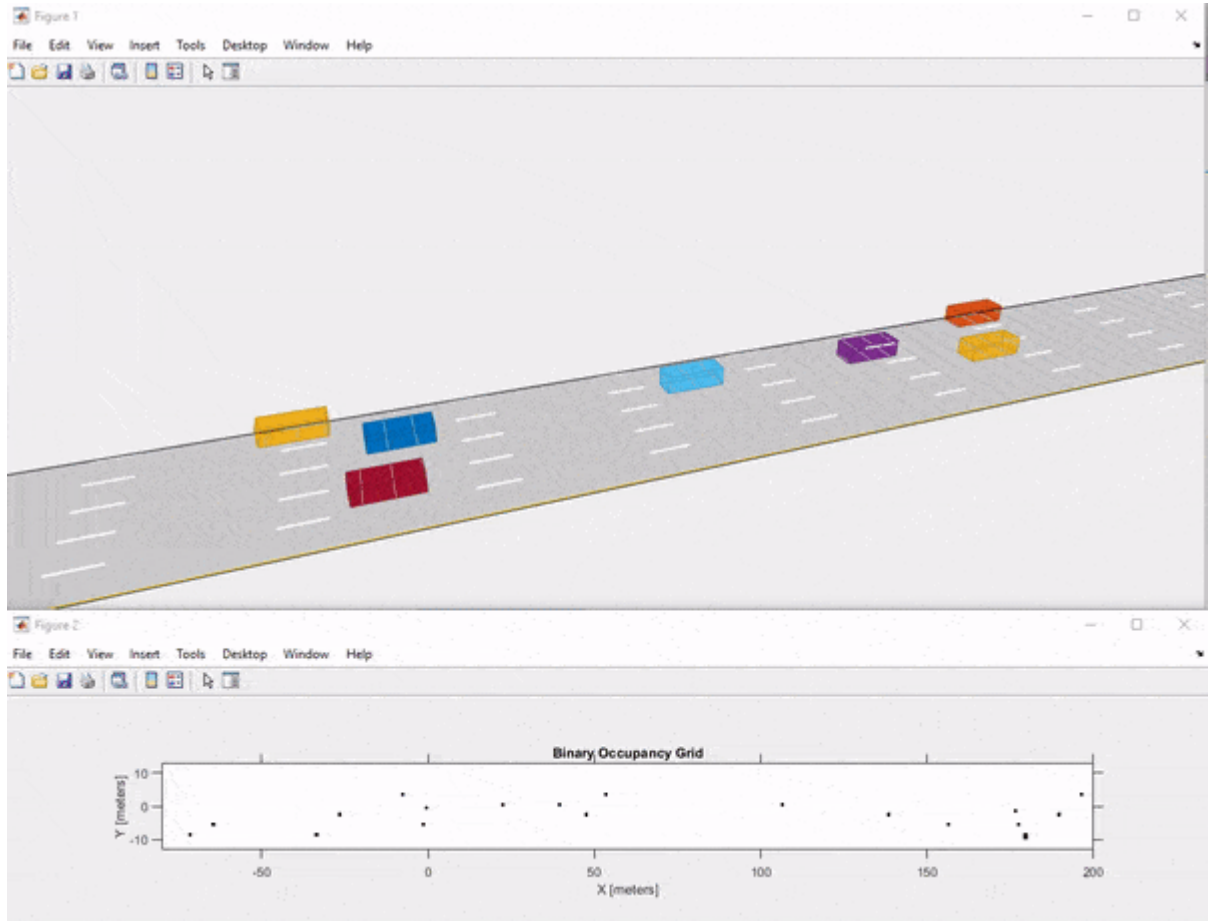
- Reinforcement learning
- Training agent to perform task
- Developing reward system to optimize performance

Deployment

- Multiplatform code generation (CPU, GPU)
- Edge deployment
- Enterprise Deployment

Why MATLAB and Simulink for Reinforcement Learning?

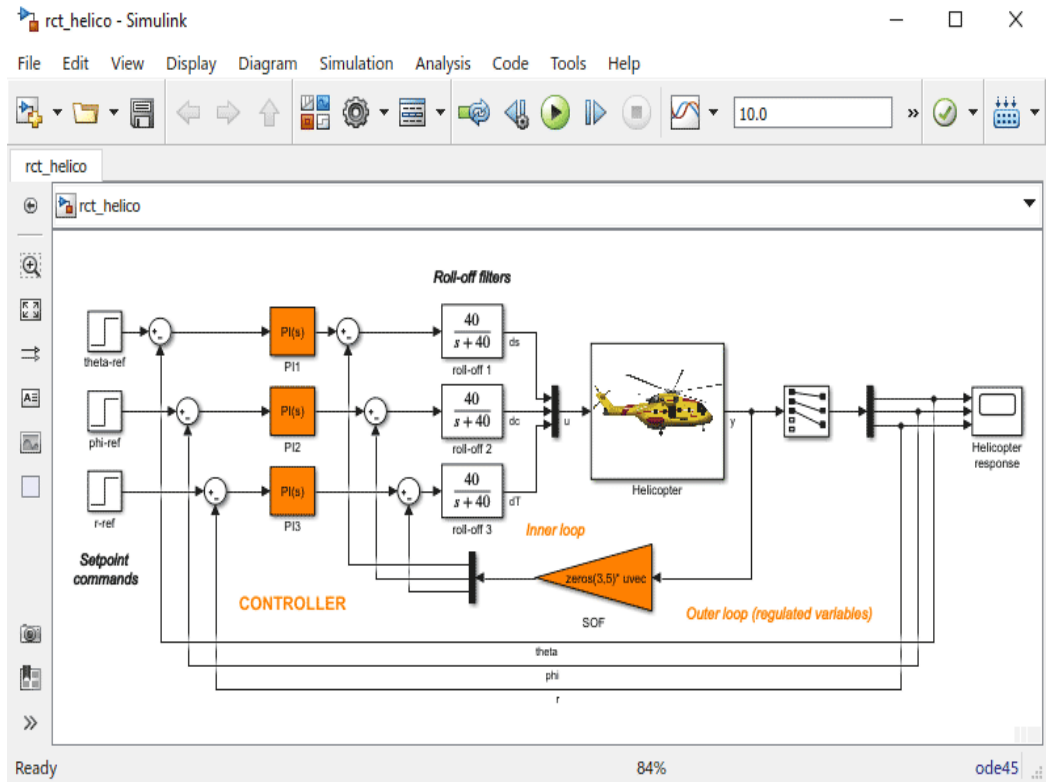
Virtual models allow you to simulate conditions hard to emulate in the real world.



Using MATLAB and Simulink for Reinforcement Learning

- Reinforcement learning is a dynamic process

- Decision making problems
  - Financial trading, calibration, etc.
- Controls-based problems
  - Lane-keep assist, adaptive cruise control, robotics, etc.



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Increased productivity with interactive tools

Generate simulation data for complex models and systems

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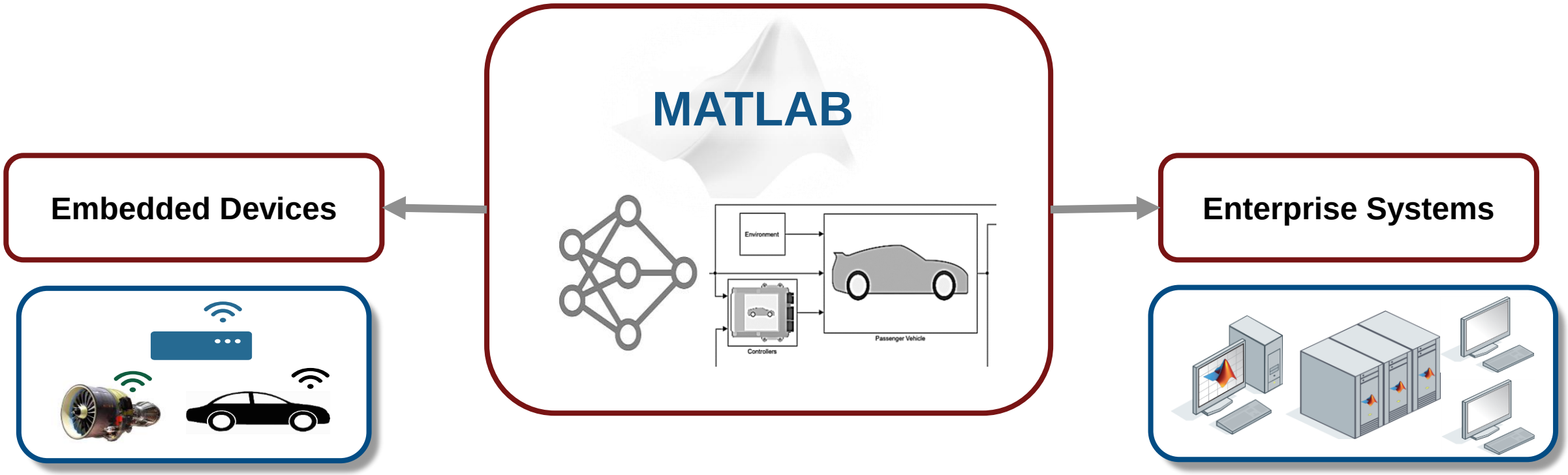
Deployment and Scaling for A.I.



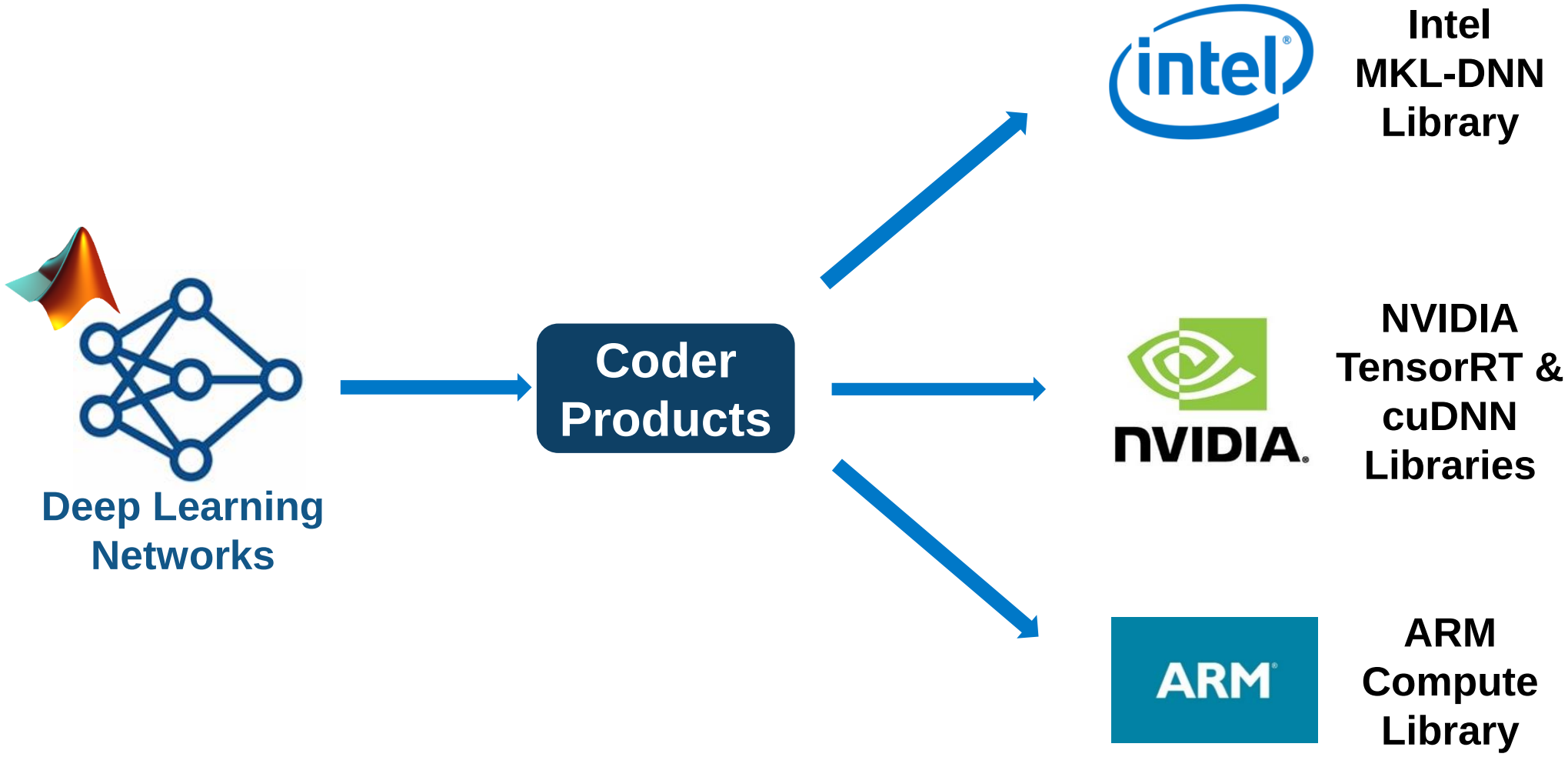
Embedded Devices – Automatic Code Generation

MATLAB Code

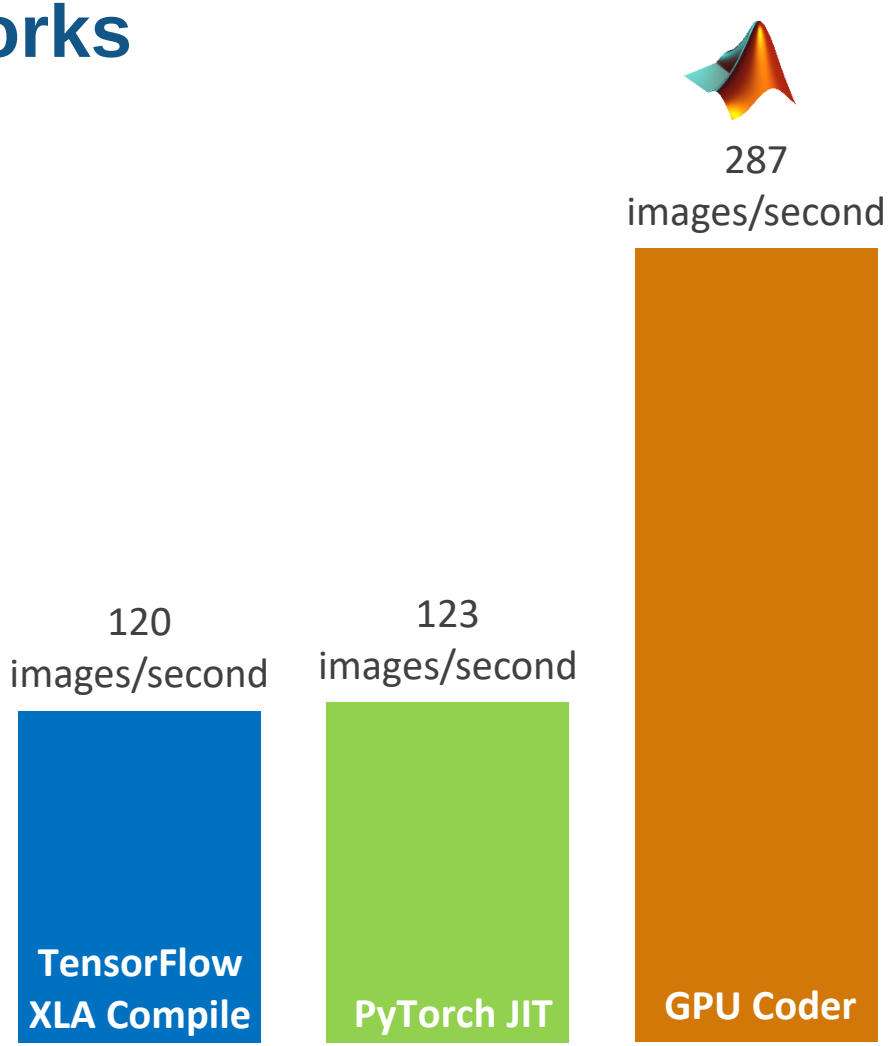
Auto-generated Code (C/C++/CUDA)

Deployment Target

Deploying Deep Learning Models for Inference



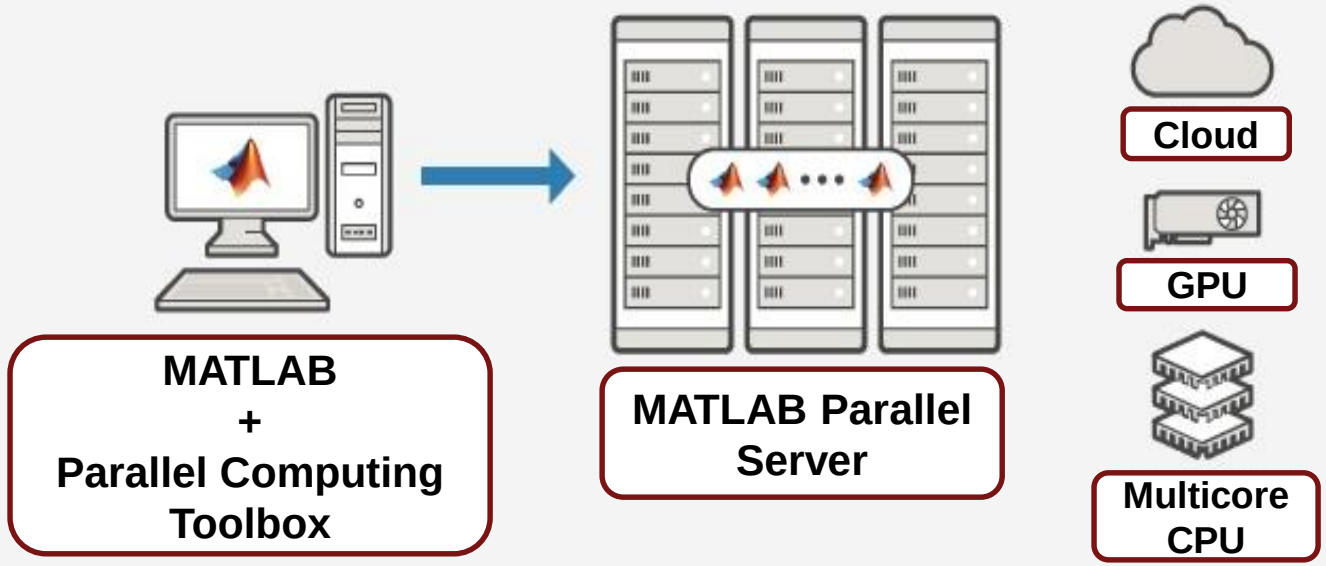
GPU Coder is more than twice as fast as other compiled deep learning frameworks



Intel® Xeon® CPU 3.6 GHz with NVIDIA® Titan V GPU - NVIDIA libraries: CUDA® – cuDNN - Frameworks: TensorFlow™ 1.13.0, PyTorch 1.1.0 – ResNet-50 pre-trained model

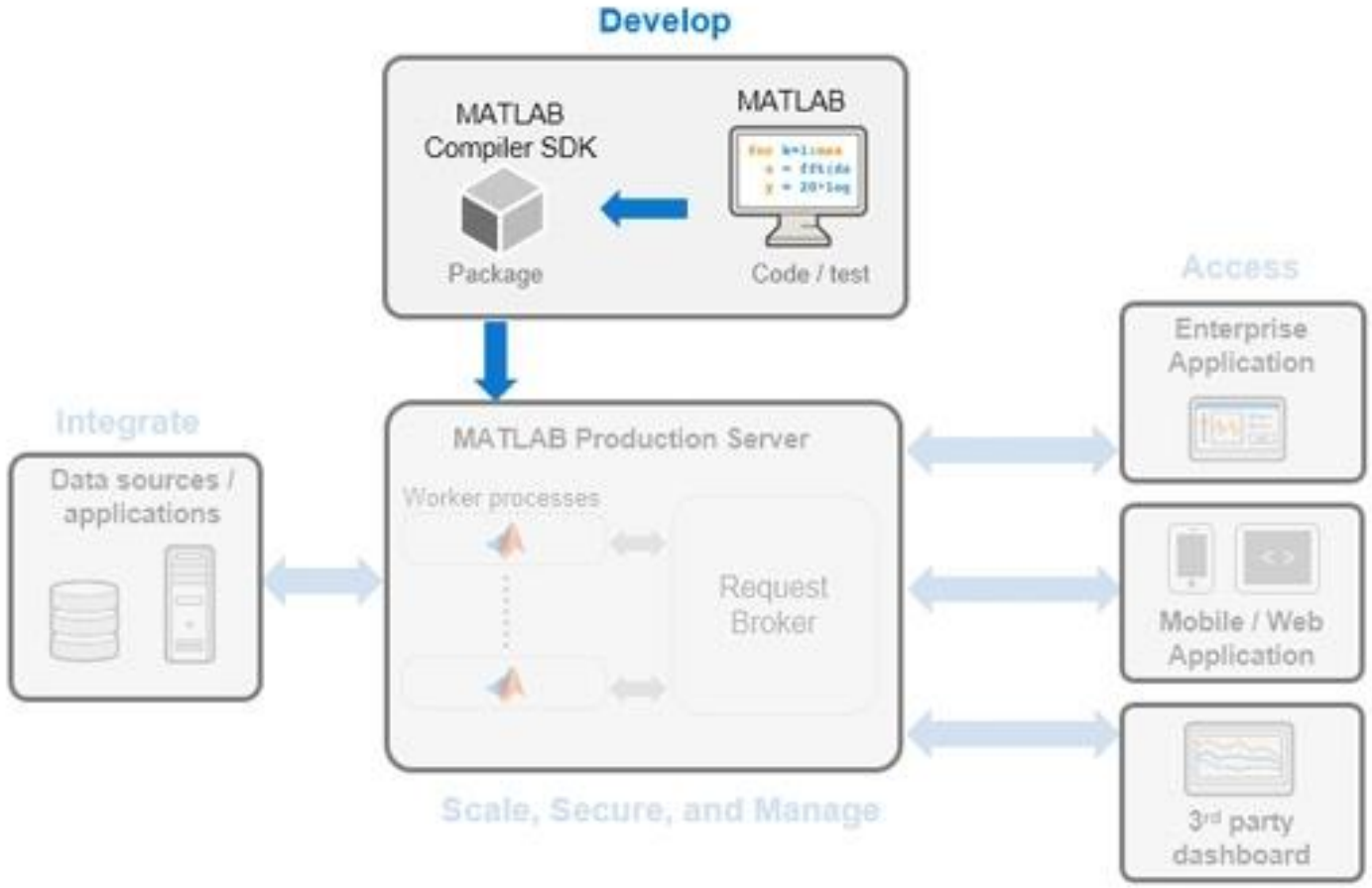
Enterprise Deployment

```
>> parpool(parcluster('HPC1'),100);
>> parfor i = 1:3000,
>>    c(:,i) = eig(rand, 1000);
>> end
```



Run thousands of simulations in parallel with MATLAB Parallel Server to save hours of training time.

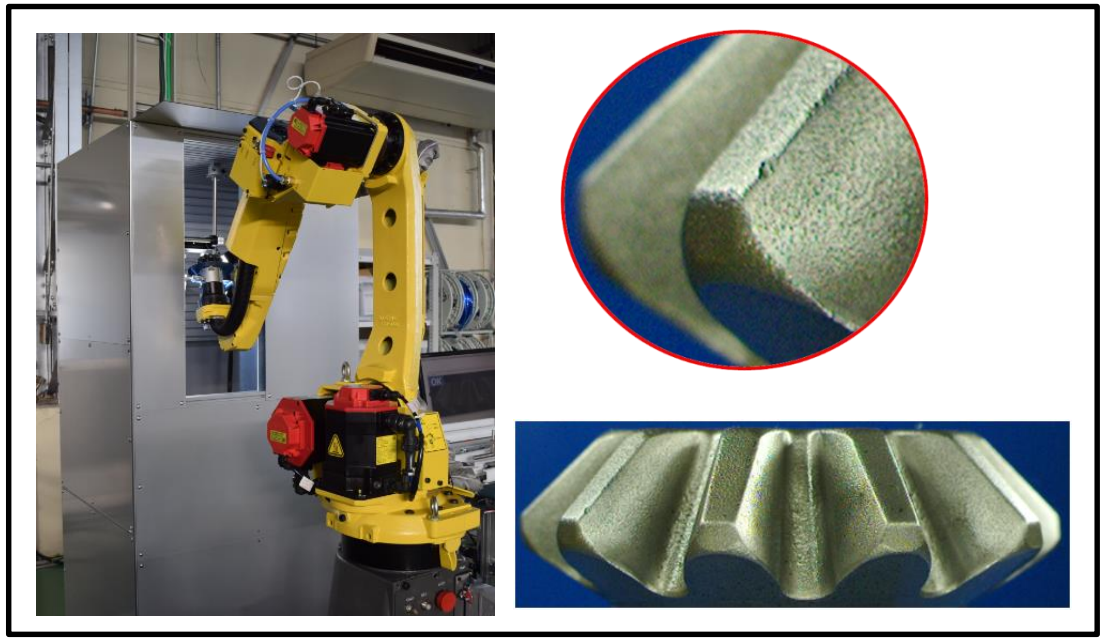
Enterprise Deployment



Deployment to the cloud with MATLAB Compiler and MATLAB Production Server

Musashi Seimitsu Industry Co.,Ltd.

Detect Abnormalities in Automotive Parts



Automated visual inspection of 1.3 million bevel gear per month

MATLAB use in project:

- Preprocessing of captured images
- Image annotation for training
- Deep learning based analysis
  - Various transfer learning methods (Combinations of CNN models, Classifiers)
  - Estimation of defect area using Class Activation Map (CAM)
  - Abnormality/defect classification
- Deployment to NVIDIA Jetson using GPU Coder

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Call to action

- Visit the Deep Learning Booth!
- Related upcoming talks:
  - AI Techniques for Signals, Time-series, and Text Data
  - Sensor Fusion and Tracking for Autonomous Systems
  - Deploying Deep Neural Networks to Embedded GPUs and CPUs