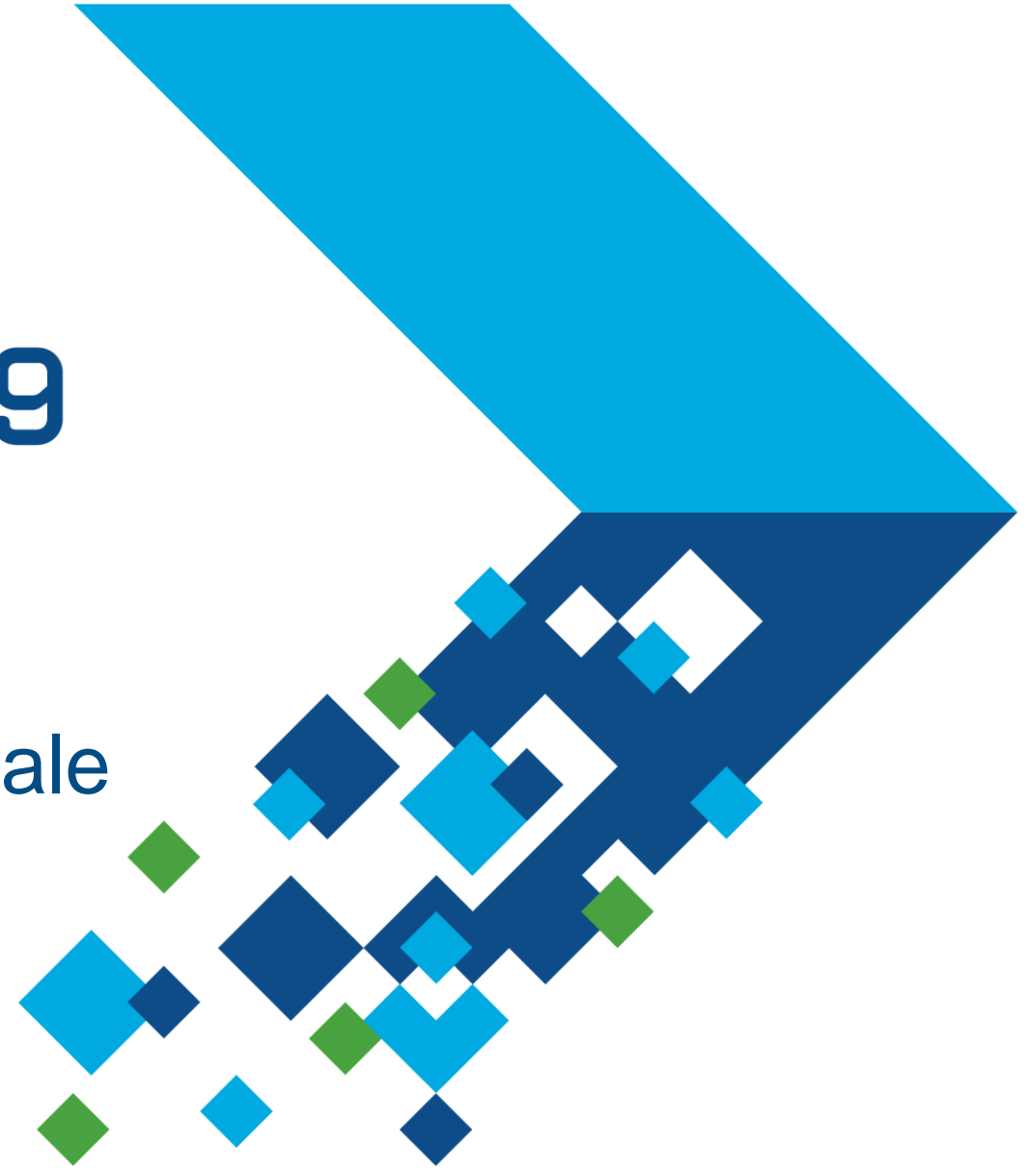


# MATLAB EXPO 2019

Deep Learning e Reinforcement  
Learning per l'intelligenza artificiale

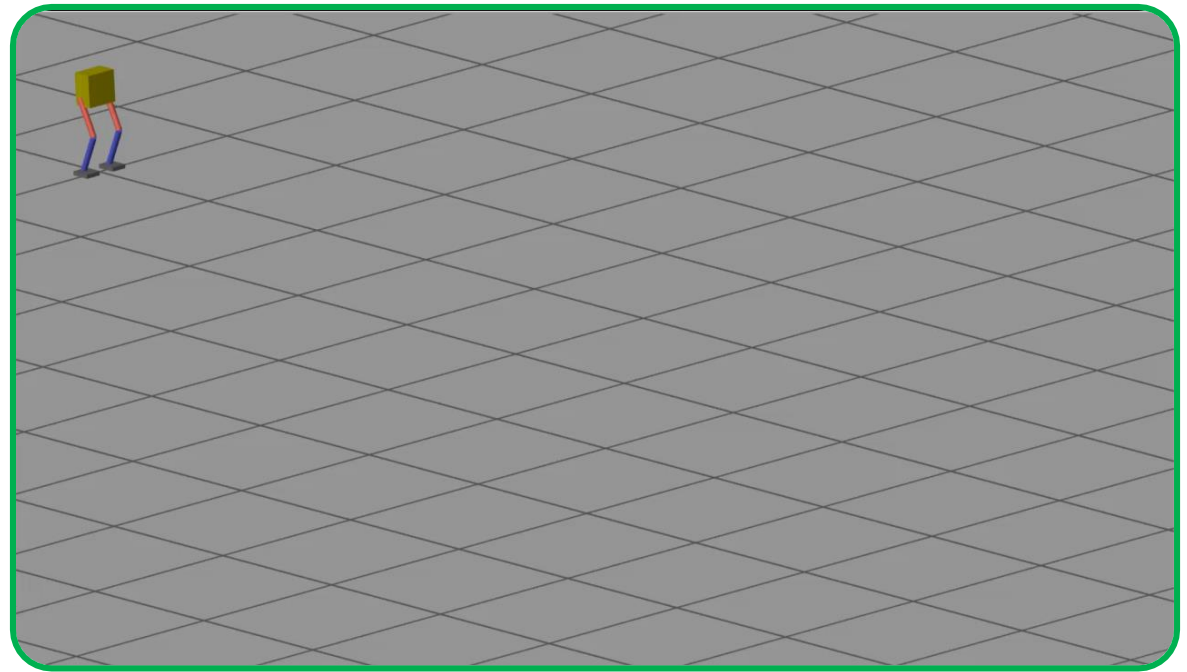
Giuseppe Ridinò



# Why MATLAB for Artificial Intelligence?

# Artificial Intelligence

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



# A.I. Applications



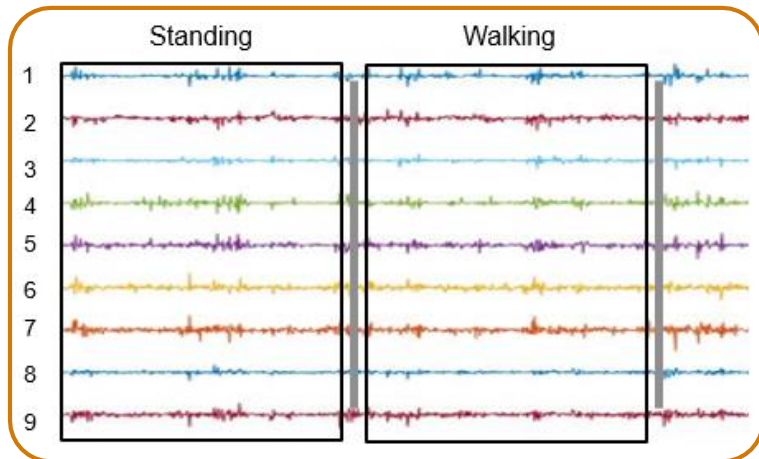
*Object Classification*



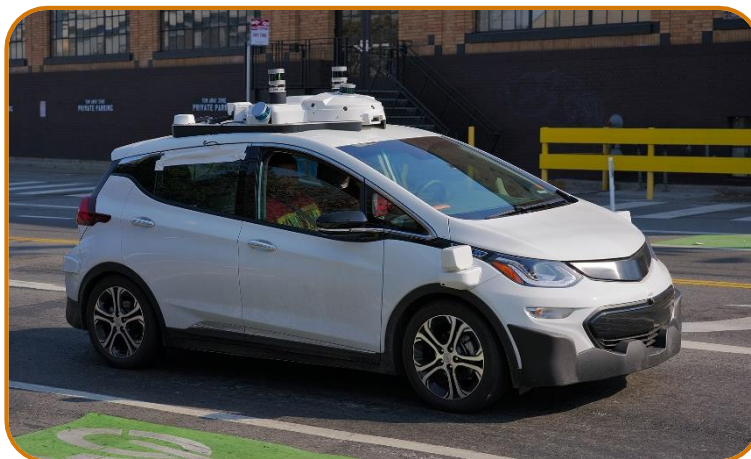
Speech Recognition



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

Decision  
Trees

**Deep  
Learning**

Logistic  
Regression

K-means

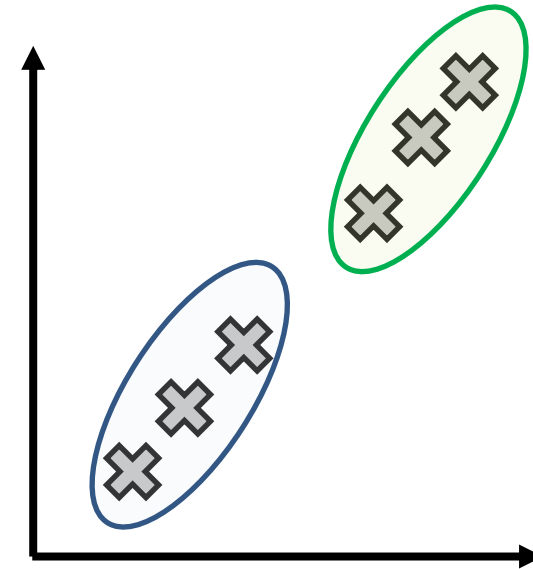
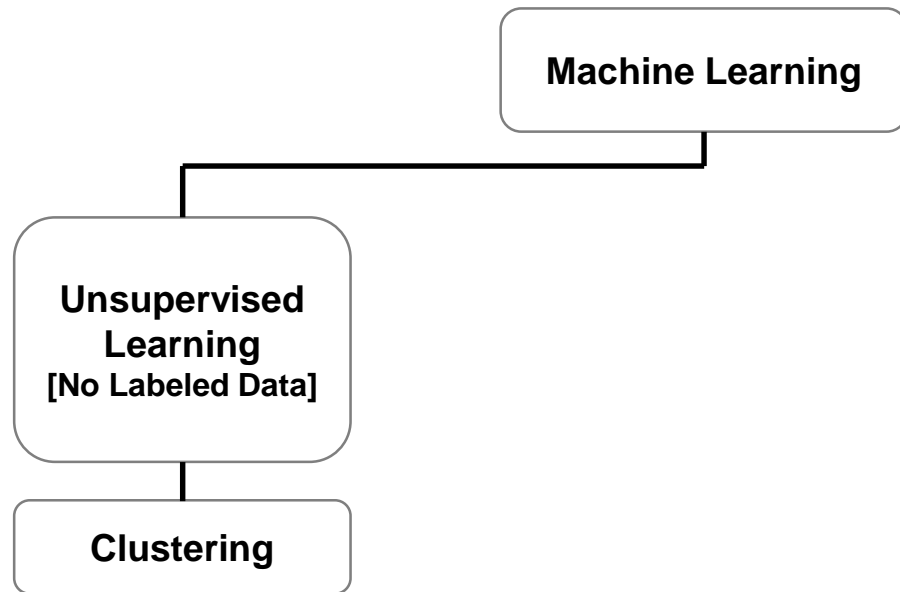
SVM

Nearest  
Neighbor

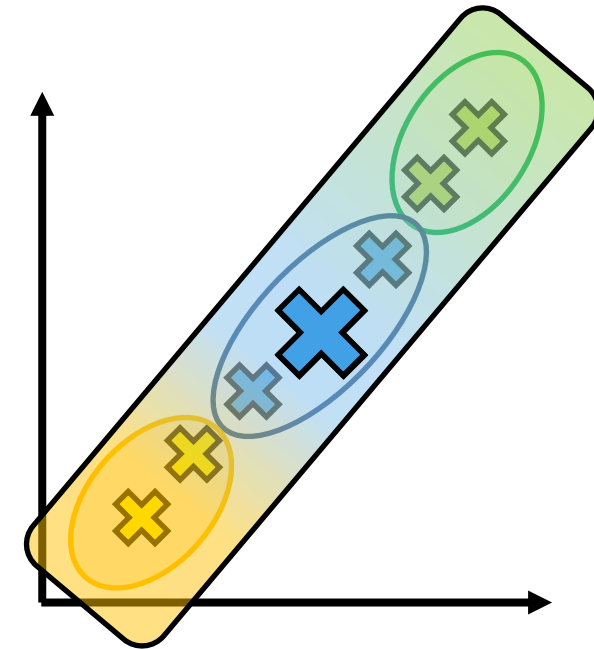
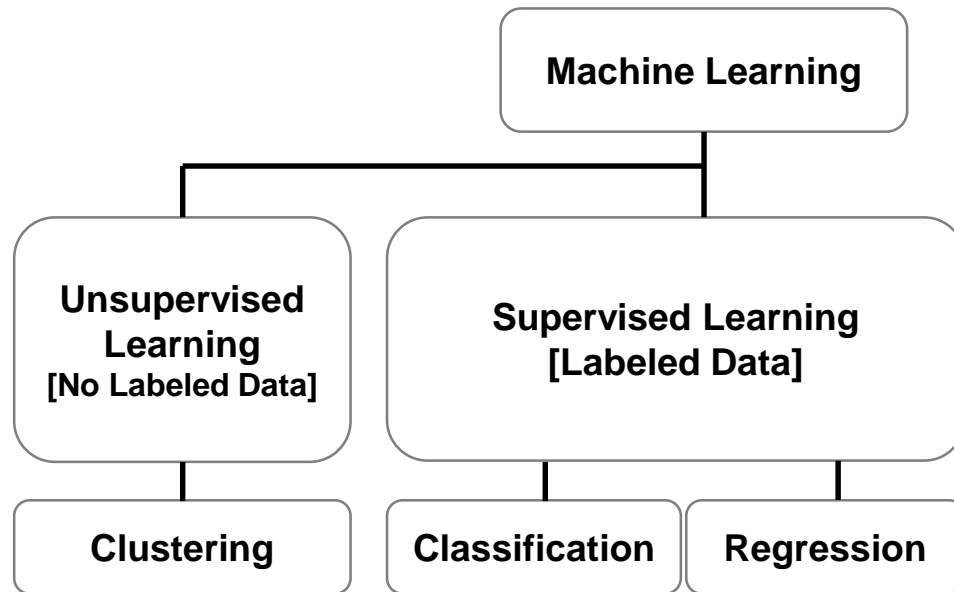
**Reinforcement Learning**

Gaussian  
Mixture

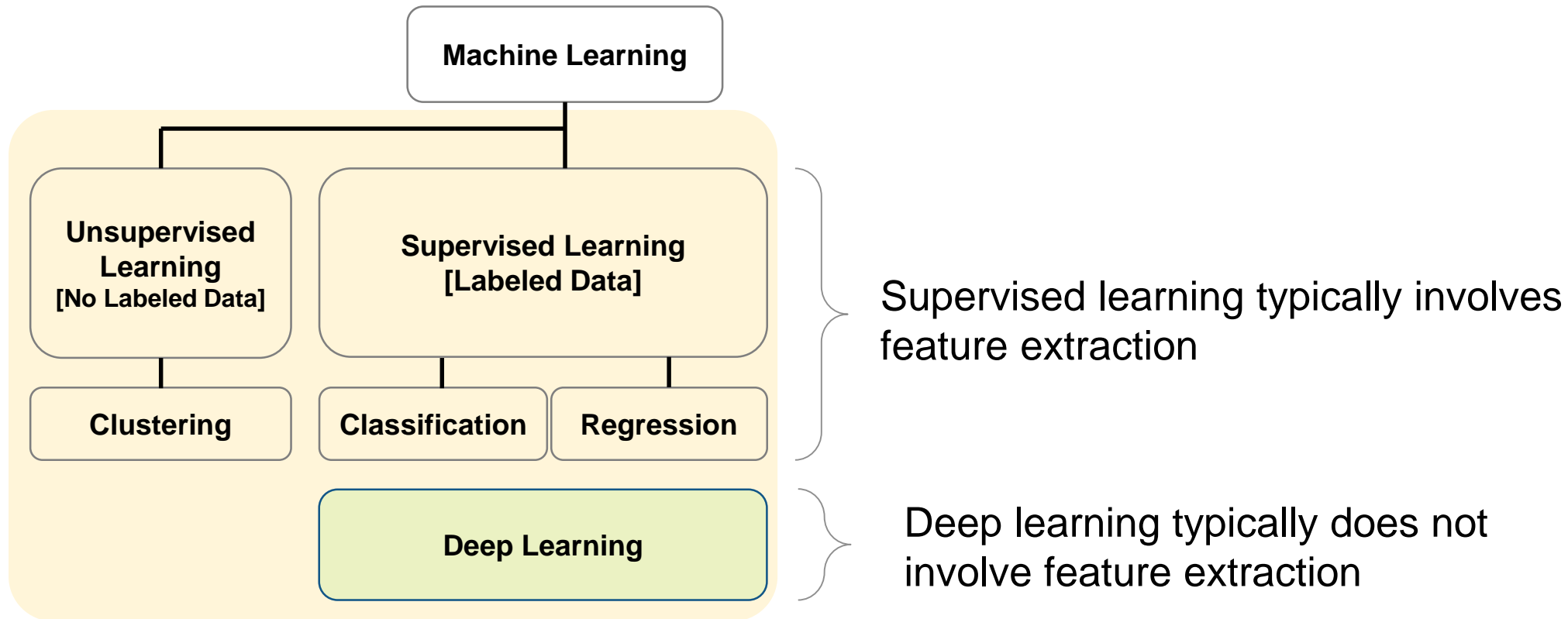
# Machine Learning and Deep Learning



# Machine Learning and Deep Learning



# Machine Learning and Deep Learning

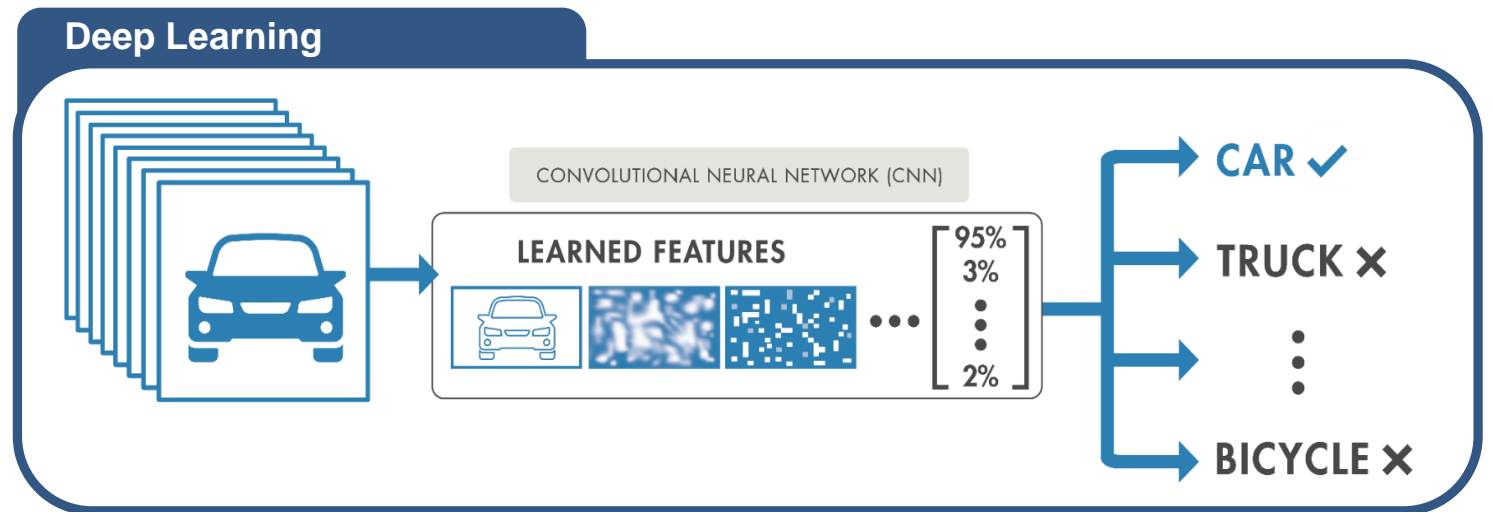


# Deep Learning

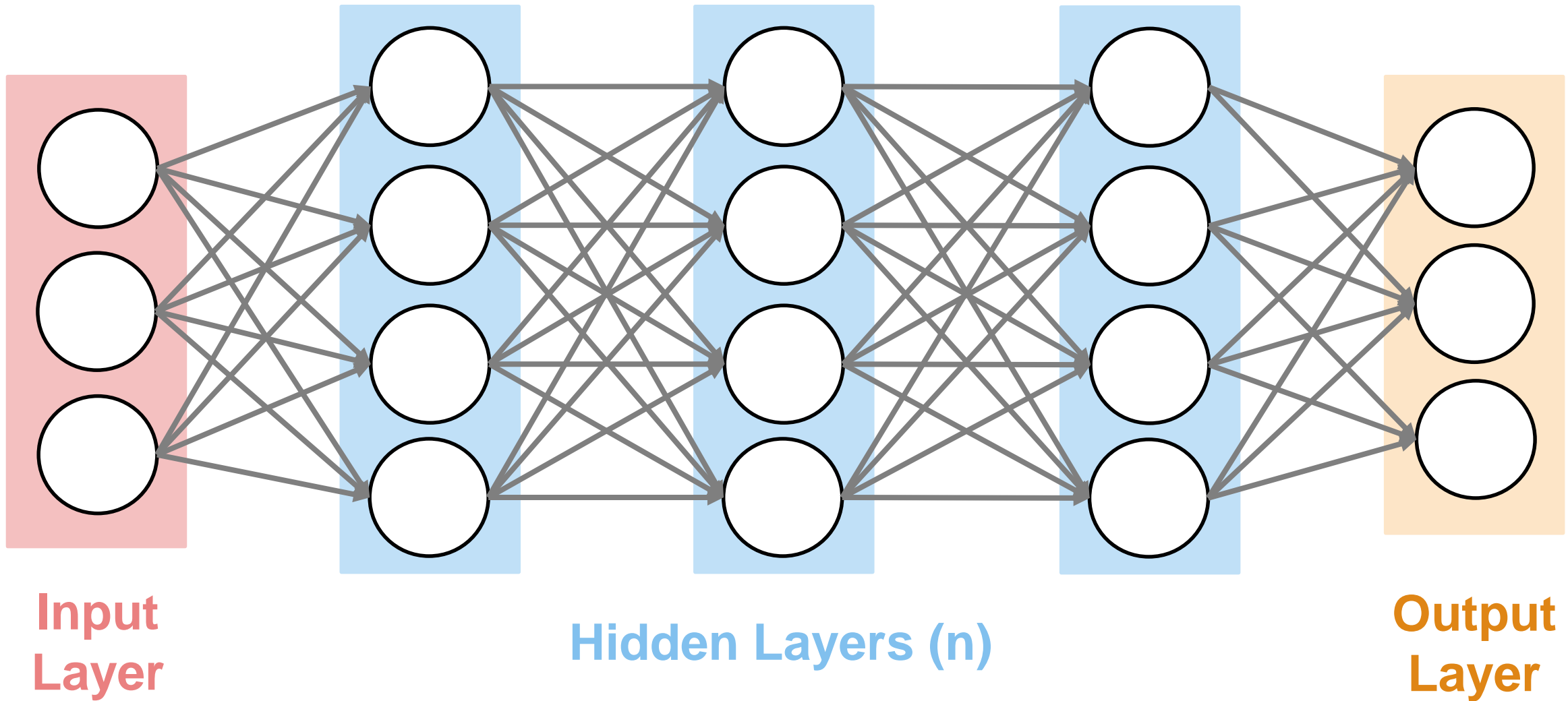
- Subset of machine learning with **automatic feature extraction**
  - Learns features and tasks directly from data
  - More Data = better model

**Machine  
Learning**

**Deep  
Learning**



# Deep Learning Uses a Neural Network Architecture





# 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**

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

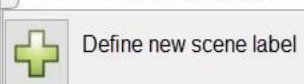
**but necessary**

Car Image 1



► **Vehicle**

### Scene Label Definition



Apply to Image

Remove from Image

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



LABEL

Load

Save

Import Labels

Label

Zoom In

Zoom Out

Pan

Layout

Show ROI Labels

Show Scene Labels

Algorithm:

Select Algorithm

Configure Automation

Automate

View Label Summary

Export Labels

FILEMODEVIEWAUTOMATE LABELINGSUMMARYEXPORT

ROI Label Definition

Label

Sublabel

Attribute

Lane

Scene Label Definition

Define new scene label

Current Frame


Add Label

Time Interval

Remove Label

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

05\_highway\_lanechange\_25s.mp4



00.00000

05.80000

25.00000

25.00000

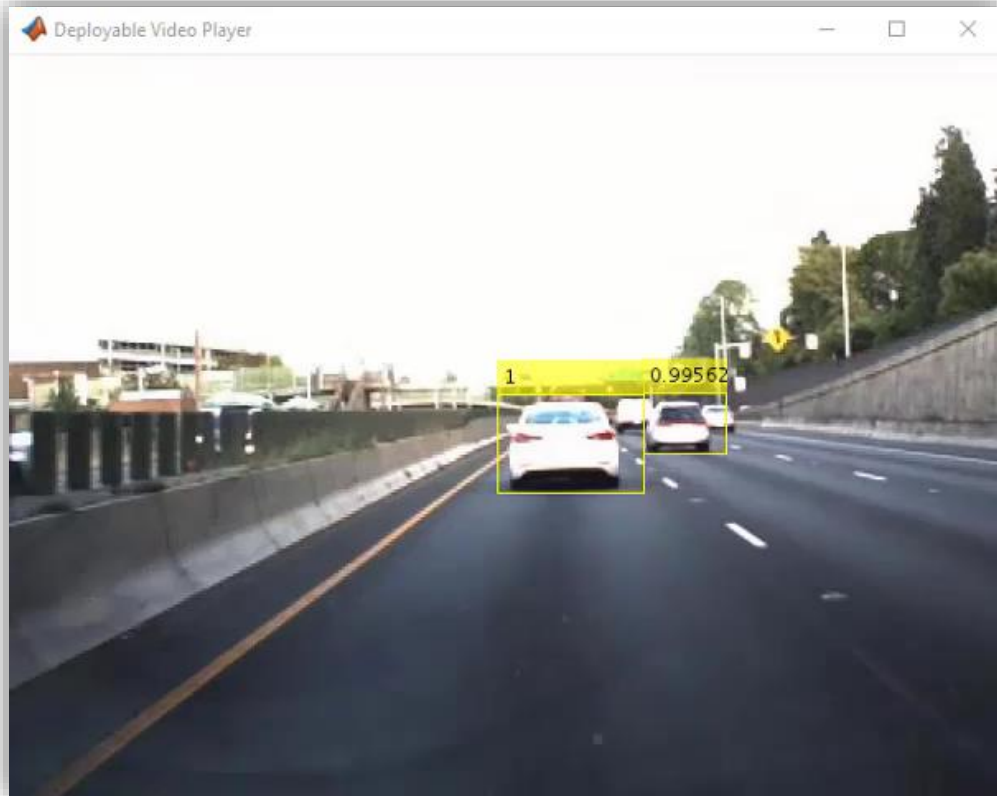
Start Time

Current

End Time

Max Time

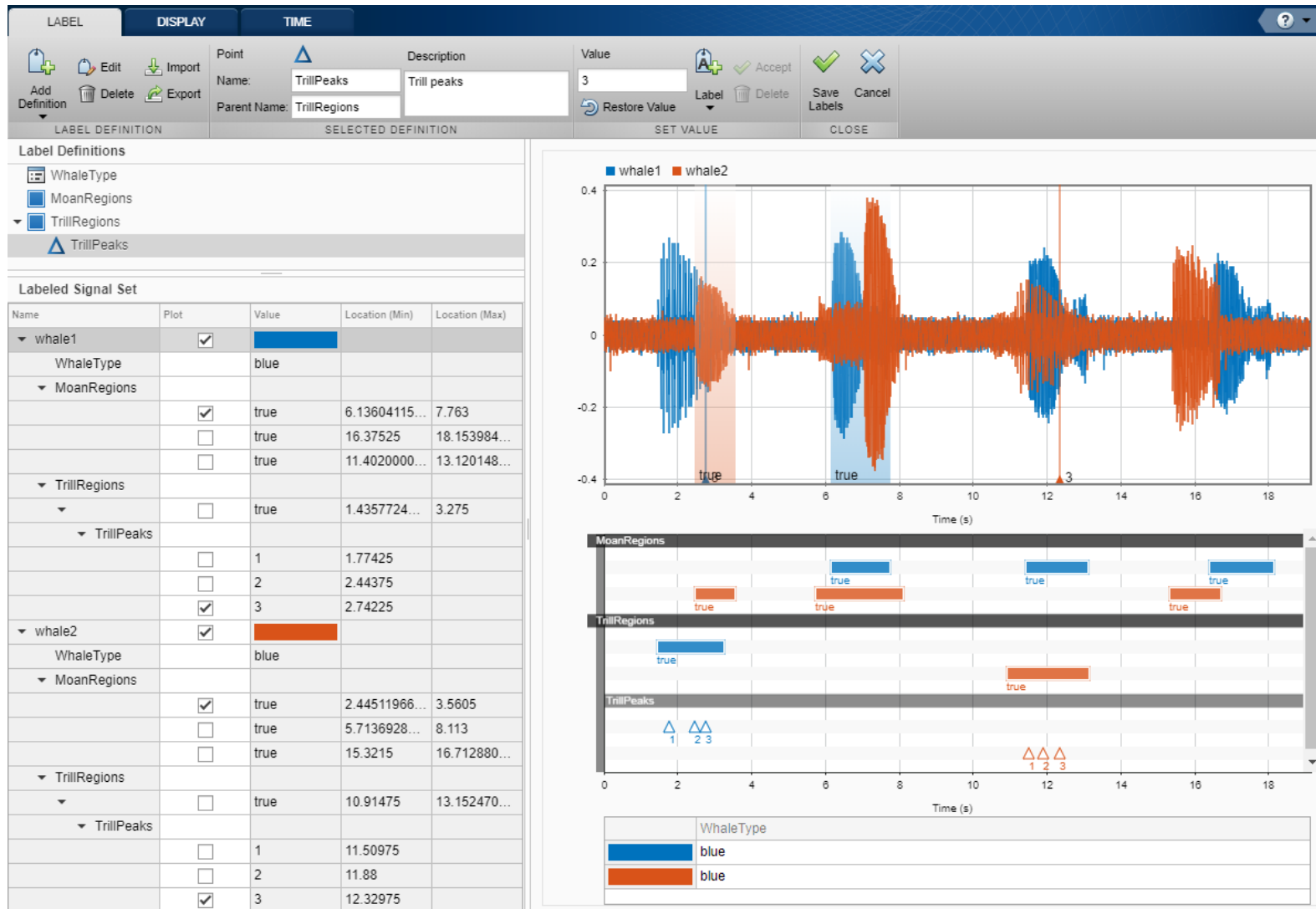
Zoom In Time Interval



# Signal Labeler

Define  
Labels

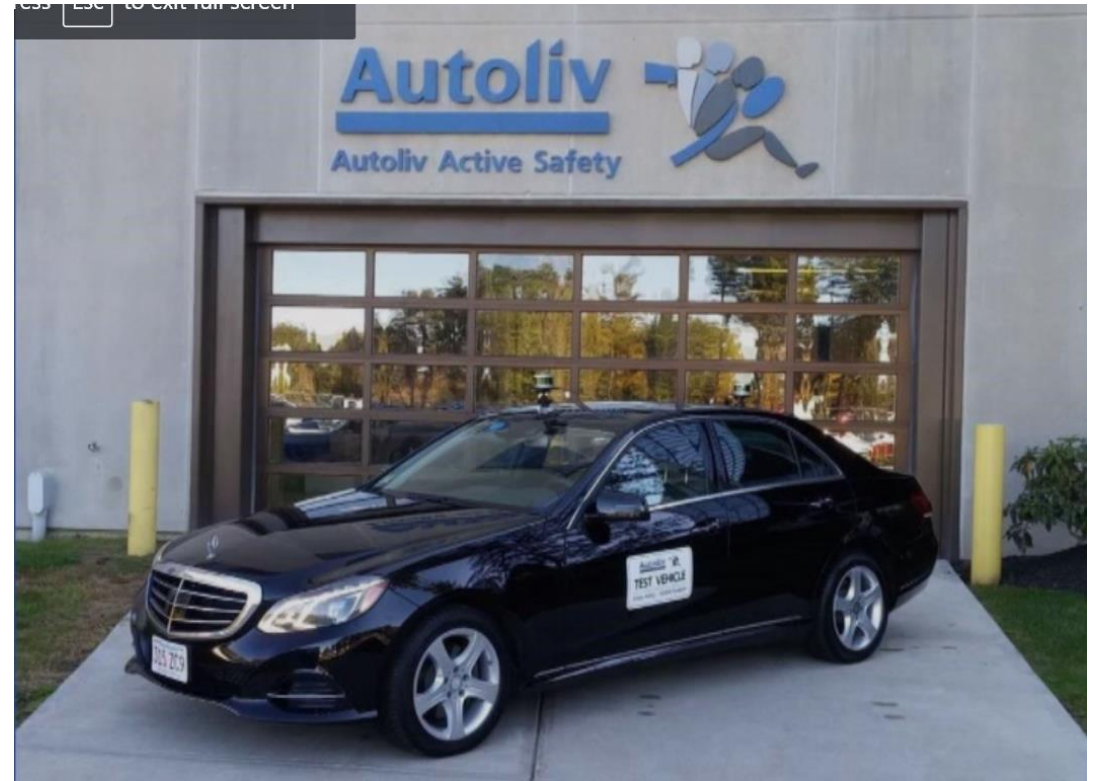
View  
properties  
of labels



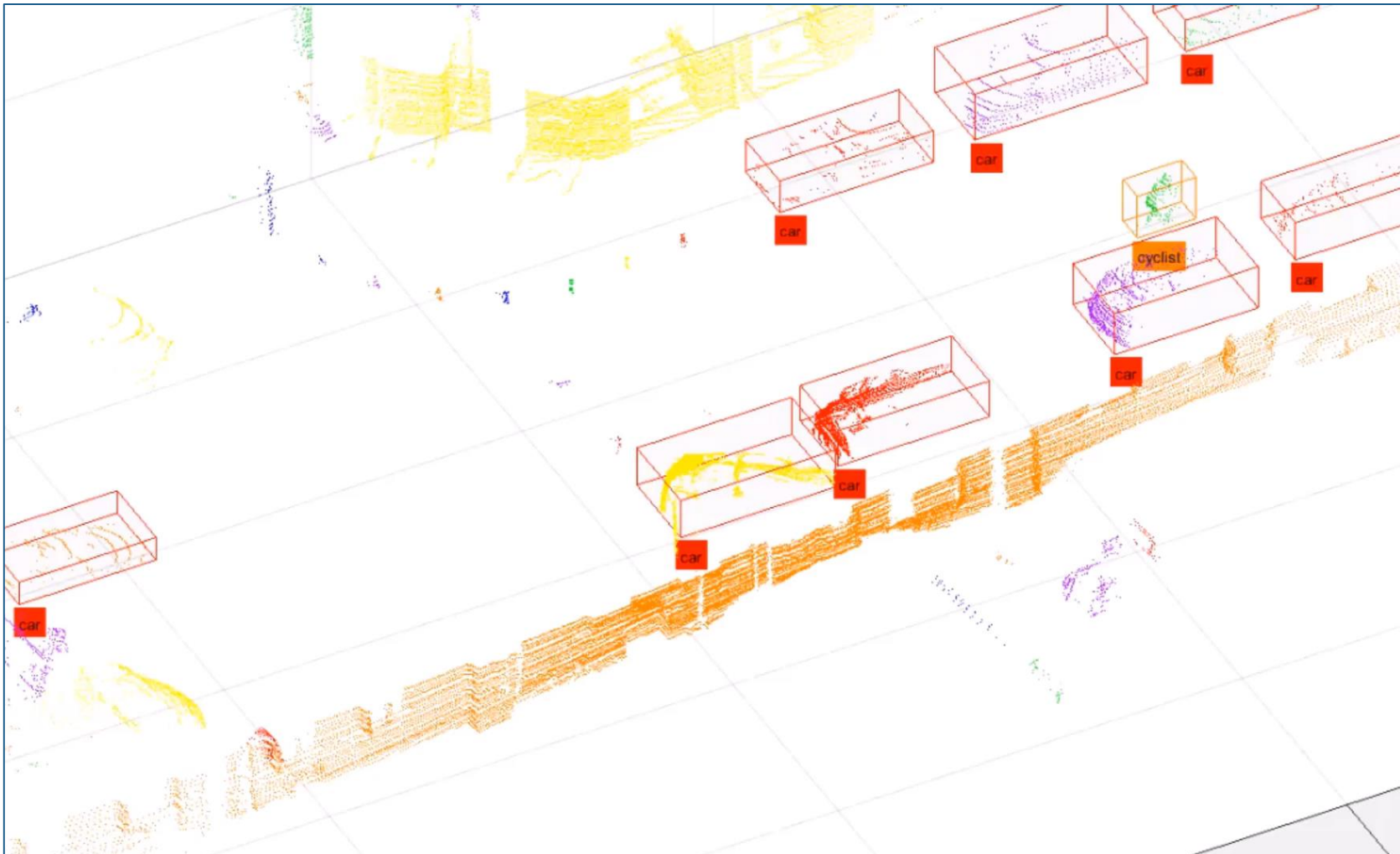
Interactively  
Label Signals

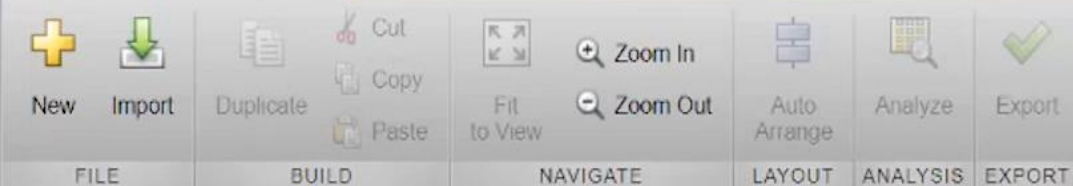
# User Story – Veoneer (Autoliv)

- 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**





## 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**

**SqueezeNet**

**AlexNet**

**ResNet-50**

**VGG-19**

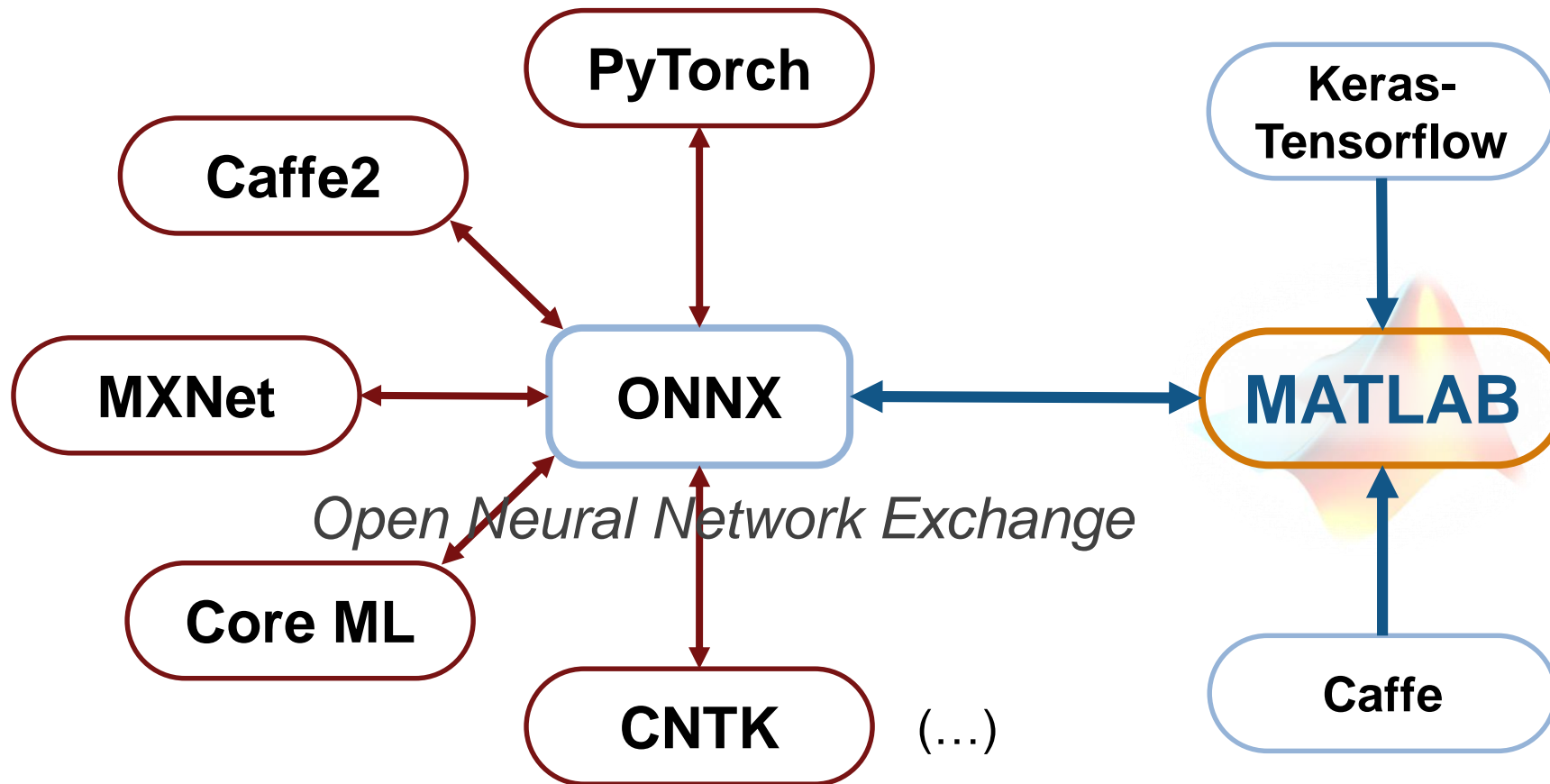
## Import & Export Models Between Frameworks

**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**

# Why MATLAB for A.I. Tasks?

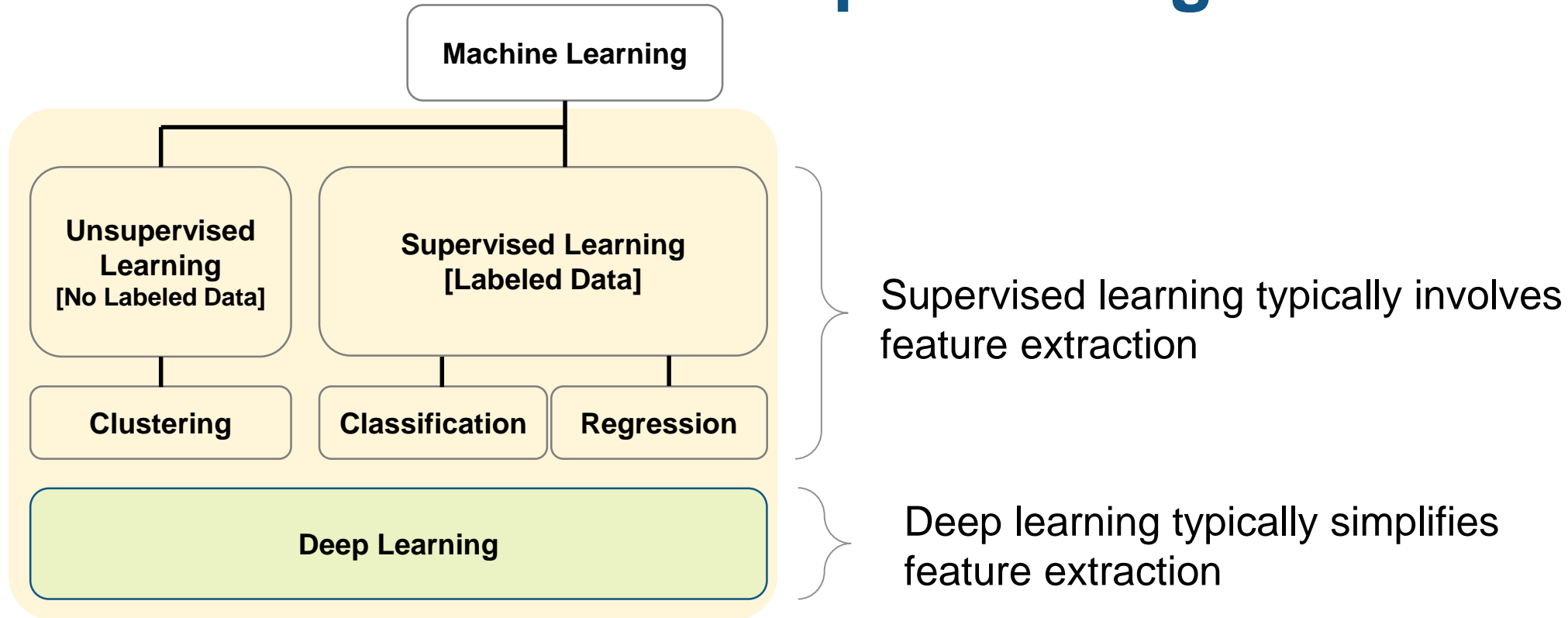
**Generate simulation data for complex models and systems**

**Reinforcement  
Learning**

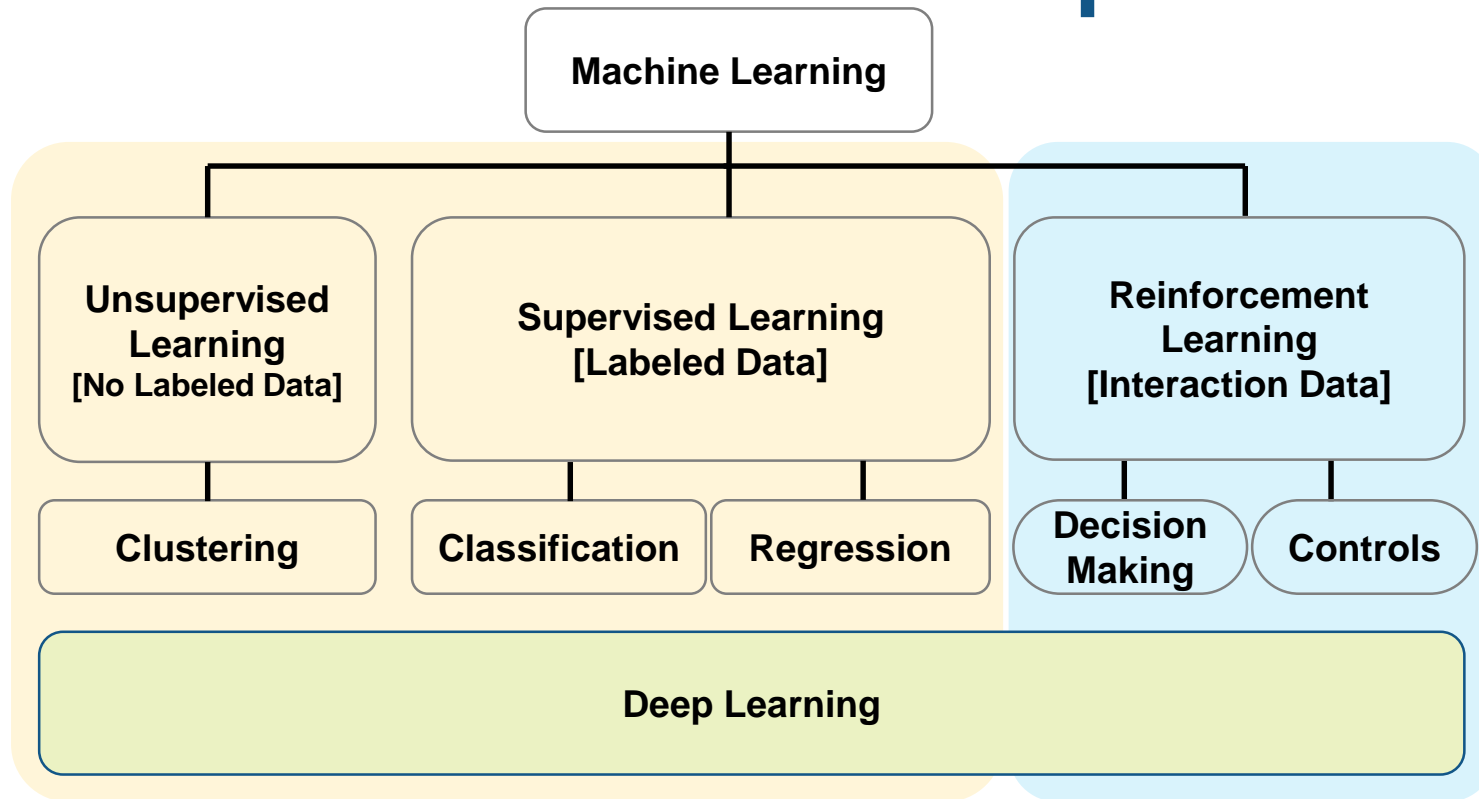
---

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

# Reinforcement Learning vs Machine Learning vs Deep Learning



# Reinforcement Learning vs Machine Learning vs Deep Learning

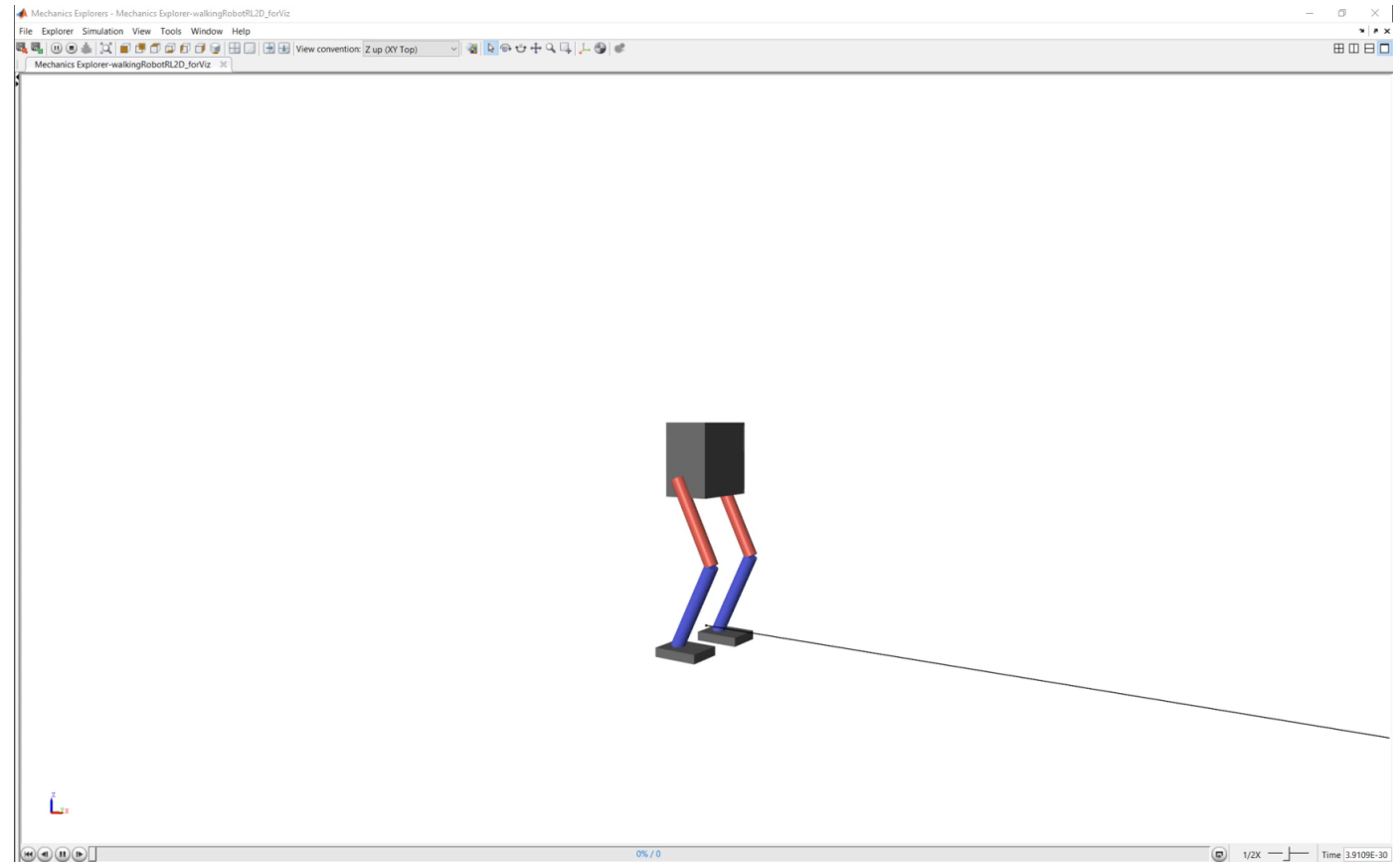


## Reinforcement learning:

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

# What is Reinforcement Learning?

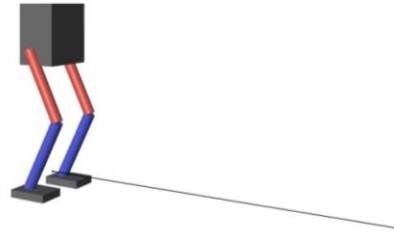
- What is Reinforcement Learning?
  - Type of machine learning that trains an **'agent'** through repeated interactions with an environment
- How does it work?
  - Through a trial & error process that uses a reward system to maximize success



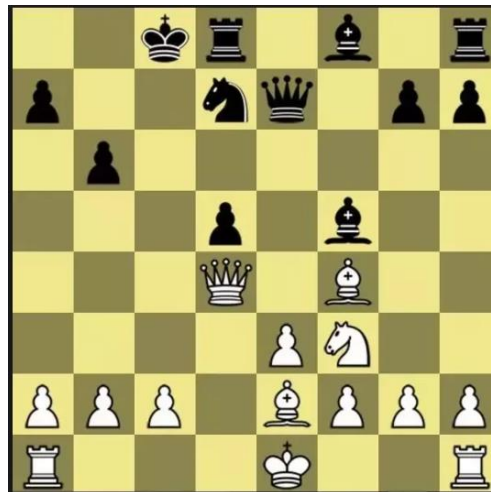
# Reinforcement Learning enables the use of Deep Learning for Controls and Decision Making Applications



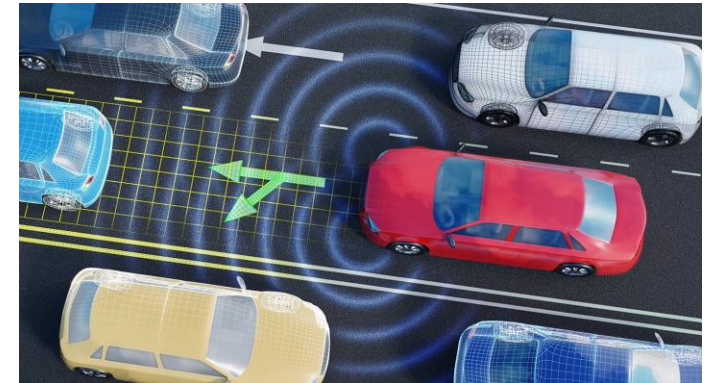
Controls



Robotics

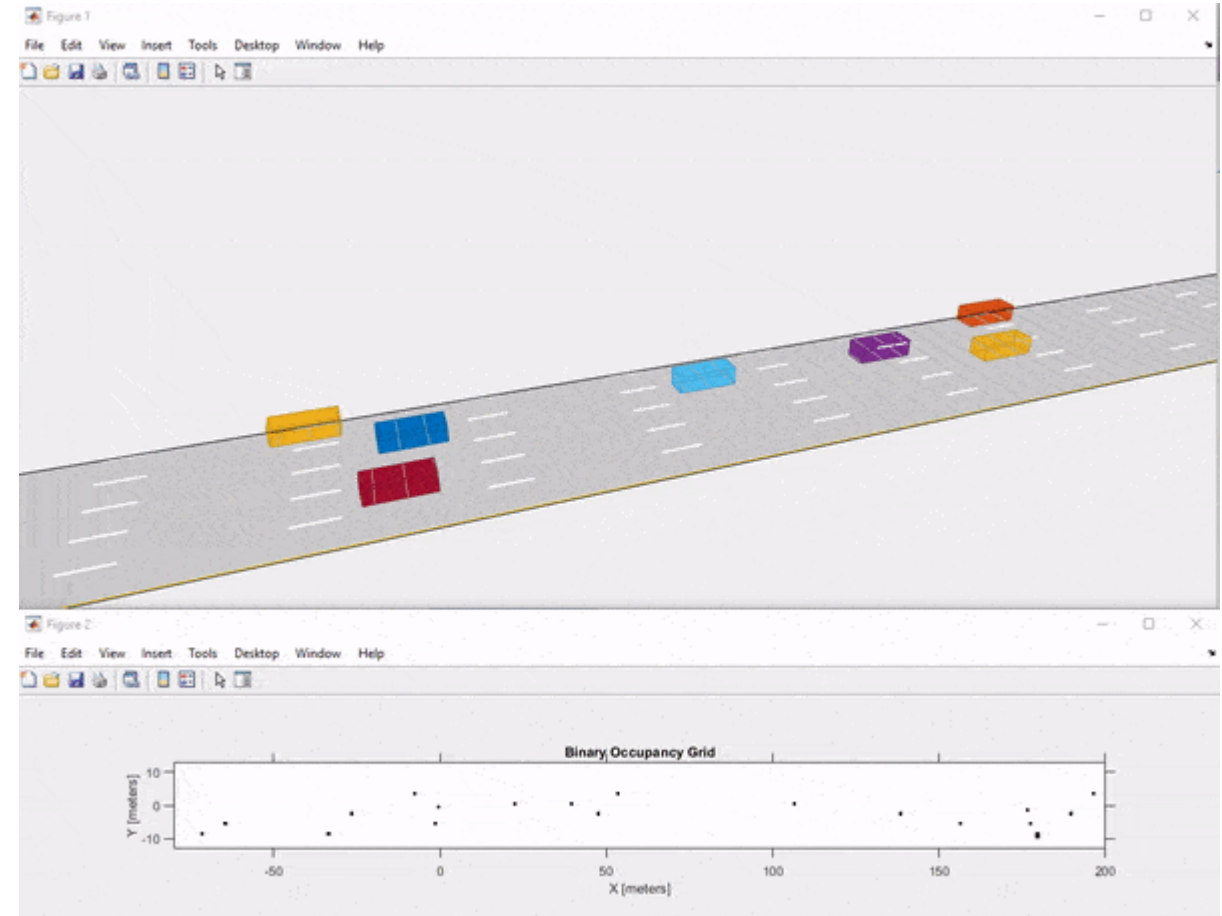
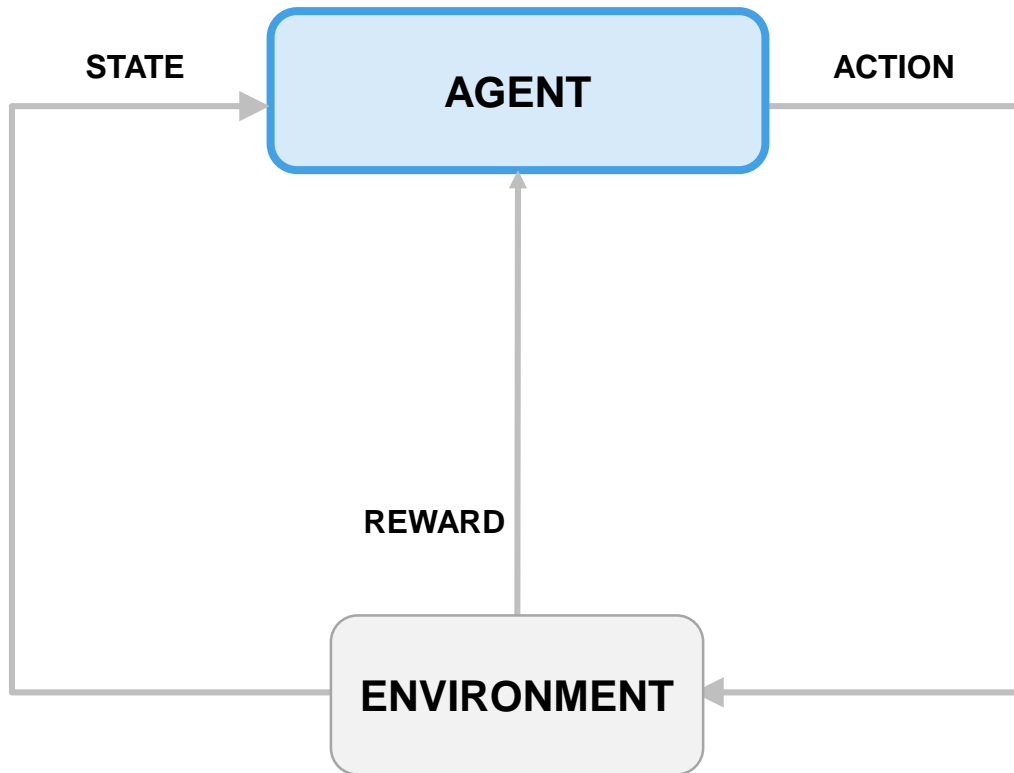


A.I. Gameplay



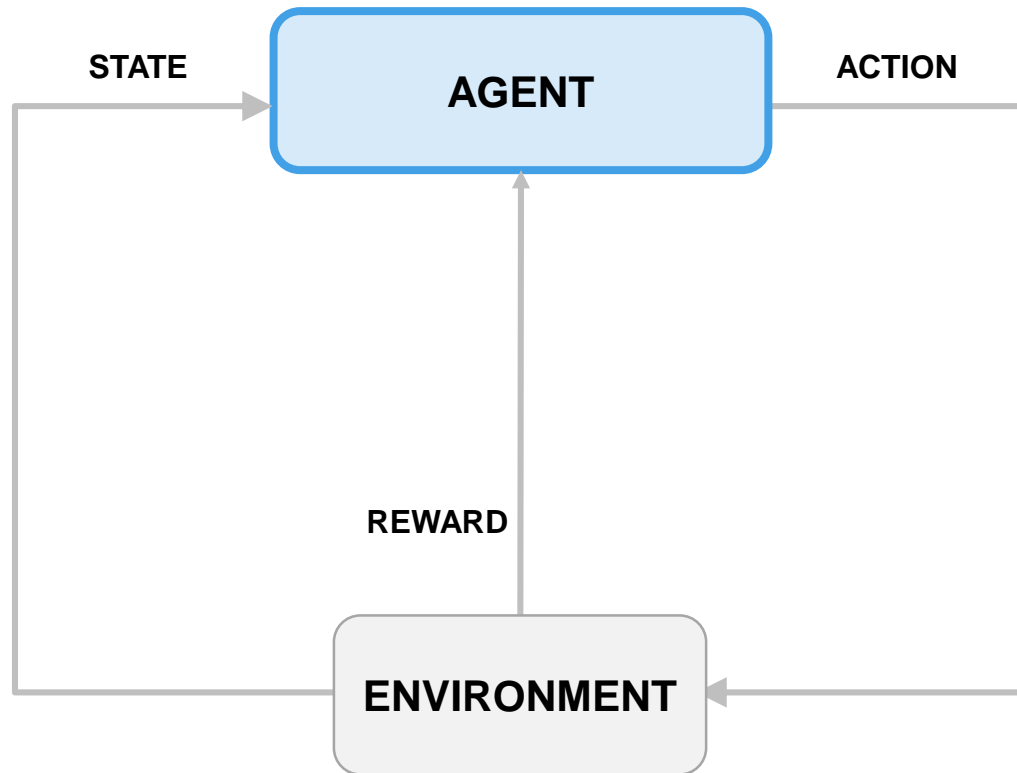
Autonomous driving

# How Does Reinforcement Learning Work?



# A Practical Example of Reinforcement Learning

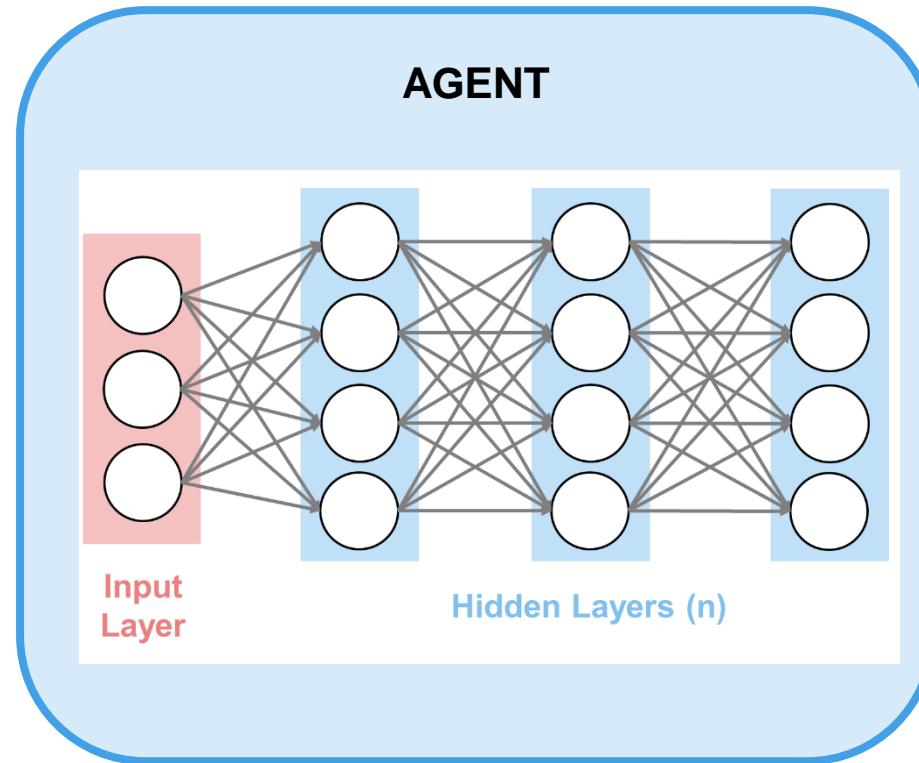
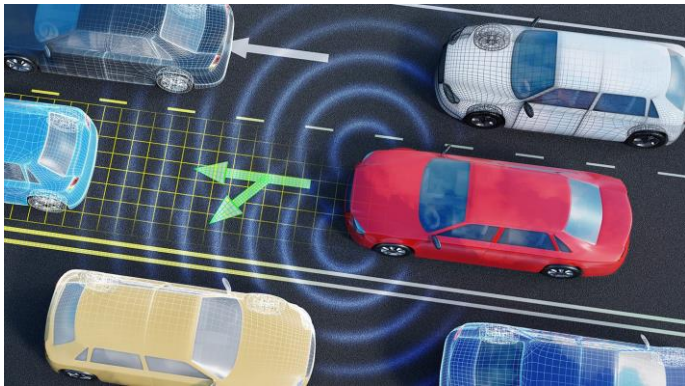
## Training a Self-Driving Car



- 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**).

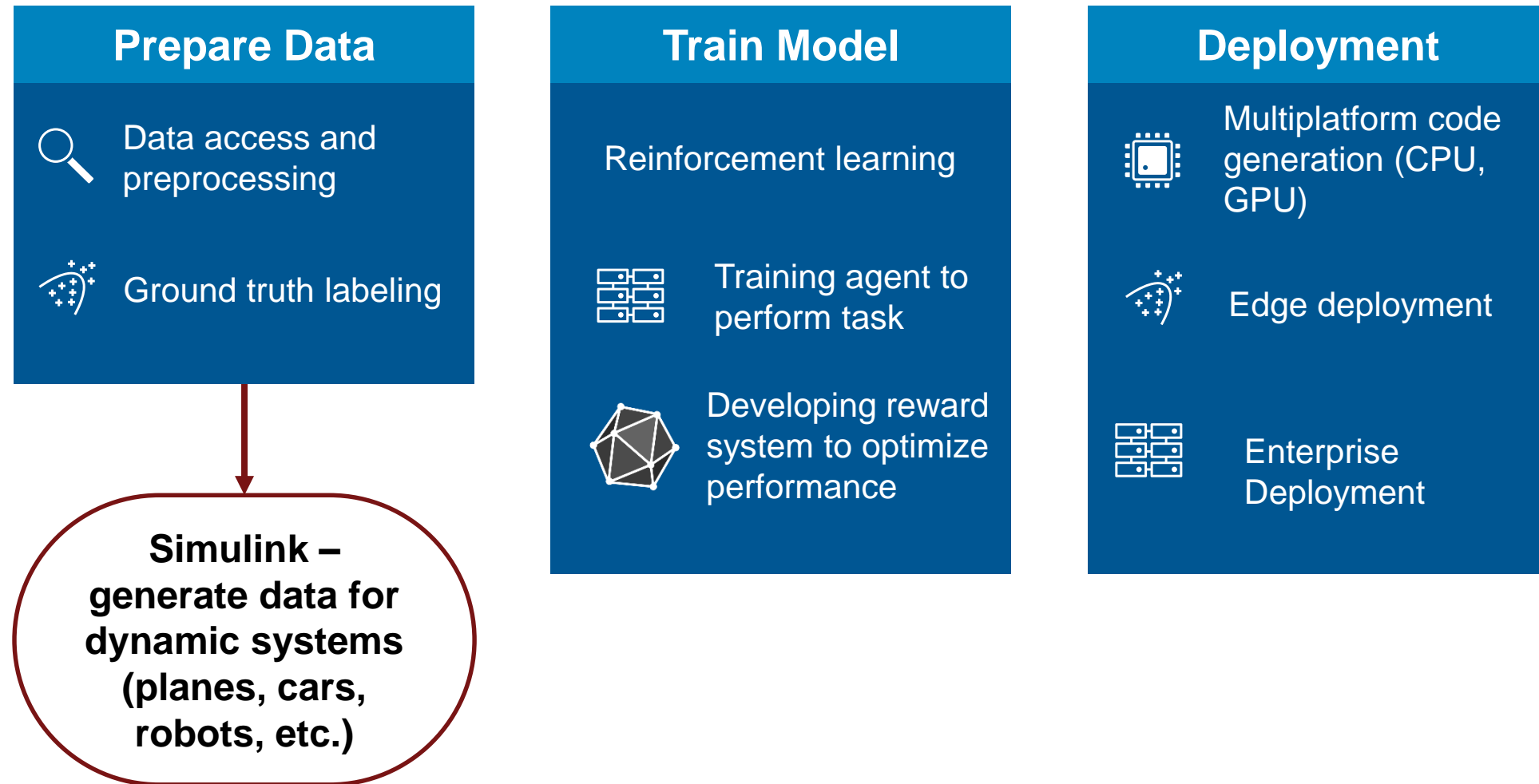
**The goal of Reinforcement learning is for the agent to find an optimal algorithm for performing a task**

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



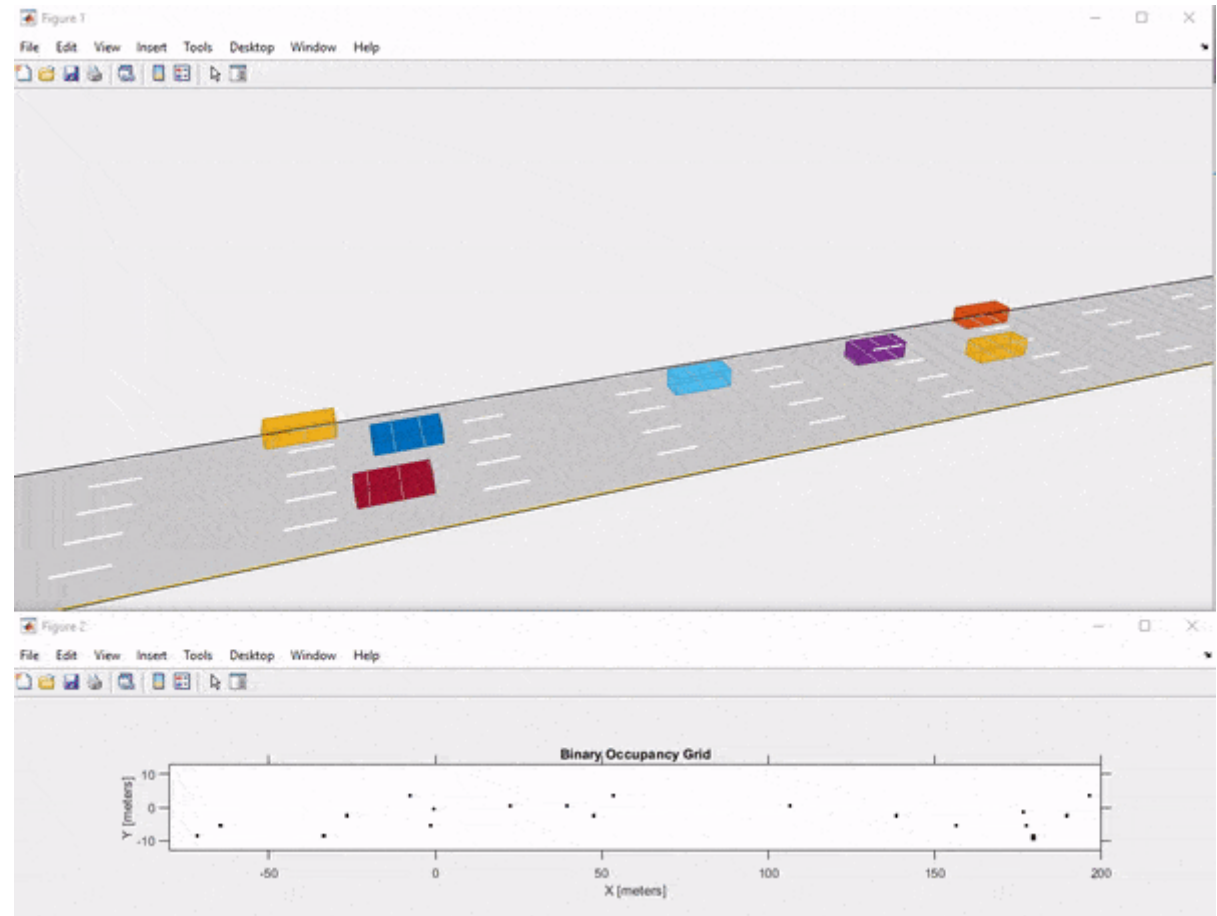
- **Turn left**
- **Turn right**
- **Brake**
- **Accelerate**

# Reinforcement Learning Workflow



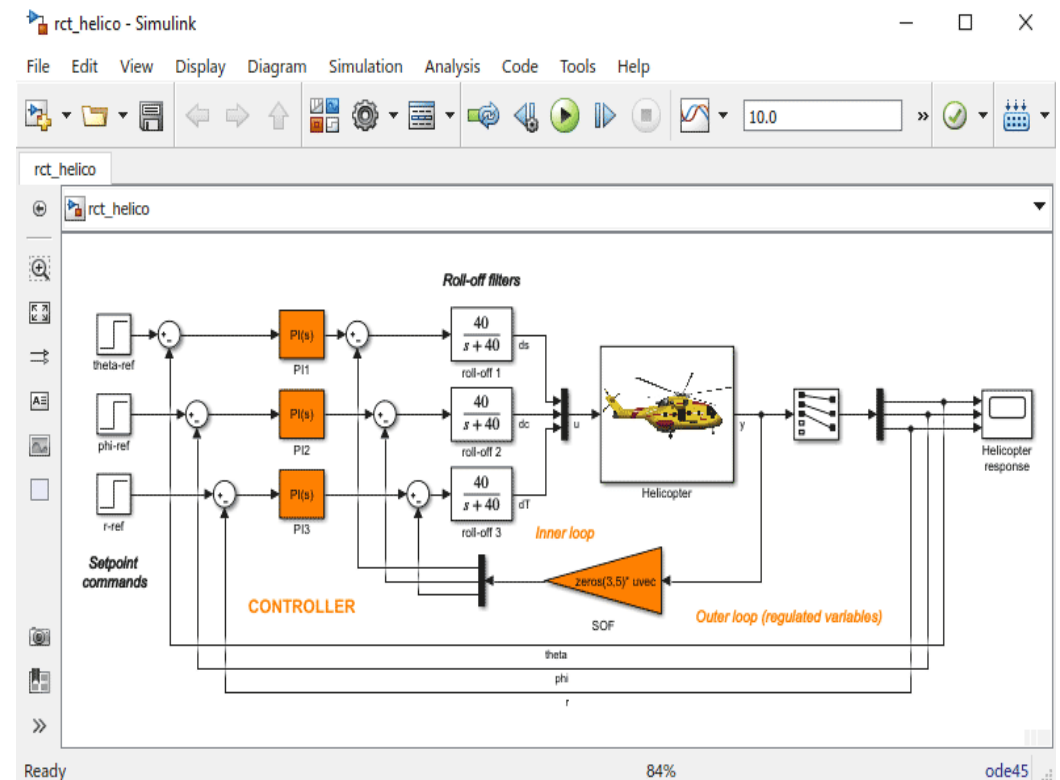
# Why MATLAB and Simulink for Reinforcement Learning?

*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.



# 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**

**Generate simulation data for complex models and systems**

Code

Embedded

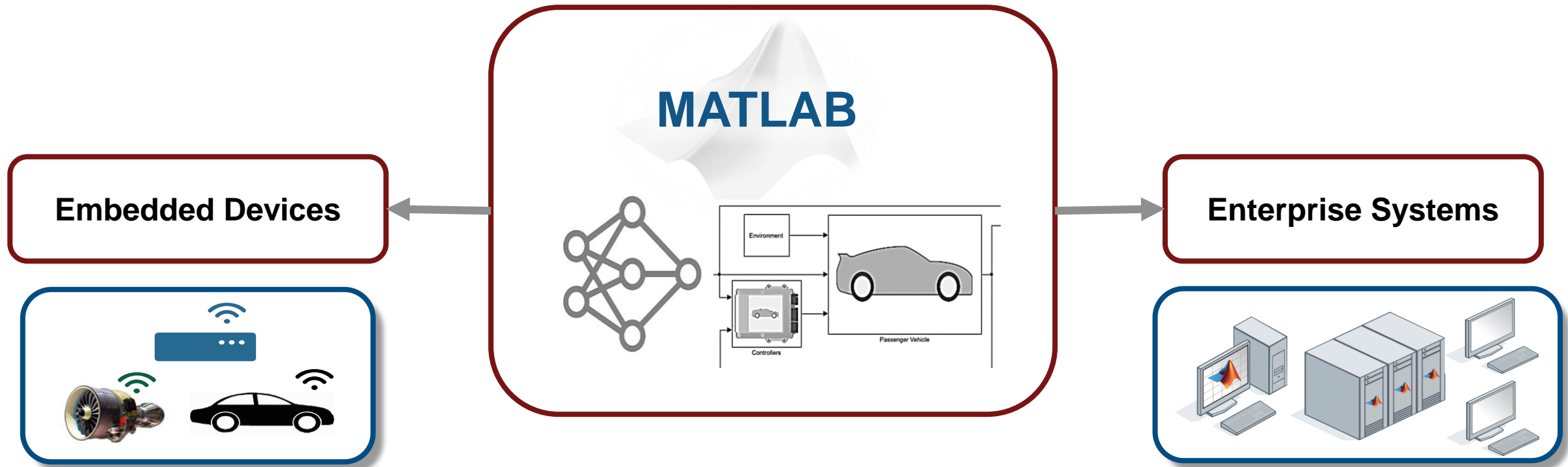
Enterprise

**Ease of deployment and scaling to various platforms**

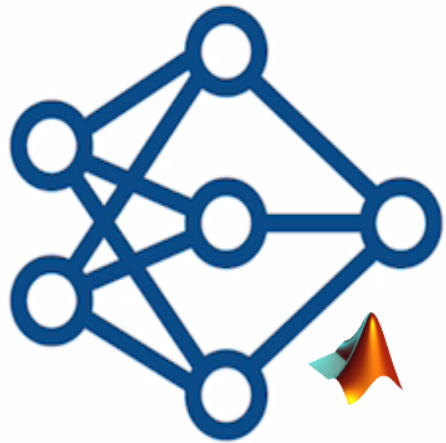
---

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

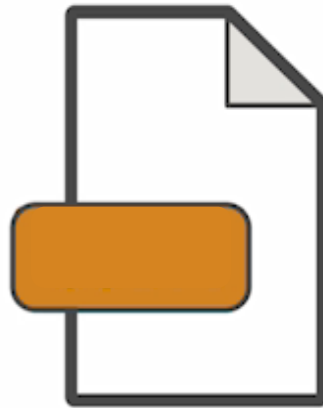
# Deployment and Scaling for A.I.



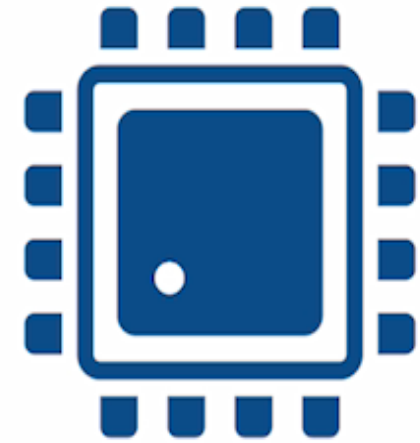
# Embedded Devices – Automatic Code Generation



MATLAB Code

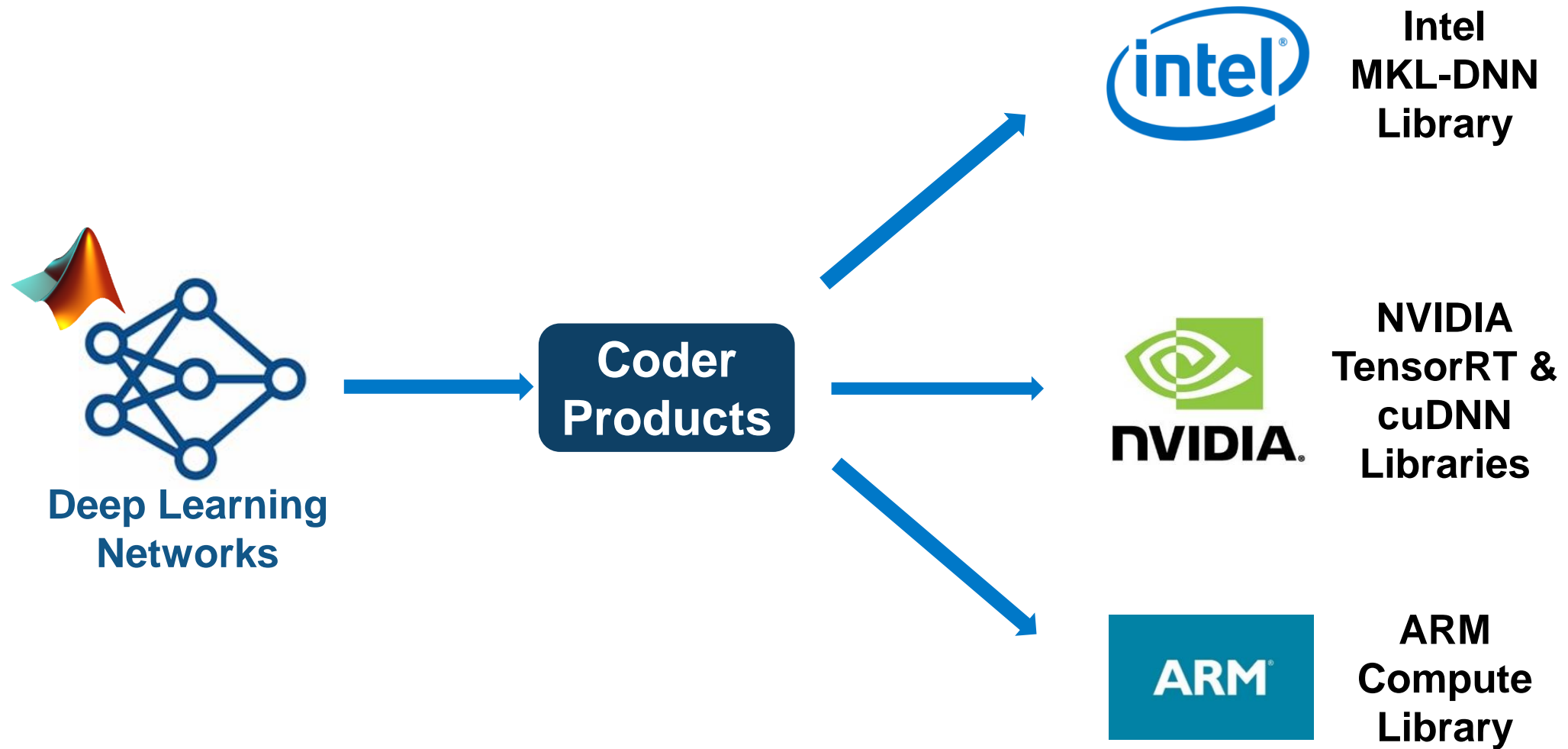


Auto-generated  
Code  
(C/C++/CUDA)



Deployment  
Target

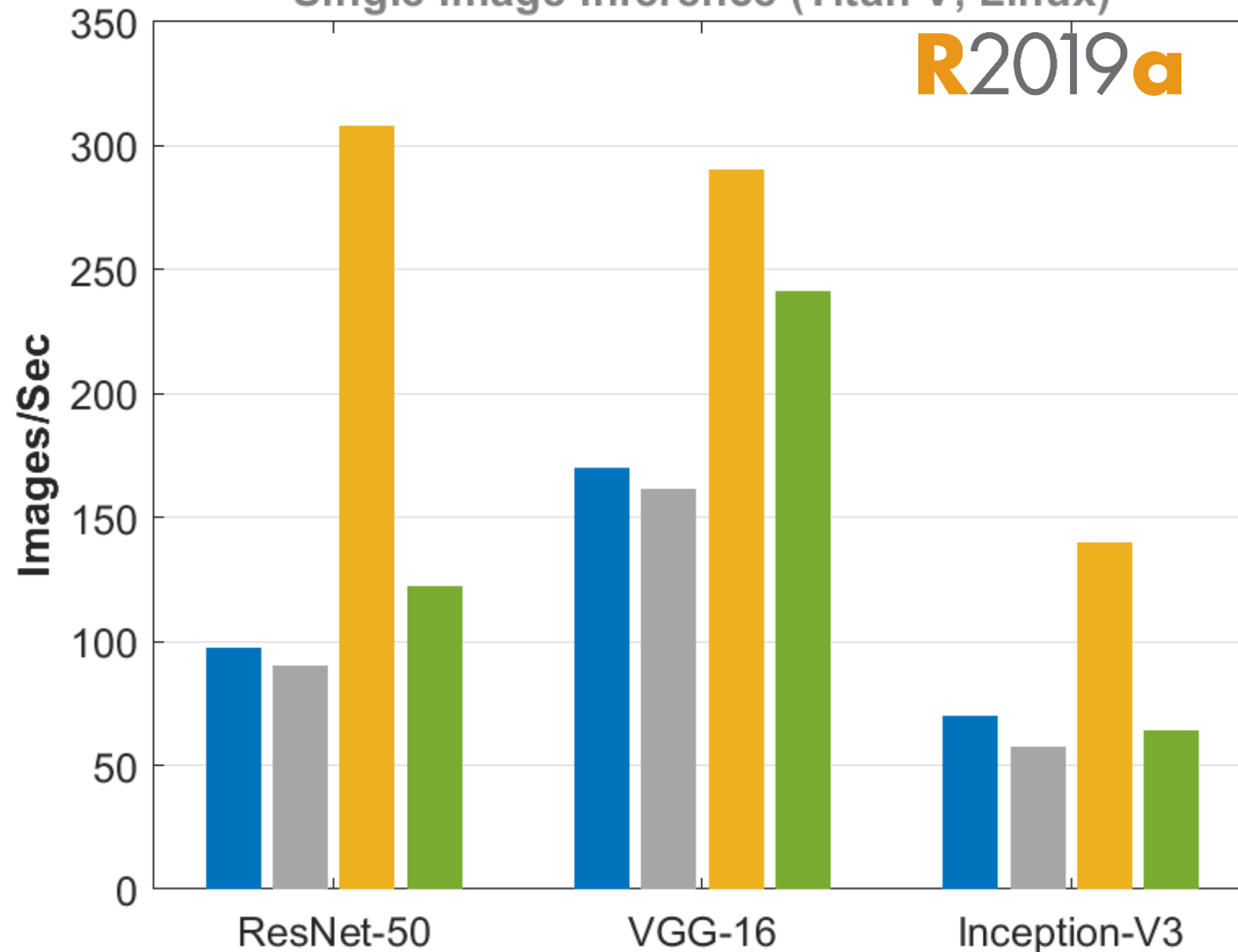
# Deploying Deep Learning Models for Inference



# With GPU Coder, MATLAB is fast

Single Image Inference (Titan V, Linux)

R2019a

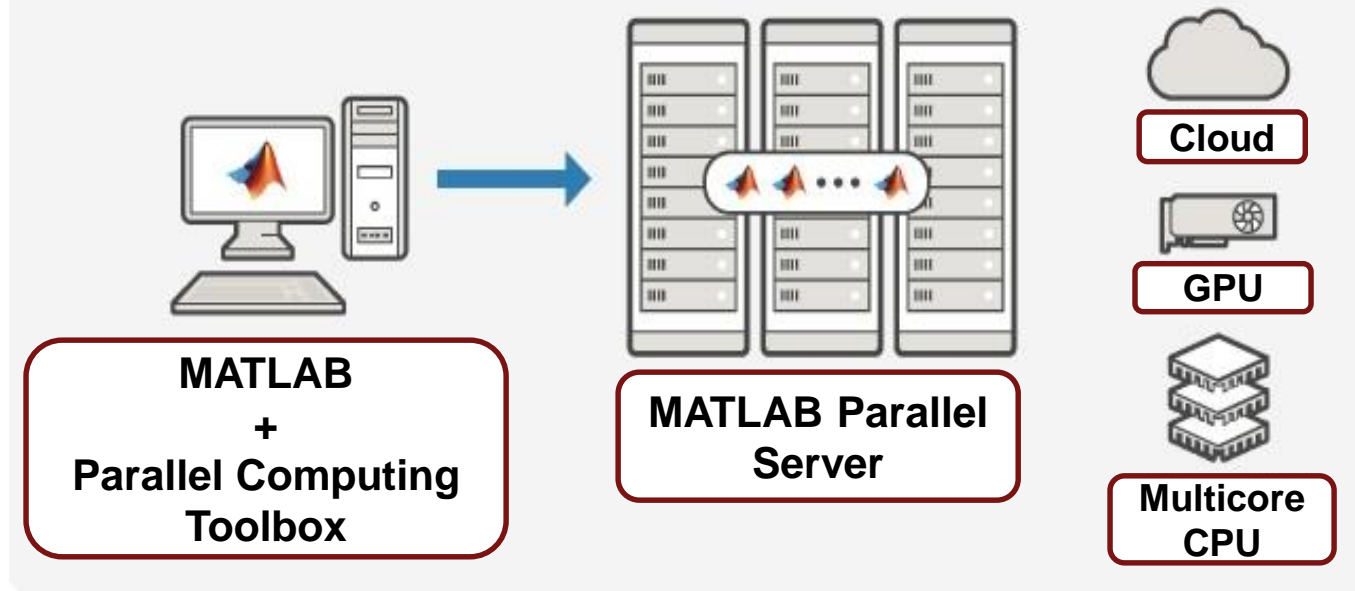


GPU Coder is faster than TensorFlow, MXNet and Pytorch

- TensorFlow
- MXNet
- GPU Coder
- PyTorch

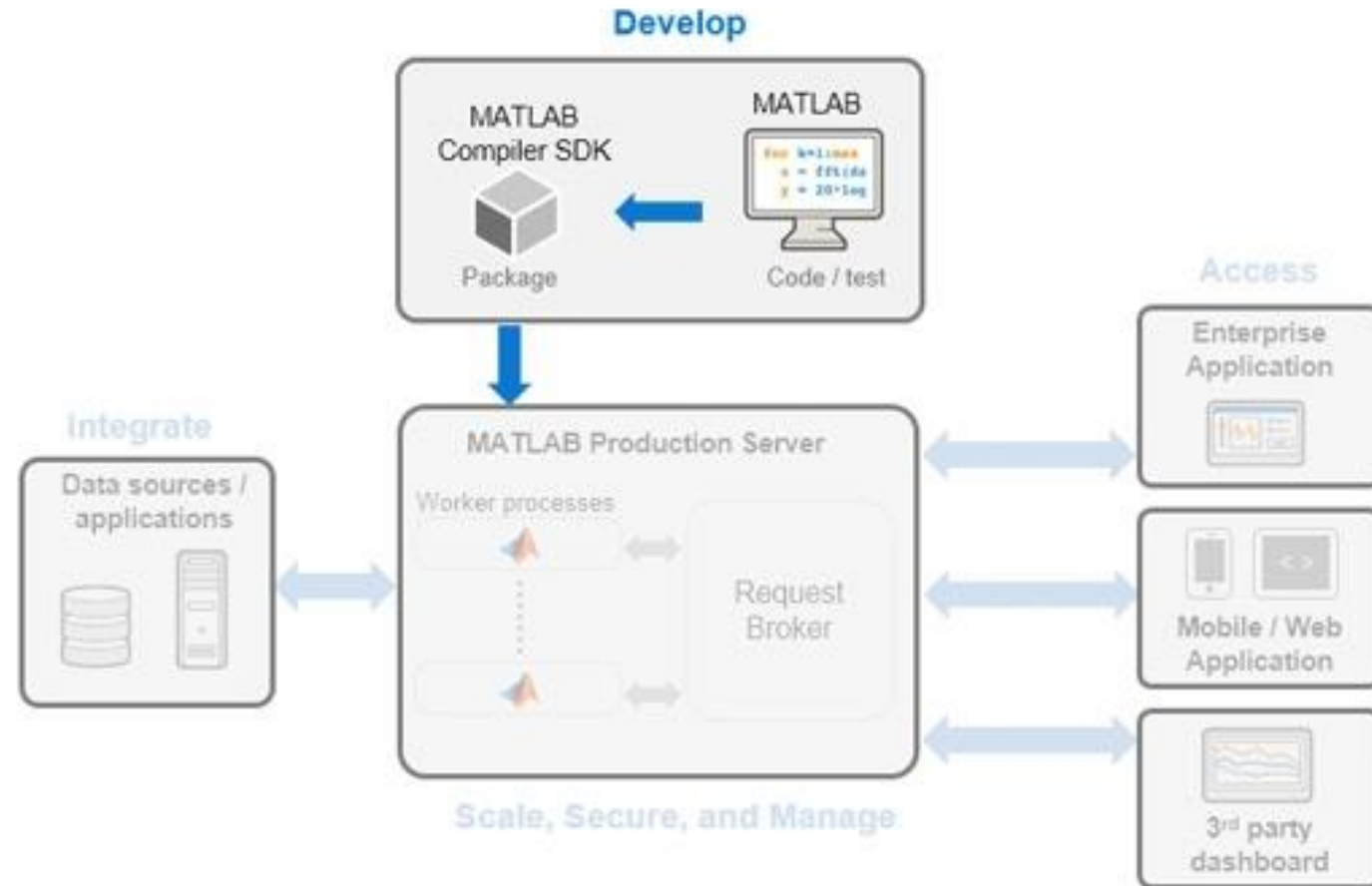
# Enterprise Deployment

```
>> 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.*

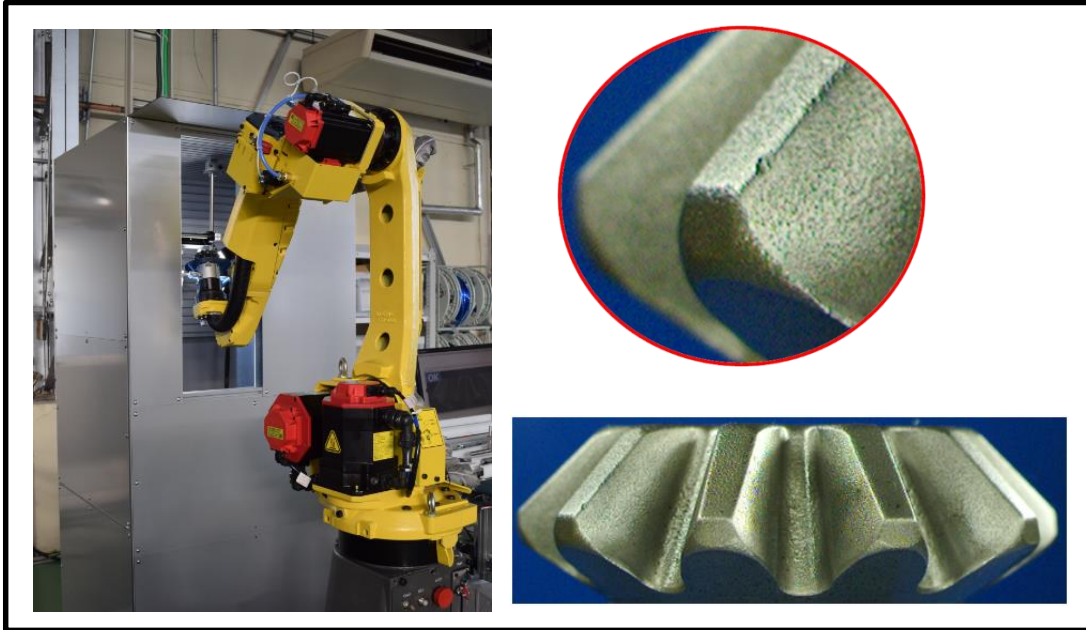
# Enterprise Deployment



*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



# Why MATLAB for A.I. Tasks?

**Increased productivity with interactive tools**

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