Deep Learning Overview
Signals and Time-Series

MathWorks®

Agenda

I. Deep learning in engineering and science

II. Developing a deep learning solution in MATLAB

III. MathWorks deep learning support

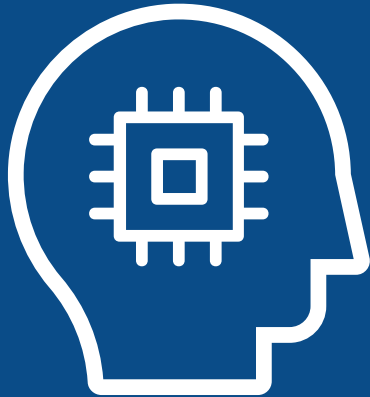MathWorks®

Agenda

I. Deep learning in engineering and science

II. Developing a deep learning solution in MATLAB

III. MathWorks deep learning support

MathWorks®

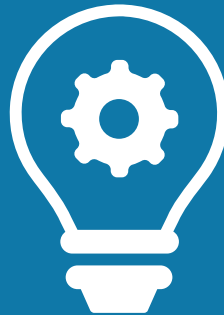# Deep learning is a key technology driving the AI megatrend

ARTIFICIAL INTELLIGENCE
Any technique that enables machines to mimic human intelligence
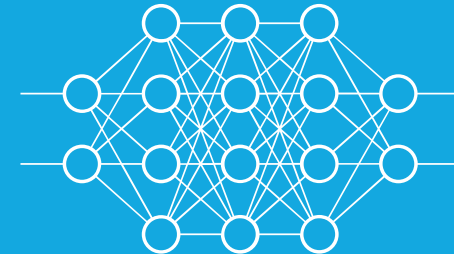
MACHINE LEARNING
Statistical methods that enable machines to "learn" tasks from data without explicitly programming

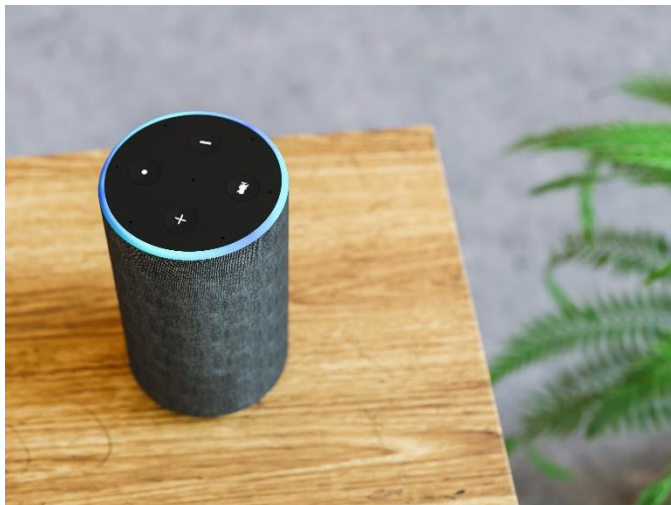**DEEP LEARNING**
Neural networks with many layers that learn representations and tasks "directly" from data

1950s   1980s   2010s
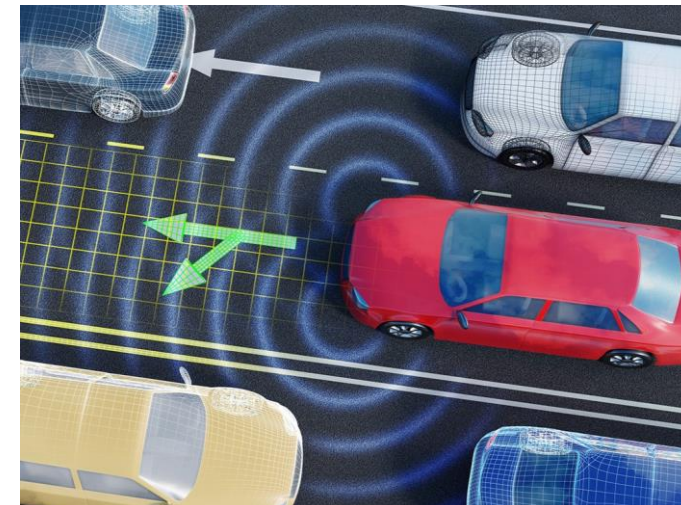
MathWorks

Deep learning is part of our everyday lives

Speech Recognition

Face Detection

Automated Driving

Deep learning applications: mainstream vs. engineering

Mainstream

Detecting Objects

Engineering and Science

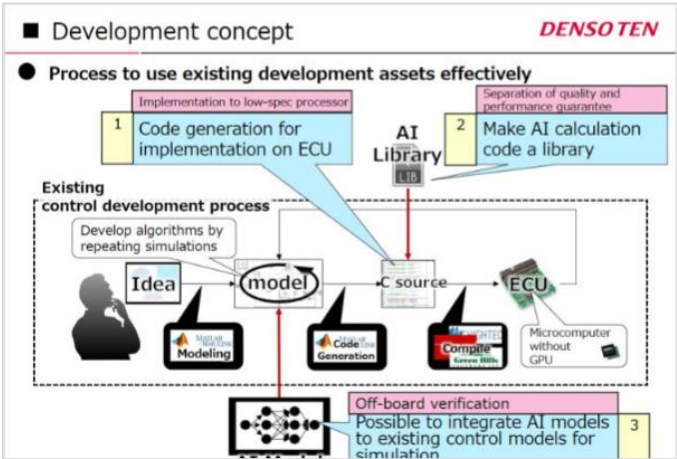Identifying Machinery at Shell
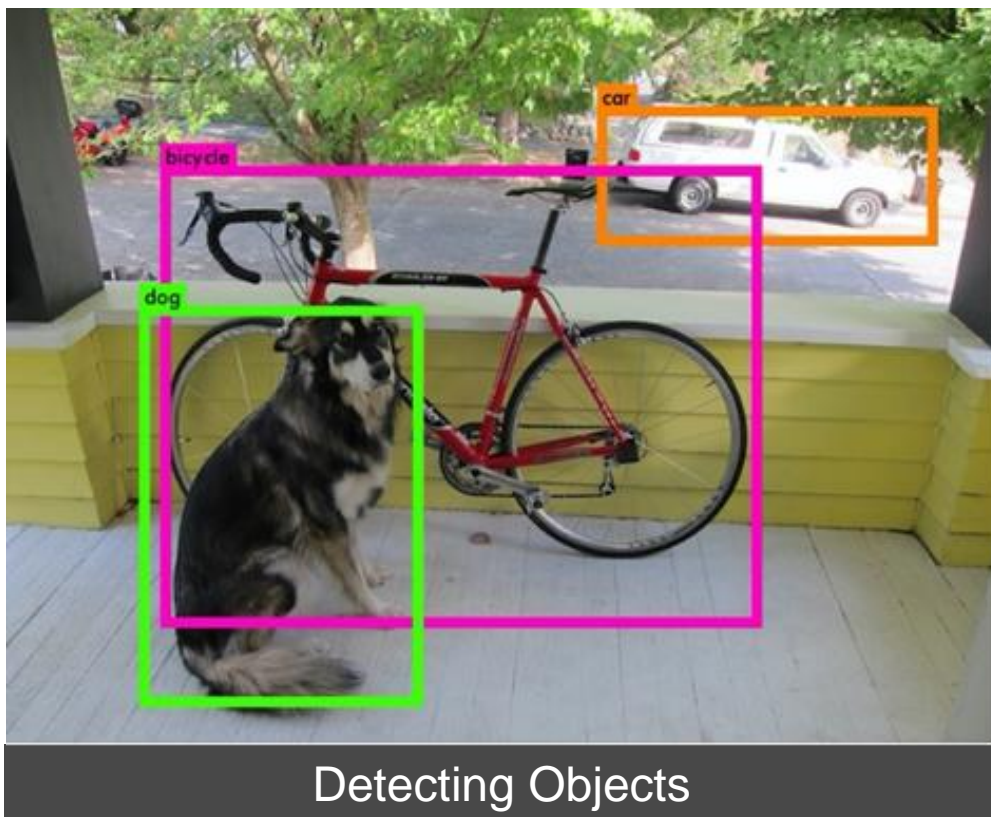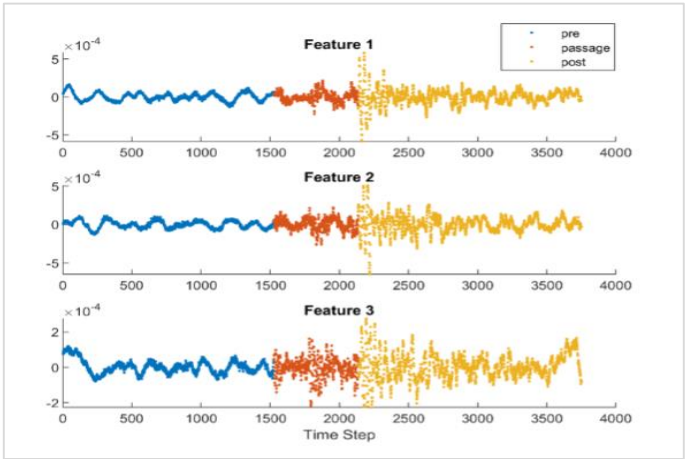
Deep Learning Detection

MATLAB Deep Learning used in Industry

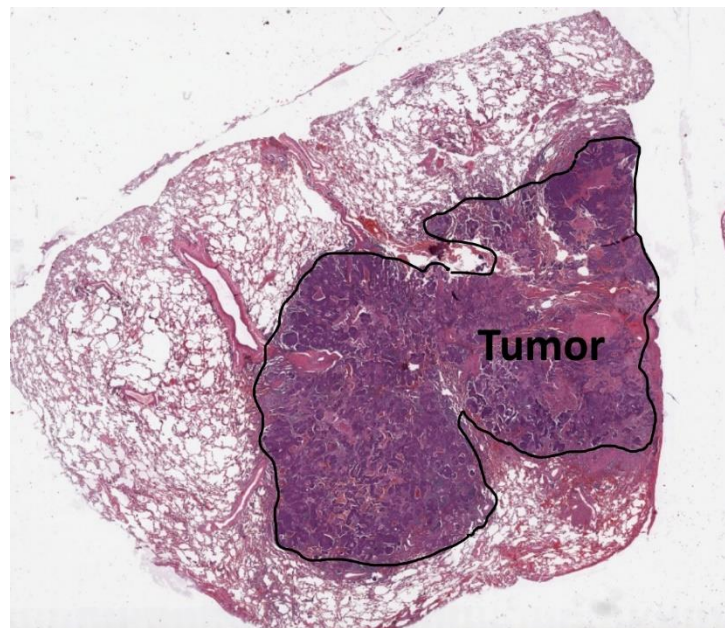**Automatic Defect Detection**
Airbus
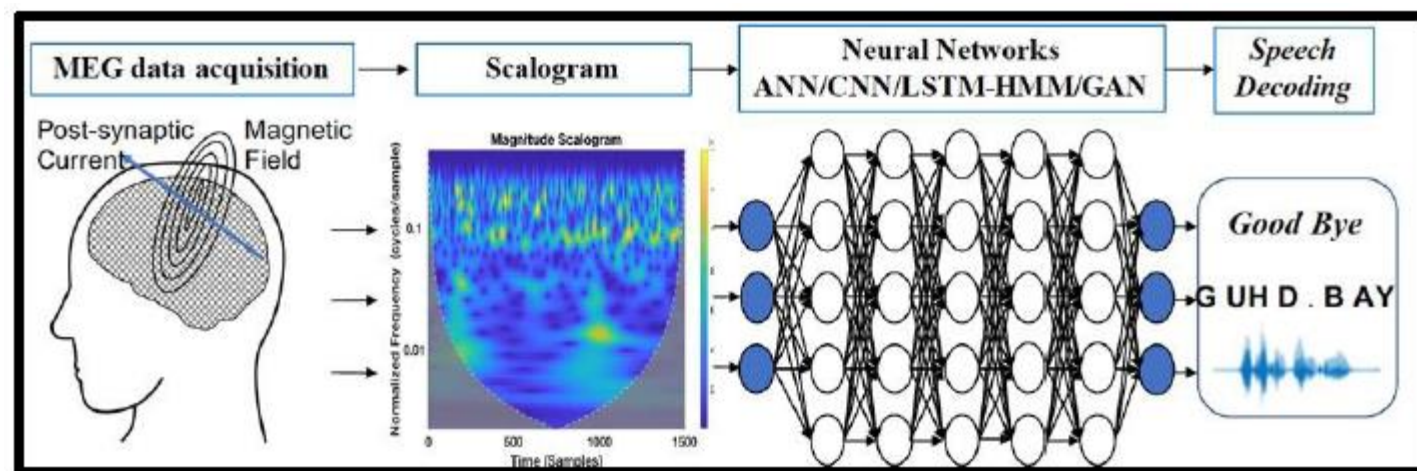
ECU Vehicle Control
Denso

Seismic Event Detection
Shell

MATLAB Deep Learning used in Research

Predicting gastrointestinal cancer (July 2019)

Converting brain waves to speech to help ALS patients communicate (Nov 2019)

MathWorks®

Evolution of Deep Learning in MATLAB

2016

CNN's
Pretrained Models
Caffe Importer

2017

Name Change
- Neural Network Toolbox to Deep Learning Toolbox

Algorithms
- LSTM's
- Directed Acyclic Graphs
- Multi-GPU Training

Code Generation
- GPU Coder

Apps
- Image Labeler

Interoperability
- TensorFlow-Keras Importer

2018

Examples
- Signal Processing
- Audio
- Text Analytics

Algorithms
- Wavelet Scattering

Code Generation
- MATLAB Coder C++

Apps
- Deep Network Designer
- Video Labeler
- Audio Labeler

Interoperability
- ONNX Support

2019

- Reinforcement Learning

Algorithms
- Automatic Differentiation
- Custom Training Loops
- Weight Sharing
- Big Image

Examples
  - GANs
  - Siamese Network
  - Autoencoders
- 3-D support
- **Explainable AI**
  - Occlusion
  - Grad-CAM

Code Generation
- MATLAB Coder (ARM)

Apps
- Signal Labeler

2020

- Deep Learning Data Sets

Apps
- Experiment Manager

Examples
- 5G Communications
- **Over 200+ examples!**

Algorithms
- Point Cloud

Code Generation
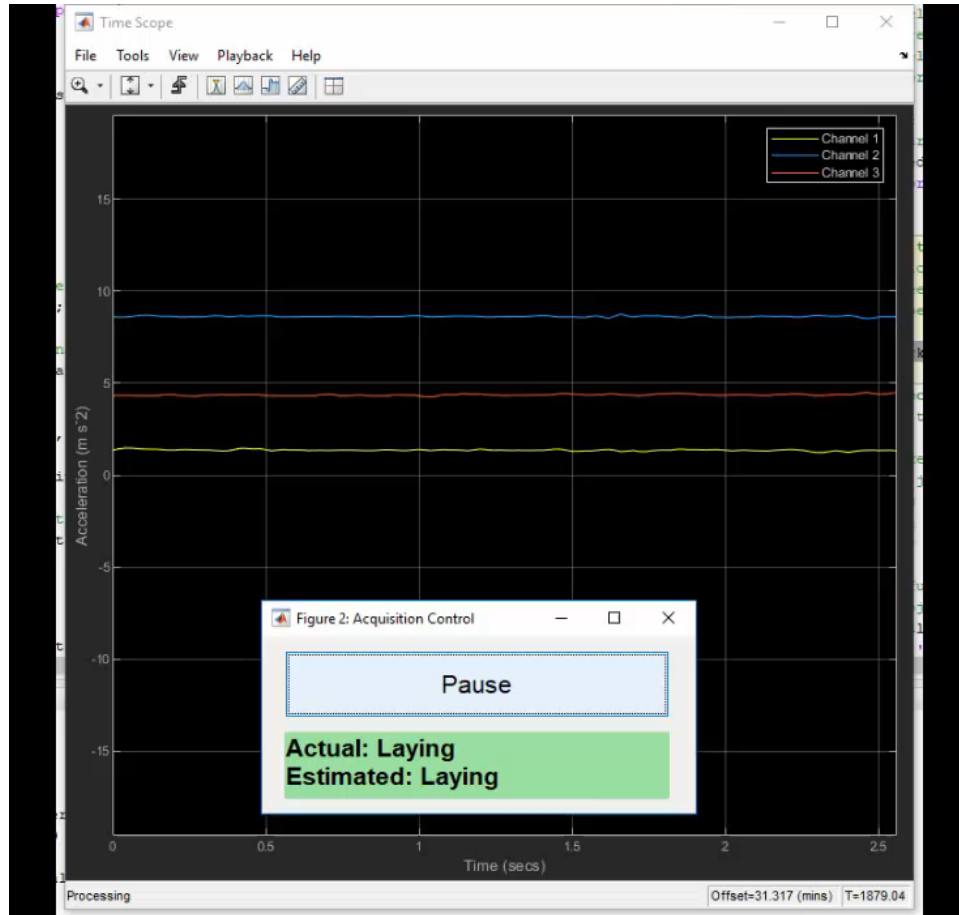- Quantization

Applications of deep learning for images and video
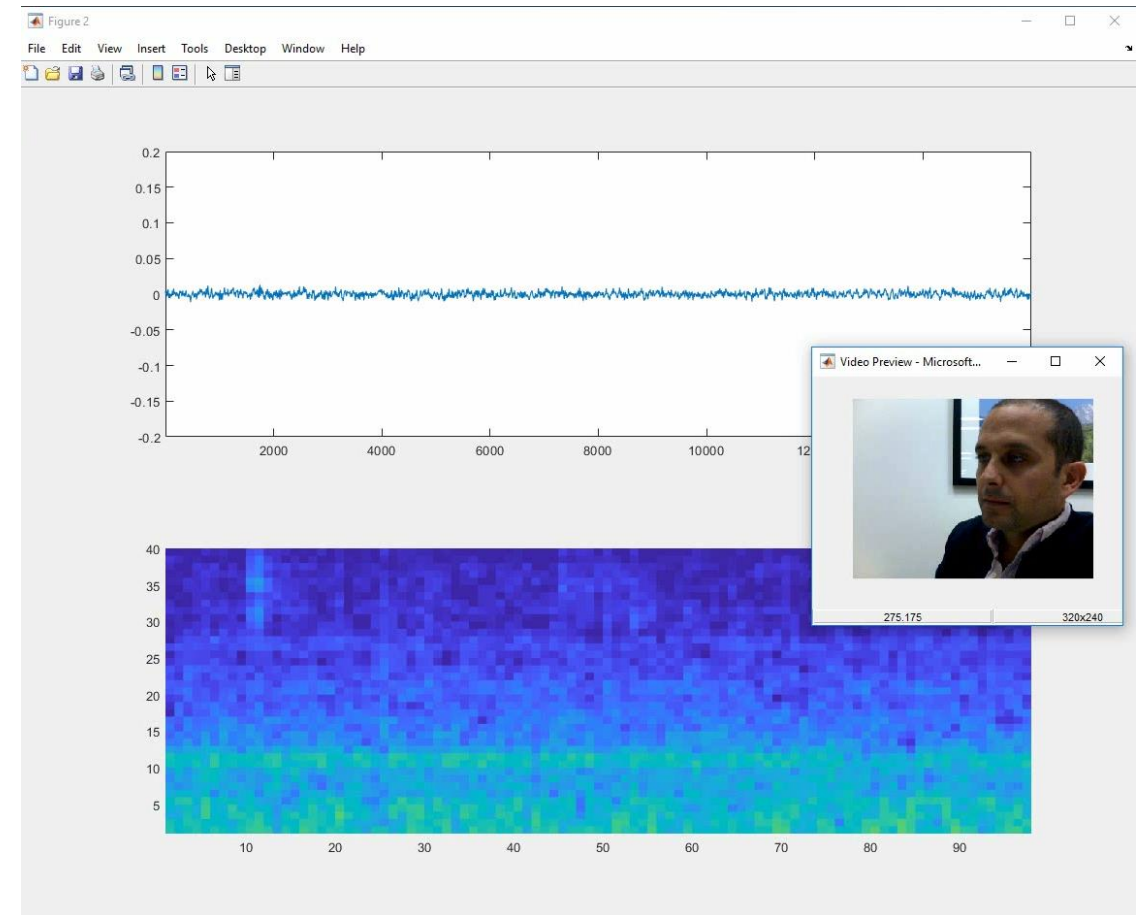

YOLO v2 (You Only Look Once)

Semantic Segmentation using SegNet

MathWorks

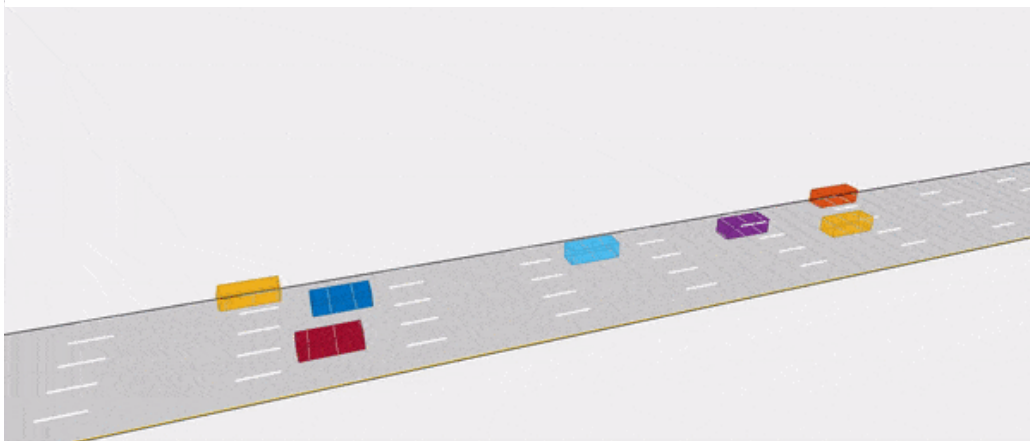# Applications of deep learning for signal processing
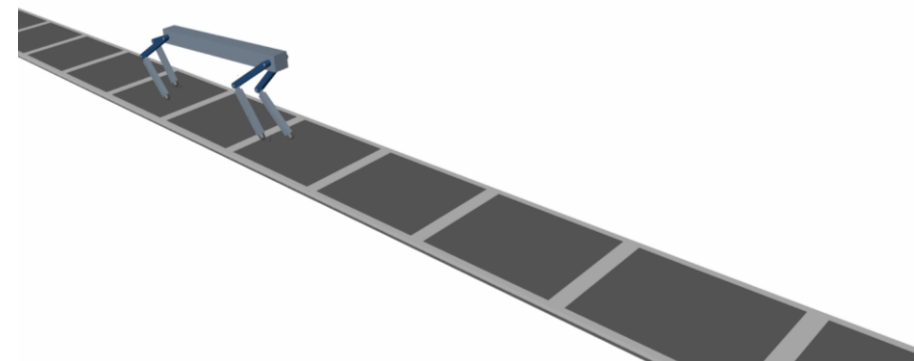

Signal Classification using LSTMs

Speech Recognition using CNNs
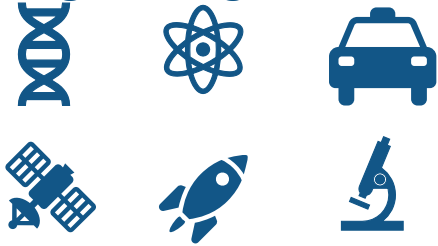
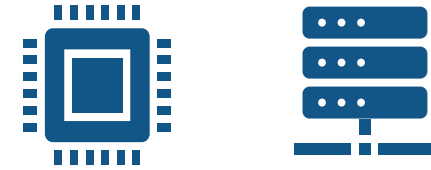# Applications of reinforcement learning

Teach a car to navigate traffic

Train a Quadruped robot to walk

MathWorks®

Why MATLAB & MathWorks for Deep Learning?

Domain-specialized workflows for **engineering and science**

People

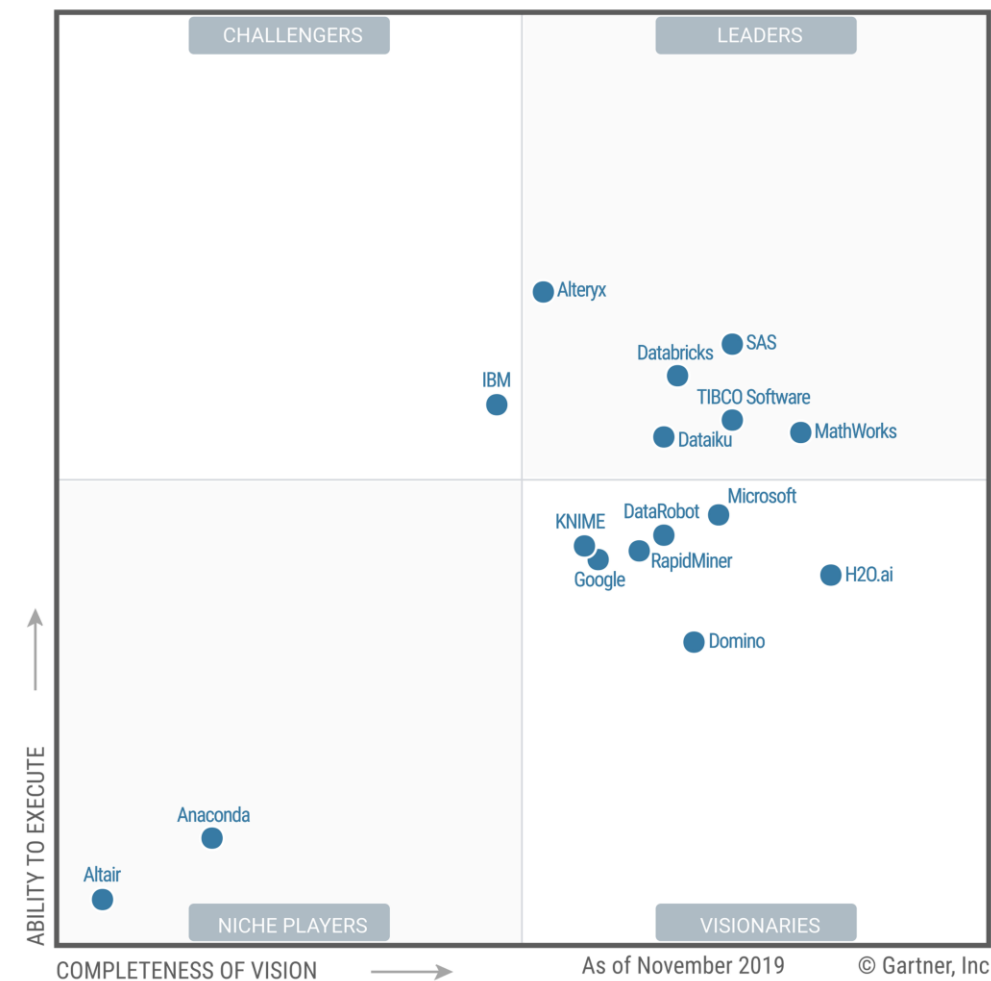Multi-platform **deployment of full applications and systems**

Platform productivity

Interoperability with TensorFlow and PyTorch

MathWorks

MathWorks®
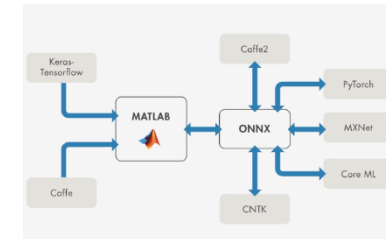
is a **Leader** in the Gartner Magic Quadrant for 2020 Data Science and Machine Learning Platforms

Figure 1. Magic Quadrant for Data Science and Machine Learning Platforms

*Gartner Magic Quadrant for Data Science and Machine Learning Platforms, Peter Krensky, Erick Brethenoux, Jim Hare, Carlie Idoine, Alexander Linden, Svetlana Sicular, 11 February 2020 .

AI-driven system design

Data Preparation	AI Modeling	Simulation & Test	Deployment
Data cleansing and preparation	Model design and tuning	Integration with complex systems	Embedded devices
Human insight	Hardware accelerated training	System simulation	Enterprise systems
Simulation-generated data	Interoperability	System verification and validation	Edge, cloud, desktop

MathWorks

Agenda

I. Deep learning in engineering and science

II. Developing a deep learning solution in MATLAB

III. MathWorks deep learning support

Featured Example: Classifying Air Compressor Sounds

Build, test, and deploy a deep learning solution that can classify sequences in signal data.

- [Long Short-Term Memory Networks](#)
- Classify sequence data
- Anomaly detection, natural language processing (NLP)

Data preparation represents most of your AI effort…

Transforming raw data for useful modeling and analysis is a critical step.

Data Preparation

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

Amount of lost sleep over…
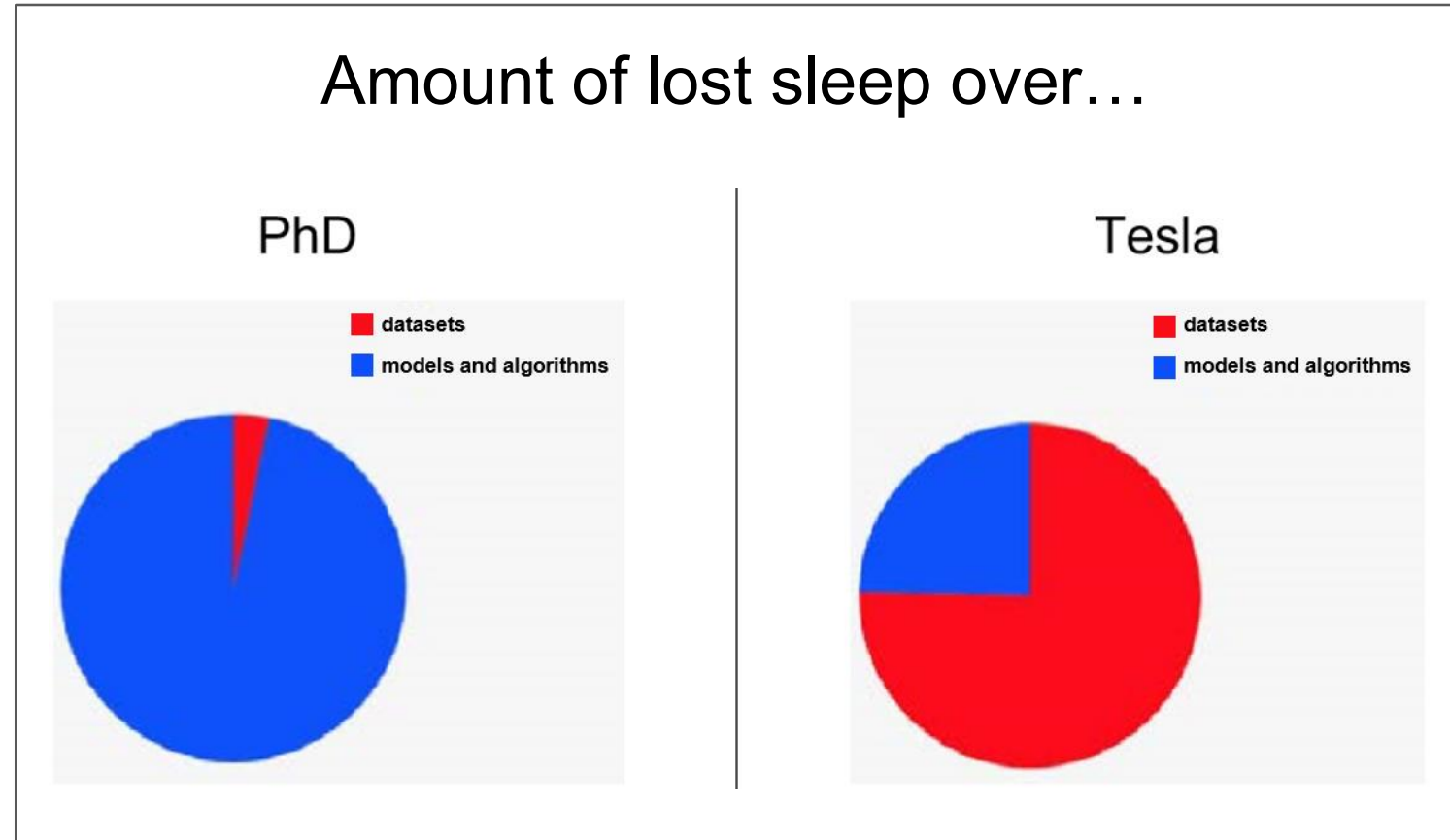
Source: Andrej Karpathy slide from TrainAI 2018

Spend less time preprocessing and labeling data

Synchronize disparate time series, filter noisy signals, automate labeling of video, and more.
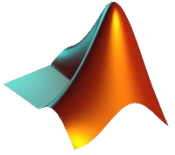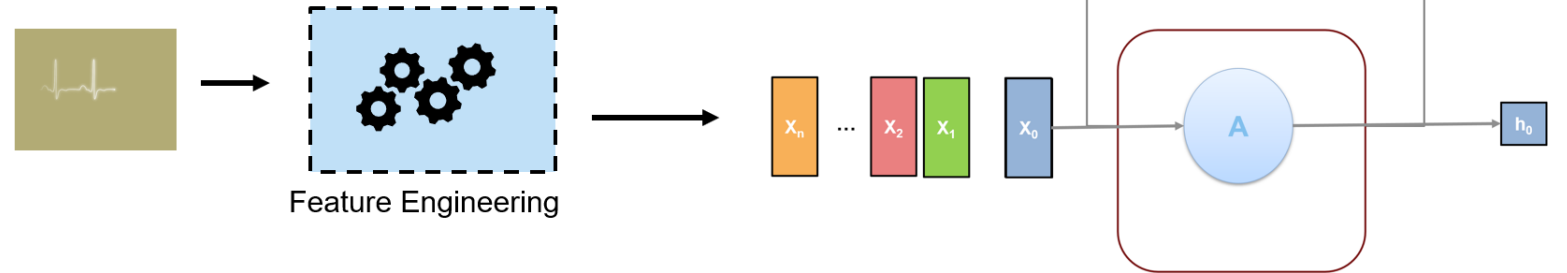

Data Preparation

Data cleansing and preparation

Human insight

Simulation-generated data
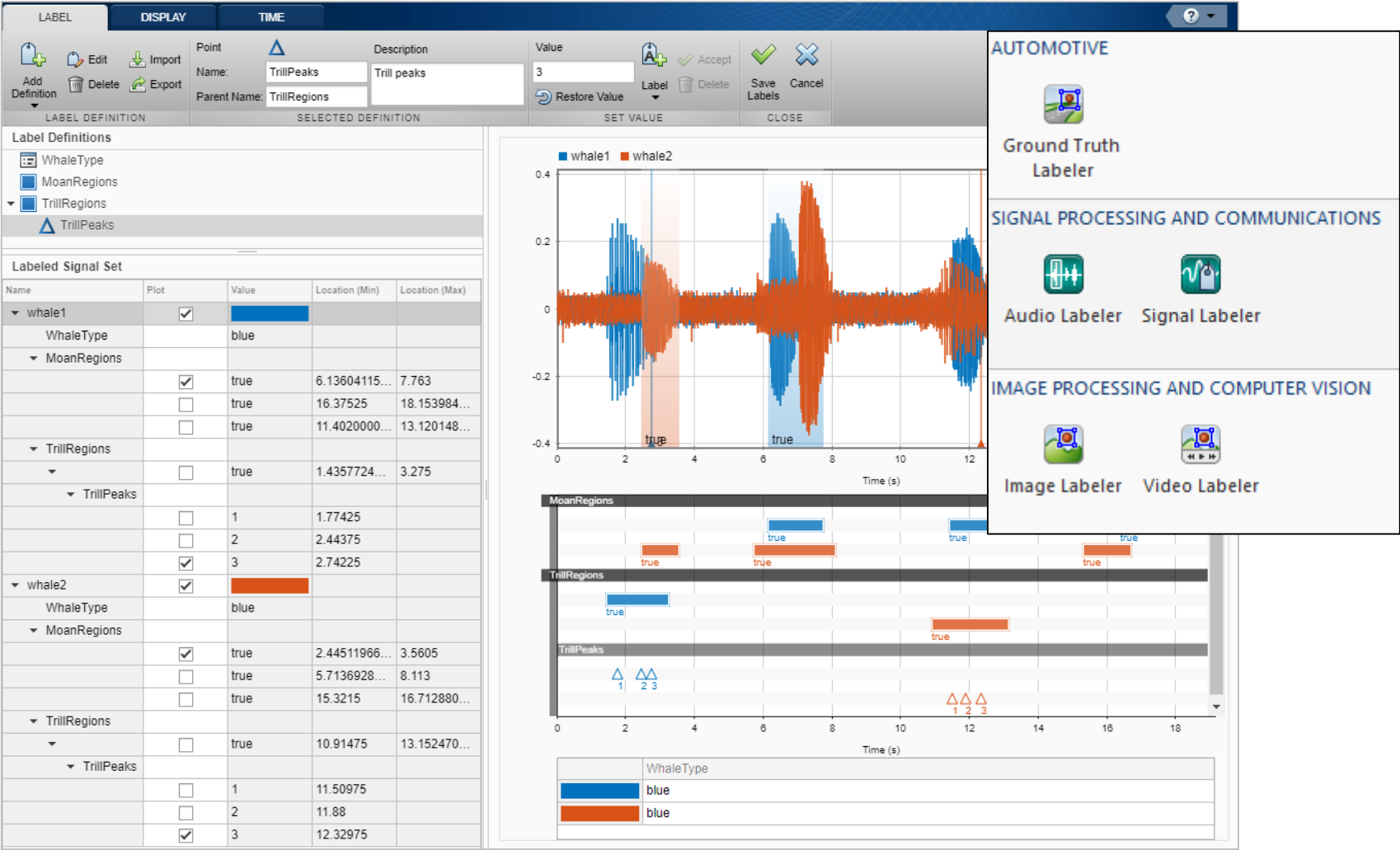
Data Preparation Demo

Open Script
Part 1

Data Preparation

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

Long Short Term Memory (**LSTM**) Networks

Feature Engineering

x_n ... x_2 x_1 x_0 A h_0

MathWorks

Start with a complete set of algorithms and pre-built models

AI Modeling

- Model design and tuning
- Hardware accelerated training
- Interoperability

Algorithms

Machine learning
Trees, Naïve Bayes, SVM…

Deep learning
CNNs, GANs, LSTM, MIMO…

Reinforcement learning
DQN, A2C, DDPG…

Regression
Linear, nonlinear, trees…

Unsupervised learning
K-means, PCA, GMM…

Predictive maintenance
RUL models, condition indicators…

Bayesian optimization

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…

MathWorks®

Increase productivity using Apps for design and analysis

Use MATLAB Apps to design deep learning networks, explore a wide range of classifiers, train regression models, train an optical character recognition model, and more.
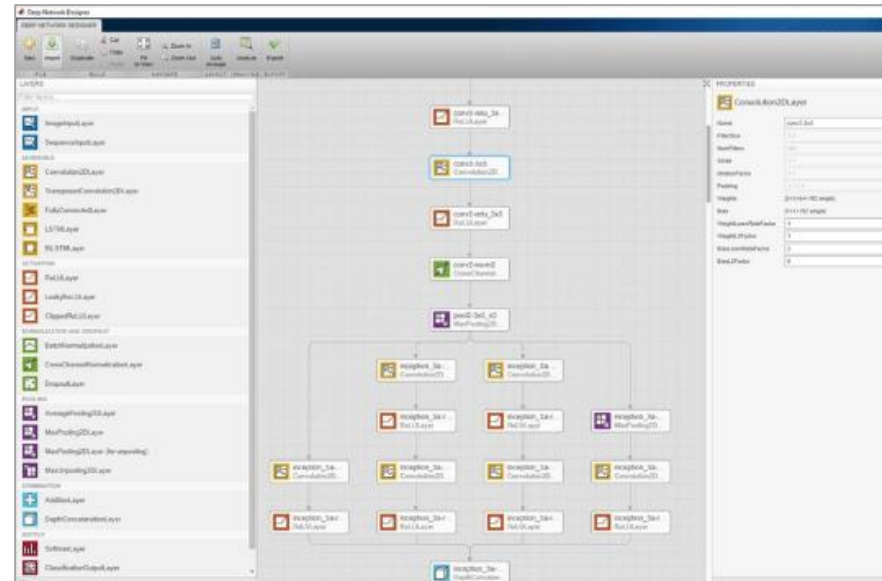
AI Modeling

Model design and tuning
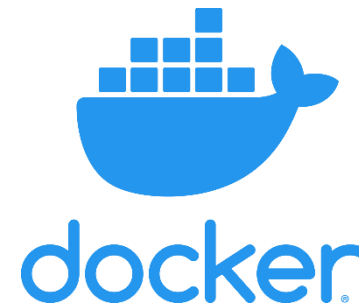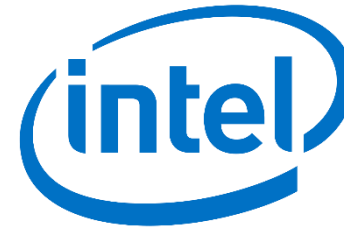
Hardware accelerated training

Interoperability

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

Experiment Manager app to manage multiple deep learning experiments, analyze and compare results and code

MathWorks®

Hardware acceleration and scaling are critical for training

MATLAB accelerates AI training on GPUs, cloud, and datacenter resources without specialized programming.
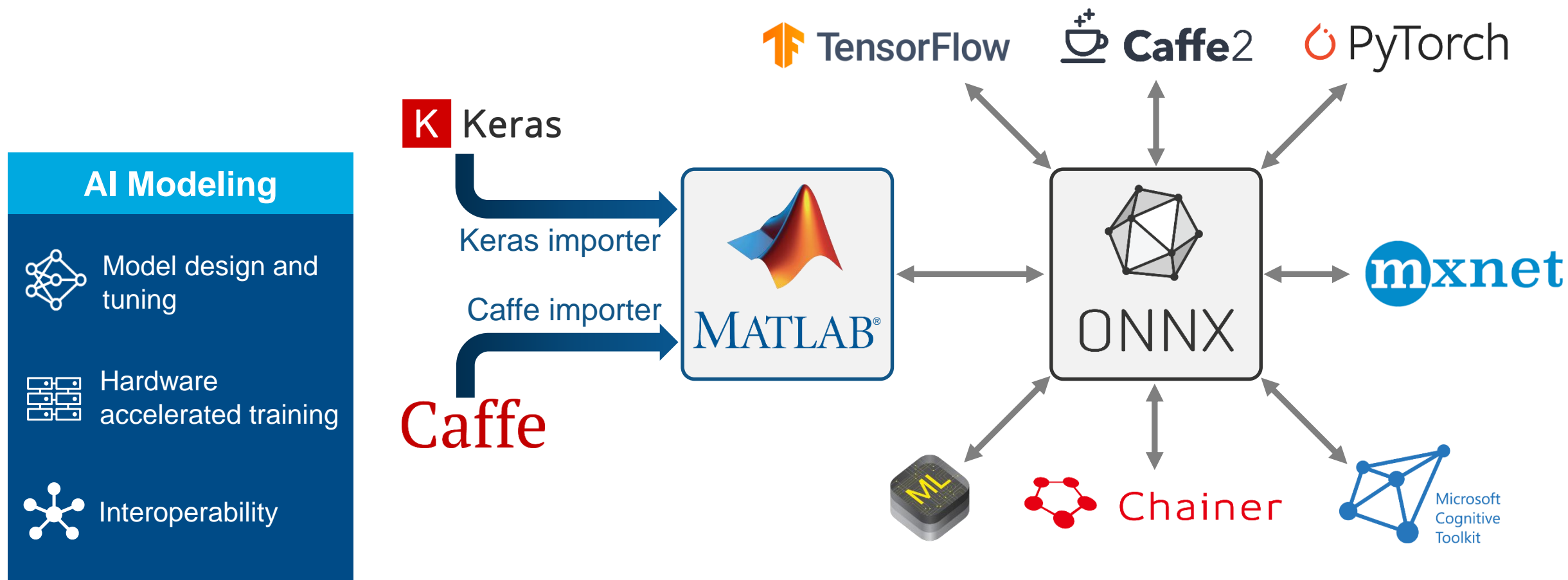

AI Modeling
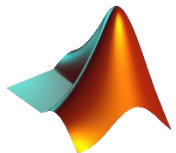
- Model design and tuning
- Hardware accelerated training
- Interoperability

MathWorks®

MATLAB interoperates with other frameworks

Supports ONNX and can exchange models with PyTorch, TensorFlow, and other frameworks.

Modeling Demo

Open Script Part 2

AI Modeling

Model design and tuning

Hardware accelerated training

Interoperability

Confusion matrix with True Class (rows) and Predicted Class (columns):

True Class \ Predicted	Bearing	Flywheel	Healthy	LIV	LOV	NRV	Piston	Riderbelt
Bearing	20	4					1	
Flywheel	2	18						
Healthy			21					
LIV				19	1	1		
LOV			1	2	19	1		
NRV				1	1	19	1	
Piston						1	20	
Riderbelt					1			22

MathWorks

Models need to exist within a complete system

In automated driving systems, AI for perception must integrate with algorithms for path planning, braking, acceleration, and other controls.

Simulation & Test

Integration with complex systems

System simulation

System verification and validation

MathWorks
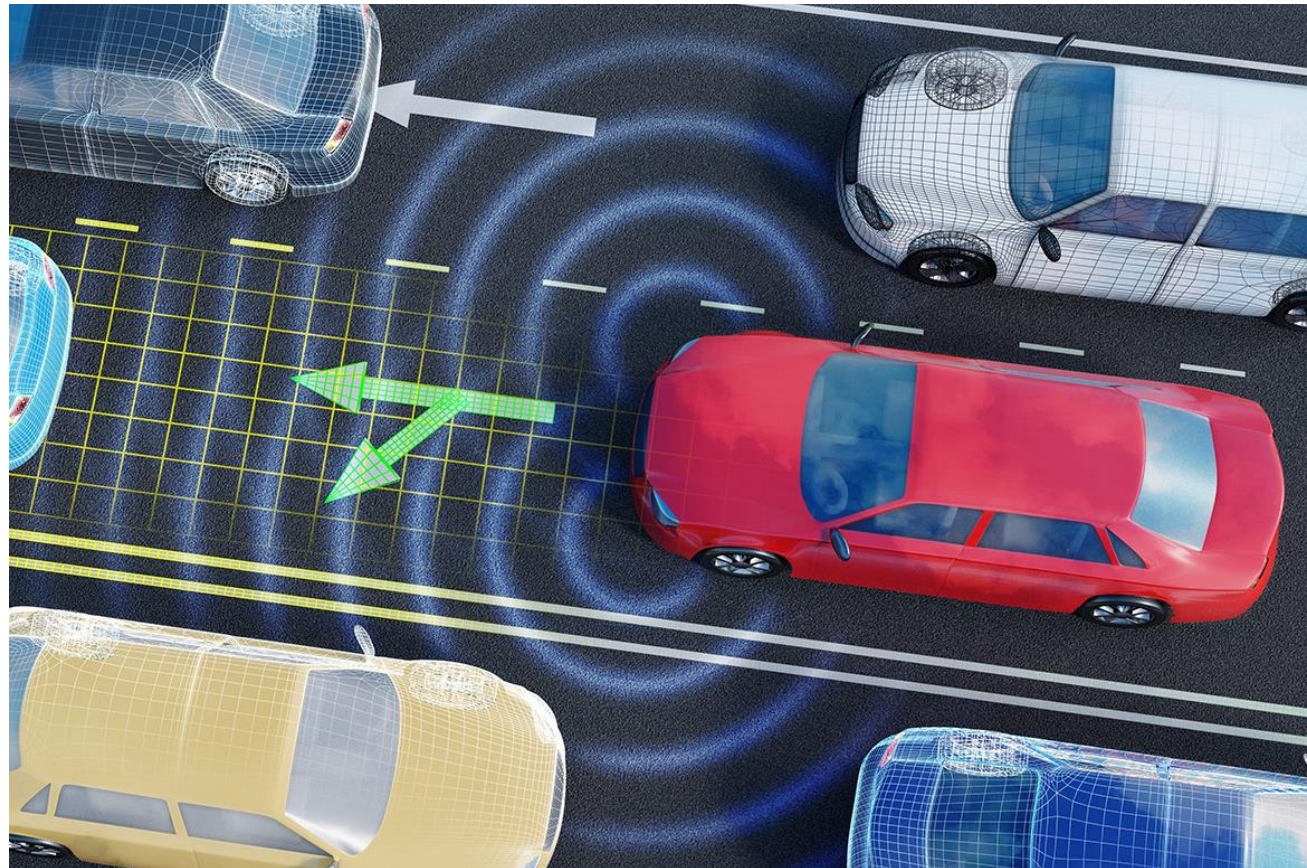
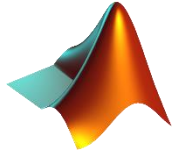# Deploy to any processor with best-in-class performance

AI models in MATLAB and Simulink can be deployed on embedded devices, edge devices, enterprise systems, the cloud, or the desktop.
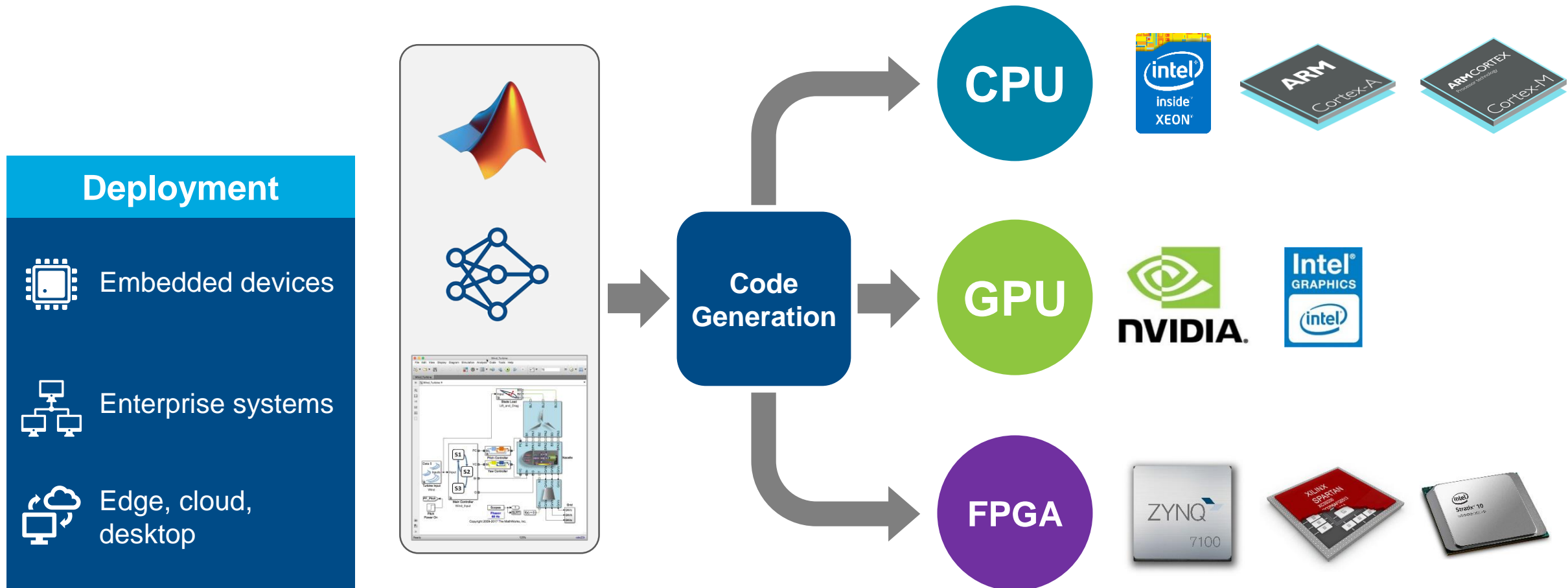
Deploy to enterprise IT infrastructure
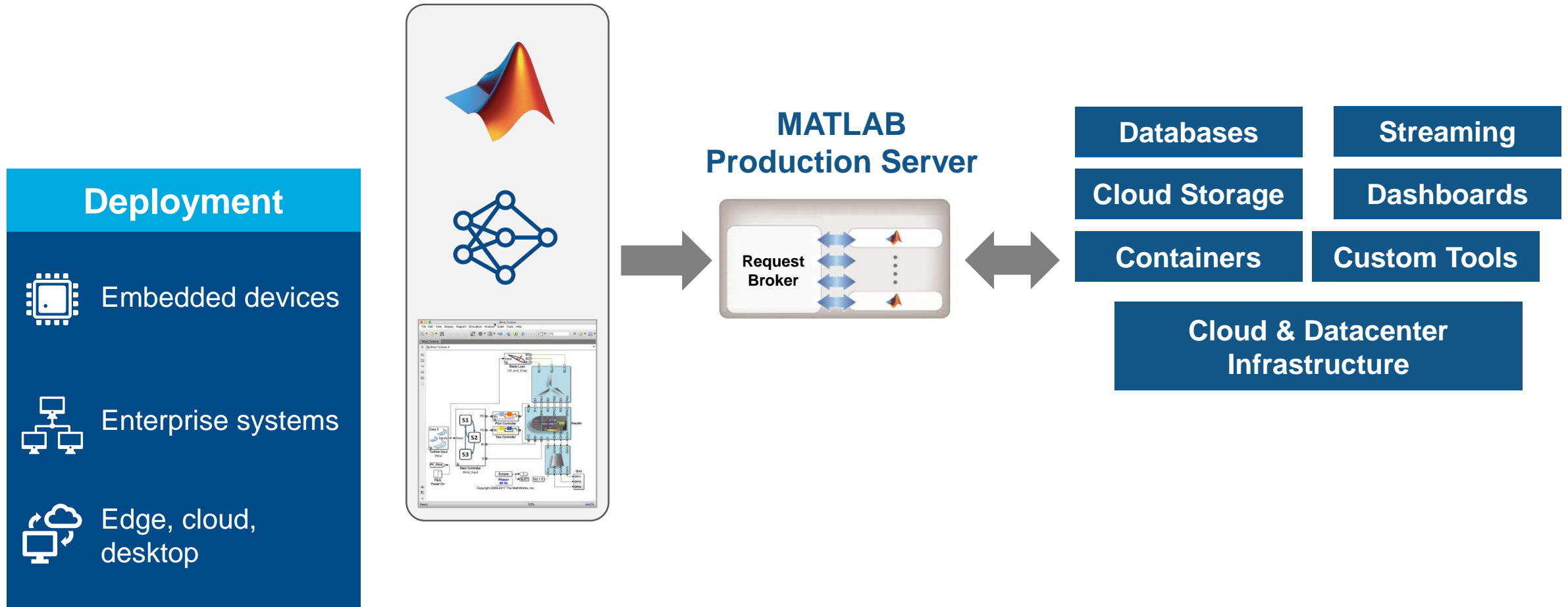
Deployment Demo

Open Script
Part 3

Deployment

Embedded devices

Enterprise systems

Edge, cloud, desktop

Agenda

I. Deep learning in engineering and science

II. Developing a deep learning solution in MATLAB

III. MathWorks deep learning support

MathWorks®

MathWorks is your Deep Learning partner

The Platform
MATLAB, Simulink, and over 100 add-on products for specialized applications

Your People
Helping you build an agile workforce today and preparing tomorrow's engineers

Our Expertise
From onboarding and implementation to solving advanced engineering challenges

MathWorks®

MathWorks Engineering Support

Training

Guided Evaluations

Onsite Workshops

Consulting

Technical Support

MathWorks®

Why MATLAB & MathWorks for Deep Learning?

Domain-specialized workflows for **engineering and science**
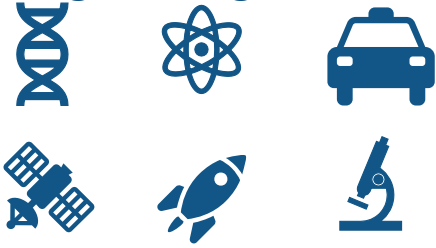
People

Multi-platform **deployment of full applications and systems**
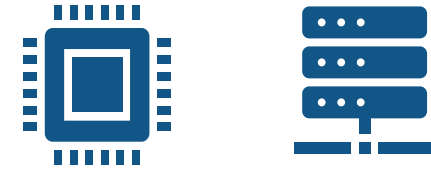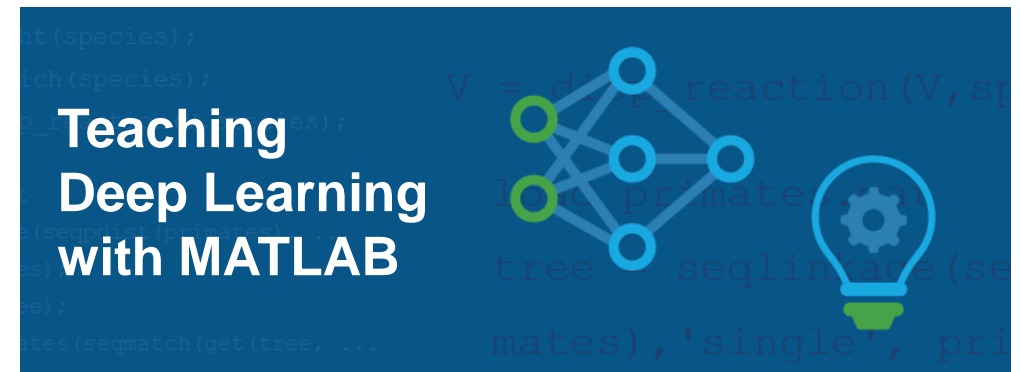

Platform productivity

Interoperability with TensorFlow and PyTorch
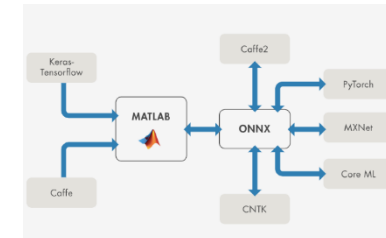
Further Learning & Teaching

- **[Deep Learning Onramp](#)**
  - 2 hr online tutorial

- **Deep Learning Workshop**
  - 3 hr hands on session
  - Contact us to schedule

- **[Deep Learning Training](#)**
  - 16 hr in depth course
  - Online or Instructor Lead

- **[Teaching Deep Learning with MATLAB](#)**
  - Curriculum support

Deep Learning Onramp

Teaching Deep Learning with MATLAB

MathWorks®

Where to find this content on GitHub

- **https://tinyurl.com/deeplearningmatlabsignal**