Deep Learning Overview

Signals and Time-Series

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Agenda

I. Deep learning in engineering and science
II. Developing a deep learning solution in MATLAB
III. MathWorks deep learning support

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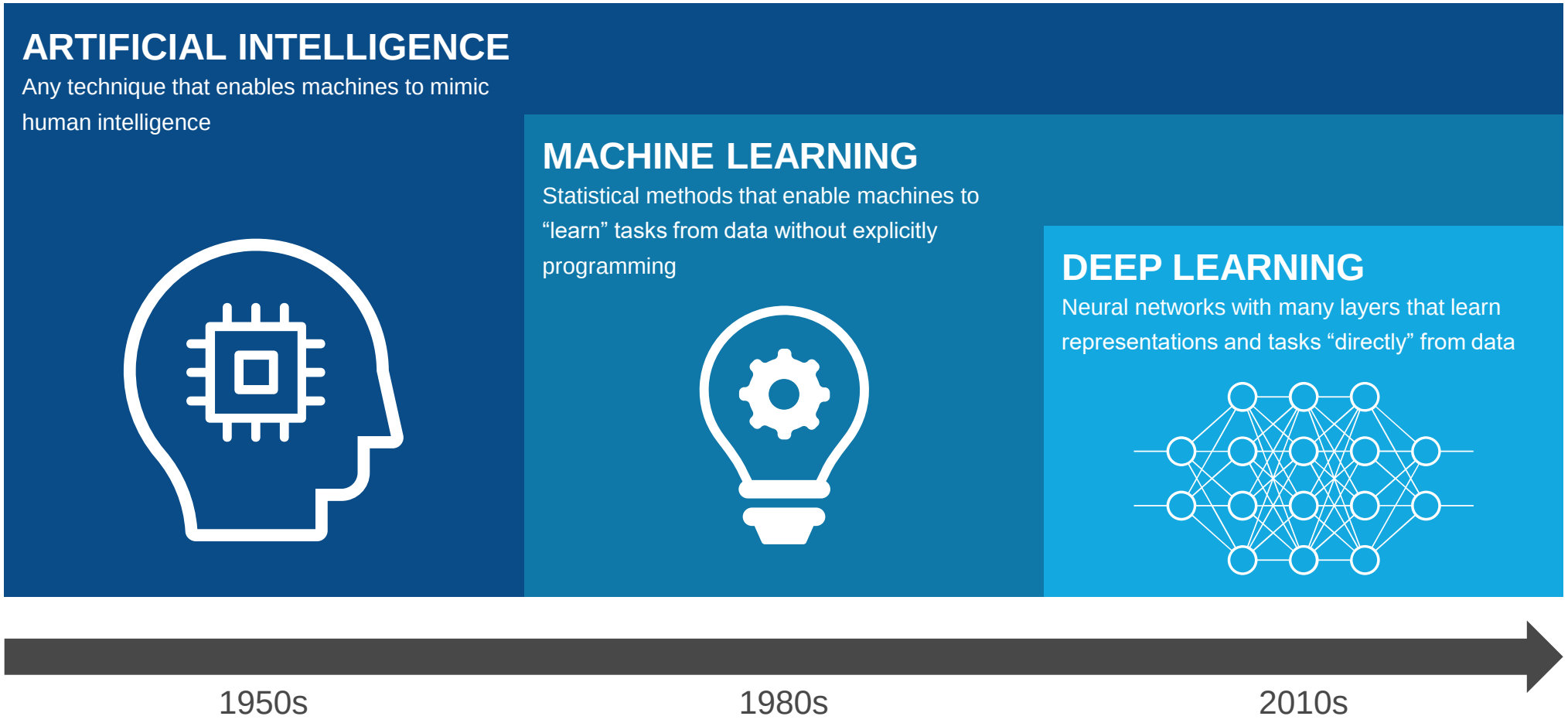
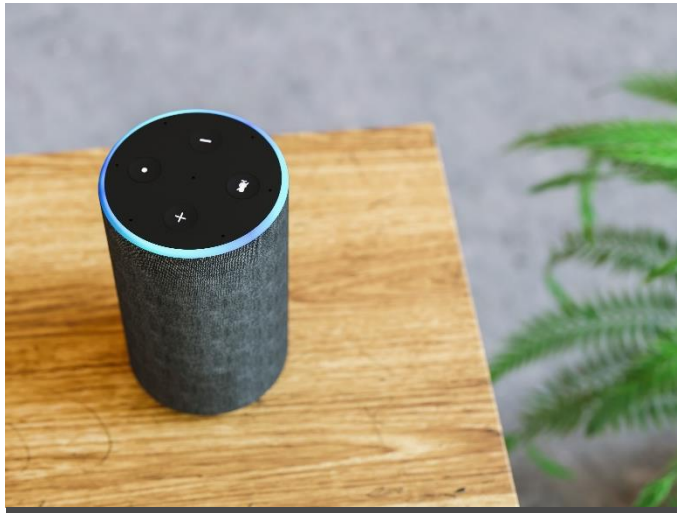
Deep learning is a key technology driving the AI megatrend

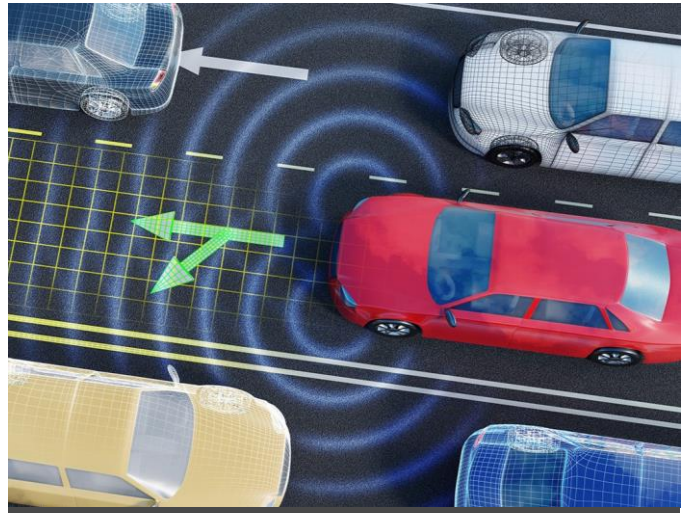


Deep learning is part of our everyday lives



Speech Recognition

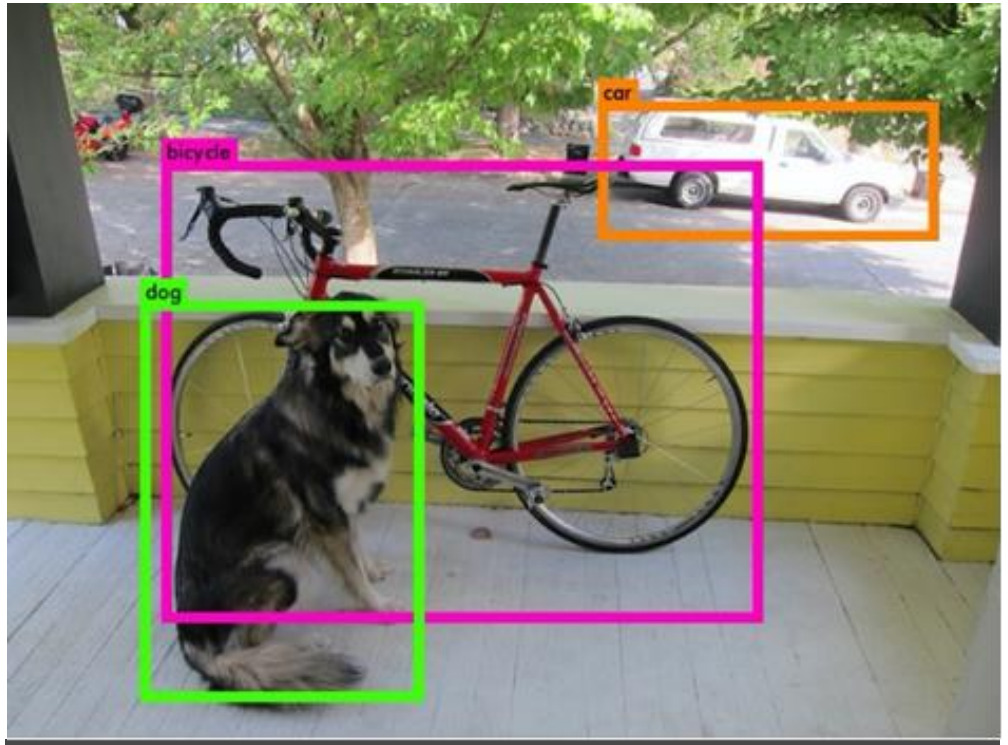
Face Detection



Automated Driving

Deep learning applications: mainstream vs. engineering

Mainstream



Detecting Objects

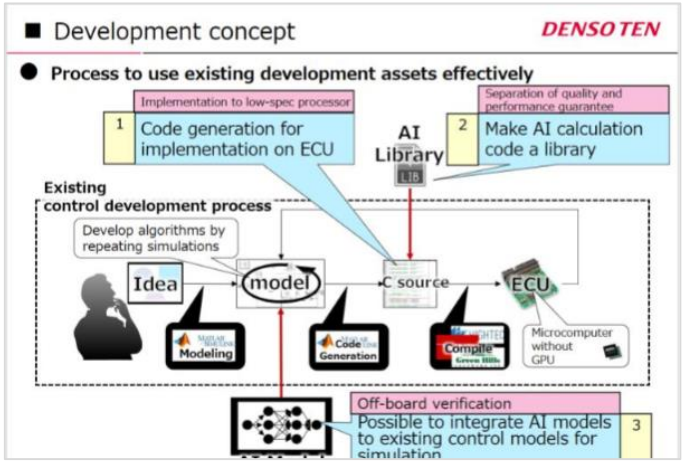
Engineering and Science

Identifying Machinery at Shell

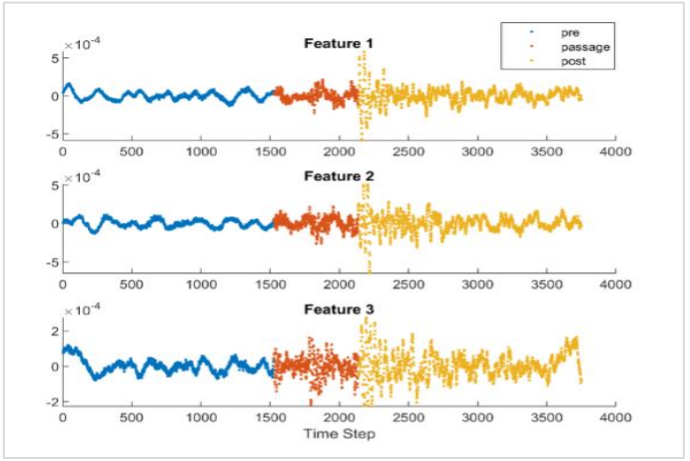
Deep Learning Detection

MATLAB Deep Learning used in Industry

Automatic Defect Detection
Airbus

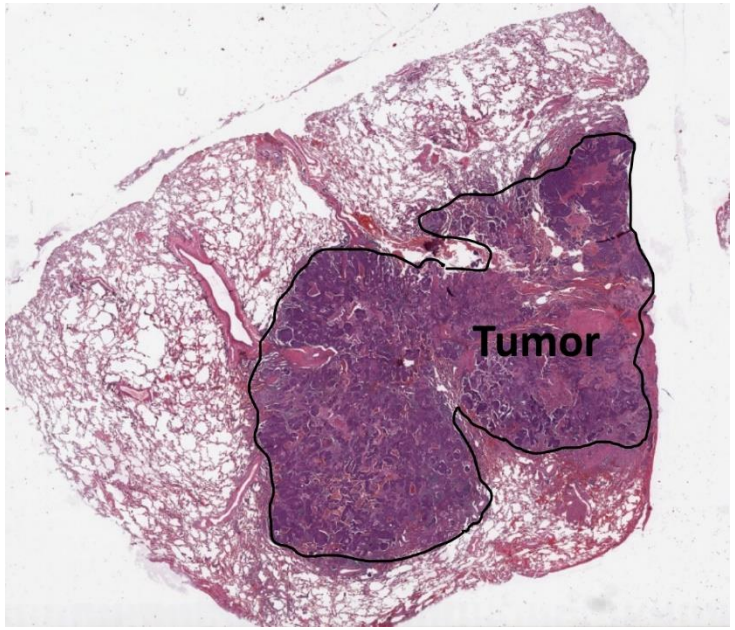


ECU Vehicle Control
Denso

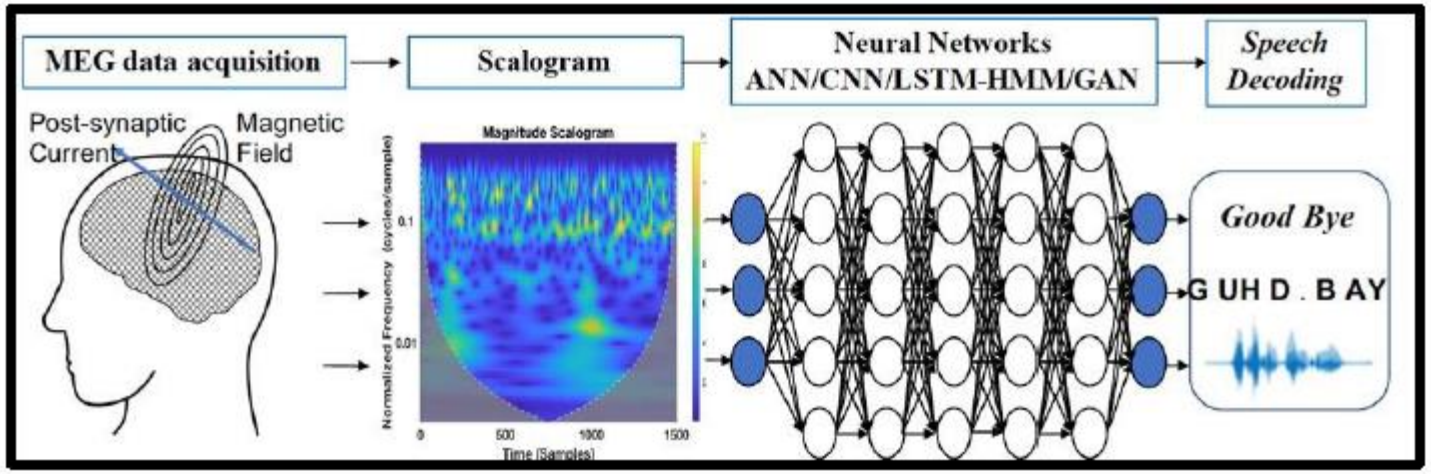


Seismic Event Detection
Shell

MATLAB Deep Learning used in Research



[Predicting gastrointestinal cancer](#) (July 2019)



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

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
- Lidar Labeler

Examples

- 5G / Wireless
- Lidar
- **Over 200+ examples!**

Algorithms

- Point Cloud

Explainable AI

- **Lime**

Code Generation

- Quantization
- Deep Learning HDL Coder

Model Based Design

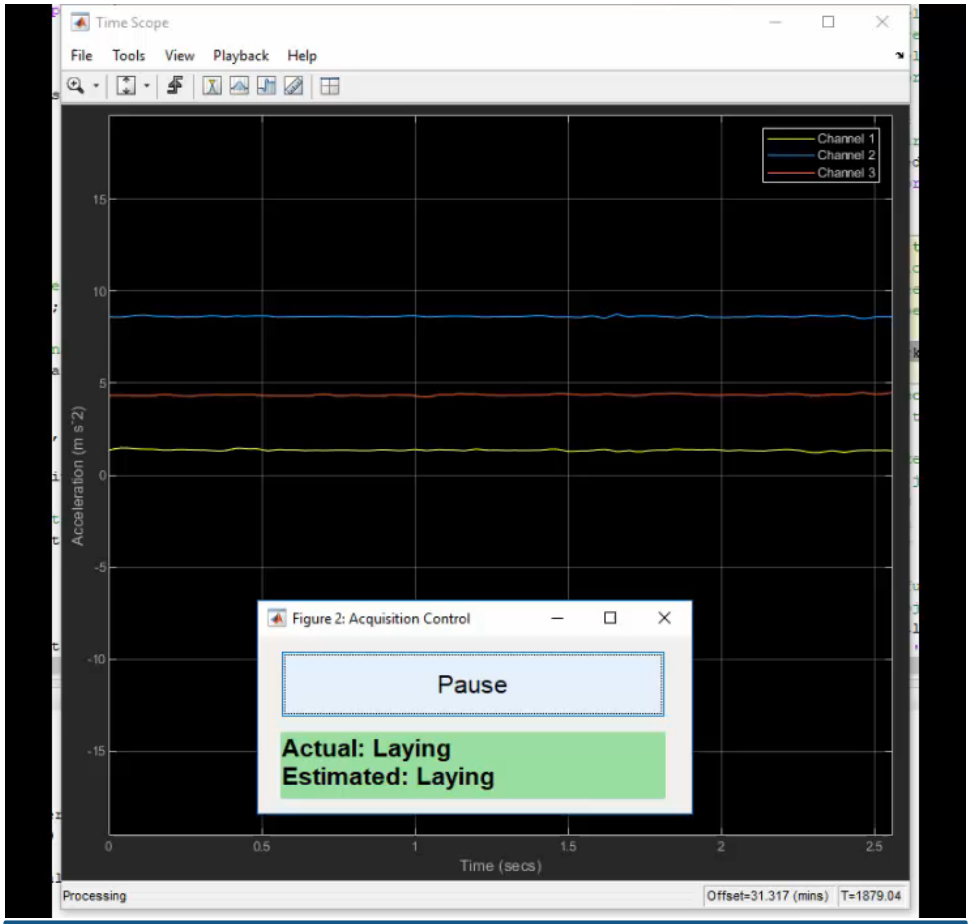
- Deep Learning in Simulink

Applications of deep learning for images and video

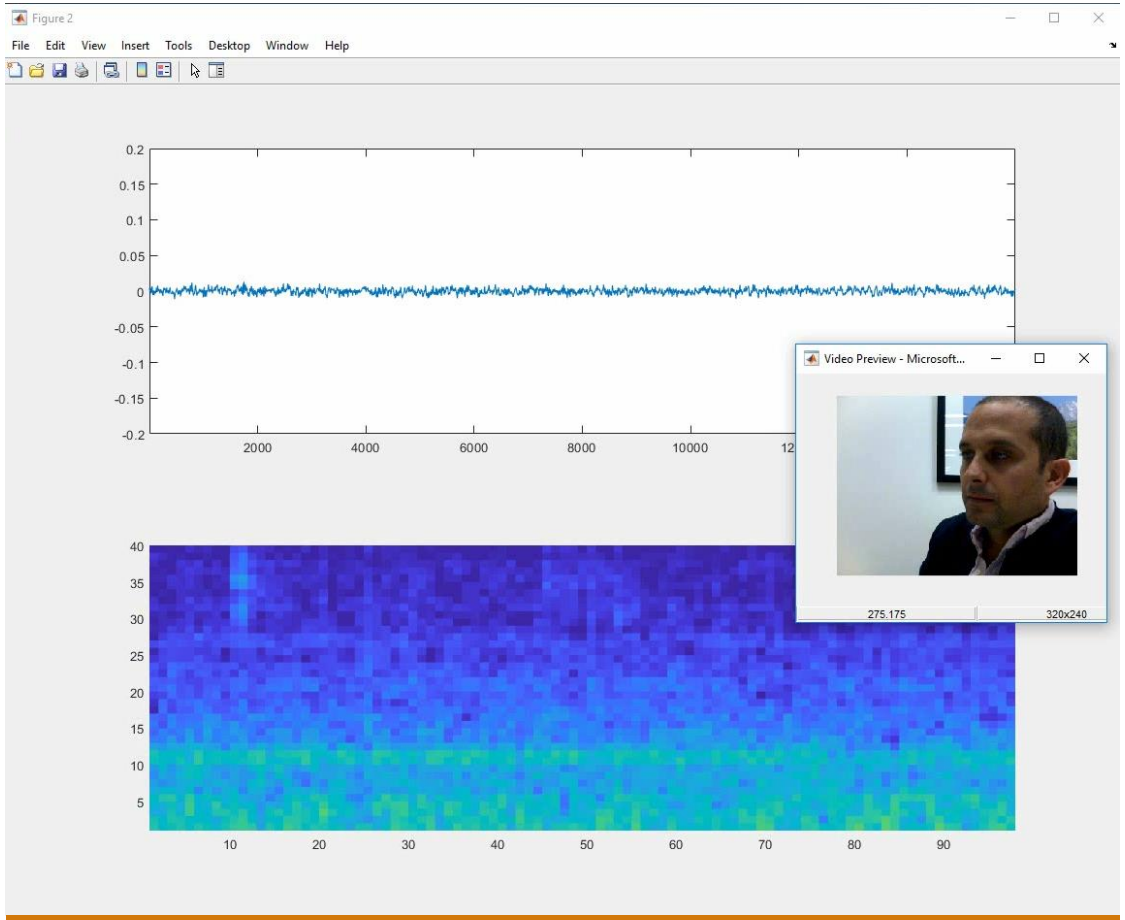
YOLO v2 (You Only Look Once)

Semantic Segmentation using SegNet

Applications of deep learning for signal processing



Signal Classification using LSTMs



Speech Recognition using CNNs

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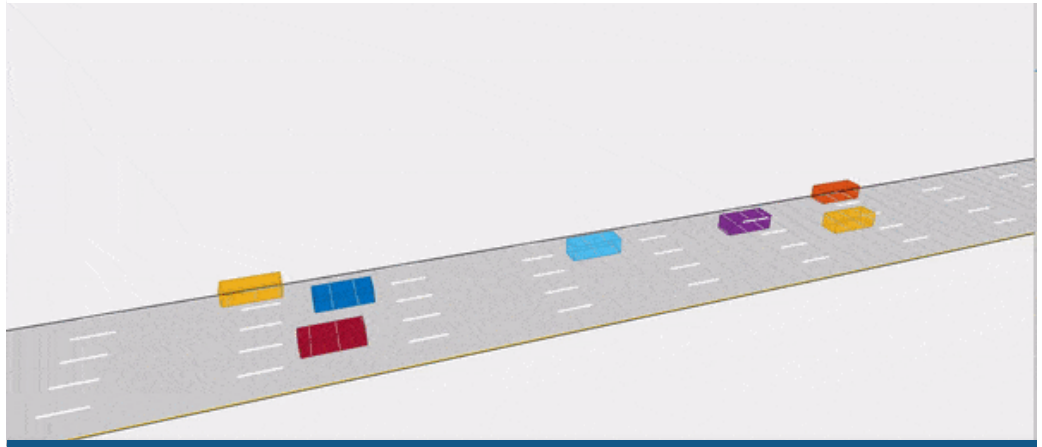
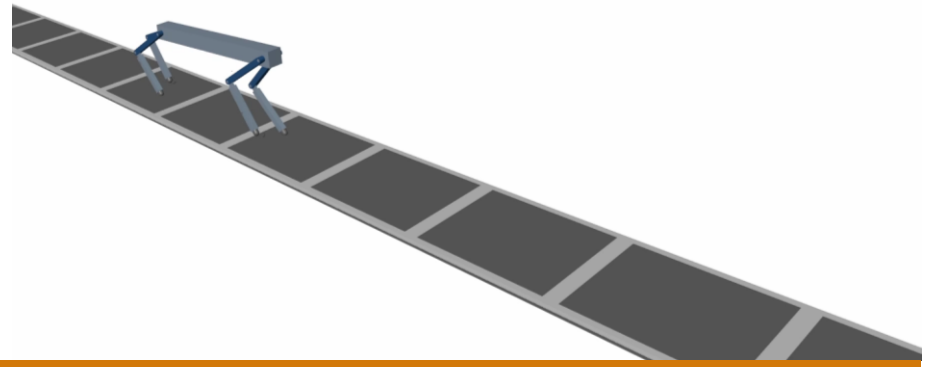
Applications of reinforcement learning



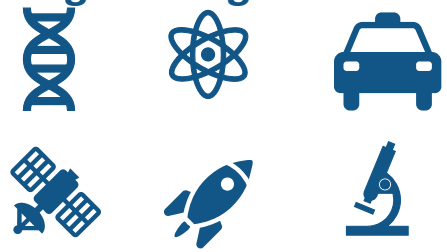
Teach a car to navigate traffic



Train a Quadruped robot to walk

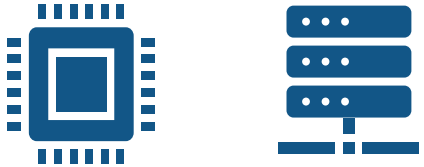
Why MATLAB & MathWorks for Deep Learning?

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



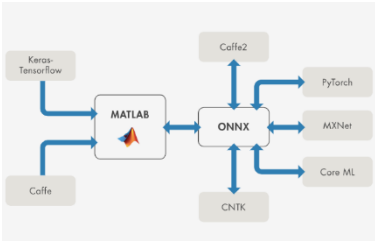
People

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



Platform productivity

Interoperability with TensorFlow and PyTorch



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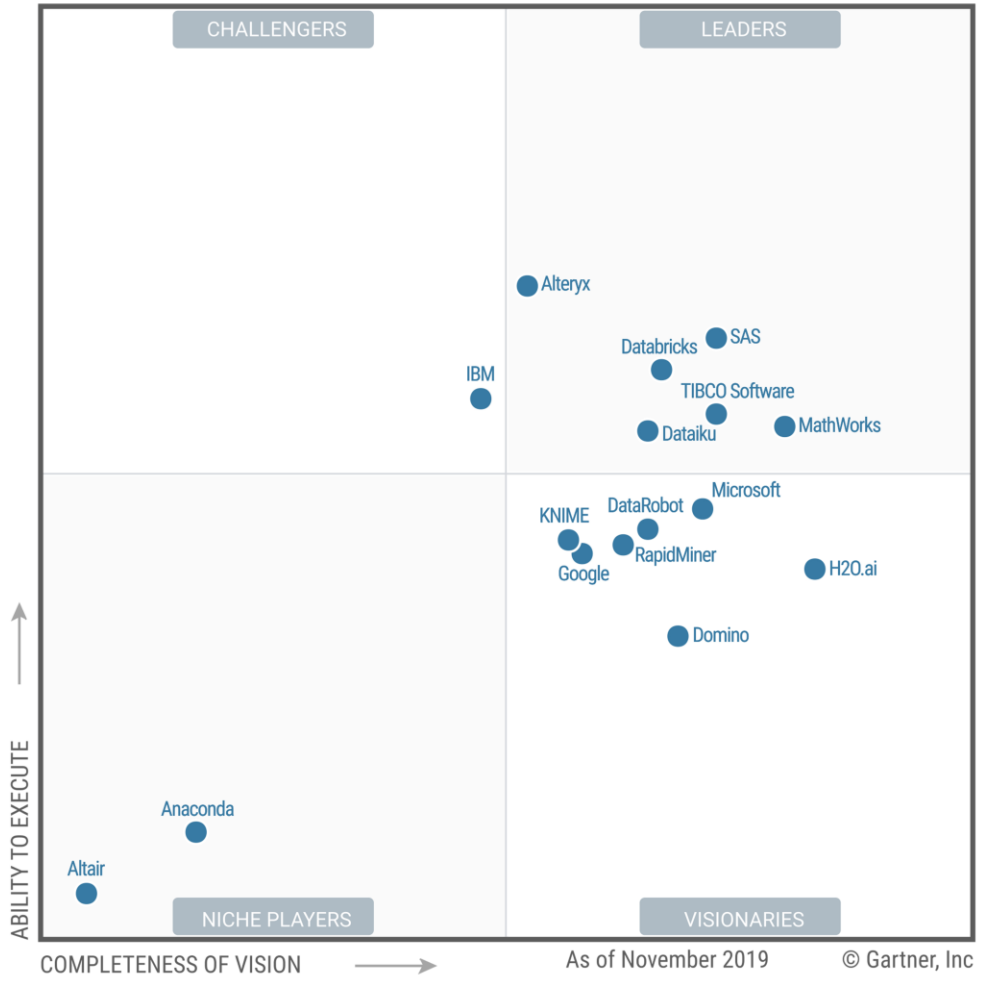
is a **Leader** in the Gartner Magic Quadrant for 2020 Data Science and Machine Learning Platforms

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



Source: Gartner (February 2020)

*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 .

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A 2020 Gartner Peer Insights Customers' Choice for Data Science and Machine Learning Platforms

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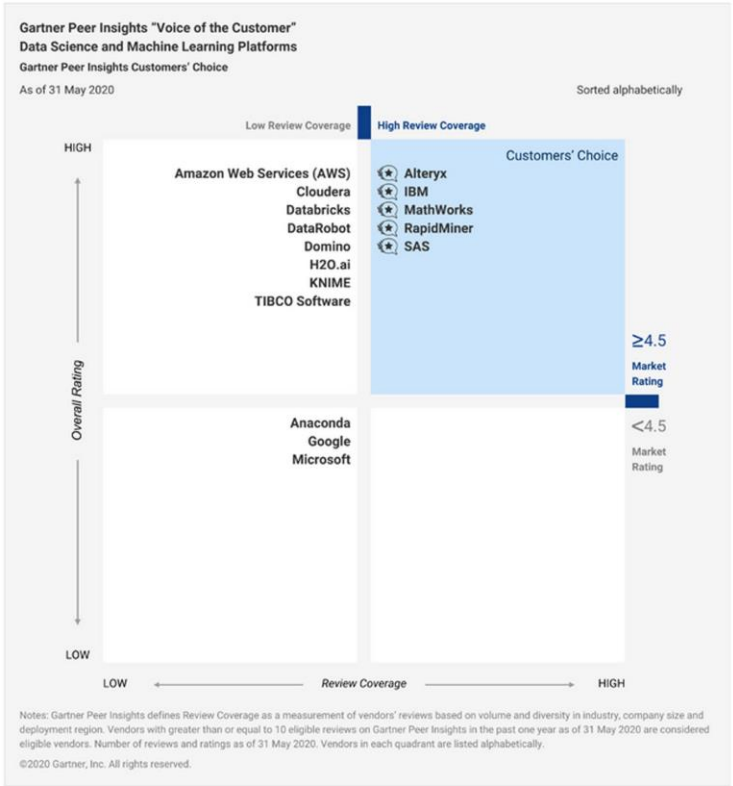
is named a 2020 Gartner Peer Insights Customers' Choice for Data Science and Machine Learning Platforms.

Figure 1. Gartner Peer Insights "Voice of the Customer" Data Science and Machine Learning Platforms Customers' Choice



Source: Gartner (July 2020)

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AI-driven system design

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

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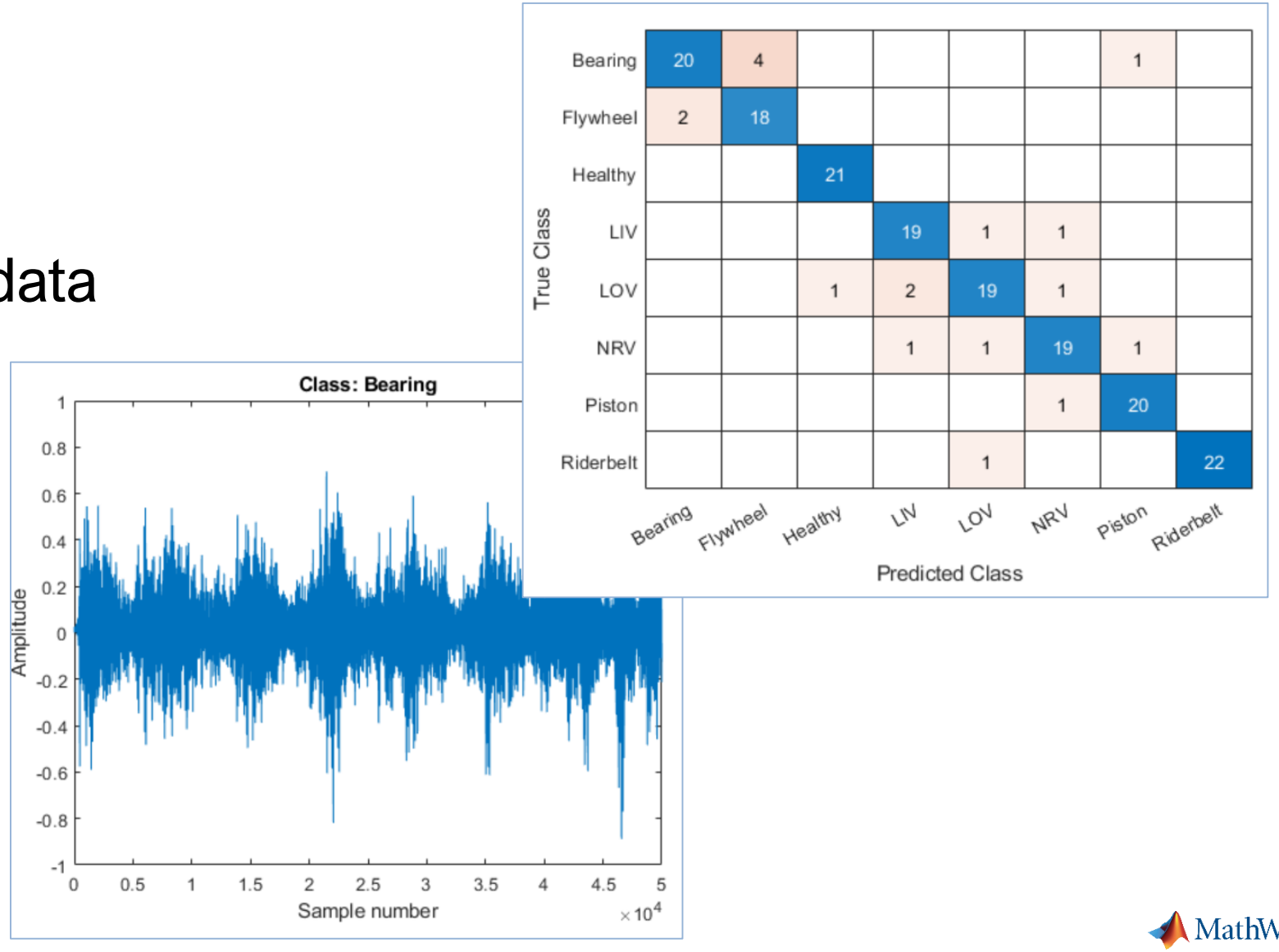
Featured Example: Classifying Air Compressor Sounds

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)

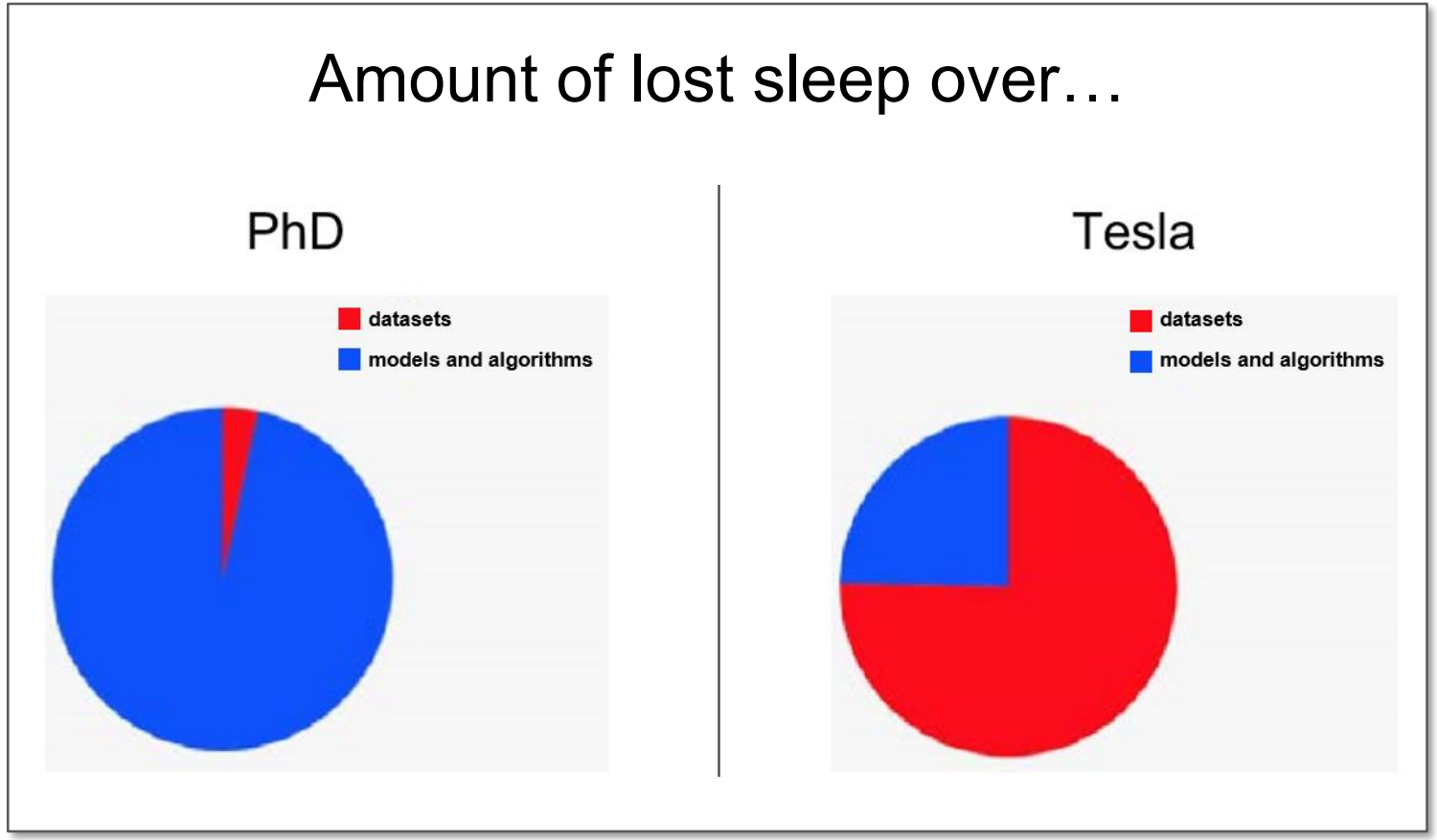


Data preparation represents most of your AI effort…

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

Data Preparation

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



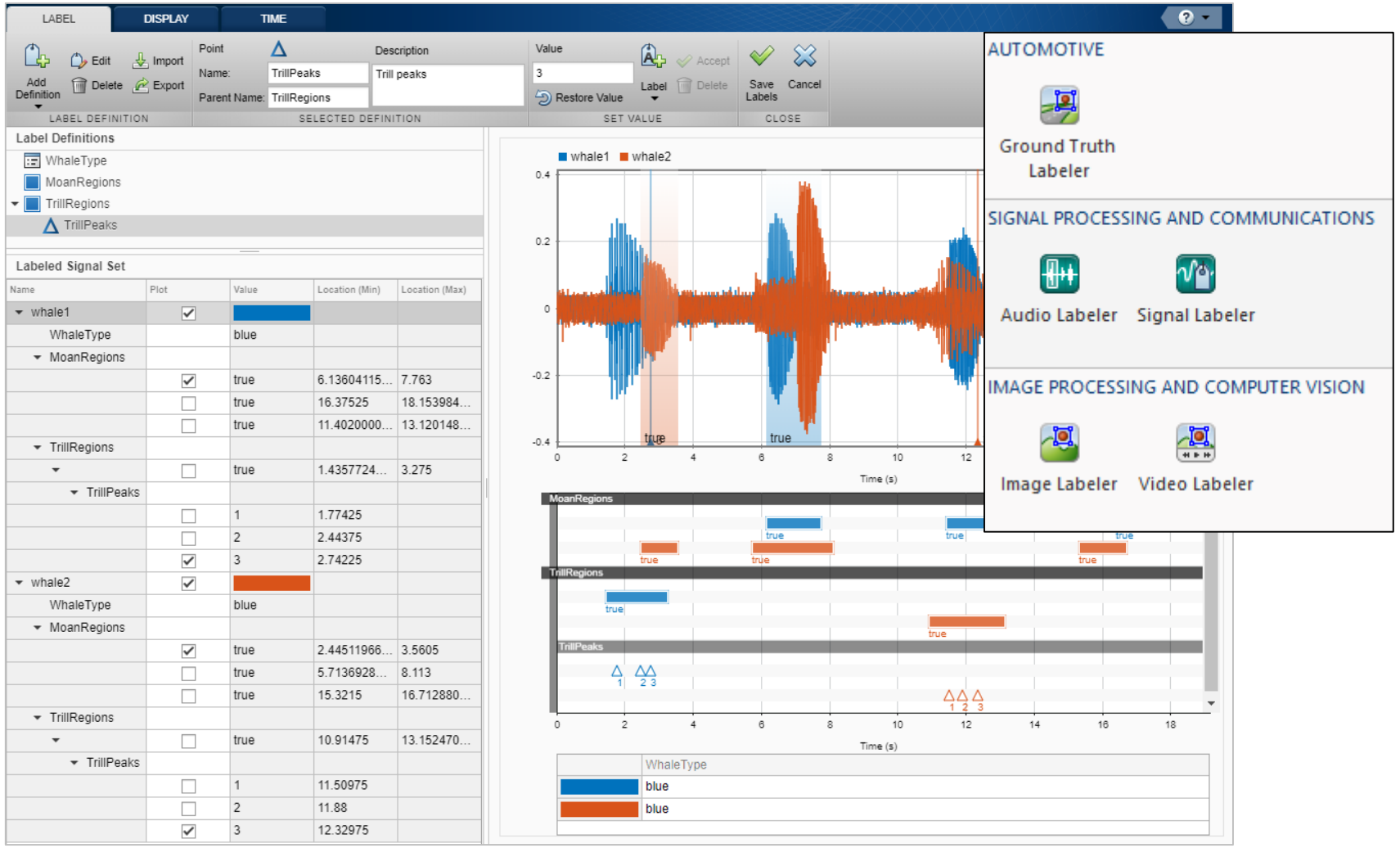
Source: Andrej Karpathy slide from TrainAI 2018

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



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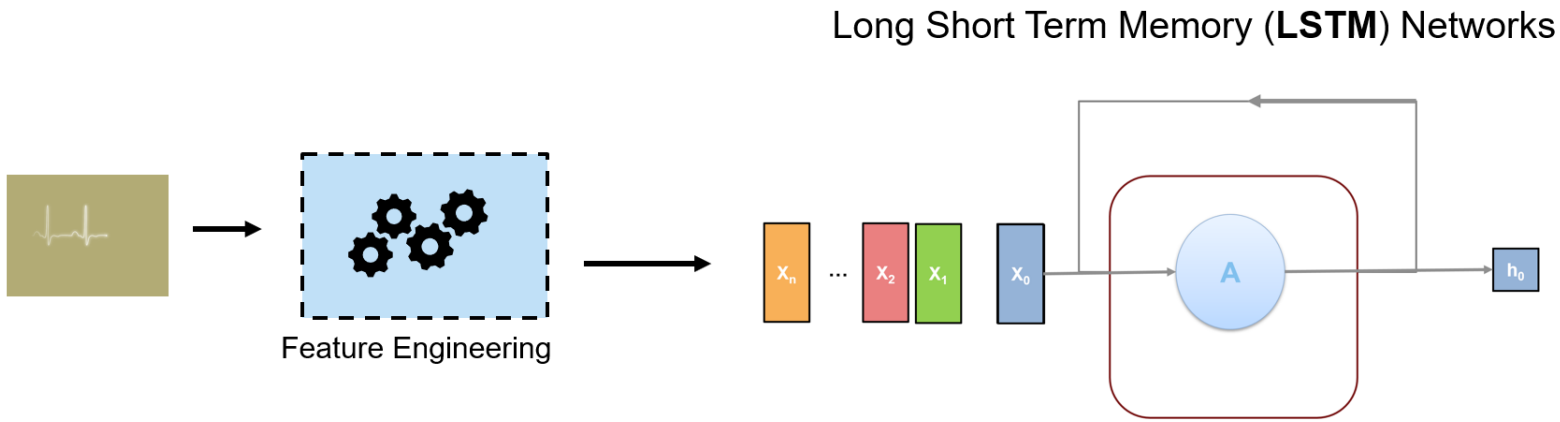
Data Preparation Demo

Open Script Part 1

Data Preparation

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



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…

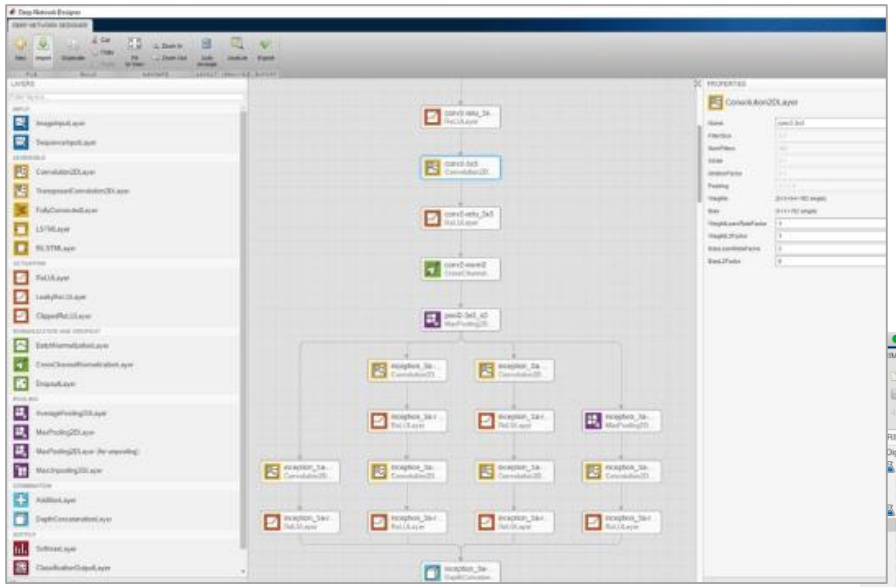
…and more…

Increase productivity using Apps for design and analysis

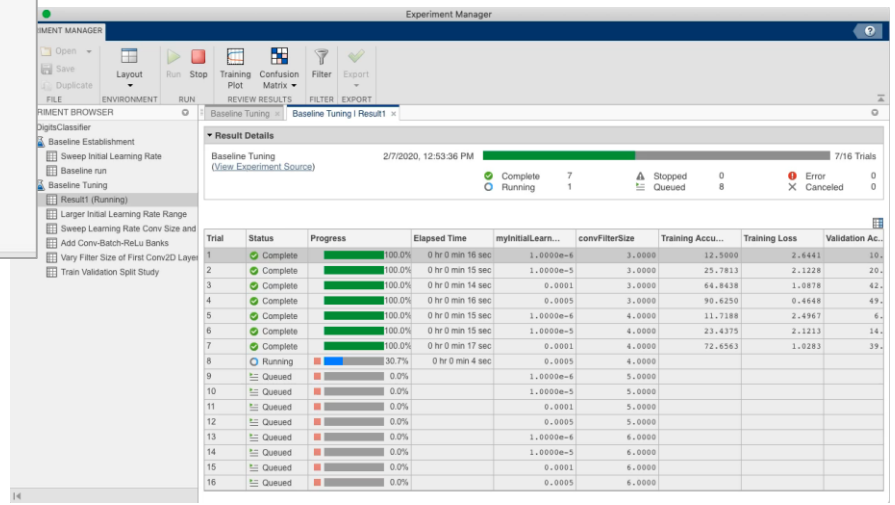
Use MATLAB Apps to design deep learning networks, explore a wide range of classifiers, train regression models, train an optical character recognition model, and more.

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

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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

Performance is Continuously Improving

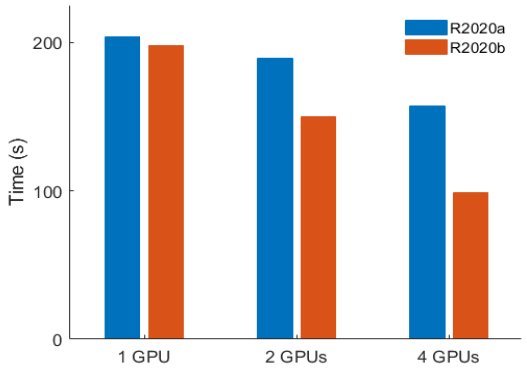
Development continuously measures, tracks, and improves performance for training and inference

AI Modeling

- Model design and tuning
- Hardware accelerated training
- Interoperability

Training — R2020a-R2020b

Multi-GPU **1.6x speedup**



Windows 10, Intel® Xeon® E5-2623 v4 @ 2.60 GHz
NVIDIA® Titan V 12GB GPUs

Inference — R2018b-R2020b

GPU **2.8x speedup**

CPU **3x speedup**

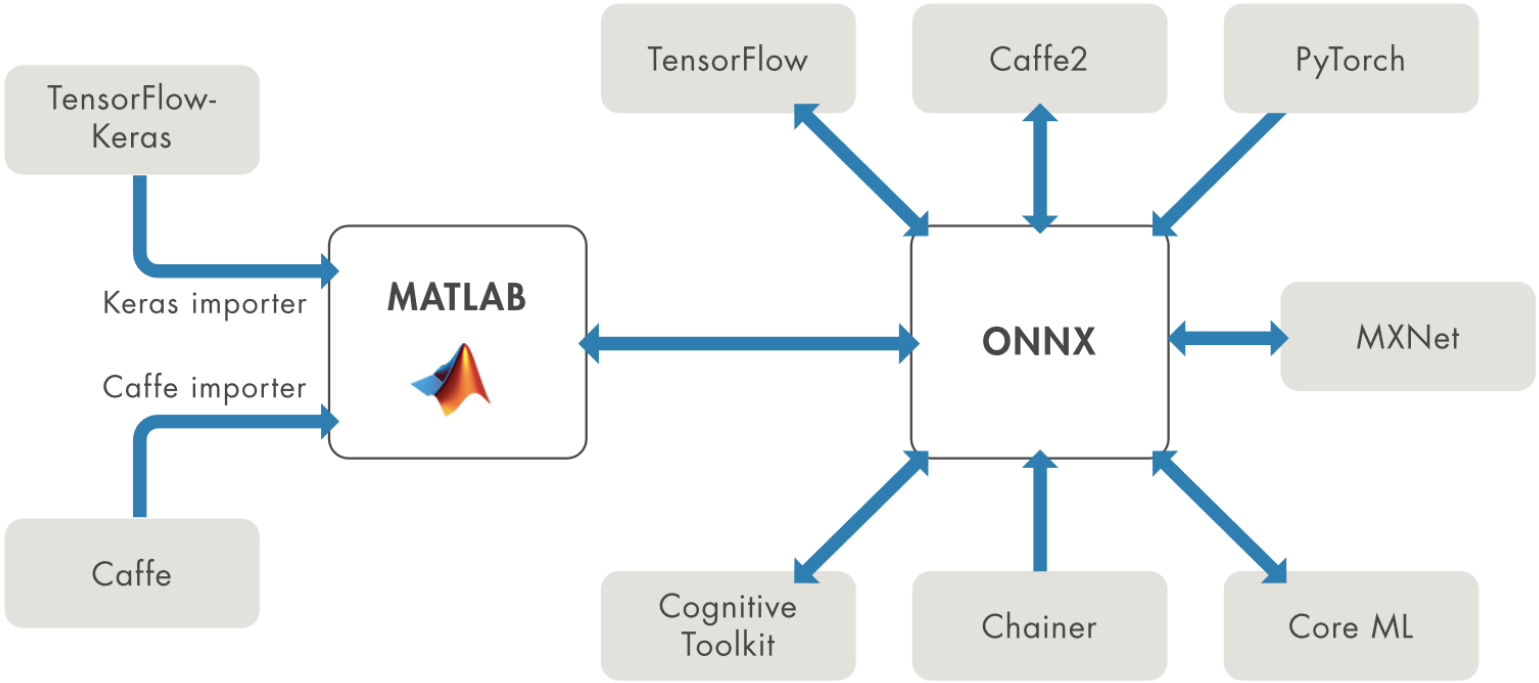
ResNet-50, Batch Size 32, *Intel® Xeon® CPU 3.6 GHz – Titan V. NVIDIA*

MATLAB interoperates with other frameworks

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

AI Modeling

- Model design and tuning
- Hardware accelerated training
- Interoperability

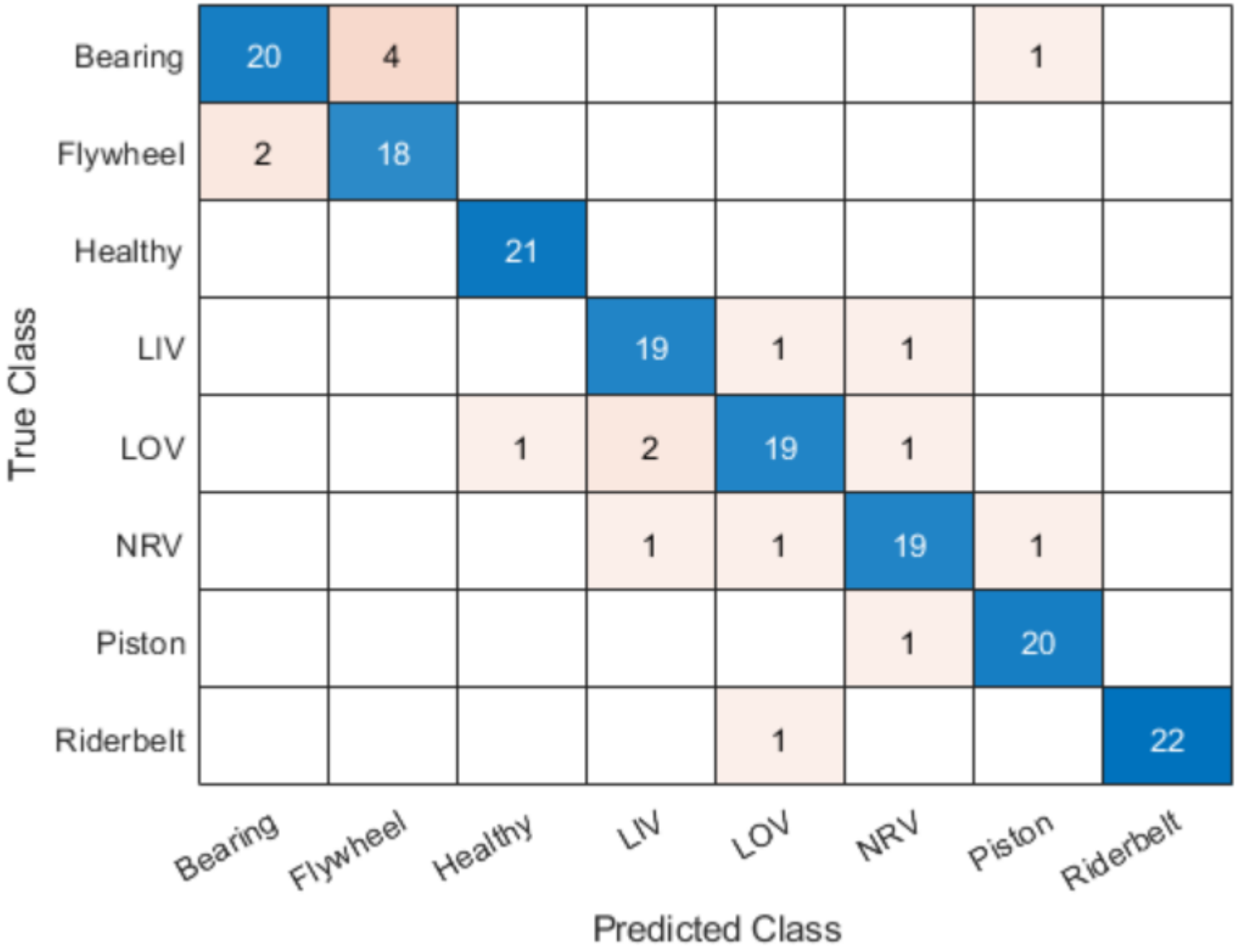


Modeling Demo

Open Script Part 2

AI Modeling

- Model design and tuning
- Hardware accelerated training
- Interoperability

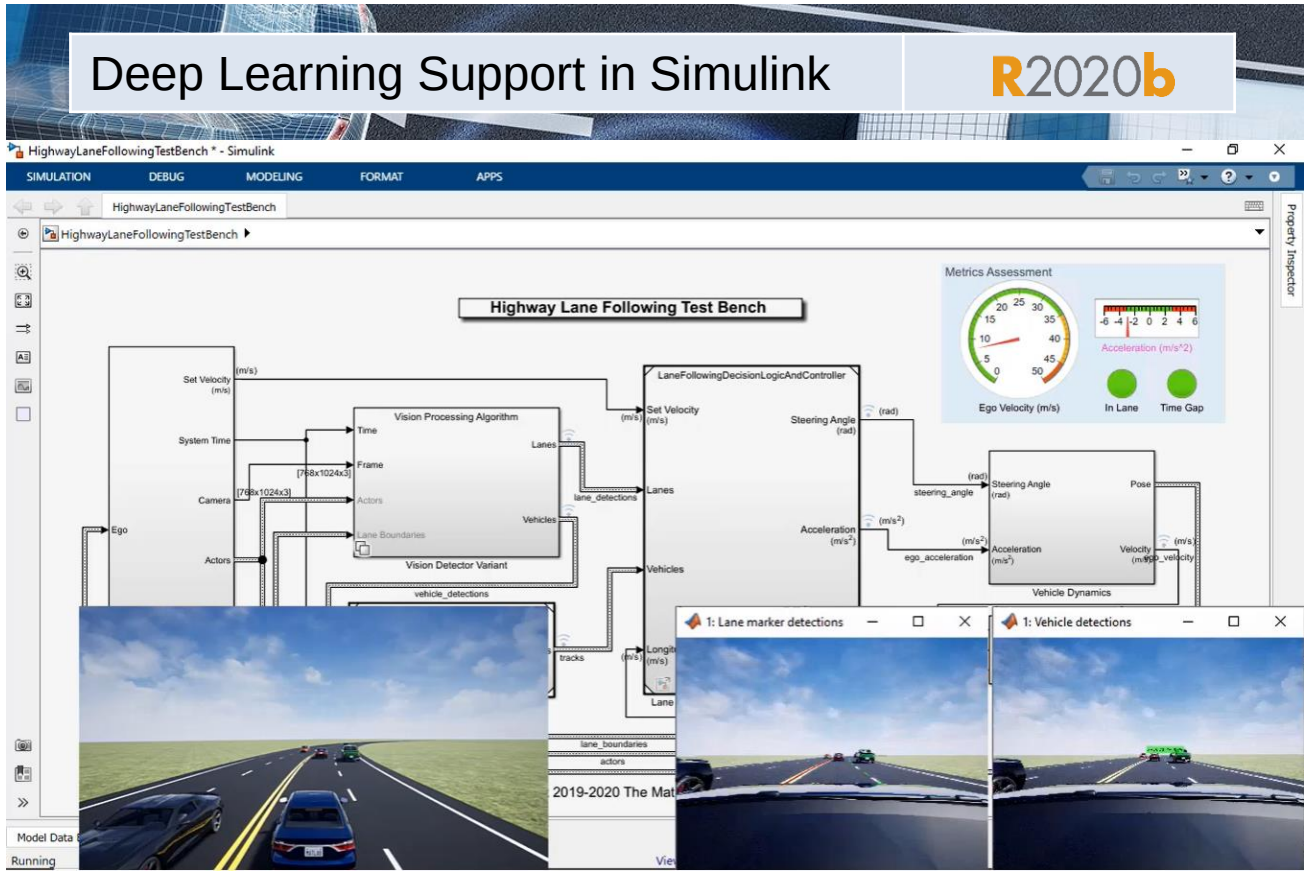


Models need to exist within a complete system

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



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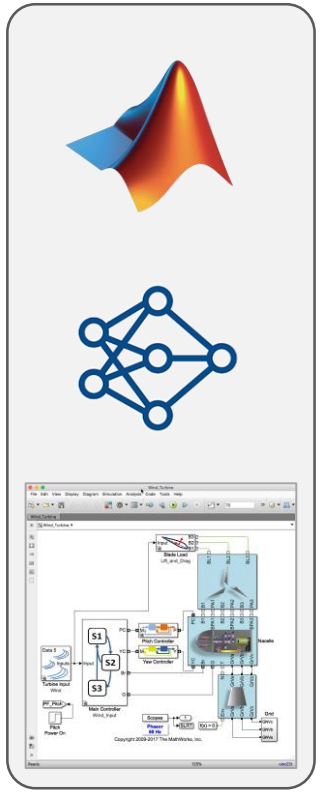
Deploy to any processor with best-in-class performance

AI models in MATLAB and Simulink can be deployed on embedded devices, edge devices, enterprise systems, the cloud, or the desktop.

Deployment

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



Code Generation

CPU

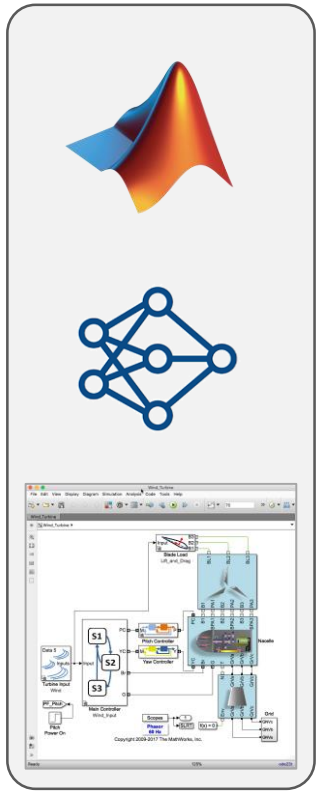
GPU

FPGA

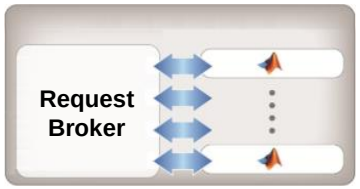
Deploy to enterprise IT infrastructure

Deployment

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



MATLAB Production Server



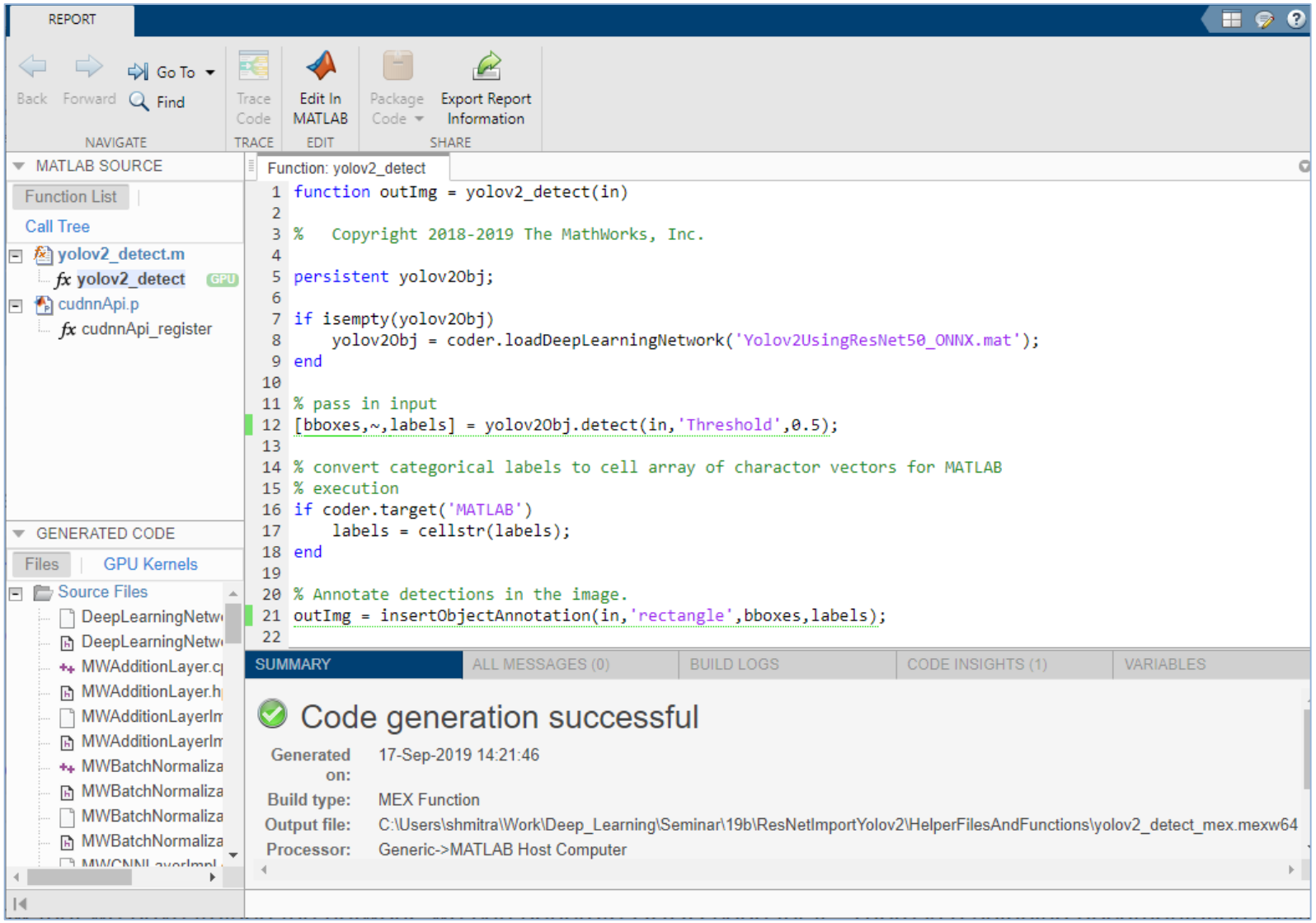
- Databases
- Streaming
- Cloud Storage
- Dashboards
- Containers
- Custom Tools
- Cloud & Datacenter Infrastructure

Deployment Demo

Open Script Part 3

Deployment

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



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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 Engineering Support

Training

Guided Evaluations

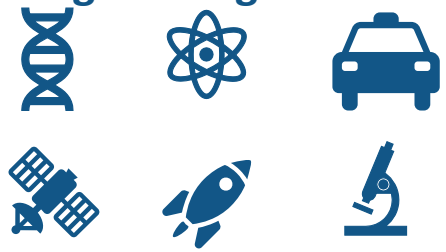
Onsite Workshops

Consulting

Technical Support

Why MATLAB & MathWorks for Deep Learning?

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

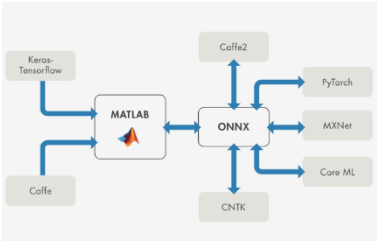


People

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

Platform productivity

Interoperability with TensorFlow and PyTorch



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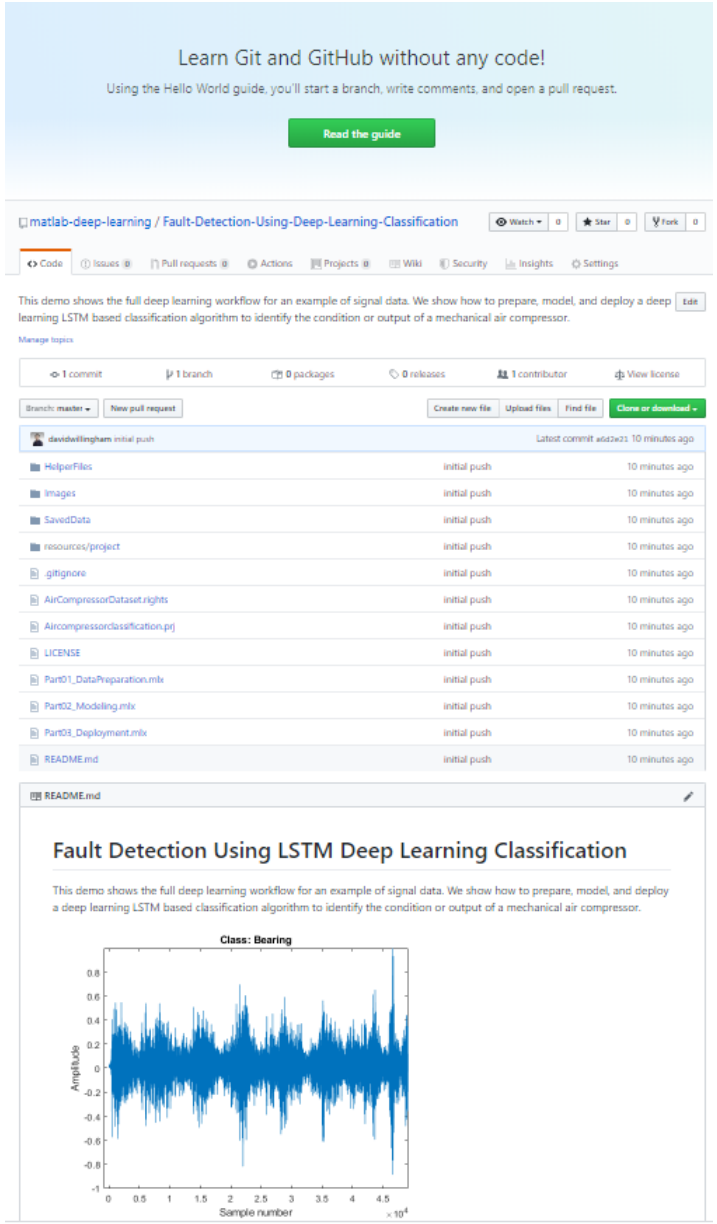
Further Learning & Teaching

- 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

Where to find this content on GitHub

- https://tinyurl.com/deeplearningmatlabsignal



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