MathWorks
AUTOMOTIVE CONFERENCE 2023
North America

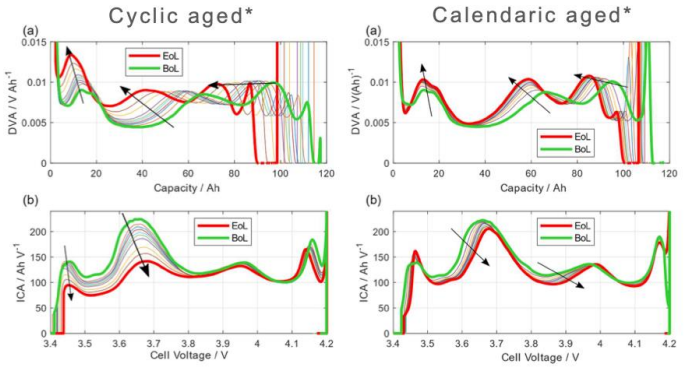
How AI Trends are Impacting Automotive Development

Mary Ann Freeman, MathWorks

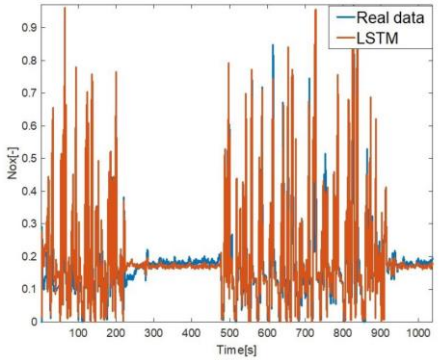
MathWorks®

Significant increase in use of AI in Automotive Development

R&D

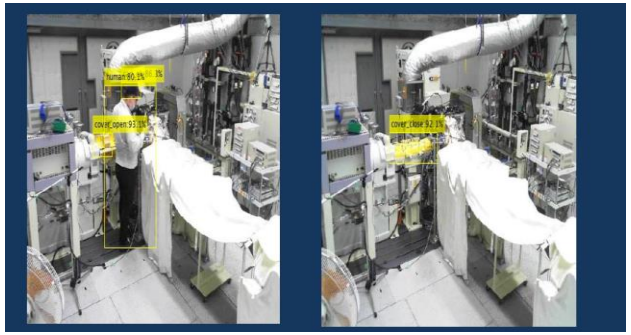


Gotion
Battery SOH Estimation



Renault
Virtual sensor for NOx estimation

Manufacturing



Toyota
Predictive maintenance of engine bench

Daihatsu
Engine knock detection

Goals for this talk

Trends observed across MATLAB/Simulink users incorporating AI in automotive development

How MathWorks is supporting these trends

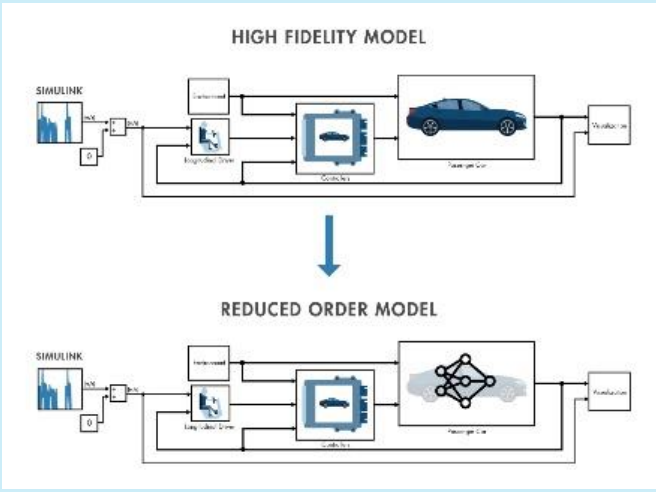
Market trends driving **AI in Automotive Development**

	MathWorks Response
1. AI improves **existing systems and processes**	
2. Integration of AI with automotive software development process	
3. Government regulation and certification efforts	
4. Shift from general-purpose AI to solving domain-specific problems using AI	

Trend #1
AI being used to improve existing systems and processes

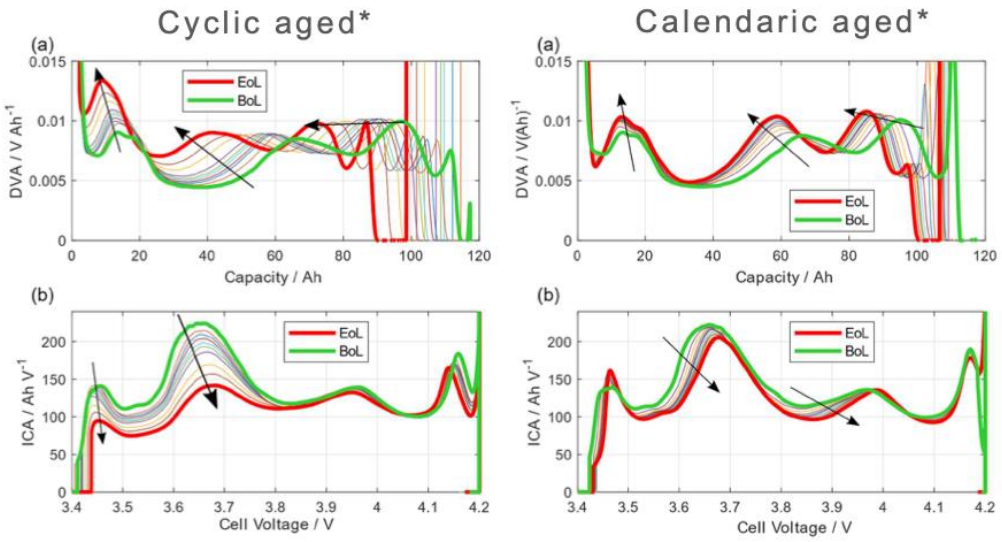
Solving previously unsolvable problems now possible with AI

Improving existing systems and processes with AI



2015 2016 2017 2018 2019 2020 2021 2022 Today

AI-Based Virtual Sensor for Battery State-of-Health



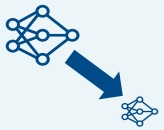
Gotion

- Combined AI with traditional battery analysis techniques
- Implemented in Simulink for testing, requirements validation, and certification

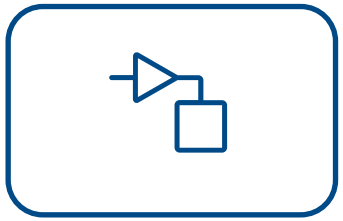
Trend #1
AI being used to improve existing systems and processes

Impact on MATLAB and Simulink Users

Increase interest and use of AI in Simulink



Increase use of smaller/simpler models

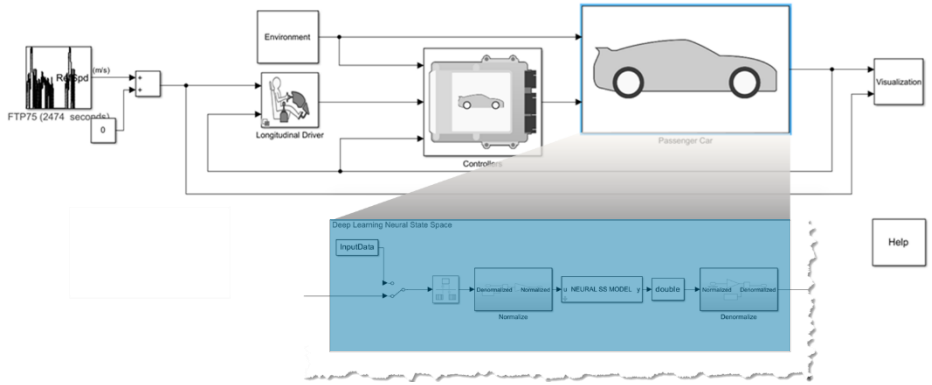


AI in Simulink

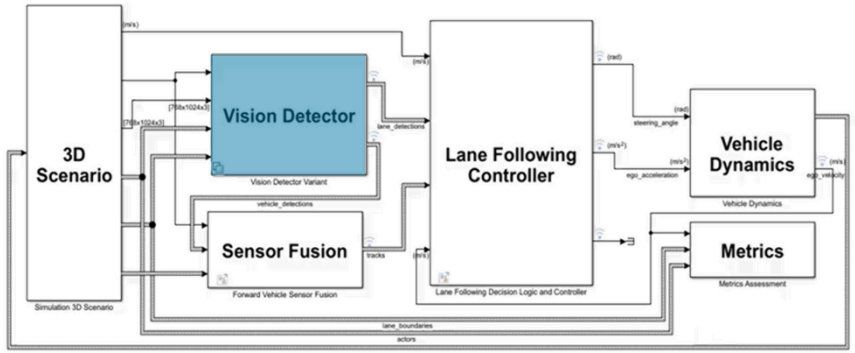
AI is often part of a larger system

Virtual sensor for battery SOC estimation

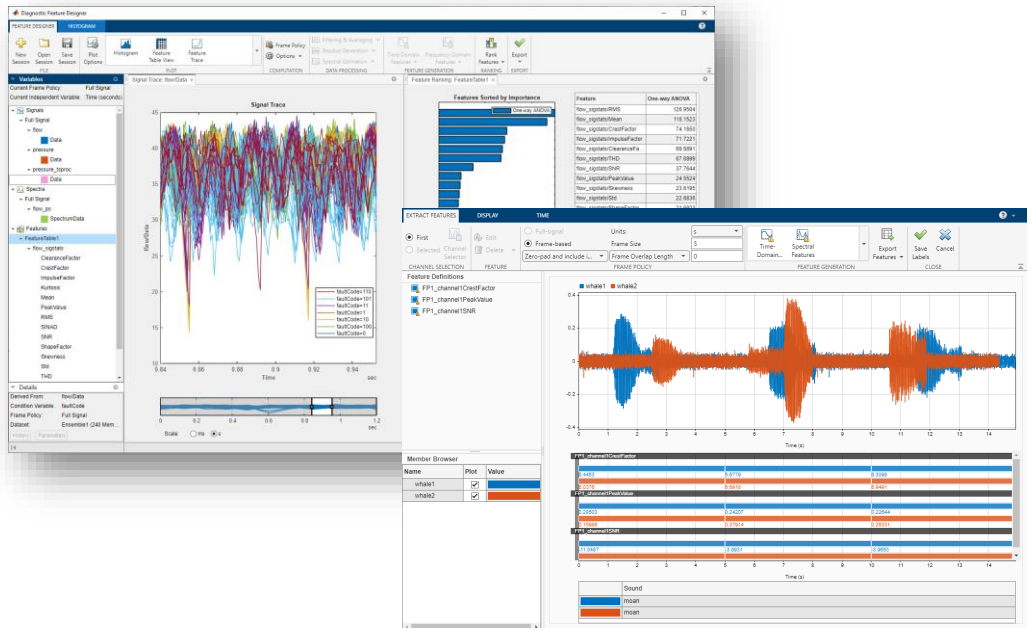
AI-based Reduced-Order Modeling



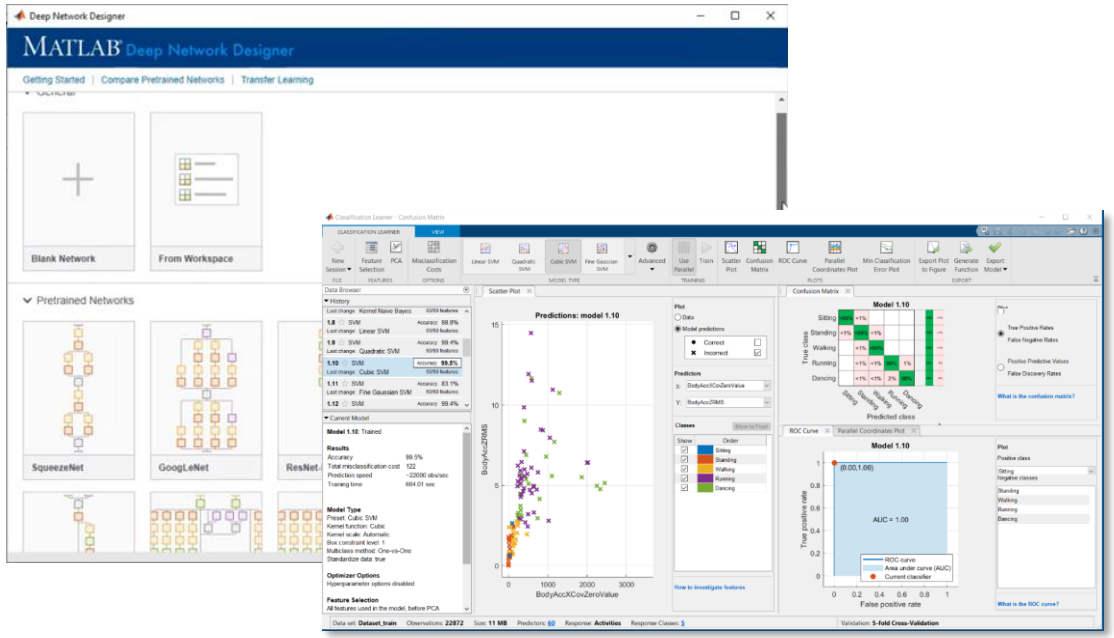
Vision Detector for a Highway Lane Following System



Get started faster with low-code app-based workflows

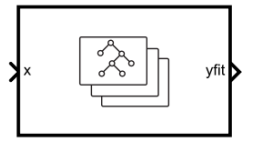


Feature Extraction



Deep Learning and Machine Learning Training

AI libraries in Simulink are expanding to include more AI blocks for more applications

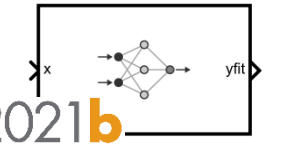


RegressionEnsemble Predict

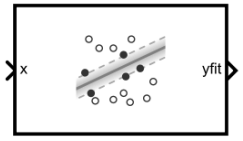
R2022a

RegressionGP Predict

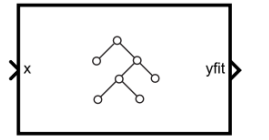
R2021b



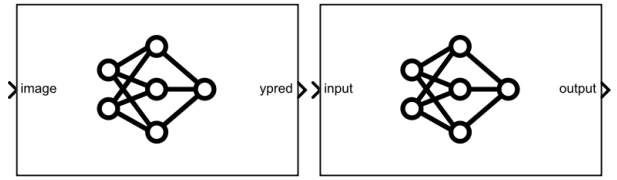
RegressionNeuralNetwork Predict



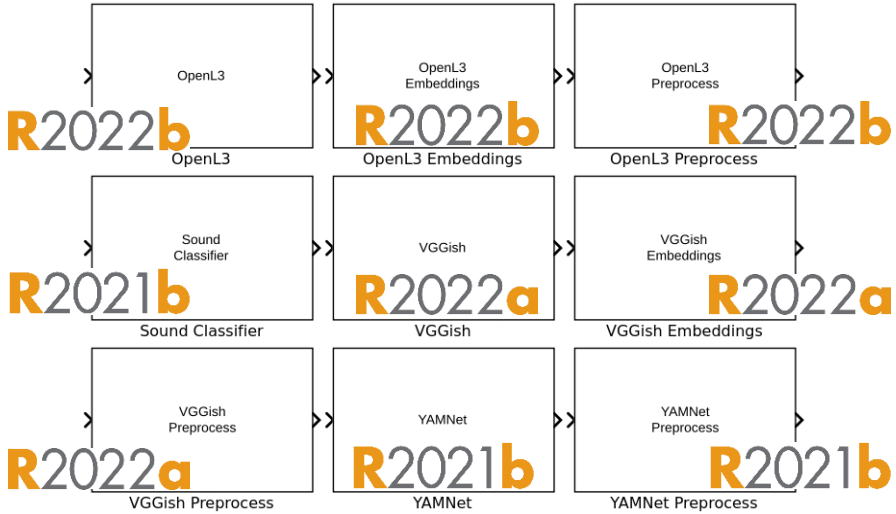
RegressionSVM Predict



RegressionTree Predict

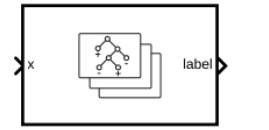


Deep Learning Toolbox



Audio Toolbox

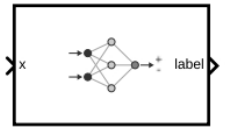
R2022b



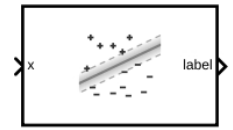
ClassificationEnsemble Predict

ClassificationKNN Predict

R2021b



ClassificationNeuralNetwork Predict

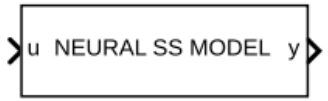


ClassificationSVM Predict

ClassificationTree Predict

Statistics and Machine Learning Toolbox

R2022b

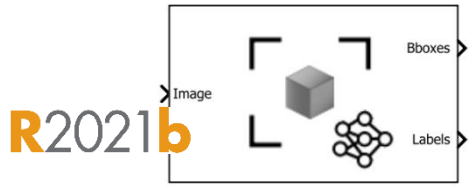


Neural State Space Model

Nonlinear ARX Model

System Identification Toolbox

R2021b



Deep Learning Object Detector

Computer Vision Toolbox

Evolution of AI in MATLAB

2016 - 2019

Toolboxes

- Deep Learning Toolbox
- Text Analytics Toolbox
- Reinforcement Learning
- Predictive Maintenance Toolbox

Code Generation

- GPU Coder
- MATLAB Coder

Apps

- Image Labeler
- Deep Network Designer
- Video Labeler
- Signal Labeler

Interoperability

- TensorFlow-Keras Importer
- ONNX Support

2020 - 2021

Apps

- Experiment Manager
- Lidar Labeler
- Reinforcement Learning Designer

Compression

- Quantization

Code Generation

- Deep Learning HDL Coder

Model-Based Design

- Image Classification & Model Prediction
- Recurrent Neural Networks
- Object Detectors

Interoperability

- TensorFlow Model Importer

2022 - 2023

Accessibility

- Deep Learning Model Hub

Compression

- Taylor, Projection Pruning

Code Generation

- TensorFlow Lite

Interoperability

- TensorFlow Export
- PyTorch Import
- Co-execution examples

Verification

- Out of distribution detection
- Robustness

Domain Specific AI

- Medical Imaging
- Automated Visual Inspection

Over 500+ examples

Market trends driving **AI in Automotive Development**

1. AI improves **existing systems and processes**

2. Integration of AI with automotive software development process

3. Government regulation and certification efforts

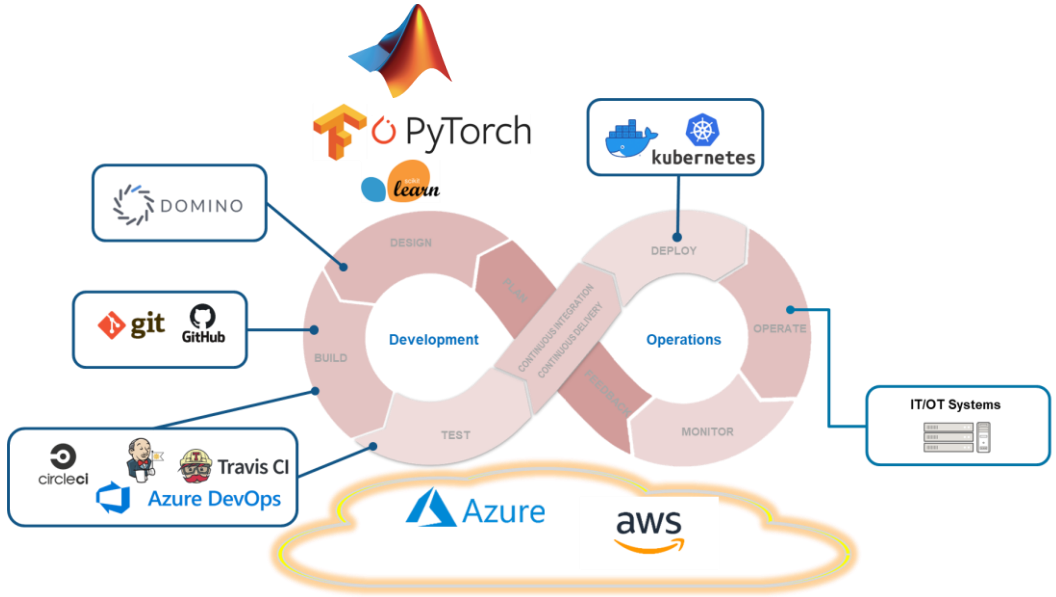
4. Shift from general-purpose AI to solving domain-specific problems using AI

MathWorks Response

AI in Simulink

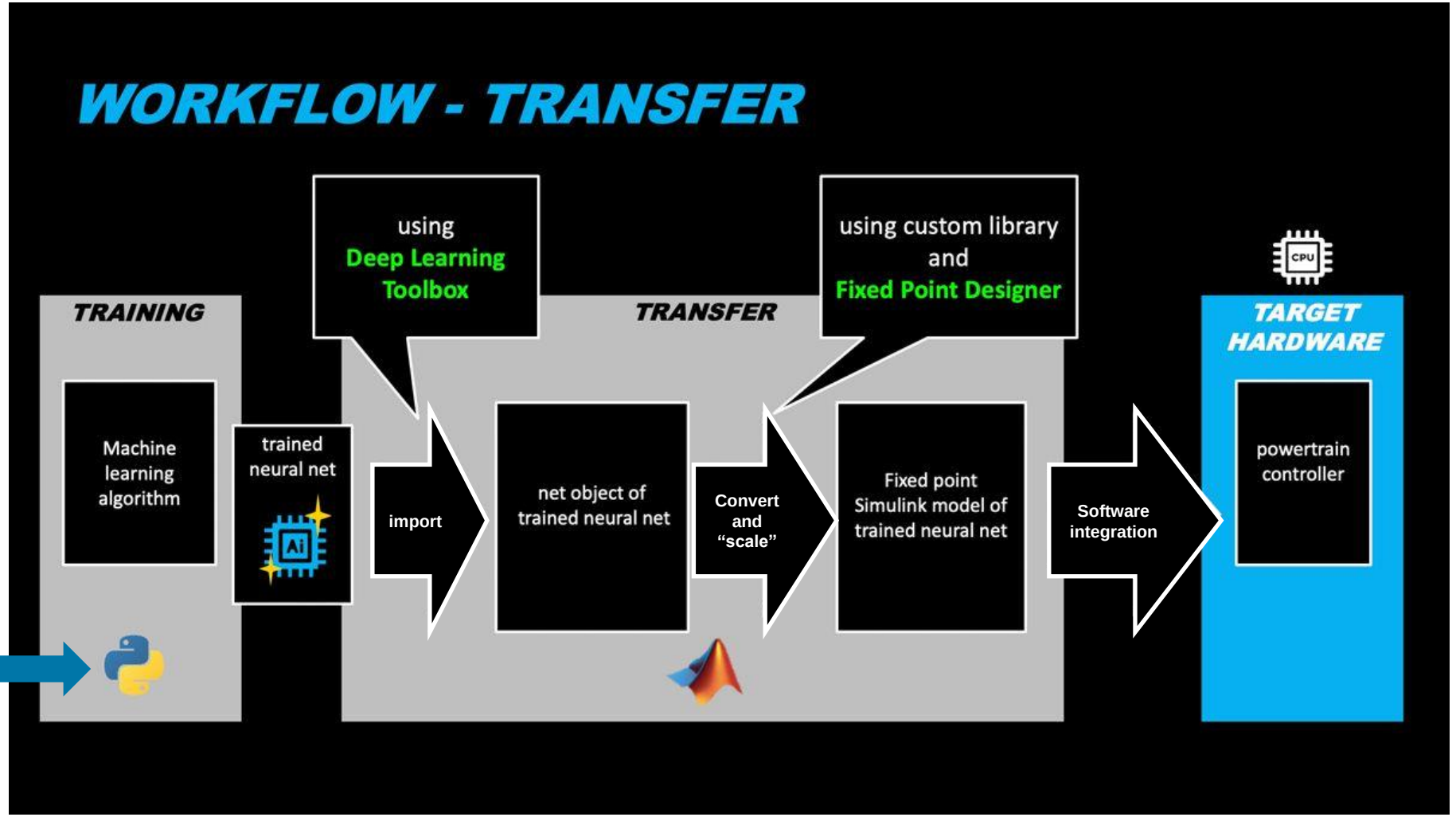
Trend #2
Integration of AI with software development process

AI Frameworks



2018 **2019** **2020** **2021** **2022** **Today**

Mercedes-Benz Simulates Hardware Sensors with Deep Neural Networks based Virtual Sensor



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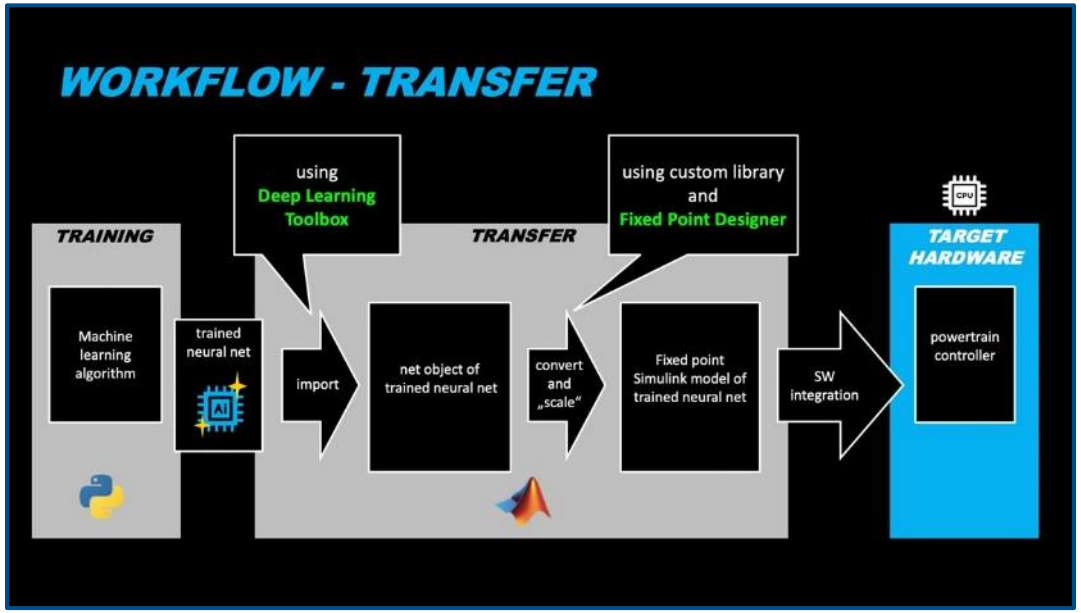


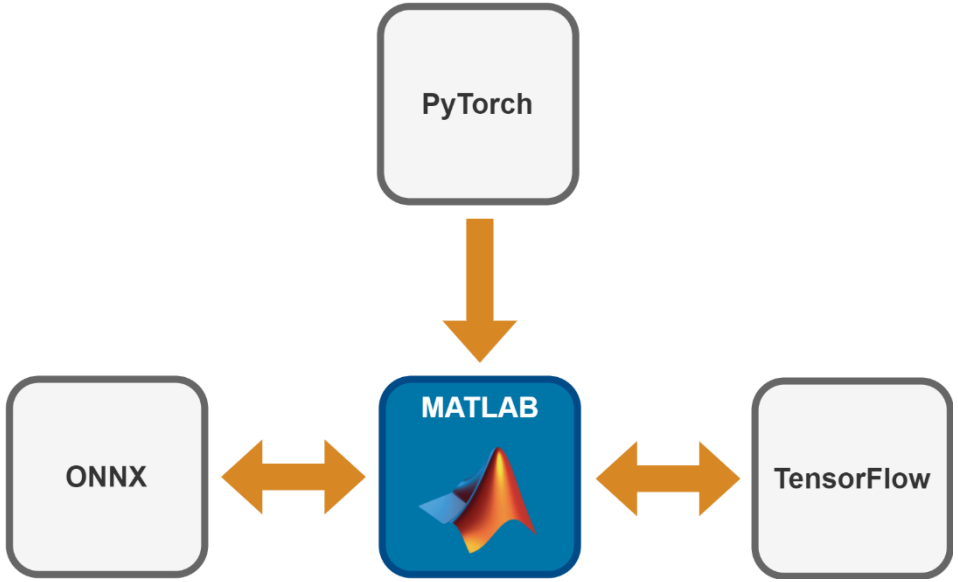
Automated workflow for deploying virtual sensors to powertrain ECU.

Use Deep Learning Toolbox, and Fixed-Point Designer to convert Python AI models into code that can be deployed to an automotive ECU.

- CPU, memory, performance requirements met
- Flexible process established
- Development speed increased 600%

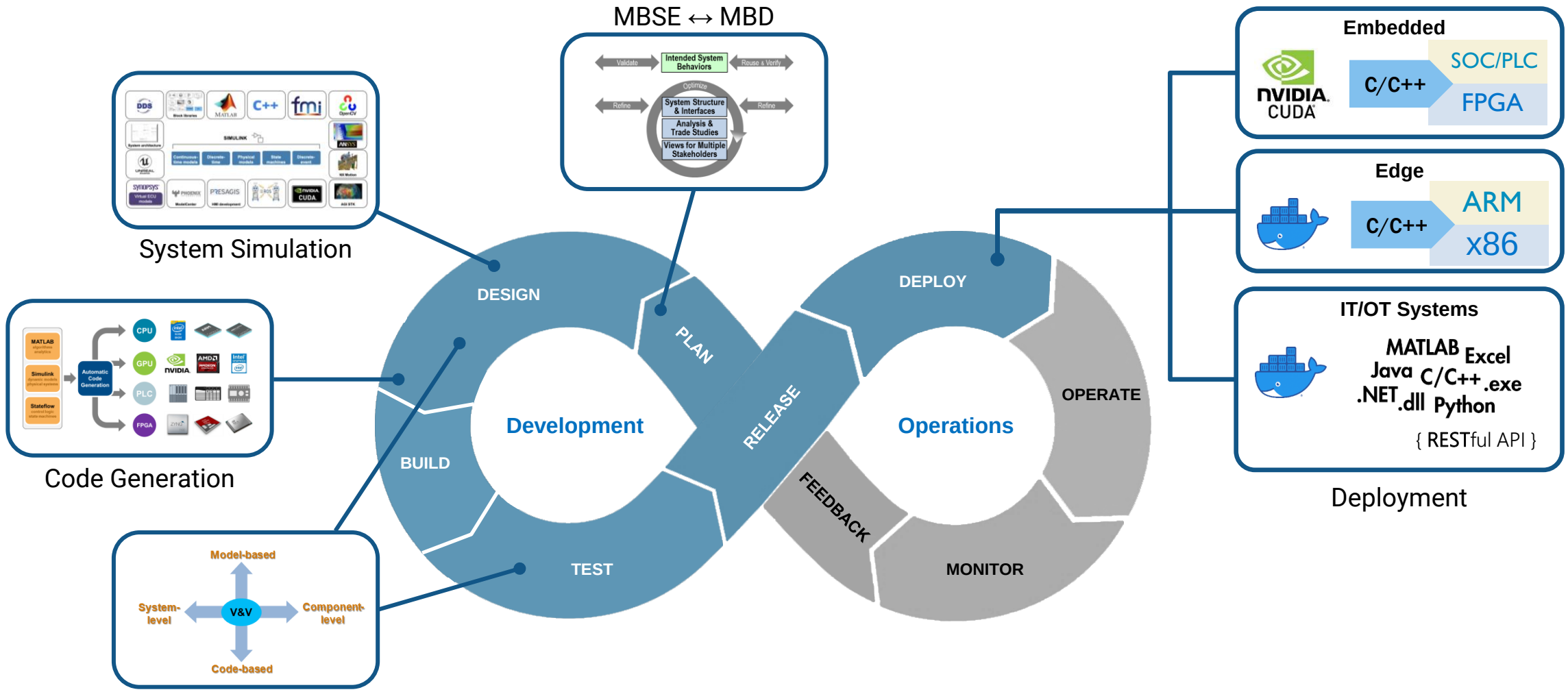
Continued investment into importing and exporting AI models into MATLAB and Simulink

TensorFlow-Keras Import	R2017b
ONNX Converter (Import & Export)	R2018a
TensorFlow Converter (Import)	R2021a
TensorFlow Converter (Export)	R2022b
PyTorch Converter (Import)	R2022b



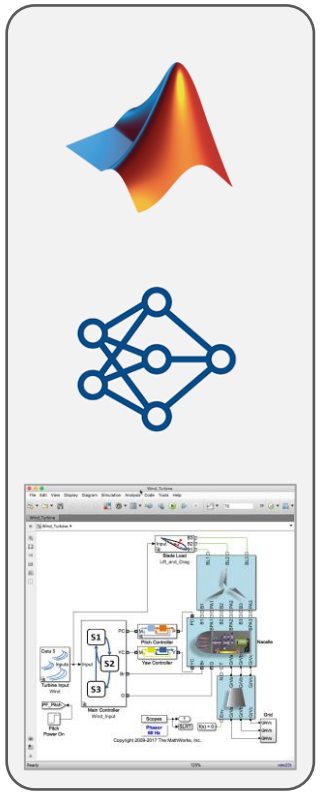
15

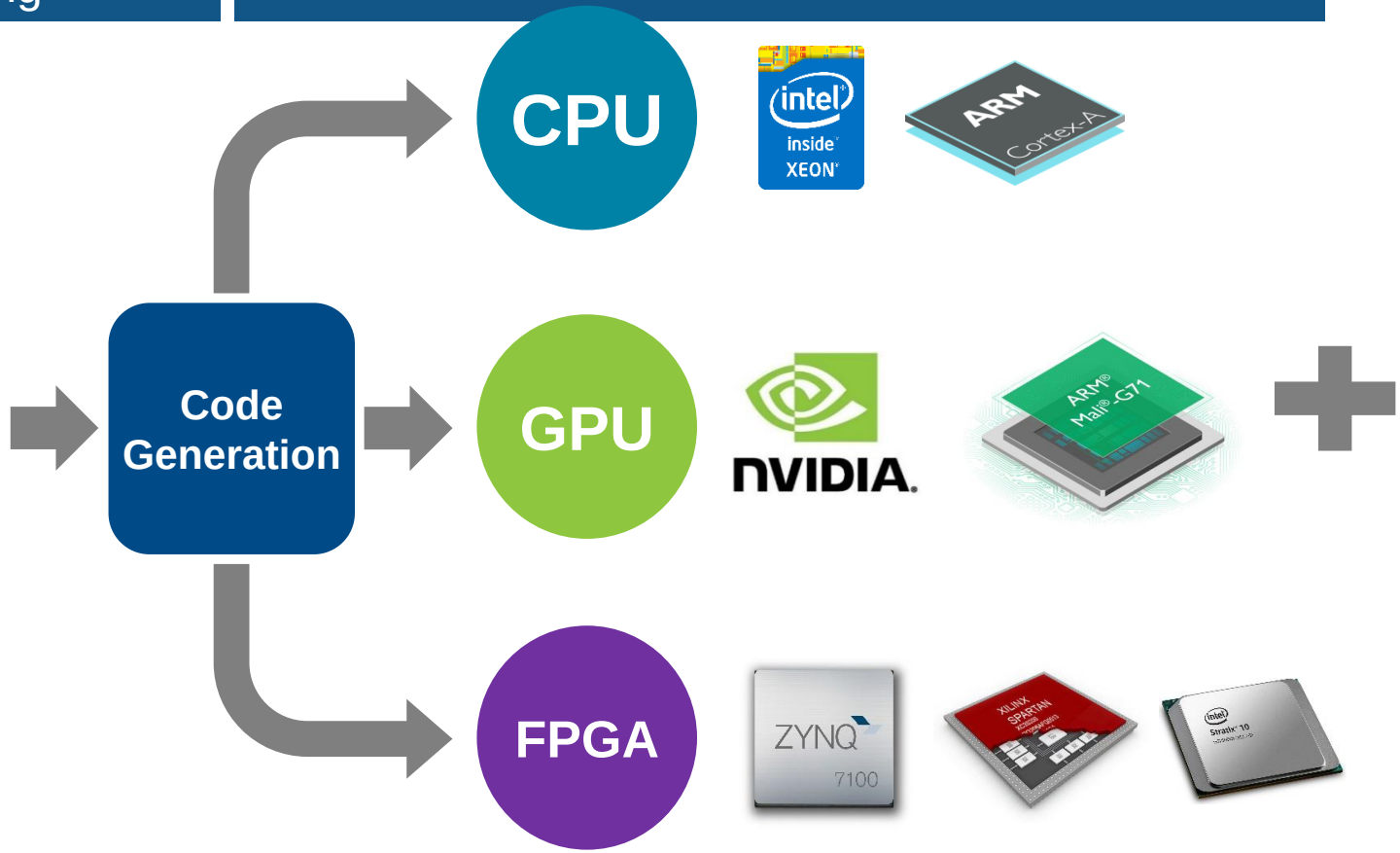
Integrate AI with Software Development Workflows

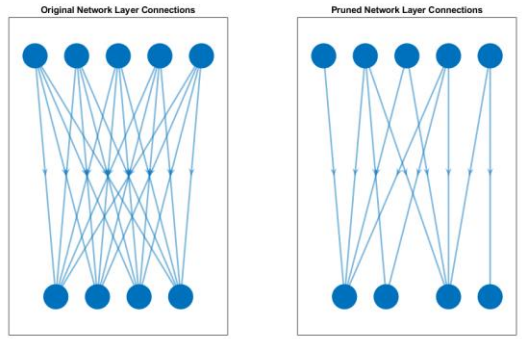


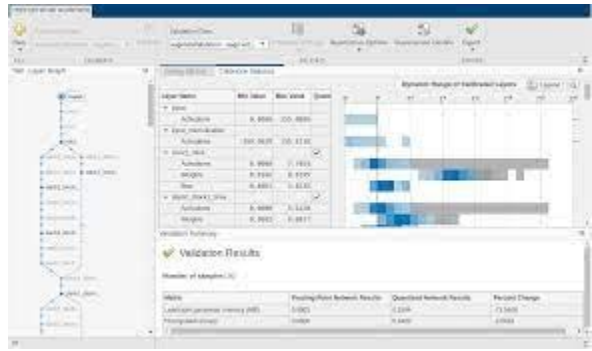
Leveraging 30 years of code generation experience for AI workflows

Generate code for AI model + pre- and post-processing	Performant multi-processor deployment	Pruning and quantization





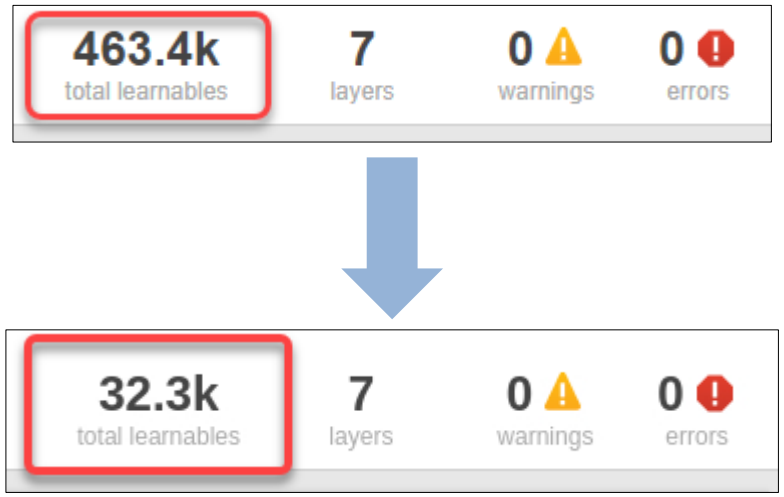


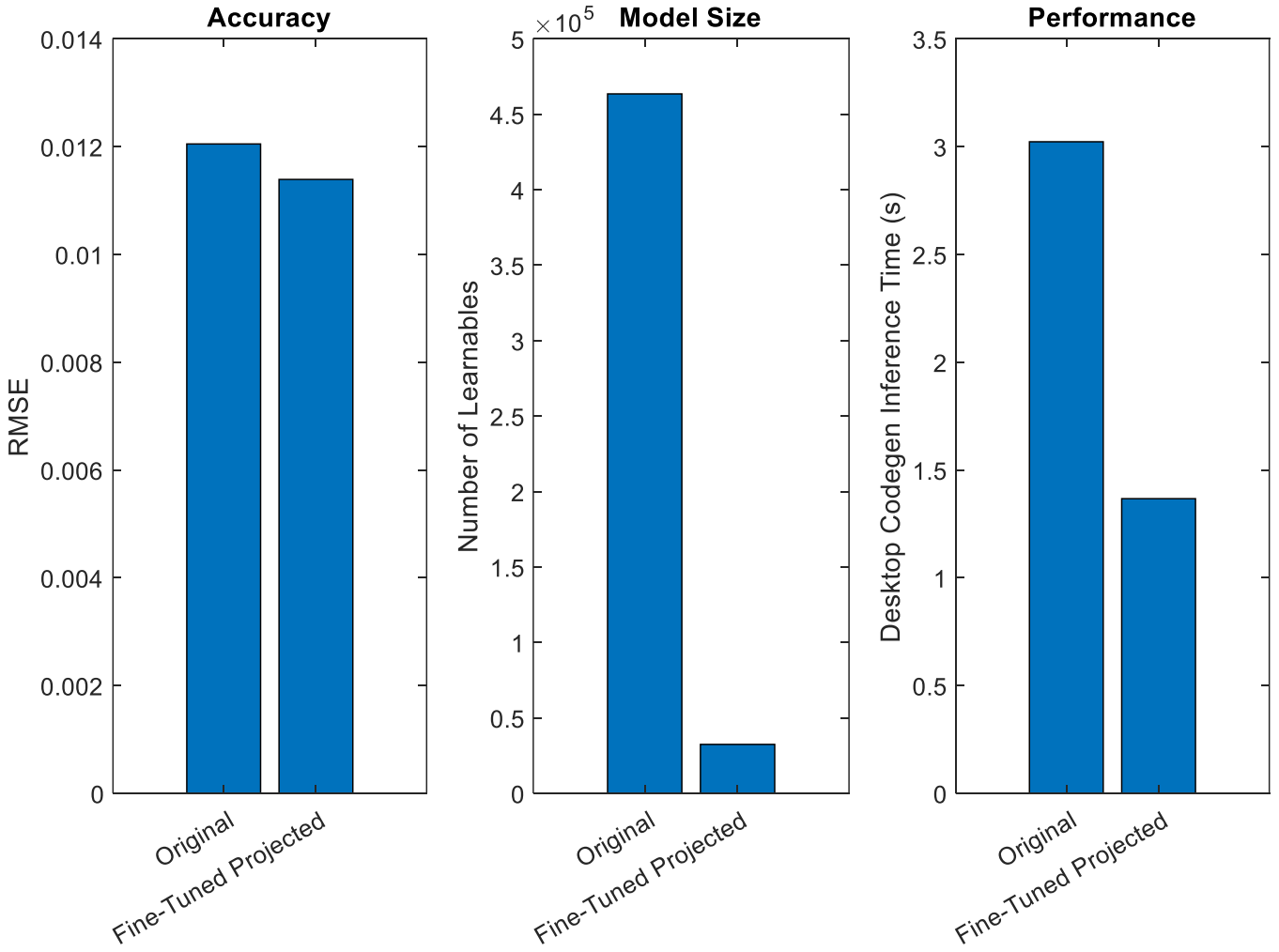


Manage AI tradeoffs for your system

Battery SOC Estimation

Model Compression Using Projection: 93% size reduction with 2x speedup





Market trends driving **AI in Automotive Development**

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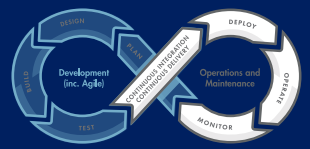
MathWorks Response

AI in Simulink



Interoperability & DevOps

Code generation

Trend #3
Increase in government regulation and certification efforts

THE AI ACT

About | The Act | Assessment | Analyses | Developments | Contact

The Artificial Intelligence Act

What is the EU AI Act?

The AI Act is a proposed European law on artificial intelligence (AI) – the first law on AI by a major regulator anywhere. The law assigns applications of AI to three risk categories. First, applications and systems that create an **unacceptable risk**, such as government-run social scoring of the type used in China, are banned. Second, **high-risk applications**, such as a CV-scanning tool that ranks job applicants, are subject to specific legal requirements. Lastly, applications not explicitly banned or listed as high-risk are largely left unregulated.

Automated Vehicles for Safety | The Topic | NHTSA In Action | Resources

NHTSA IN ACTION

NHTSA is dedicated to advancing the lifesaving potential of new vehicle technologies

NHTSA demonstrates its dedication to saving lives on our nation's roads and highways through its approach to the safe development, testing, and deployment of new and advanced vehicle technologies that have enormous potential for improving safety and mobility for all Americans.

NHTSA supports the Safe System Approach, a data-driven, holistic, and equitable method to roadway safety that fully integrates the needs of all users. As part of this approach, vehicle safety technologies offer unique opportunities to reduce traffic deaths, injuries, and harm.

In 2021, NHTSA issued a Standing General Order that requires manufacturers and operators of automated driving systems and SAE Level 2 advanced driver assistance systems equipped vehicles to report crashes to the agency.

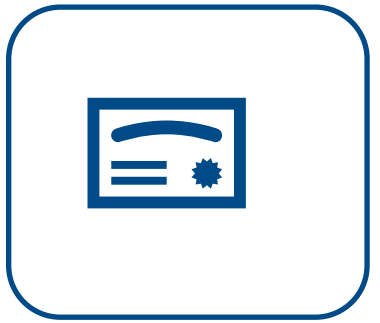
In 2020, NHTSA launched Automated Vehicle Transparency and Engagement for Safe Testing. As part of the AV TEST initiative, states and companies can voluntarily submit information about testing of automated driving systems to NHTSA, and the public can view the information using NHTSA's interactive tool.

In September 2016, NHTSA and the U.S. Department of Transportation issued the Federal Automated Vehicles Policy, which sets forth a proactive approach to providing safety assurance and facilitating innovation. Building on that policy and incorporating feedback received through public comments, stakeholder meetings, and Congressional hearings the agency issued *Automated Driving Systems: A Vision for Safety*.

Trend #3
Increase in government regulation and certification efforts

Impact on MATLAB and Simulink Users

Increased interest in explainable AI & certification



XAI & Certification

Scenario-based Testing

Significant progress in Robustness: AI Verification & Certification

- Released Support Package in October 2022

Deep Learning Toolbox Verification Library

by MathWorks Deep Learning Toolbox Team STAFF

Test robustness properties of deep learning networks

MathWorks Optional Feature

Neural Network

Road

No road

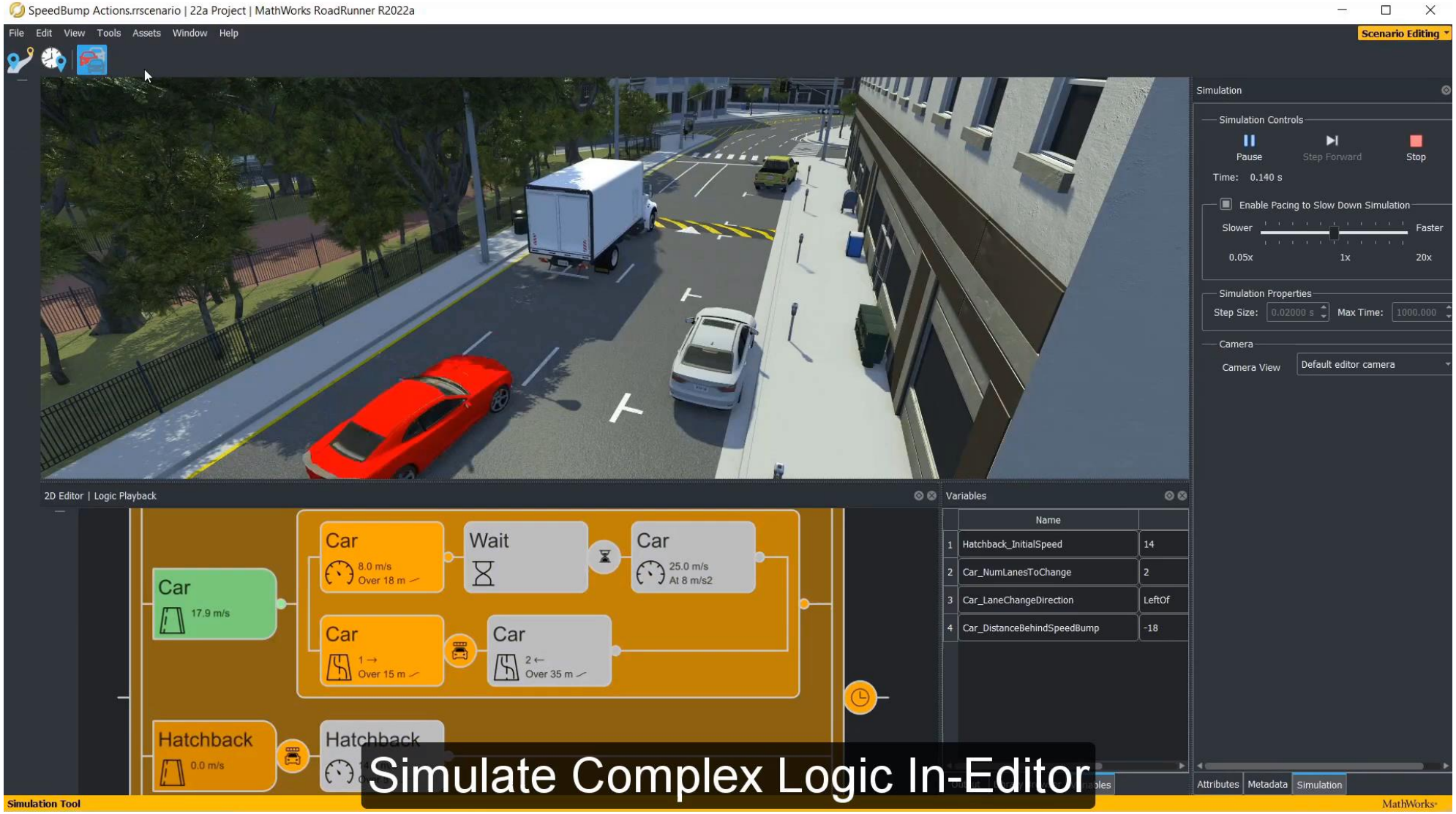
- Released techniques focusing on fairness: bias detection and mitigation

- Engagement with certification bodies and working groups

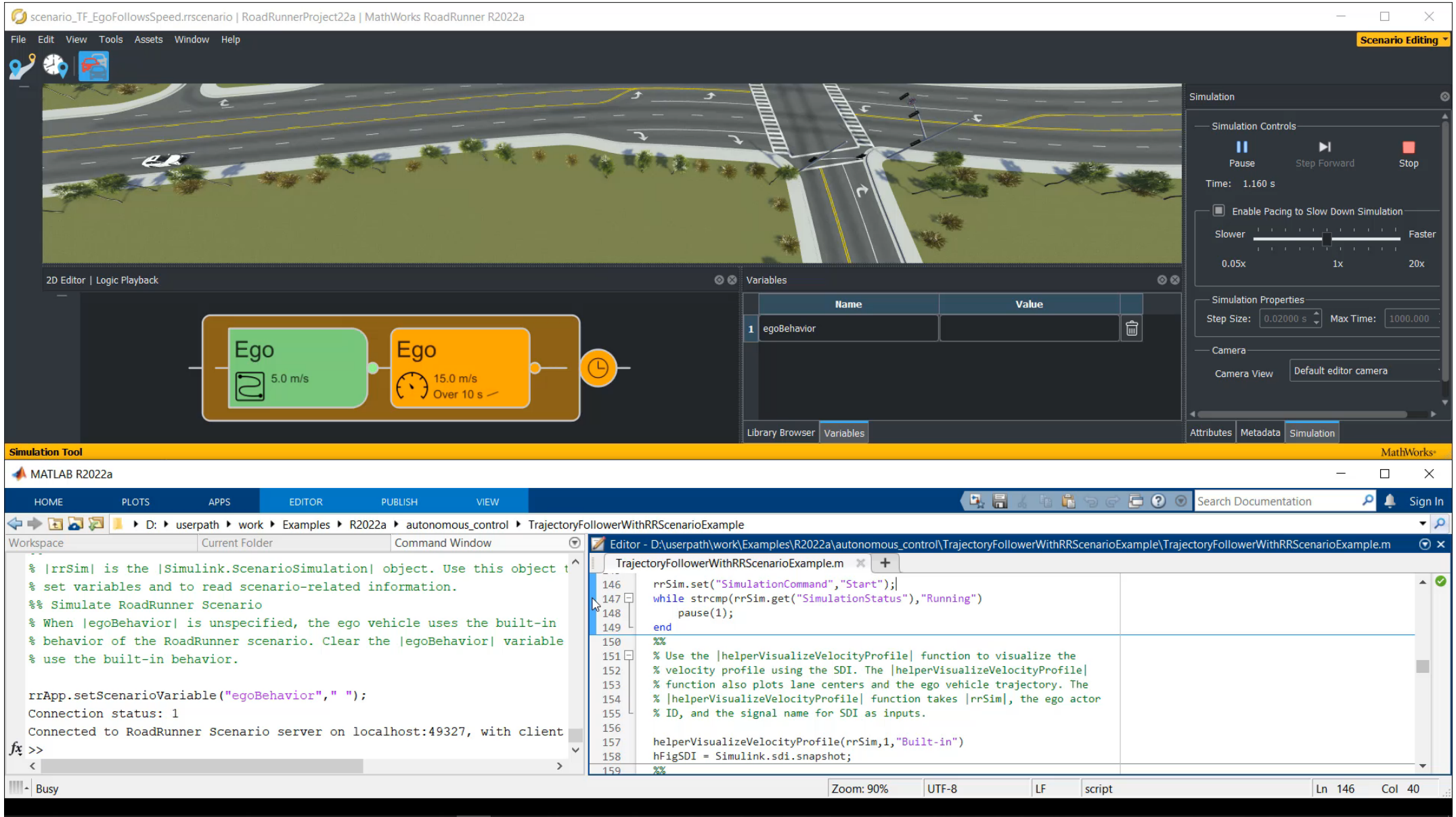
SAE INTERNATIONAL™

EUROCAE

Test AI based systems with scenario-based testing



Test AI based systems with scenario-based testing



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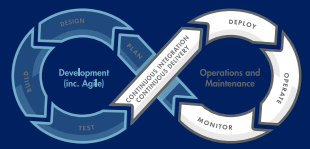
MathWorks Response

AI in Simulink



Interoperability & DevOps

Code generation

XAI & Certification

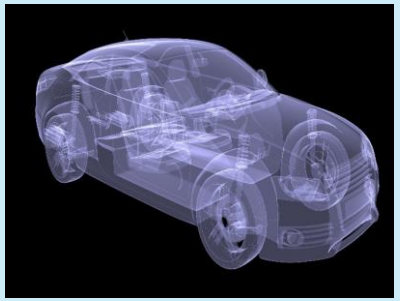
Scenario-based Testing

Trend #4

Industry shift from investing in general-purpose AI to solving domain-specific problems using AI

General Purpose

Domain Specific



Automotive controls

Predictive maintenance

NVH

2015 2016 2017 2018 2019 2020 2021 2022 Today

Road Condition Estimation with AI at Mahindra Truck and Bus

- Built model that estimates road condition from existing vehicle sensors
- Integrated with other control algorithms to improve fuel economy

Trend #4
Industry shift from investing in general-purpose AI to solving domain-specific problems using AI

Impact on MATLAB and Simulink users

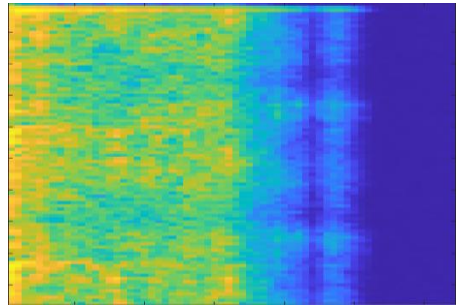
- Reduced interest in *learning* AI
- Increase in interest to *apply AI* for specific applications
- Focus shift from model-centric to data-centric AI

Verticals & Data-centric AI

Data-centric AI investments span many teams, data-types and domains

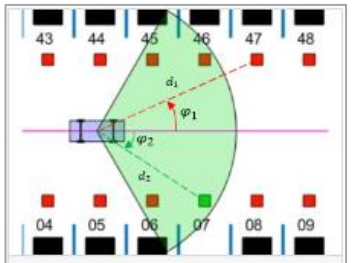
Data Synthesis

Labeling

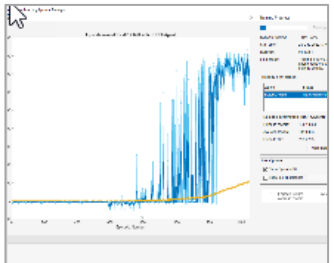


Feature Engineering

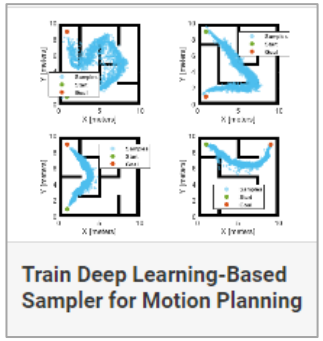
MathWorks provides you with reference applications for a variety of automotive use-cases



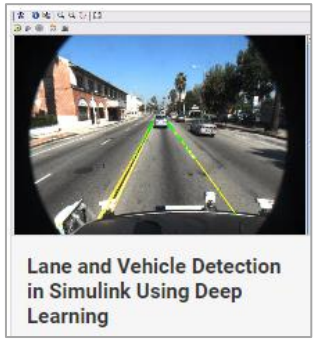
Train PPO Agent for Automatic Parking Valet



Train DDPG Agent for Path-Following Control

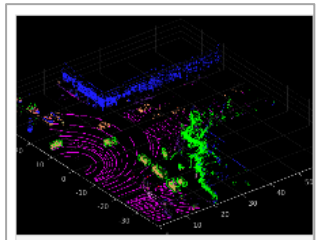


Train Deep Learning-Based Sampler for Motion Planning



Lane and Vehicle Detection in Simulink Using Deep Learning

Highway Lane Following with RoadRunner Scenario

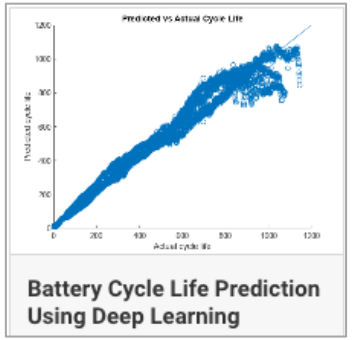


Code Generation for Lidar Object Detection Using SqueezeSegV2 Network

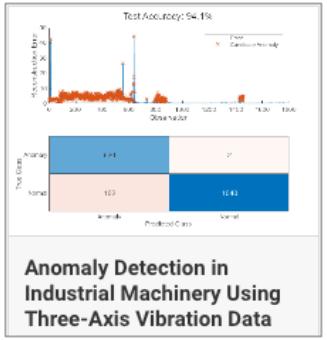
Reinforcement Learning

Automated Driving

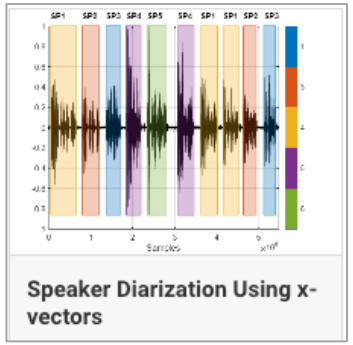
Lidar



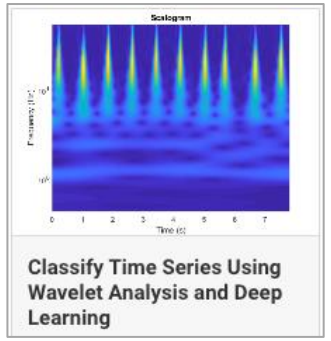
Battery Cycle Life Prediction Using Deep Learning



Anomaly Detection in Industrial Machinery Using Three-Axis Vibration Data



Speaker Diarization Using x-vectors



Classify Time Series Using Wavelet Analysis and Deep Learning

Predictive Maintenance

Audio and Signal Processing

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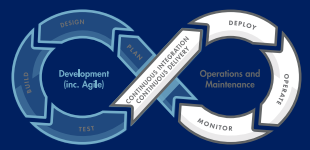
MathWorks Response

AI in Simulink



Interoperability & DevOps

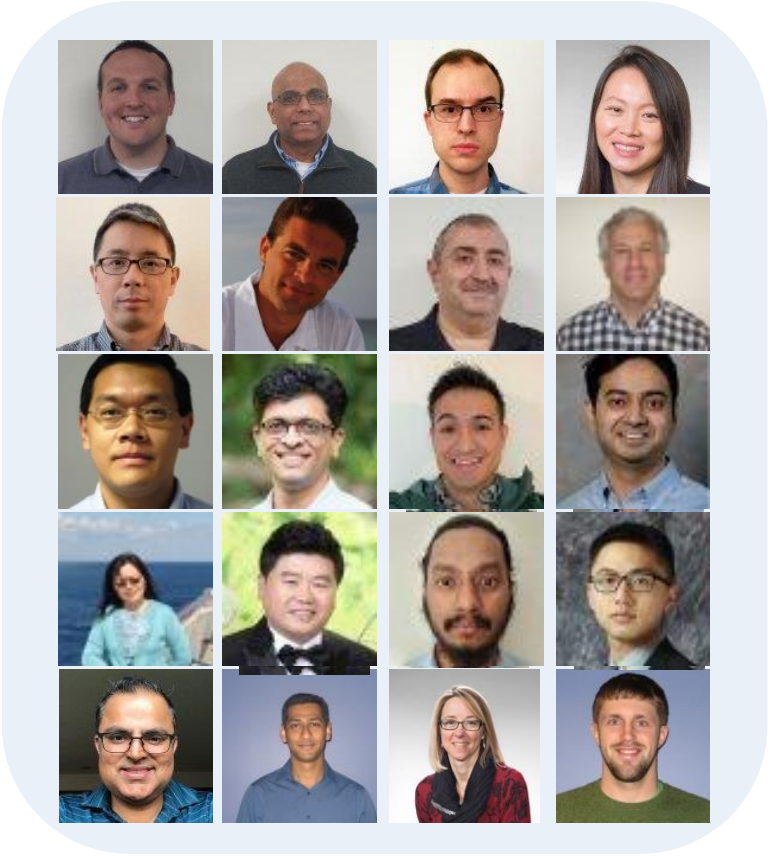
Code generation

XAI & Certification

Scenario-based Testing

Verticals & Data-centric

MATLAB and Simulink for AI in Automotive Development



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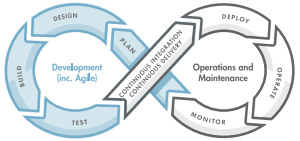
AI in Simulink



Interoperability & DevOps

Code generation

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Scenario-based Testing

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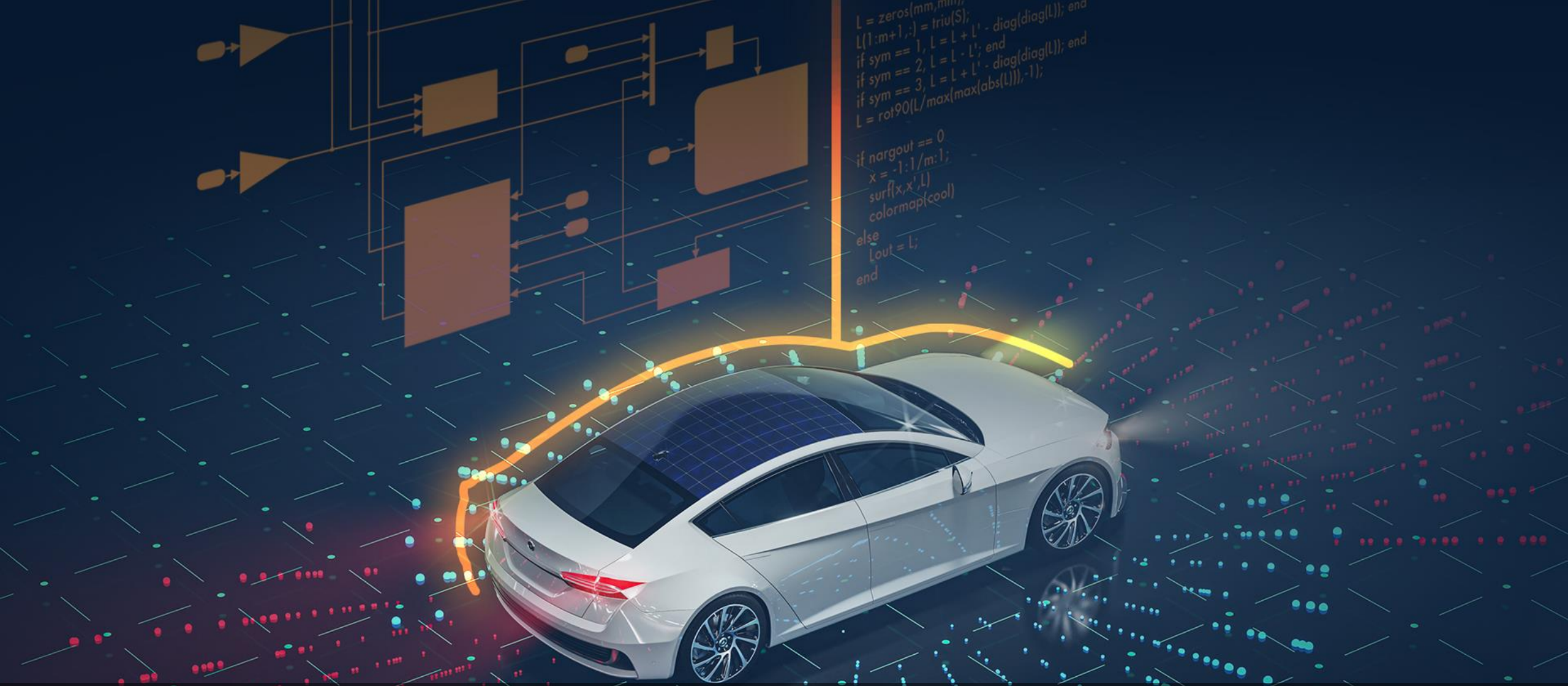

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