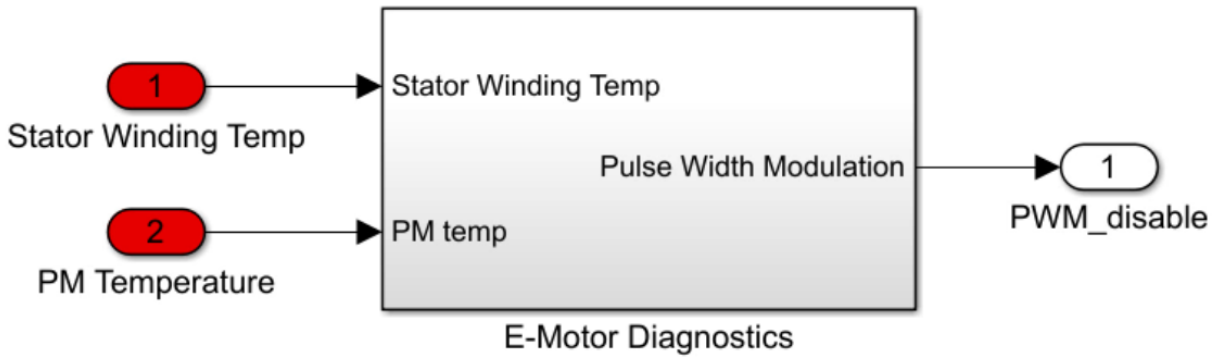
MATLAB EXPO 2021

Integrating AI into Model-Based Design

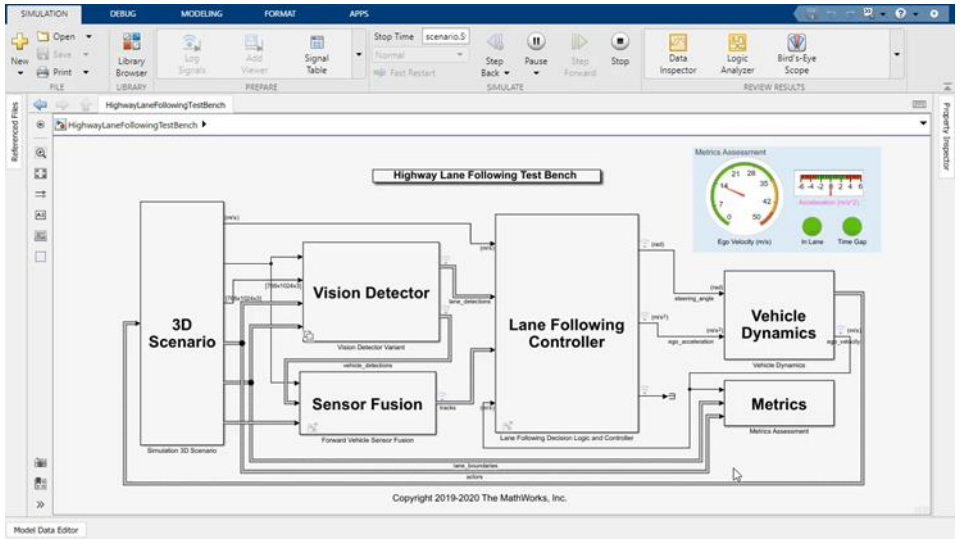
Shyam Keshavmurthy and Javier Gazzarri

MathWorks®

Two Projects



Motor Diagnostic



Lane and vehicle detection

Our Goal

Integrate trained AI models into Simulink

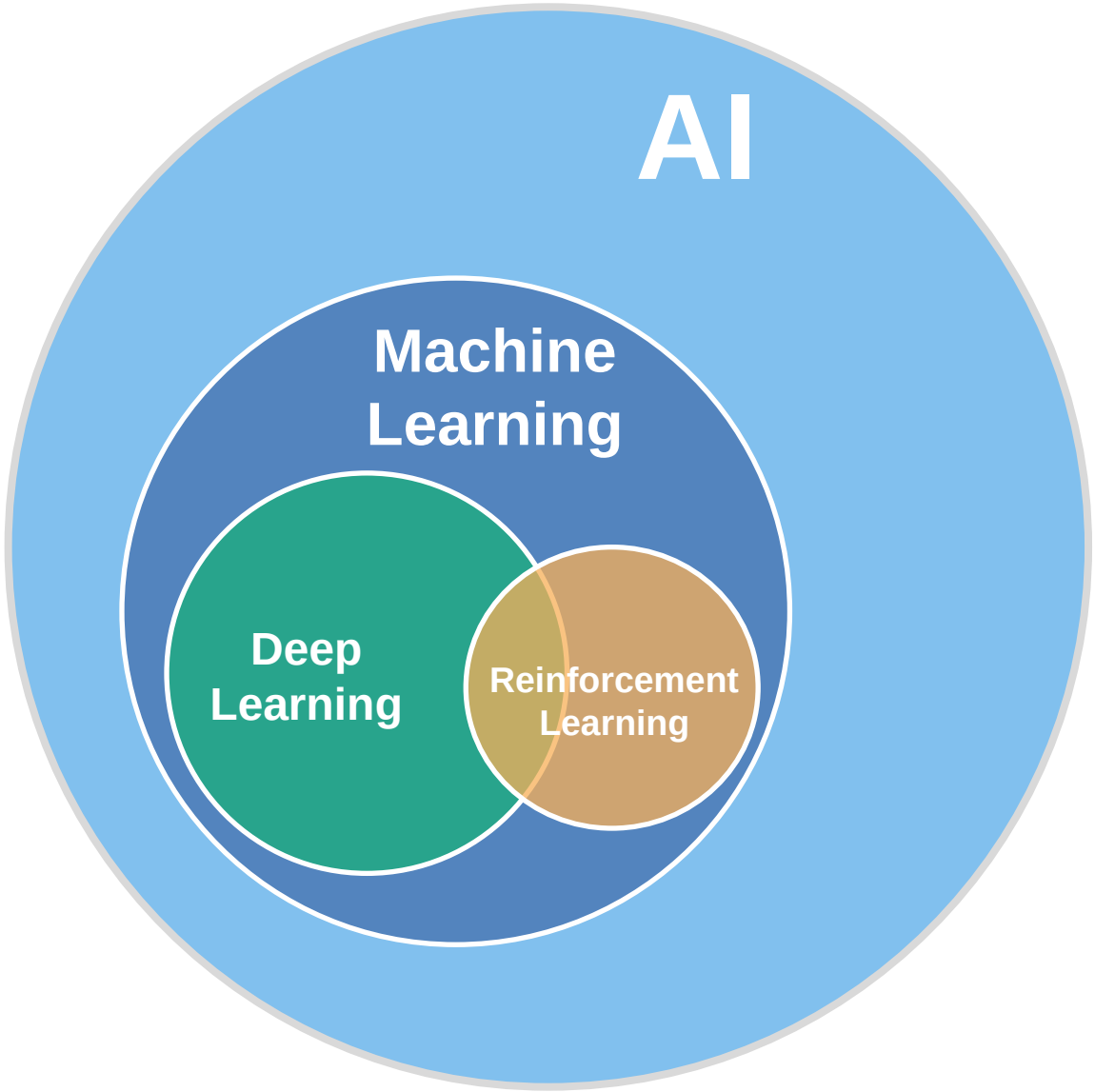
- Test design in simulation
- Code generation
- Import external AI models

Poll questions

What type of application are you considering with AI?

1. **Automated driving**
2. **Robotics**
3. **Powertrain**
4. **Radar & wireless**
5. **Other**
6. **I haven’t and am not planning to anytime soon.**

Learning Algorithms Driving the AI Megatrend



Statistics and Machine Learning Toolbox

Deep Learning Toolbox

Reinforcement Learning Toolbox

Increasing System Complexity

Model-Based Design and AI can help build complex systems

System Requirements	System Functionality and Architecture	Subsystem Design	Subsystem Implementation	System Integration and Qualification

Increasing System Complexity

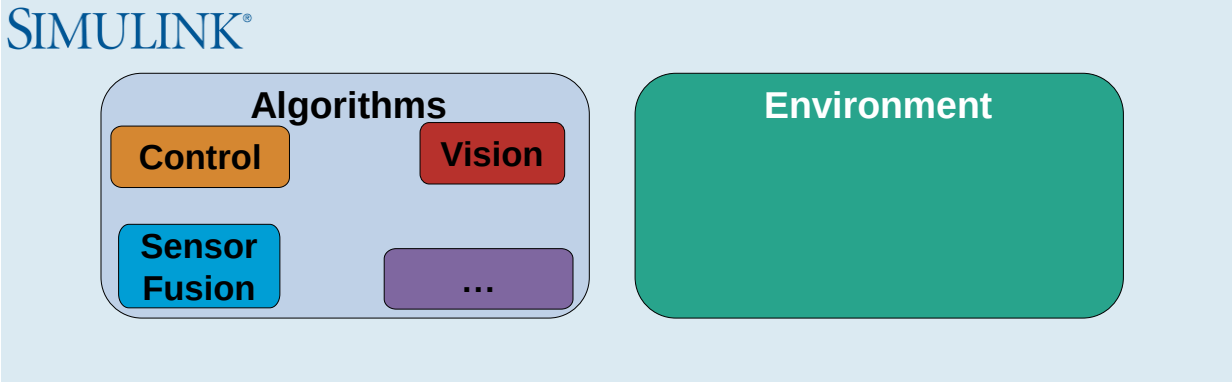
Model-Based Design and AI can help build complex systems

System Requirements	System Functionality and Architecture	Subsystem Design	Subsystem Implementation	System Integration and Qualification
Use Cases	AI	Data Preparation Modeling & Training	Deployment	Simulation & Test

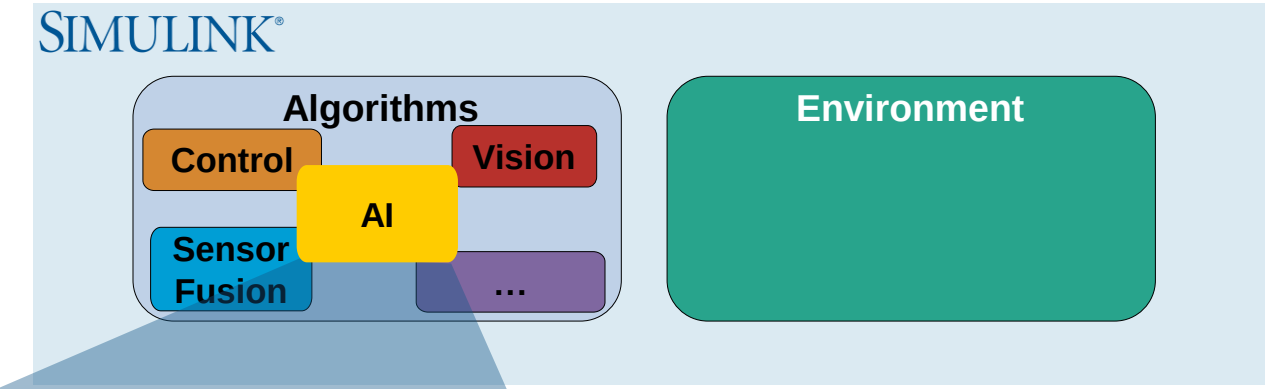
AI-driven system design workflow

Data Preparation → Modeling & Training → Simulation & Test → Deployment

AI Models in Simulink



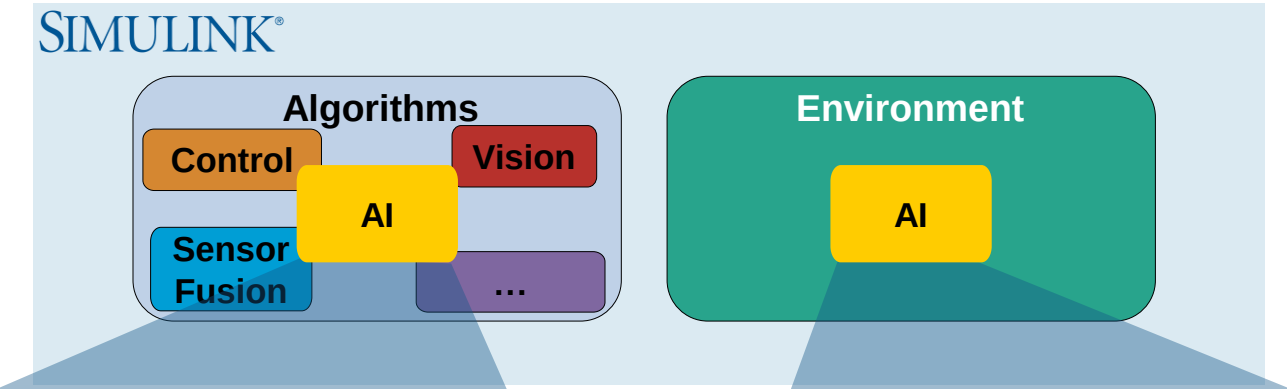
AI Models in Simulink



AI for algorithm development

- Simulate for system-level testing
- Verify system requirements
- Deploy to CPU/GPU/ECU/FPGA

AI Models in Simulink



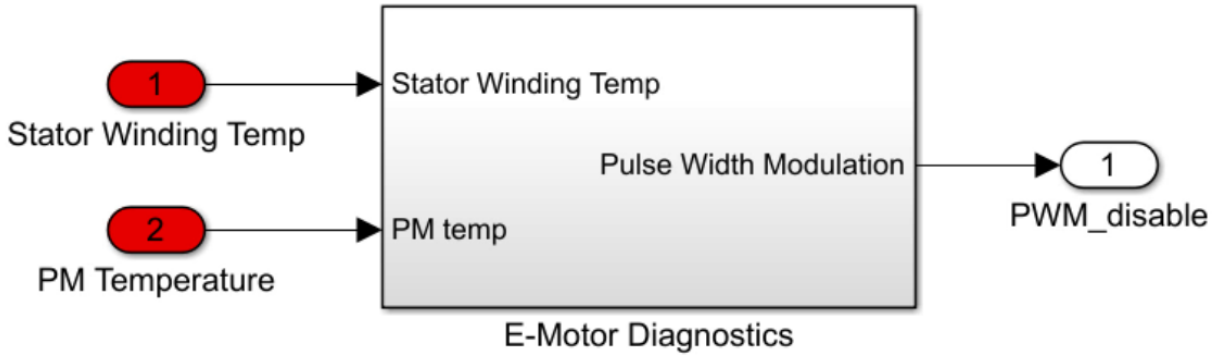
AI for algorithm development

- Simulate for system-level testing
- Verify system requirements
- Deploy to CPU/GPU/ECU/FPGA

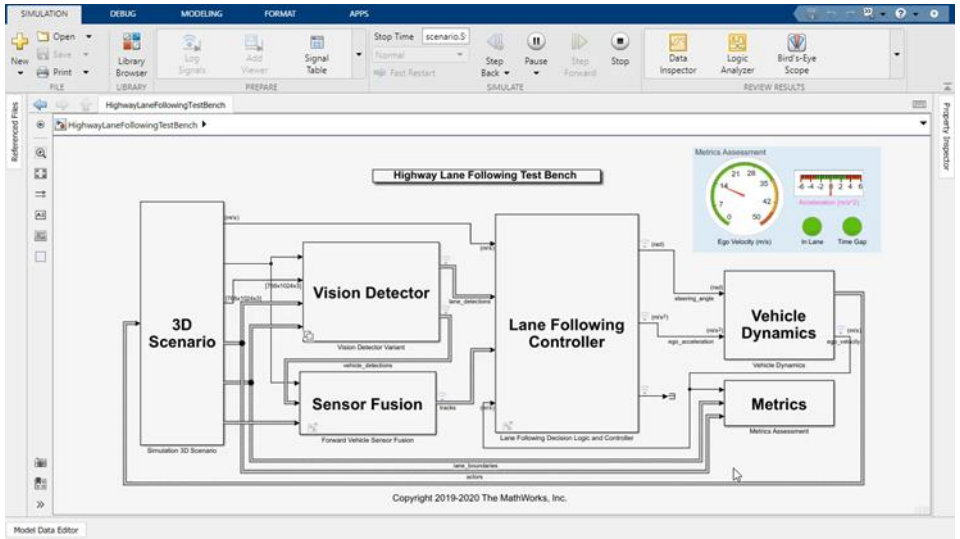
AI for environment modeling

- Speed up high-fidelity model
- Reduce complexity - First principles → data driven
- Enable HIL tests
- Share component

Case Study 1



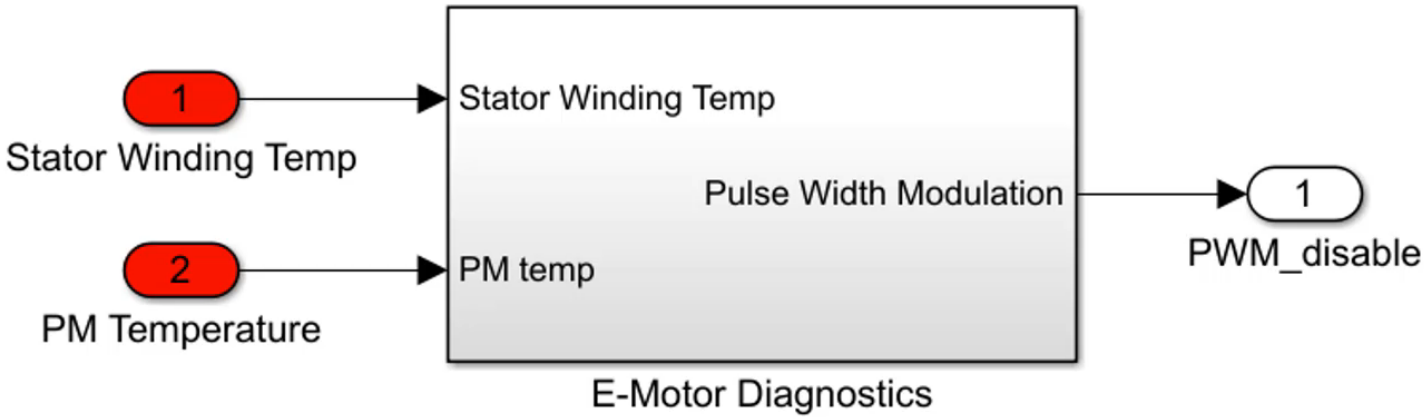
Motor Diagnostic



Lane and vehicle detection

One Week Later

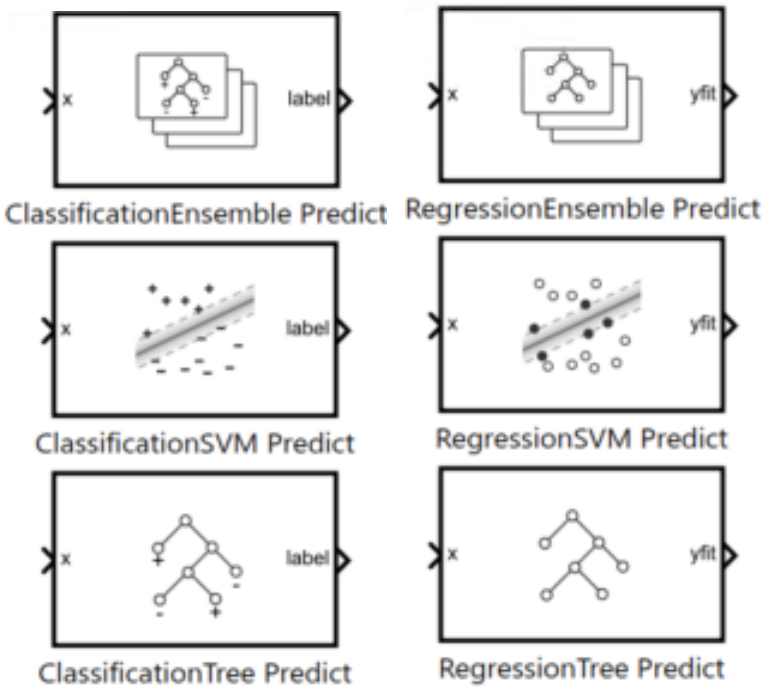
Estimate Motor States with Machine Learning



How to Integrate Machine Learning?

Built-in Machine Learning blocks

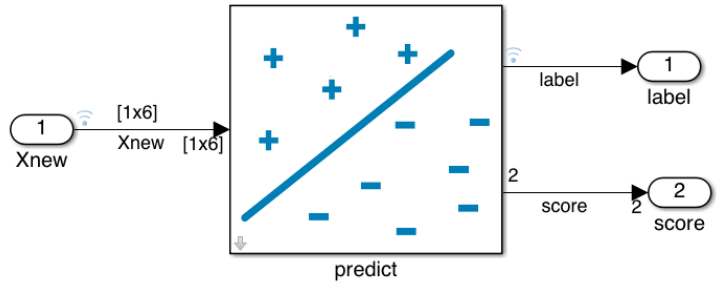
R2021a

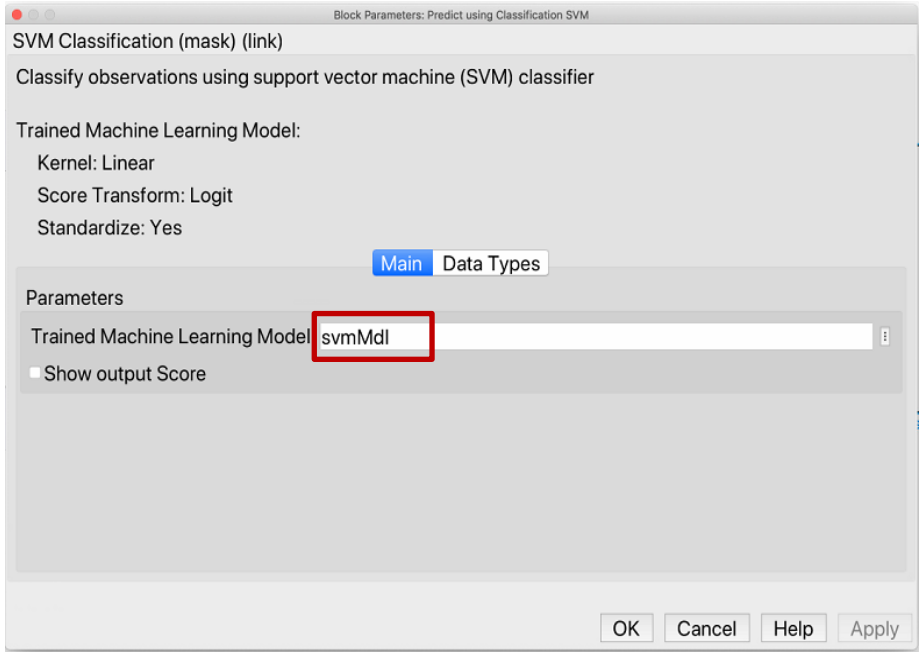


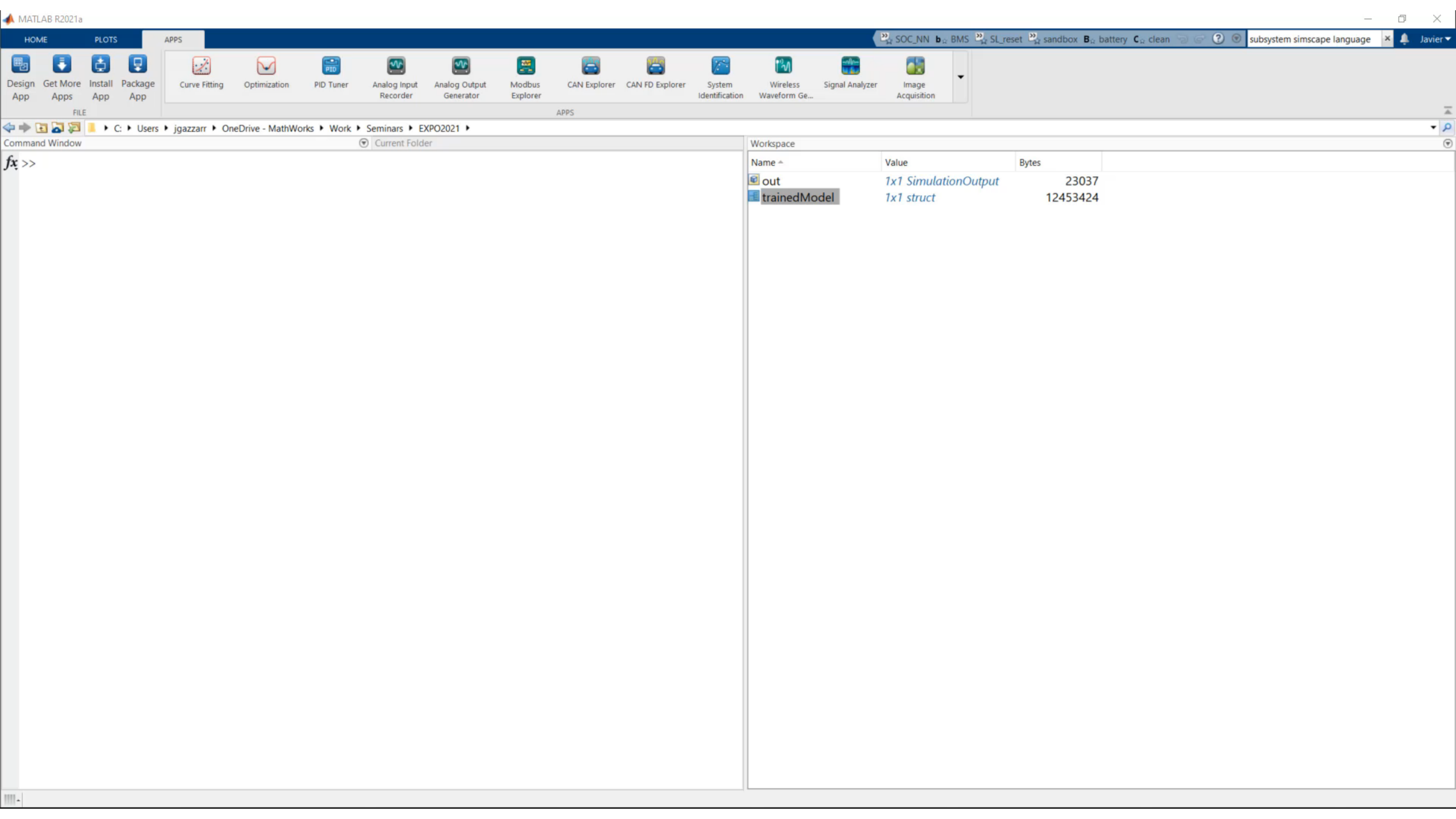
MATLAB Function Blocks

- Preprocessing
- Feature Extraction
- Other models

Example: SVM Classification block





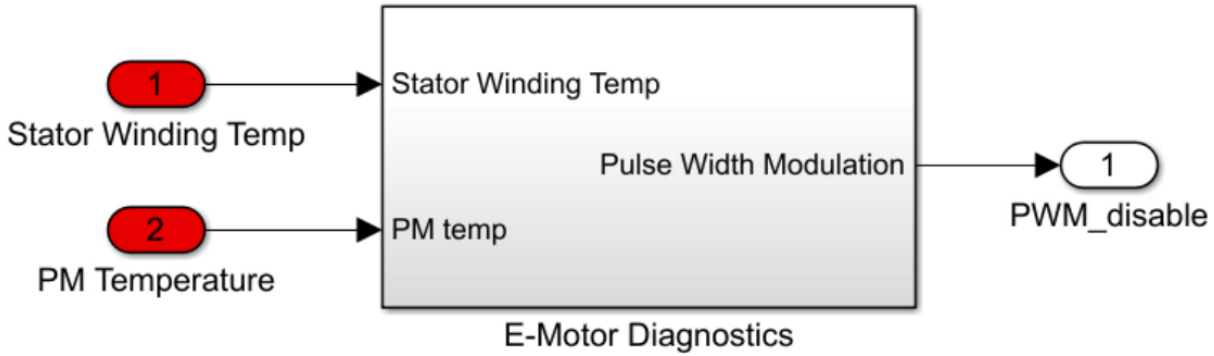

MATLAB R2021a
HOME
PLOTS
APPS
SOC_NN
BMS
SL_reset
sandbox
battery
clean
subsystem simscape language
Javier
Design App
Get More Apps
Install App
Package App
FILE
Curve Fitting
Optimization
PID Tuner
Analog Input Recorder
Analog Output Generator
Modbus Explorer
CAN Explorer
CAN FD Explorer
System Identification
Wireless Waveform Ge...
Signal Analyzer
Image Acquisition
APPS
C: Users jgazzarr OneDrive - MathWorks Work Seminars EXPO2021
Command Window
Current Folder
>>
Workspace
Name
Value
Bytes
out
1x1 SimulationOutput
23037
trainedModel
1x1 struct
12453424

Poll questions

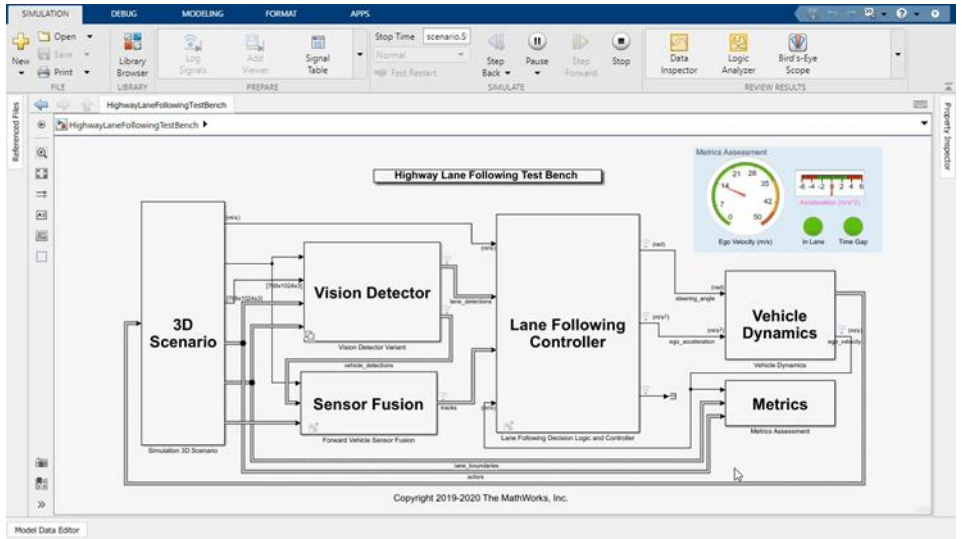
- **How would you be interested in using AI?**

1. **For algorithm development (algorithm that will be eventually deployed)**
2. **For environment modeling (using reduced-order/surrogate modeling of the environment/plant)**

Case Study 2

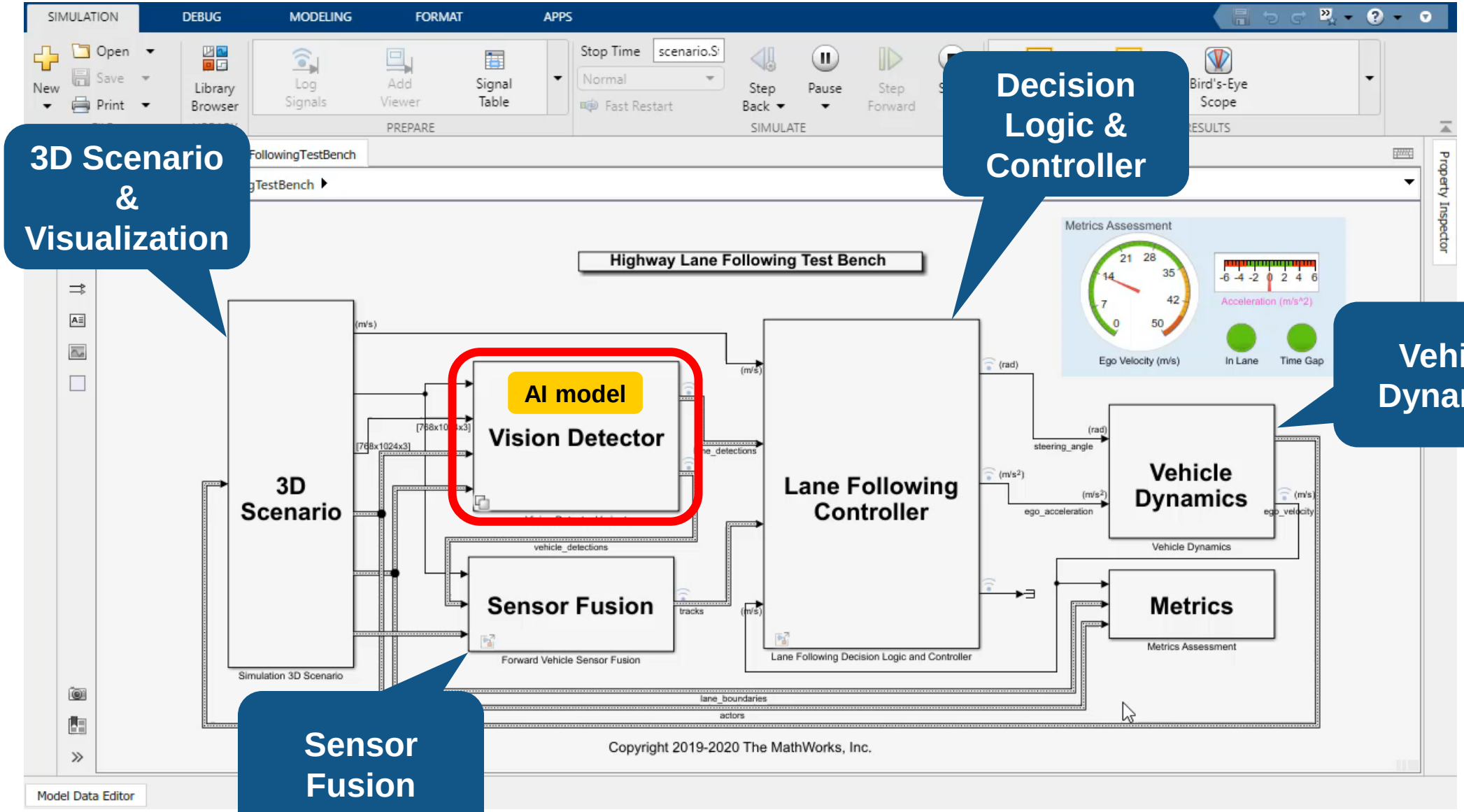


Motor Diagnostic



Lane and vehicle detection

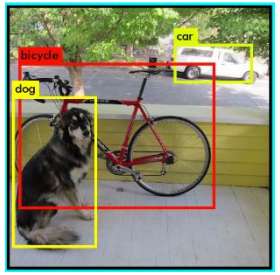
Highway Lane Following Model



Deep Learning Networks in MATLAB/Simulink

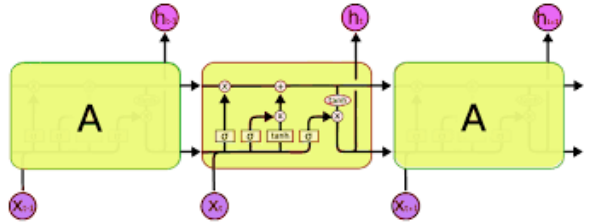
Image Classification, Semantic Segmentation

- ResNet
- Inception v3
- MobileNet v2
- GoogLeNet
- VGG



Object Detectors

- YOLO v2
- SSD



Sequence Networks

- LSTM
- BiLSTM

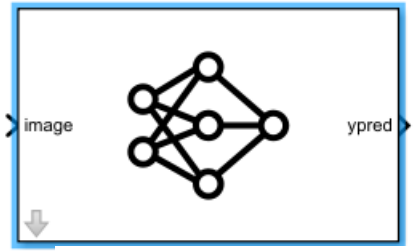
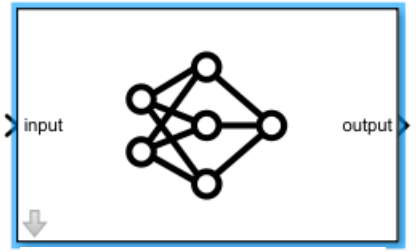
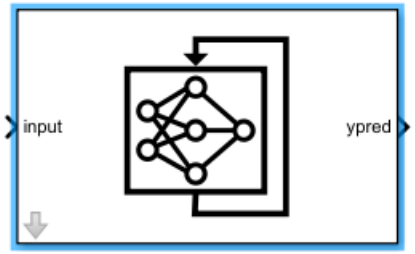


IMAGE CLASSIFIER

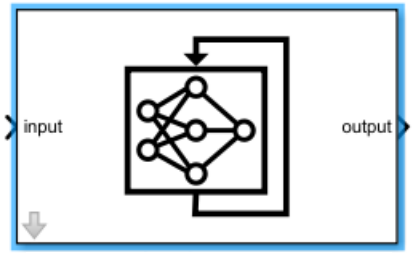


PREDICT

MATLAB FUNCTION

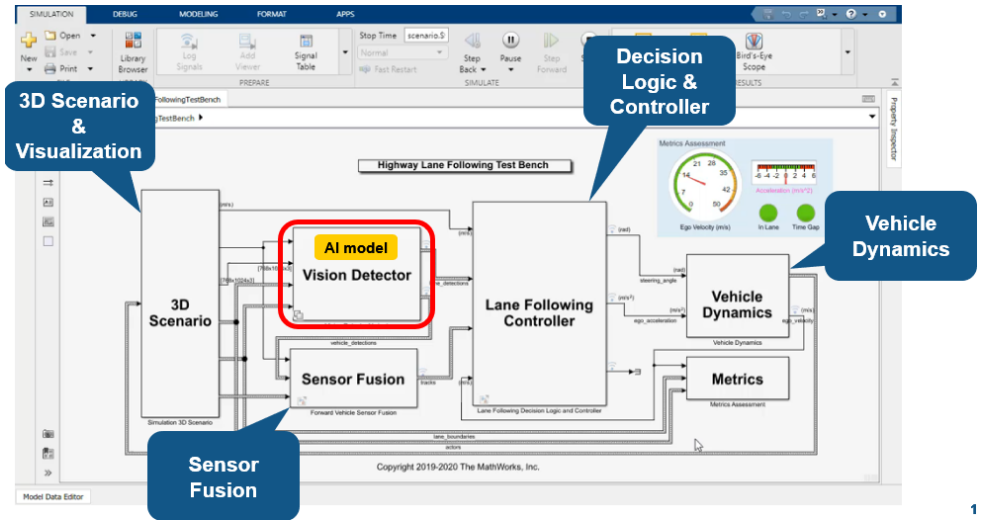


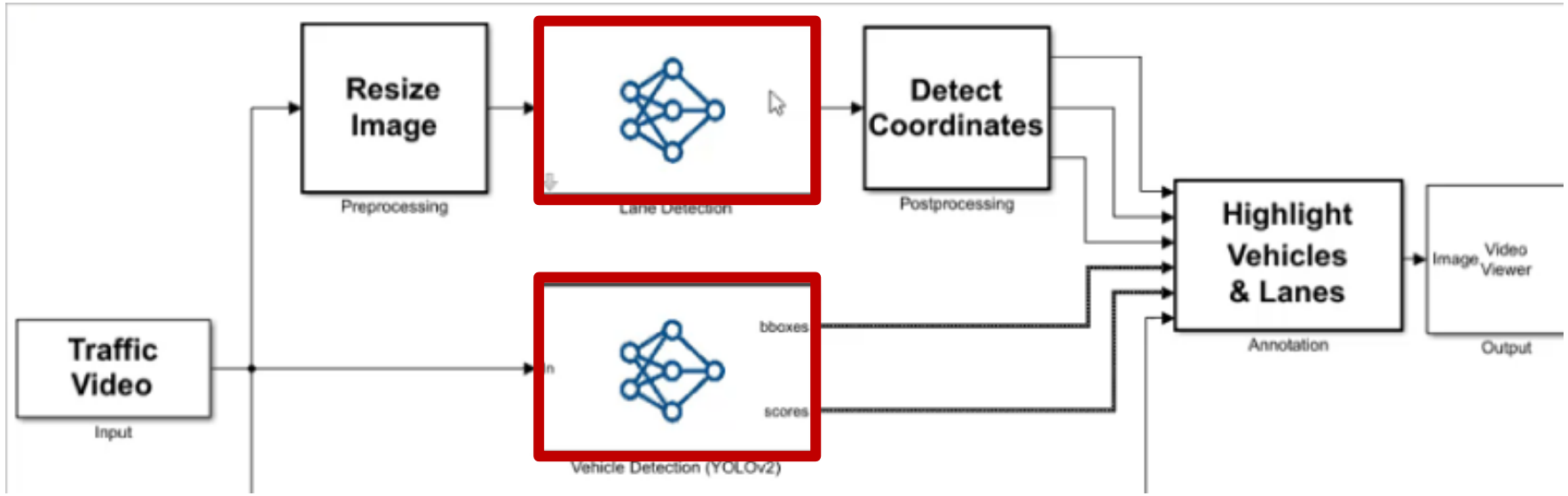
STATEFUL CLASSIFY



STATEFUL PREDICT

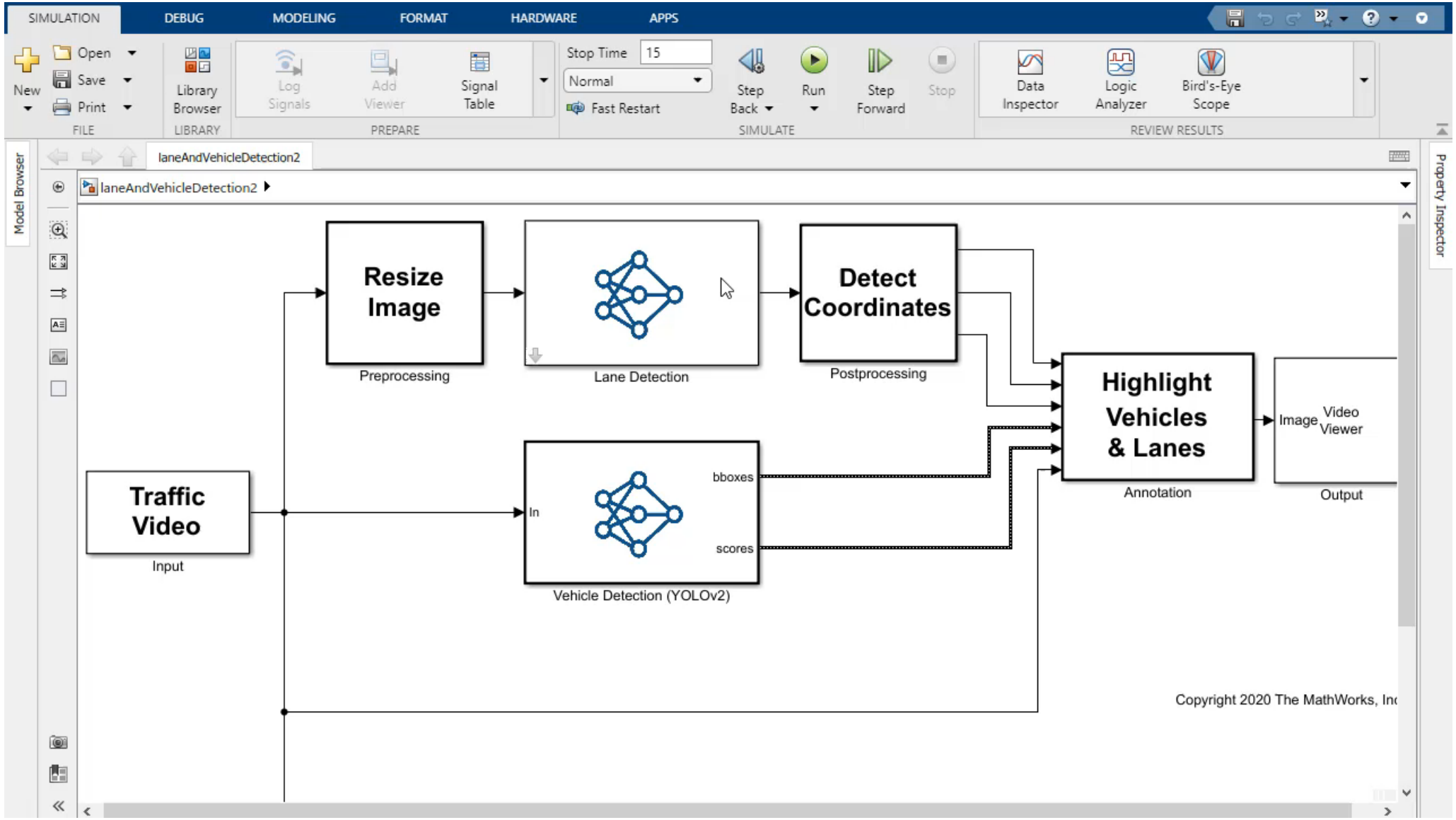
AI Lane Following Model





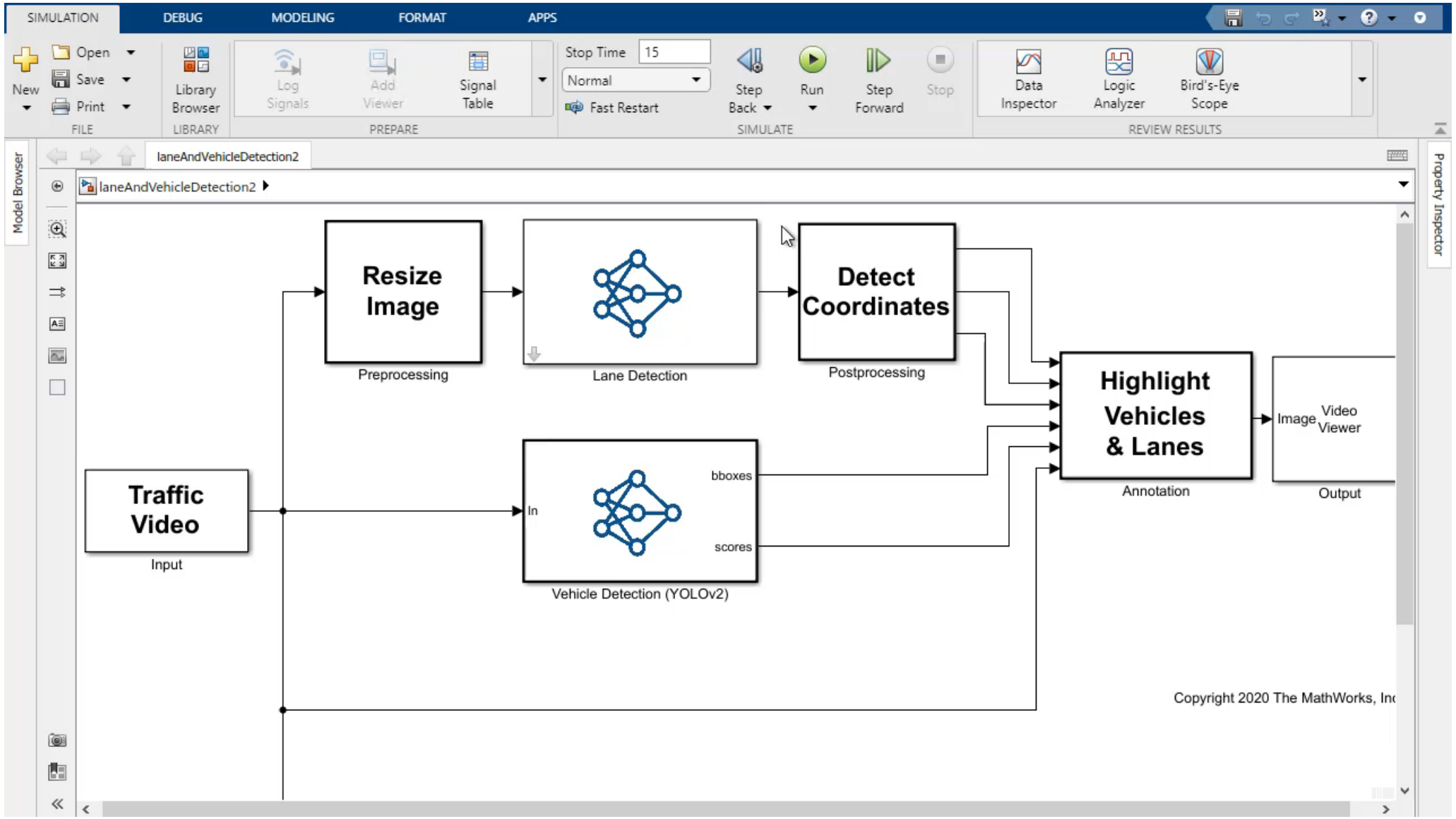
CPU Simulation

Intel CPU

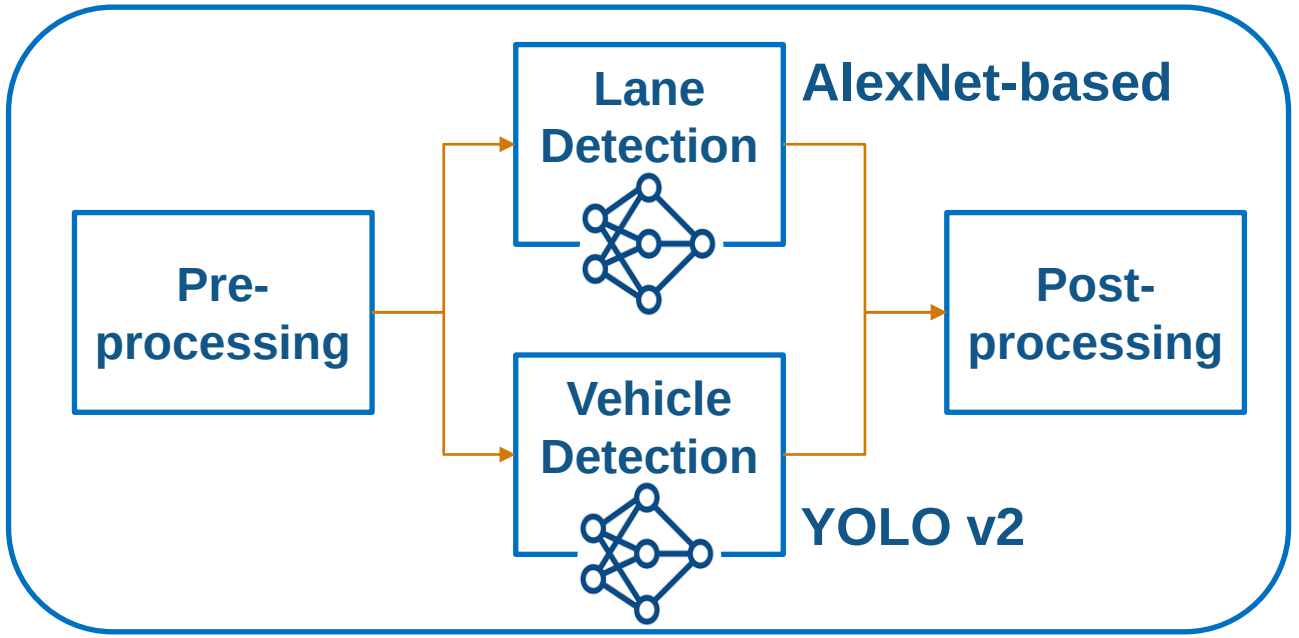


GPU Simulation

NVIDIA GPU



Run on Jetson AGX Xavier



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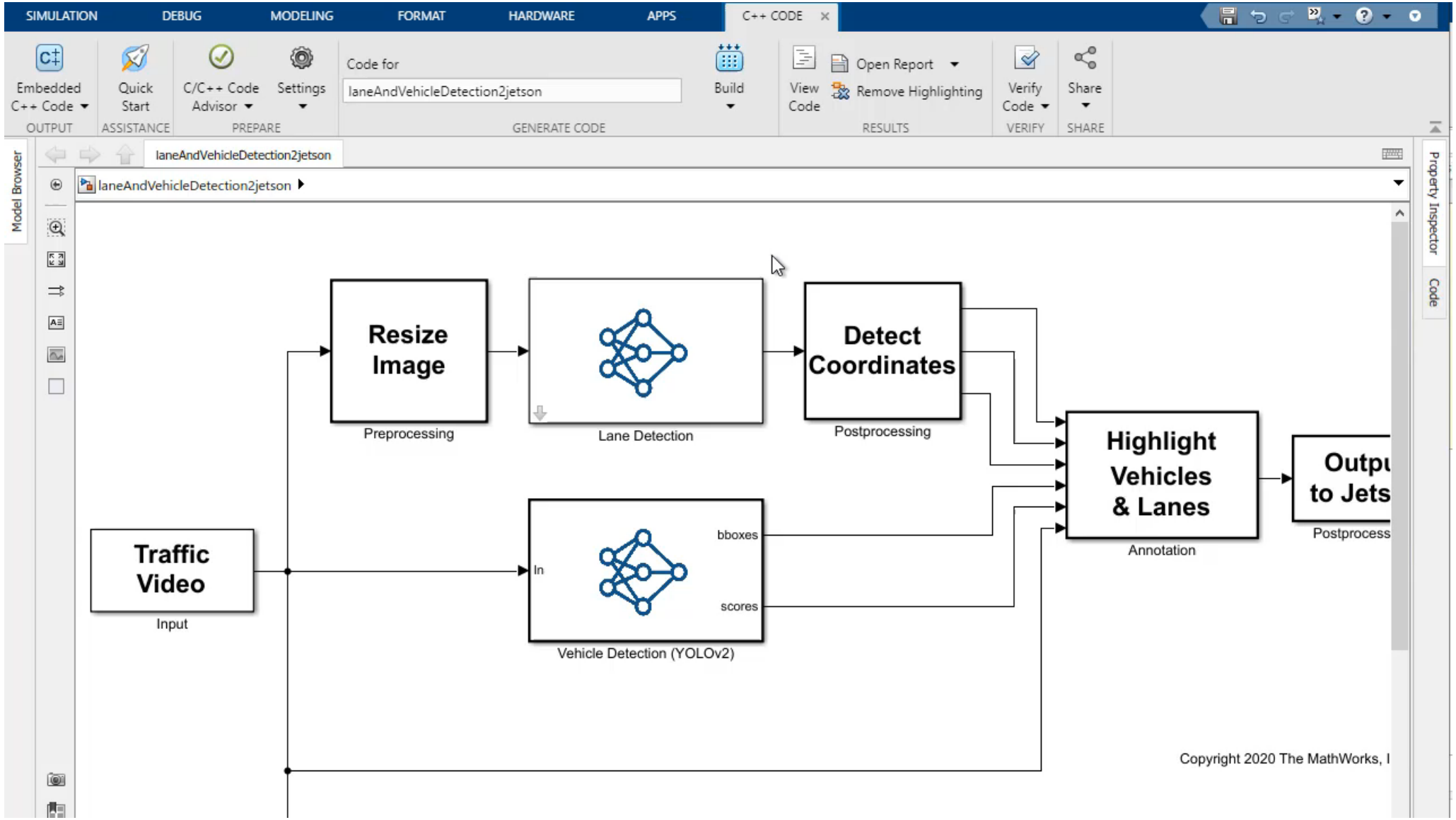
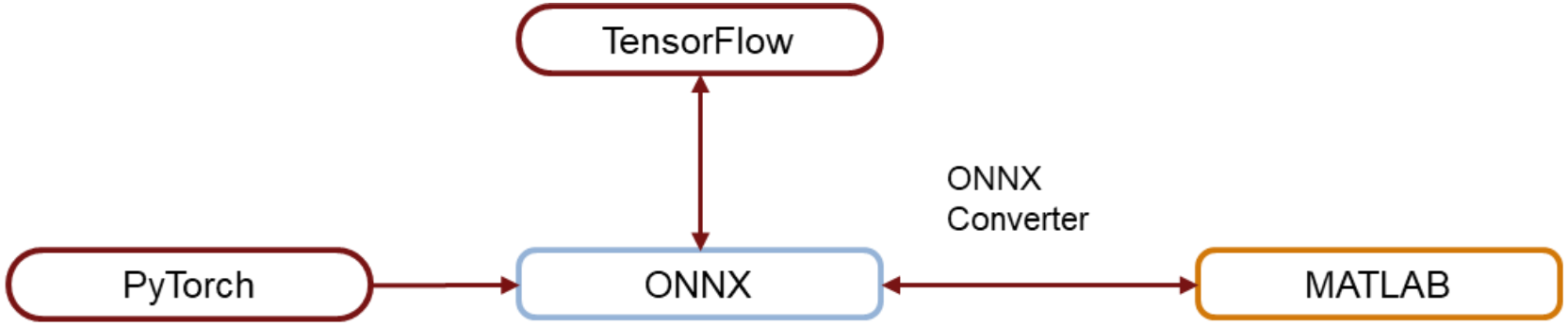
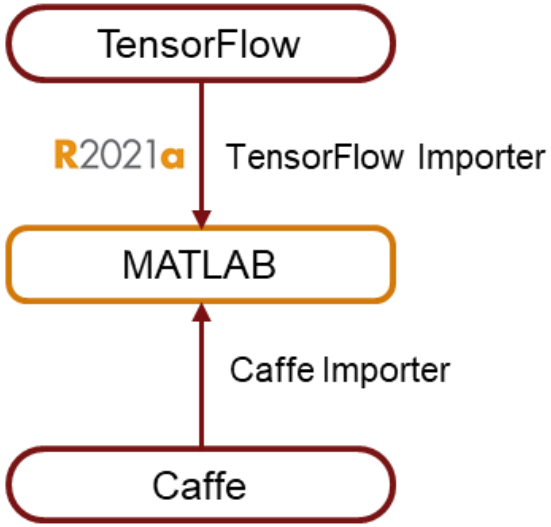


Import Trained Models

External Deep Learning Framework Support



Model exchange using ONNX model format



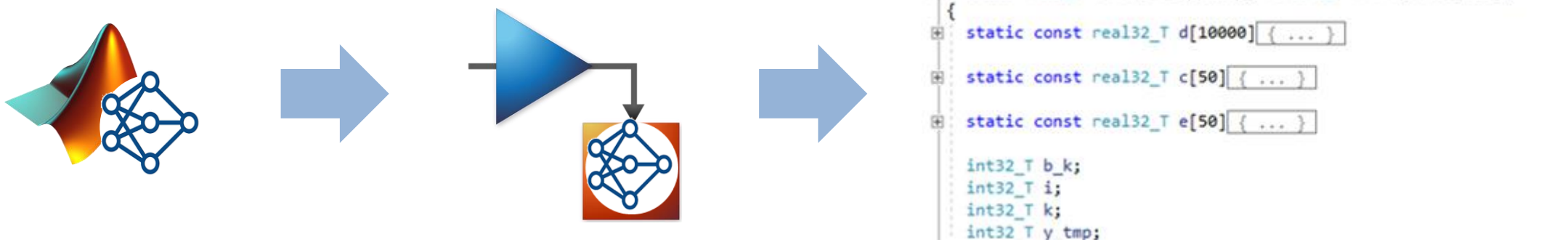
Model importers

Poll questions

- **Where would you deploy AI?**

1. **CPU (including microprocessor & ECU)**
2. **GPU**
3. **FPGA**

User Story - Denso Ten



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"A model-based development workflow is essential in order to use AI for control ECUs. Combining the existing control model and the AI model enables us to establish a simulation environment and accelerate product development."

- Natsuki Yokoyama, Denso Ten

Key Takeaways

Integrate trained AI models into Simulink

- Test design in simulation
- Code generation
- Integrate AI models from others

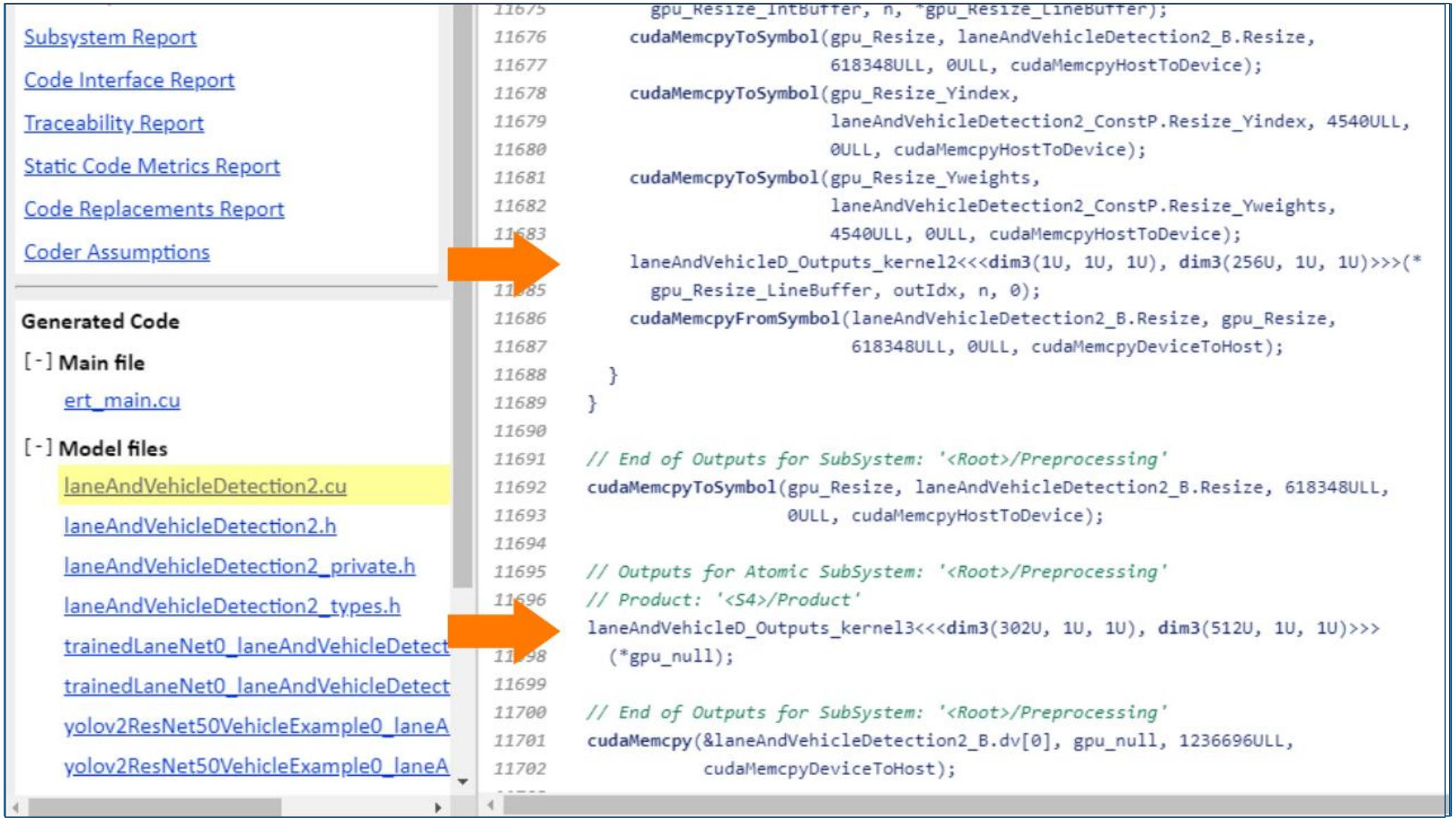
MATLAB EXPO 2021

Thank you

Engagement plan

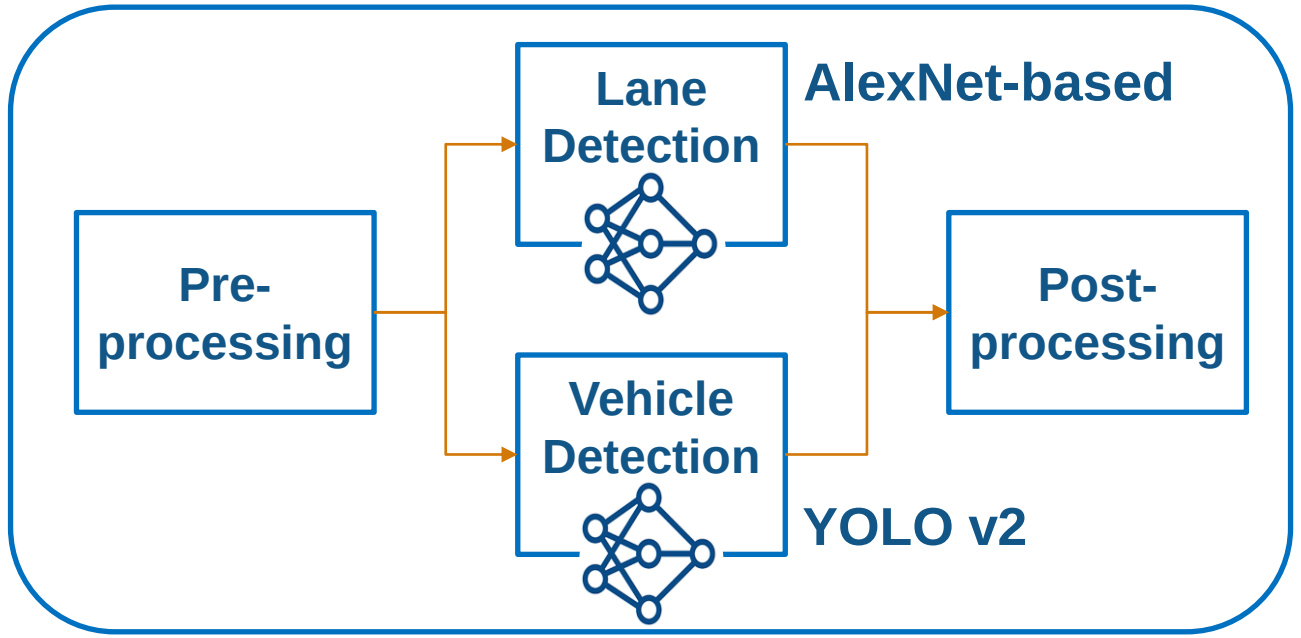
- Dialogue-style presentation
- Hook with angry boss recording
- Polls on slides 6, 18, 32
- Handout in the end

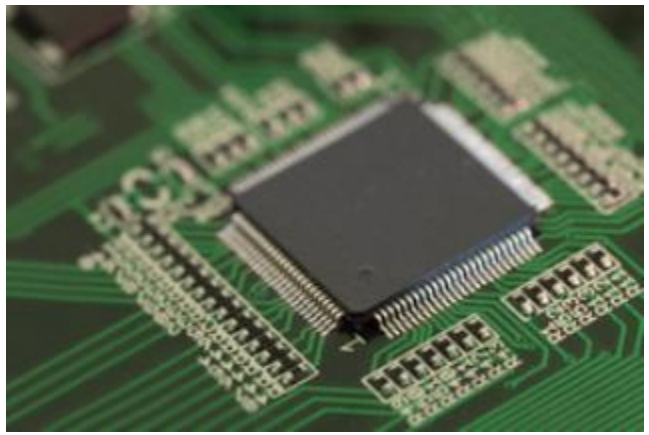
(3) Generate CUDA Code



(5) Run on CPUs

ARM CPU
Generic CPU



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