MATLAB EXPO 2021

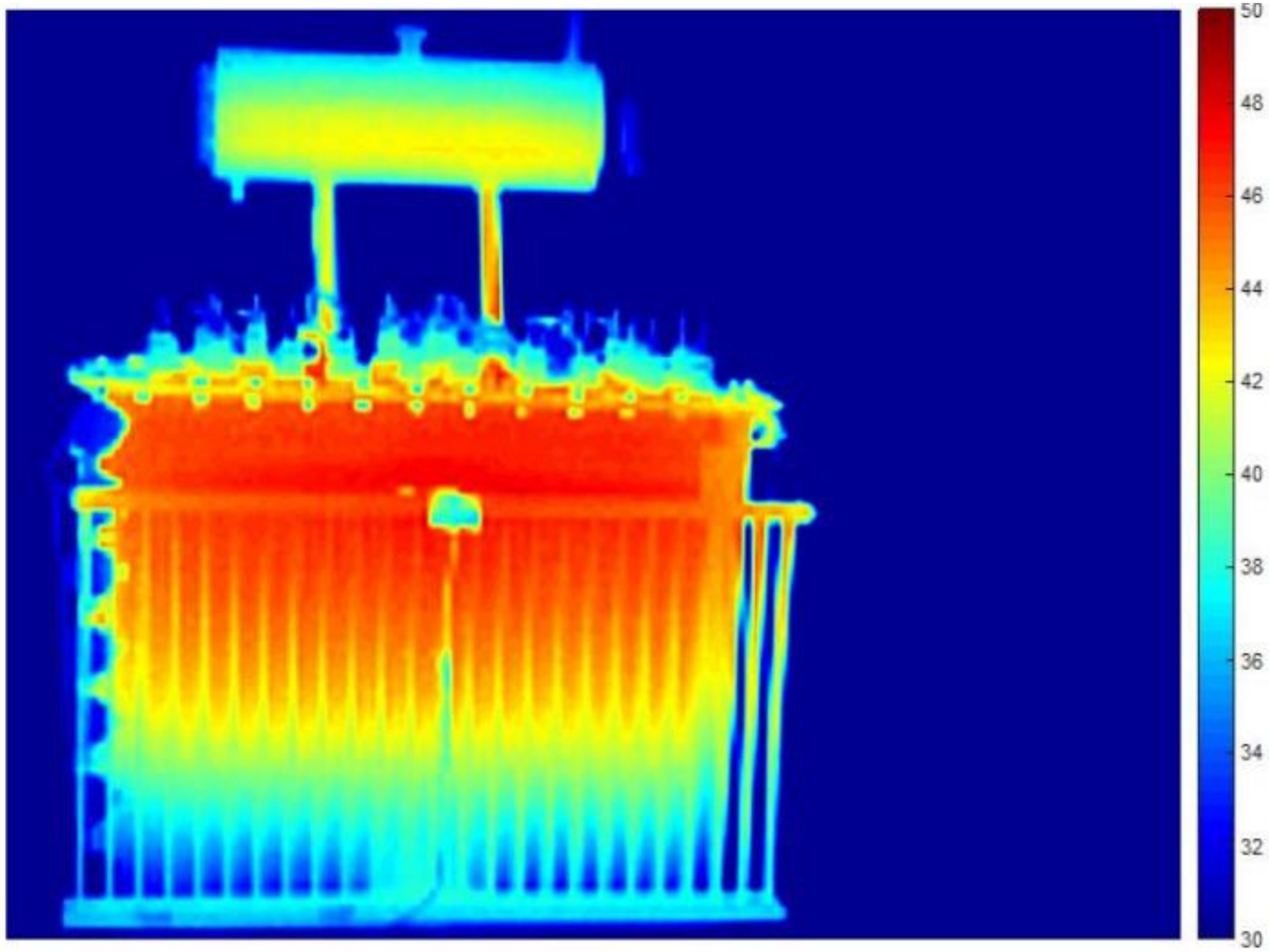
MATLAB을 활용한 임베디드 및 프로덕션 시스템으로의 AI 배포

장규환 차장

MathWorks

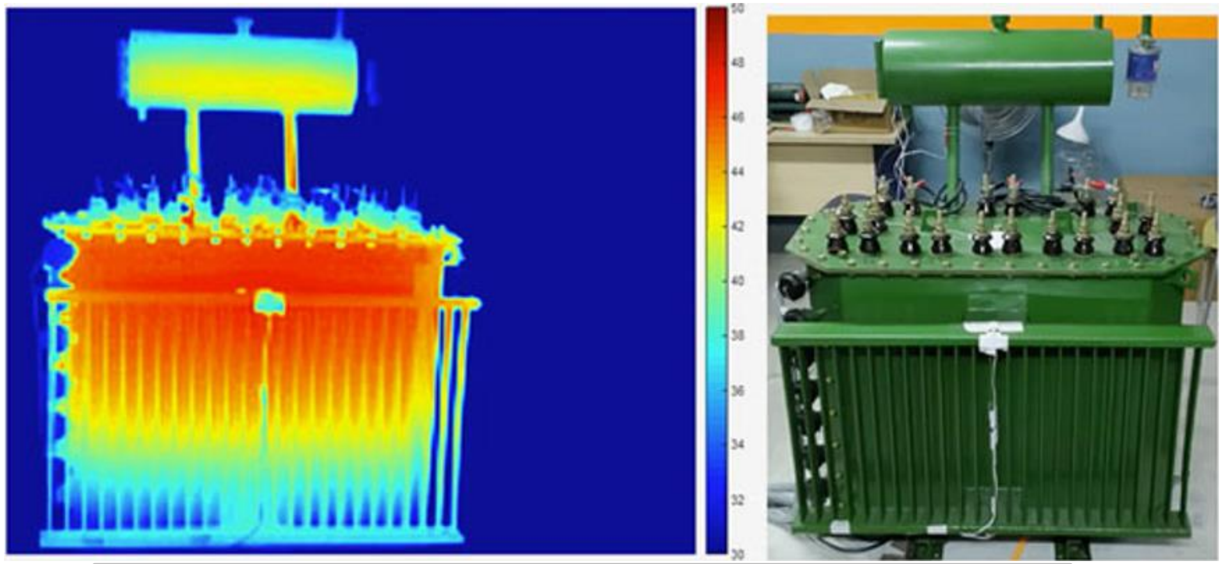
Using the concept of convective heat transfer to estimate the amount of oil in a transformer tank

SIEMENS
Ingenuity for life



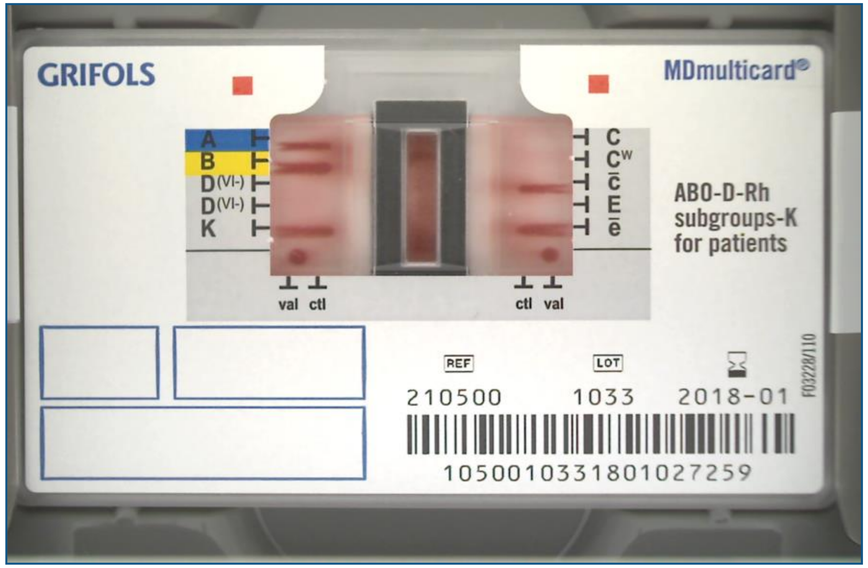
Deployment to Embedded and Enterprise Systems

Enterprise



Health Monitoring of Distribution Transformers SIEMENS

Embedded



Card to Classify Blood Type
IDNEO

Agenda

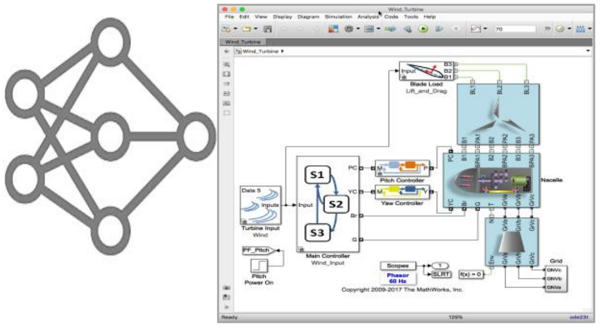
Deploying AI to production is difficult

Three specific challenges:

1. Limitations of Embedded hardware
2. Ongoing changes in environment or system behavior
3. Scale to production load in Enterprise systems

Two Approaches for integrating AI with Larger System

MATLAB



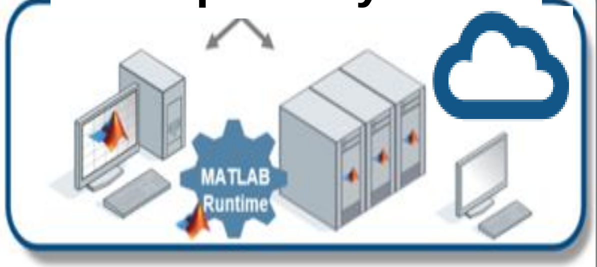
Code Generation

Compiler

Embedded Systems

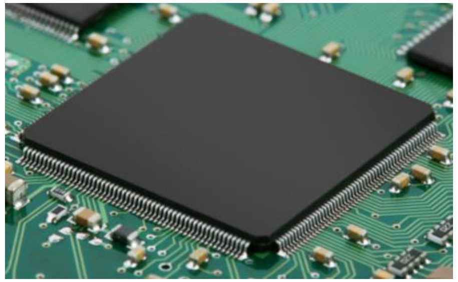
CPU GPU FPGA

Enterprise Systems



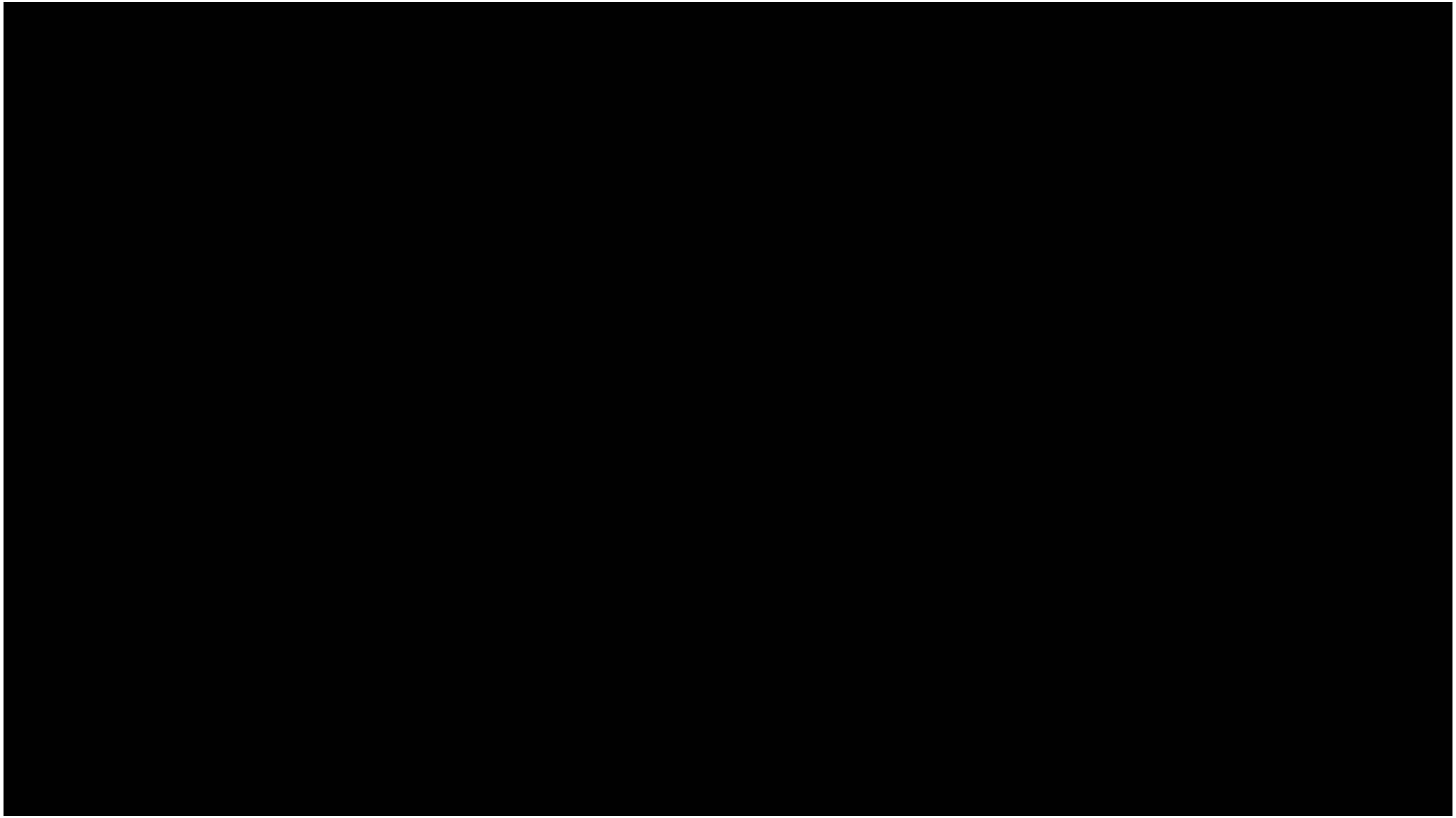
Embedded Deployment of Acoustic Scene Recognition

Squeezenet ~5MB
ResNet-50 ~100MB



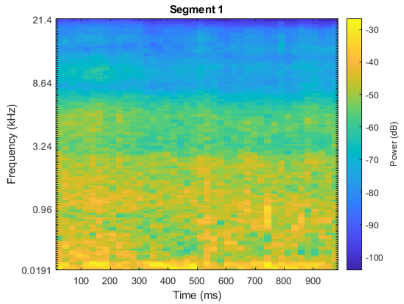
Limited resources

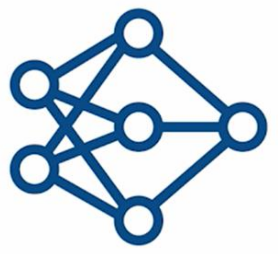
Quiz: Which Sounds do you hear?



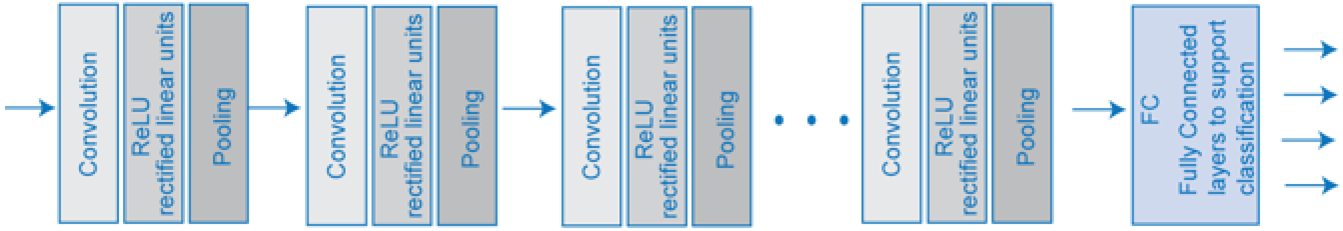
Embedded Deployment of Acoustic Scene Recognition

Reformat the data





Convolutional Neural Networks (**CNN**)



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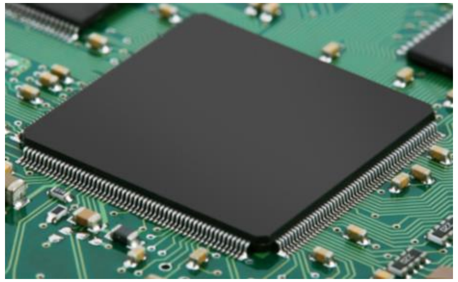
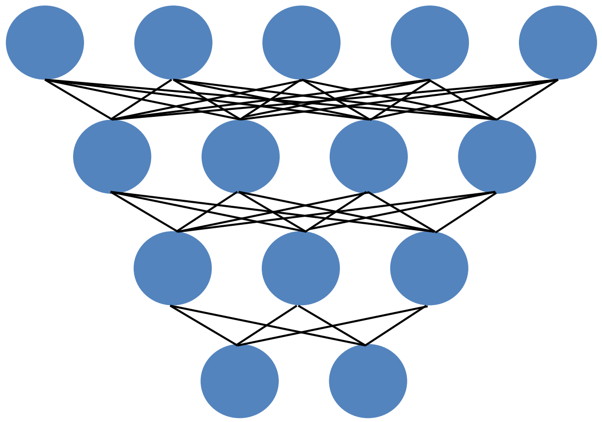


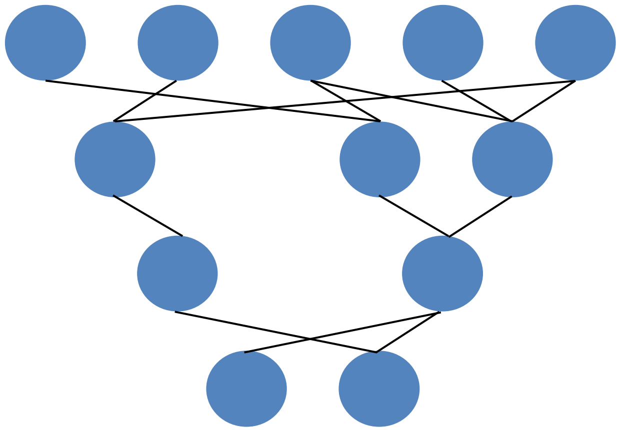
Limited resources

How can Embedded Deployment Be Enabled?

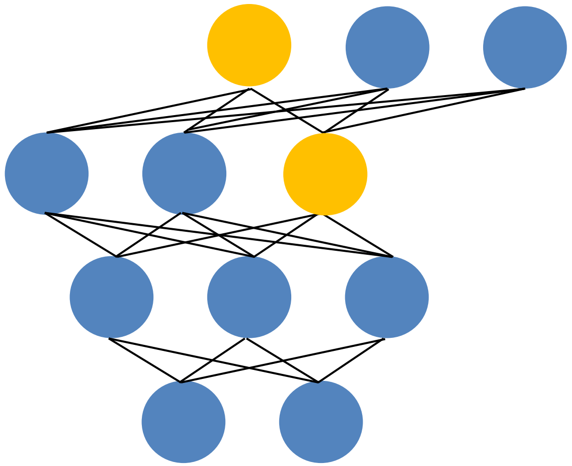
Original



Pruning



Layer Fusion



Quantizing

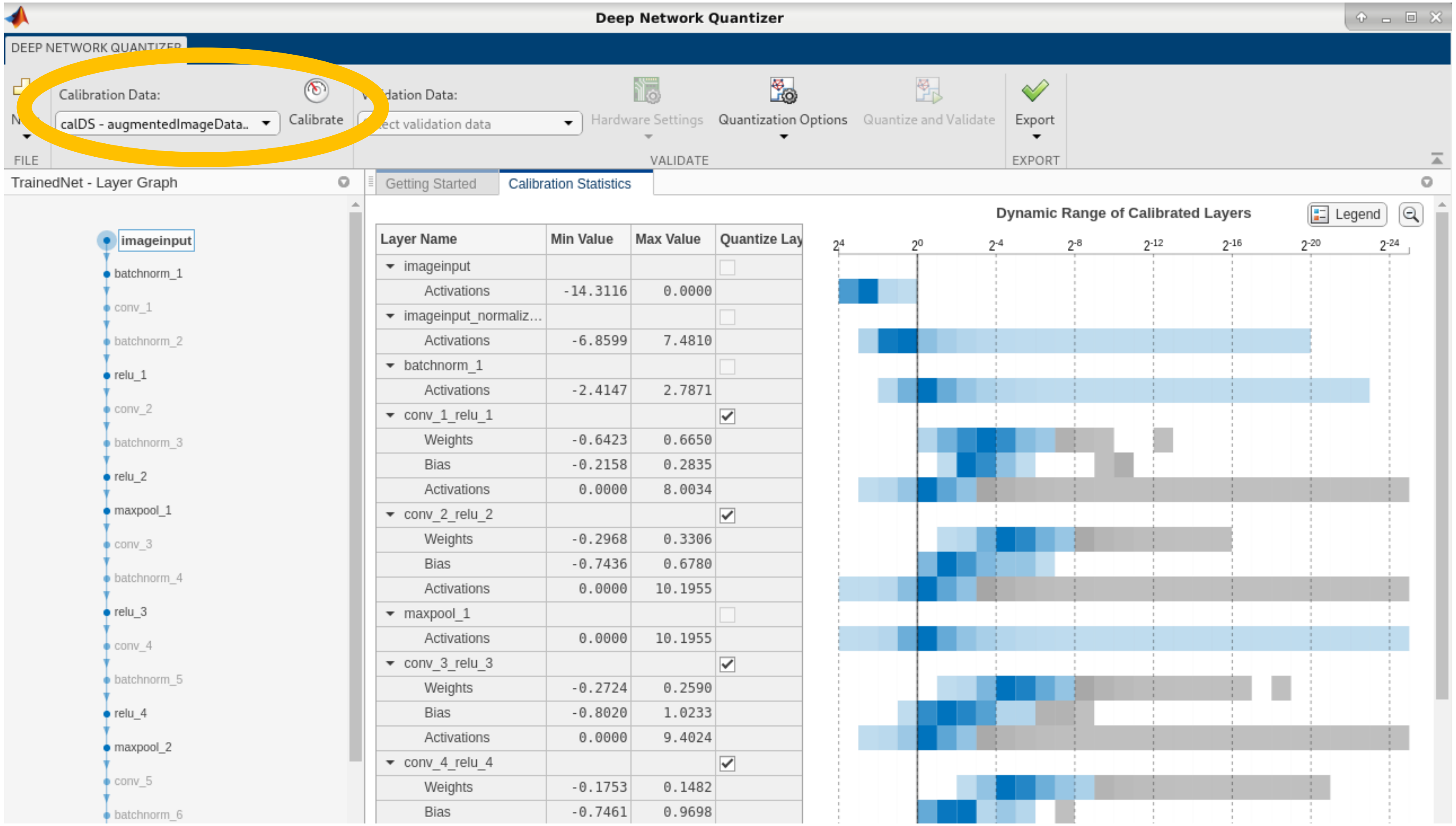
Deep Learning Quantization: Acoustic Scene Classification

Use Deep Network Quantizer to Optimize the Inference Network

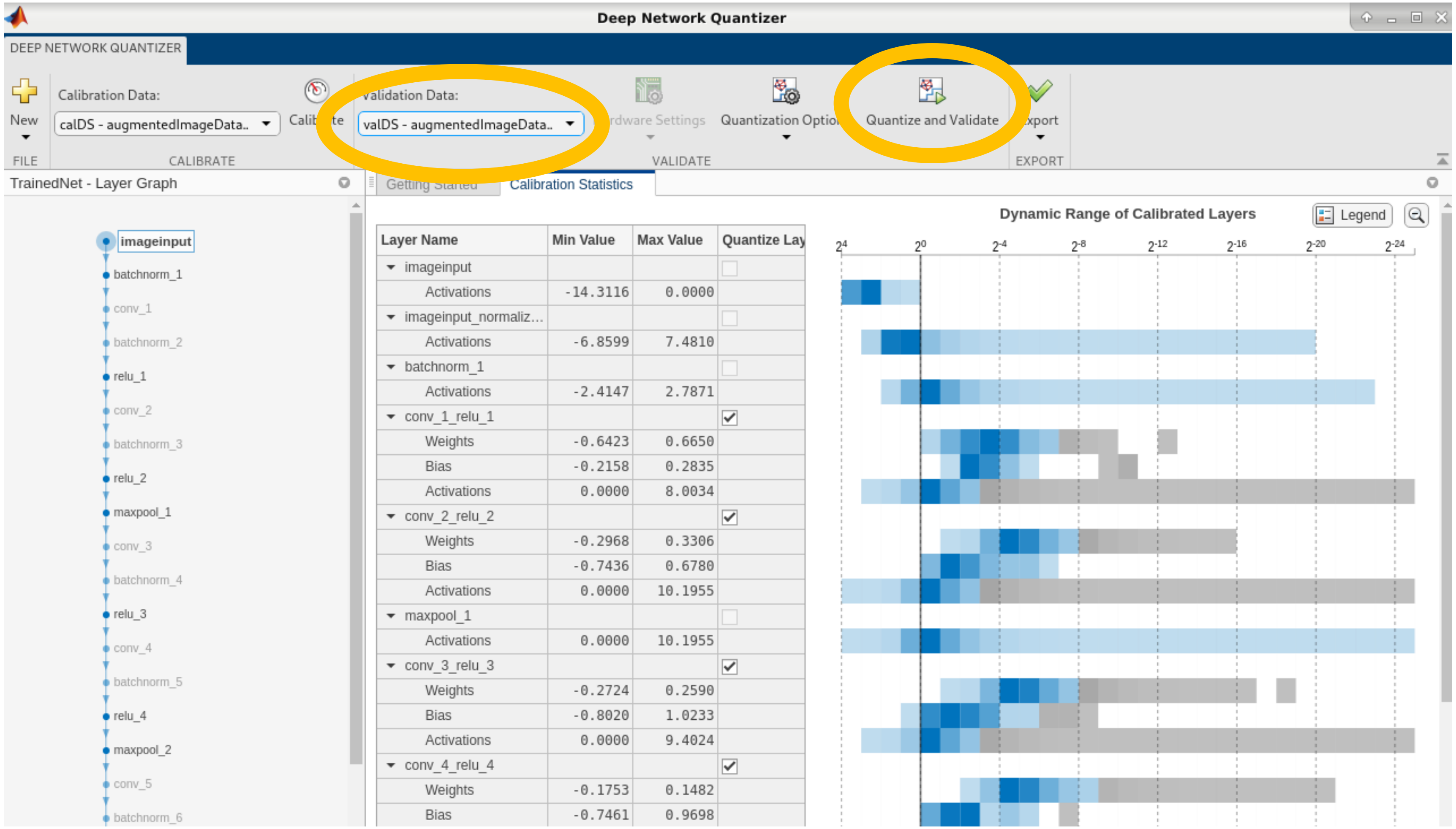
```
load('trainedNet');
analyzeNetwork(trainedNet);
numData = size(xTrain);
numData = numData(end);
augImds = augmentedImageDatastore(trainedNet.Layers(1).InputSize, xTrain, yTrain);
calDS = augImds.subset(1:floor(numData * 0.8));
valDS = augImds.subset(floor(numData * 0.8)+1:numData);
dq = dlquantizer(trainedNet, 'ExecutionEnvironment', 'GPU');
dq.calibrate(calDS)
```

- Load trained network
- Split data: calibration – 80%, validation – 20%
- Launch Deep Network Quantizer App

Deep Learning Quantization: Acoustic Scene Classification

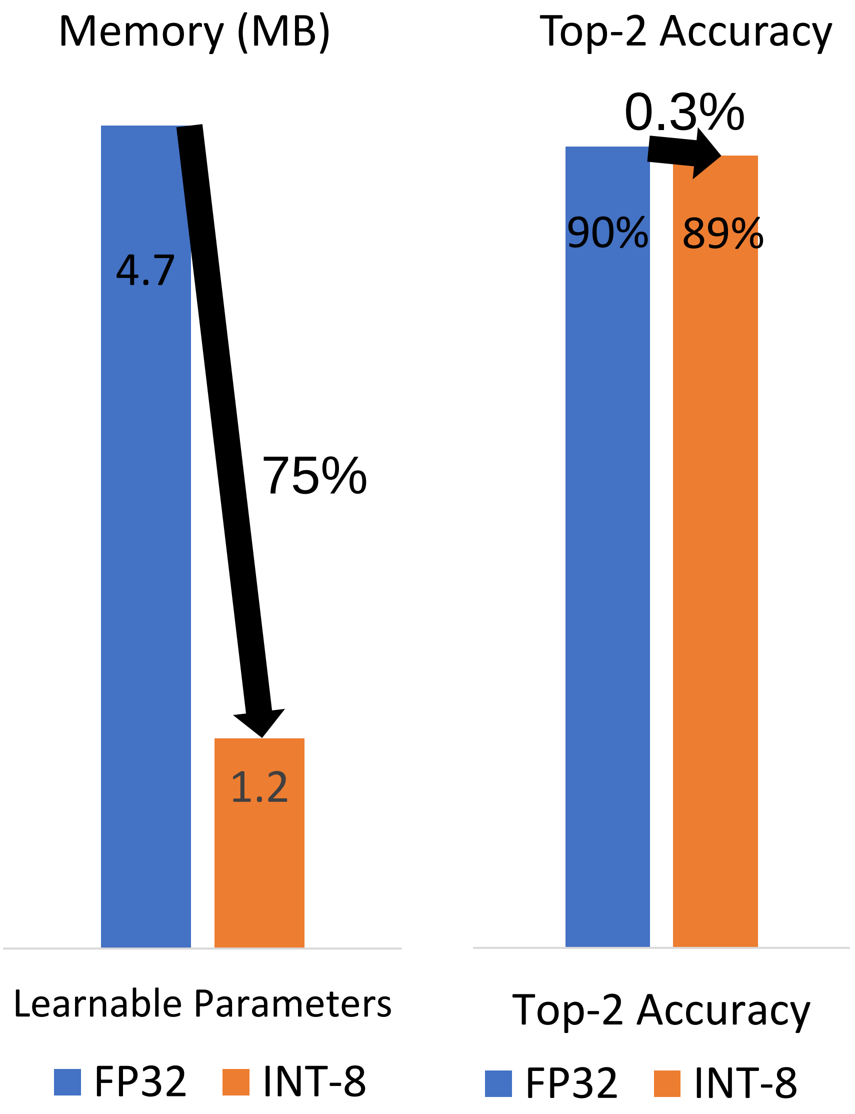


Deep Learning Quantization: Acoustic Scene Classification



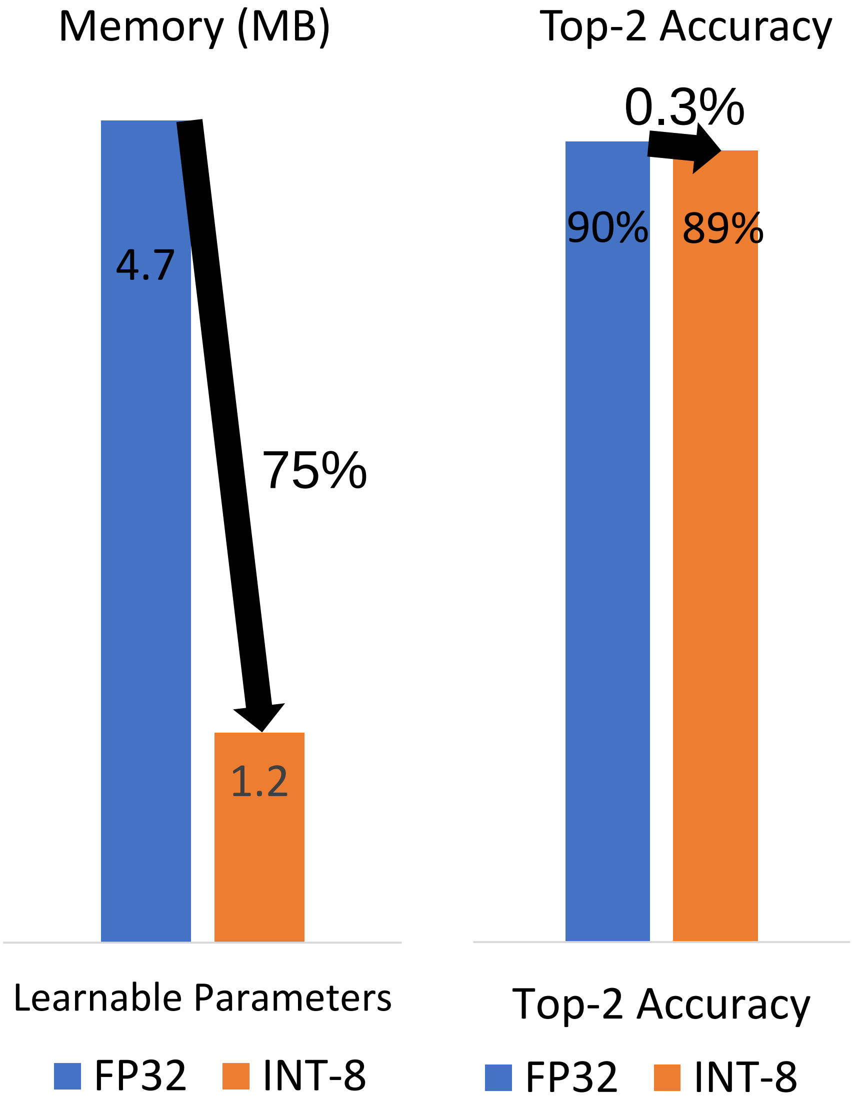
Deep Learning Quantization: Acoustic Scene Classification

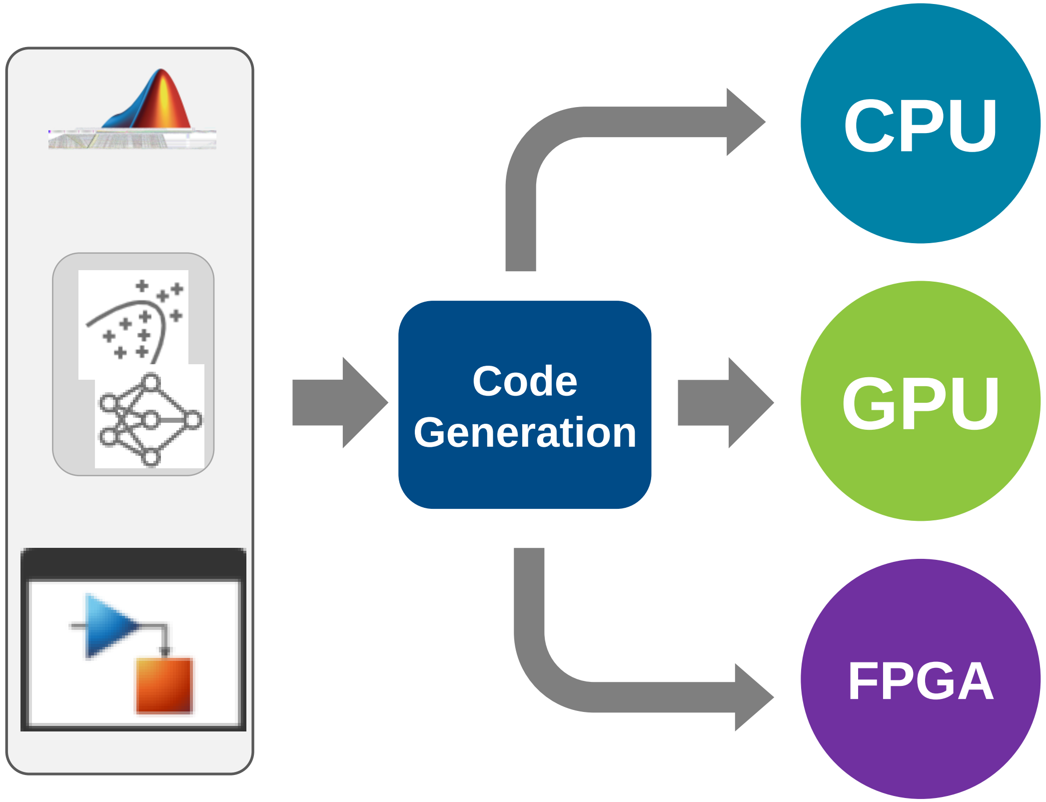
Validation Results



Deep Learning Quantization: Acoustic Scene Classification

Validation Results





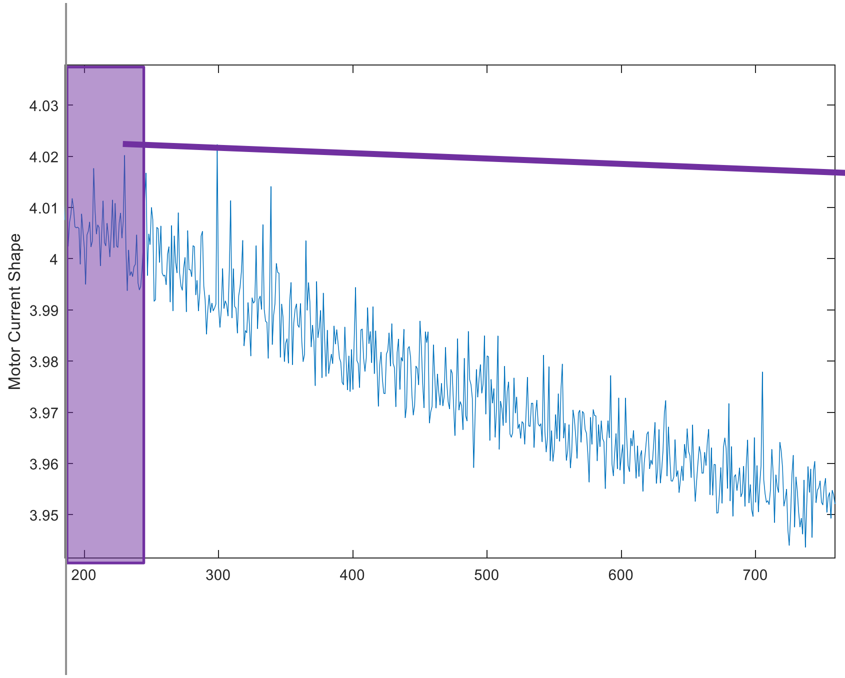
Agenda

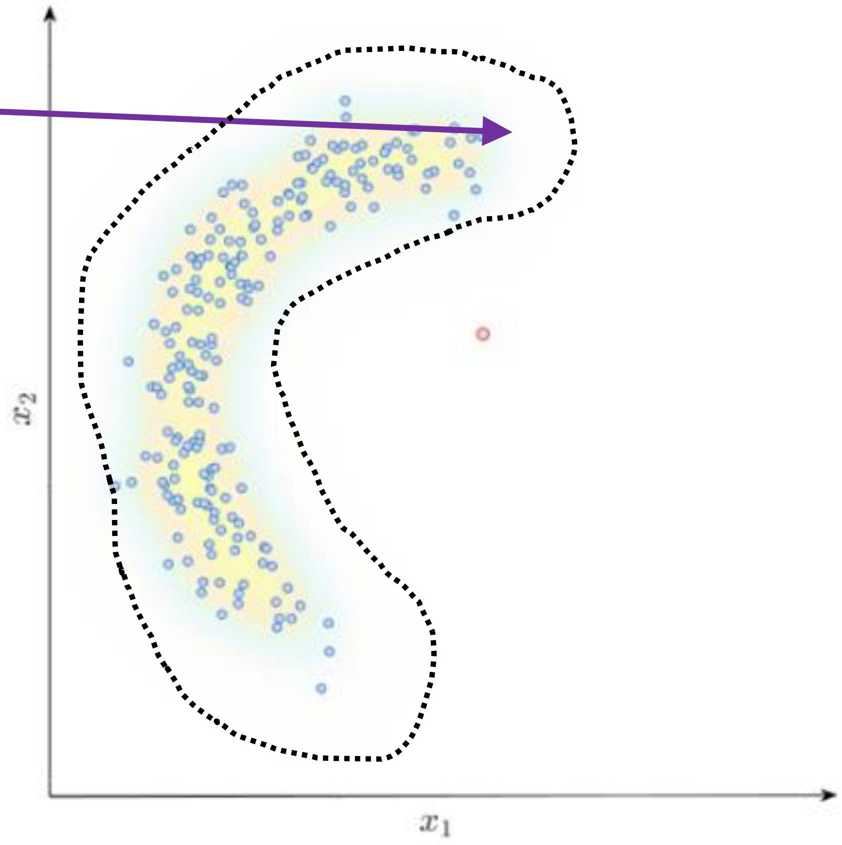
Deploying AI to Embedded and Enterprise systems is difficult

Three specific challenges:

1. Limitations of Embedded hardware ✓
2. Ongoing changes environment or system behavior
3. Scale to production load in Enterprise systems

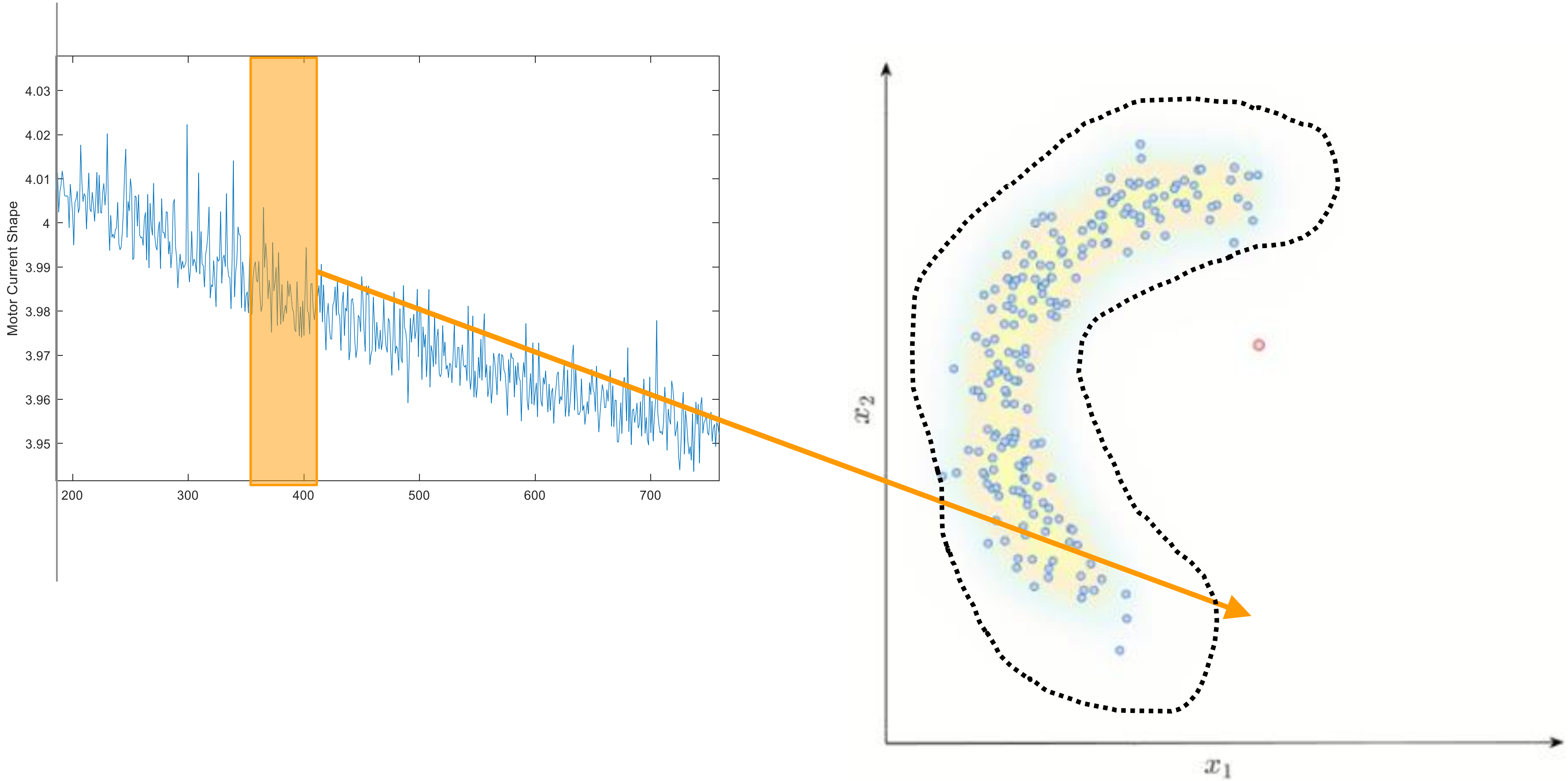
AI models reflect System behaviors and Environment



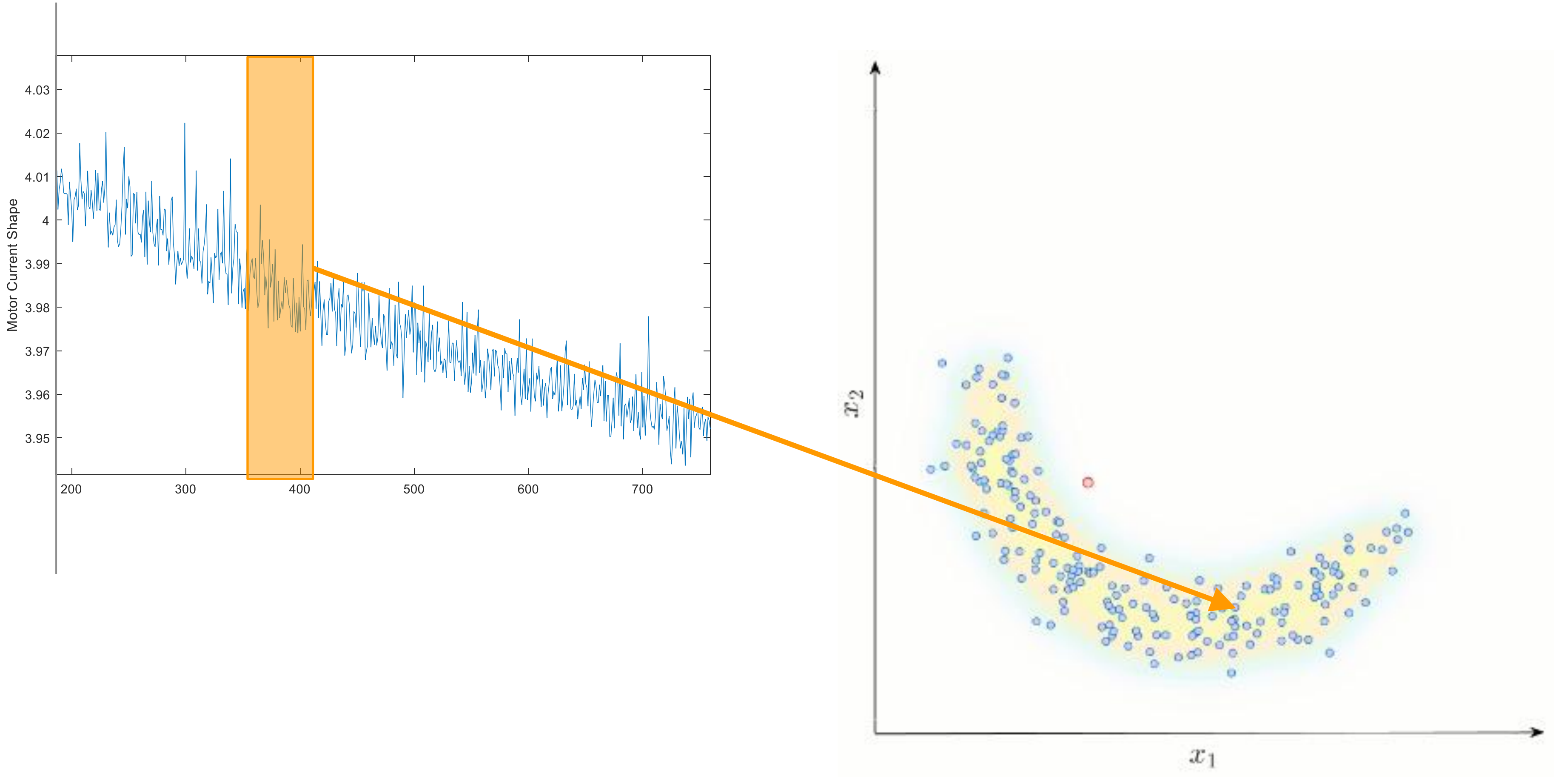


(illustration only; not based on actual data)

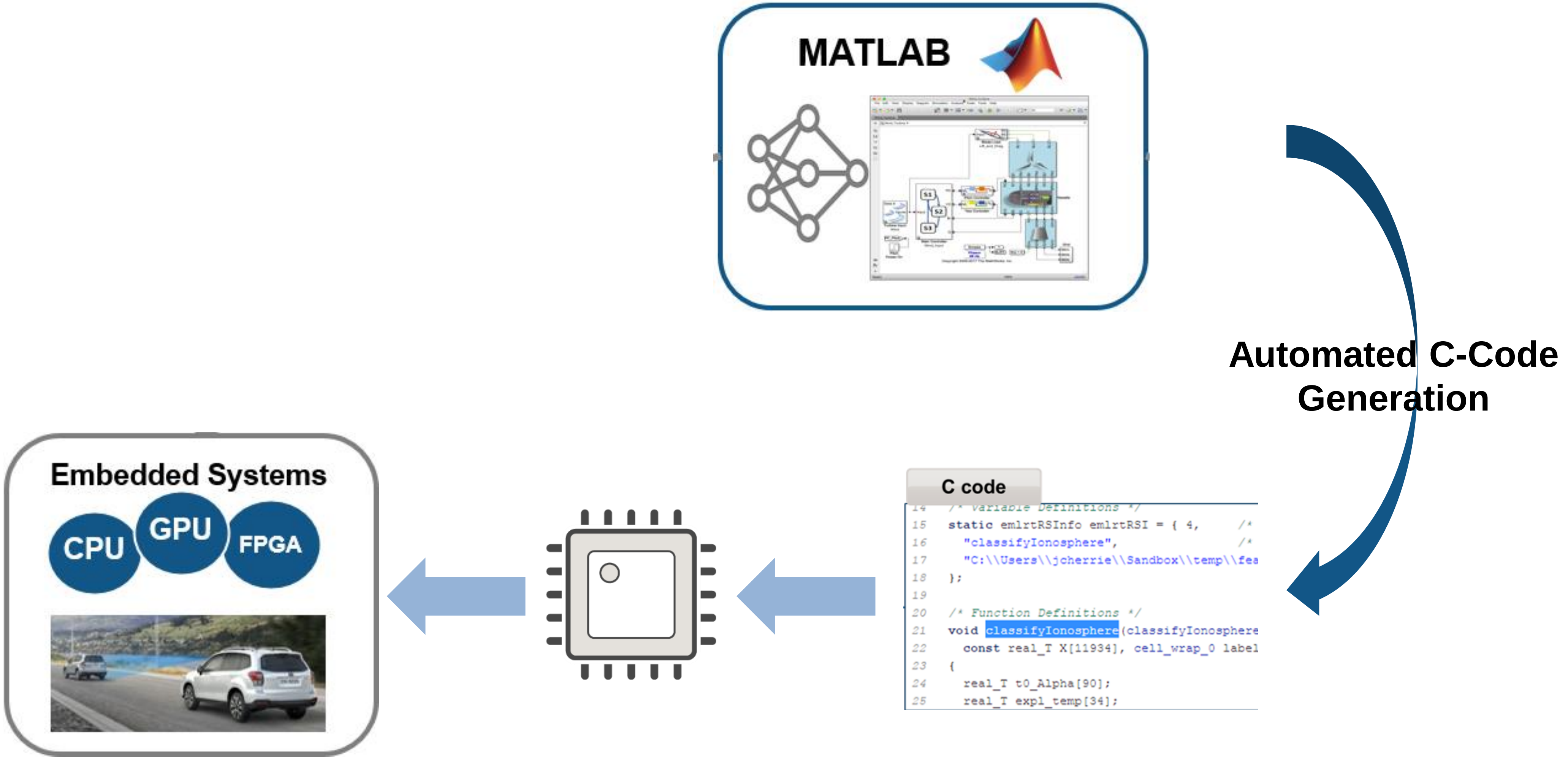
AI models reflect System behaviors and Environment



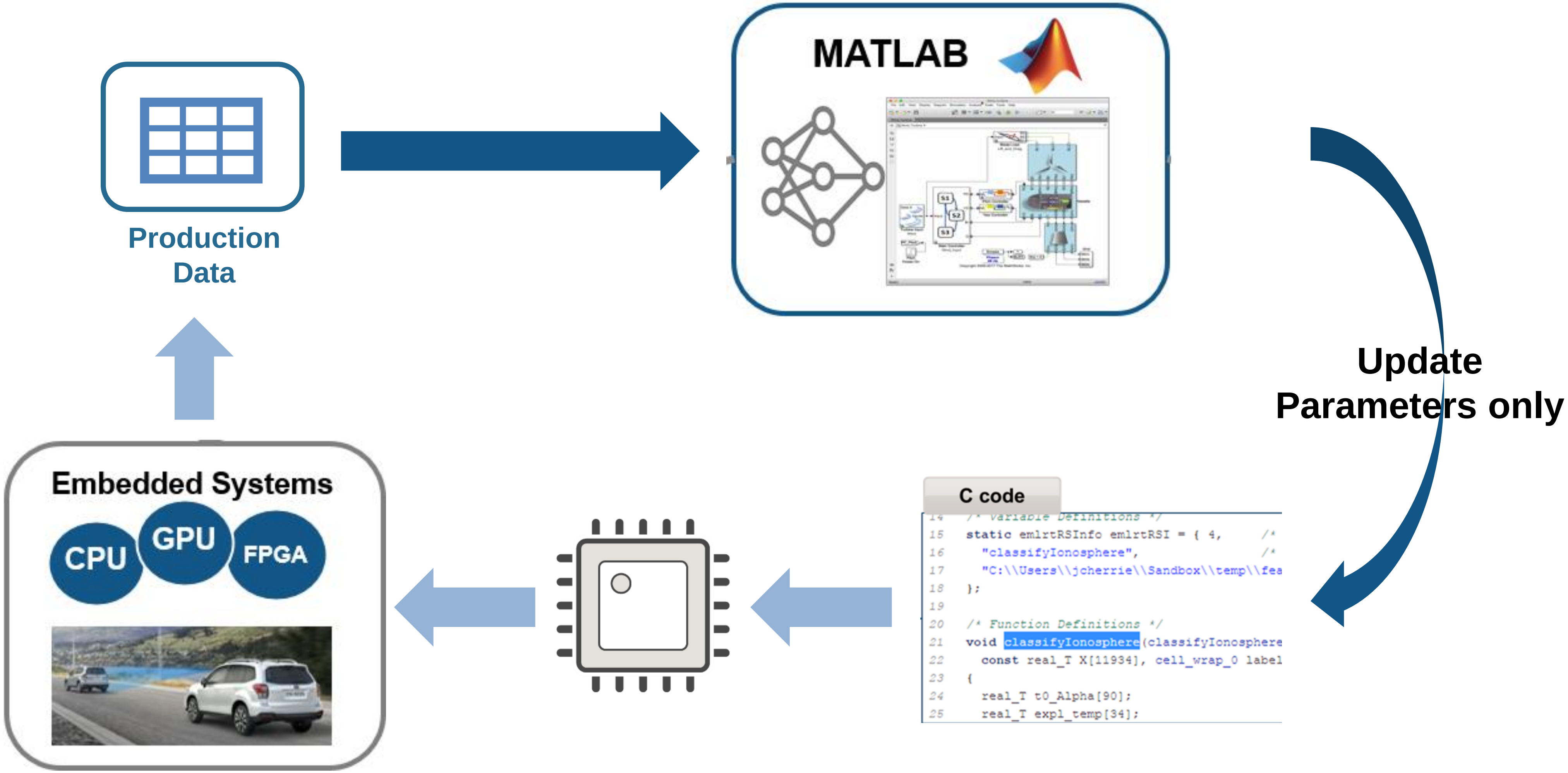
Deployed Models Need to Adapt.



Model Updates in Embedded Deployment



Model Updates in Embedded Deployment



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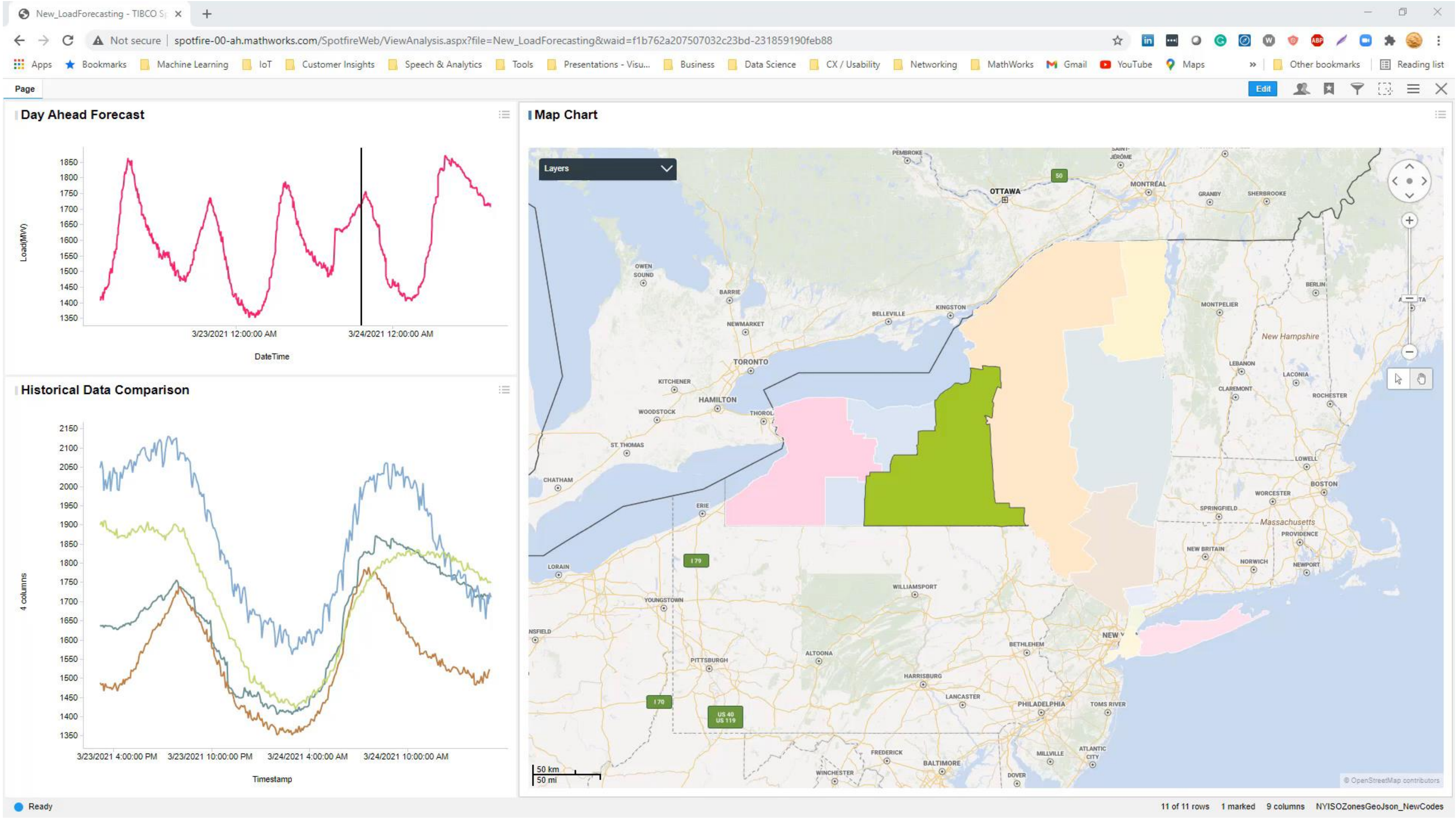
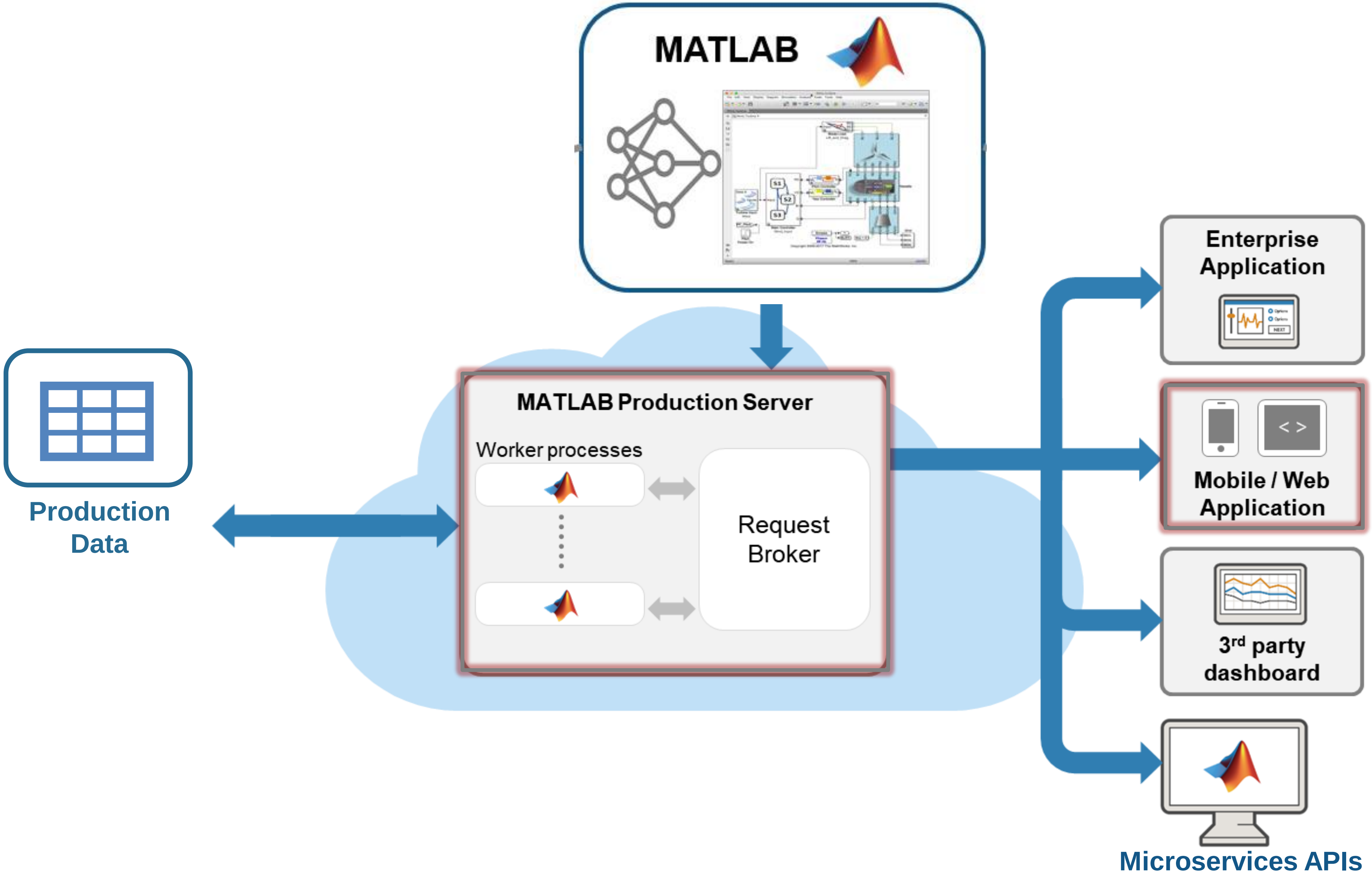
Enterprise Deployment of AI

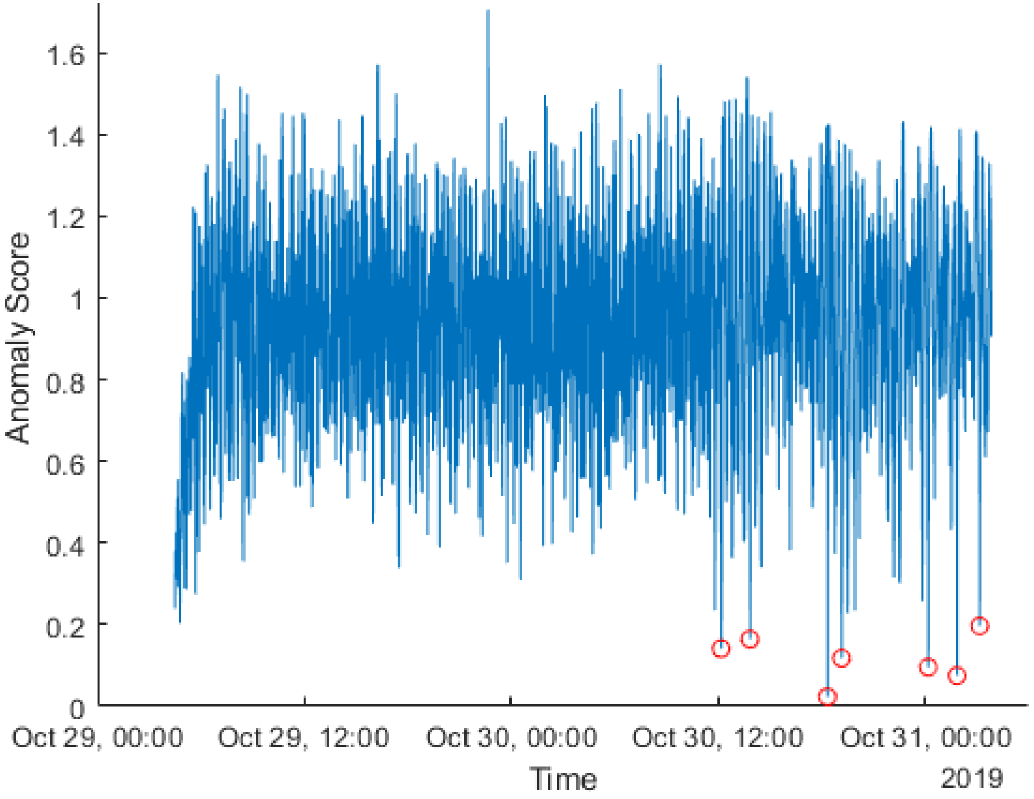


Integrate with Enterprise Systems and Scale to Production Load



Example: Incremental Health Monitoring

Sensor data



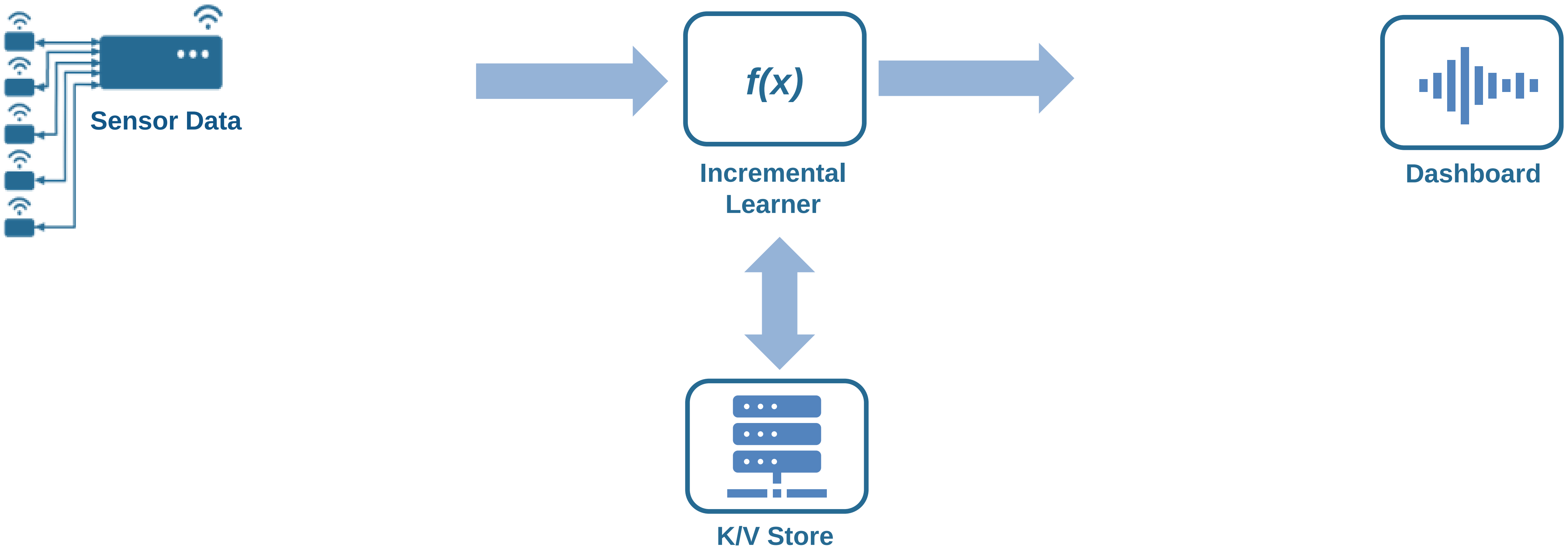
Anomaly Detection loop

```
while seqn % ... there's more data to process

    % Retrieve buffer of data
    datafilter = (sensordata.key == thisAsset) & (sensordata.Seque
        (sensordata.SequenceNumber <= seqn+batchsize);

    streamdata = sensordata(datafilter,:);

    % Detect Anomalies with incremental One-class SVM
    [nextState, results] = detectAnomalyLocal(streamdata, state);

    % Remember results and update state of incremental learner
    anomalies(datafilter) = results.anomaly;
    score(datafilter) = results.score;
    timestamps(datafilter) = results.timestamp;
    state = nextState;

    seqn = seqn + batchsize; % step through batch test data
end
```

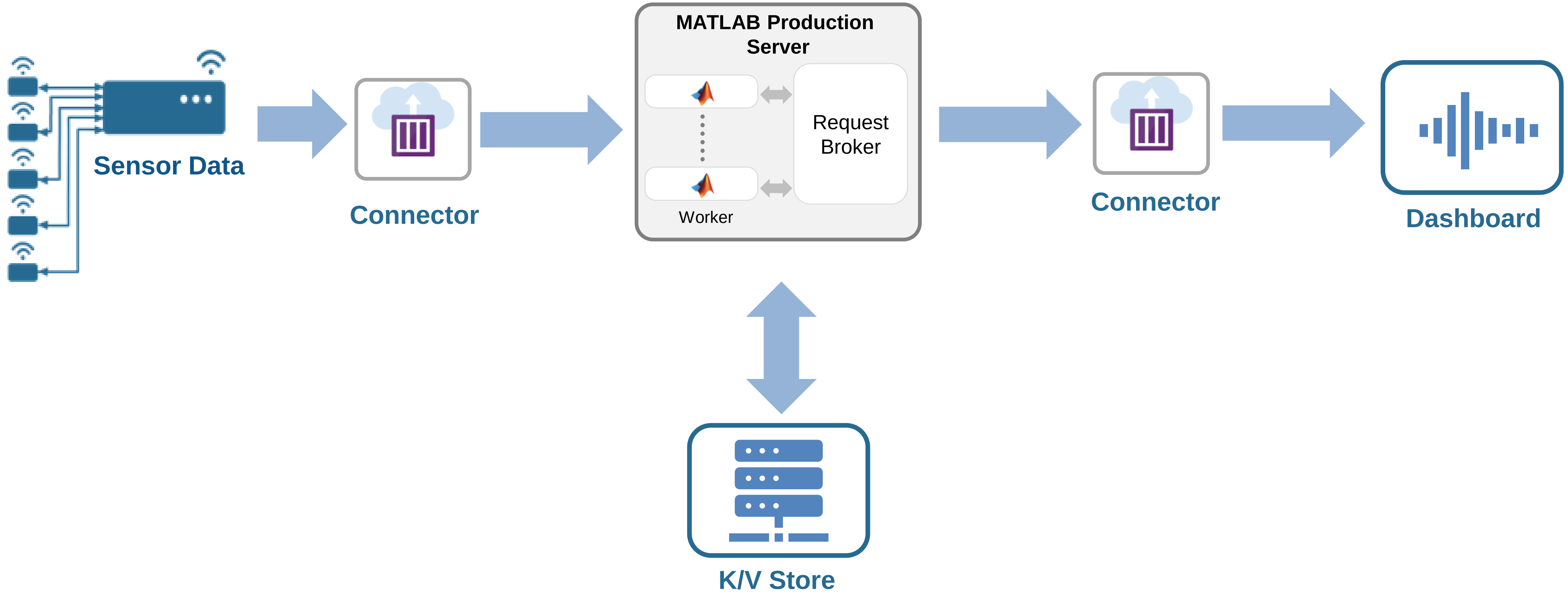
Incremental Learning within Streaming Architecture

R2020b

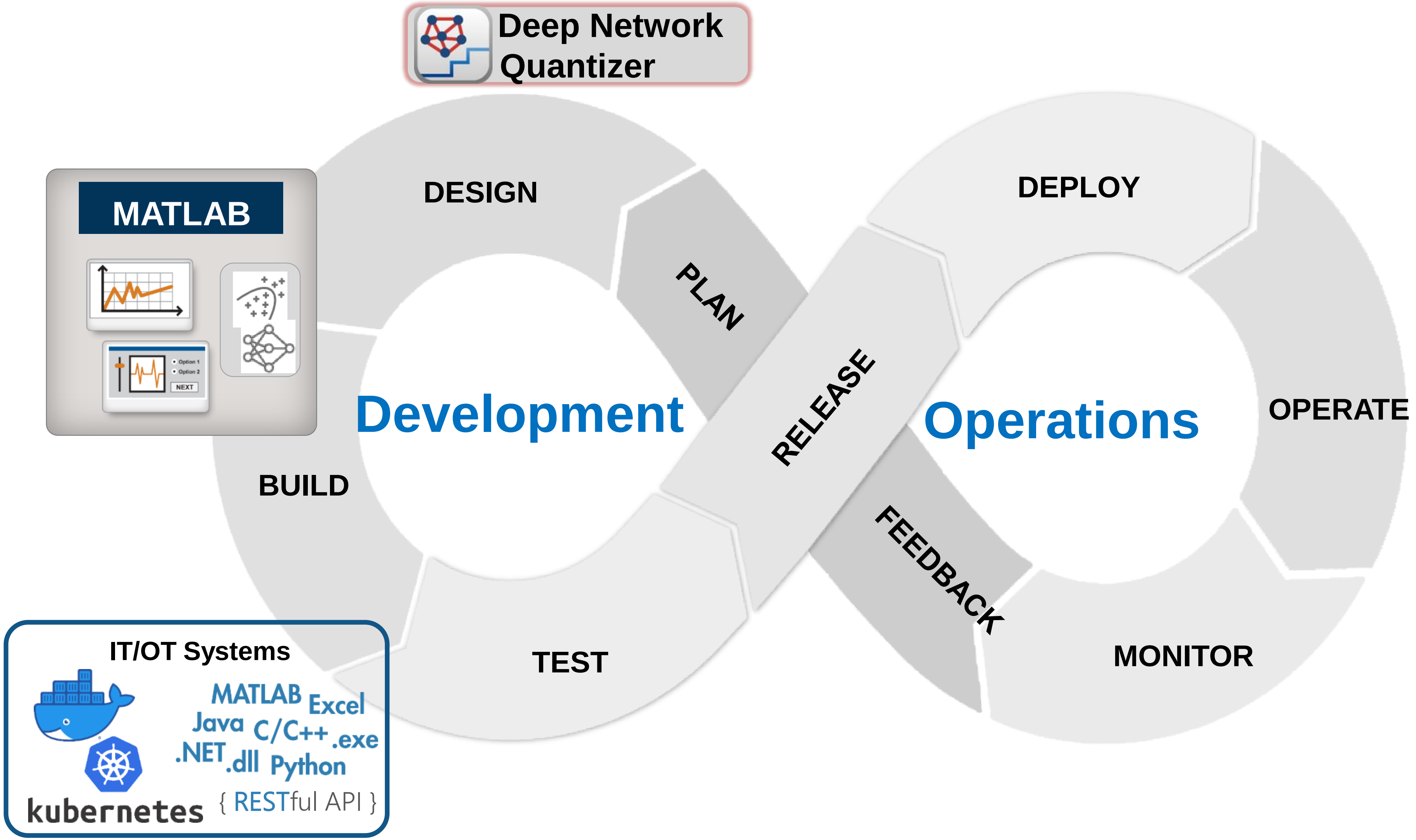
```
incMdl = incrementalLearner(mdl);

while dataStreaming
   featureChunk = extractFeatures(streamdata);
   inclMdl = updateMetricsAndFit(incMdl,featureChunk,labels);
End
```



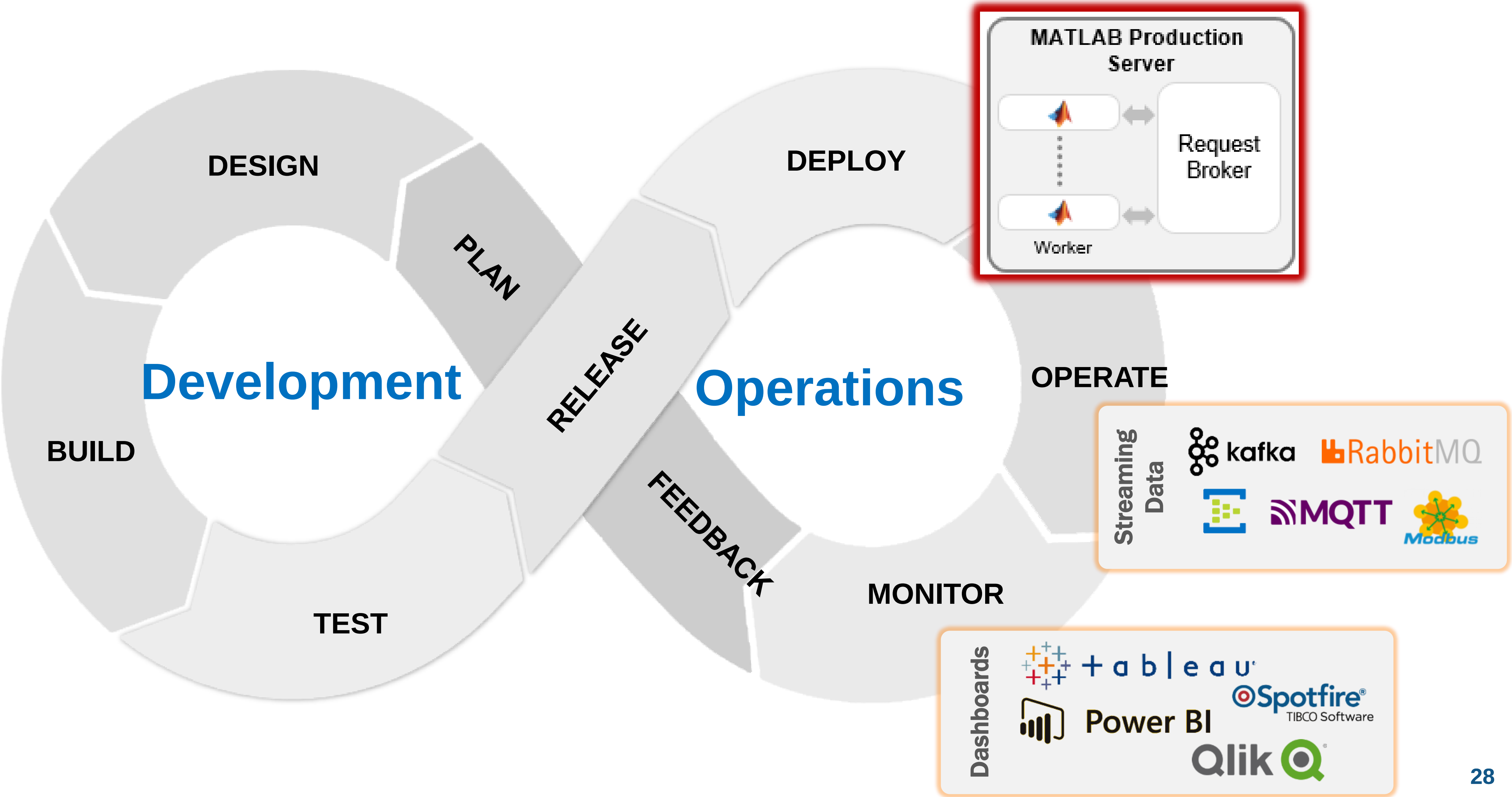
Incremental Learning within Streaming Architecture



Operationalize AI without recoding



Model DevOps: Operationalize AI without recoding



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Conclusions

Deploy to Embedded and Enterprise systems from one codebase

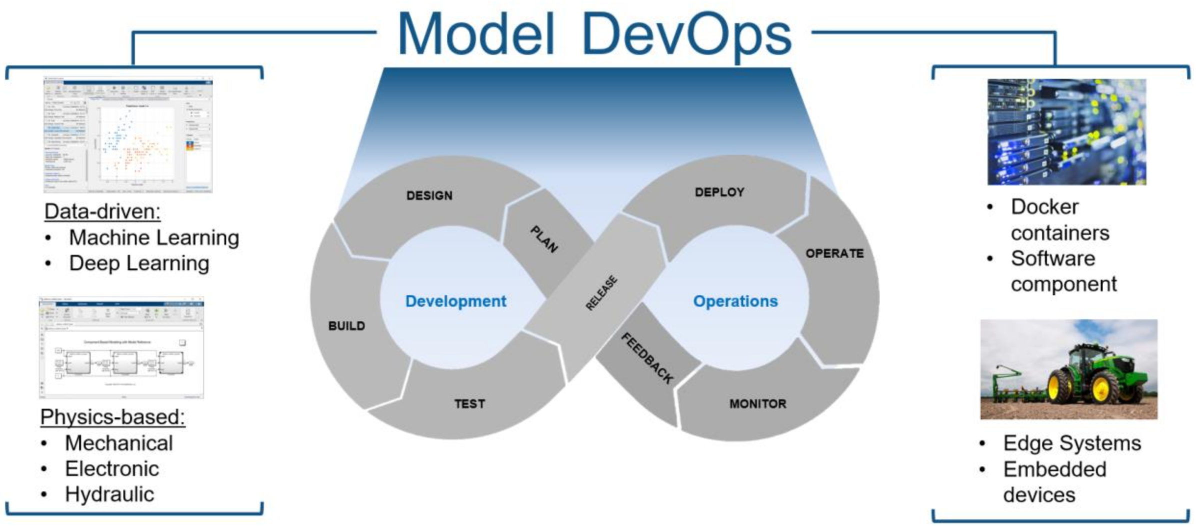
Tools for handling deployment-specific challenges:

- Fit models to embedded hardware with Quantization / Fixed-Point conversion
- Scale to data and users with MATLAB Production Server
- Incrementally adapt deployed models to maintain performance

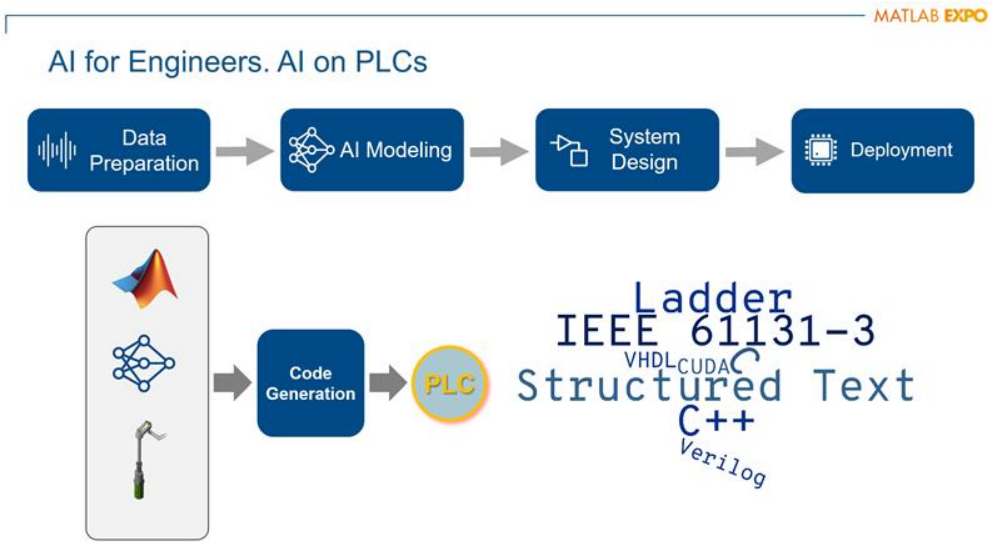
Design, Deploy and Maintain AI-powered systems in one framework

Learn More

Check out our handout with links to customer stories, documentation – and examples which you can try out in MATLAB Online



DevOps for Software and Systems: Operationalization of Algorithms and Models



Deploying AI on PLCs

MATLAB EXPO
2021

감사합니다

MathWorks