MATLAB EXPO 2019

Industrial IoT and Digital Twins
Key Takeaways

- You can use MATLAB and Simulink for IIoT and Digital Twin applications, leveraging their strong modeling, system simulation, and data analytics capabilities.

- MathWorks’ pilot and consulting teams can help you get your project started with applications such as predictive maintenance, operations optimization, and fleet management.
Megatrend: Digital Transformation and IoT

Overall Goals

By connecting machines in operation you can use data, algorithms, and models to make better decisions, improve processes, reduce cost, improve customer experience.

- Industrial IoT
- Digital Twin
- Industry 4.0
- Smart ‘XYZ’
- Digital Transformation
Organizations are Defining Infrastructure for Digitalization

Smart assets → Edge systems → OT systems → IT systems

Local Communications ↔ Long-Range Communications ↔ Integration

How are these used in an actual application?
Operations Optimization: BuildingIQ

HVAC real-time closed-loop control

Supervisory Control

- Current building condition
- Data preprocessing
- Tuned setpoints on each HVAC system
- Machine learning models of building, BMS, comfort
- Multi-objective optimization for energy efficiency
- Robustness analysis

Reduced HVAC energy consumption by 10–25%

Operations Optimization

- Time of Use Energy Price
- Demand Forecast
- Predicted Weather

Local Communications

Long-Range Communications

Integration

IT systems

Digital Twin

BuildingIQ Cloud

HVAC

BMS

Machine learning models

Supervisory Control

Reduced HVAC energy consumption by 10–25%

Current building condition

Tuned setpoints on each HVAC system

Machine learning models of building, BMS, comfort

Multi-objective optimization for energy efficiency

Robustness analysis

HVAC strategy updated for next 12 hours

IT systems
Performance Management: Electrical Grid Operator

- Real-time closed-loop control
- Operator notified if adjustment needed to increase energy reserve
- Operator adjusts grid controllers, if needed. Process is repeated in 30 min.
- Current status of electrical grid
- Model parameters are tuned using updated grid data
- Hundreds of what-if scenarios simulated in cloud to confirm energy reserve is sufficient

Energy reserve level is ensured for potential scenarios
Other Examples of Digital Twins Across Industries

Commercial Vehicles
Driving-data logs and digital twin used to verify and tune automatic braking system

Space
Controller retuned to adjust for degraded thruster, confirmed with digital twin, and uploaded during deep space mission

Aerospace
Operation data used to plan maintenance, improve aircraft availability, and reduce engine out-of-service time

Industrial Automation
Statistical models constantly updated to inform operators when plant is performing outside of optimal range
Applications at the Asset, the Edge, or Operational Technology Platform

Value of data to decision making

- **Anomaly Detection**
- **Predictive Maintenance**
- **Asset Performance Management**
- **Operations Optimization**
- **Fleet Management**
- **Input to Next-Gen Design**

**Speed**
- Milliseconds
- Seconds
- Minutes
- Hours
- Days
- Months

**Scope**

**Hard real-time control**

**Real-time decisions**

**Time-sensitive decisions**

**Big Data processing on historical data**

Smart assets → Edge systems → OT Infrastructure → IT Systems

Local Communications → Long-Range Communications → Integration

Fleet Management

Input to Next-Gen Design
Development for Fast and Highly-Deterministic Systems

Smart assets → Edge systems

Value of data to decision making

- Model-Based Design with automatic code generation
- Edge Processing Model-Based Design, code generation

Hard real-time control → Real-time decisions

Speed

Milliseconds → Seconds → Minutes → Hours

Model-Based Design

- Multi-domain system modeling
- Parameter estimation
- Automatic code generation

MATLAB EXPO 2019
Development to OT/IT On-Prem and in Cloud

- Variety and Volumes of Data
- Machine Learning and Deep Learning
- Optimization
- Enterprise system integration, (on-prem/cloud)

Time-sensitive decisions
Stream Processing
Big Data processing on historical data
Hadoop/Spark, and other enterprise IT integration

Scope
Time
- Hours
- Days
- Months
A Complex Collection of Tools, Platforms and Protocols

Smart assets → Local Communications → Edge systems → Long-Range Communications → OT systems → Integration → IT systems

TCP/IP, Rest APIs, Azure Stream Analytics, IoT Hub, Spotfire, Xilinx, NVIDIA, Intel, Windows, MindSphere, ThingWorx, Analyst/Engineer
A Complex Collection of Tools, Platforms and Protocols

Smart assets

Edge systems

Local Communications

Long-Range Communications

OT systems

Integration

IT systems

Automatic CUDA code generation

MATLAB Deep Learning Container for NVIDIA GPU Cloud

Analyst/Engineer
Example Problems with a Triplet Replicating Pump

1. **Fault Classification is a time consuming manual process**
   
   Current system requires operator to manually monitor operational metrics for anomalies. Their expertise is required to detect and take preventative action.

2. **Trouble using data to update digital twin and make use of it**

   Current system gathers operational data from the pump, but not expertise on how to leverage data to update the digital twin and apply it to run what-if analysis in a scalable way.
# Two Demos

## 1 Fault Classification Using MATLAB

<table>
<thead>
<tr>
<th><img src="#" alt="kafka" /></th>
<th><img src="#" alt="Azure" /></th>
<th><img src="#" alt="kibana" /></th>
</tr>
</thead>
</table>
| Machine Learning fault classifier model | Visualization dashboard | • MATLAB  
• Statistics & Machine Learning Toolbox  
• MATLAB Production Server |

## 2 “What-If” Analysis Using Simulink/Simscape Digital Twin

<table>
<thead>
<tr>
<th><img src="#" alt="Database" /></th>
<th><img src="#" alt="Windows" /></th>
<th><img src="#" alt="Azure" /></th>
</tr>
</thead>
</table>
| Model tuned during operation | Parallel sims to explore scenarios | • Simulink/Simscape  
• Simulink Design Optimization  
• MATLAB Parallel Server |
Fault Classification Using MATLAB

Fault Classification is a time consuming manual process

Current system requires operator to manually monitor operational metrics for anomalies. Their expertise is required to detect and take preventative action.
Demo 1

Fault Classification Using MATLAB

1. Machine Learning fault classifier model

Data:
- Processed in chunks or
- Streaming continuously via Kafka

- A previously designed classifier, processes incoming stream, identifying faults
- Processing is elastic and can scale to any number of incoming streams/pumps via MATLAB Production Server

• MATLAB
• Statistics & Machine Learning Toolbox
• MATLAB Production Server

Visualization dashboard (Kibana) shows data stream and deduced fault classification

Triplex Pump
Complete Your Application
“What-If” Analysis Using Simulink/Simscape Digital Twin

- Model tuned during operation
- Parallel sims to explore scenarios

- Simulink/Simscape
- Simulink Design Optimization
- MATLAB Parallel Server

Trouble using data to update digital twin and make use of it

Current system gathers operational data from the pump, but not expertise on how to leverage data to update the digital twin and apply it to run what-if analysis in a scalable way
"What-If" Analysis Using Simulink/Simscape Digital Twin

1. Model tuned during operation
2. Parallel sims to explore scenarios

- Simulink/Simscape
- Simulink Design Optimization
- MATLAB Parallel Server

- Data streaming from asset, saved and selected for tuning using cloud storage connectivity
- Tune Digital Twin Parameters from latest available data from real asset using Simulink Design Optimization
- Run 100s "what-if" Scenarios with Parallel Server reference architecture on Azure
- Process output for possible operational decision

Triplex Pump
Demo 2 part I: Setting up MATLAB Reference Architect on Azure
Demo 2 Part II: Updating Digital Twin with Parameter Estimation
Demo 2 Part III: Run What-if Analysis From Current State
In addition to the approaches shown in these two demos, there are other ways to use MATLAB and Simulink to operationalize your applications.

These include running MATLAB and Simulink directly on the platform, deploying compiled applications, running generated code, and more.

We can work with you to define the right approach, based on your application requirements.
In Conclusion

- You can use MATLAB and Simulink for IIoT and Digital Twin applications, leveraging their strong modeling, system simulation, and data analytics capabilities.

- MathWorks’ pilot and consulting teams can help you get your project started with applications such as predictive maintenance, operations optimization, and fleet management.

Call to Action:
Talk to us about your IIoT and Digital Twin applications today.
IIoT and Digital Twin Relevant Solution Pages

- A view on the breath of MathWorks IIoT integration options
- MathWorks support on-prem and public cloud operations
- Physical Modeling
- Predictive Maintenance
- Data Science with MATLAB
- MathWorks products access for startups
- Service offering with consulting
- Third Party Connections