AI Based Fault detection on Industrial Controllers

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Monitor Processes

- Improve asset availability
- Monitor energy use
- Manage inventory

Improve Quality

- Diagnose defects on production line
- Optimize yield

Schedule Maintenance

- Predict faults in equipment
- Decrease downtime

Why do companies care about anomaly detection for industrial processes and machinery?

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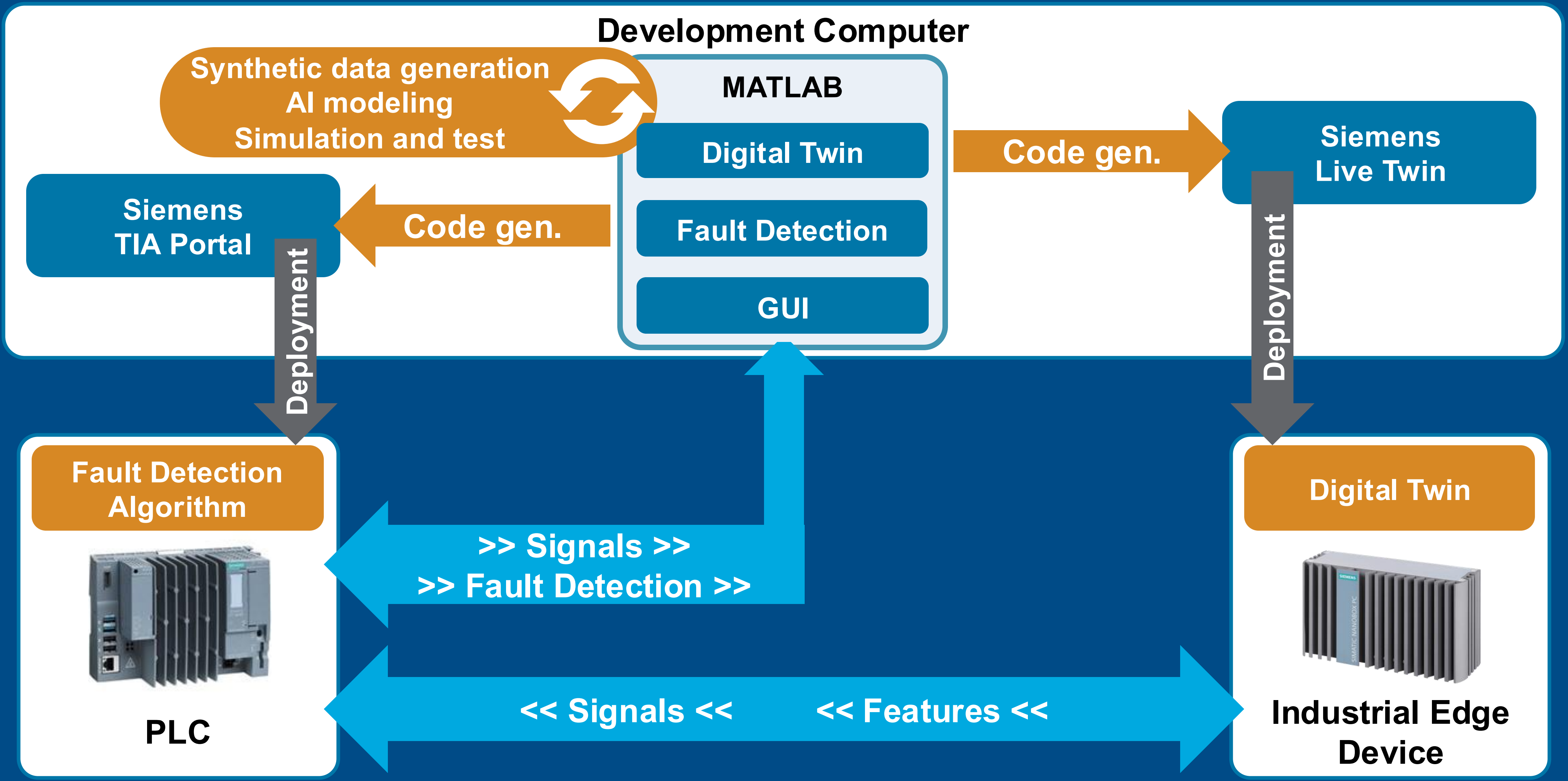

Demonstrator setup

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1 Data Preparation

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

2 AI Modeling

- Model design and tuning
- Hardware accelerated training
- Interoperability

3 Simulation and Test

- Integration with complex systems
- System simulation
- System verification and validation

4 Deployment

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

End-to-End Workflows for Artificial Intelligence Software Development

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1 Data Preparation | 2 AI Modeling | 3 Simulation and Test | 4 Deployment

MATLAB Help Center | Community | Learning | MATLAB

Documentation | Examples | Functions | Apps | Videos | Answers

Industrial Cooling Fan Anomaly Detection Algorithm Development for Deployment to a Microservice Docker Image

R2024b

Open in MATLAB Online

Copy Command

Detection of anomalies from sensor measurements is an important part of an equipment condition monitoring process for preventing catastrophic failure. This example shows the first part of a two-part end-to-end workflow for creating a predictive maintenance application from the development of a machine learning algorithm that can ultimately be deployed as a trained machine learning model in a Docker® microservice.

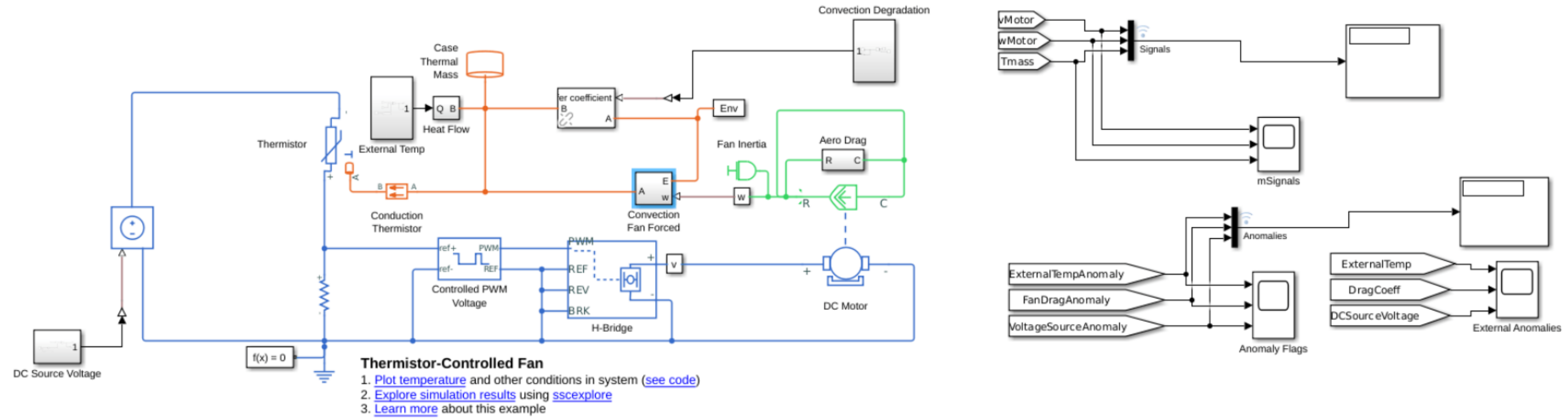
The example uses a Simulink® model to synthetically create measurement data for both normal and anomalous conditions. A support vector machine (SVM) model is trained for detecting anomalies in load, fan mechanics, and power consumption of an industrial cooling fan. The model detects a load anomaly when the system is working on overloaded conditions, that is, when the system work demand exceeds designed limits. A fan anomaly is detected when a fault occurs within the mechanical subsystem of the motor or the fan. Finally, a power supply anomaly can be detected by a drop in the voltage.

The companion example, Deploy Industrial Cooling Fan Anomaly Detection Algorithm as Microservice (MATLAB Compiler SDK), shows the actual deployment of the model in a Docker environment.

Data Generation

In this example, a thermistor-controlled fan model defined using Simscape™ Electrical™ blocks, generates the measurements. This Simulink model includes thermal, mechanical and electrical components of a fan. You can learn more about this model in Thermistor-Controlled Fan (Simscape Electrical).

```
addpath('Data_Generator/', 'Data_Generator/VaryingConvectionLib/');
mdl = "CoolingFanWithFaults";
open_system(mdl)
```



https://www.mathworks.com/help/predmaint/ug/industrial-cooling-fan-anomaly-detection-with-docker-deployment.html

Industrial Fan Shipping Demo: Digital Twin

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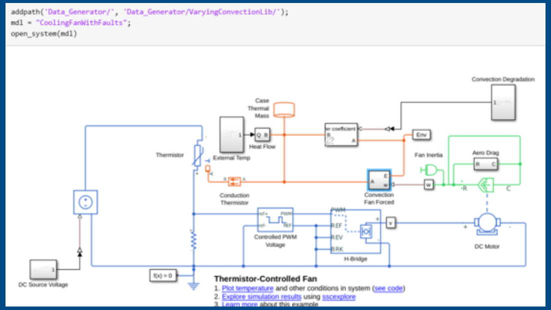
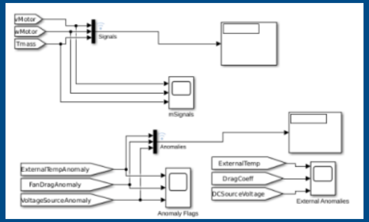
1 Data Preparation | 2 AI Modeling | 3 Simulation and Test | 4 Deployment

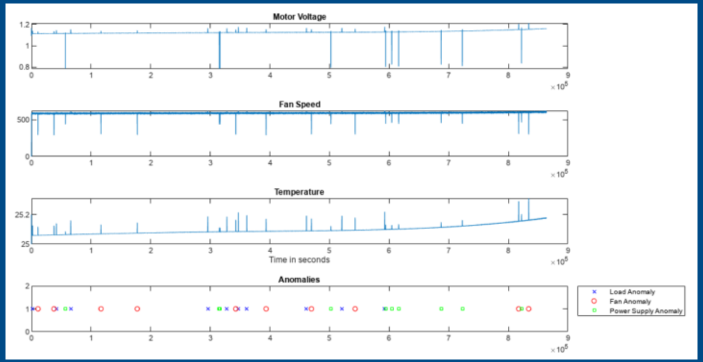
- Simulink/Simscape model simulates fan with electrical, thermal, and mechanical components



- Anomalies injected: Load, Fan Mechanics, Power Supply



- Data collected from voltage, power, and temperature sensors



Industrial Fan Shipping Demo: Digital Twin

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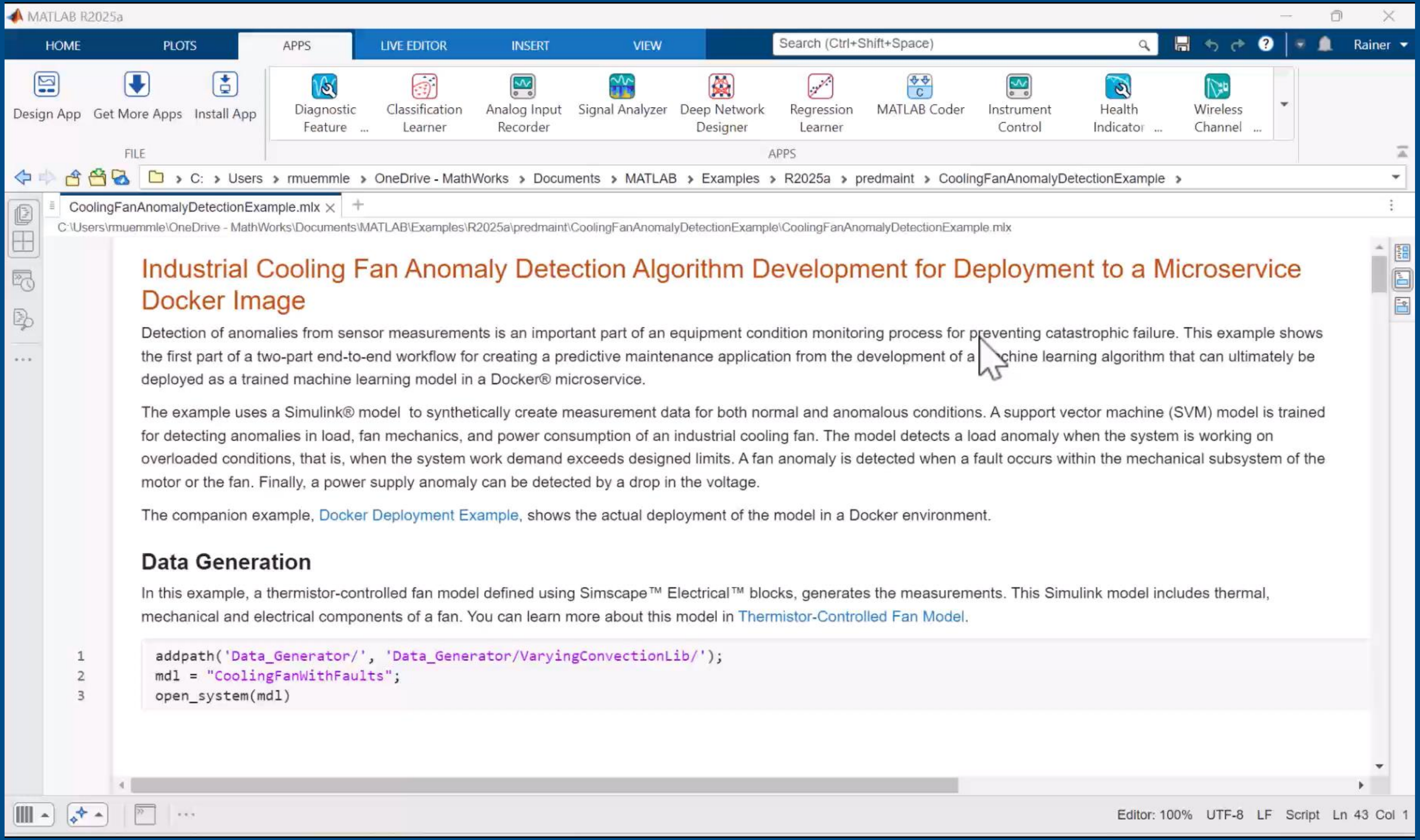
1 Data Preparation

2 AI Modeling

3 Simulation and Test

4 Deployment



Data Generation and Preprocessing

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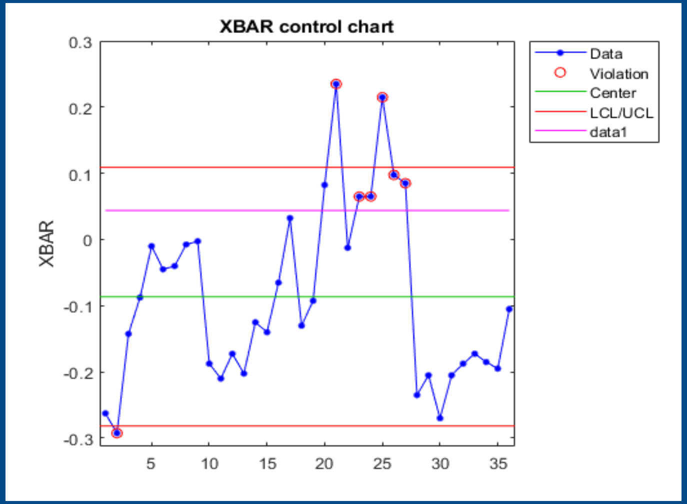
1 Data Preparation

2 AI Modeling

3 Simulation and Test

4 Deployment

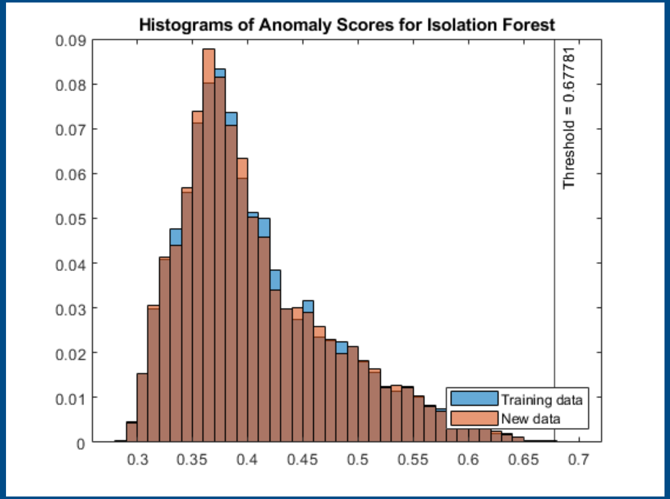


Supervised Methods

Works with plenty available data

Simple Statistics

e.g., Outlier Detector



Anomaly Detection Approaches

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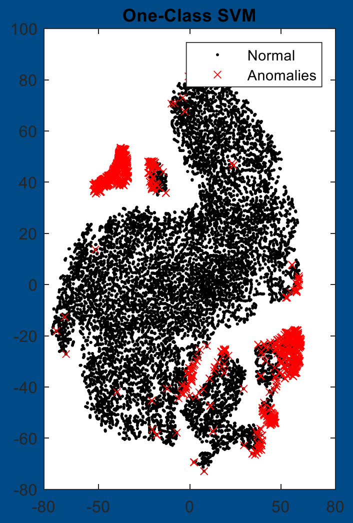
1 Data Preparation

2 AI Modeling

3 Simulation and Test

4 Deployment

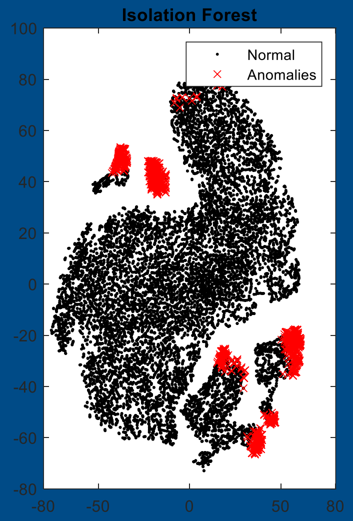


Unsupervised Methods

"Normal Only" data available

Supervised Methods

Works with plenty available data



Simple Statistics

e.g., Outlier Detector

Anomaly Detection Approaches

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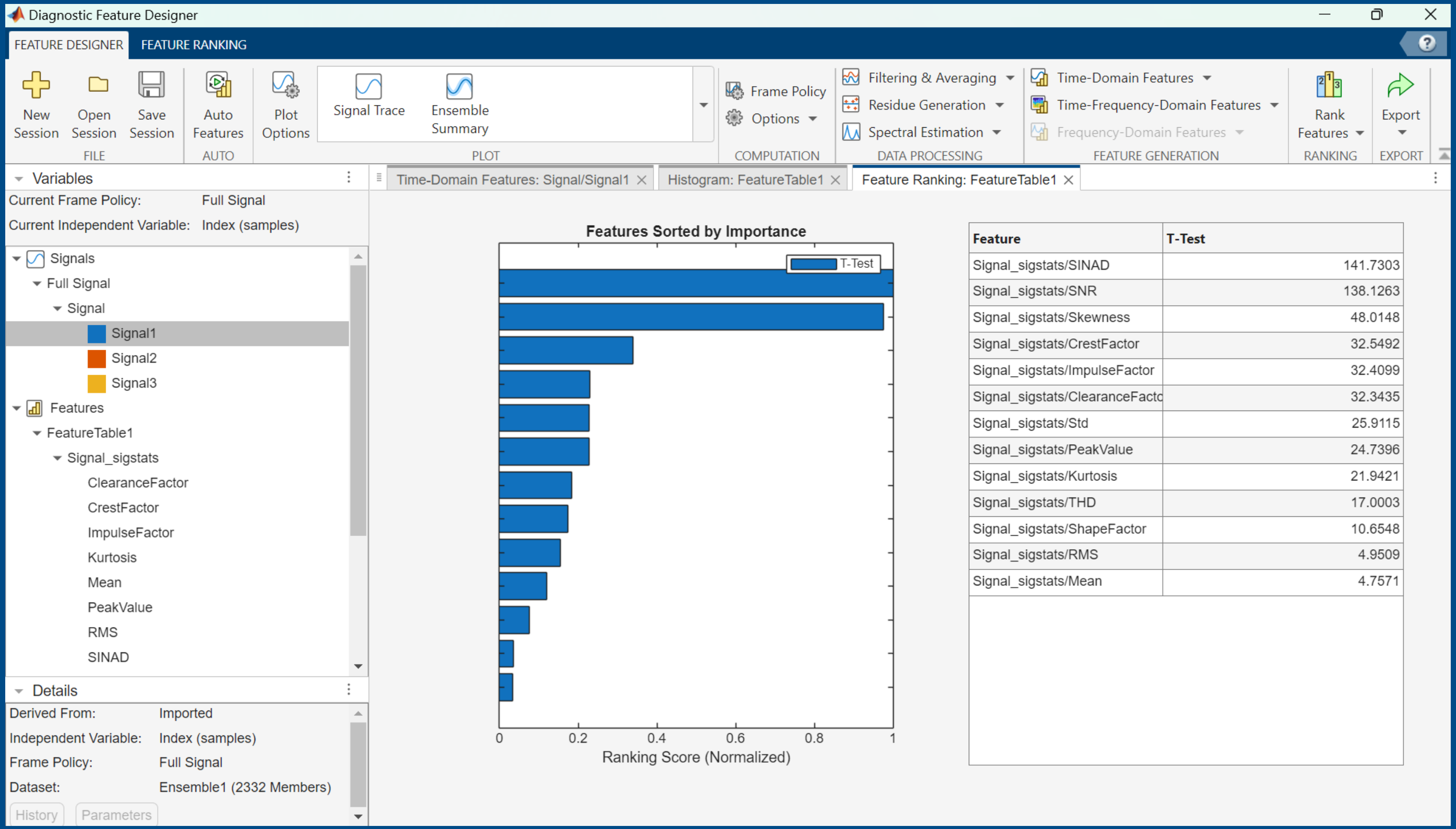
1 Data Preparation

2 AI Modeling

3 Simulation and Test

4 Deployment



Feature Extraction / Fault Classification

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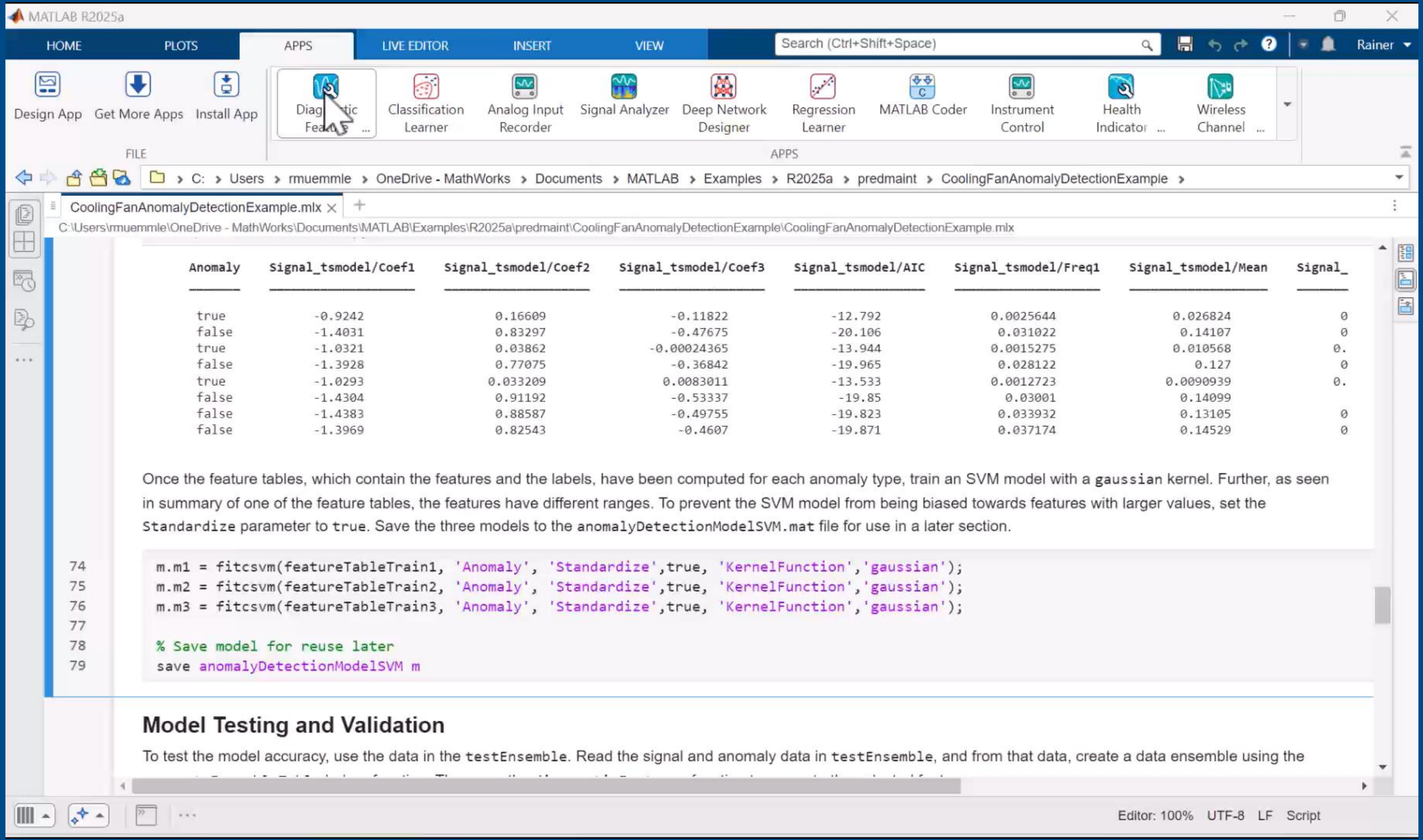
1 Data Preparation

2 AI Modeling

3 Simulation and Test

4 Deployment



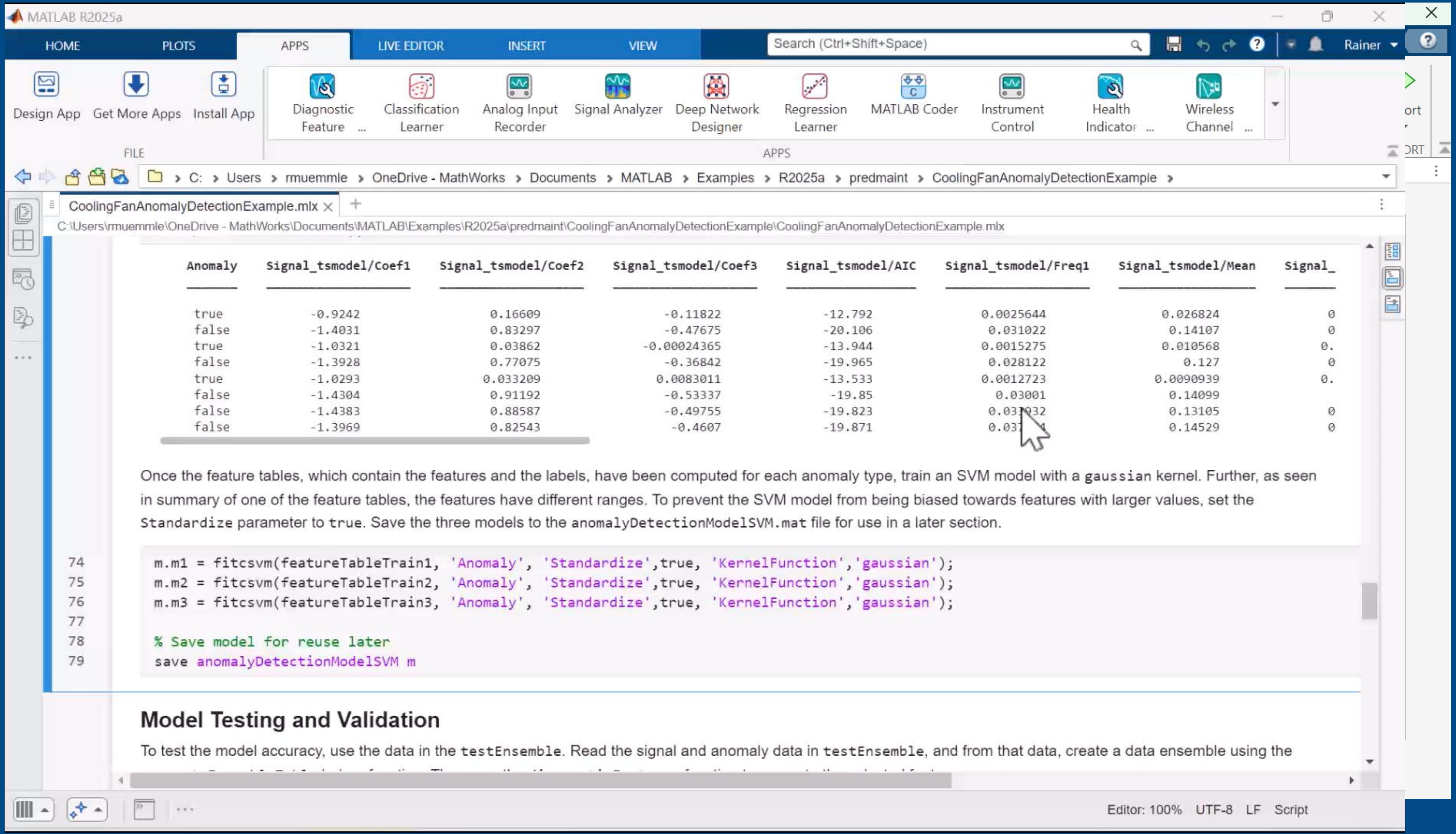
Feature Extraction using **Diagnostic Feature Designer App**

1 Data Preparation

2 AI Modeling

3 Simulation and Test

4 Deployment



Model Testing and Fault Classification

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- Features extracted using **D**iagnostic **F**eature **D**esigner **APP**

- Three SVM classifiers trained for each anomaly type

- Deployment options:
  - Microservice (Docker)
  - **Code Generation to be implemented on PLC/Edge Device**

Feature Extraction, Classifier training and Fault Classification

1 Data Preparation

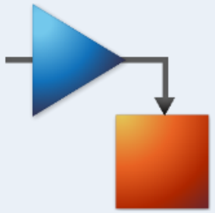
2 AI Modeling

3 Simulation and Test

4 Deployment

Build model

Model

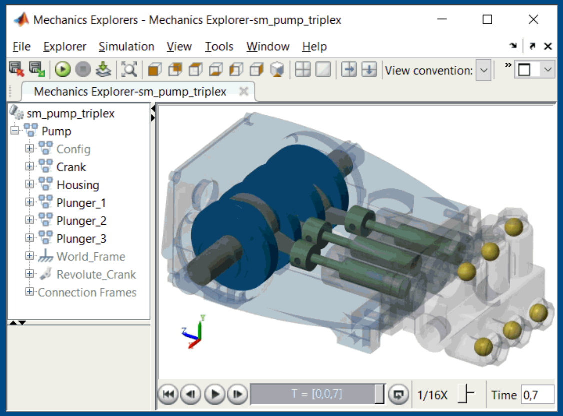


Sensor Data

Fine tune model

Run simulations

Generated Failure Data



Inject Failures

Incorporate failure modes

Use data from sensors and simulations

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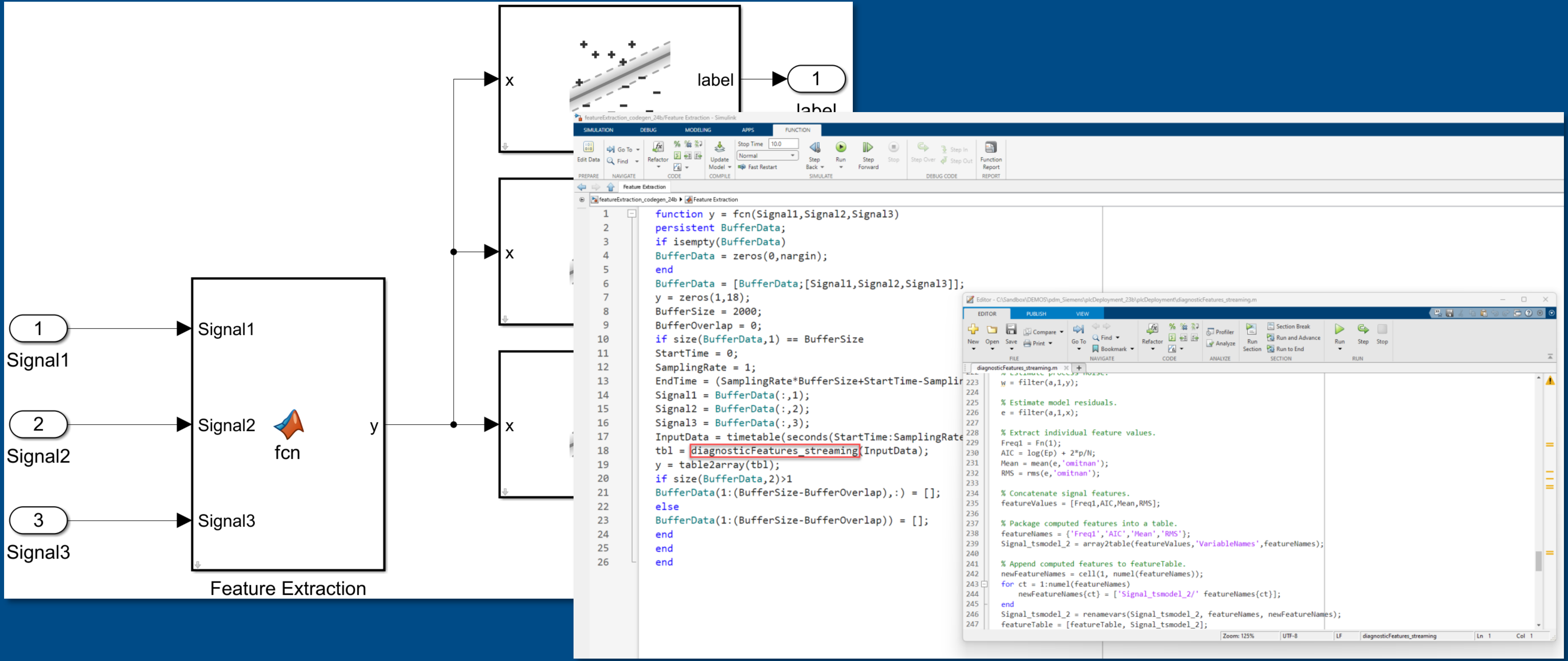
1 Data Preparation

2 AI Modeling

3 Simulation and Test

4 Deployment



Feature Extraction / Fault Classification

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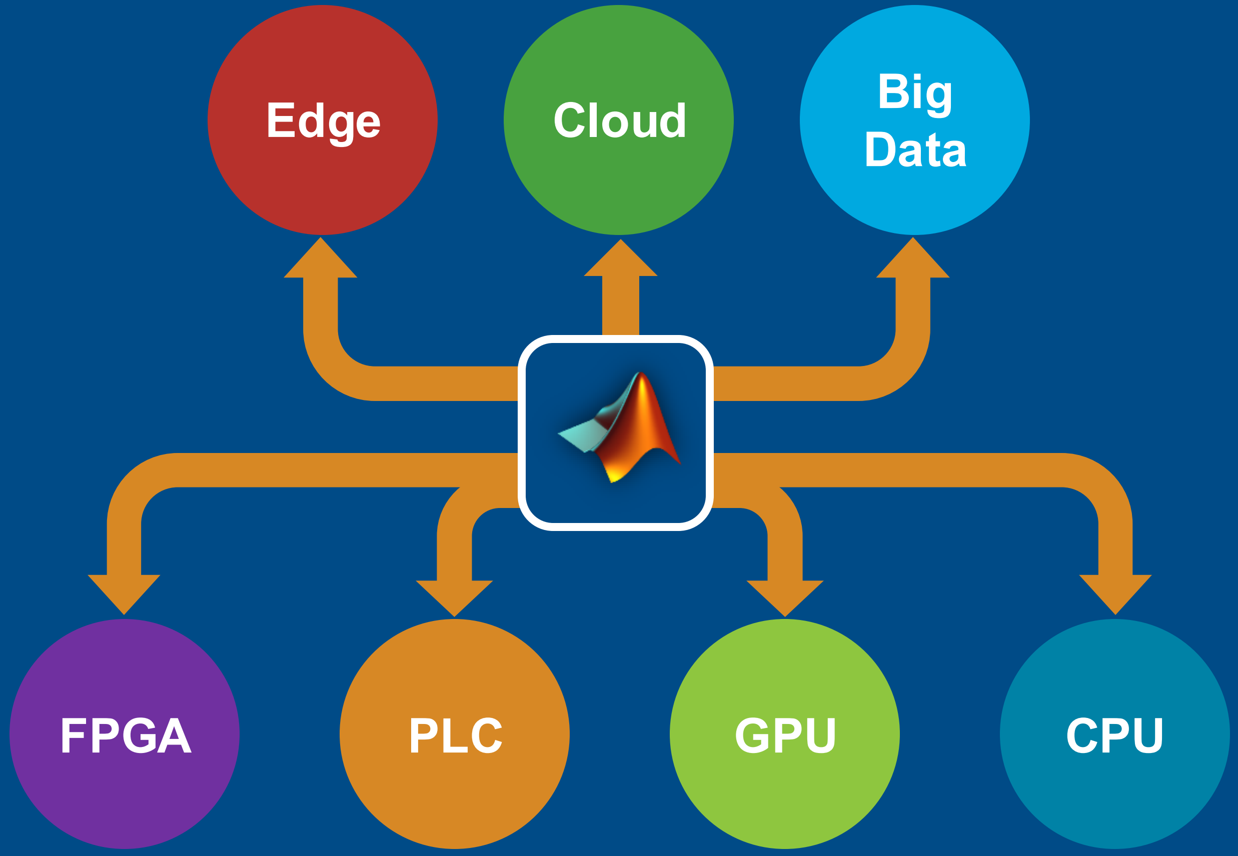
1 Data Preparation

2 AI Modeling

3 Simulation and Test

4 Deployment



Deploy with zero coding errors

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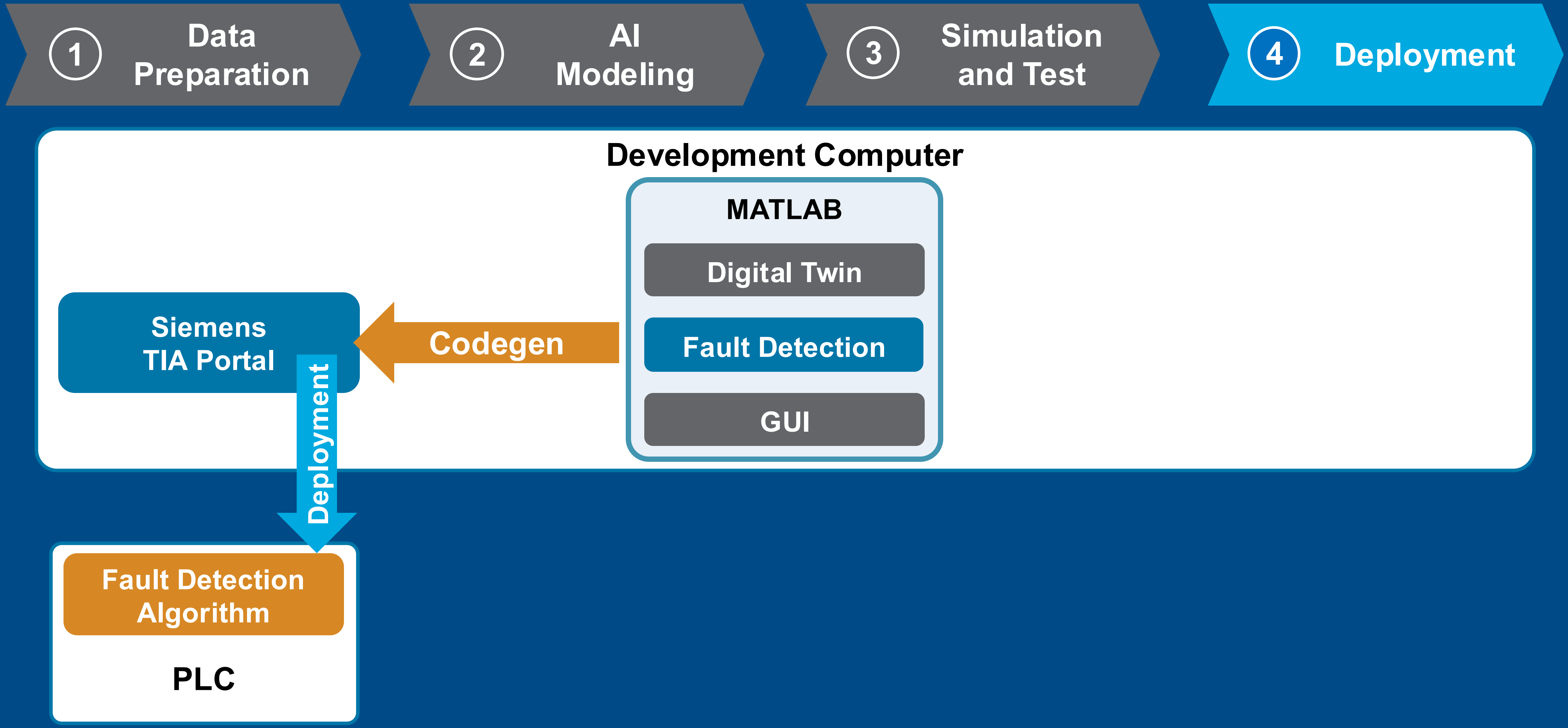

Code Generation: Feature Extraction and Fault Classification

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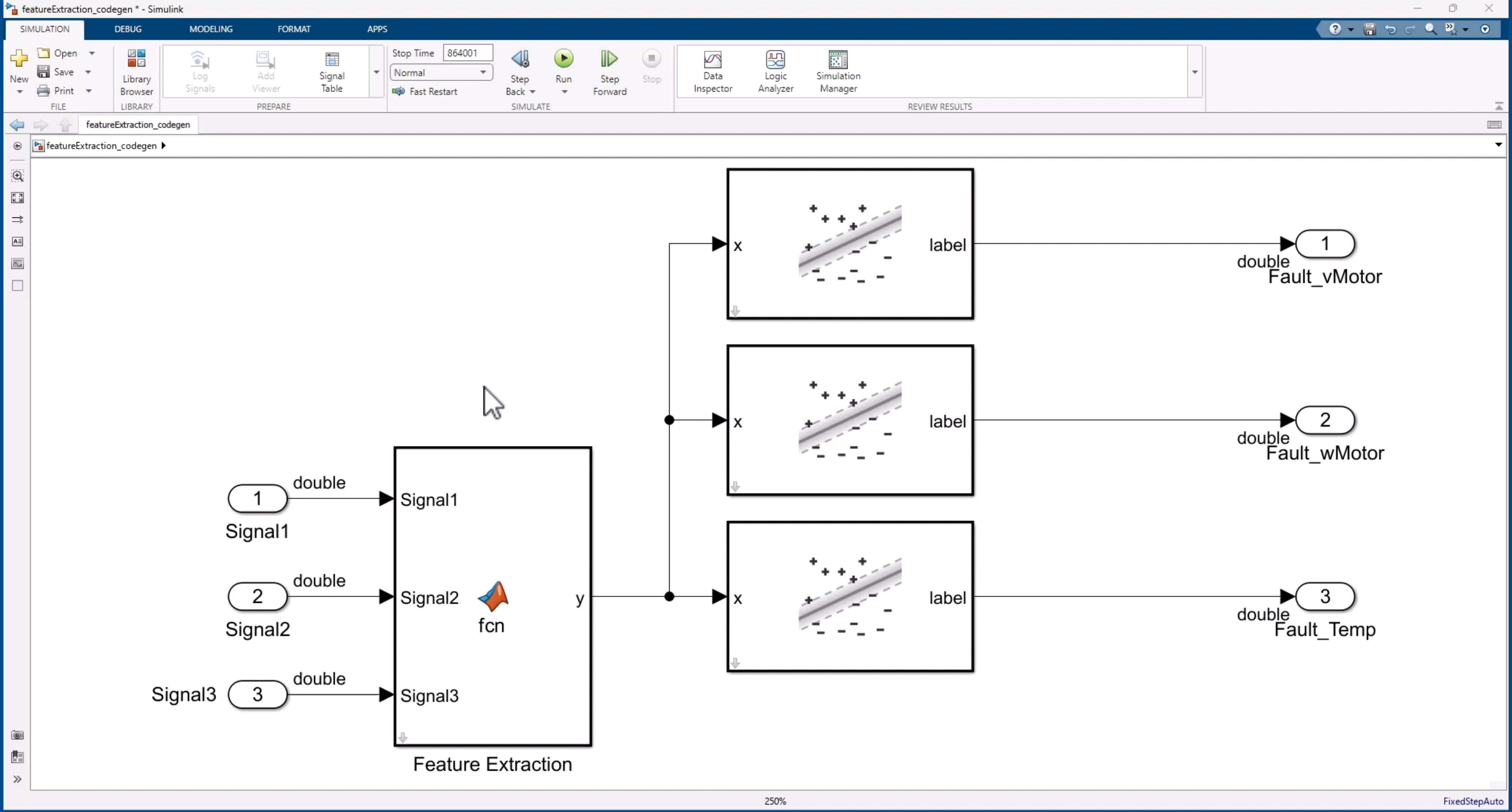

Code Generation: Feature Extraction and Fault Classification

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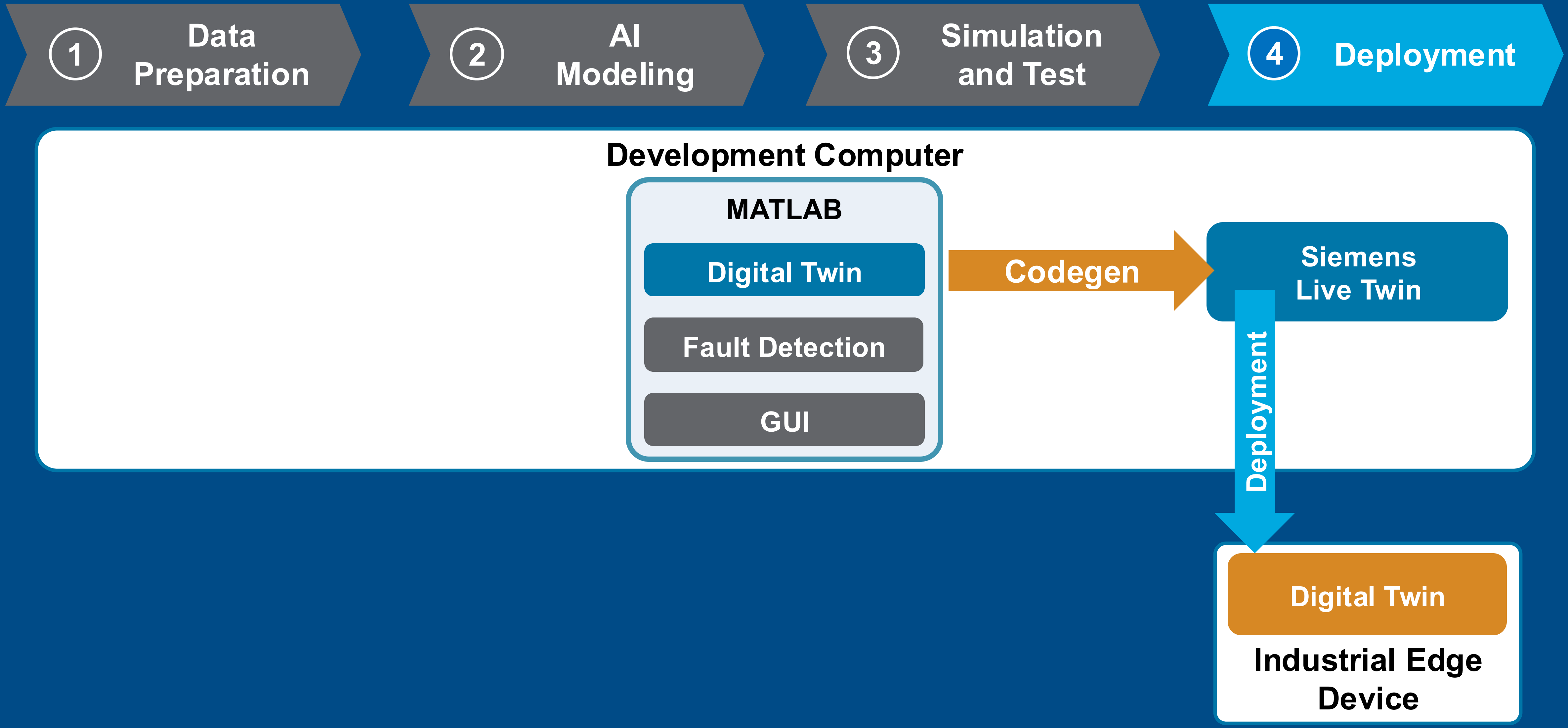

Code Generation: Digital Twin

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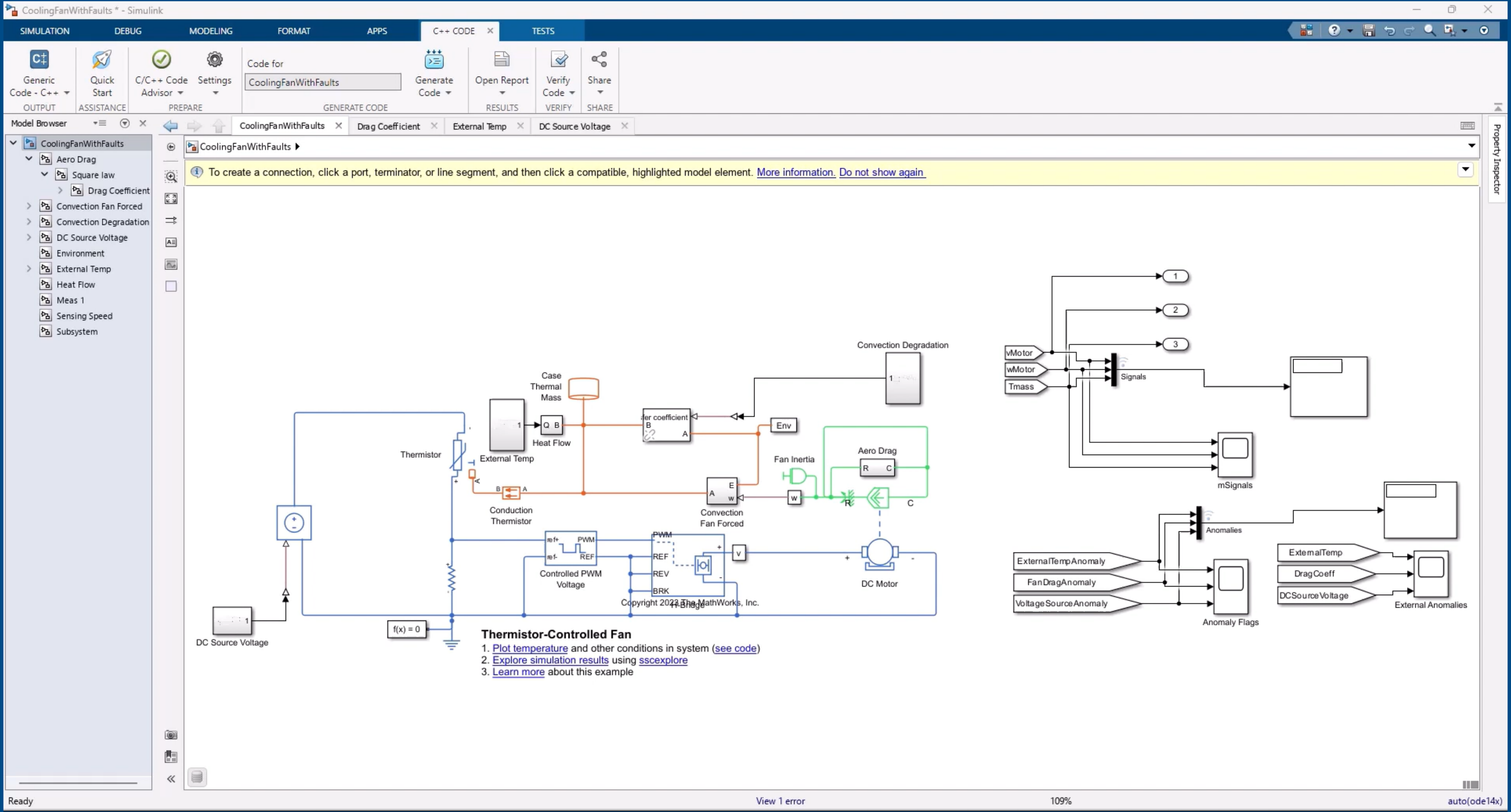
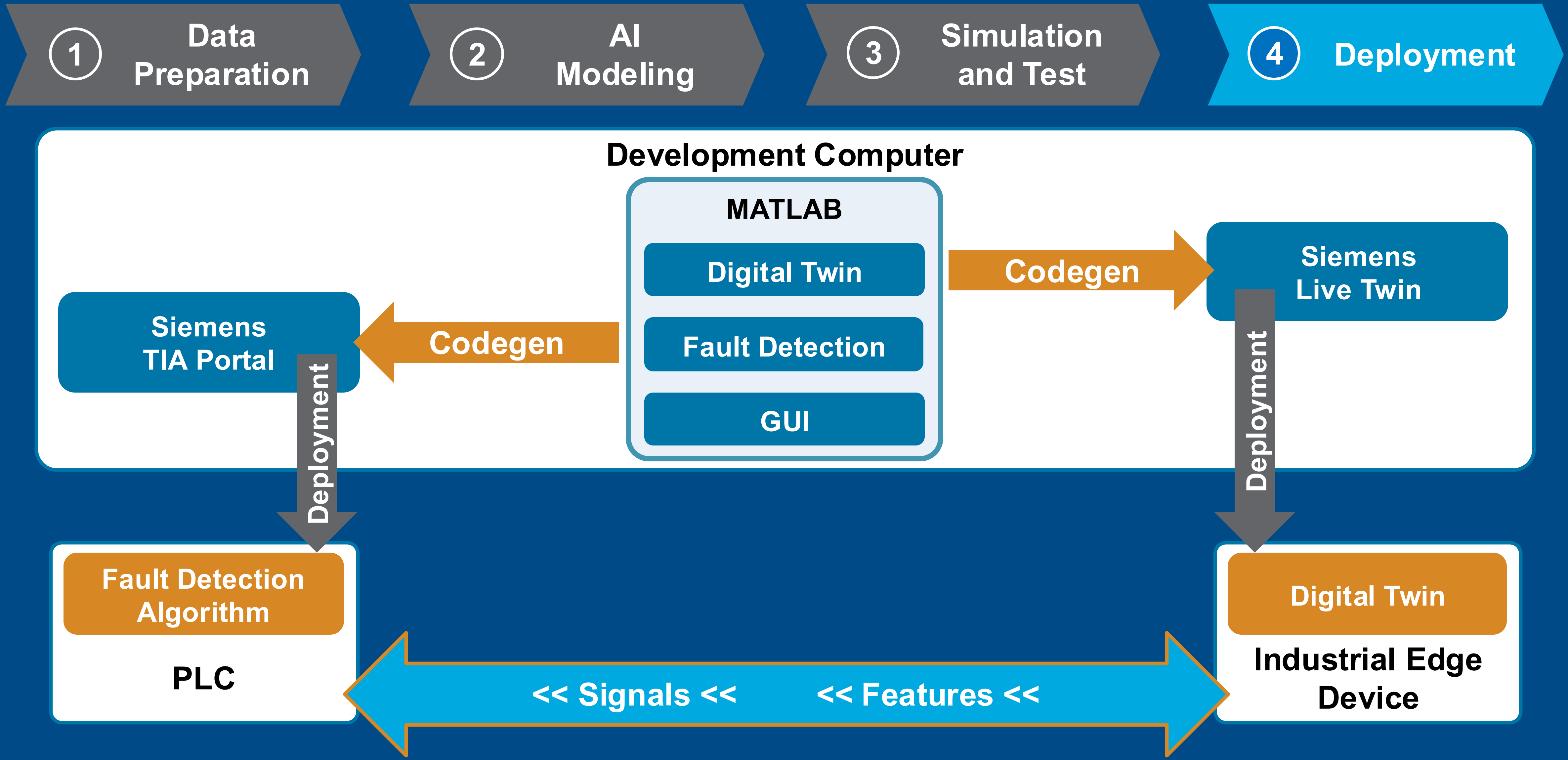
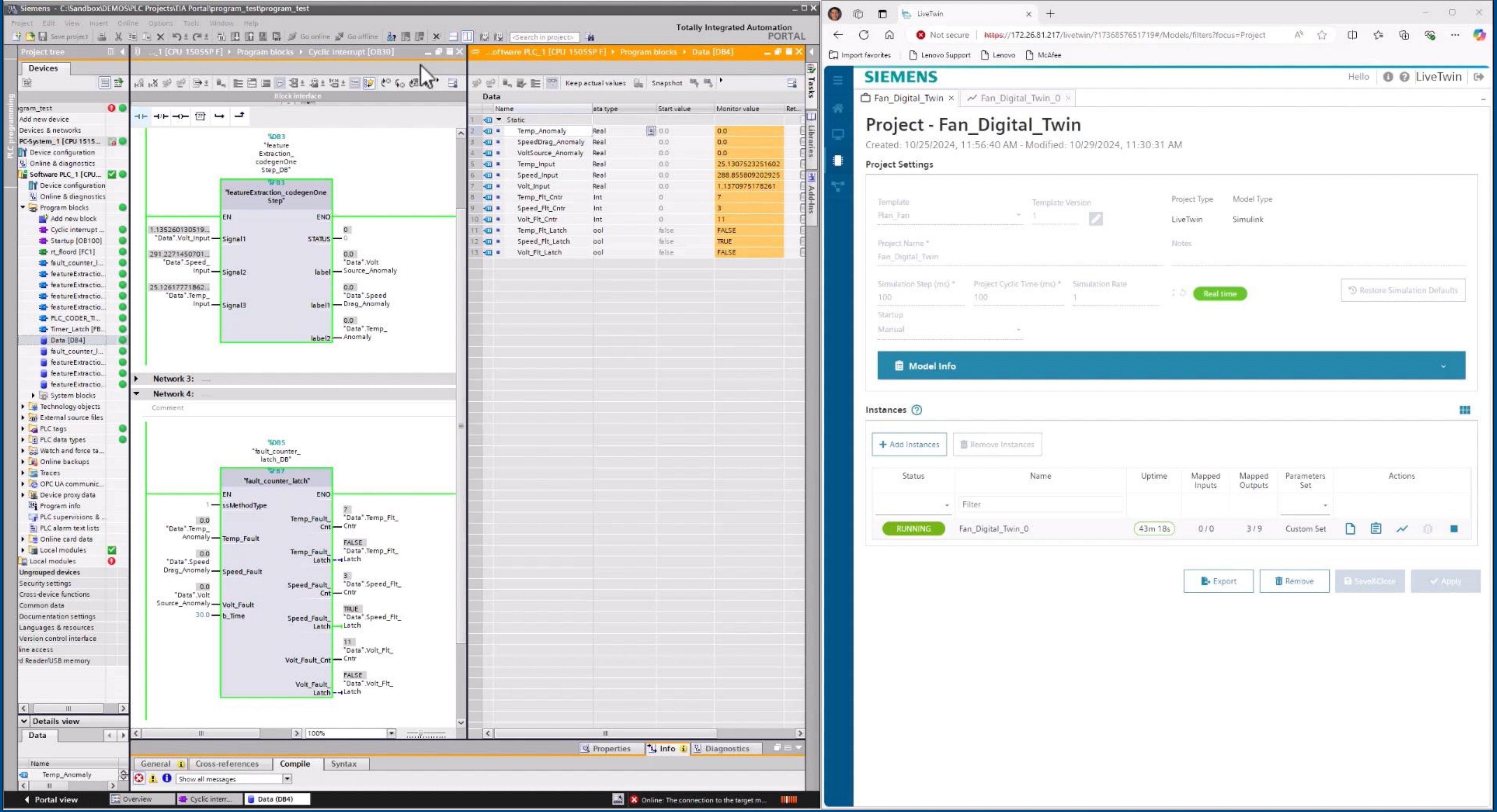


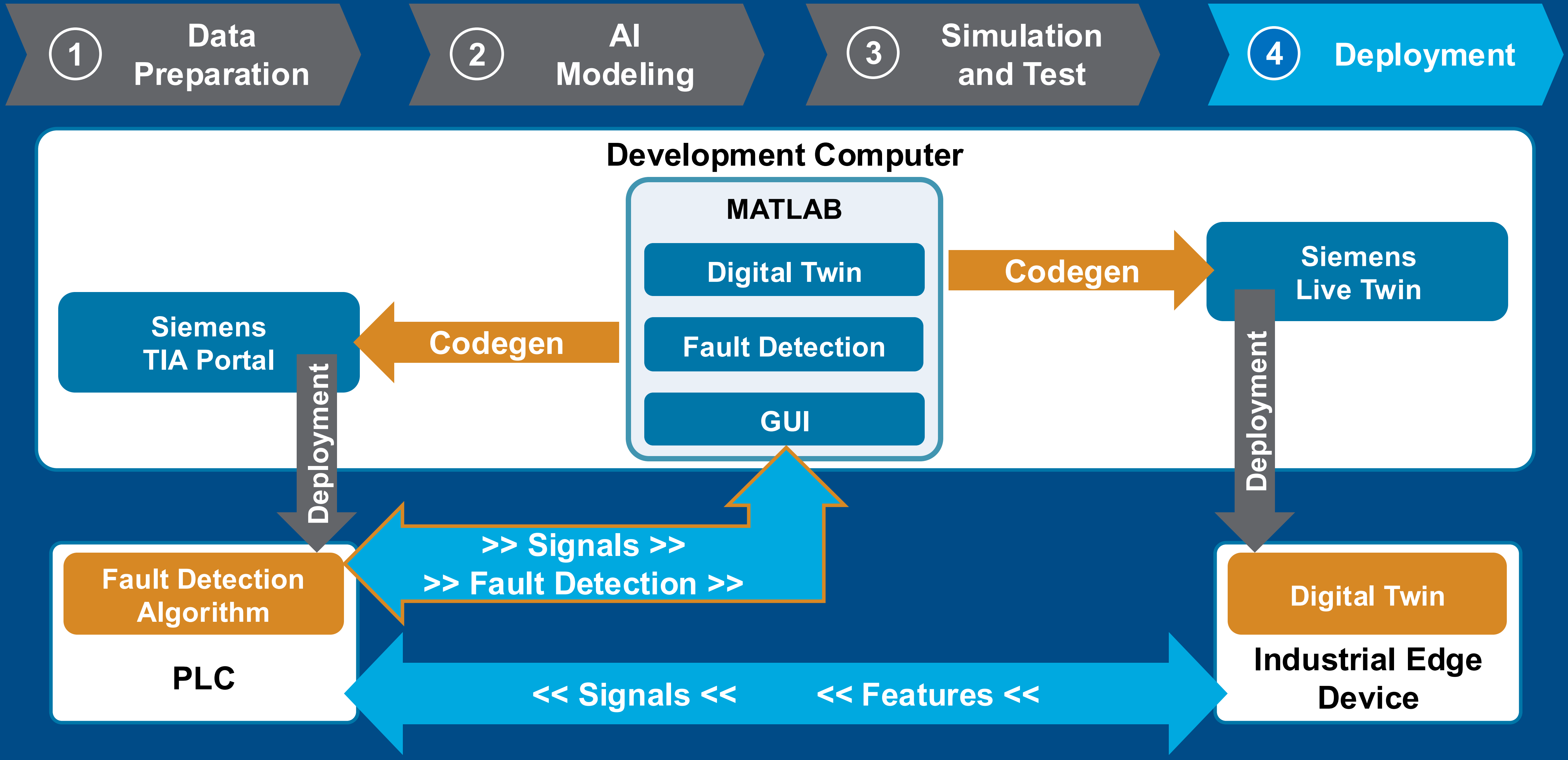
Code Generation: Digital Twin



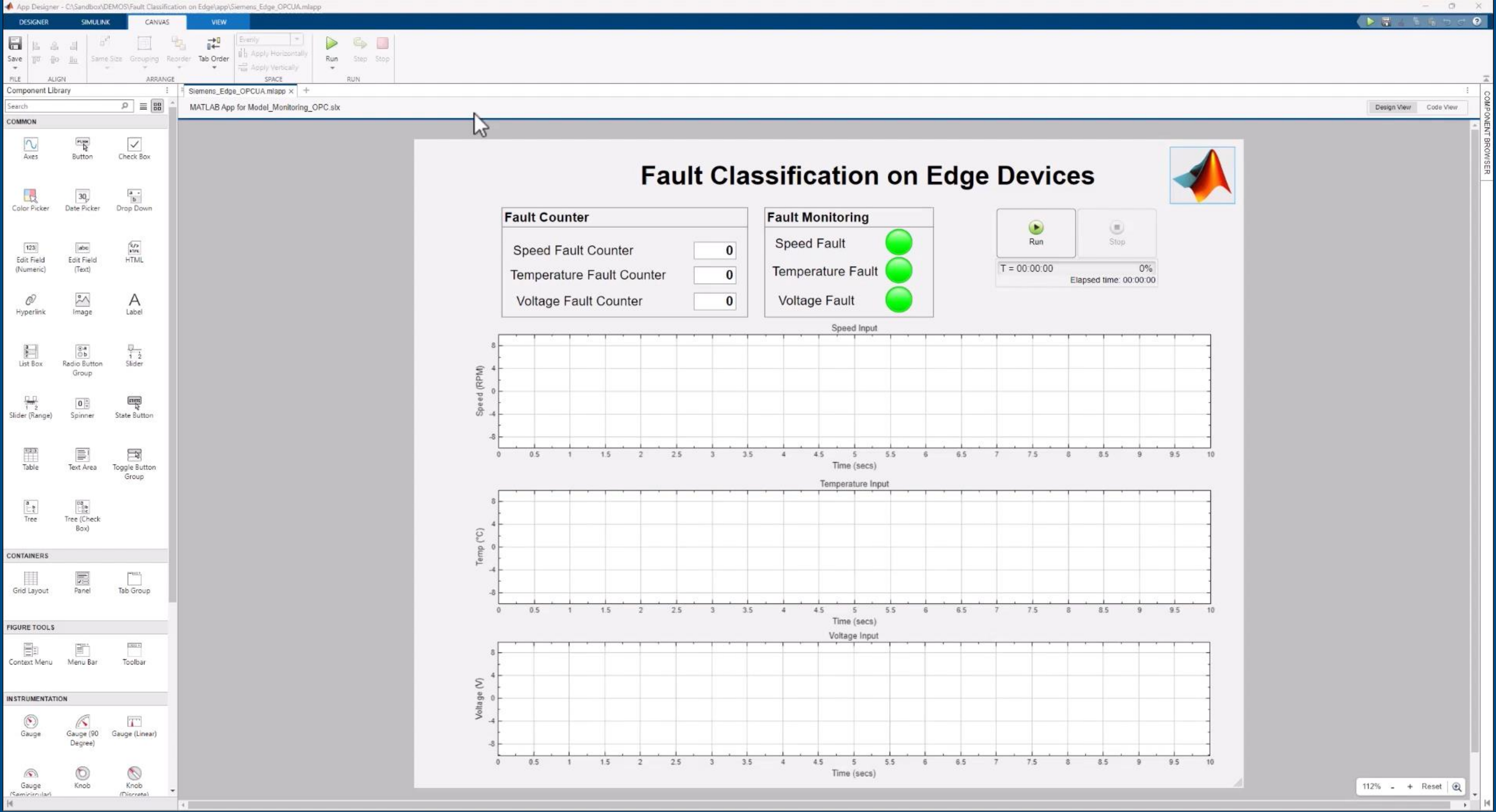
Algorithm Export and Integration
TIA Portal and Live Twin



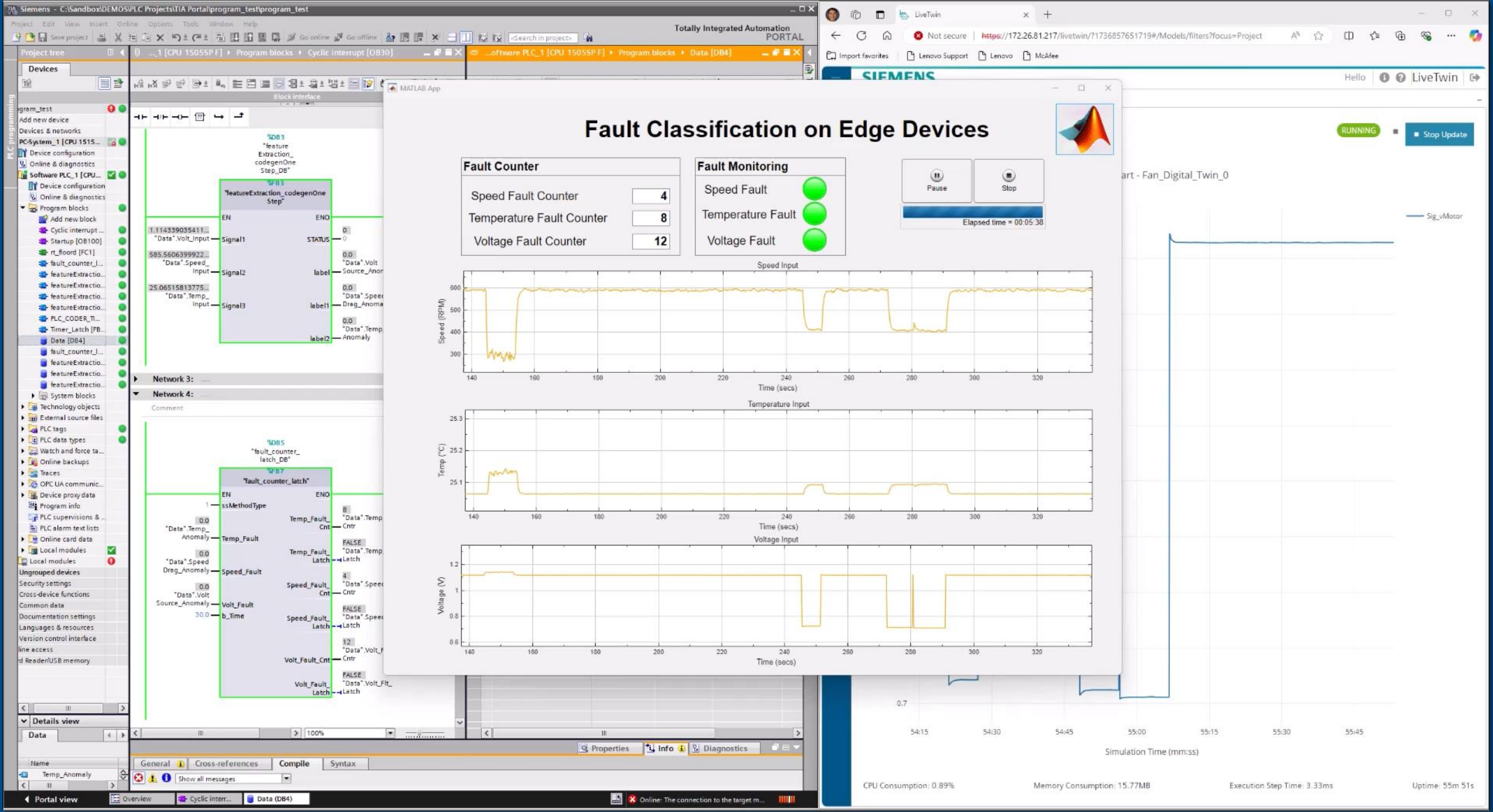
Algorithm Export and Integration: TIA Portal and Live Twin



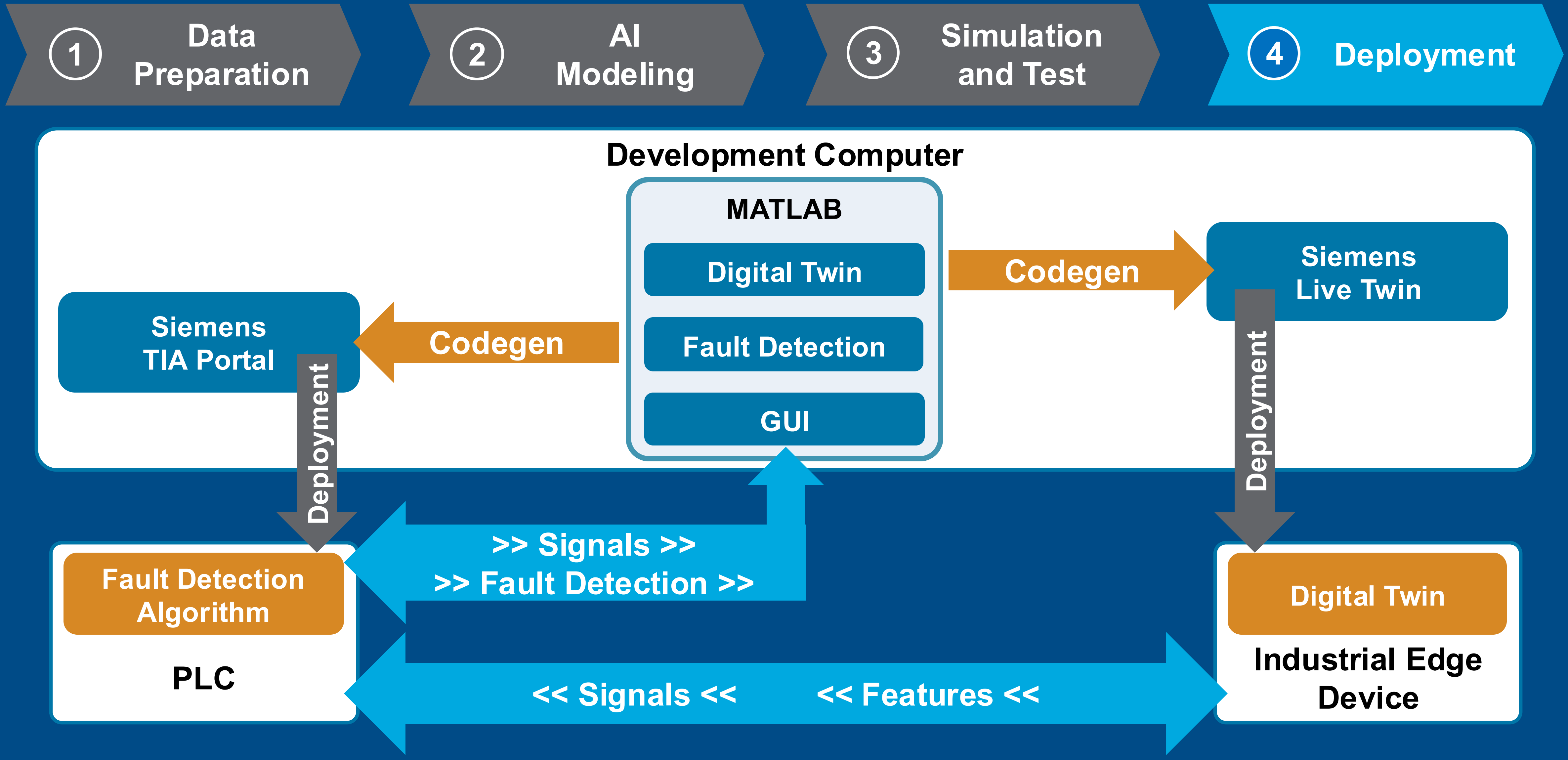
Industrial Communication – OPC UA



Industrial Communication – OPC UA



Anomaly Detection GUI / HMI



AI Based Fault Detection on Industrial Controllers

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- Empower domain experts, including ones with limited AI experience
- Build better data sets with domain-specific tools
- Use modeling and simulation to tackle integration challenges and reduce risk
- Deploy AI models to wherever you need them

1 Data Preparation

- Data cleansing and preparation
- Human insight
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Lessons learned: Use End-to-End Workflows for Artificial Intelligence

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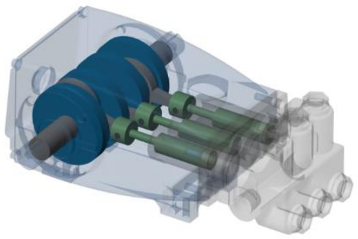
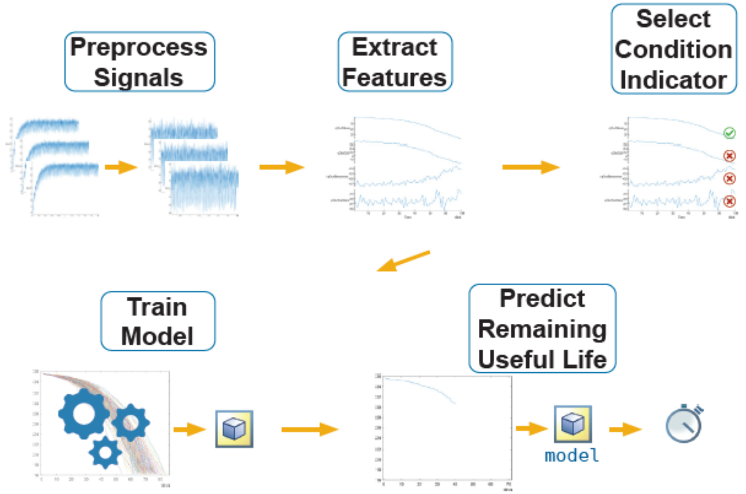
MathWorks Training & Consulting

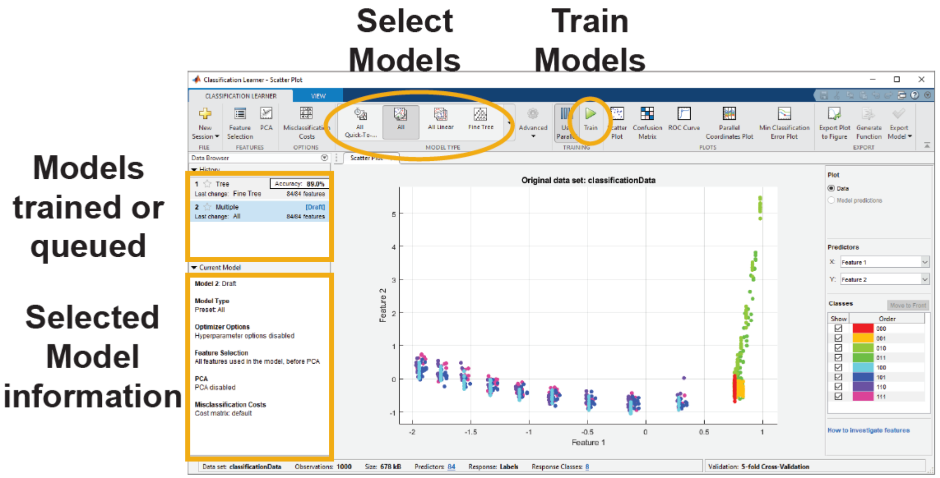
Predictive Maintenance with MATLAB

Topics included in this 2-day course:



- Importing and organizing data
- Creating custom visualizations
- Fault Detection/Classification
- Preprocessing to improve data quality, and extract time and frequency domain features
- Estimating Remaining Useful Life (RUL)
- Interactive workflows with apps

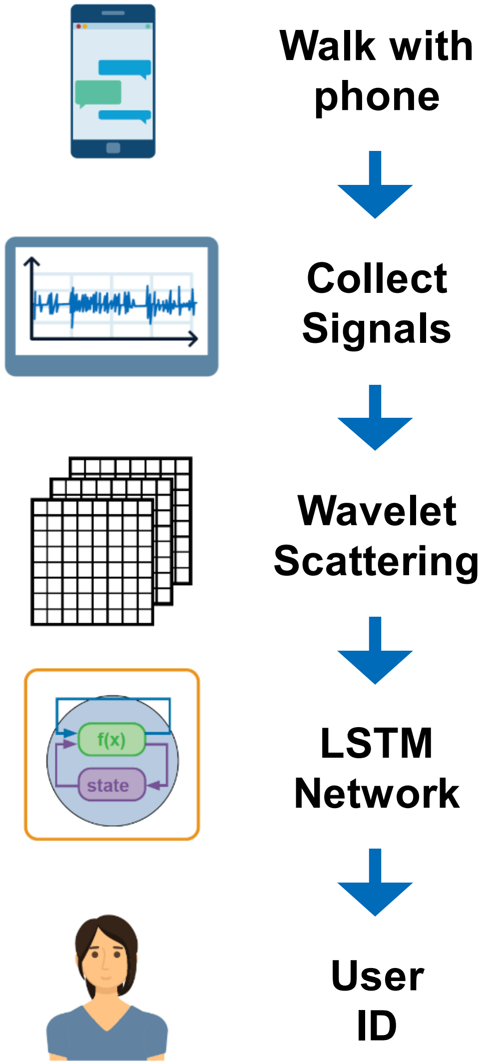


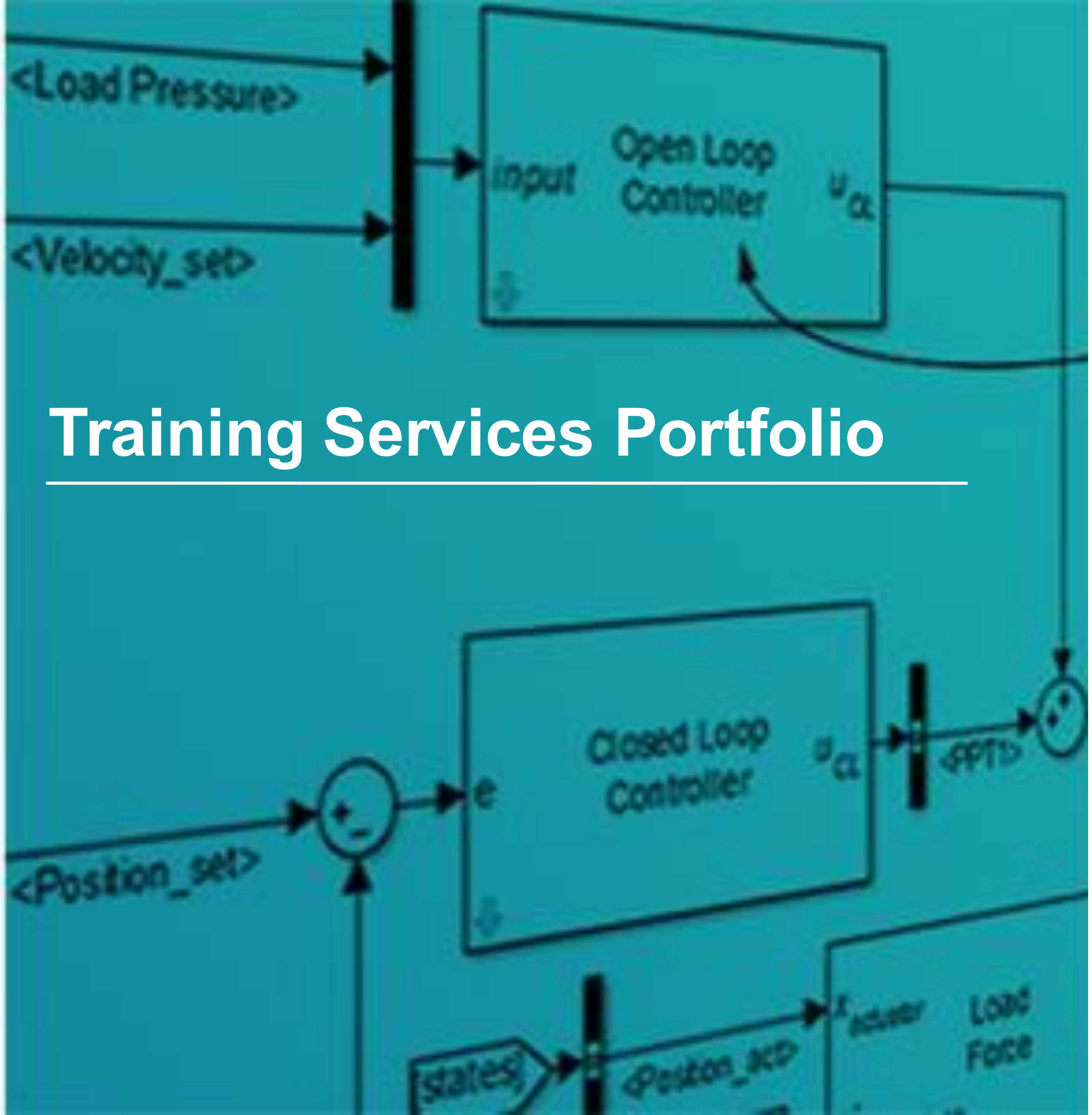


Deep Learning for Signals in MATLAB

After this 1-day training you will be able to:

- Import and label signal data
- Use CNNs for signal classification
- Create custom LSTMs for signal classification
- Apply Deep Learning for anomaly detection





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Tuesday, October 21, 2025 | The Westin Grand Munich

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