MATLAB EXPO 2021

Deploying Artificial Intelligence on PLCs

Gianfranco Fiore, Rareș Curatu

MathWorks®

AI for Engineers. AI on PLCs

Engineers and domain specialists can achieve success with **AI and Machine Learning** and download programs **on PLCs** without having to specialize in data science. What they need is the right tools throughout the workflow.

IMA Active builds predictive maintenance algorithms for tablet press production machine

Challenge

Minimize the risk of machine failure while avoiding unrequired pre-emptive maintenance.

Solution

Analyzed data Predictive Maintenance Toolbox apps. Trained a fault classification model that estimates the health of critical moving parts.

Results

- Built a **Machine Learning** classification model that achieved **89% classification accuracy** using only **5 extracted features**
- Optimized Operations

IMA ACTIVE
Solid Dose Solutions

IMA's tablet press machine series - Prexima. (Picture: IMA)

*"Using MATLAB tools, we managed to extract and select the best features to build a classification model. The most promising algorithm uses five features and has an **accuracy of 89%**."*
- Alessandro Ferri, IMA Active

Learn more

The AI workflow for real-life engineering applications

Data Preparation

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

AI Modeling

- Model design and tuning
- Hardware accelerated training
- Interoperability

System Design

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

Deployment

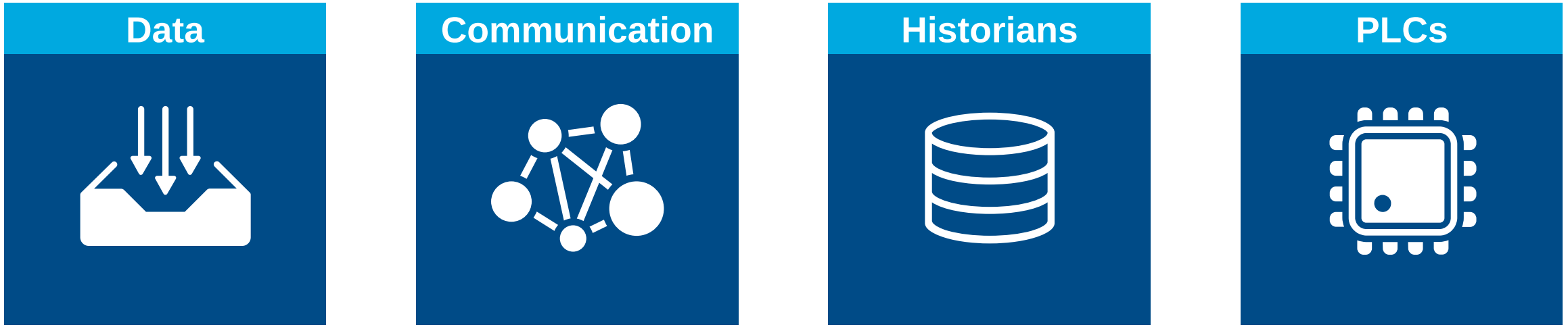
- Embedded devices
- Enterprise systems
- Edge, cloud, desktop

Poll 1: **Why** AI on PLCs? Why now? (multiple choices)

- Improving existing products or systems
- Enabling the offering of new services
- Changing business model
- Available funding (e.g., European Union funding)
- Following trends (e.g., Industry 4.0)

Why AI on PLCs? Why now?

- Field Data: we're measuring more parameters than ever
- Field Communication: we're streaming more machine data than ever
- Historians: we're storing more data (and better!) than ever
- Processing Power: PLCs are more powerful than ever



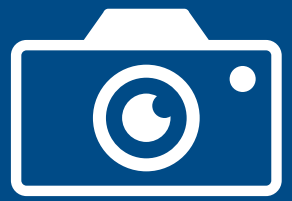
Poll 2: **What** can you do with AI on PLCs? (multiple choices)

- Machine vision (e.g., automated visual inspection)
- Machine control (e.g., reinforcement learning)
- Route planning (e.g., pick & place robots)
- Predictive analytics (e.g., predictive maintenance)
- I don’t know yet
- Other

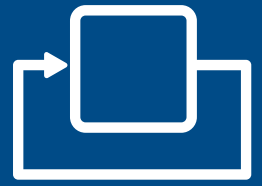
Poll 2: **What** can you do with AI on PLCs?

- Machine vision (e.g., automated visual inspection)
- Machine control (e.g., reinforcement learning for motion application)
- Route planning (e.g., pick & place robots)
- Predictive analytics (e.g., predictive maintenance)

Inspection

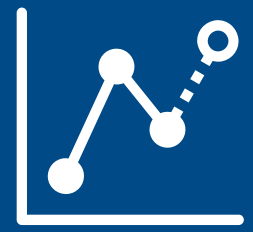


Control



Robotics

Analytics

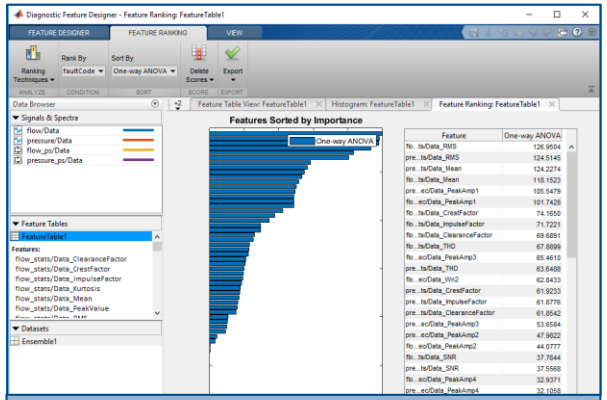


Preprocess and Label Data, Extract Features

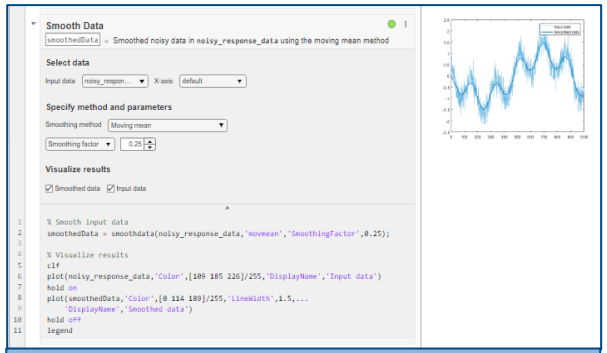
MATLAB and MATLAB Apps facilitate the process of efficiently working with DATA

Data Preparation

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



Diagnostic Feature Designer App
Feature extraction and ranking for different domains and purposes



MATLAB Live Editor Tasks
Data filtering and cleansing with easy-to-use interfaces, and access to multiple algorithms and tunable parameters

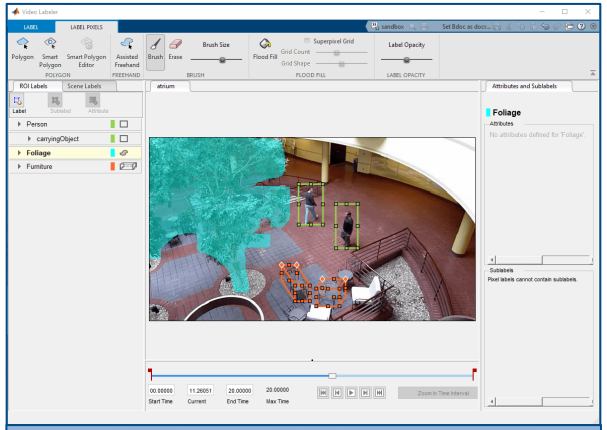


Image Labeler & Video Labeler Apps
Interactive labeling of ground truth data taking advantage of CV algorithms for automation

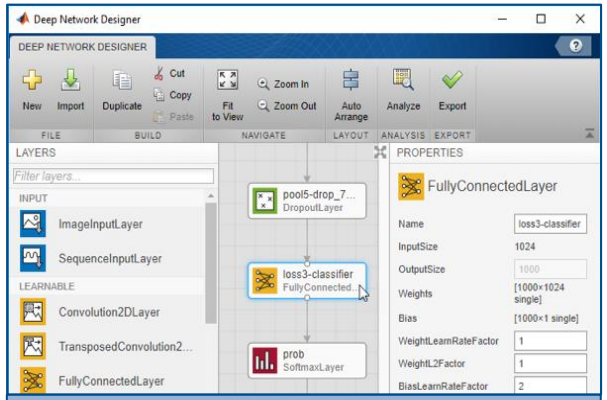
From MATLAB Apps it is possible to generate MATLAB code for repeating tasks completed within the Apps

Design, Choose and Train Algorithms and Models

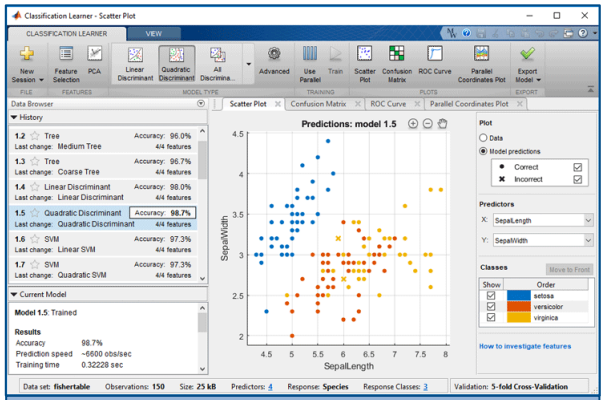
MATLAB Apps make the training of Neural Networks, Classifiers, and Regression models easy.

AI Modeling

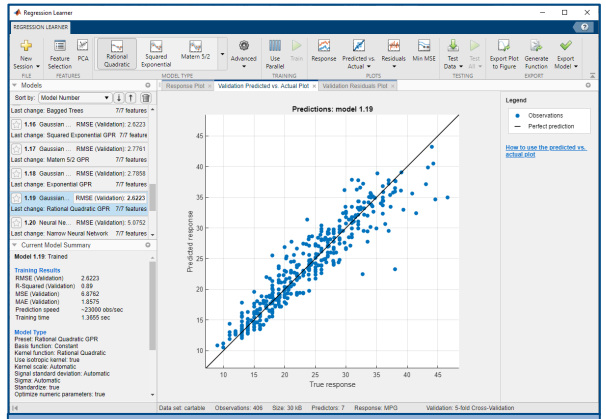
- Model design and tuning
- Hardware accelerated training
- Interoperability



Deep Network Designer & Experiment Manager Apps
Build, Modify, Train and Compare Neural Networks



Classification Learner App
Train models to classify Data using Supervised Machine Learning



Regression Learner App
Train Regression Models to predict Data using Supervised Machine Learning

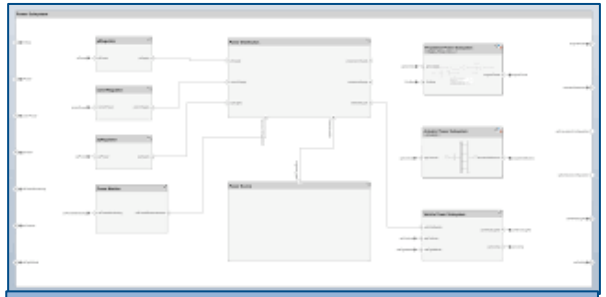
MATLAB integrates with other Development Languages and Environments.

Simulation is key to AI success

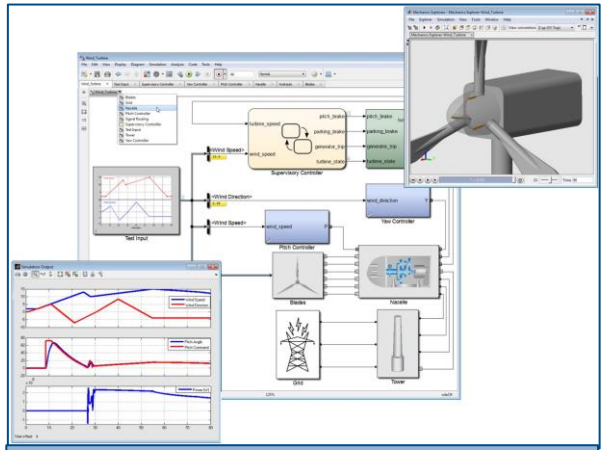
AI tools and Model-Based Design capabilities for the Integration, Test and Validation of Complex Systems

System Design

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



System Composer and V&V Tools
Design and Analyze Complex Embedded System and SW Architectures.



Simulink, Stateflow, Simscape
Design and Simulate Systems, Decision Logic, and Multidomain Physical Systems

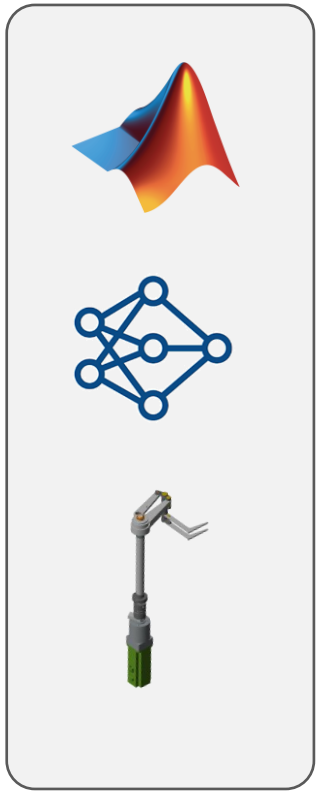
Bonus: Synthetic failure data generated from a Simulink model can train an AI algorithm.

Deploy to any processor with best-in-class performance

AI models in MATLAB and Simulink can be deployed on different targets including Industrial Controllers.

Deployment

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



Code Generation

CPU

GPU

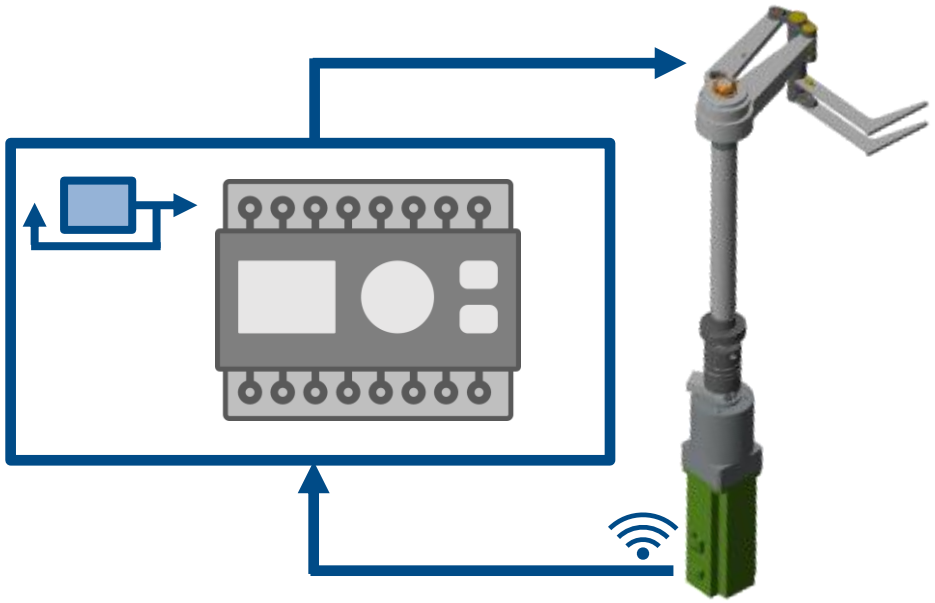
PLC

FPGA

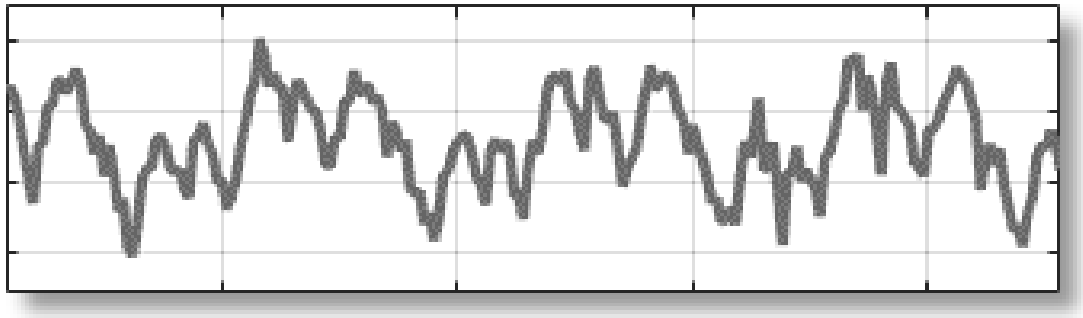
IEC 61131-3
VHDL CUDA
Structured Text
C++
Verilog

MATLAB Coder, Simulink Coder, Embedded Coder, Simulink PLC Coder and Other Code Generation Tools

Case Study: Condition Monitoring of a Packaging Machine



- Mechanical parts
- Electrical components
- Sensors
- Controllers



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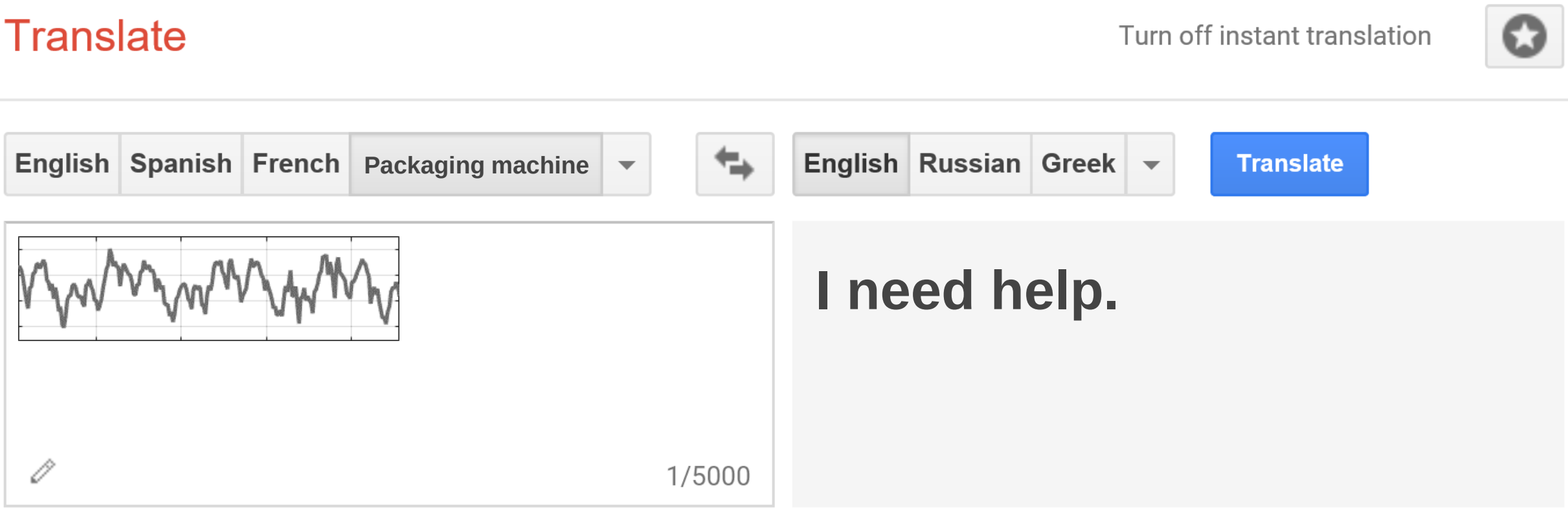


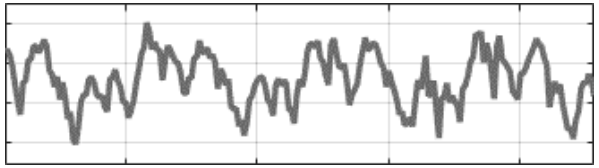
Case Study: Condition Monitoring of a Packaging Machine

Translate

Turn off instant translation

English | Spanish | French | Packaging machine

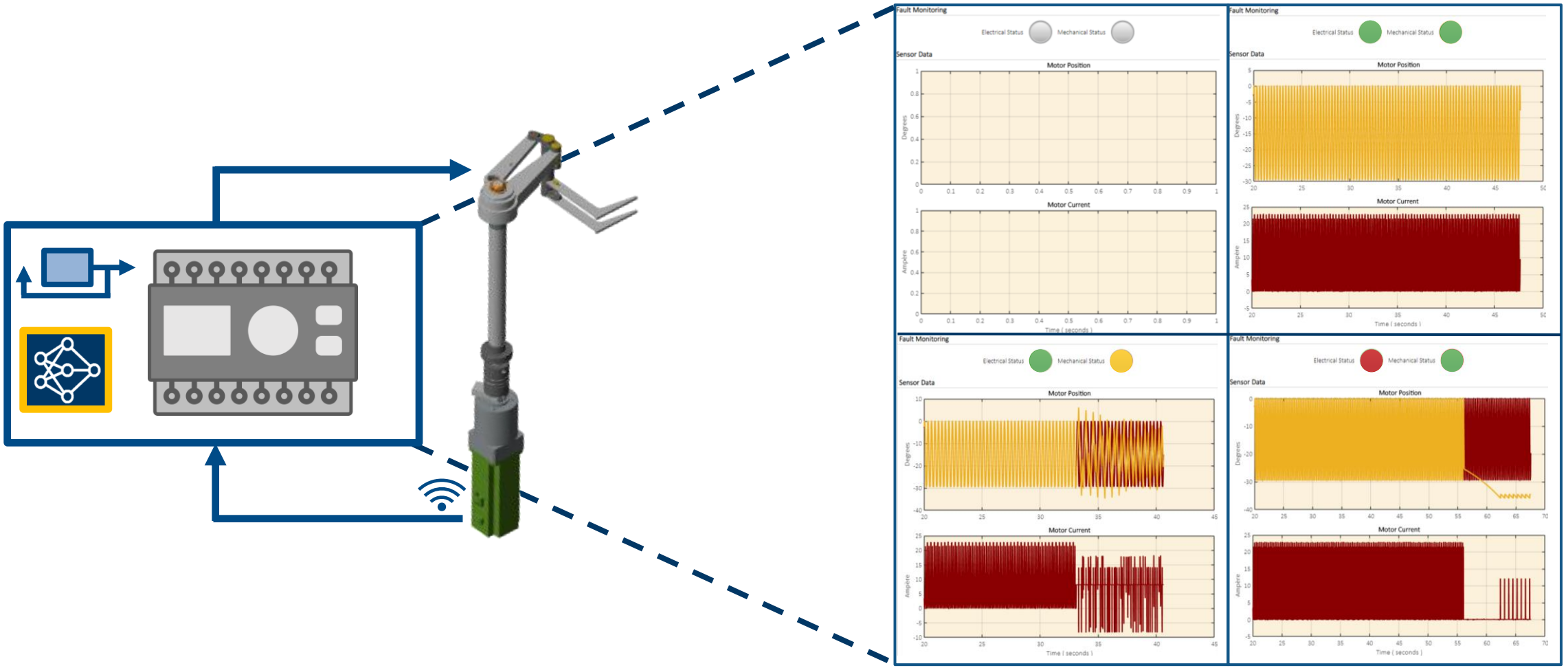
English | Russian | Greek | Translate



1/5000

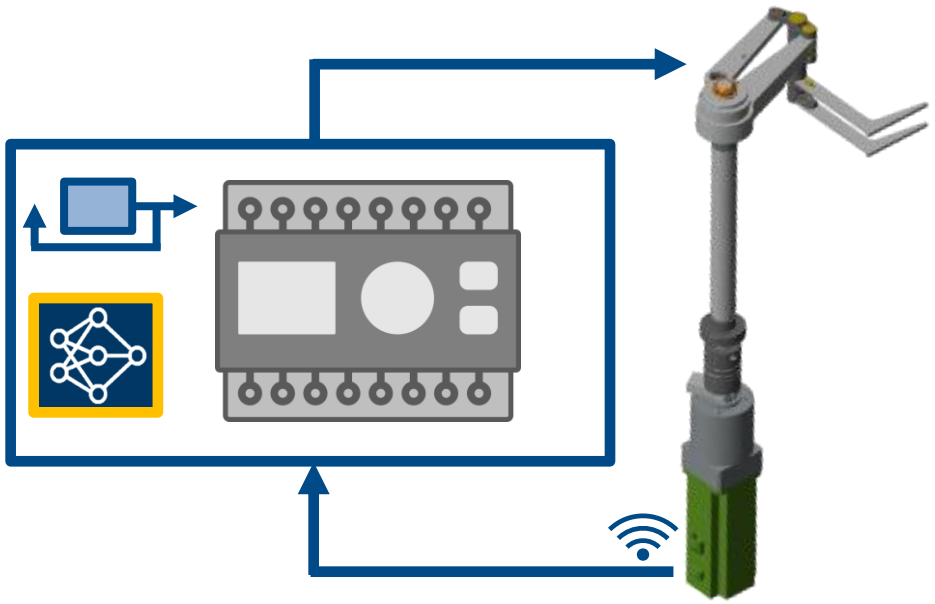
I need help. I have a bad bearing.

Case Study: Condition Monitoring of a Packaging Machine



Case Study Demo

Case Study: Condition Monitoring of a Packaging Machine



Data Preparation

- Synthetic data from **Simulink/Simscape.**
- Data processing: **MATLAB** and **Diagnostic Feature Designer App**

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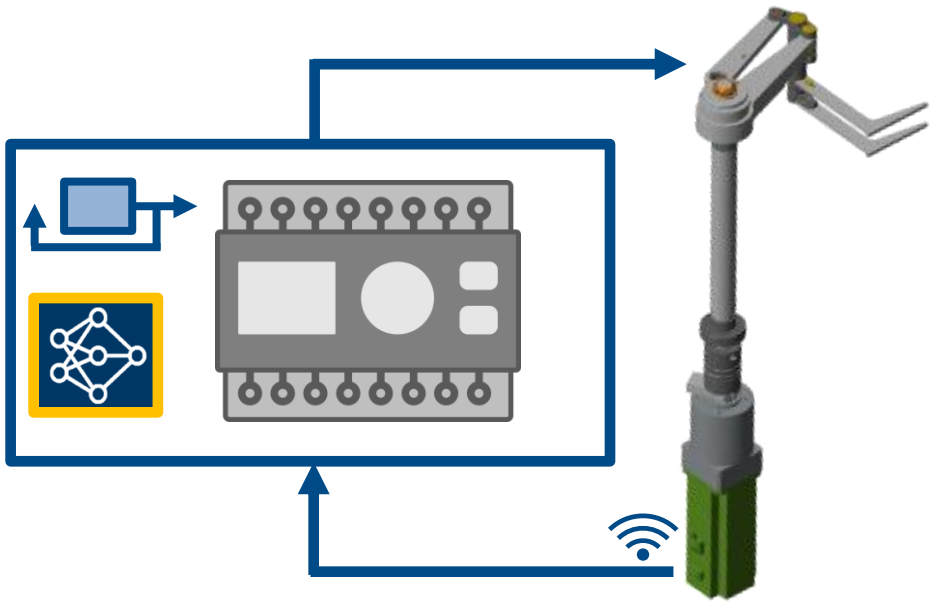

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AI Modeling

- Classifier Training and Validation: **Classification Learner App**

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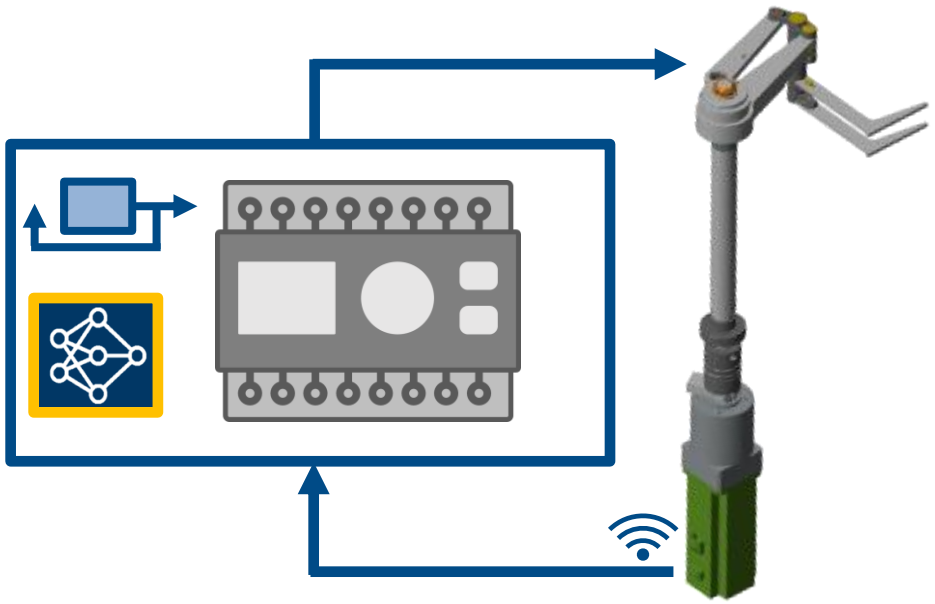

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- System Integration: **Simulink, Simscape, MATLAB**

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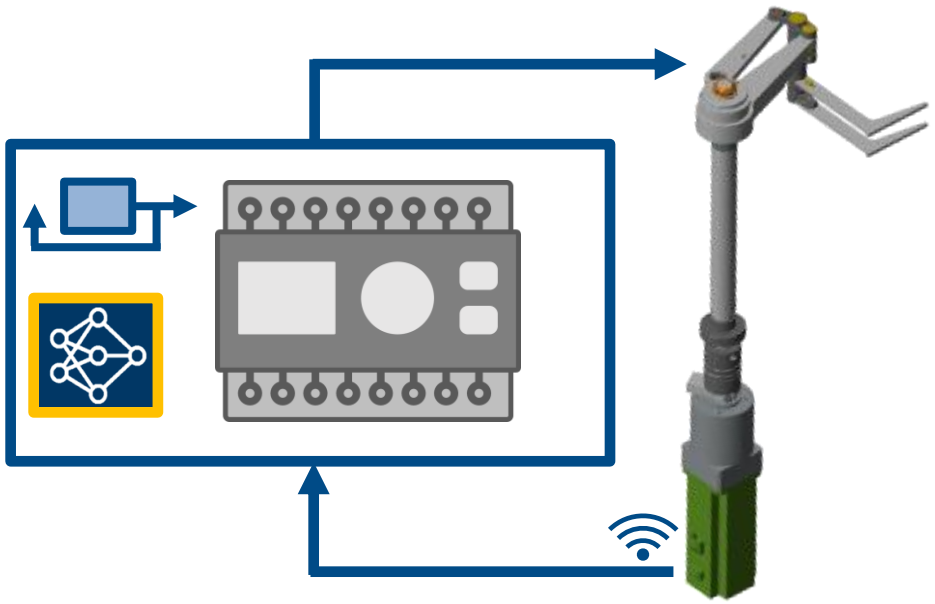

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AI Modeling

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System Design

- System Integration: **Simulink, Simscape, MATLAB**

Deployment

- Code Generation for PLC: **Embedded Coder, Automation Studio Target for Simulink**

Poll 3: What do you think is the most challenging part of this workflow? (single choice)

a. Data Preparation
b. AI Modeling
c. System Design
d. Deployment

Poll 3: What do you think is the most challenging part of this workflow?

Data Preparation

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System Design

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Deployment

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Hardware partners

BECKHOFF

SIEMENS

PHOENIX CONTACT

Vendor	IDE	IEC 61131-3	C/C++
3S - Smart Software Solutions	CODESYS™	✓	
B&R Industrial Automation	Automation Studio™	✓	✓
Bachmann Electronic	SolutionCenter	✓	✓
Beckhoff Automation	TwinCAT®	✓	✓
Bosch Rexroth	IndraWorks	✓	✓
Mitsubishi® Electric	CW Workbench		✓
Ingeteam	Ingesys IC3		✓
Omron®	Sysmac® Studio	✓	
Phoenix Contact®	PC WORX™	✓	✓
Rockwell Automation®	RSLogix™/Studio 5000	✓	
Siemens®	TIA Portal/STEP® 7	✓	✓

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Q&A

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Thank you

Gianfranco Fiore
Application Engineer
gfiore@mathworks.com

Rareș Curatu
Industrial Automation and Machinery Industry Manager
rcuratu@mathworks.com

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