Predictive Maintenance

Identify and prevent failures before they occur:
- Reduces unnecessary maintenance
- Eliminates unplanned downtime

Consists of:
- Algorithms to predict Time-to-Failure or Remaining Useful Life
- Interfaces to communicate information to maintenance crew

Source: Tensor Systems
Why is Predictive Maintenance Important?

- Improved Operating Efficiency
- New Revenue Streams
- Competitive Differentiator

$35M Saved
Unplanned downtime rate reduced by 30%

Source: GE Oil & Gas
Industry Agrees that Predictive Maintenance is Important

- Improved operating efficiency
- New revenue streams
- Competitive differentiator
What should a Predictive Maintenance Algorithm do?

*Turn large volumes of complex data into decisions*

- What is the condition of my machine?
- When will my machine fail?
- How do I prevent this failure?
MATLAB Helps Build Predictive Maintenance Algorithms

*Turn large volumes of complex data into decisions*

[Diagram showing the flow from Data to Decision with three steps:]

1. **Work with all of your data**
2. **Your domain experts can do data science**
3. **Your algorithms can run anywhere**

**Questions:**
- What is the condition of my machine?
- When will my machine fail?
- How do I prevent this failure?
Baker Hughes Develops Predictive Maintenance Software for Gas and Oil Extraction Equipment

Challenge
Develop a predictive maintenance system to reduce pump equipment costs and downtime

Solution
Use MATLAB to analyze nearly one terabyte of data and create a neural network that can predict machine failures before they occur

Results
- Savings of more than $10 million projected
- Development time reduced tenfold
- Multiple types of data easily accessed

Truck with positive displacement pump.
Predictive Maintenance Algorithm Workflow

Access and Explore Data

Preprocess Data

Develop Predictive Models

Integrate Analytics with Systems

Business Data

Sensor Data

Data Reduction/Transformation

Feature Extraction

Model Creation

Model Validation

Enterprise Systems

Embedded Devices
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Data

Preprocess

Transform

Feature

Extract

Develop

Predictive

Models

Integrate

Analytics

Systems

MATLAB CONFERENCE 2017
Access and Preprocess Data

Challenges
- I don’t have enough data
- I have no data
- I have too much data to handle easily
- I have too many data sources
- My data is too messy
Access and Preprocess Data

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Feature Extraction
Access and Preprocess Data

- Point and click tools to access variety of data sources
- High-performance environment for big data
- Built-in algorithms for data preprocessing
Access and Preprocess Data

- Baker Hughes Develops Predictive Maintenance Software for Gas and Oil Extraction Equipment

“MATLAB gave us the ability to convert previously unreadable data into a usable format; automate filtering, spectral analysis, and transform steps for multiple trucks and regions; and ultimately, apply machine learning techniques in real time to predict the ideal time to perform maintenance.”

– Gulshan Singh, Baker Hughes
Build Predictive Models

1. Access and Explore Data
   - Business Data
   - Sensor Data

2. Preprocess Data
   - Data Reduction/Transformation
   - Feature Extraction

3. Develop Predictive Models
   - Model Creation
   - Model Validation

4. Integrate Analytics with Systems
   - Enterprise Systems
   - Embedded Devices
Build Predictive Models

Challenges

- I need to incorporate my domain knowledge
- I need to extract and verify health indicators
- I lack machine learning experience
- I have deadlines to meet
Build Predictive Models

Preprocess Data

Data Reduction/Transformation

Feature Extraction

Develop Predictive Models

Model Creation

Model Validation
Build Predictive Models

- Easy to use apps across multiple domains
- Documentation, examples, and videos to get started
- Automatic MATLAB code generation

Preprocess Data

Data Reduction/Transformation

Feature Extraction

Apps

MATLAB

Simulink

Develop Predictive Models

Your domain experts can do data science

Model Creation

Model Validation

MATLAB CONFERENCE 2017
“As a manufacturing company we don’t have data scientists with machine learning expertise, but MathWorks provided the tools and technical knowhow that enabled us to develop a production preventative maintenance system in a matter of months.”

– Dr. Michael Kohlert, MONDI

“…[We] enable engineers to quickly and easily layout algorithms without special knowledge in computer science…”

– Jérôme Lacaille, Safran
Deploy and Integrate

Access and Explore Data

1. Business Data
2. Sensor Data

Preprocess Data

1. Data Reduction/Transformation
2. Feature Extraction

Develop Predictive Models

1. Model Creation
2. Model Validation

Integrate Analytics with Systems

1. Enterprise Systems
2. Embedded Devices
Deploy and Integrate

**Challenges**

- I have multiple end users – plant managers, operations analysts, maintenance staff, etc.
- I have to allow access through different target platforms
- I need to scale to meet production needs
- I need to reduce bandwidth consumption
Deploy and Integrate

Develop Predictive Models

- Model Creation
- Model Validation

Integrate Analytics with Systems

- Enterprise Systems
- Embedded Devices

MathWorks

MATLAB Conference 2017
Deploy and Integrate

Your algorithms can run anywhere

MATLAB + SIMULINK

Code Generation    Compiled Applications

C, C++  HDL  PLC  RESTful API  C, C++  .NET
Spark  Python  Java  Standalone Application  MATLAB Production Server

Develop Predictive Models

Integrate Analytics with Systems

Model Creation

Model Validation

Embedded Hardware    Enterprise Systems

- Royalty-free deployment
- Web services, apps, and cloud platforms
- Computation on smarter edge devices
- Automatic C/C++ code generation

Enterprise Systems

Embedded Devices
Deploy and Integrate

“The protection algorithms for our conventional HVDC system took about six months to develop and test in C. I re-implemented the same algorithms in Simulink and Stateflow and had them working in a single week.”

– Anthony Totterdell, Alstom Grid

“Using MATLAB and MATLAB Compiler, I can develop an application at least 100 times faster than I could with Visual Basic or C. The time we saved on the very first application that we wrote in MATLAB more than paid for the software.”

– Roger Schultz, Halliburton Energy Services
Summary: MATLAB Helps Build Predictive Maintenance Algorithms

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   - Sensor Data

2. Your domain experts can do data science
   - Data Reduction/Transformation
   - Feature Extraction

3. Your algorithms can run anywhere
   - Model Creation
   - Model Validation

Integrate Analytics with Systems
- Enterprise Systems
- Embedded Devices