빅데이터 분석을 통한
자동 고장 진단 및 예측 유지보수 시스템 개발

Application Engineer
엄 준 상 과장
Medical Devices
Aeronautics
Retail

Railway Systems
Automotive

Off-highway vehicles

Industrial Automation

Oil & Gas

Clean Energy

Automotive

Fleet Analytics

Prognostics

Condition Monitoring

Retail Analytics

Operational Analytics

Risk Analysis

Supply Chain

Data Analytics

Process Analytics

Health Monitoring

Healthcare Analytics

Mfg Process Analytics

Healthcare Management

Healthcare Management

Medical Devices

Financial

Internet

Logistics

Retail

Finance
Why perform predictive maintenance?

- Example: faulty braking system leads to windmill disaster
  - [https://youtu.be/-YJuFvjtM0s?t=39s](https://youtu.be/-YJuFvjtM0s?t=39s)

- Wind turbines cost millions of dollars

- Failures can be dangerous

- Maintenance also very expensive and dangerous
Types of Maintenance

- **Reactive** – Do maintenance once there’s a problem
  - Example: replace car battery when it has a problem
  - Problem: unexpected failures can be expensive and potentially dangerous

- **Scheduled** – Do maintenance at a regular rate
  - Example: change car’s oil every 5,000 miles
  - Problem: unnecessary maintenance can be wasteful; may not eliminate all failures

- **Predictive** – Forecast when problems will arise
  - Example: certain GM car models forecast problems with the battery, fuel pump, and starter motor
  - Problem: difficult to make accurate forecasts for complex equipment
Benefits of Predictive Maintenance

Increase “up time” and safety  
Reliability

Minimize maintenance costs  
Cost of Ownership

Optimize supply chain  
Reputation
What Does Success Look Like?
Safran Engine Health Monitoring Solution

- Monitor Systems
  - Detect failure indicators
  - Predict time to maintenance
  - Identify components

- Improve Aircraft Availability
  - On time departures and arrivals
  - Plan and optimize maintenance
  - Reduce engine out-of-service time

- Reduce Maintenance Costs
  - Troubleshooting assistance
  - Limit secondary damage

http://www.mathworks.com/company/events/conferences/matlab-virtual-conference/
Predictive Maintenance of Turbofan Engine

Sensor data from 100 engines of the same model

Predict and fix failures before they arise
- Import and analyze historical sensor data
- Train model to predict when failures will occur
- Deploy model to run on live sensor data
- Predict failures in real time

Data provided by NASA PCoE
http://ti.arc.nasa.gov/tech/dash/pcoe/prognostic-data-repository/
Predictive Maintenance of Turbofan Engine

Sensor data from 100 engines of the same model

Scenario 1: No data from failures

- Performing scheduled maintenance
- No failures have occurred
- Maintenance crews tell us most engines could run for longer
- Can we be smarter about how to schedule maintenance **without** knowing what failure looks like?

Data provided by NASA PCoE

http://ti.arc.nasa.gov/tech/dash/pcoe/prognostic-data-repository/
Machine Learning
Characteristics and Examples

- **Characteristics**
  - Too many variables
  - System too complex to know the governing equation (e.g., black-box modeling)

- **Examples**
  - Pattern recognition (speech, images)
  - Financial algorithms (credit scoring, algo trading)
  - Energy forecasting (load, price)
  - Biology (tumor detection, drug discovery)
  - Engineering (fleet analytics, predictive maintenance)
Overview – Machine Learning

Type of Learning

- **Supervised Learning**
  - Develop predictive model based on both input and output data

- **Unsupervised Learning**
  - Group and interpret data based only on input data
Principal Components Analysis – what is it doing?

- Variable 1
- Variable 2
- Variable 3
- PC 1
- PC 2

Score on PC 1
Score on PC 2
Residual
Example Unsupervised Implementation

Initial Use/
Prior Maintenance

Round 1
Engine1
Engine2
Engine3

Round 2
Engine1
Engine2
Engine3

Round 3
Engine1
Engine2
Engine3

125 Flights
135 Flights
150 Flights

Maintenance
Predictive Maintenance of Turbofan Engine

Sensor data from 100 engines of the same model

Scenario 2: Have failure data
- Performing scheduled maintenance
- Failures still occurring (maybe by design)
- Search records for when failures occurred and gather data preceding the failure events
- Can we predict how long until failures will occur?

Data provided by NASA PCoE
http://ti.arc.nasa.gov/tech/dash/pcoe/prognostic-data-repository/
Overview – Machine Learning

**Type of Learning**

- **Supervised Learning**
  - Develop predictive model based on both input and output data
- **Unsupervised Learning**
  - Group and interpret data based only on input data

**Categories of Algorithms**

- **Regression**
- **Classification**
How Data was Recorded

Initial Use/ Prior Maintenance

- Recording Starts
- Failure
- Maintenance

Historical

- Engine1
- Engine2
- Engine100

Live

- Engine200
Integrate analytics with your enterprise systems

MATLAB Compiler and MATLAB Coder
MathWorks Services

- **Consulting**
  - Integration
  - Data analysis/visualization
  - Unify workflows, models, data
  
  [www.mathworks.com/services/consulting/](http://www.mathworks.com/services/consulting/)

- **Training**
  - Classroom, online, on-site
  - Data Processing, Visualization, Deployment, Parallel Computing

  [www.mathworks.com/services/training/](http://www.mathworks.com/services/training/)
Key Takeaways

- Frequent maintenance and unexpected failures are a large cost in many industries
- MATLAB enables engineers and data scientists to quickly create, test and implement predictive maintenance programs
- Predictive maintenance
  - Saves money for equipment operators
  - Increases reliability and safety of equipment
  - Creates opportunities for new services that equipment manufacturers can provide
MATLAB Differentiators

1. Analytics that increasingly require both business and engineering data

DATA
- Engineering, Scientific, and Field
- Business and Transactional

2. Developing embedded systems which have increasing analytic content

3. Deploying applications that run on both traditional IT and embedded platforms

4. Enable Domain Experts to do Data Science

Smart Connected Systems

Business Systems

Data Analytics