Predictive Maintenance with MATLAB

A data-driven approach

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Why perform predictive maintenance?

- Example: faulty braking system leads to windmill disaster
  - https://youtu.be/-YJuFvjtM0s?t=39s
- Your equipment can cost millions of dollars
- Failures can be dangerous
- Maintenance also very expensive and dangerous

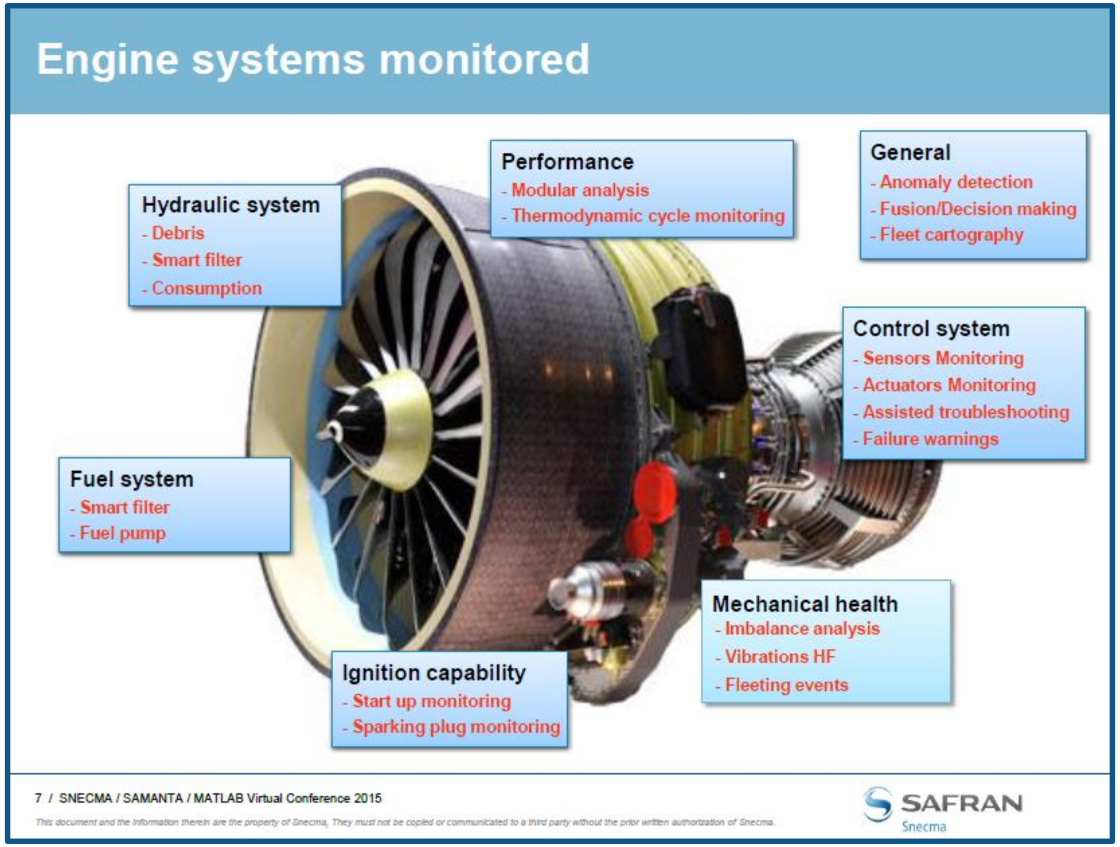
Types of Maintenance

- 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
- Preventive – 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

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



Desktop	Compiled Shared	Enterprise Integration
• Ad-hoc data analysis • Analytics to predict failure	• Suite of MATLAB Analytics • Shared with other teams • Proof of readiness	• Real-time analytics • Integrated with maintenance and service systems

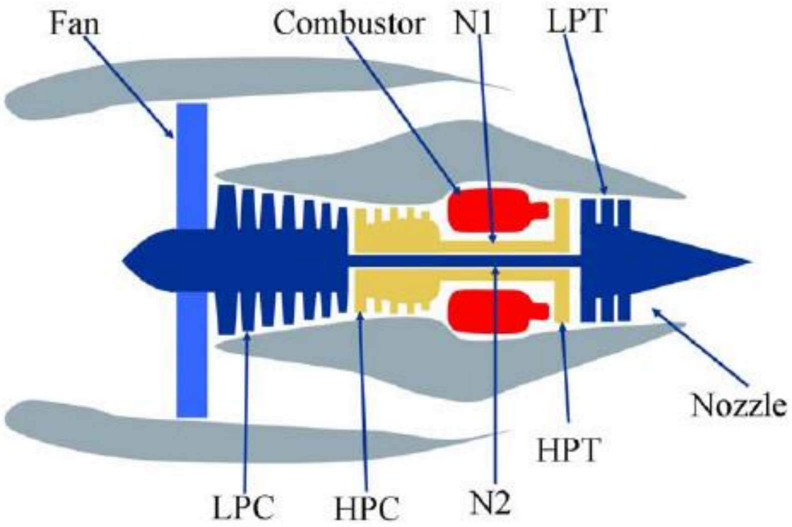
http://www.mathworks.com/company/events/conferences/matlab-virtual-conference/

Predictive Maintenance of Turbofan Engine

Sensor data from 100 engines of the same model

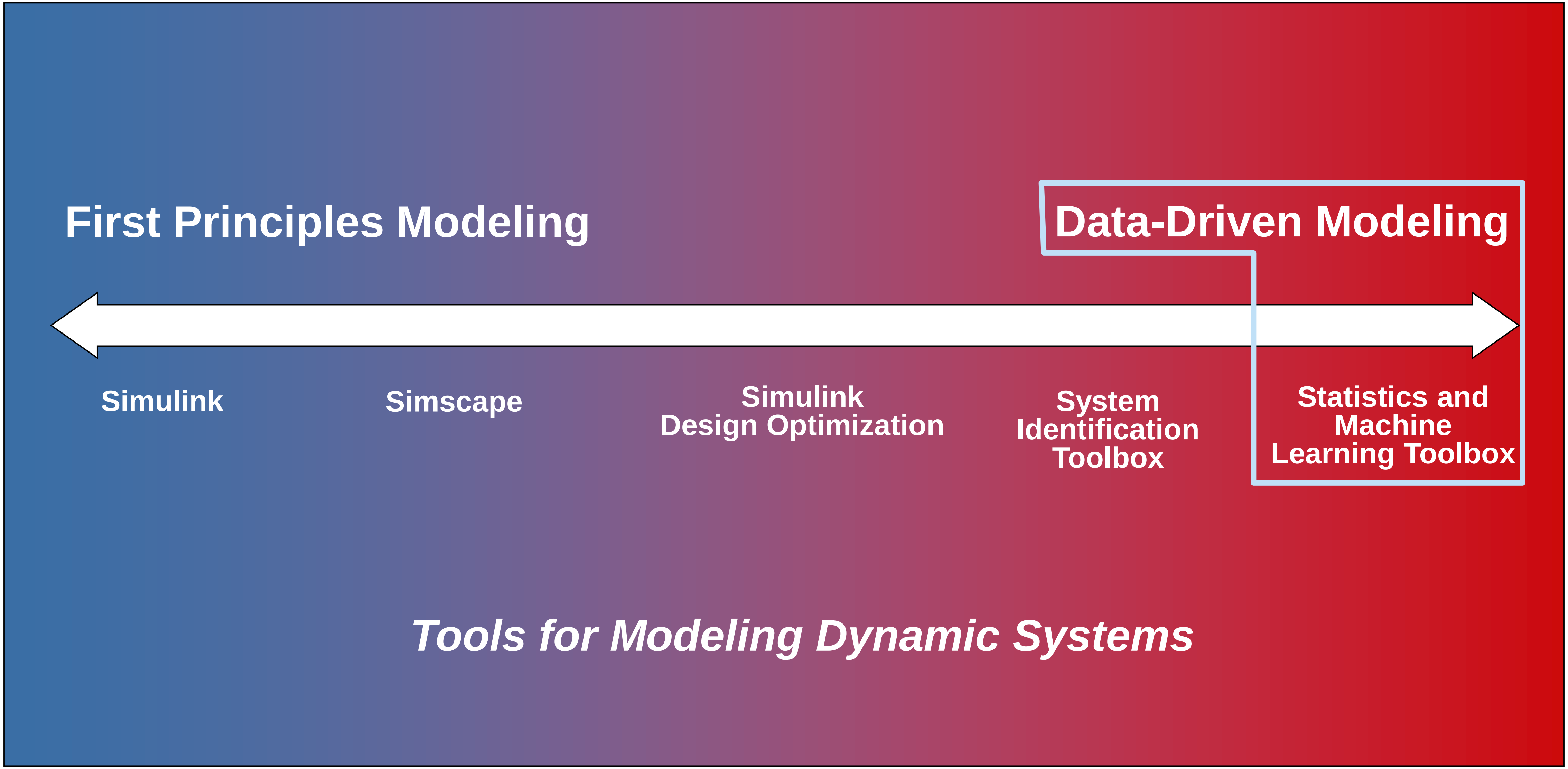
Predict and fix failures before they arise

- 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/

Modeling Approaches



Challenges

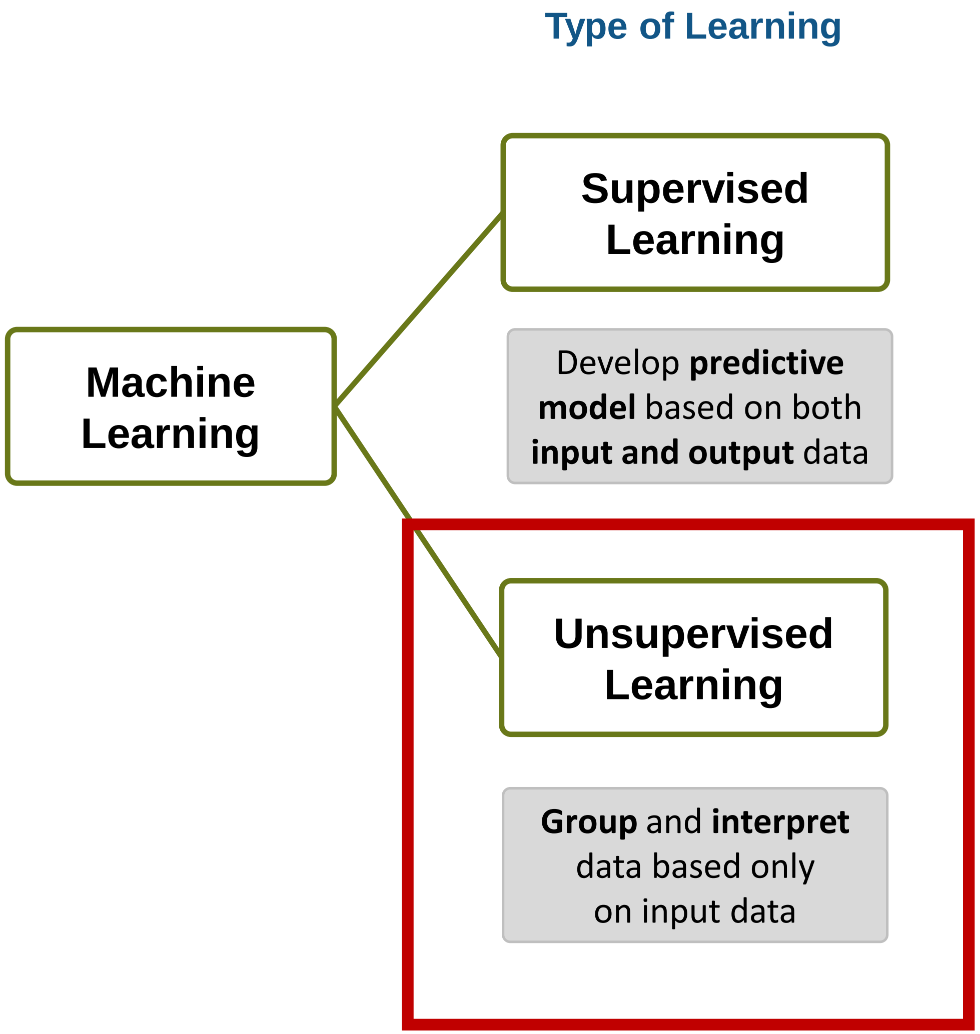
1. Data – Do you have enough/correct data?

   A failure might be a rare occurrence – how do you develop an algorithm if you don’t know what a failure looks like

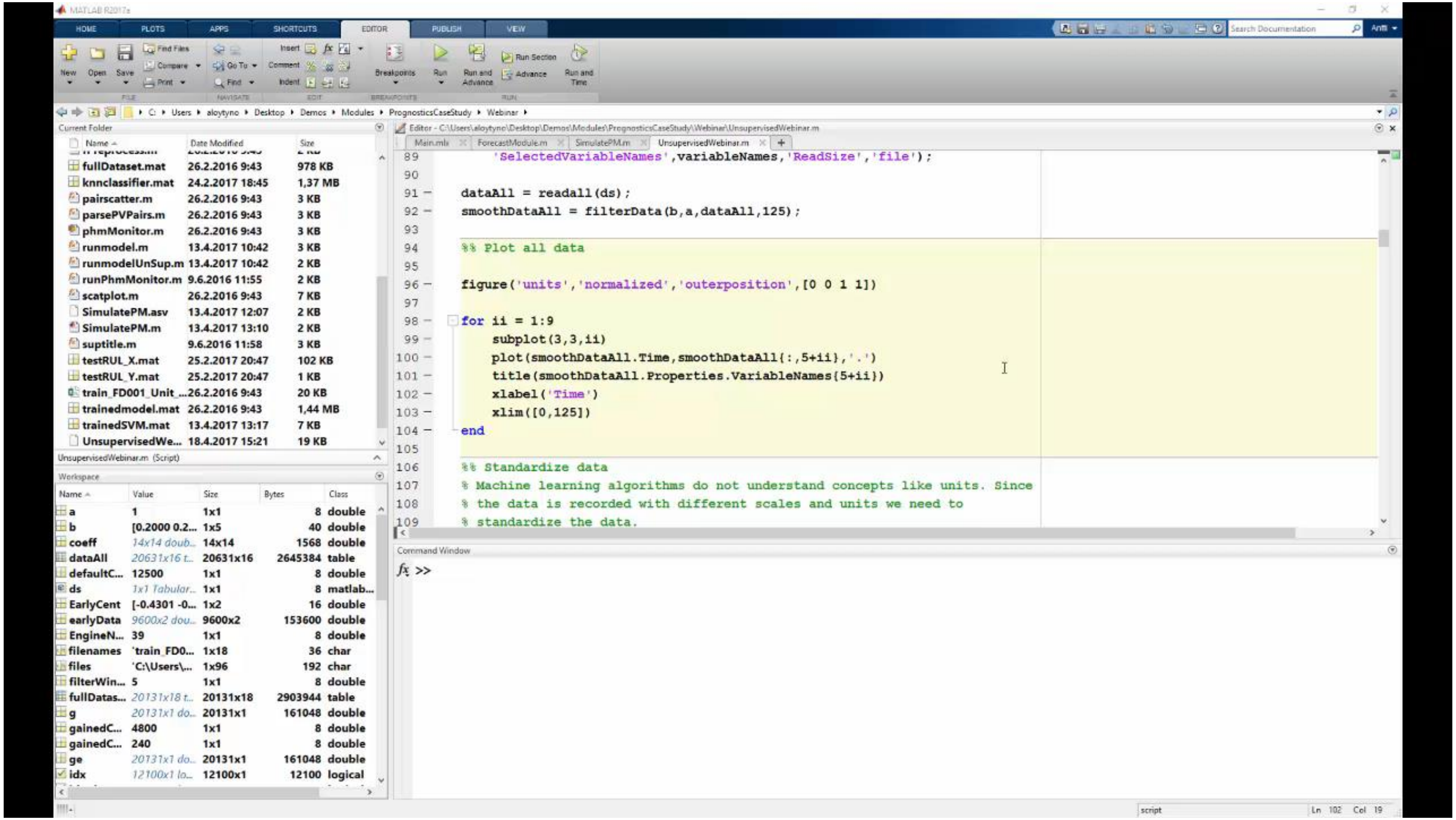
2. How do you find the best possible algorithm?

3. How do you deploy your algorithm into production?

Overview – Machine Learning



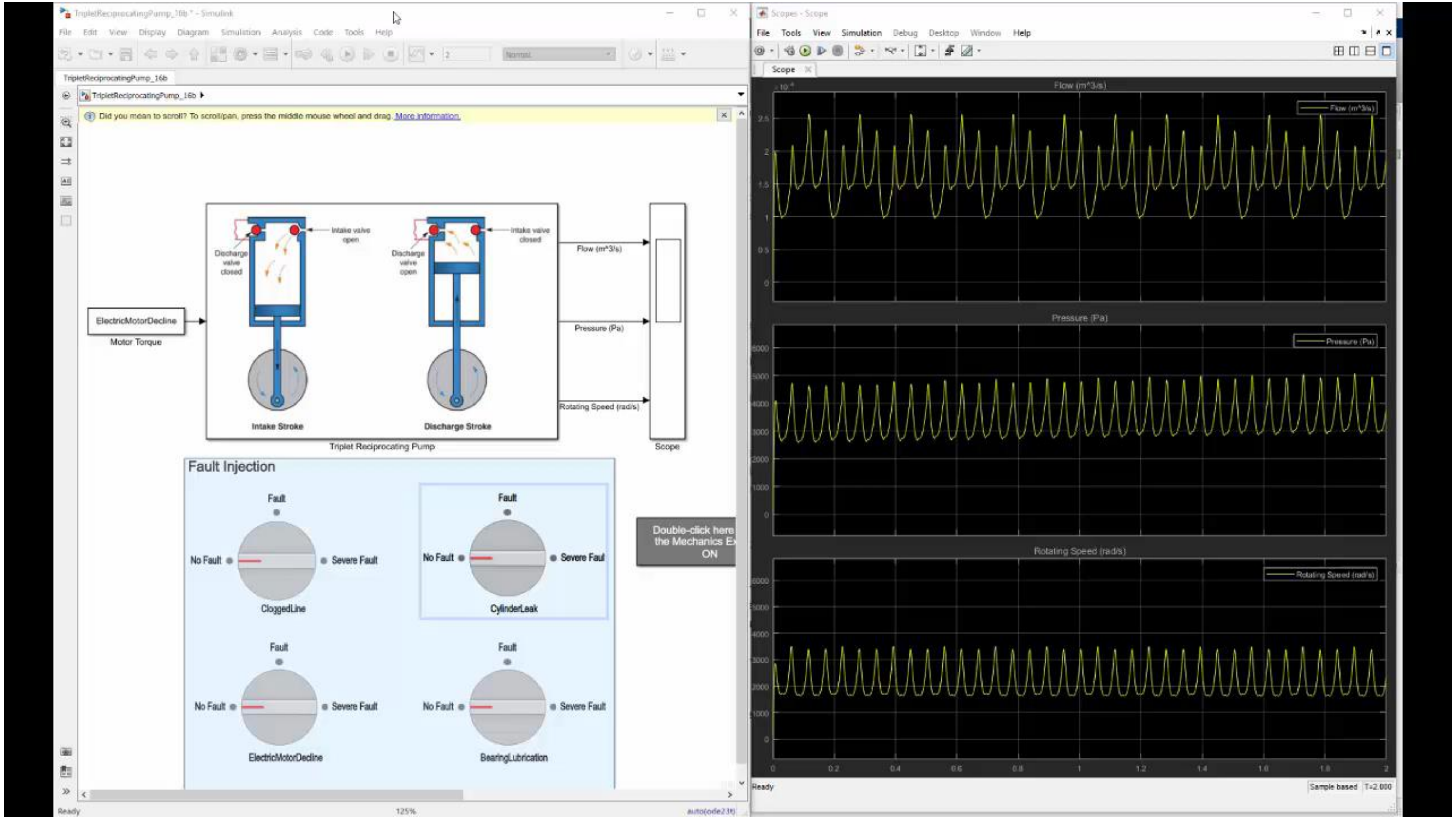
Using Unsupervised Machine Learning to Detect Deterioration of an Engine



Generating Datasets for Model Training Through Simulation

- If you don’t have real data available, consider generating data through simulation
- Model your system in Simulink, introduce errors (e.g. clogged hydraulics line), log the output of the simulation
- Use the generated dataset to develop a model to predict e.g. remining useful lifetime

Generating Datasets for Model Training Through Simulation

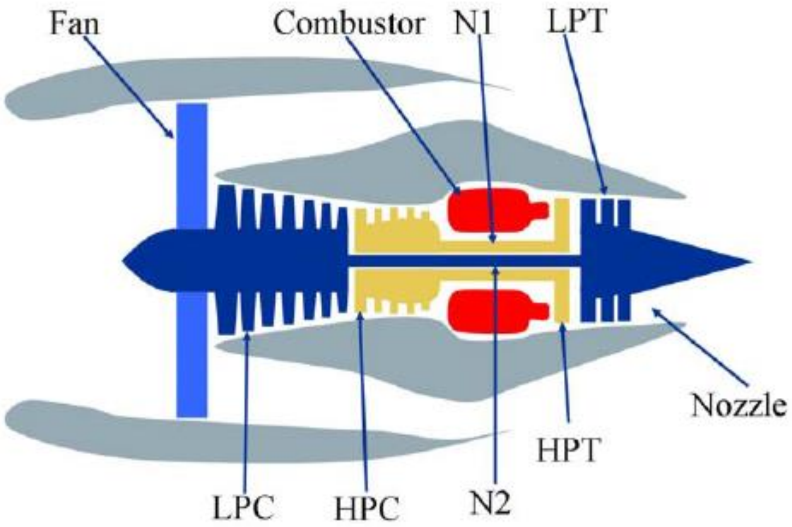


Predictive Maintenance of Turbofan Engine

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?



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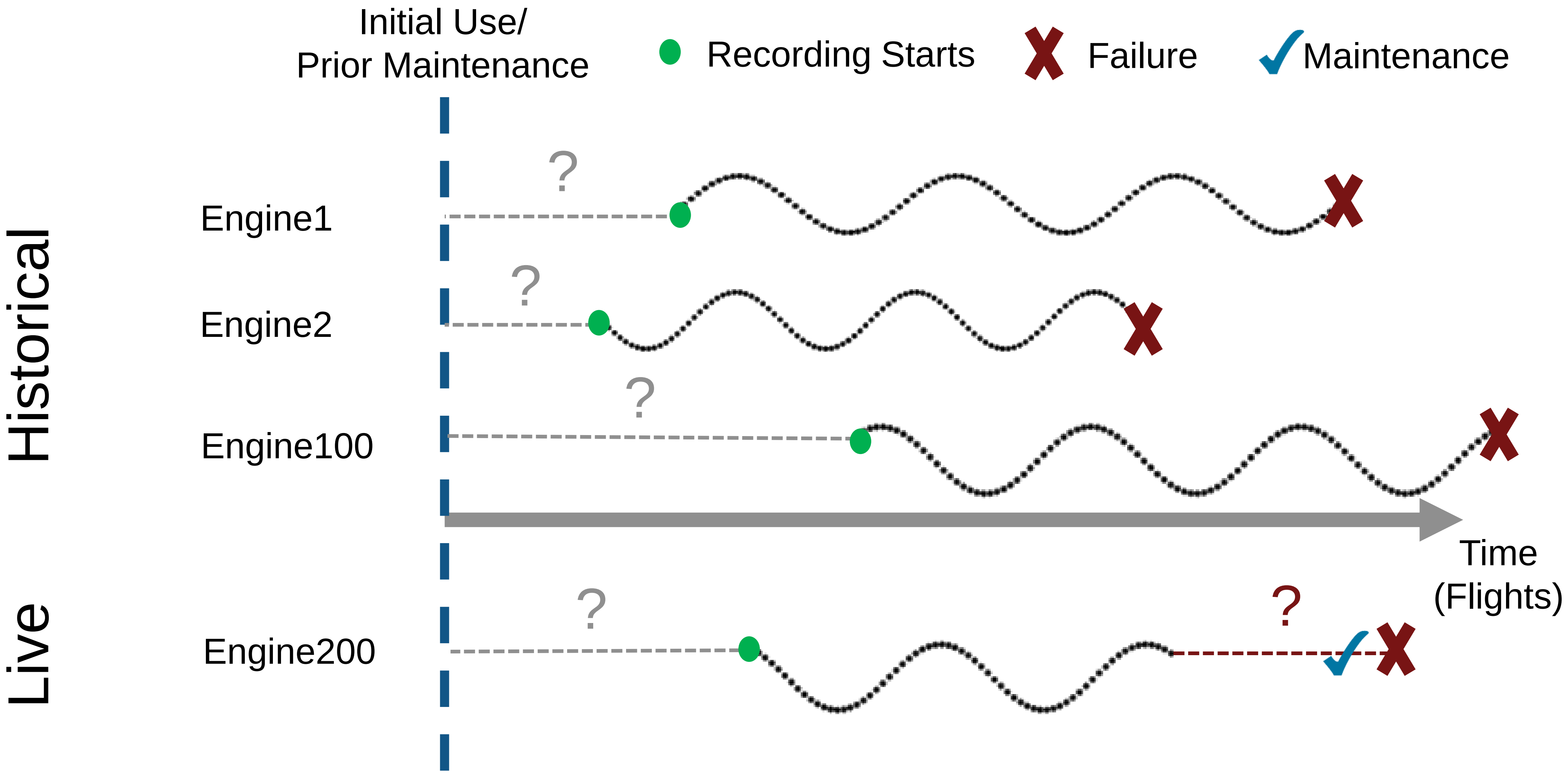
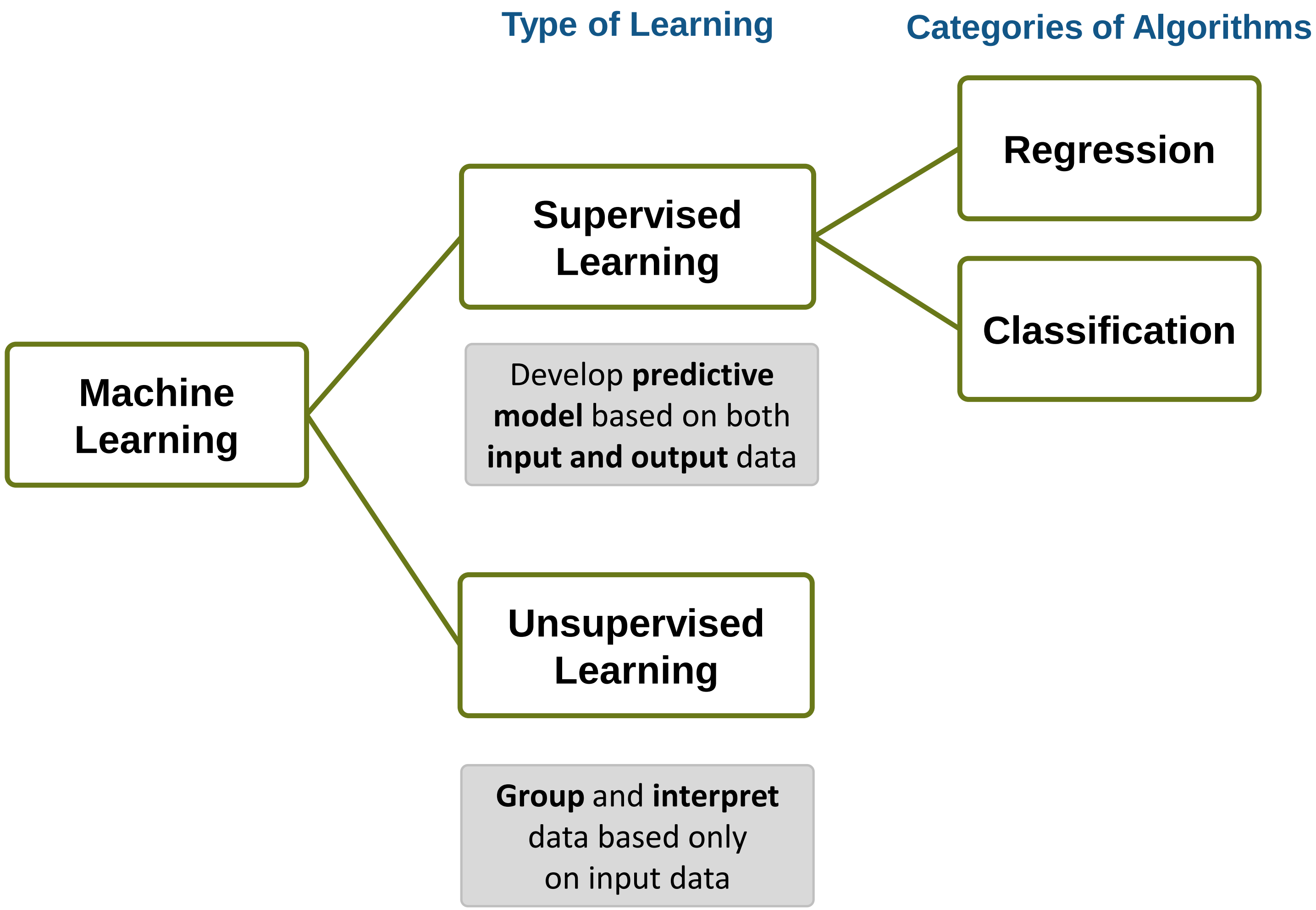
How Data was Recorded



Overview – Machine Learning



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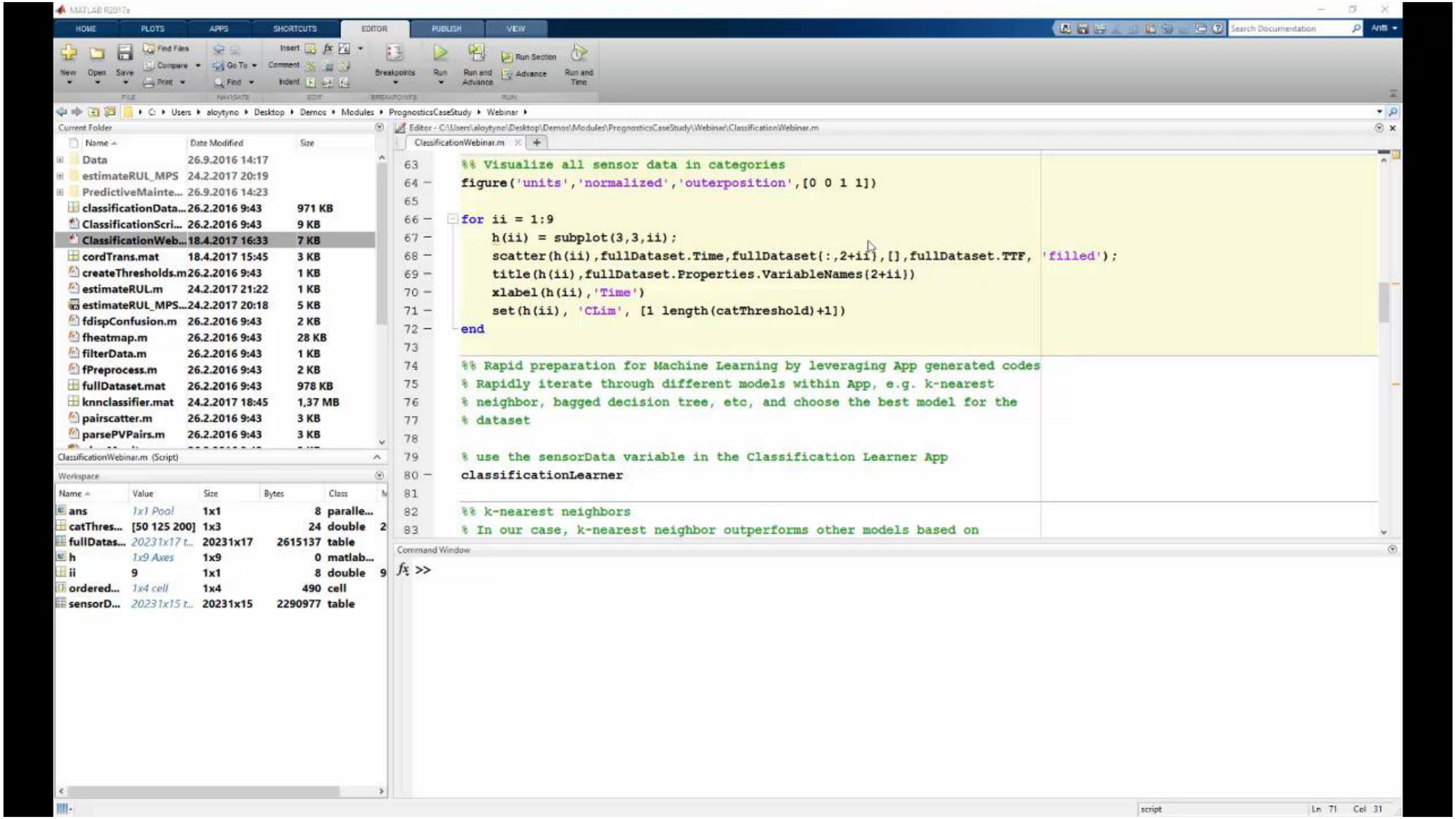
   There are dozens of modeling techniques

3. How do you deploy your algorithm into production?

Identifying the Best Classifier Using Classification Learner App



Challenges

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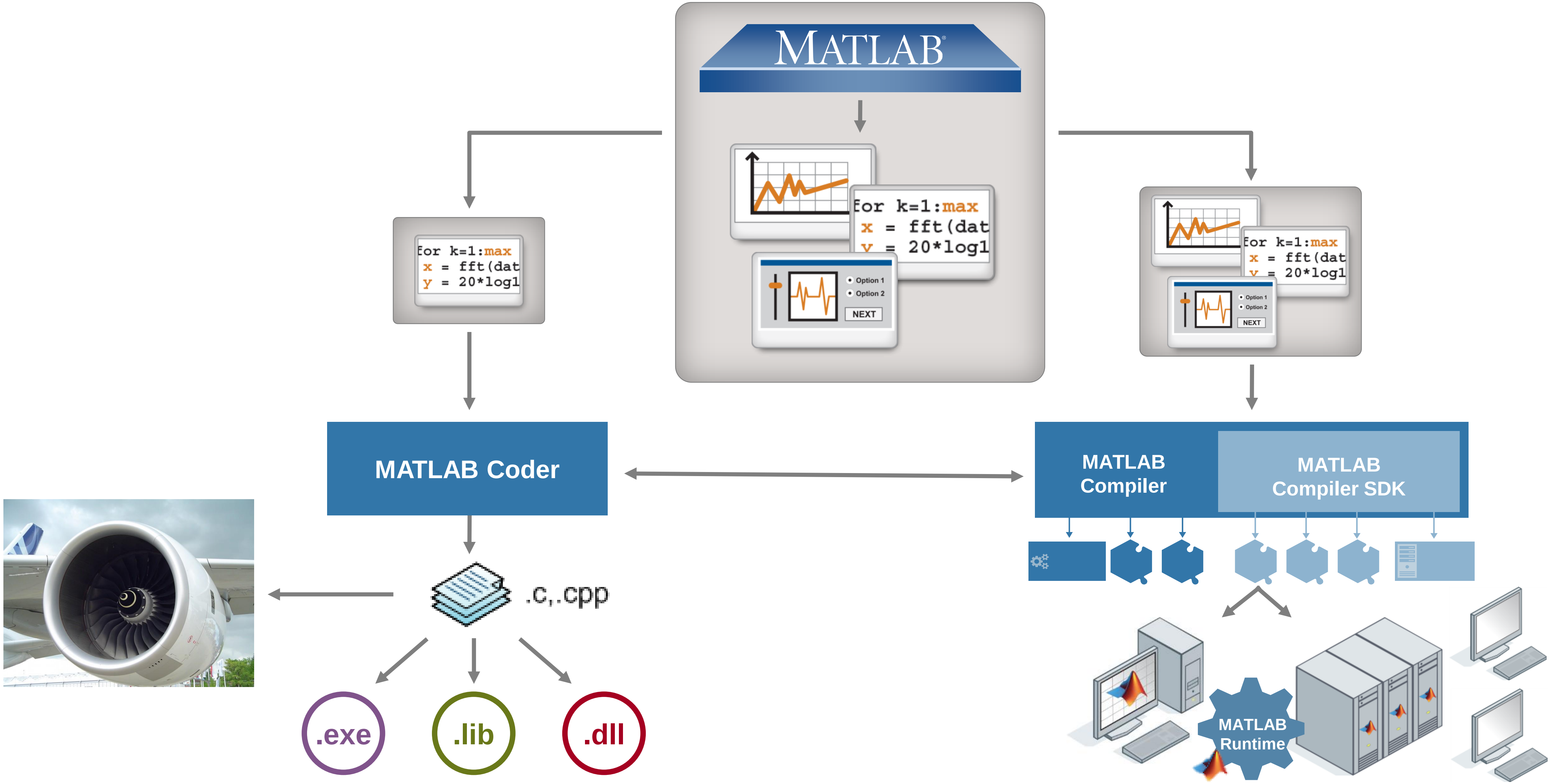
3. How do you deploy your algorithm into production?

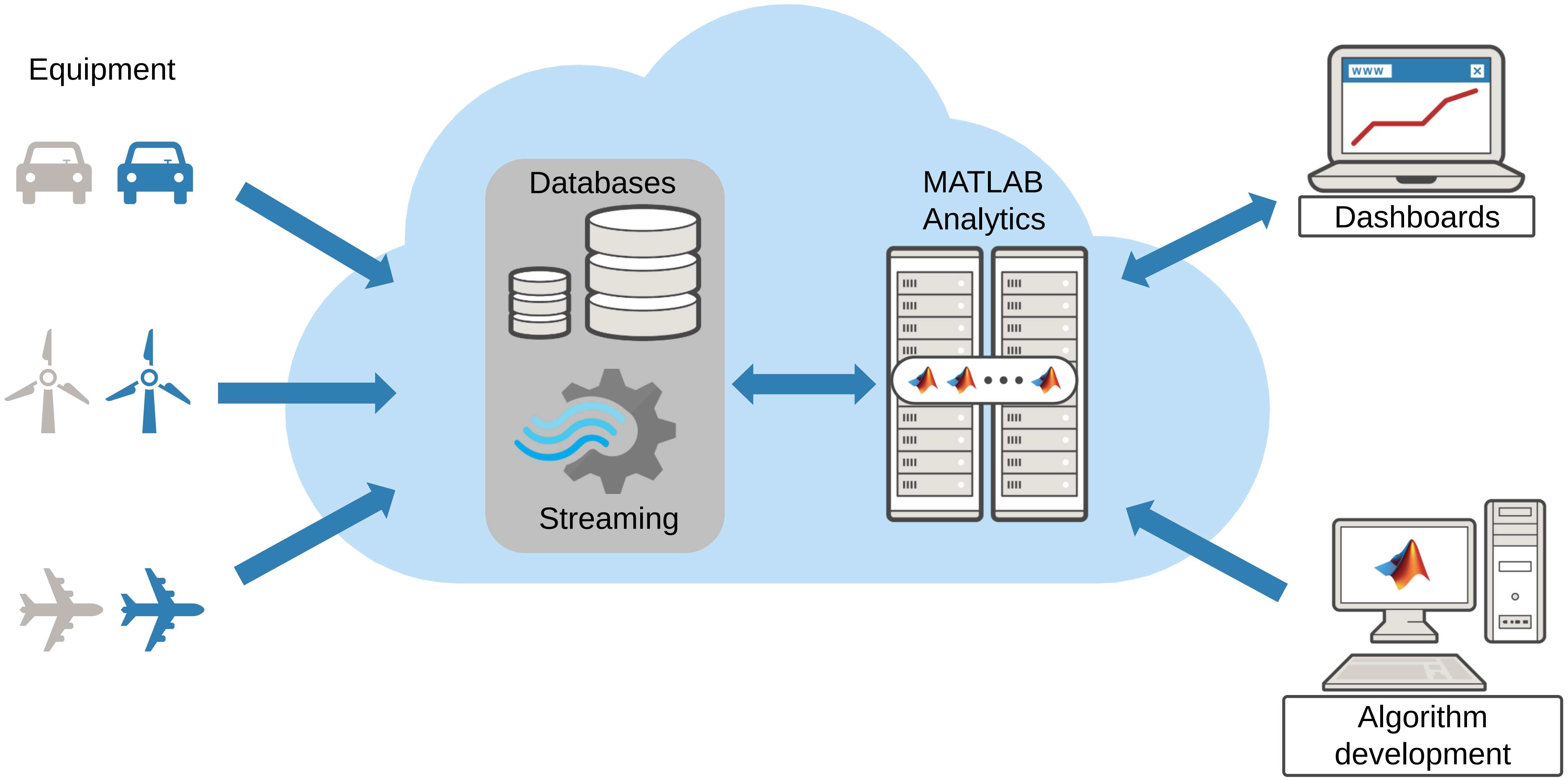
   Manually translating MATLAB into other languages can be error prone, and building a production-quality back-end from scratch is expensive

Integrate Analytics with Your Enterprise Systems

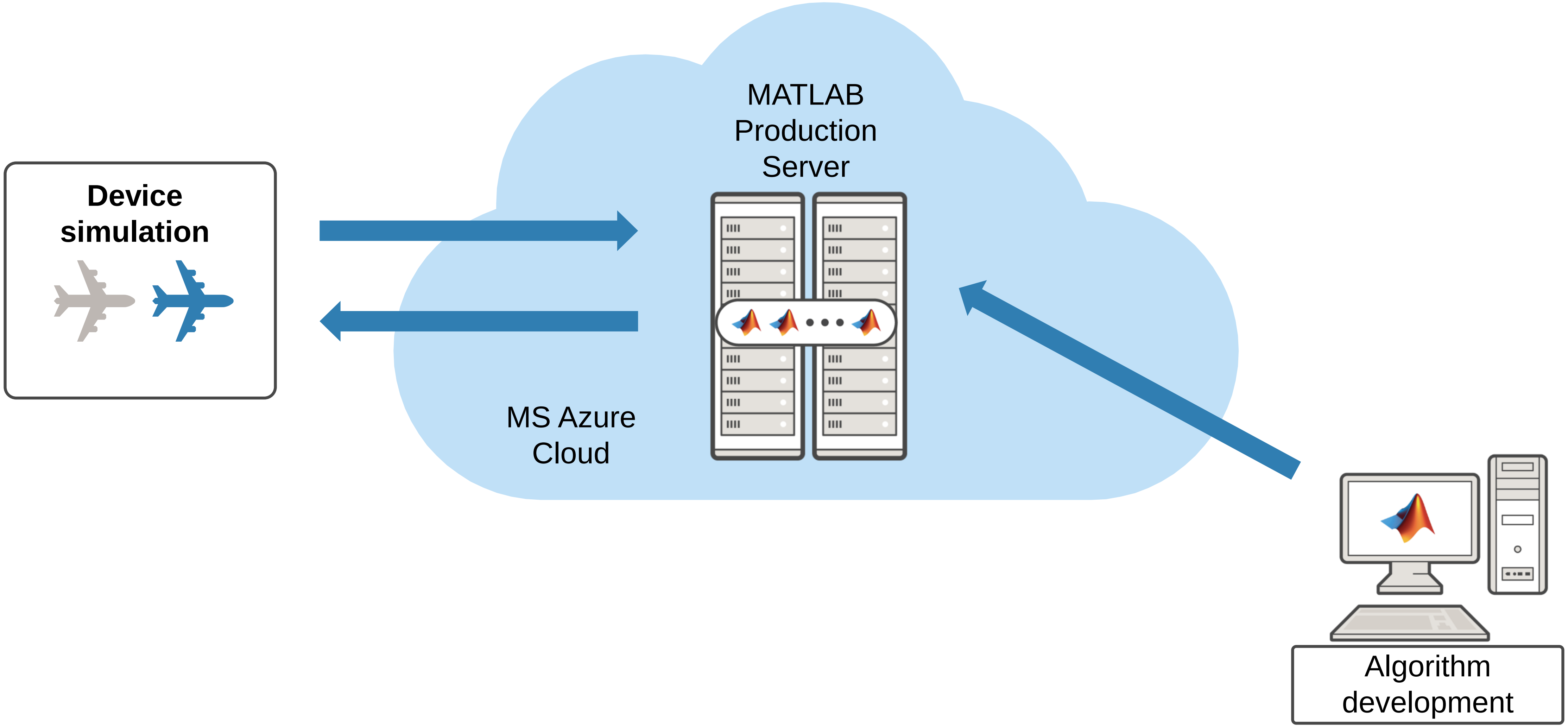
MATLAB Compiler and MATLAB Coder



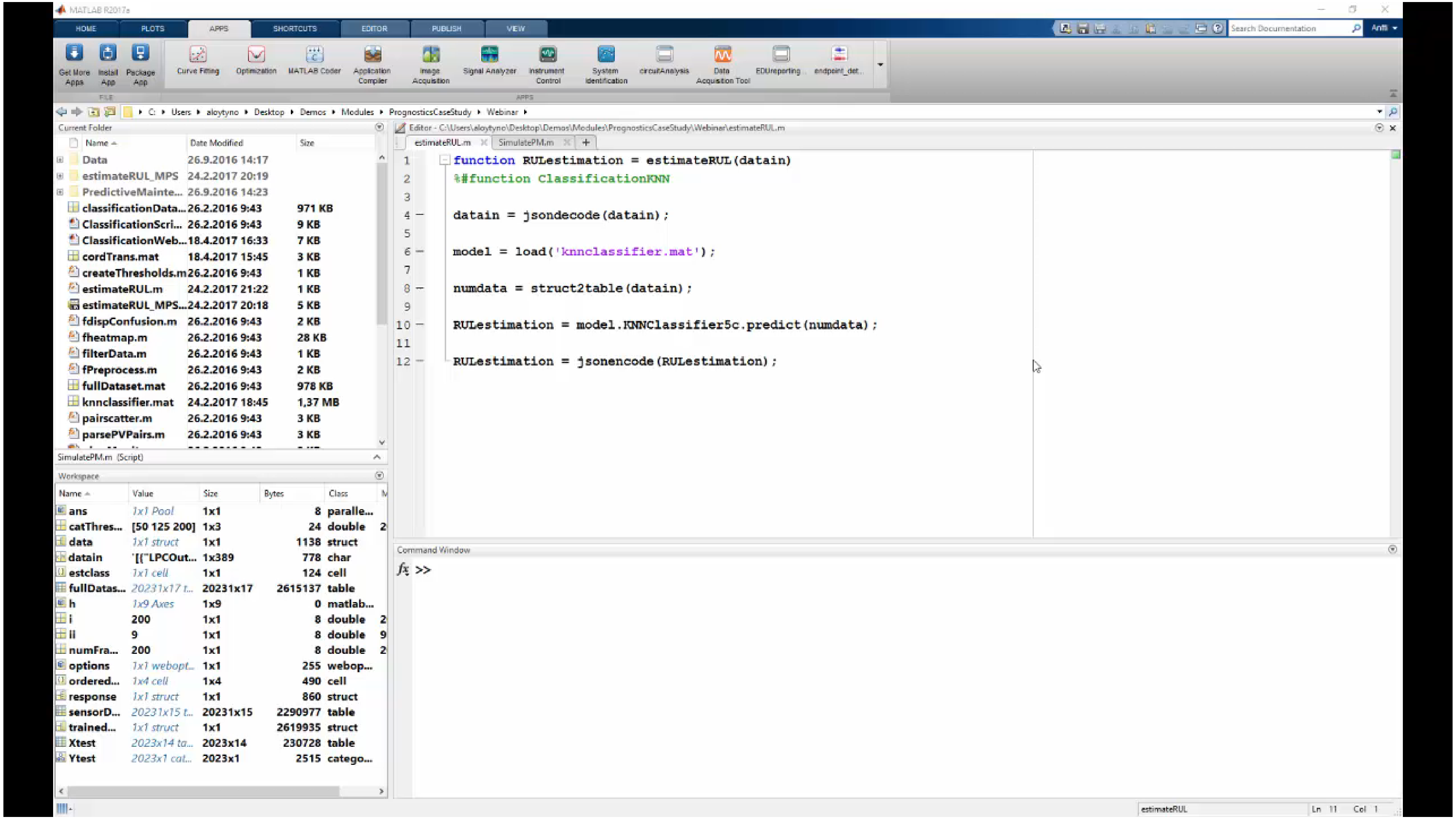
Building a MATLAB-based service



Demo: Predictive Maintenance Analytics in the Cloud

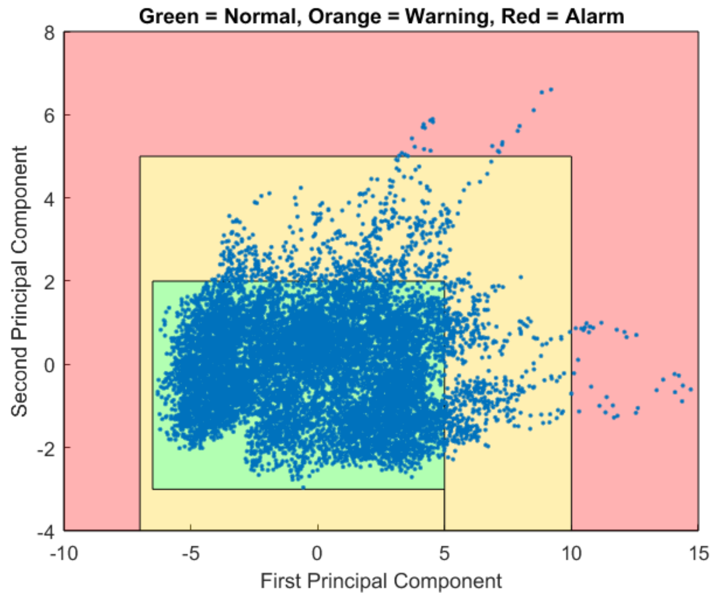


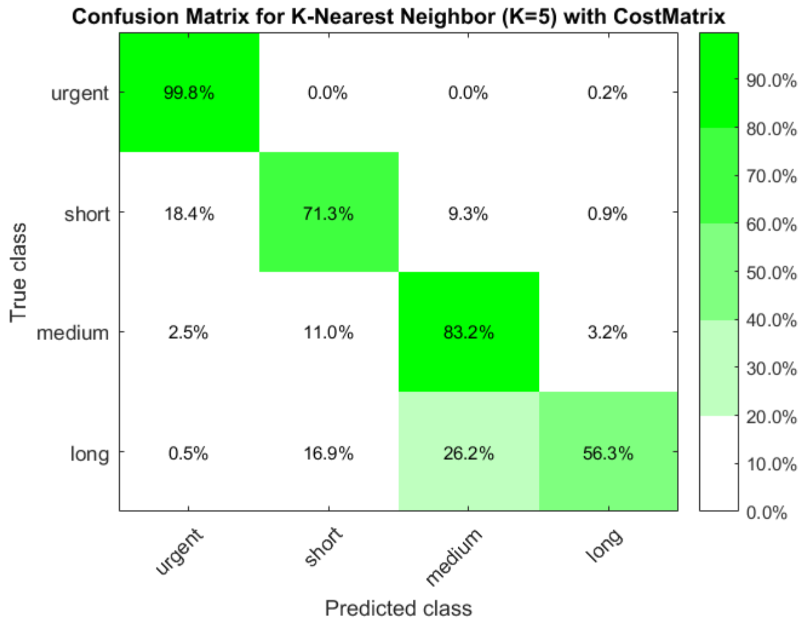
Performing RUL Classification in the Cloud



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





Predictive Maintenance with MATLAB

- Stop by at the ”Data Analytics” -demo station to learn more

- Full webinar at: http://se.mathworks.com/videos/predictive-maintenance-with-matlab-a-prognostics-case-study-118661.html

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