MATLAB EXPO 2017
How to build an autonomous anything

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Well, hello Sunshine. What's for breakfast?
Autonomous Technology
Autonomous

*Having the power for self-governance*
Autonomous Technology

Provides the ability of a system to act independently of direct human control under unrehearsed conditions
Capabilities of an Autonomous System

Sense
Capabilities of an Autonomous System

Sense

Perceive
Capabilities of an Autonomous System

- Sense
- Perceive
- Decide & Plan
Capabilities of an Autonomous System

- Sense
- Perceive
- Decide & Plan
- Act
Autonomous Technology Transfers Responsibility to Computers

Degree of Autonomy

Responsibility

Computer

Human
Cost of rig: >$1M
Repair cost: $100,000
Cost of valve: $200
Autonomous Service for Predictive Maintenance

Which sensor values should they use?

- Pressure
- Vibration
- Timing
- Temperature
- Other variables
Autonomous Service for Predictive Maintenance

Sense
Perceive
Decide & Plan
Act

Normal Operation
Monitor Closely
Maintenance Needed
Machine Learning or Deep Learning?

Machine Learning Approach

Sensor 1
Sensor 2
... Sensor 25

Correlation Analysis

Sensor a
Sensor b
Sensor c

Feature Extraction

Classification

Output

1. Normal
2. Monitor
3. Maintain

Deep Learning Approach

Sensor 1
Sensor 2
... Sensor 25

Feature Extraction & Classification

Output

1. Normal
2. Monitor
3. Maintain
What are the best predictors?

- Data-driven
What are the best predictors?

- Data-driven
- Model-driven

Jet Engine Monitoring
What are the best predictors?

Find out more about machine learning:
Machine Learning Simplified

Paola Jaramillo
Track B 13:15 – 13:45

Find out more about predictive maintenance:
Build predictive maintenance algorithms using physical models

Demo Station
Bazille’s Studio
Frederic Bazille (Paris, 1870)

Shuffleton’s Barbershop
Norman Rockwell (Vermont, 1950)
**Bazille’s Studio**  
Frederic Bazille (Paris, 1870)

**Shuffleton's Barbershop**  
Norman Rockwell (Vermont, 1950)
Autonomous Artistic Style Classification
Rutgers University

Sense

Perceive

Decide & Plan

Act

Image Feature Extraction

Visual Features

Machine Learning Classification

Style Classifier (SVM)

Style: Regionalism

Genre Classifier (SVM)

Genre: Interior

Artist Classifier (SVM)

Artist: Rockwell

Machine Learning Classification

Sense

Perceive

Decide & Plan

Act
Where to add autonomy with perception?

- Analyze more data
- Reduce bias
- Reduce variability
- Save time
- Improve performance

Determine Loudspeaker Quality

Virtual Semiconductor Manufacturing Calibration
Autonomous Glucose Level Management
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense
Perceive
Decide & Plan
Act

Target Glucose Level
Insulin Pump
Person
Continuous Glucose Monitor
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Target Glucose Level

Perceive

Insulin Pump

Decide & Plan

Mobile App

Act

Continuous Glucose Monitor

Person
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Target Glucose Level

Simulink, Stateflow, Polyspace

Insulin Pump

Perceive

Mobile App

Decide & Plan

Continuous Glucose Monitor

Act

Person

Simulink,
Stateflow,
Polyspace

+ -

+ +
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Perceive

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Act

Target Glucose Level

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Mobile App

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Sense
Perceive
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Act

Target Glucose Level
Insulin Pump
Mobile App
Continuous Glucose Monitor
Person
Virtual Clinic
Scaling computations to simulate 50 million patients a day
Where will you get your data?

- Simulation
- Public repositories
- In the lab
- In the field
- Internet of Things (IoT)
Where will you get your data?

- Simulation
- Public repositories
- In the lab
- In the field
- Internet of Things (IoT)

Find out more:
Verification Techniques for Model and Code
Paul Lambrechts
Track A 15:15 – 15:45

Find out more:
Predicting Customer Behavior Using Big Data Analytics with MATLAB in the Cloud
Rachid el Mimouni, NLE
Track B 15:15 – 15:45
CNH Develops Intelligent Filling System for Forage Harvesters
Autonomous Trailer Filling

Sense

Perceive

Decide & Plan

Act
Autonomous Trailer Filling

Sense

Perceive

Decide & Plan

Act

Computer Vision Algorithms

Control Algorithms

3D Camera Image

3D Scene Simulator

Control outputs
Autonomous Trailer Filling

- **Sense**
- **Perceive**
- **Decide & Plan**
- **Act**

3D Cameras

Computer vision and controls algorithms

CAN

ECU

Actuators
Autonomous Trailer Filling

- Sense
- Perceive
- Decide & Plan
- Act

3D Cameras

Vehicle Display Controller
- Driver Input
- Visualization

Computer vision and controls algorithms

ECU

CAN

Actuators
Autonomous Trailer Filling

- Sense
- Perceive
- Decide & Plan
- Act

3D Cameras

Vehicle Display Controller
- Driver Input
- Visualization
- Computer Vision
- Controls

Embedded Coder

CAN

Computer vision and controls algorithms

ECU

Actuators
Autonomous Trailer Filling

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3D Cameras

Vehicle Display Controller
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- Computer Vision
- Controls

CAN

Monitoring

Actuators

ECU
How will you put it into production?

- System Architecture
- Embedded systems
- Enterprise systems
- HMIs
How will you put it into production?

- System Architecture
- Embedded systems
- Enterprise systems
- HMIs

Find out more:
MATLAB Analytics in Enterprise Applications

Ionut Barbu
Track B  14:45 – 15:15
# How to build an autonomous anything

## Focus on Perception
- Look for autonomy in creative places
- Do more than manually possible

## Use the Best Predictors
- Data-driven
- Model-driven

## Get the Right Data
- Reduce to actionable data
- Take advantage of Big Data
- Use simulation to supplement available data

## Go to Production
- Address the architecture
- Leverage Model-Based Design for embedded
- Automate integration with enterprise IT systems
What is your autonomous anything?