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
Capabilities of an Autonomous System

- Sense
- Perceive
Capabilities of an Autonomous System

Sense

Perceive

Decide & Plan

Sense

Perceive

Decide & Plan

Sense

Perceive

Decide & Plan

Sense

Perceive

Decide & Plan
Capabilities of an Autonomous System

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

Responsibility

Degree of Autonomy

Human

Computer
Cost of rig:  \textgreater  \$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

**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
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

Image Feature Extraction

Visual Features

Machine Learning Classification

- Style Classifier (SVM)
  - Style: Regionalism
- Genre Classifier (SVM)
  - Genre: Interior
- Artist Classifier (SVM)
  - Artist: Rockwell

Sense

Perceive

Decide & Plan

Act

Sense

Perceive

Decide & Plan

Act
Where to add autonomy with perception?

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

Virtual Semiconductor Manufacturing Calibration

Determine Loudspeaker Quality
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
- Perceive
- Decide & Plan
- Act

Target Glucose Level

Insulin Pump

Mobile App

Continuous Glucose Monitor

Person
Autonomous Glucose Level Management
Bigfoot Biomedical

- Sense
- Perceive
- Decide & Plan
- Act

Simulink, Stateflow, Polyspace

Target Glucose Level

Insulin Pump

Mobile App

Continuous Glucose Monitor

Target Glucose Level + Target Glucose Level

Simulink, Stateflow, Polyspace

Insulin Pump

Mobile App

Continuous Glucose Monitor

Person
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense
Perceive
Decide & Plan
Act

Target Glucose Level
Mobile App
Continuous Glucose Monitor
Insulin Pump
Person

Autonomous Glucose Level Management
Bigfoot Biomedical

Sense
Perceive
Decide & Plan
Act

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

Sense

Perceive

Decide & Plan

Act

Target Glucose Level

Insulin Pump

Mobile App

Continuous Glucose Monitor

Person

2017

2018
Virtual Clinic
Generating data through simulation
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**

3D Cameras

**Perceive**

Computer vision and controls algorithms

**Decide & Plan**

Vehicle Display Controller
- Driver Input
- Visualization

**Act**

CAN

ECU

Actuators
Autonomous Trailer Filling

- Sense
- Perceive
- Decide & Plan
- Act

3D Cameras

Computer vision and controls algorithms

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

Embedded Coder

CAN

ECU

Actuators
Autonomous Trailer Filling

- Sense
- Perceive
- Decide & Plan
- Act

3D Cameras

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

CAN

Monitoring

ECU

Actuators

MathWorks
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?