MATLAB EXPO 2017
How to build an autonomous anything

Michelle Hirsch
Head of MATLAB Product Management
MathWorks
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

1. Sense
2. Perceive
3. Decide & Plan
4. Act
Autonomous Technology Transfers Responsibility to Computers

Responsibility

Human

Computer

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

Which sensor values should they use?

- Vibration
- Timing
- Pressure
- Temperature
- Other variables

Sense
Perceive
Decide & Plan
Act
Autonomous Service for Predictive Maintenance

Sense

Perceive

Decide & Plan

Act

Normal Operation

Monitor Closely

Maintenance Needed
Machine Learning or Deep Learning?

**Machine Learning Approach**

1. Sensor 1
2. Sensor 2
   ...  
3. 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
- Model-driven
**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

Machine Learning Classification

Style: Regionalism
Genre: Interior
Artist: Rockwell

Image Feature Extraction

Visual Features

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

Mobile App

Insulin Pump

Continuous Glucose Monitor

Person
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense
Perceive
Decide & Plan
Act

Target Glucose Level
Insulin Pump
Mobile App
Continuous Glucose Monitor

Person.
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)
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

CAN

ECU

Actuators

Computer vision and controls algorithms
Autonomous Trailer Filling

- **Sense**
  - 3D Cameras

- **Perceive**
  - Computer vision and controls algorithms

- **Decide & Plan**

- **Act**
  - ECU
  - CAN
  - Vehicle Display Controller
    - Driver Input
    - Visualization
  - Actuators
Autonomous Trailer Filling

- Driver Input
- Visualization
- Computer Vision
- Controls

Vehicle Display Controller

- 3D Cameras
- Embedded Coder
- CAN
- ECU
- Actuators

Computer vision and controls algorithms
Autonomous Trailer Filling

- Sense
- Perceive
- Decide & Plan
- Act

3D Cameras

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

Monitoring

CAN

ECU

Actuators
How will you put it into production?

- Embedded systems
- Enterprise systems
- HMIs
# 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?