MATLAB CONFERENCE 2017

How to build an autonomous anything

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

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

MathWorks
Capabilities of an Autonomous System

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

- **Human**
- **Computer**

Responsibility vs. Degree of Autonomy
Bazille’s Studio  
Bazille 1870

Shuffleton’s Barbershop  
Rockwell 1950
Autonomous Artistic Style Classification
Rutgers University

Machine Learning Classification

- **Style**: Regionalism
- **Genre**: Interior
- **Artist**: Rockwell

Image Feature Extraction

- Visual Features
- **Style Classifier (SVM)**
- **Genre Classifier (SVM)**
- **Artist Classifier (SVM)**

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

Determine Loudspeaker Quality

Virtual Semiconductor Manufacturing Calibration
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
What are the best predictors?

- Data
- Models

Jet Engine Monitoring
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

Person

Mobile App

Continuous Glucose Monitor

+ -

+ + +
Autonomous Glucose Level Management
Bigfoot Biomedical

Virtual Lab
Simulink, Stateflow
Polyspace

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

Sense

Target Glucose Level

Mobile App

Continuous Glucose Monitor

Insulin Pump

Person

Autonomous glucose level management system involving sense, perceive, decide & plan, and act. The system includes a continuous glucose monitor, an insulin pump, a mobile app, and a person to perceive, decide, and plan based on the target glucose level.
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Perceive

Decide & Plan

Act

Virtual Clinic
MATLAB, Toolboxes

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**

Diagram:
- Computer Vision Algorithms
  - 3D Camera Image
- Control Algorithms
  - 3D Scene Simulator

Control outputs
Autonomous Trailer Filling

- Sense
- Perceive
- Decide & Plan
- Act

3D Camera

Computer vision and controls algorithms

Embedded Platform MPC5121e

CAN

Actuators

- User Input
- Visualization

ECU
Autonomous Trailer Filling

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

3D Camera

Embedded Coder

Embedded Platform
MPC5121e

- User Input
- Visualization
- Computer Vision
- Controls

Monitoring

ECU

Actuators

CAN
How will you put it into production?

- Embedded Systems
- IT Systems
- Desktop Apps
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 |
| Flow to Production                   | • Address the architecture             
|                                      | • Leverage Model-Based Design for embedded |
|                                      | • Automate integration with enterprise IT systems |
What is your autonomous anything?