MATLAB EXPO 2017
How to build an autonomous anything

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

Having the power for self-governance
Autonomous Technology

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

Sense

Perceive

Decide & Plan

Act
Autonomous Technology Transfers Responsibility to Computers

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

Degree of Autonomy vs. Responsibility
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

Sense

Perceive

Decide & Plan

Act
Where to add autonomy with perception?

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

Introduction

- Even in this machine era, manual inspection of products (products like sea food, grains, products at end of line etc.) in processing industries is widely practiced
- Large variance in appearance within a class and small inter class variance make the automation of visual quality inspection complex, thereby demanding manual inspection
Where to add autonomy with perception?

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

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Decide & Plan

Act

Normal Operation  Monitor Closely  Maintenance Needed
What are the best predictors?

- Data-driven
- Model-driven

Jet Engine Monitoring
Autonomous Glucose Level Management
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Perceive

Decide & Plan

Act

Target Glucose Level

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
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Simulink, Stateflow, Polyspace

Target Glucose Level

Insulin Pump

Mobile App

Continuous Glucose Monitor

Perceive

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Person
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

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Person

Act

Mobile App

Continuous Glucose Monitor
Autonomous Glucose Level Management
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- Sense
- Perceive
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- Act

Target Glucose Level

Virtual Clinic
MATLAB, Toolboxes

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
Results Achieved

- The idea conceived during concept phase was successfully refined and transcended to Android and iOS app.

- Customer response from pilot launch of the app:

  "We can use it for special clothes, which should not get damaged."
  "the app feels like it is designed for me."

  "I didn’t use the application yet before. Now I will use this application. Highlight is machine prescribes the program according to the clothes type and dirt level."
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
Autonomous Trailer Filling

Sense

Perceive

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Computer Vision Algorithms

Control Algorithms

3D Camera Image

3D Scene Simulator

Control outputs

Autonomous Trailer Filling
Autonomous Trailer Filling

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

Diagram:
- 3D Cameras
- Computer vision and controls algorithms
- CAN
- ECU
- Actuators
Autonomous Trailer Filling

- Sense
- Perceive
- Decide & Plan
- Act

Vehicle Display Controller
- Driver Input
- Visualization

3D Cameras

Computer vision and controls algorithms

CAN

ECU

Actuators
Autonomous Trailer Filling

- **Sense**
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3D Cameras

Computer vision and controls algorithms

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

Embedded Coder

CAN

ECU

Actuators
Autonomous Trailer Filling

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3D Cameras

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

CAN

Monitoring

ECU

Actuators
How will you put it into production?

- System Architecture
- 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
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Driverless Car Challenge
What is your autonomous anything?