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 unrehearsed conditions.
Capabilities of an Autonomous System
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

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

Responsibility vs. Degree of Autonomy
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 Classifier (SVM)
  - Style: Regionalism

- Genre Classifier (SVM)
  - Genre: Interior

- Artist Classifier (SVM)
  - Artist: Rockwell

Image Feature Extraction

Visual Features

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

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?

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

Sense
Perceive
Decide & Plan
Act

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

- Data-driven
- Model-driven
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

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Person

Mobile App

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Simulink, Stateflow, Polyspace

Target Glucose Level

Insulin Pump

Mobile App

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Target Glucose Level
Mobile App
Continuous Glucose Monitor
Insulin Pump
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+ + -

35
Autonomous Glucose Level Management
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Target Glucose Level

Mobile App

+ 

+ 

+ 

Continuous Glucose Monitor

Insulin Pump

Virtual Clinic
MATLAB, Toolboxes

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

Sense

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Decide & Plan

Act
Autonomous Trailer Filling

- Sense
- Perceive
- Decide & Plan
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Computer Vision Algorithms → Control Algorithms

Control outputs

3D Camera Image

3D Scene Simulator
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**
- **Computer vision and controls algorithms**
- **Vehicle Display Controller**
  - Driver Input
  - Visualization
- **ECU**
- **Actuators**
- **CAN**
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**

**Actuators**

**ECU**
Autonomous Trailer Filling

Sense

Perceive

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Act

3D Cameras

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

CAN

ECU

Actuators

Monitoring
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?