

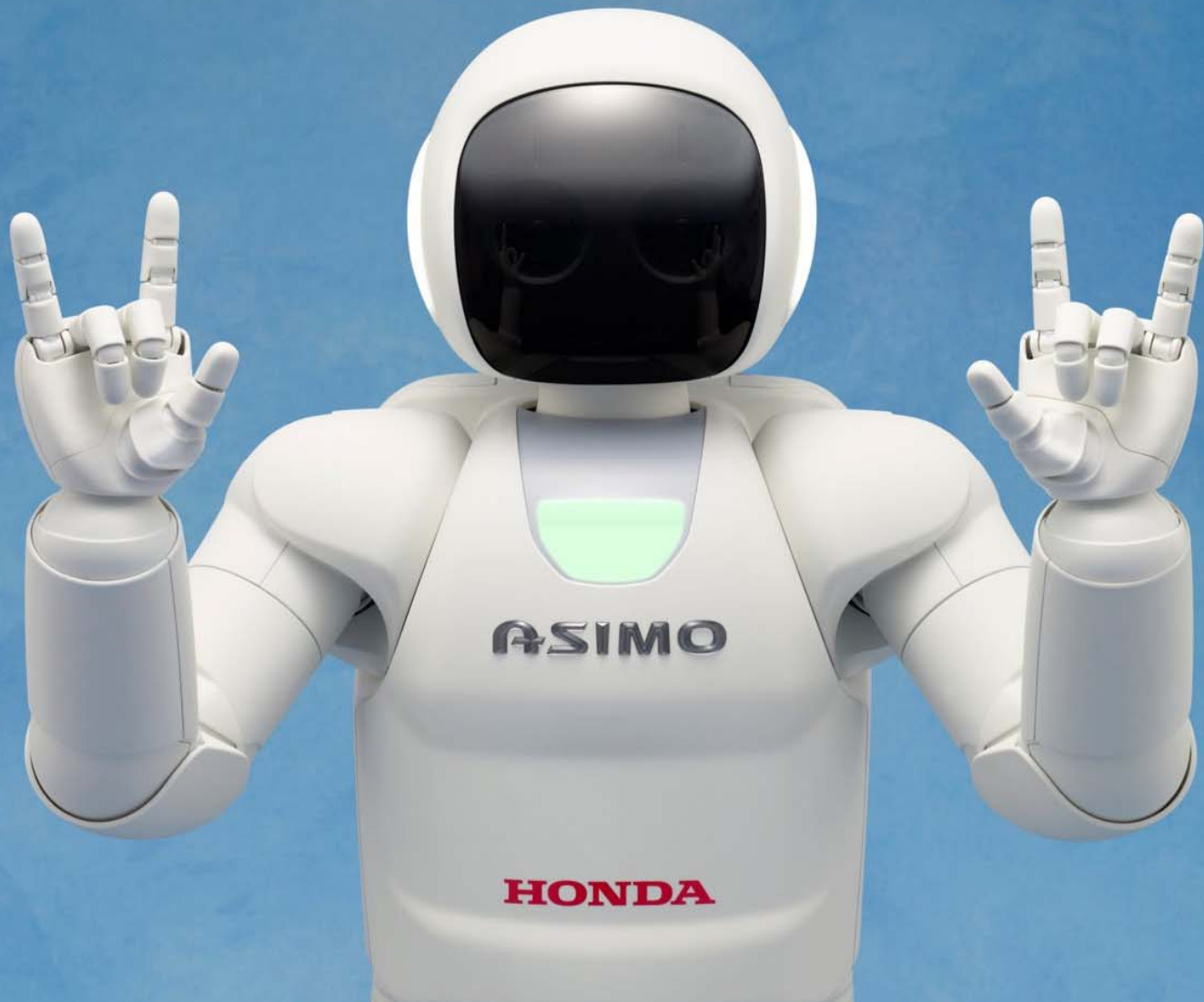
# MATLAB EXPO 2017

How to build an **autonomous** anything

**Michelle Hirsch**

Head of MATLAB Product Management  
MathWorks





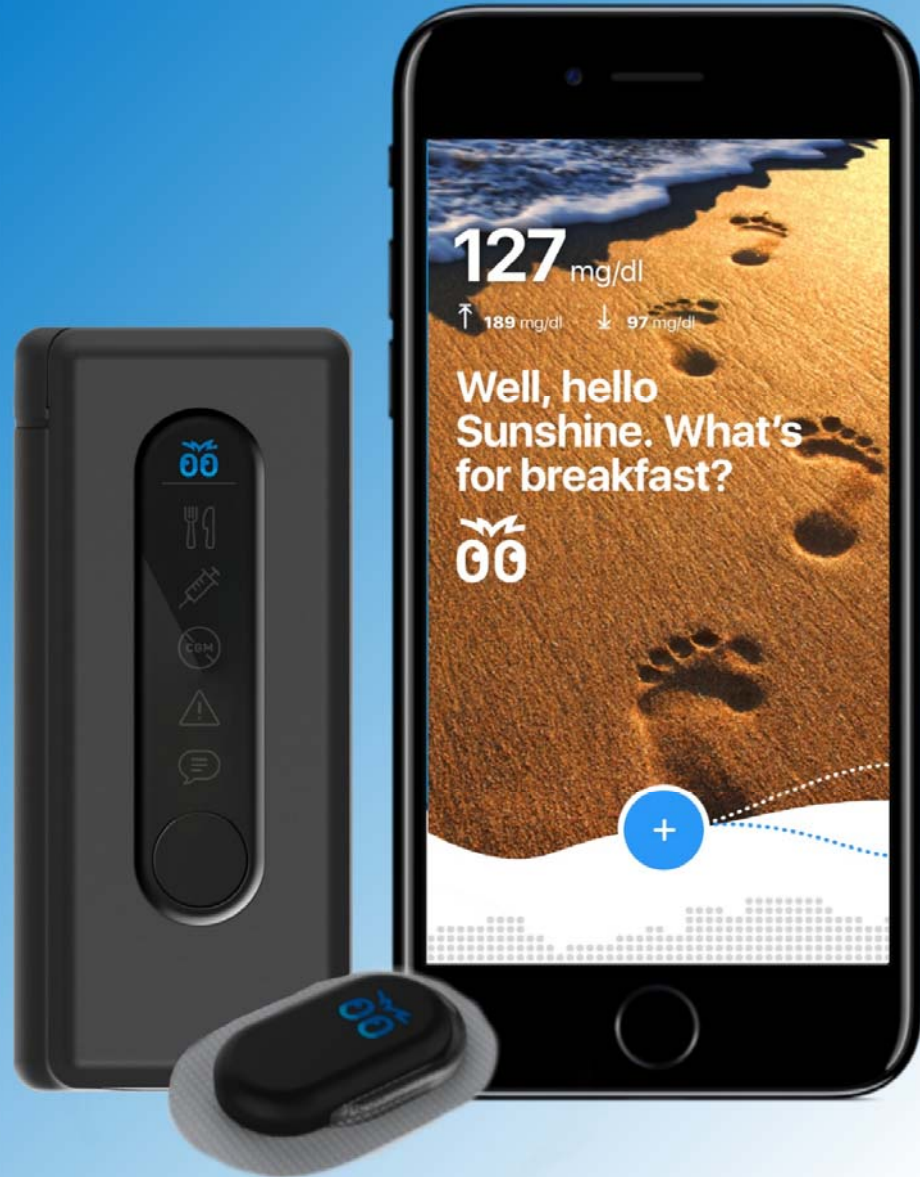
ASIMO

HONDA









127 mg/dl

↑ 189 mg/dl ↓ 97 mg/dl

Well, hello  
Sunshine. What's  
for breakfast?

00

+

00

# Autonomous Technology



# Autonomous

*Having the power for self-governance*

# Autonomous Technology

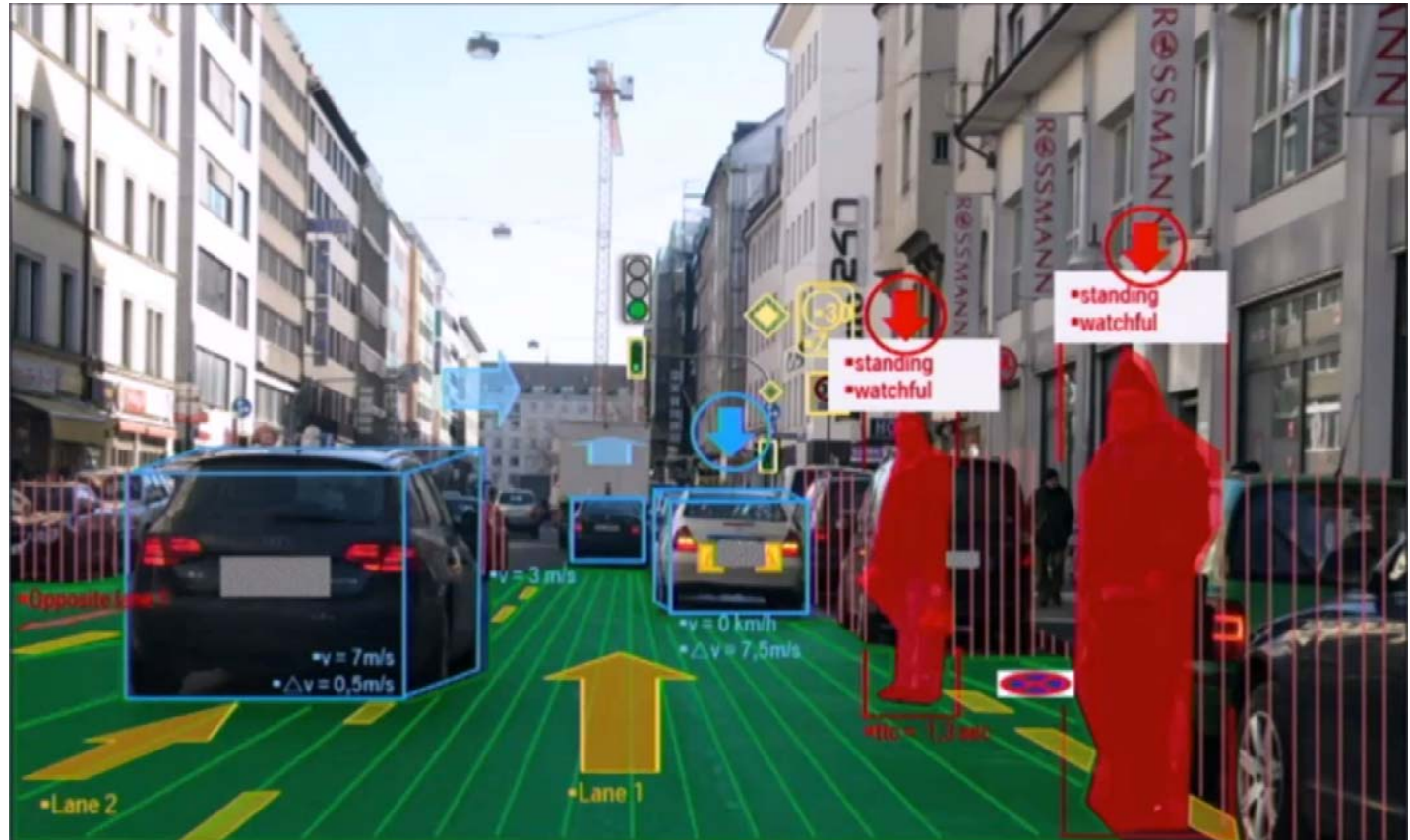
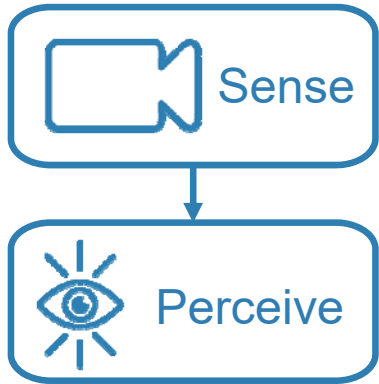
*Provides the ability of a system to act **independently** of direct human control under **unrehearsed** conditions*



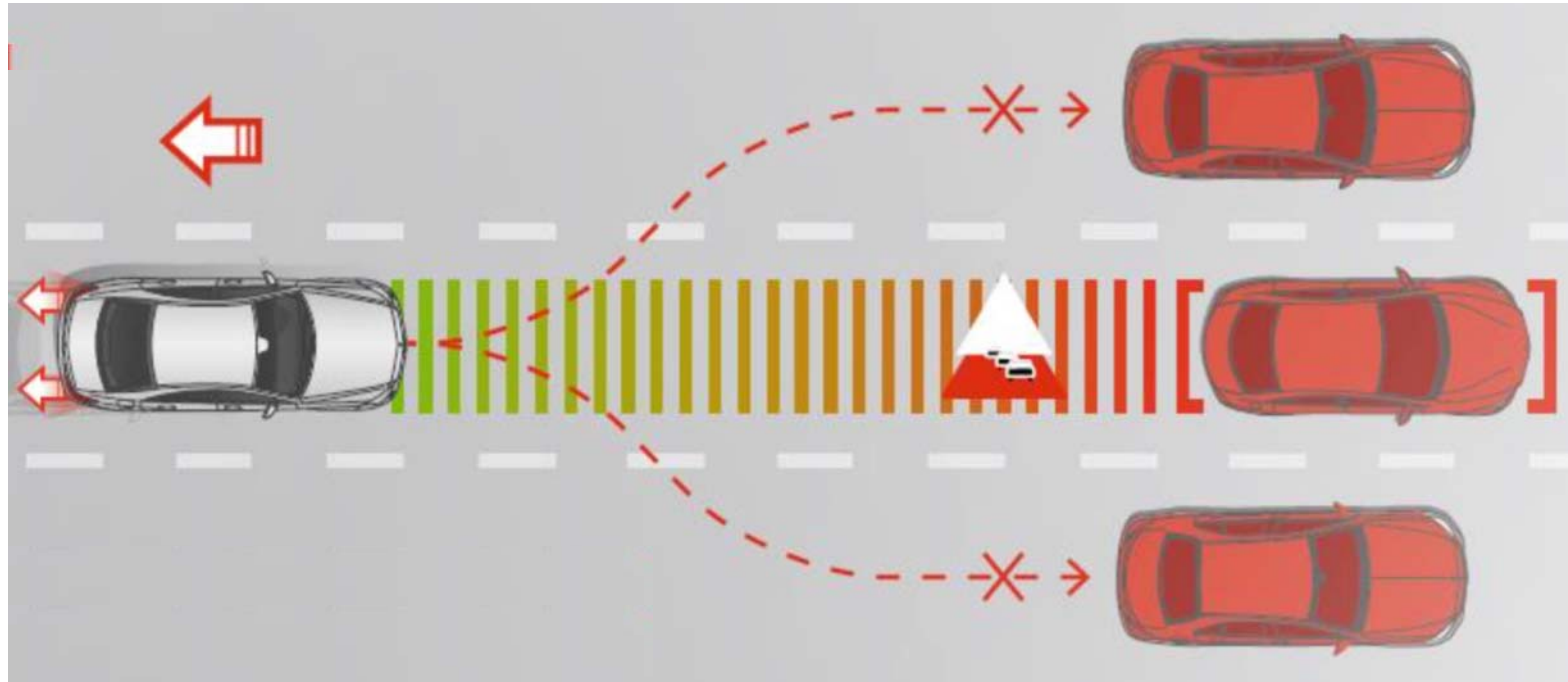
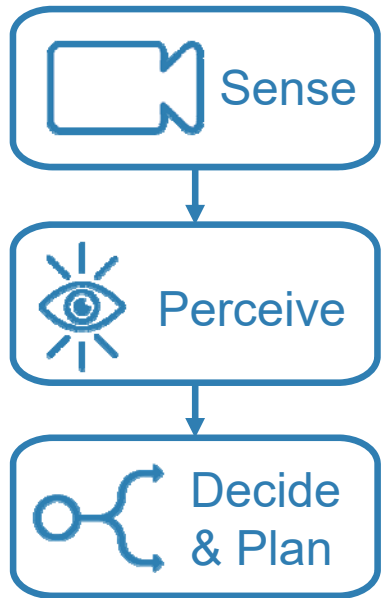
# Capabilities of an Autonomous System



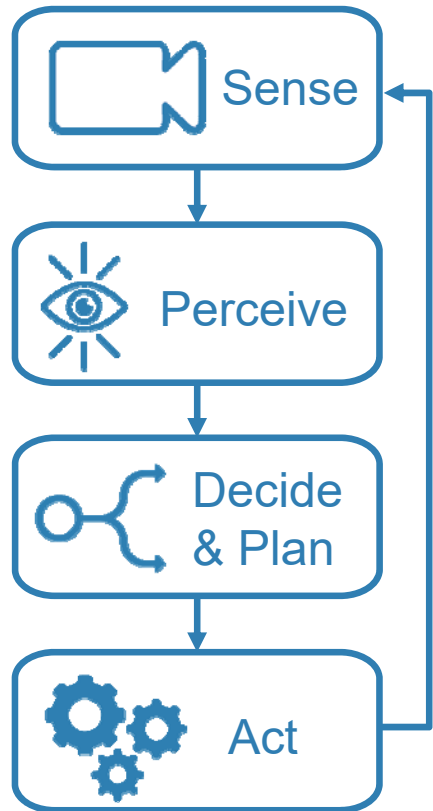
# Capabilities of an Autonomous System



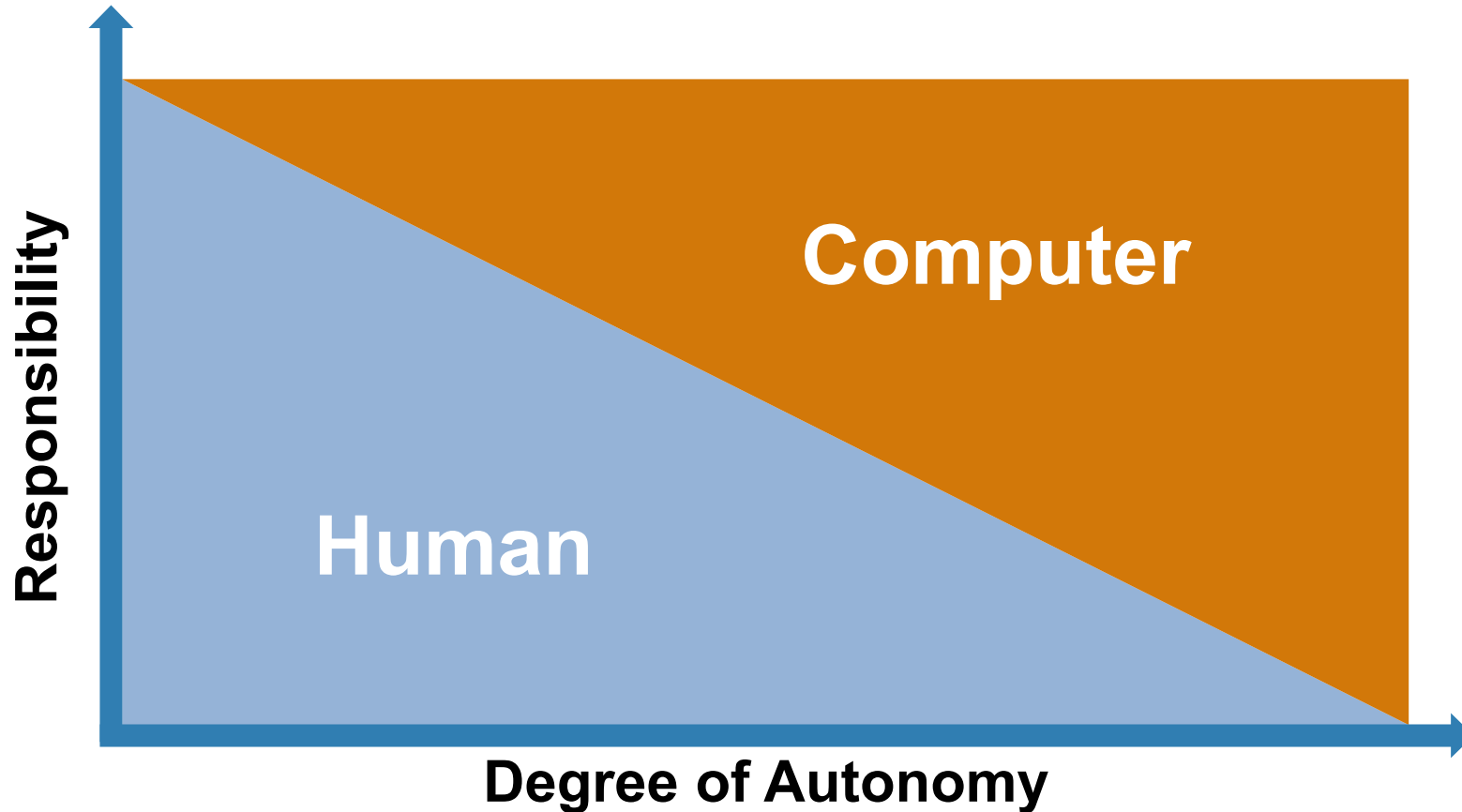
# Capabilities of an Autonomous System



# Capabilities of an Autonomous System



# Autonomous Technology Transfers Responsibility to Computers





**Cost of rig: >\$1M**

**Repair cost: \$100,000**

**Cost of valve: \$200**



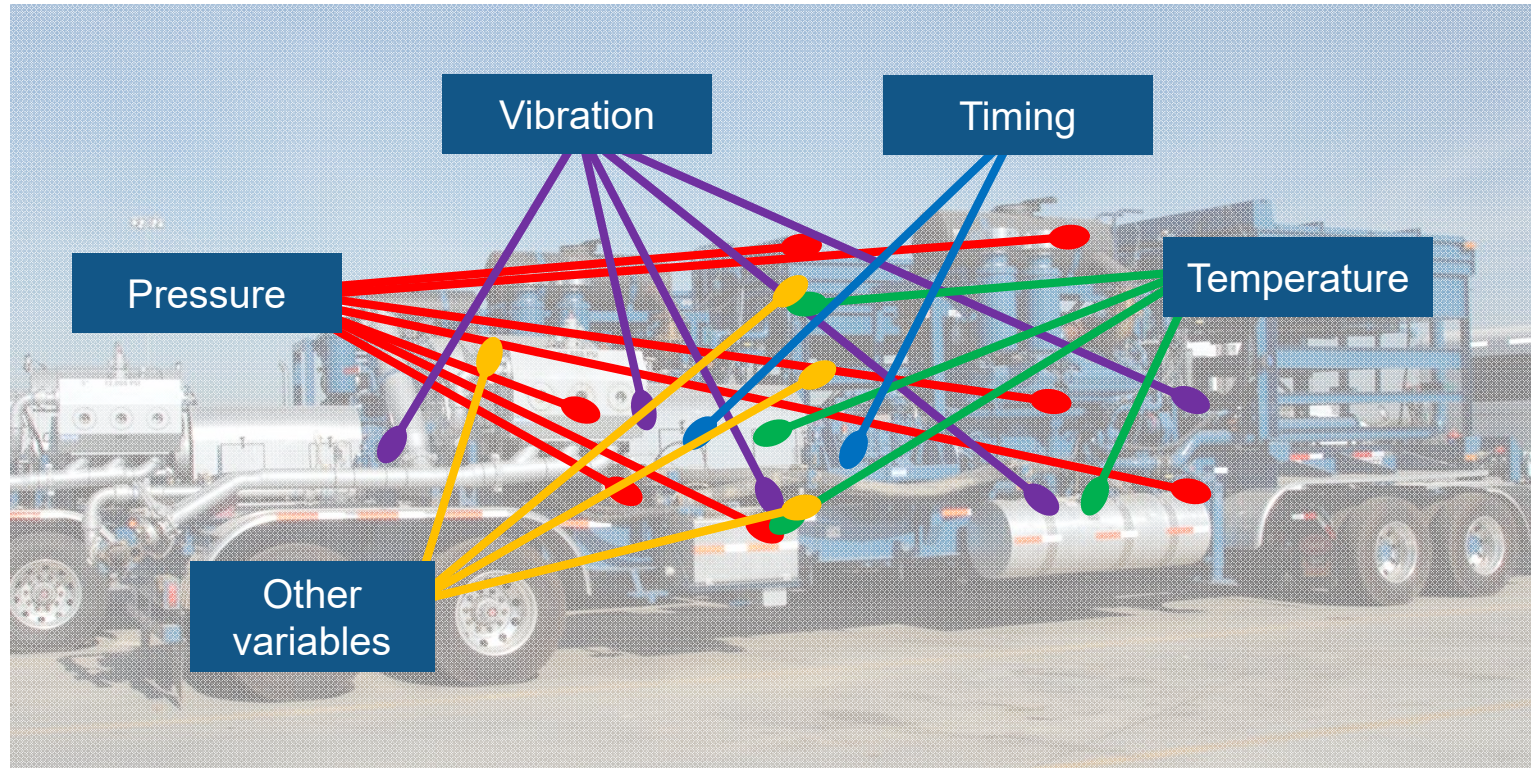




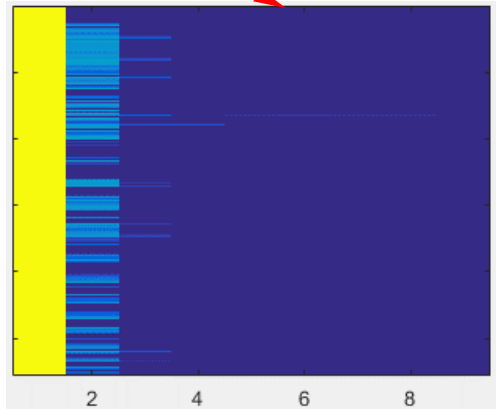
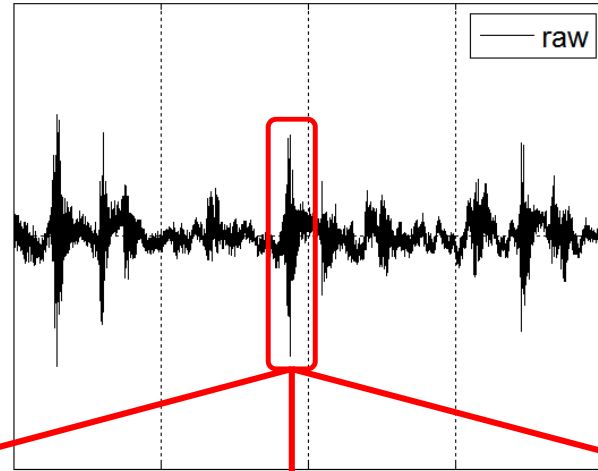


# Autonomous Service for Predictive Maintenance

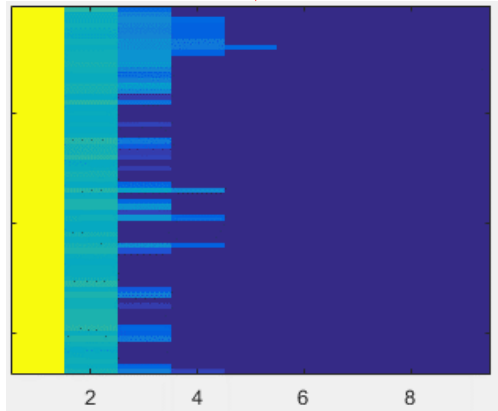
Which sensor values should they use?



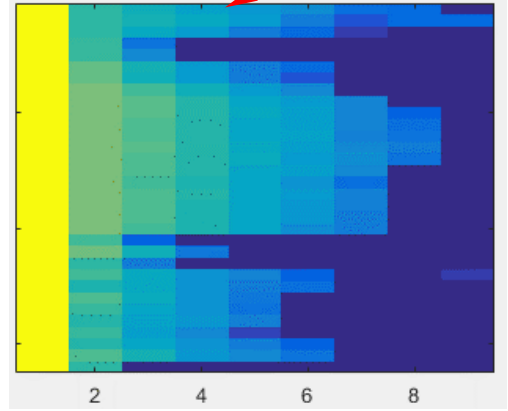
# Autonomous Service for Predictive Maintenance



Normal Operation



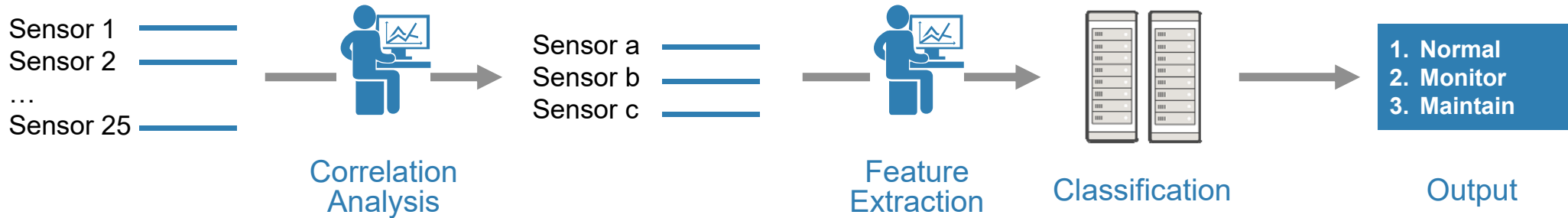
Monitor Closely



Maintenance Needed

# Machine Learning or Deep Learning?

## Machine Learning Approach



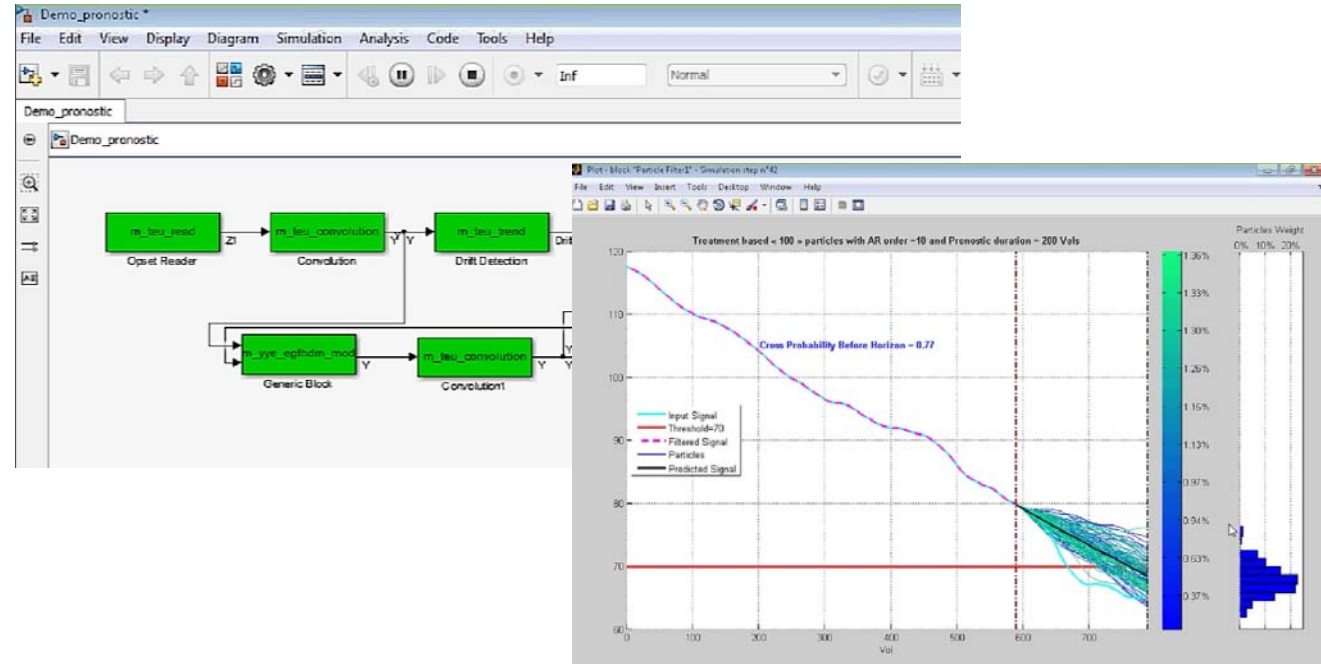
## Deep Learning Approach



# What are the best predictors?

- Data-driven
- Model-driven

## Jet Engine Monitoring



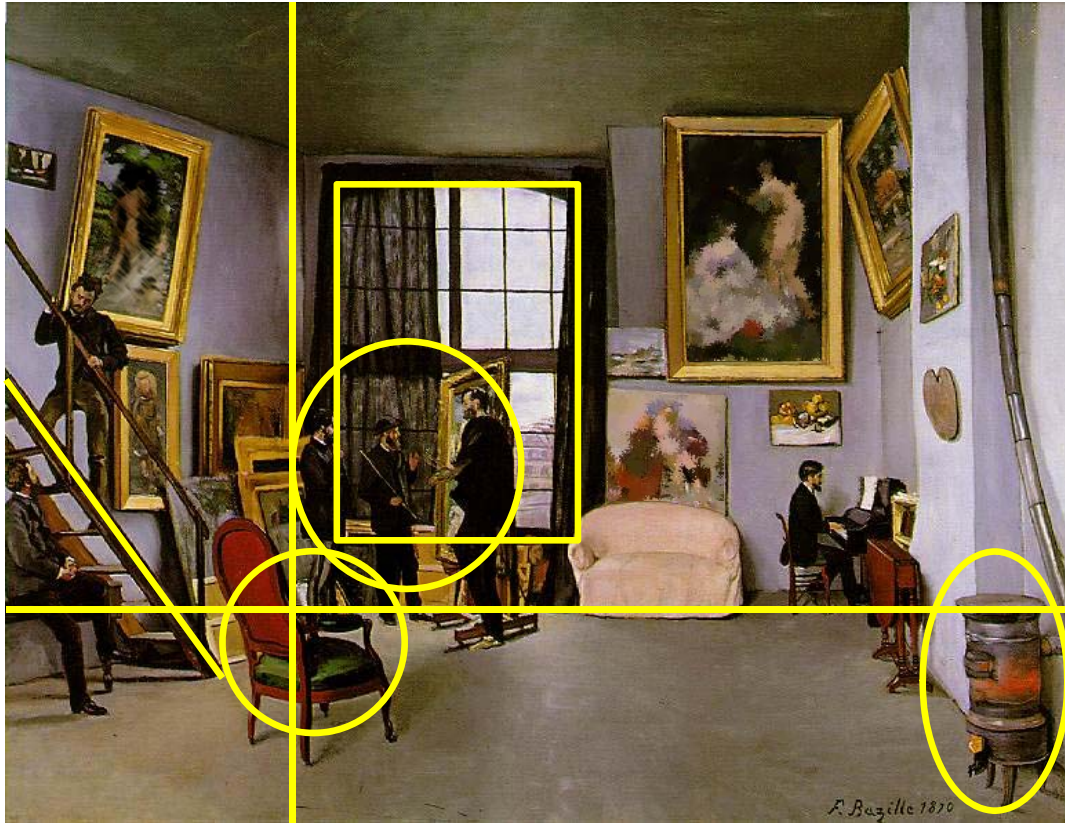




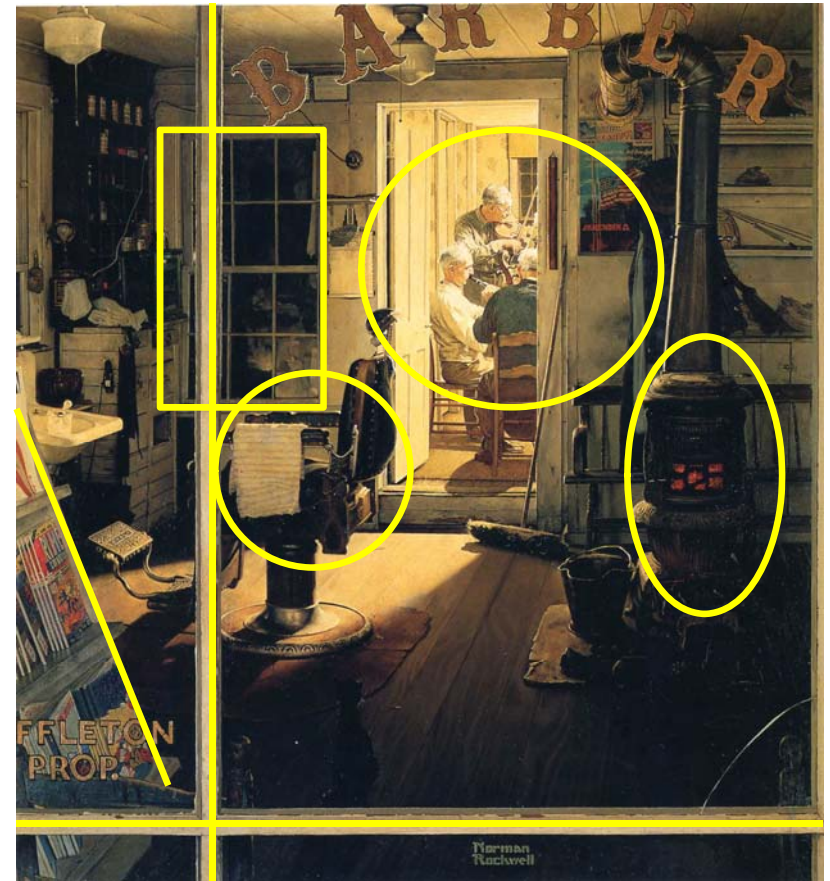
*Bazille's Studio*  
Frederic Bazille (Paris, 1870)



*Shuffleton's Barbershop*  
Norman Rockwell (Vermont, 1950)



*Bazille's Studio*  
 Frederic Bazille (Paris, 1870)



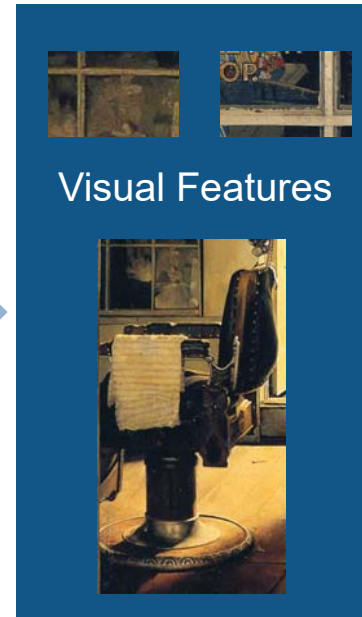
*Shuffleton's Barbershop*  
 Norman Rockwell (Vermont, 1950)

# Autonomous Artistic Style Classification

## Rutgers University



Image  
Feature  
Extraction



Machine  
Learning  
Classification



**Style:**  
Regionalism



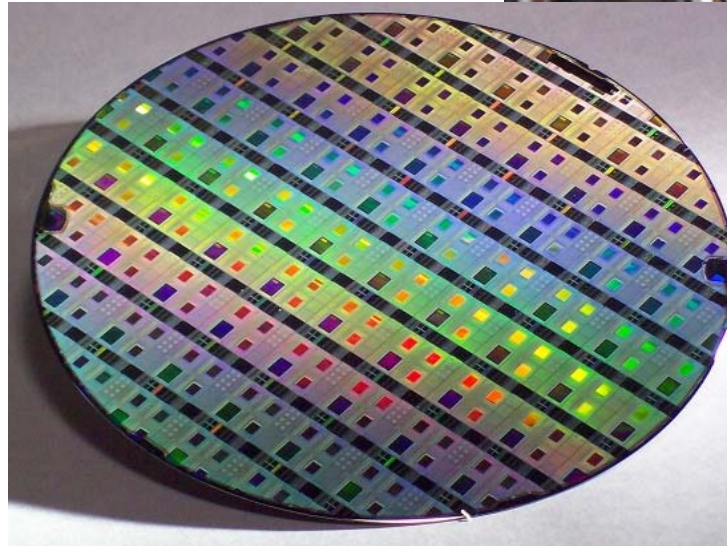
**Genre:**  
Interior



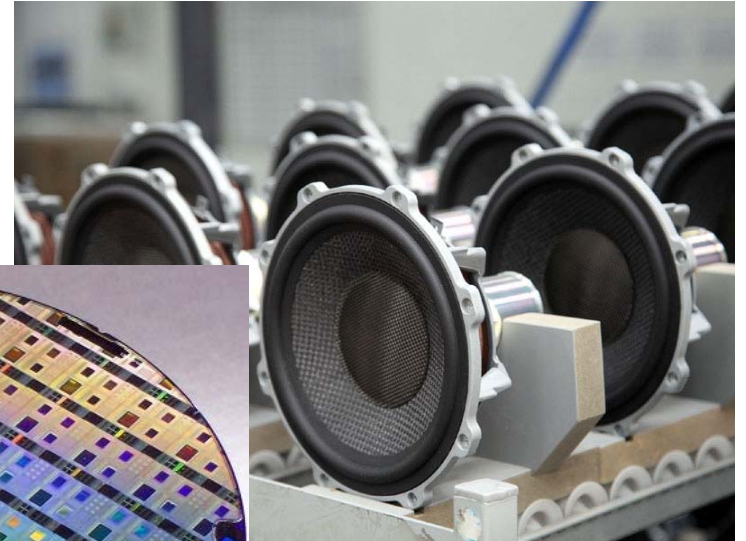
**Artist:**  
Rockwell

## Where to add autonomy with perception?

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



Virtual Semiconductor  
Manufacturing Calibration



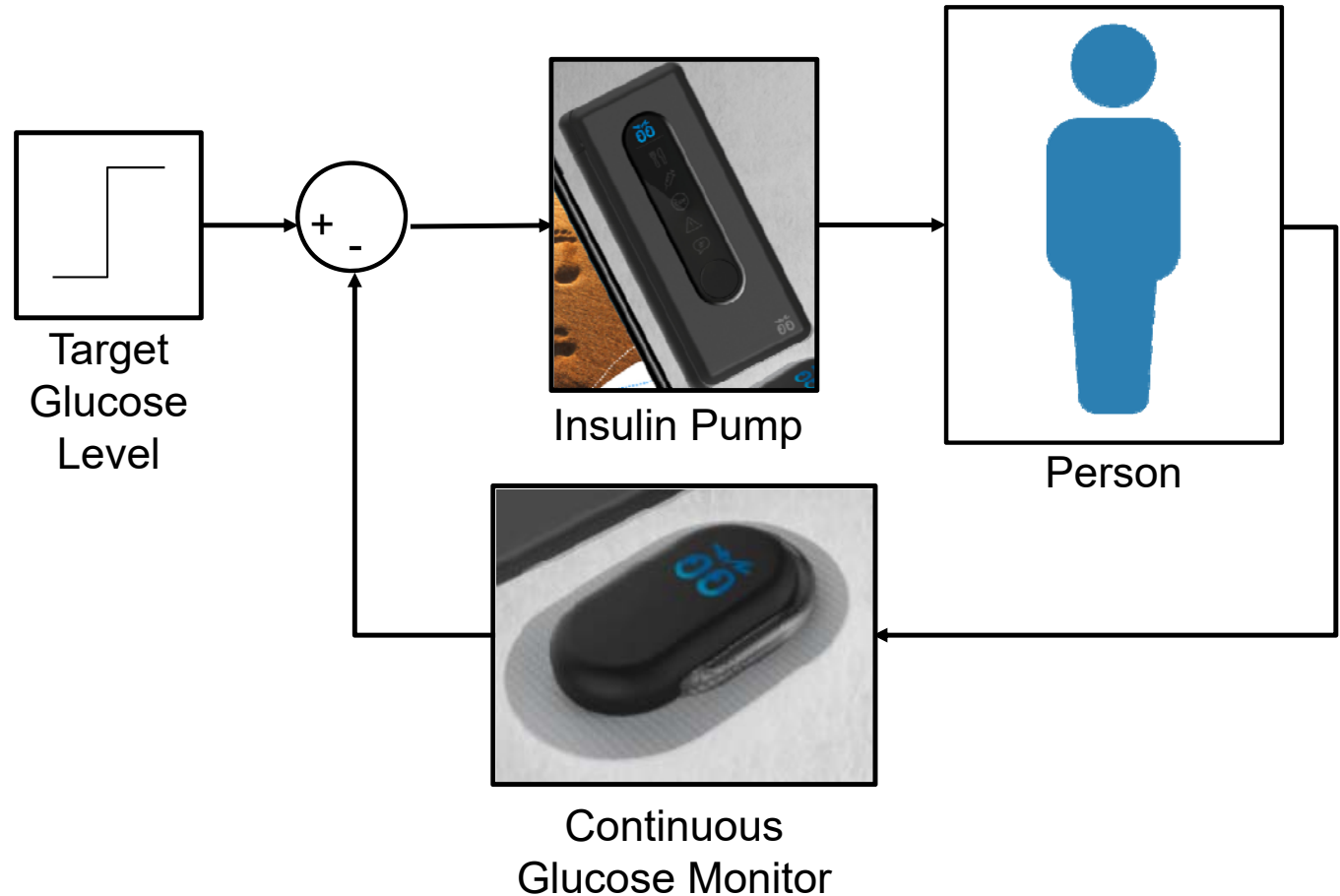
Determine  
Loudspeaker  
Quality

# Autonomous Glucose Level Management



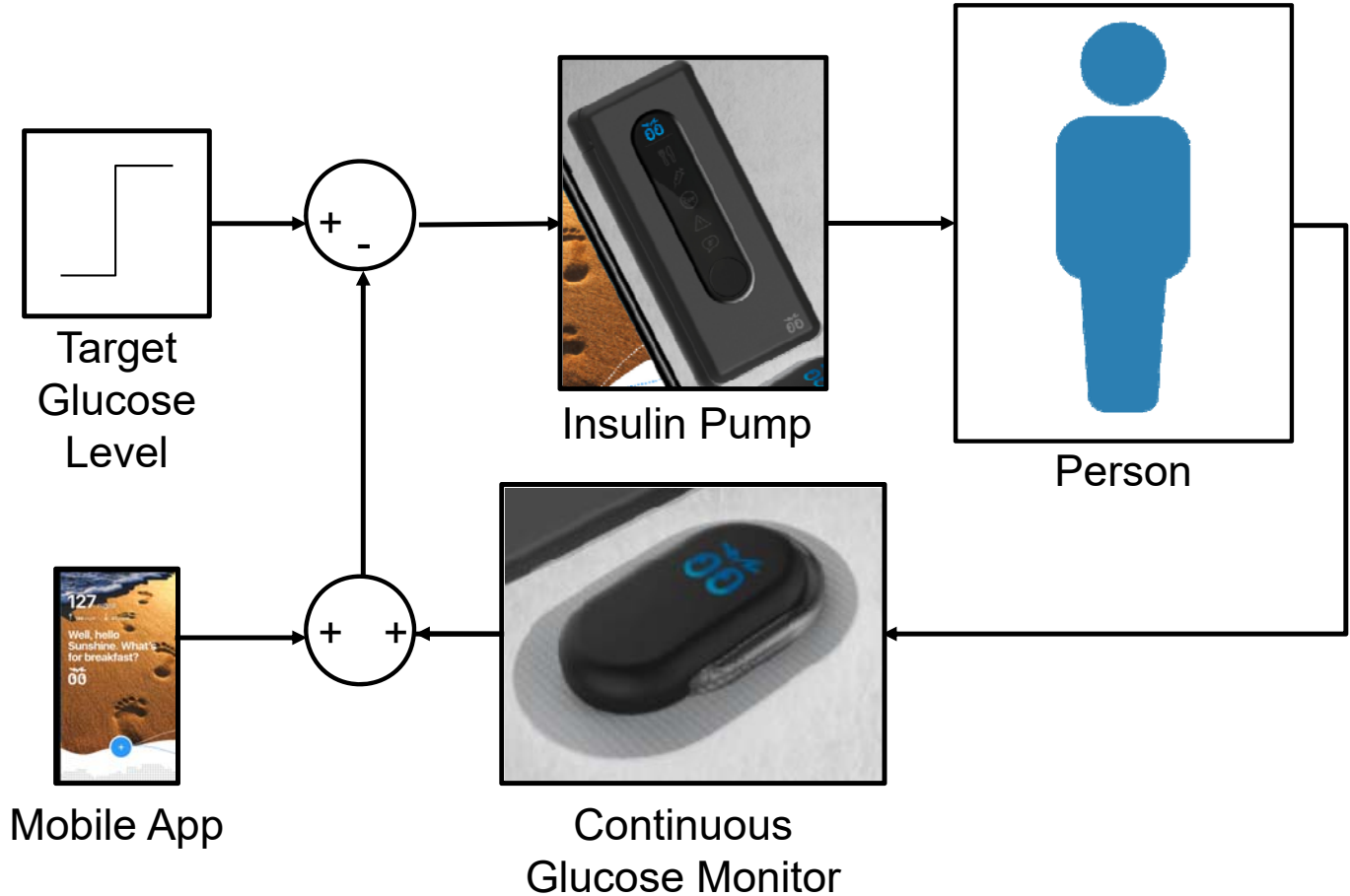
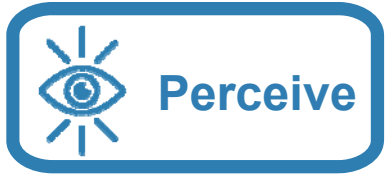
# Autonomous Glucose Level Management

## Bigfoot Biomedical



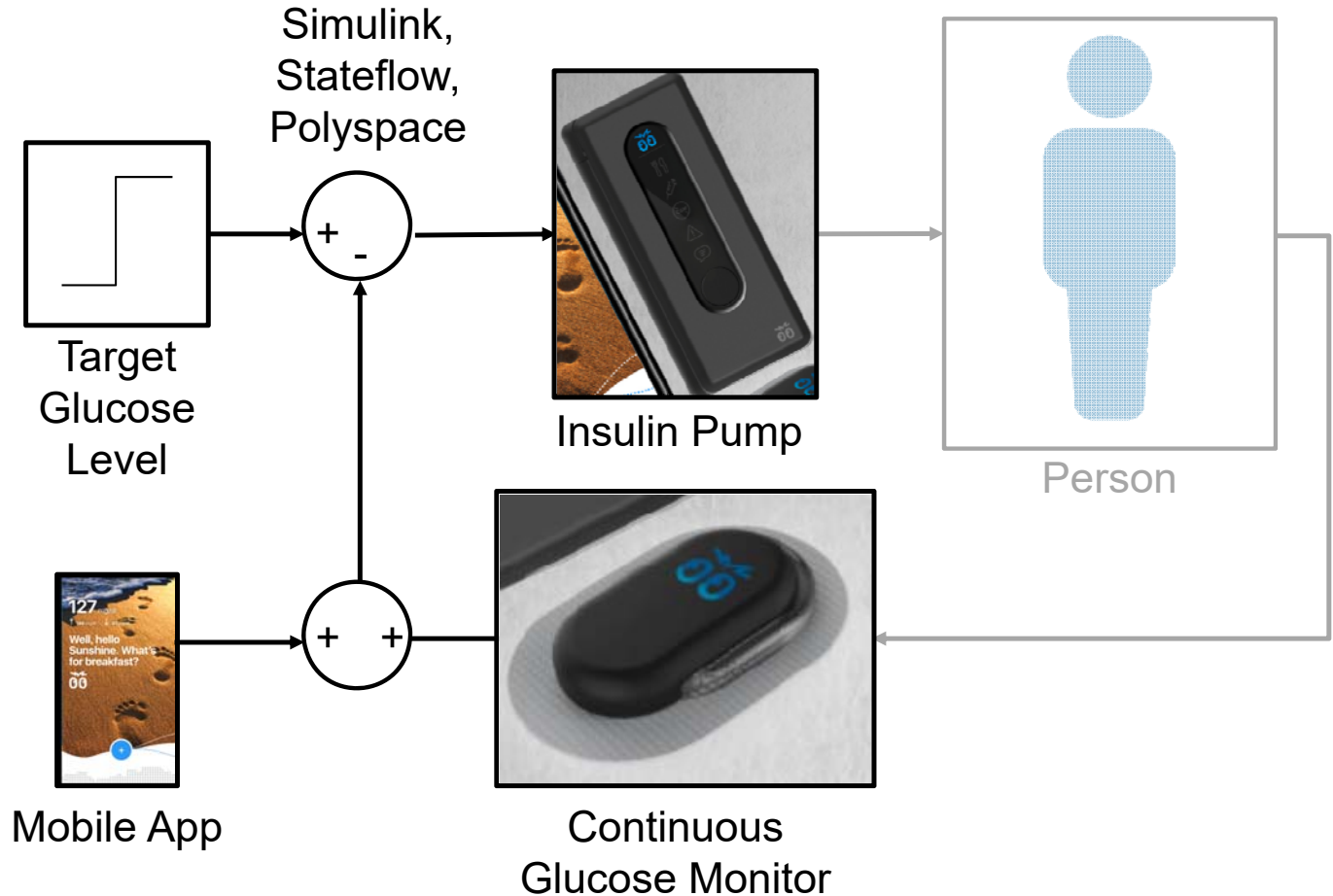
# Autonomous Glucose Level Management

## Bigfoot Biomedical



# Autonomous Glucose Level Management

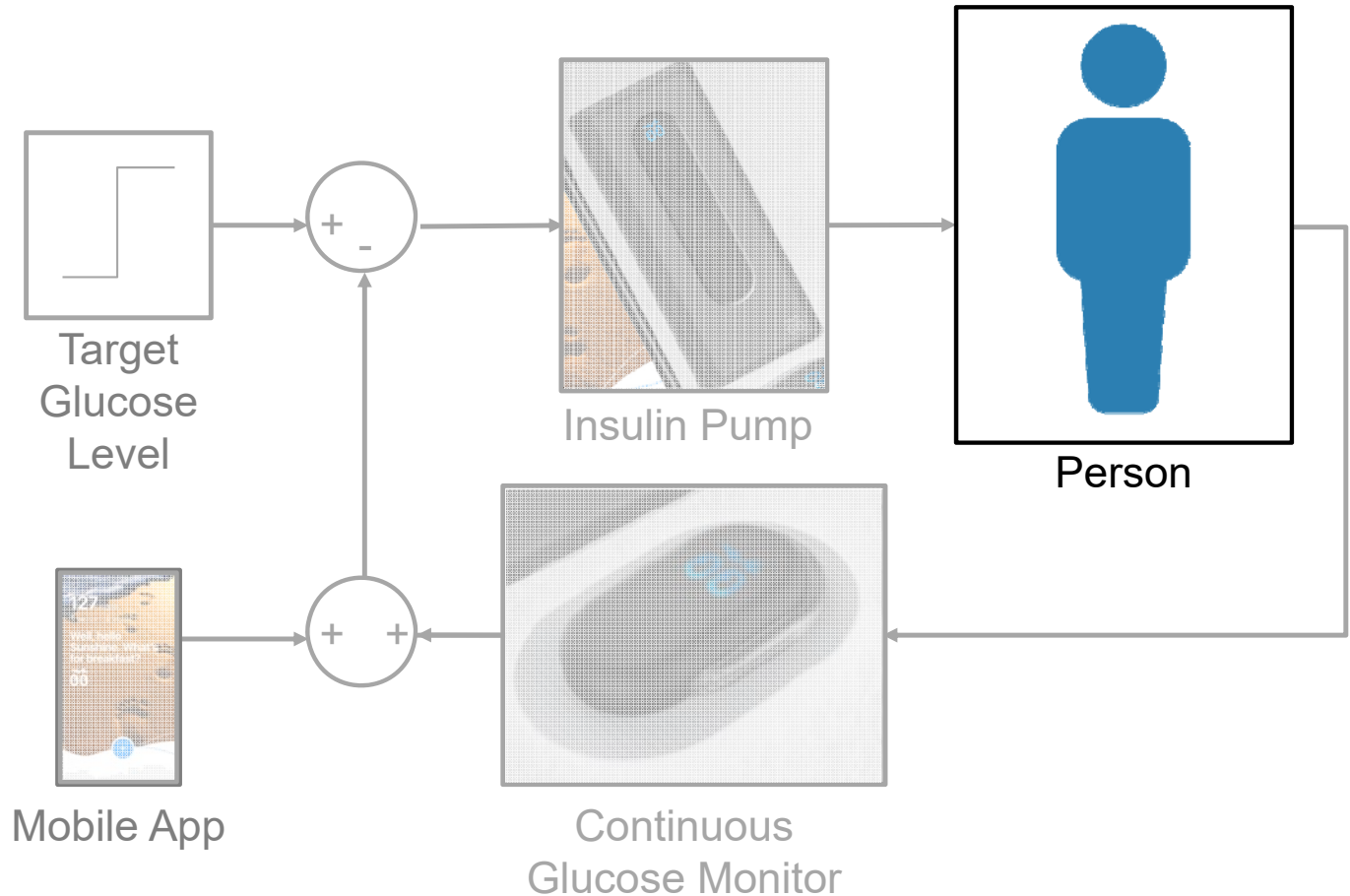
## Bigfoot Biomedical





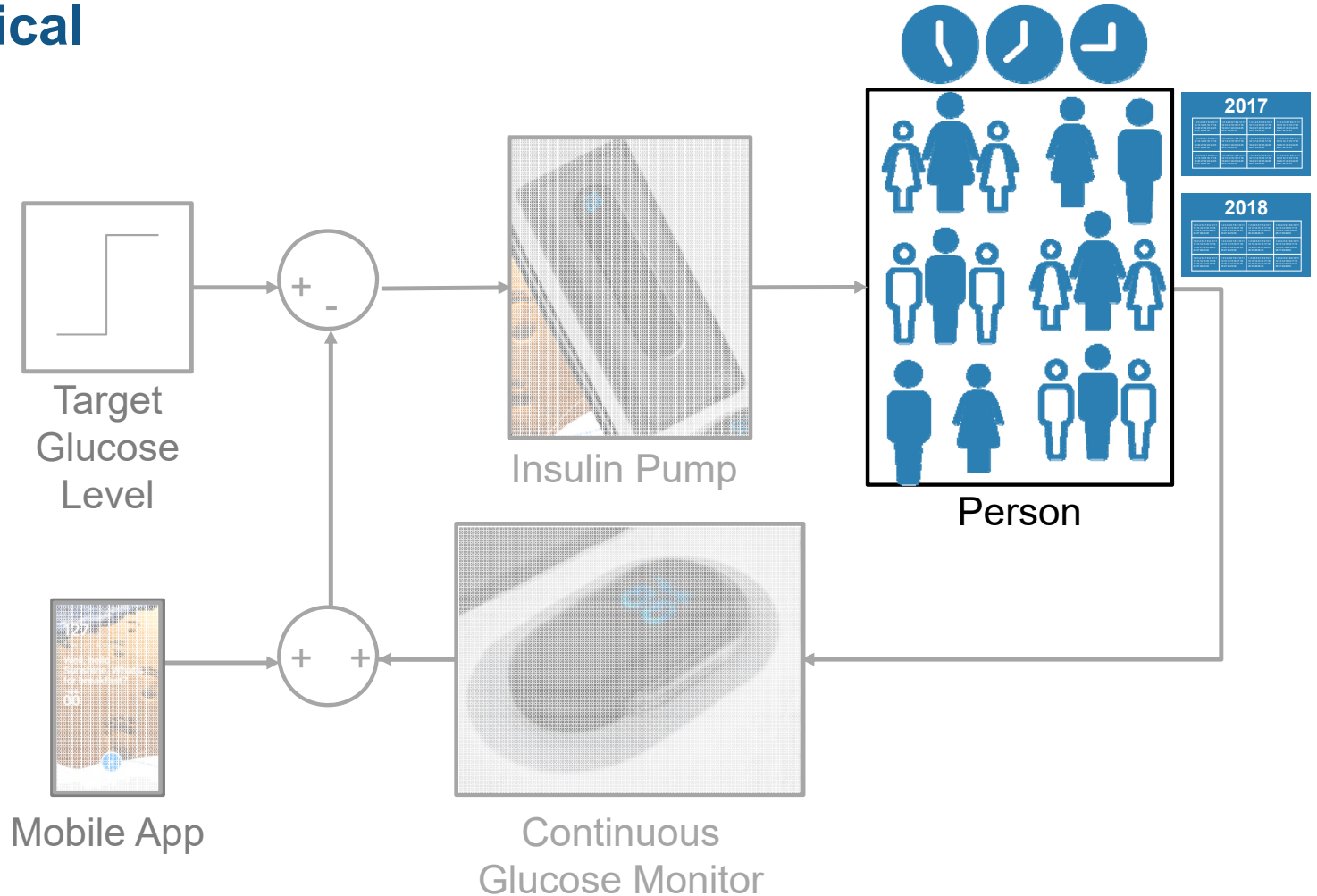
# Autonomous Glucose Level Management

## Bigfoot Biomedical



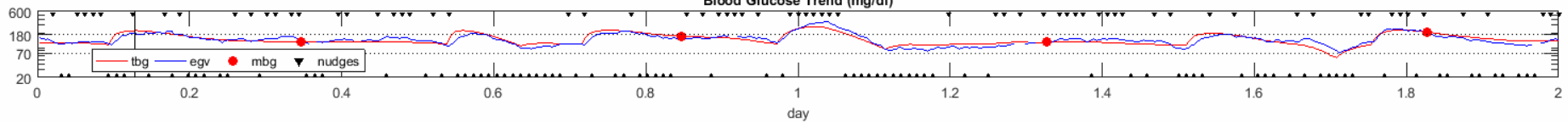
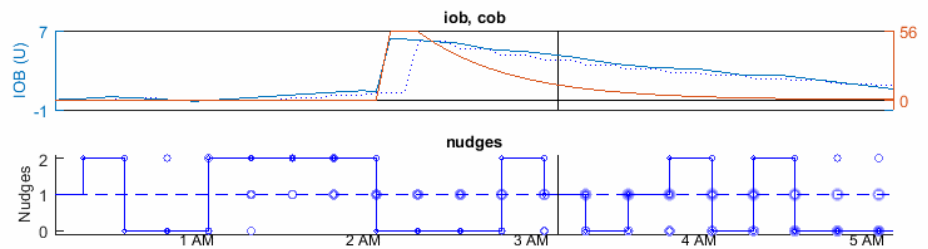
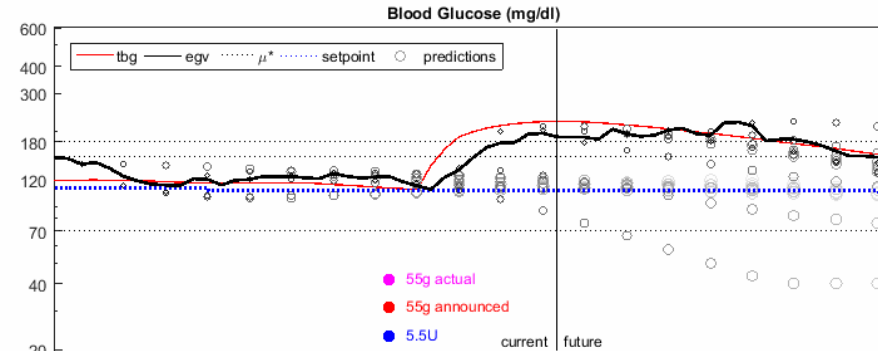
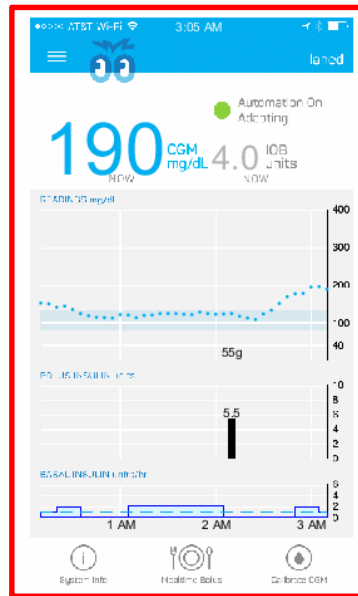
# Autonomous Glucose Level Management

## Bigfoot Biomedical



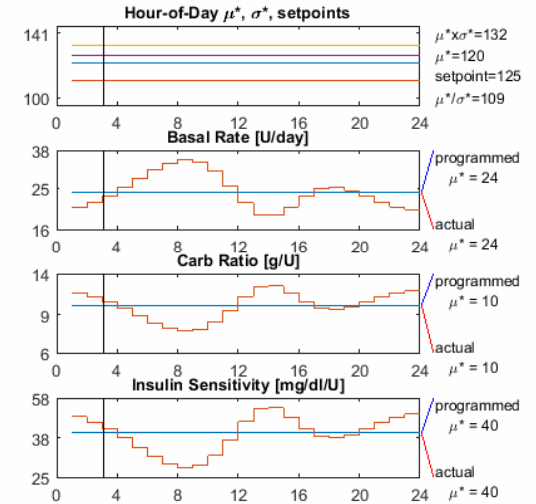
# Virtual Clinic

## Generating data through simulation



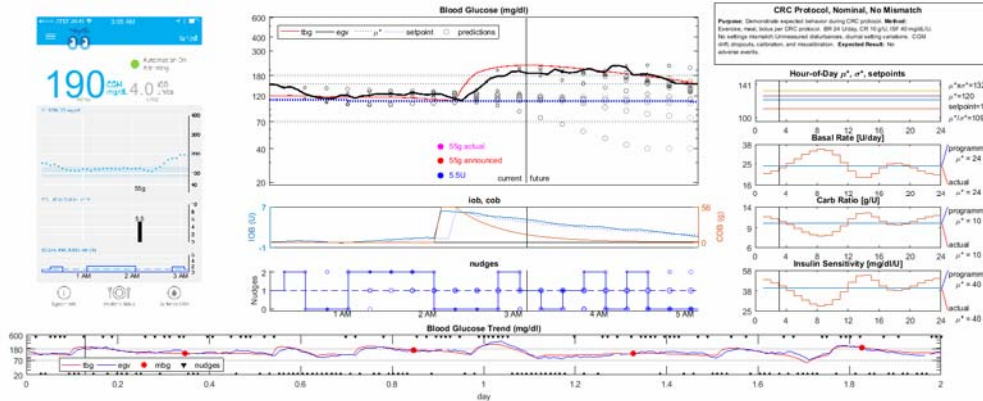
**CRC Protocol, Nominal, No Mismatch**

**Purpose:** Demonstrate expected behavior during CRC protocol. **Method:** Exercise, meal, bolus per CRC protocol. BR 24 U/day, CR 10 g/U, ISF 40 mg/dL/U. No settings mismatch. Unmeasured disturbances, diurnal setting variations. CGM drift, dropouts, calibration, and miscalibration. **Expected Result:** No adverse events.



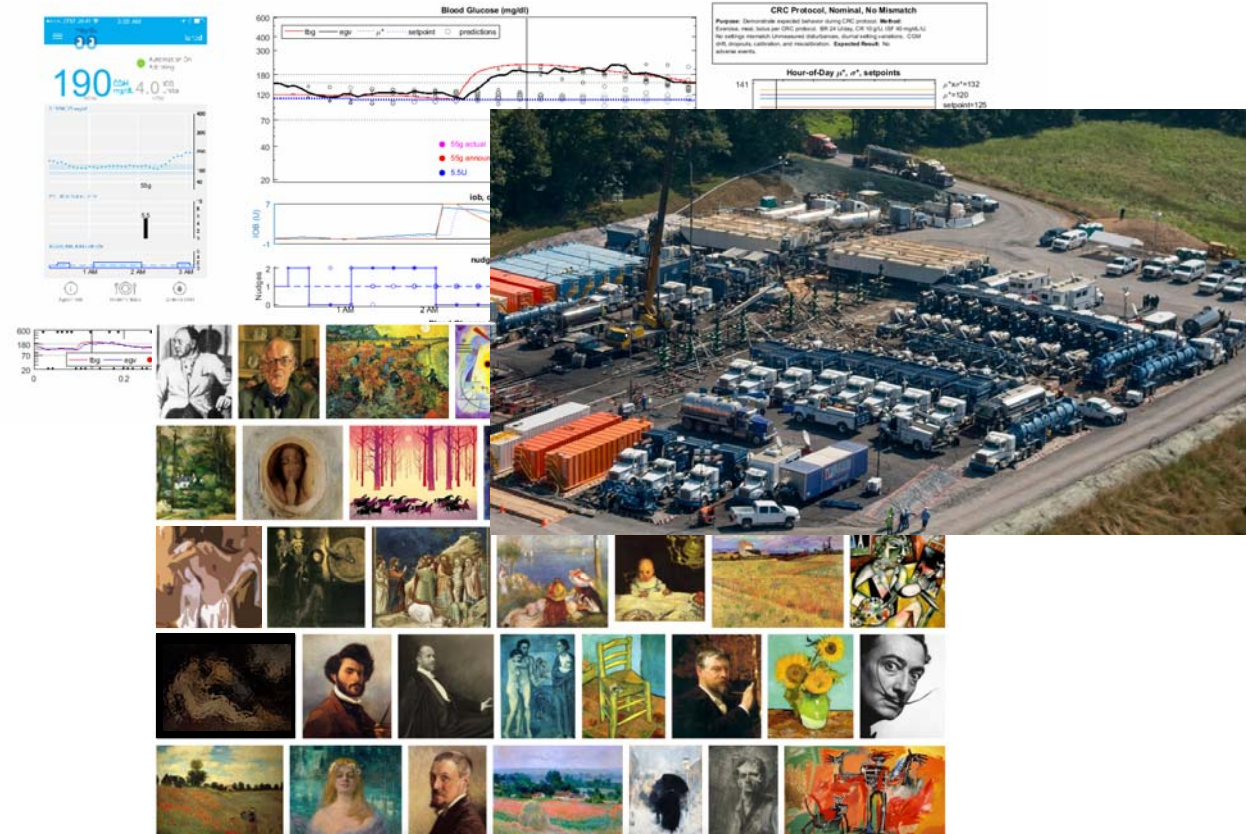
# Virtual Clinic

## 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)

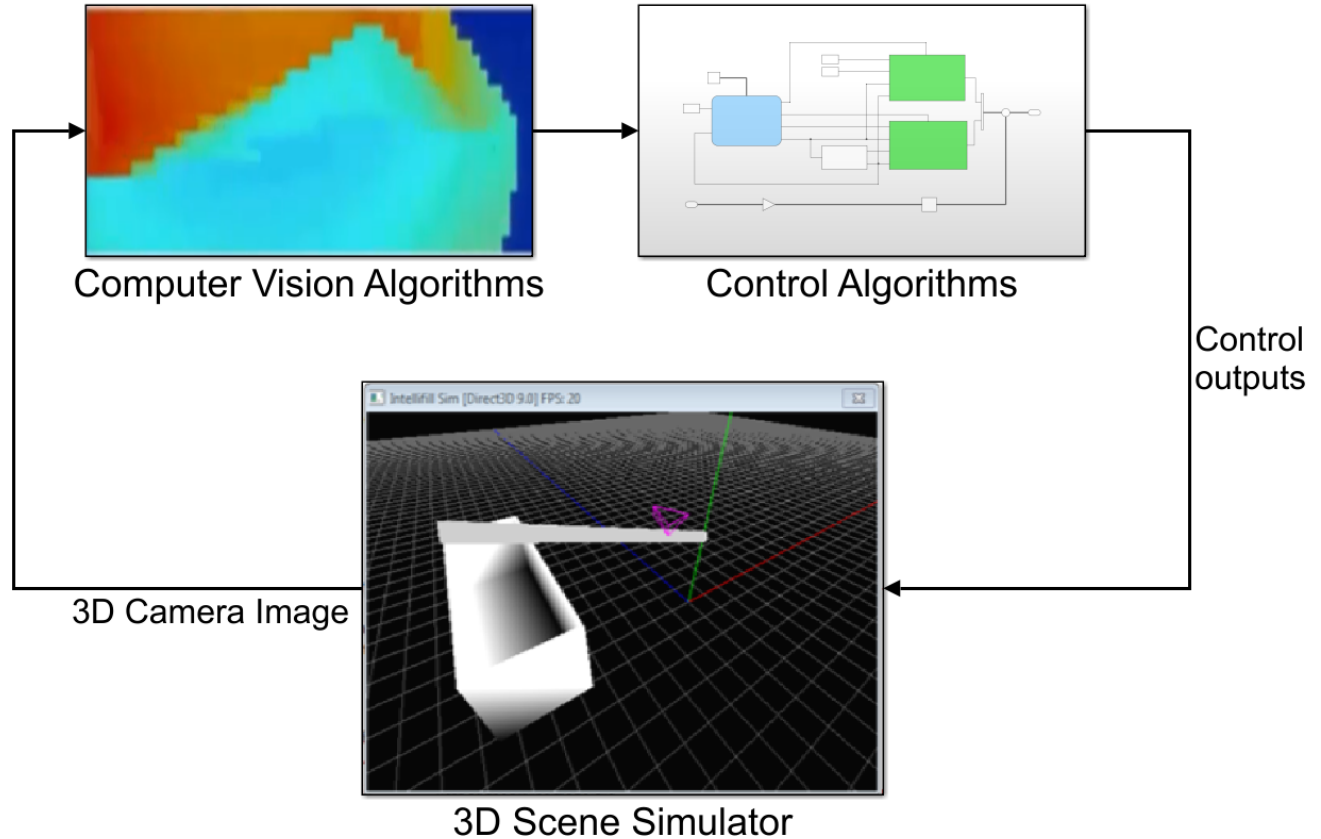




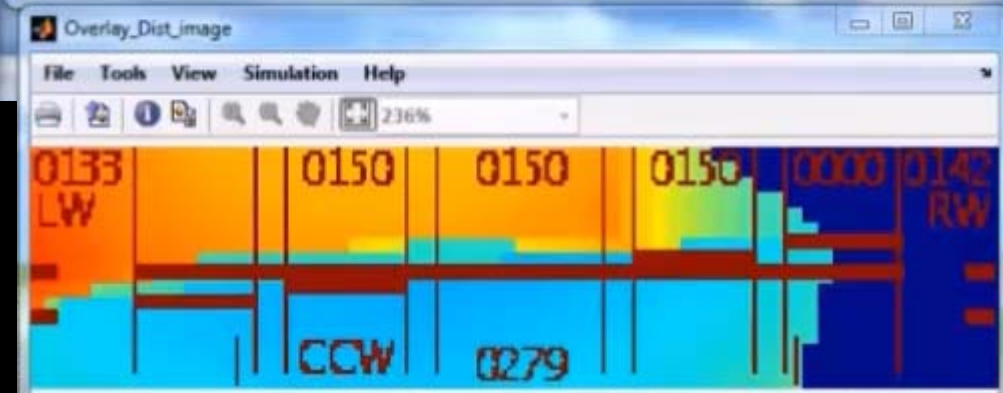
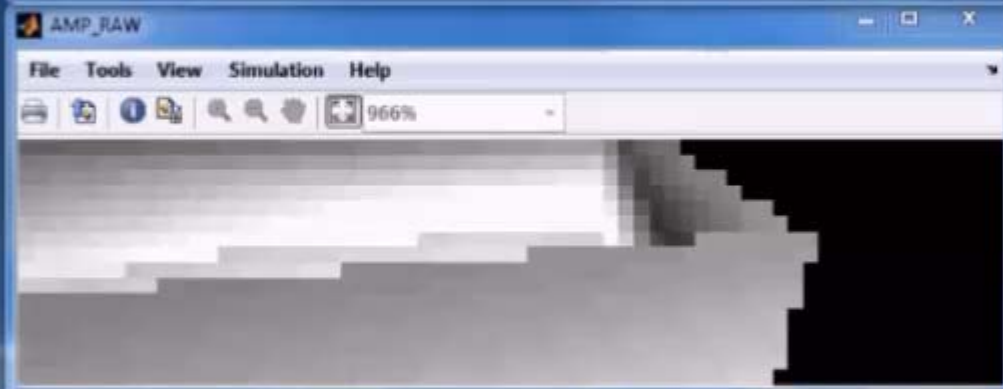
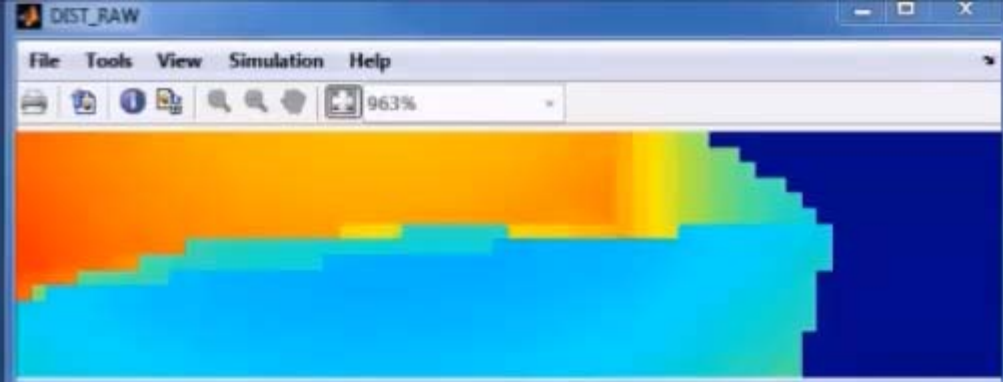
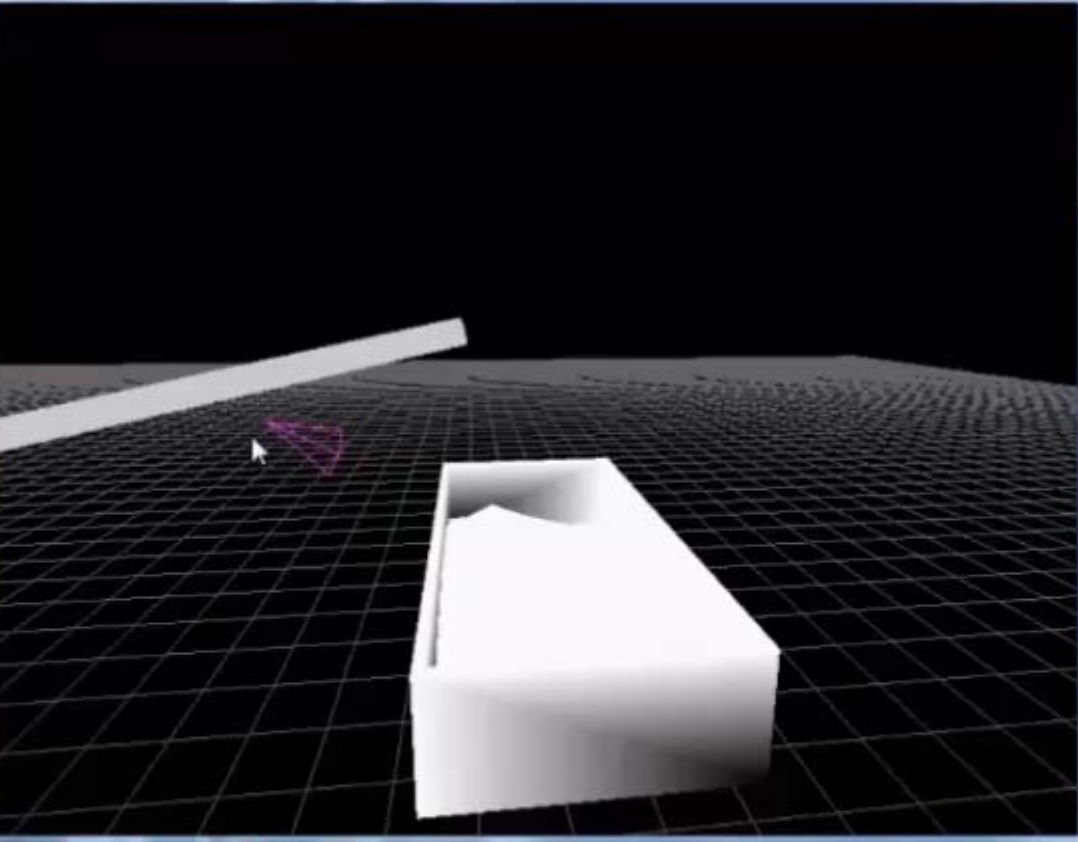
# Autonomous Trailer Filling



# Autonomous Trailer Filling







# Autonomous Trailer Filling



3D Cameras



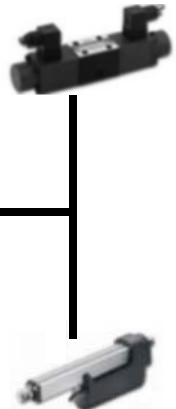
Computer vision and controls algorithms

CAN

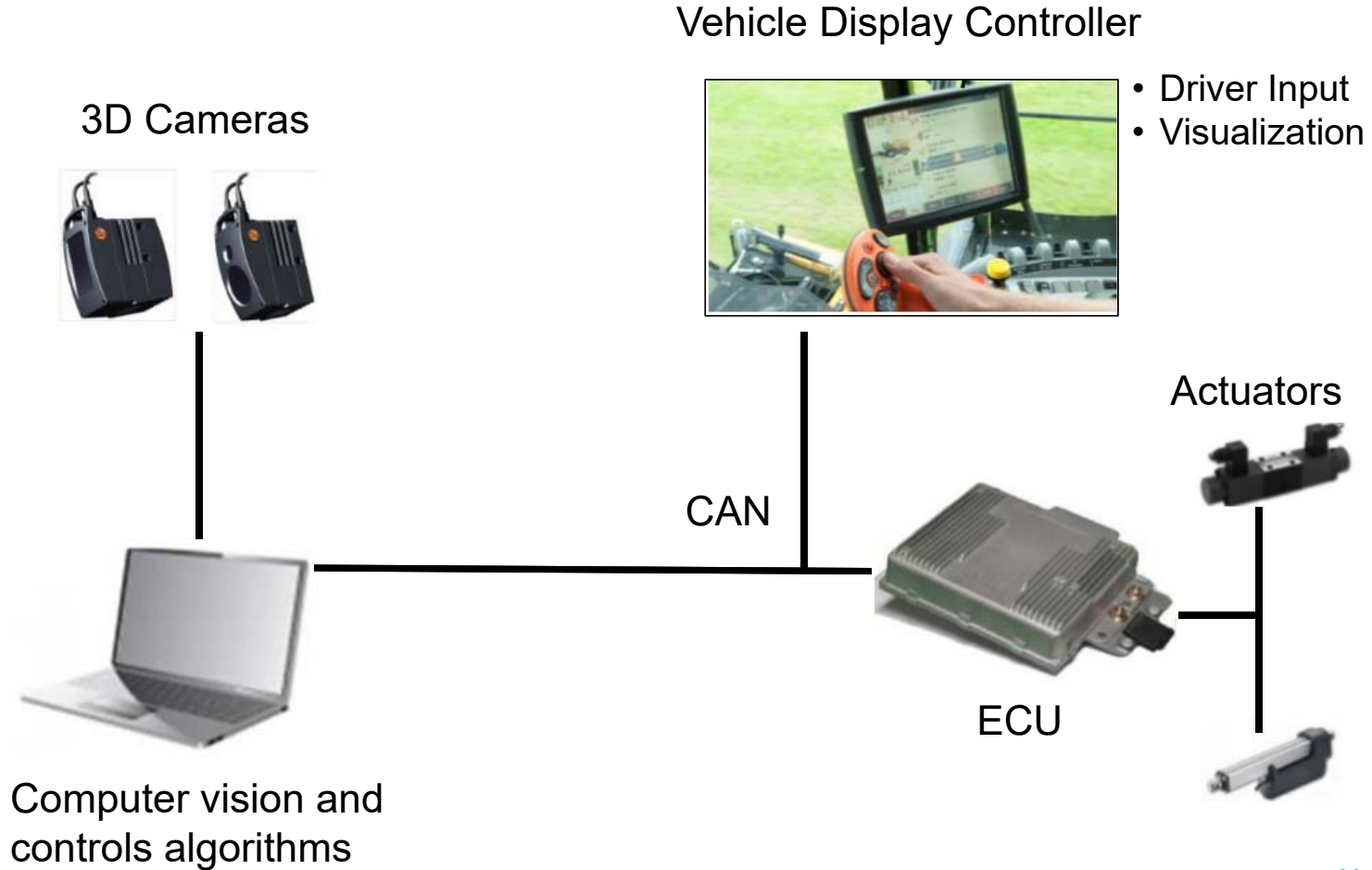


ECU

Actuators



# Autonomous Trailer Filling



# Autonomous Trailer Filling



Sense



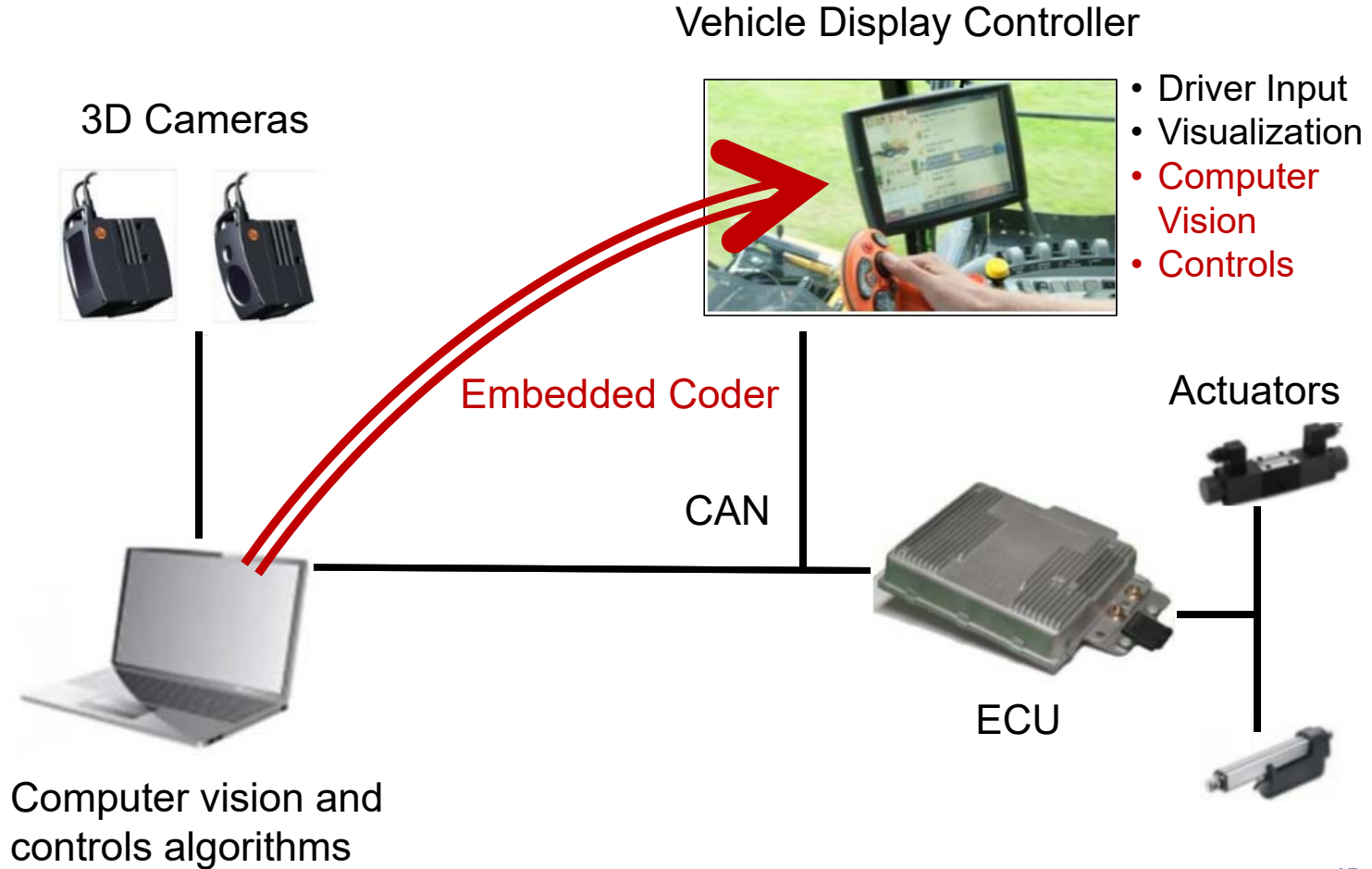
Perceive



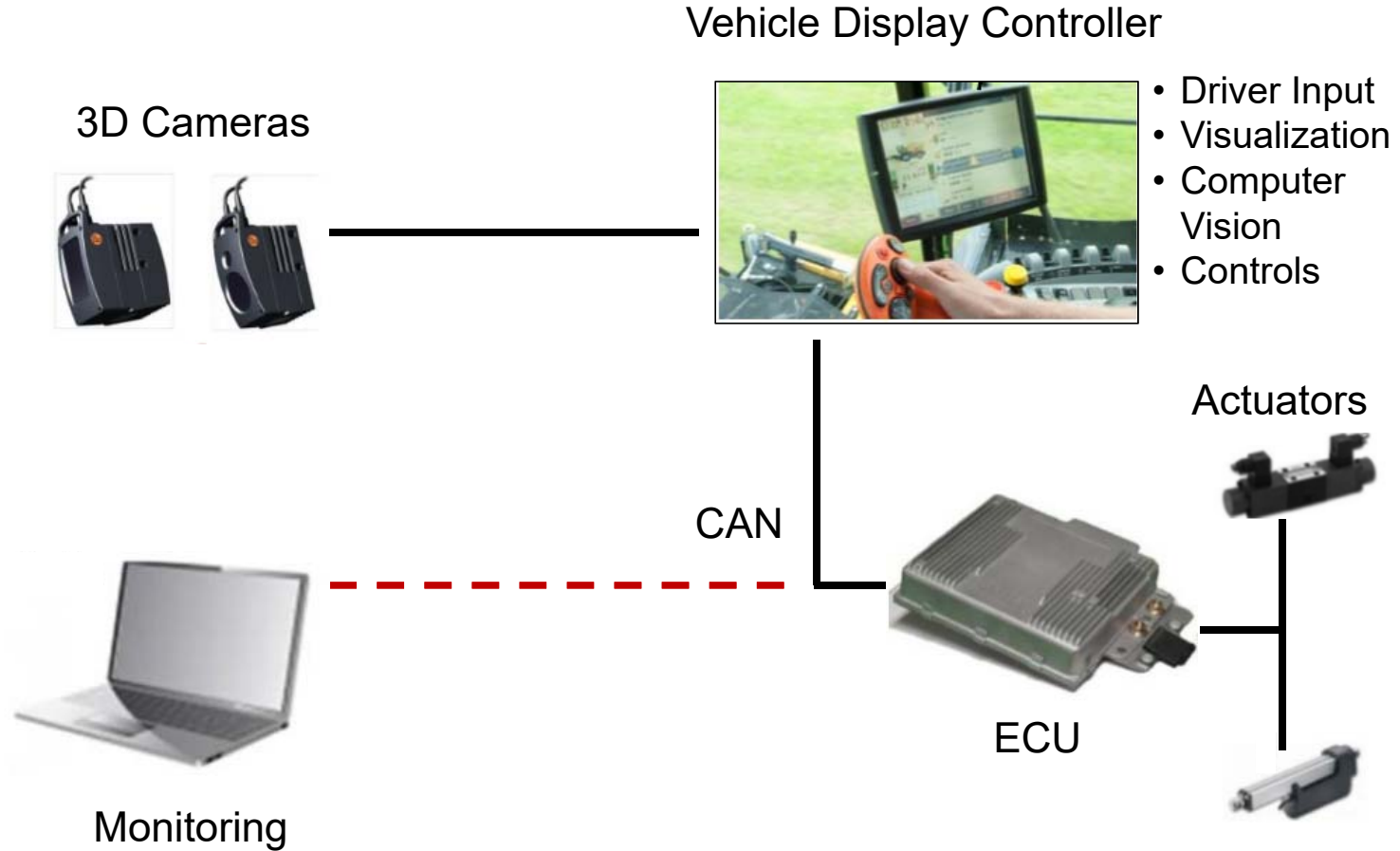
Decide  
& Plan



Act



# Autonomous Trailer Filling



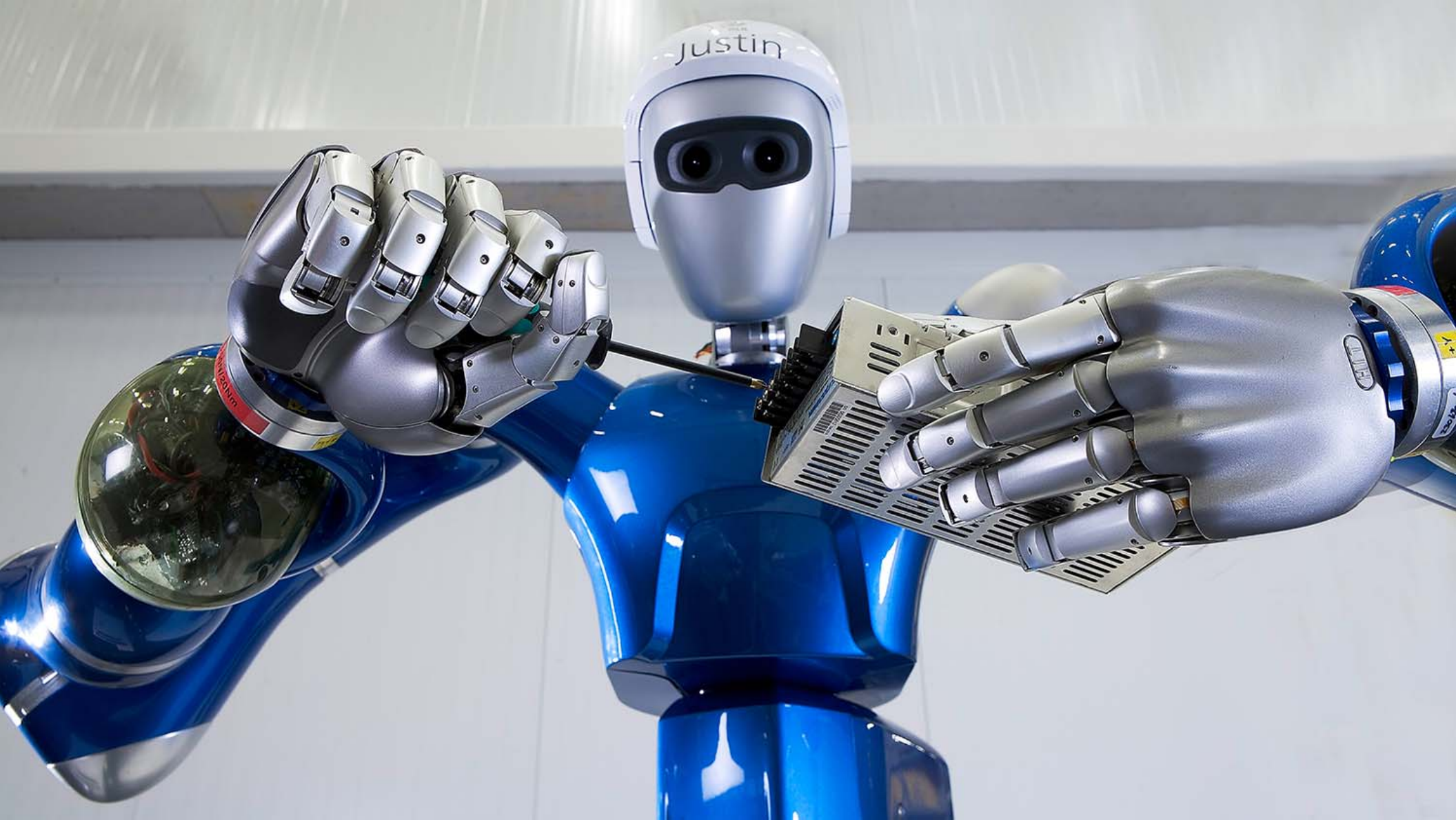
# How will you put it into production?

- System Architecture
- Embedded systems
- Enterprise systems
- HMIs

The collage illustrates various stages of industrial control system implementation:

- Operator Interface:** A person is shown operating a control panel with a large monitor displaying a graphical user interface.
- Desktop Environment:** A Windows desktop view showing a 'Rampstop' application window and a 'Desktop' folder containing 'Tools', 'Market Data Tools', and 'Physical NatGas'.
- Platform Portal:** A web-based dashboard titled 'Platform Portal' showing a 'Histogram by Job' and 'Jobs Running via Scheduler'.
- Detailed HMI:** A large, complex HMI interface for a process control system. It features:
  - Overview (Übersicht):** A list of process units (M151 to M275).
  - Process Monitoring:** Four main graphs showing 'Massendruckschwankung ExtC [-24h/1d]', 'Materialverbr. Ist-Durchsatz gesamt [-24h/1d] ID3608', 'ExtC Inline\_Regenerat\_IST\_Anteil [-24h/1d] ID43463', and 'Stippe mit Loch > 30.000 [-24h/1d]'. A red banner at the bottom reads 'Abstellen nach Vielfachen von 3200m l'.
  - Status and Parameters:** A 'Status' section with 'OK/NE' indicators and a 'Parameter' table.
 

ID	Label	Value
10001	Betriebspunkt	
10004	Stippe mit Loch	
	Fertigungsauftrag	
	Rollen Nr.	
	Massendruck A:	239
	Massendruck A: Steigung	5
	Massendruck A: Schwankung	6
	Massendruck B:	252
	Massendruck B: Steigung	3
	Massendruck B: Schwankung	4
	Massendruck C:	233
	Massendruck C: Steigung	7
	Massendruck C: Schwankung	8
  - Summary and Service Package:** A 'Summary' section with metrics like 'Number of Jobs' (121,659) and 'Success Rate' (0.990), and a 'Service Package' section with a bar chart.



# 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?