

MATLAB EXPO 2017

How to build an **autonomous** anything

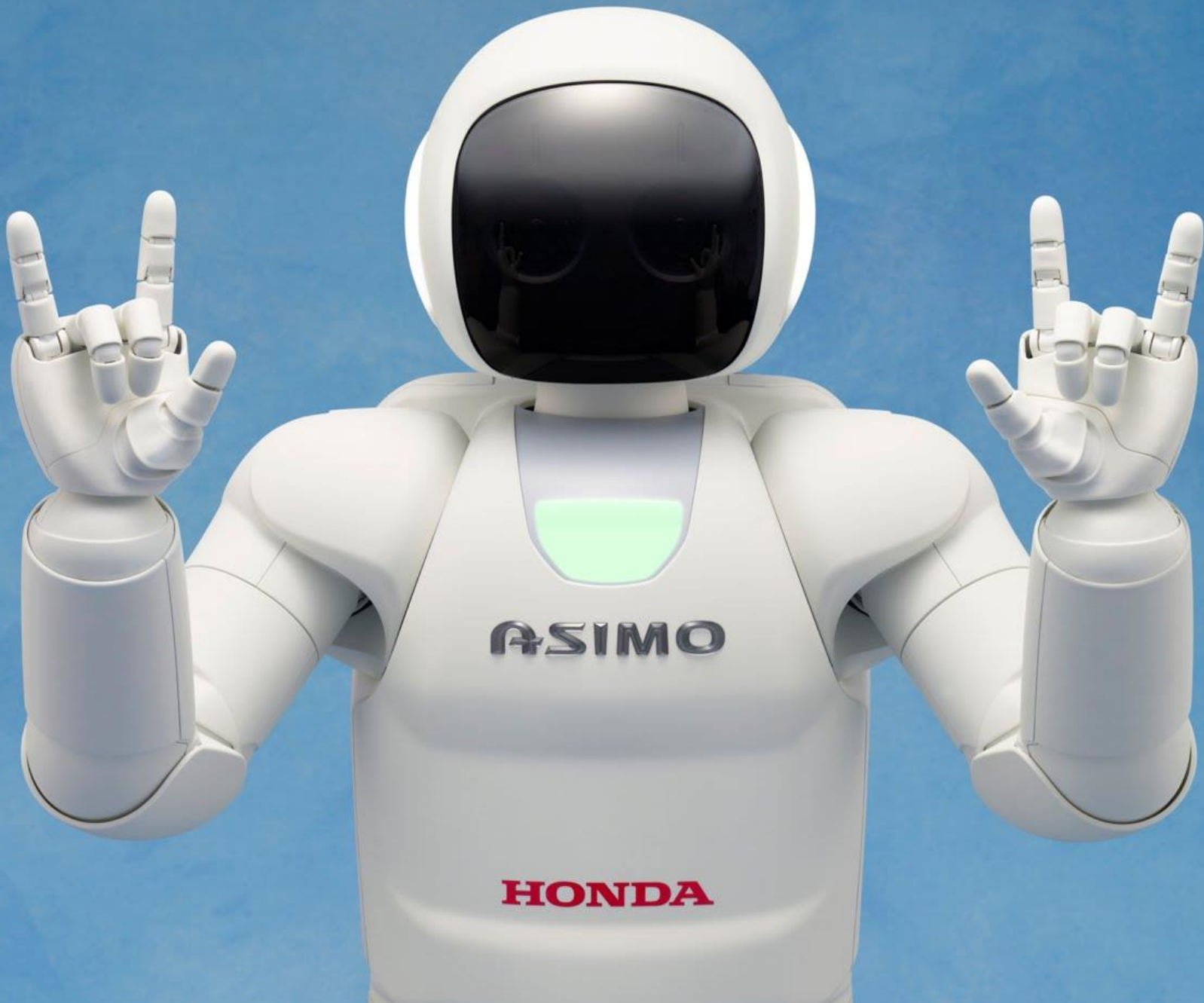
Loren Dean

Senior Director, Engineering

MATLAB Products

MathWorks

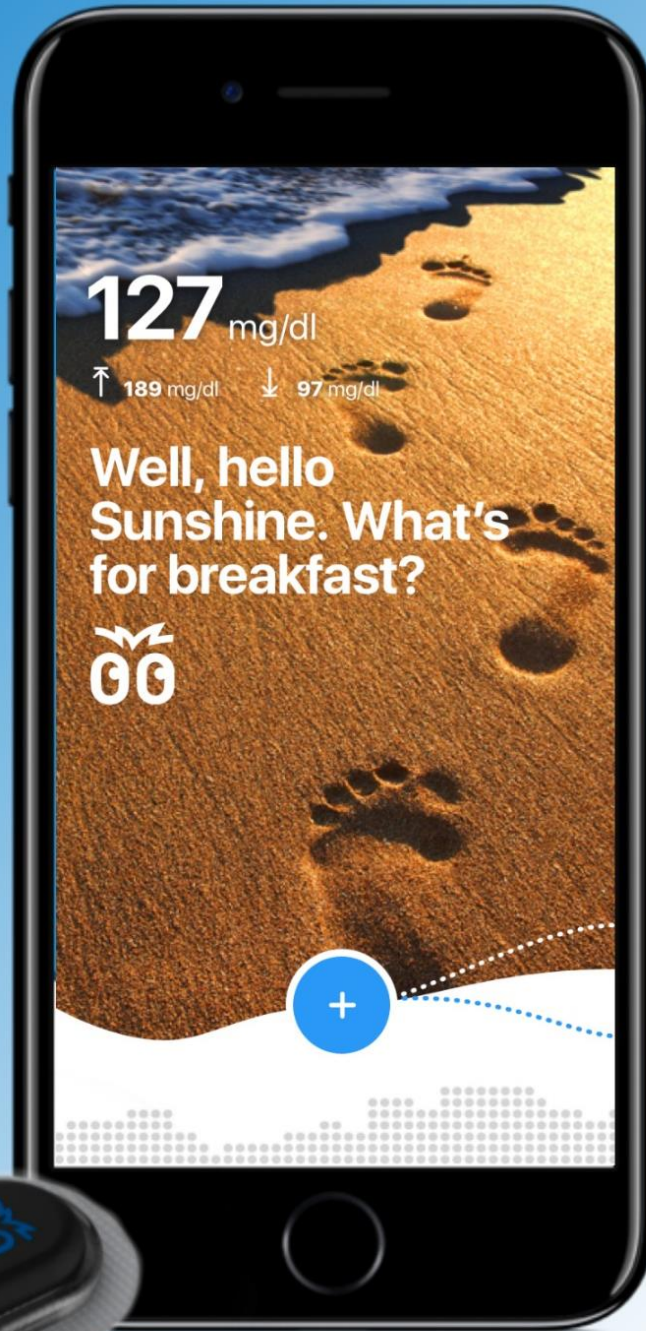












Autonomous Technology

Autonomy

Having the power for self-governance

Autonomous Technology

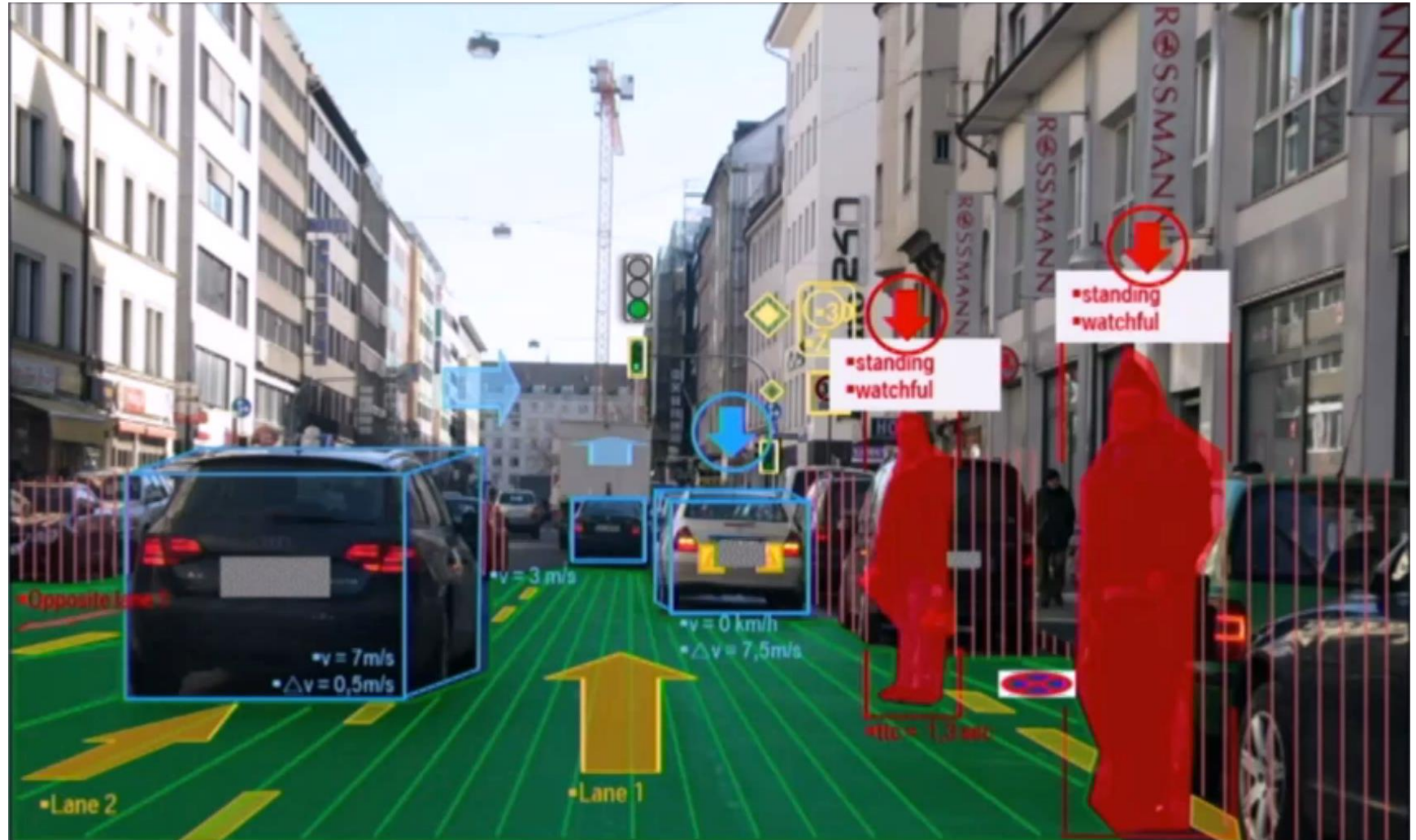
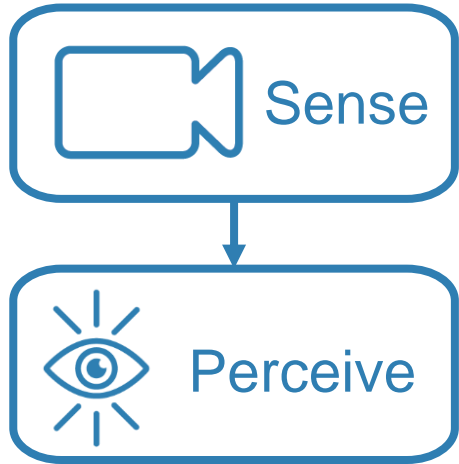
*Provides the ability of a system to act **independently** of direct human control under **unrehearsed** conditions*



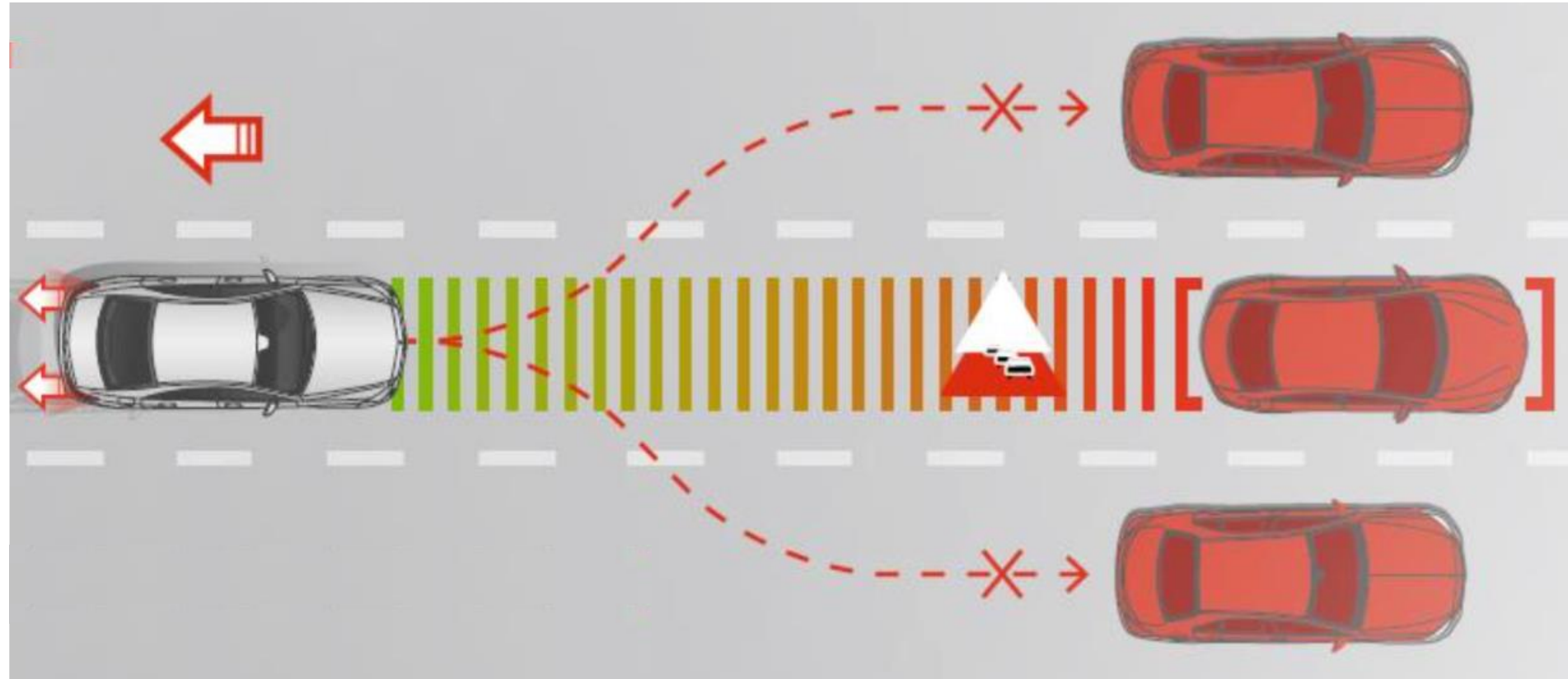
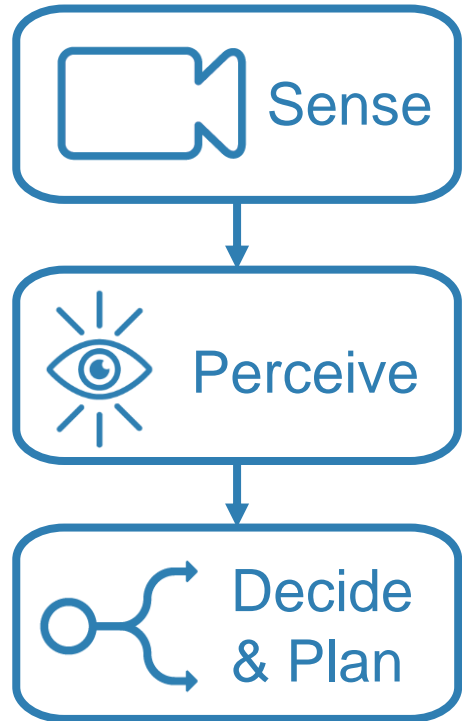
Capabilities of an Autonomous System



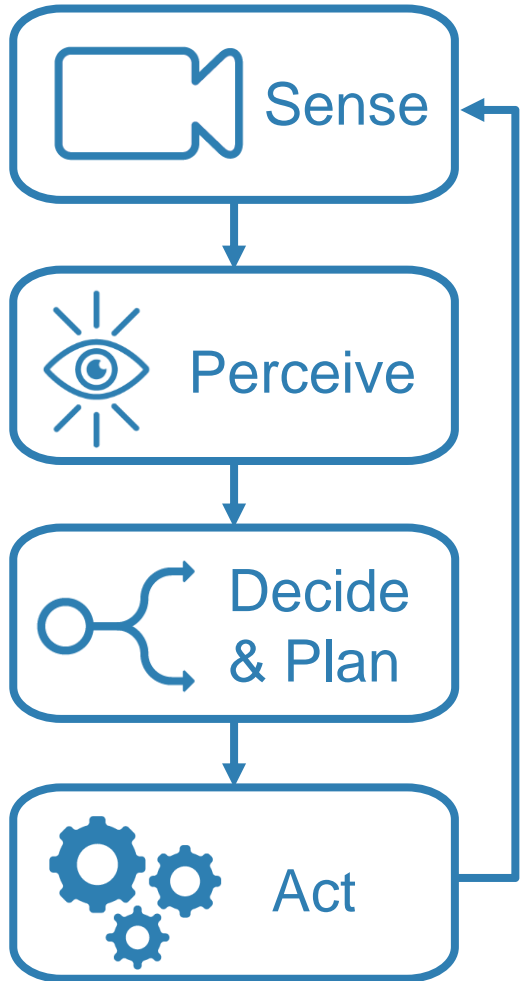
Capabilities of an Autonomous System



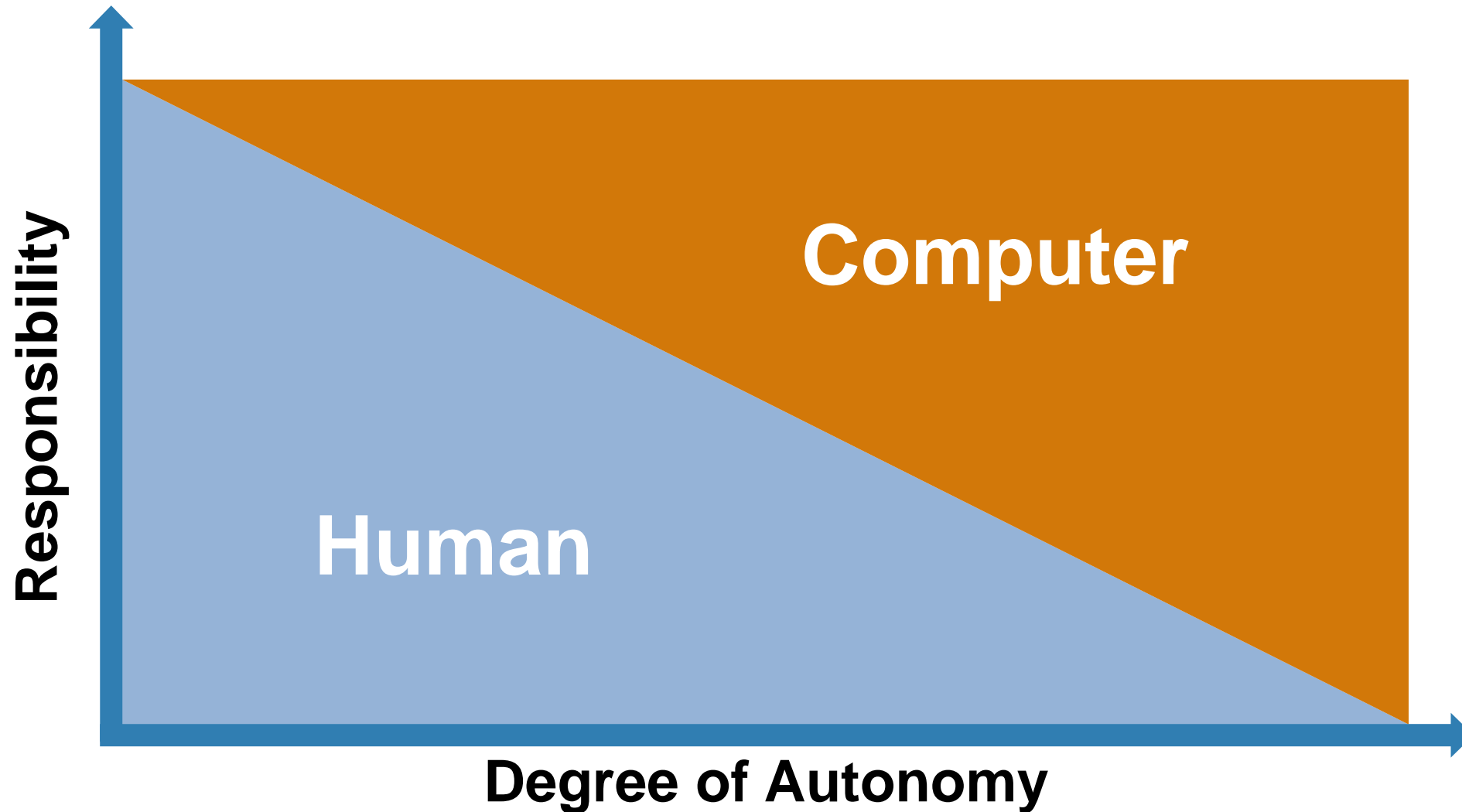
Capabilities of an Autonomous System



Capabilities of an Autonomous System



Autonomous Technology Transfers Responsibility to Computers



Cost of rig: >\$1M
Repair cost: \$100,000
Cost of valve: \$200



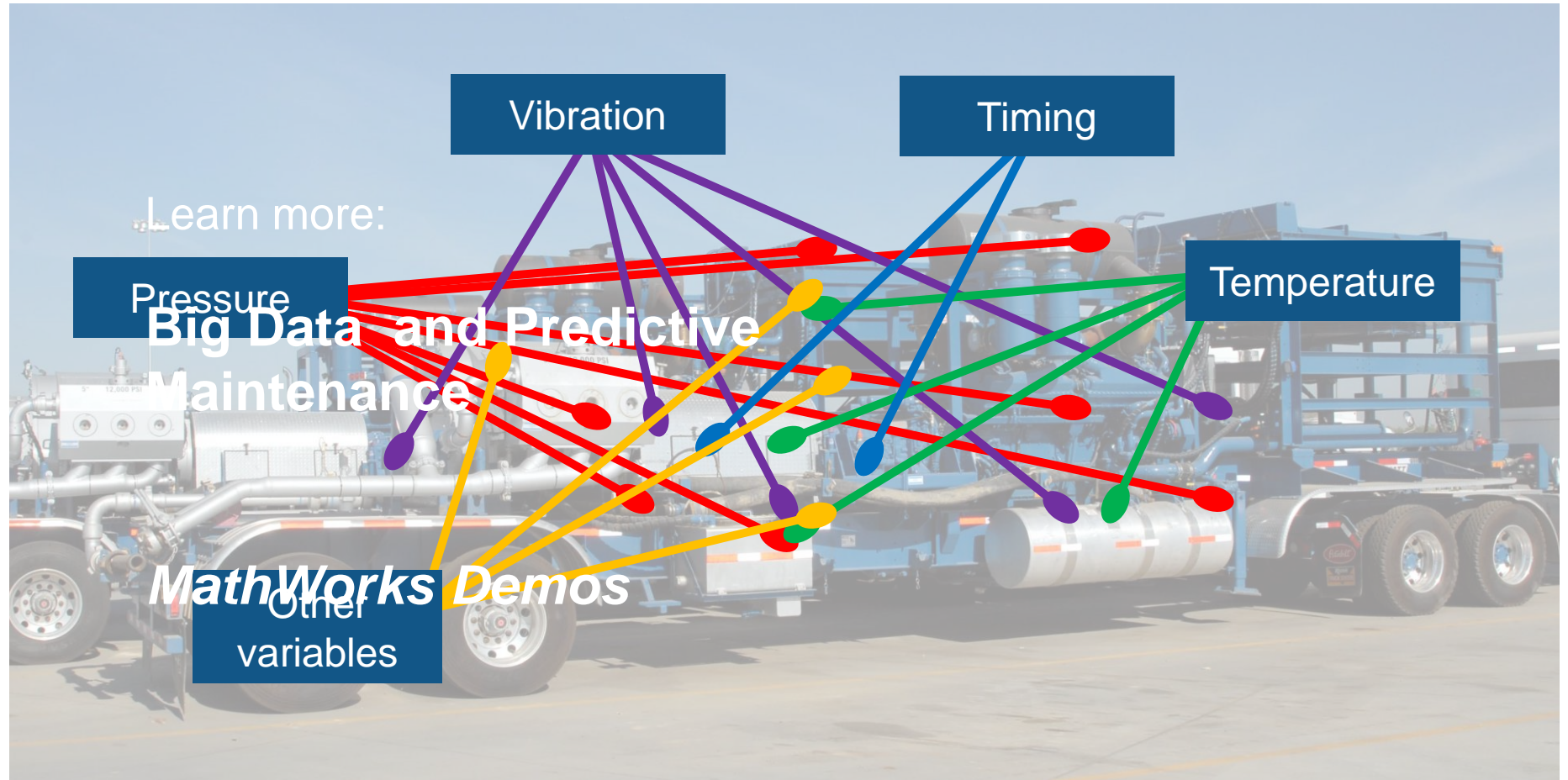
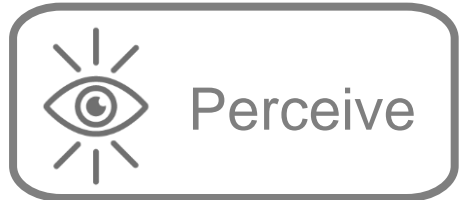




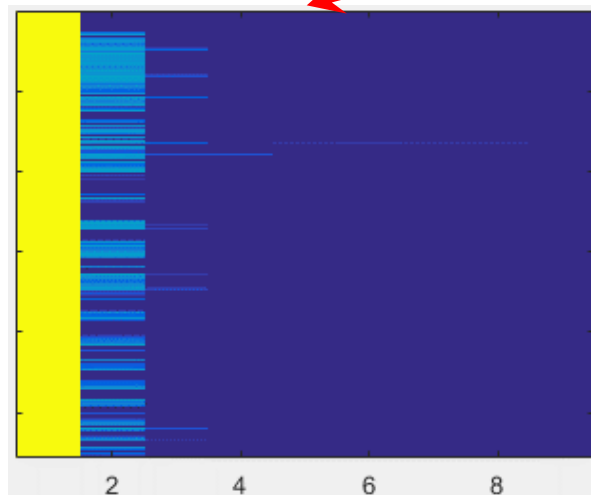
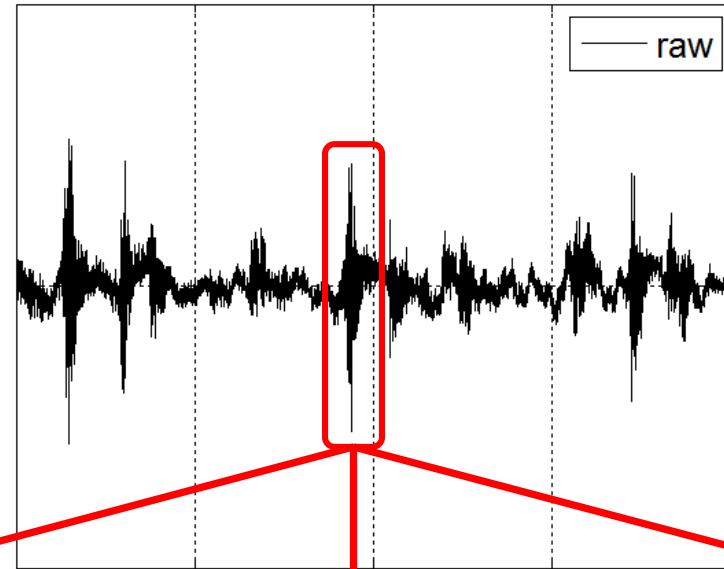
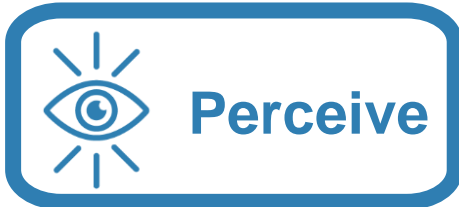


Autonomous Service for Predictive Maintenance

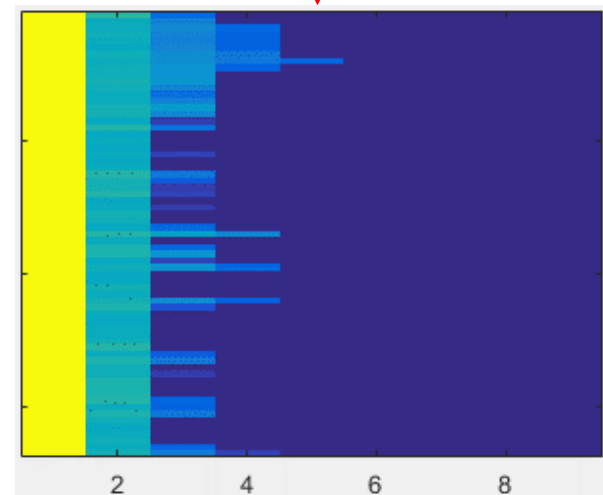
Which sensor values should they use?



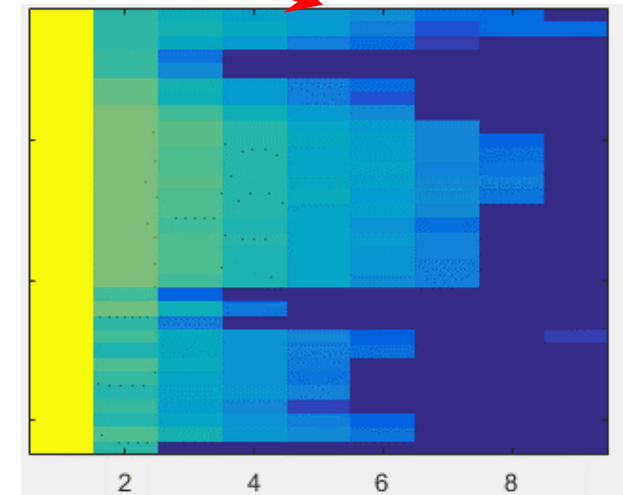
Autonomous Service for Predictive Maintenance



Normal Operation



Monitor Closely



Maintenance Needed

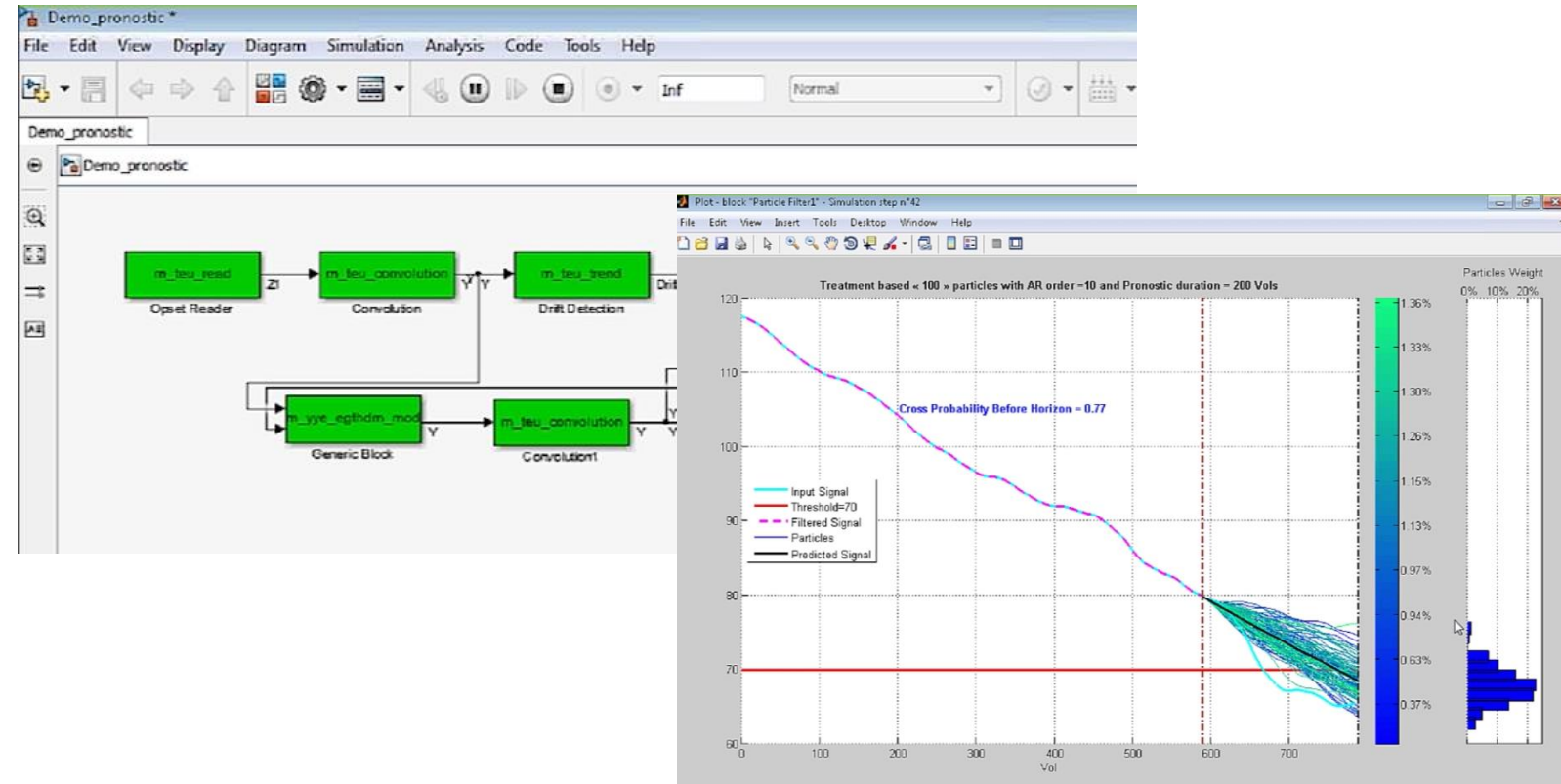
What are the best predictors?

- Data-driven

What are the best predictors?

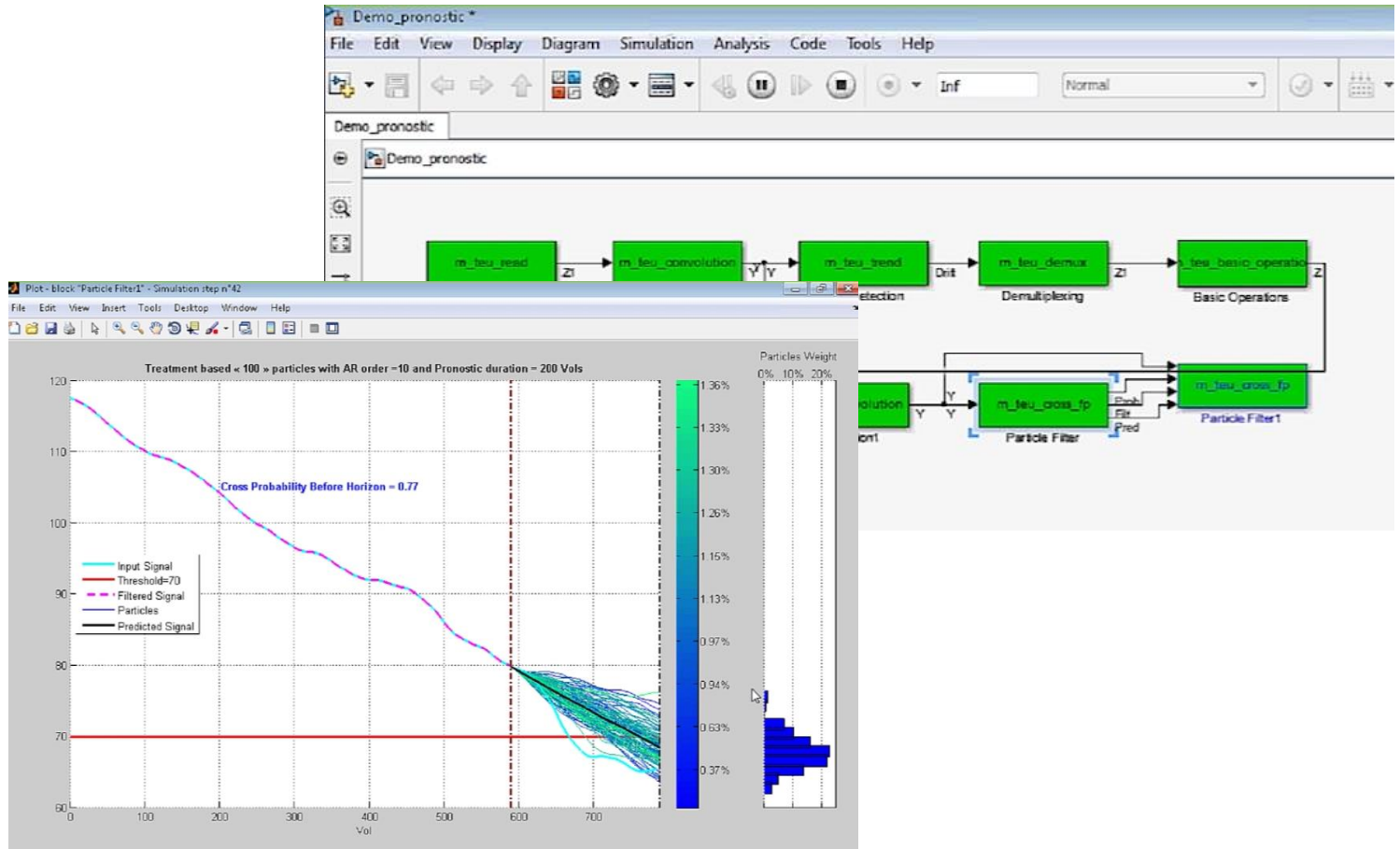
- Data-driven
- Model-driven

Jet Engine Monitoring

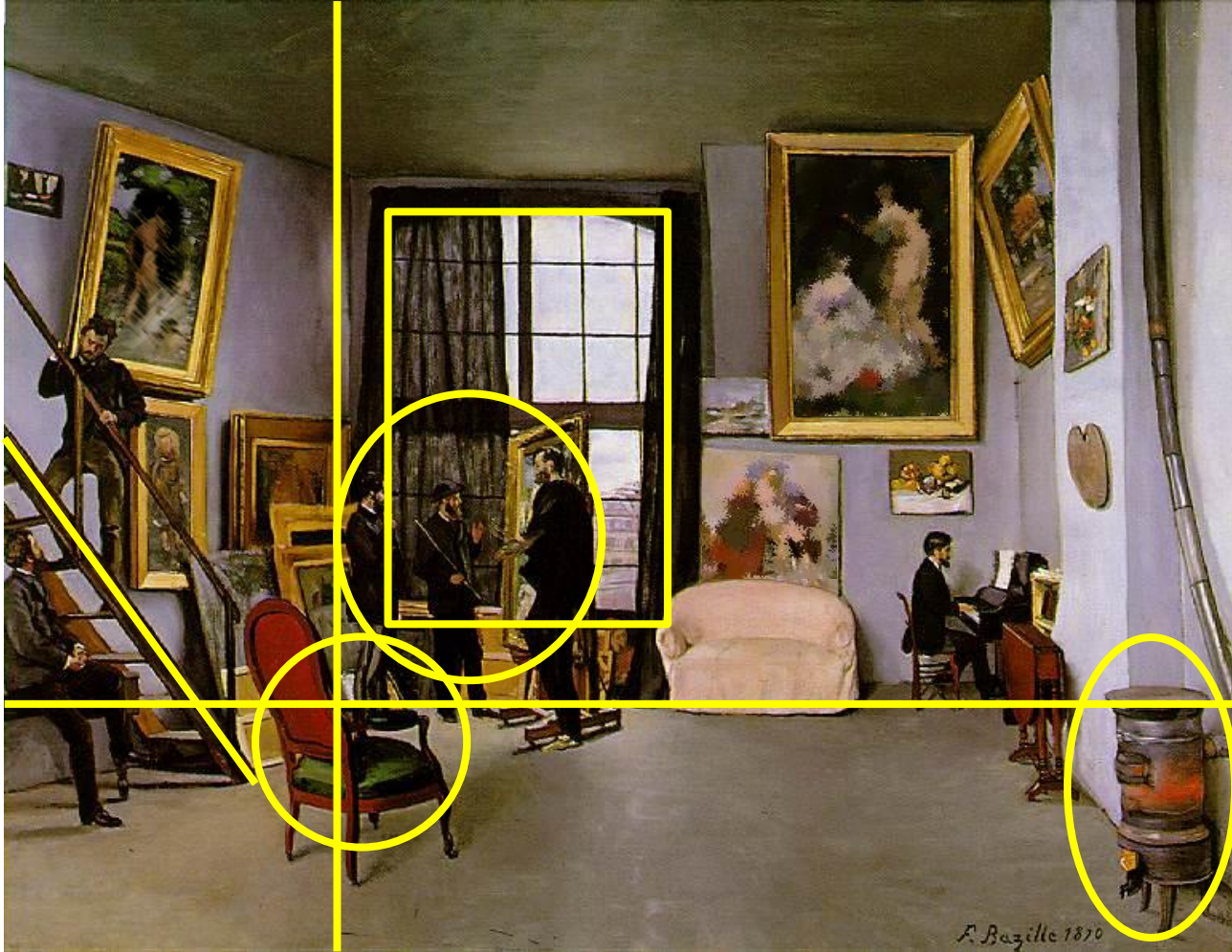


What are the best predictors?

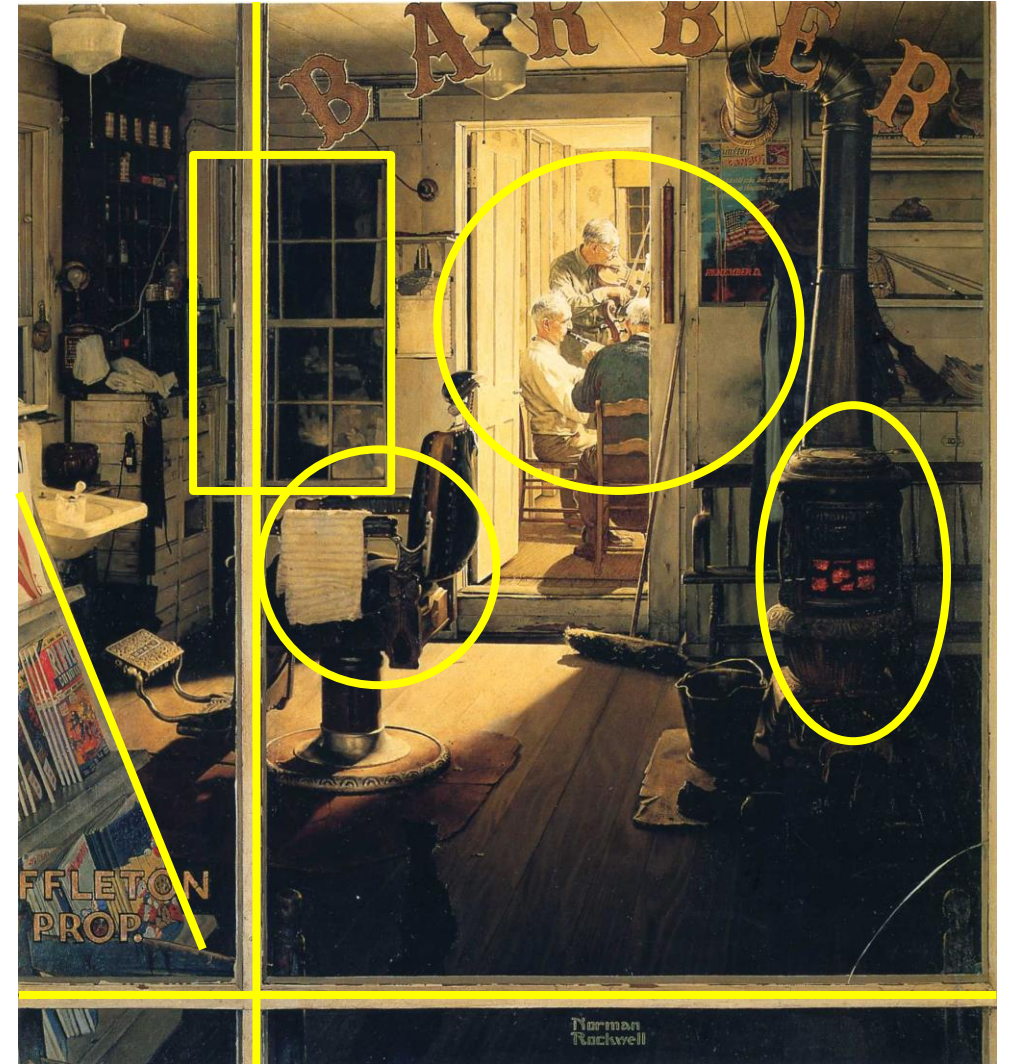
- Data
- Models



Jet Engine Monitoring



Bazille's Studio
 Frederic Bazille (Paris, 1870)



Shuffleton's Barbershop
 Norman Rockwell (Vermont, 1950)

Autonomous Artistic Style Classification

Rutgers University

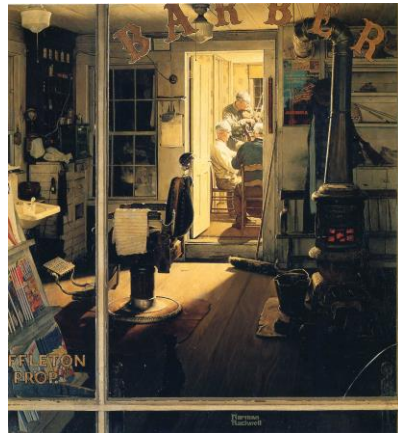
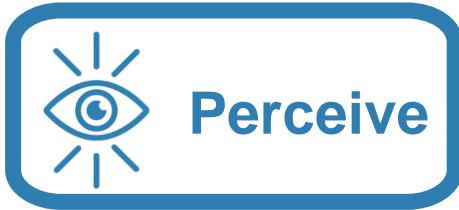
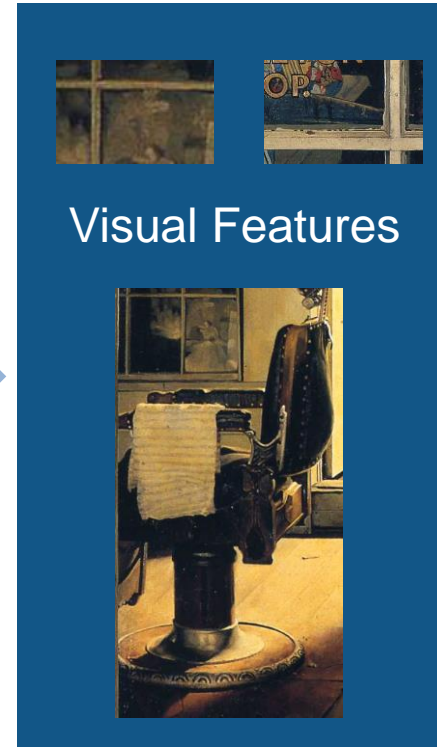


Image
Feature
Extraction



Machine
Learning
Classification



Style:
Regionalism



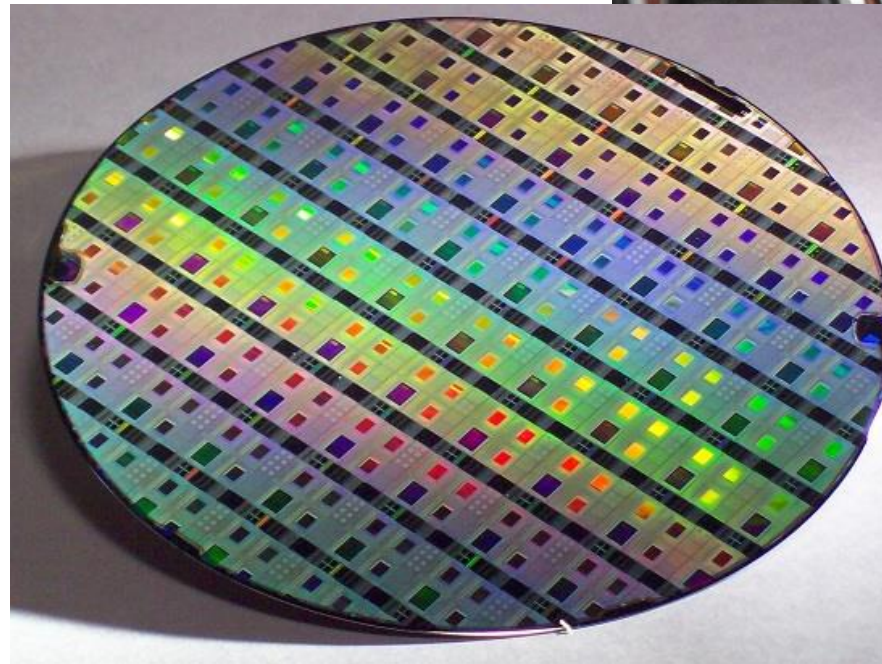
Genre:
Interior



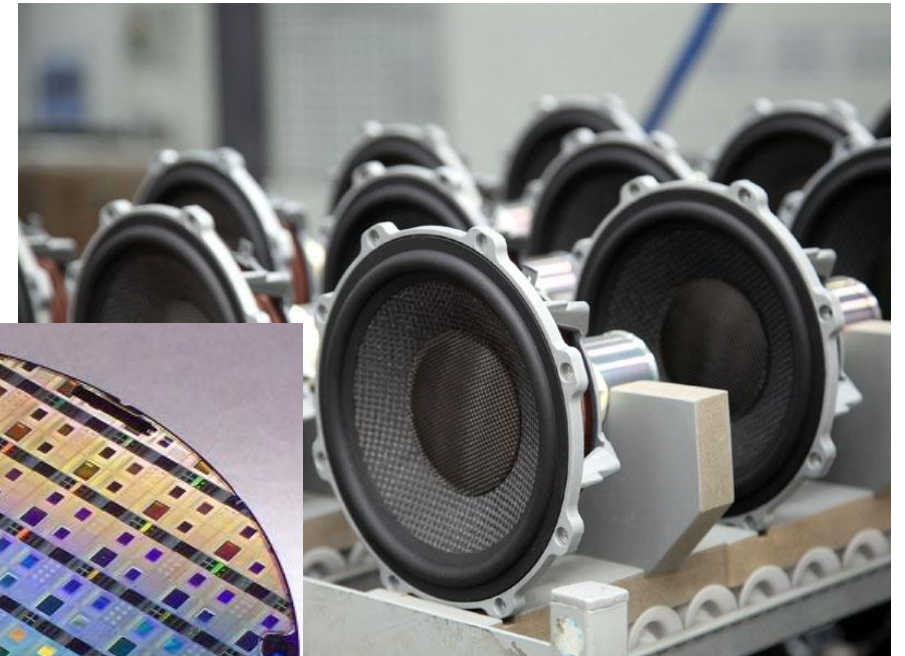
Artist:
Rockwell

Where to add autonomy with perception?

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



Virtual Semiconductor
Manufacturing Calibration



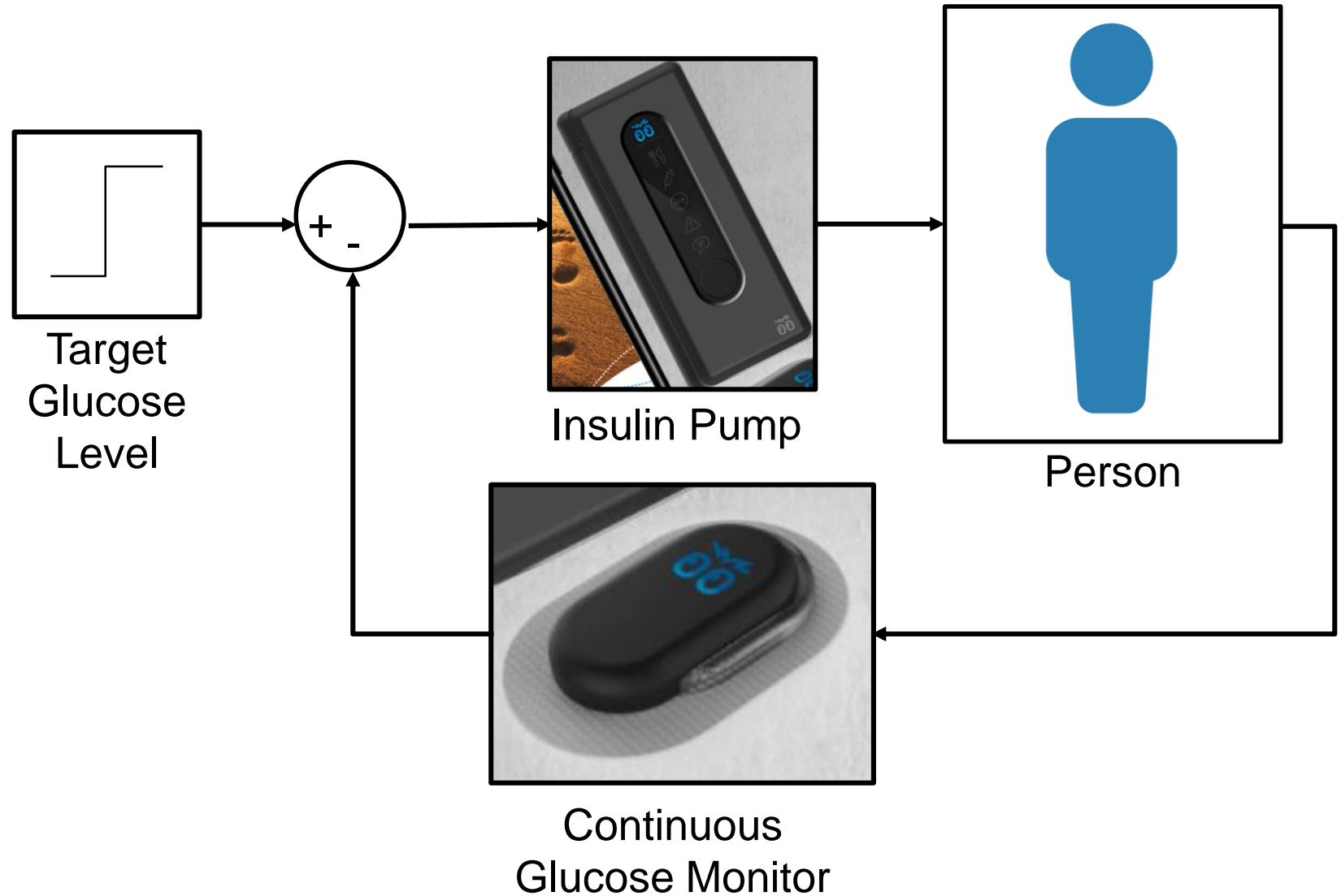
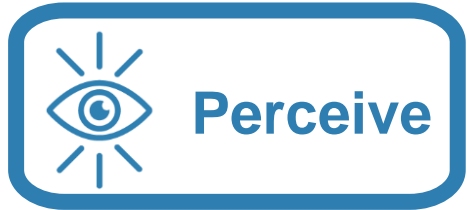
Determine
Loudspeaker
Quality

Autonomous Glucose Level Management



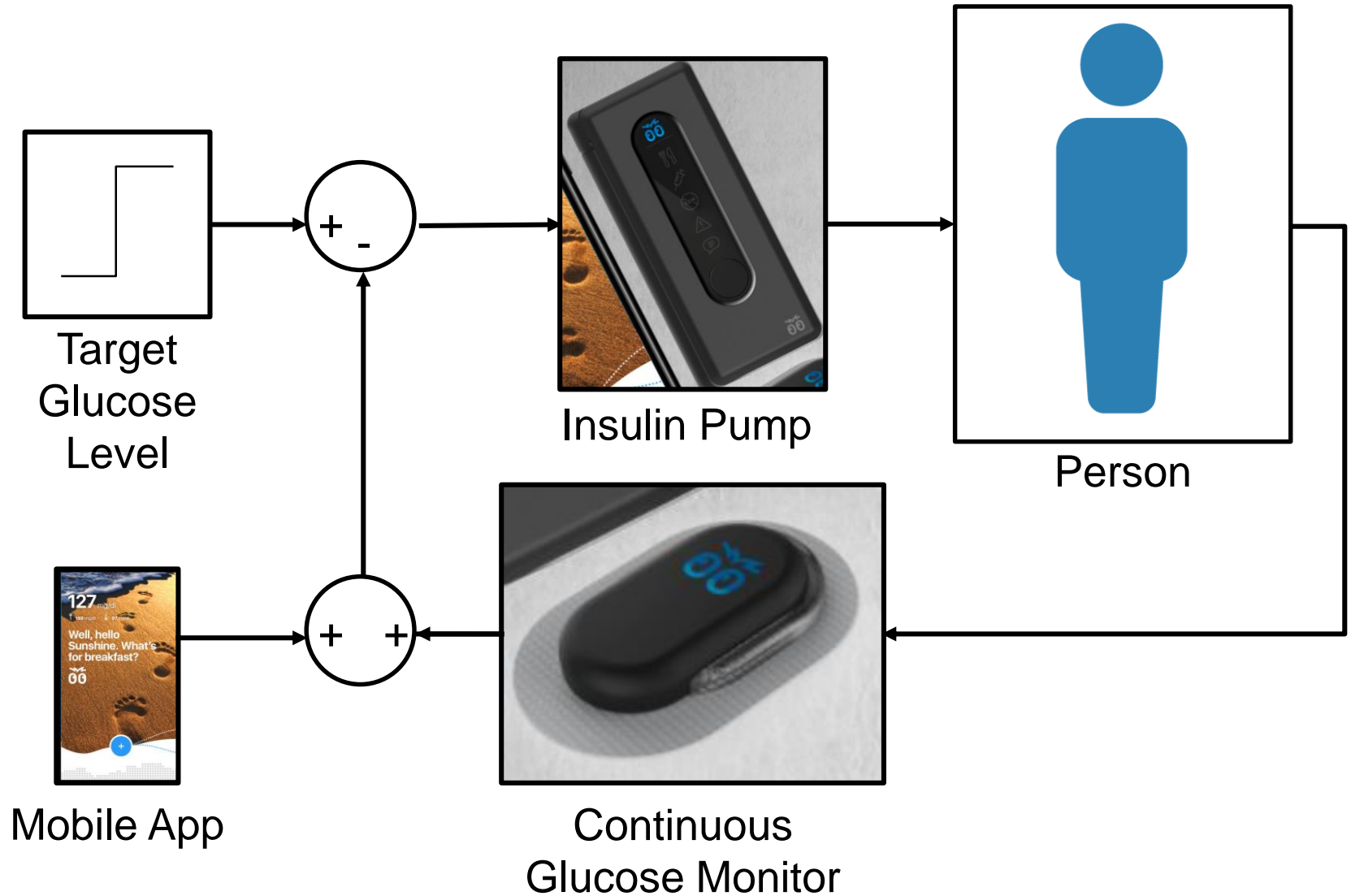
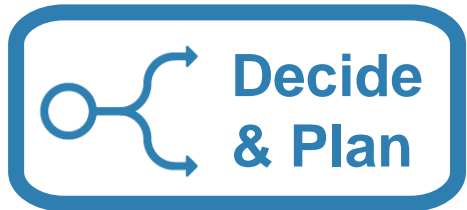
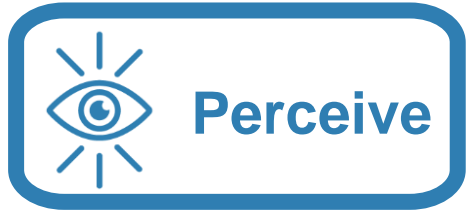
Autonomous Glucose Level Management

Bigfoot Biomedical



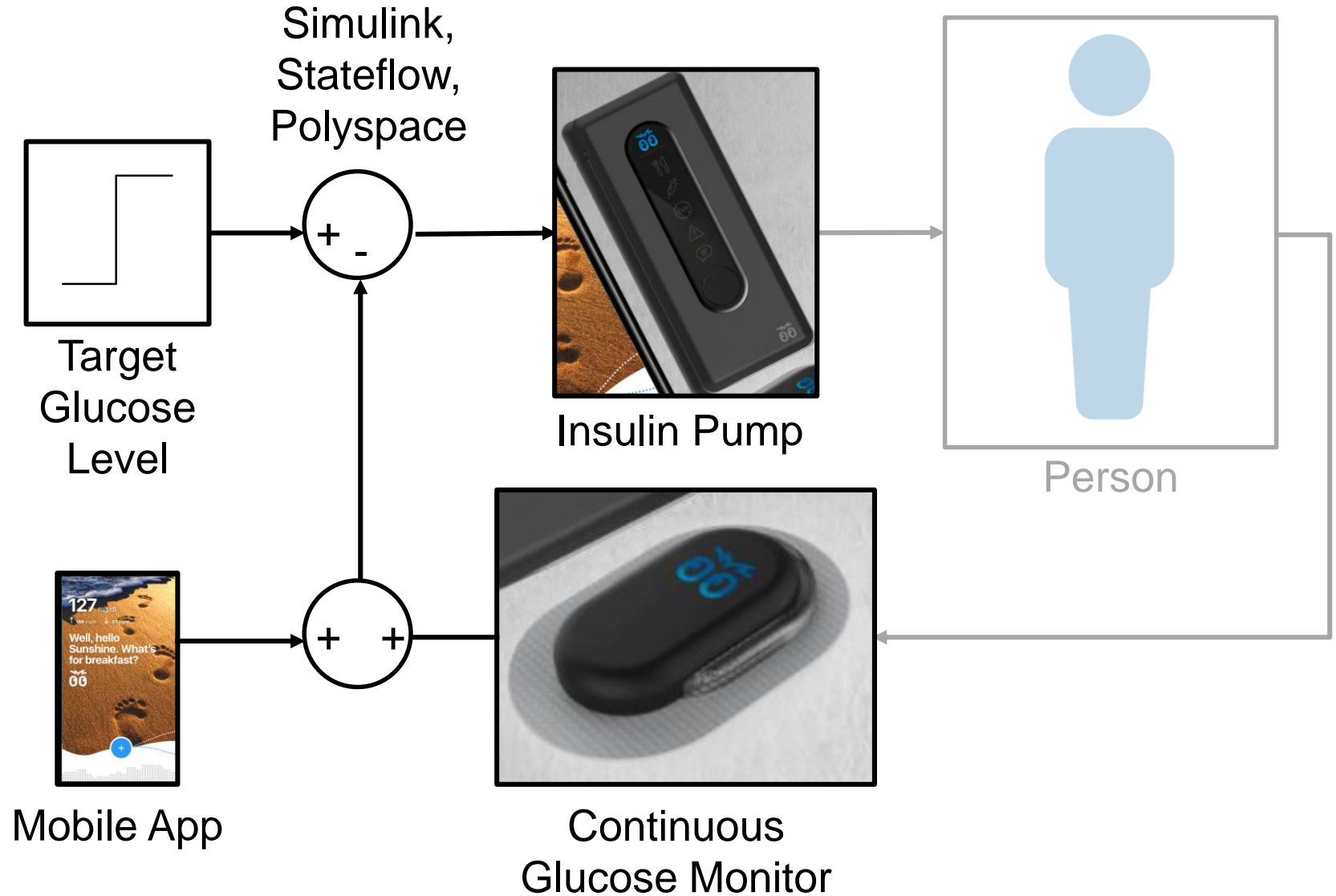
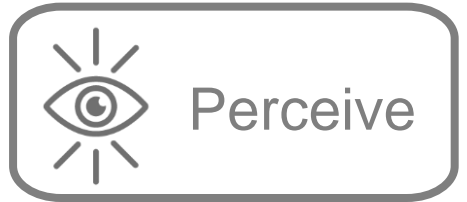
Autonomous Glucose Level Management

Bigfoot Biomedical



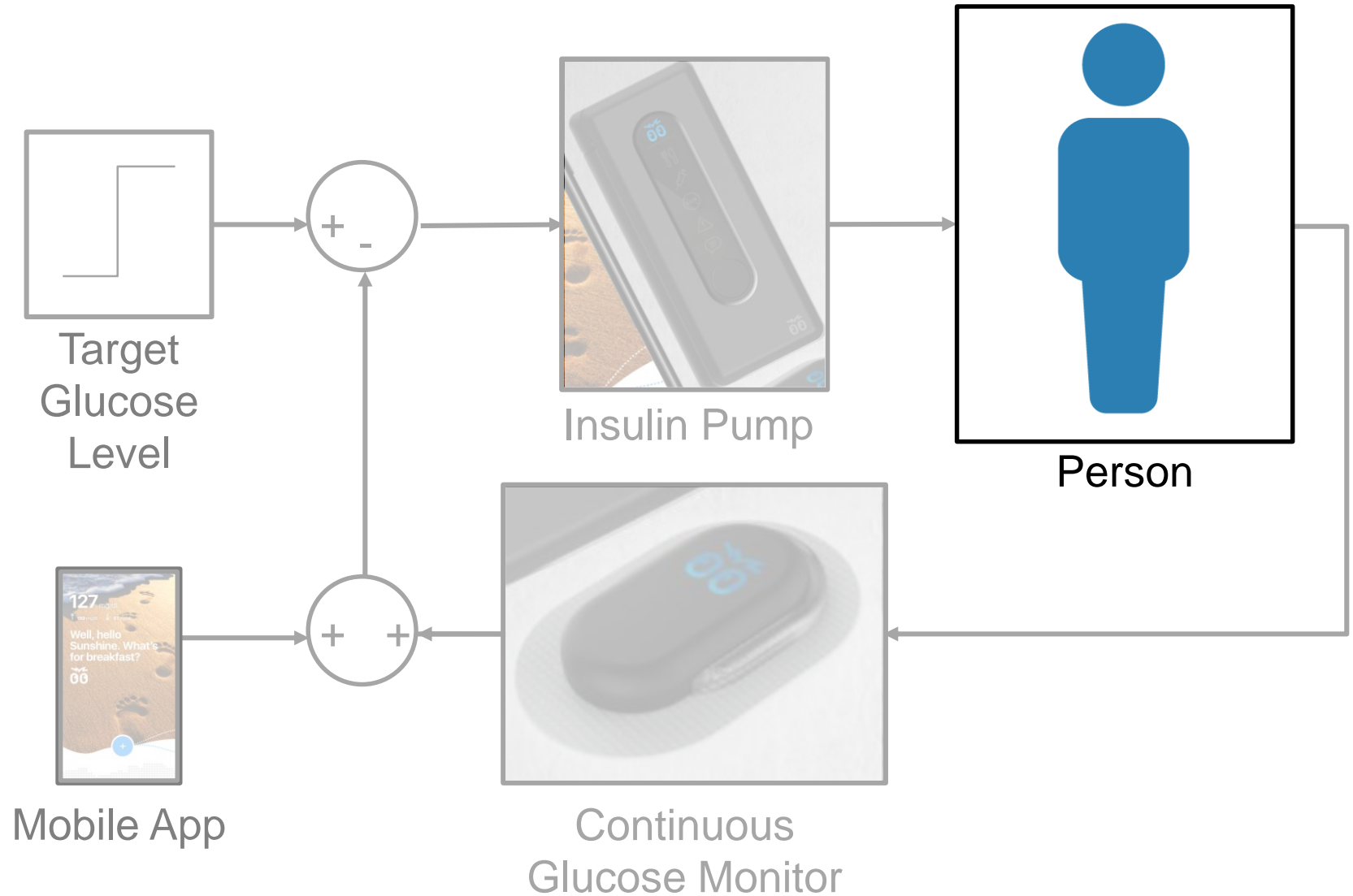
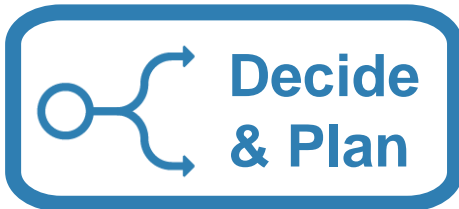
Autonomous Glucose Level Management

Bigfoot Biomedical



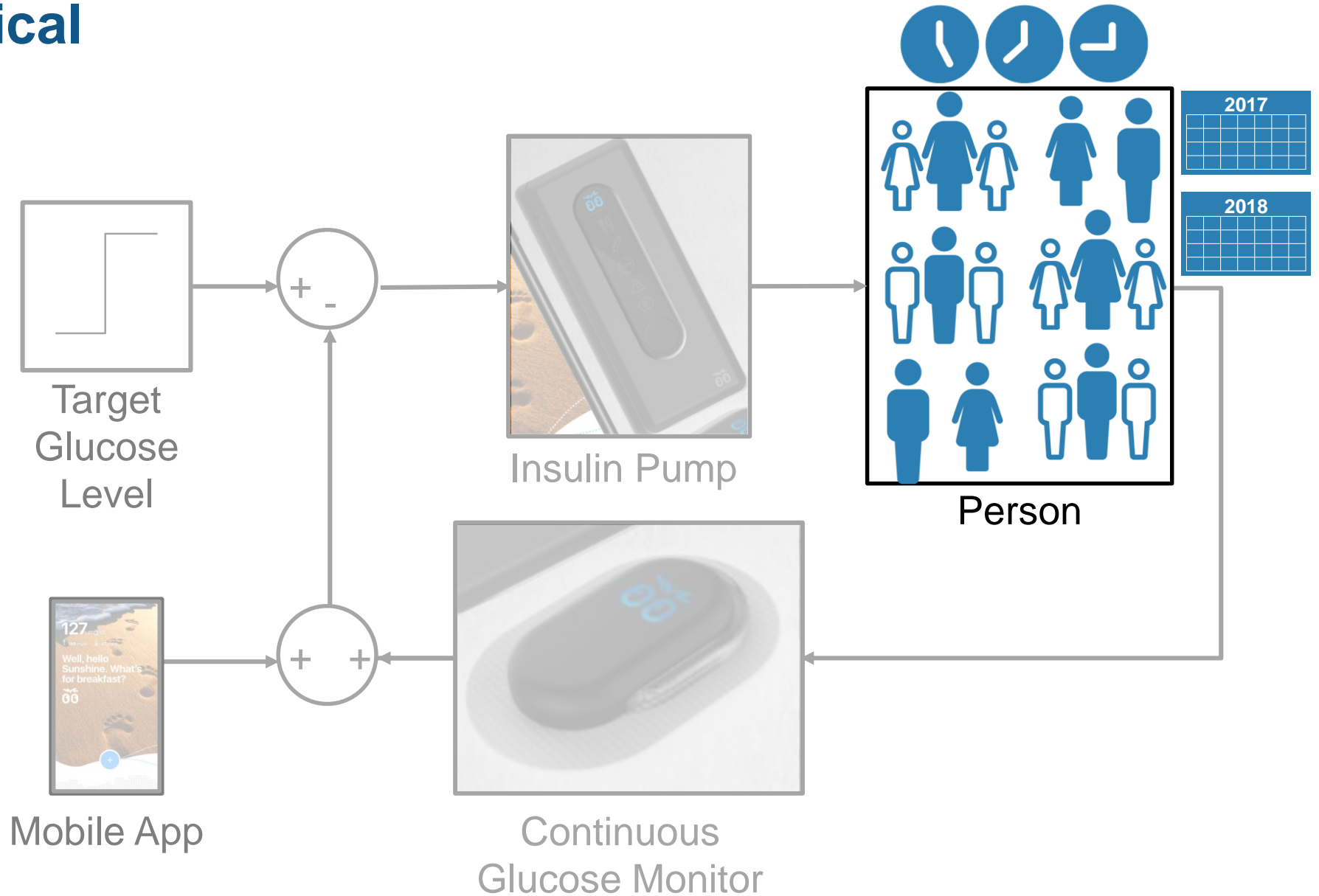
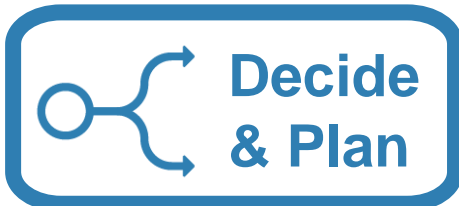
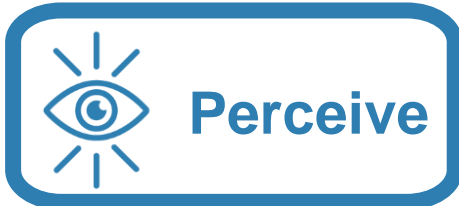
Autonomous Glucose Level Management

Bigfoot Biomedical



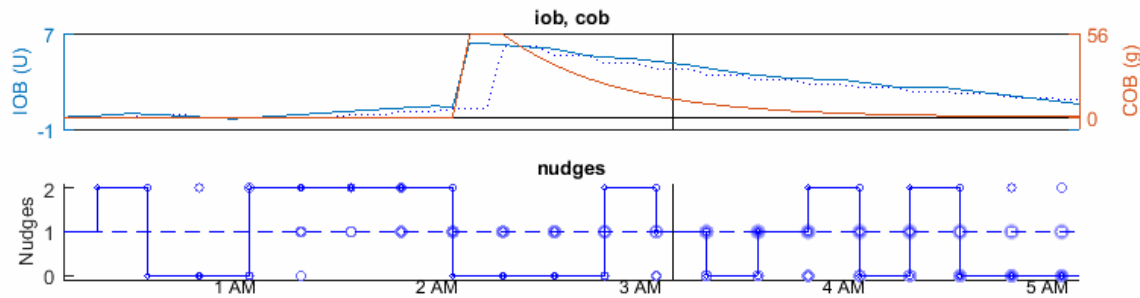
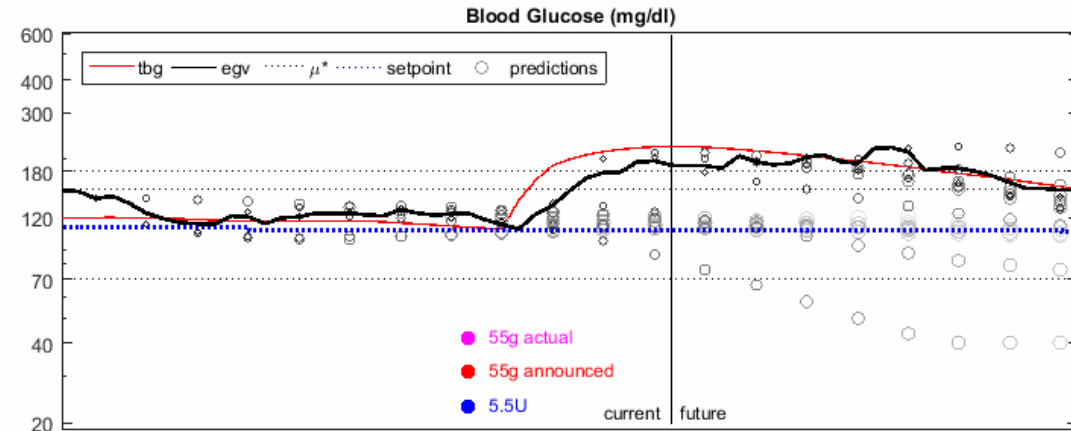
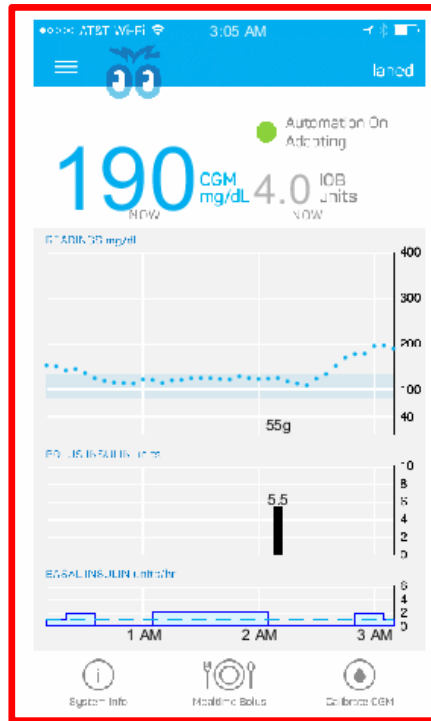
Autonomous Glucose Level Management

Bigfoot Biomedical



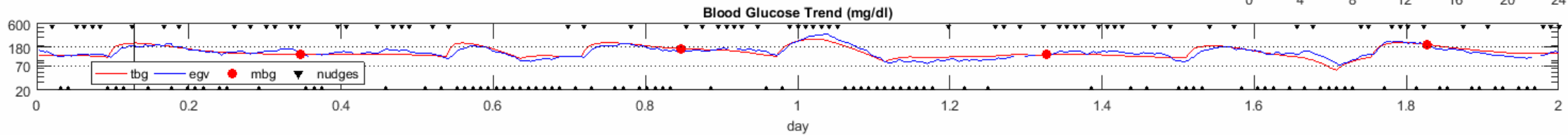
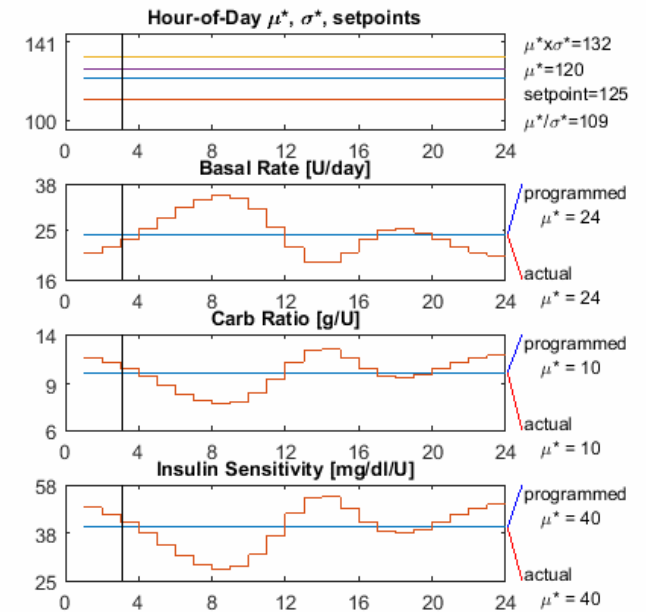
Virtual Clinic

Generating data through simulation



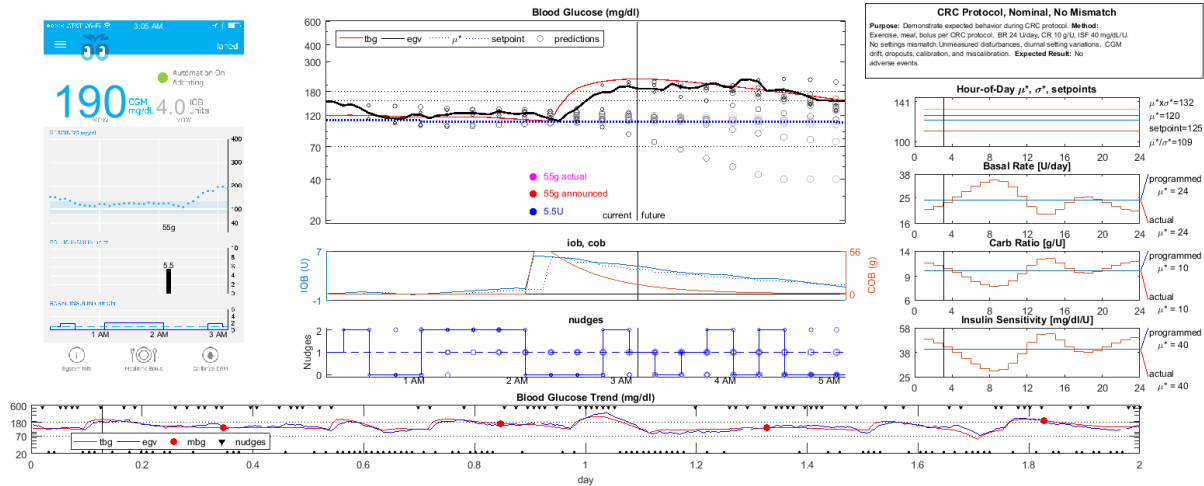
CRC Protocol, Nominal, No Mismatch

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.



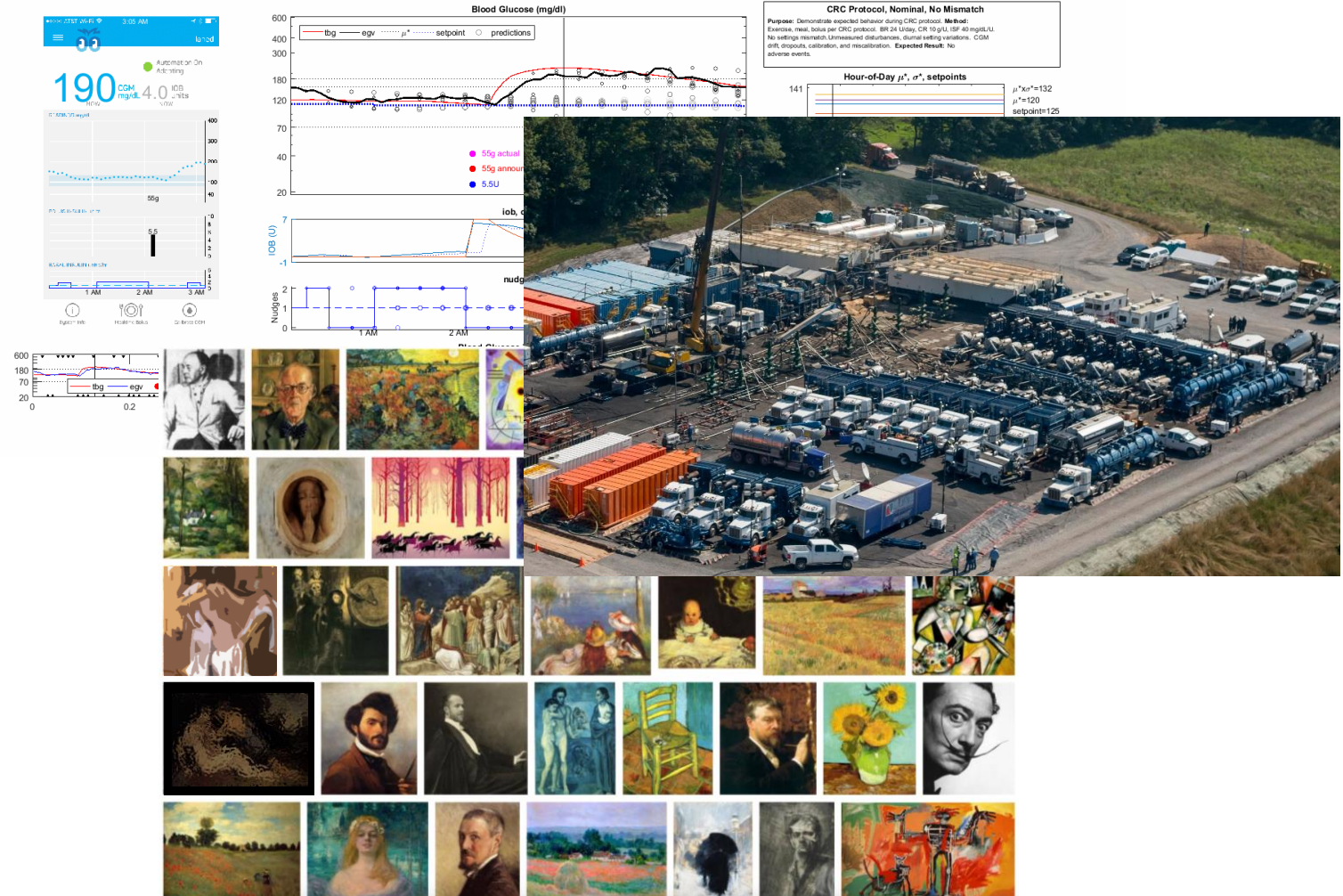
Virtual Clinic

Scaling computations to simulate 50 million patients a day



Where will you get your data?

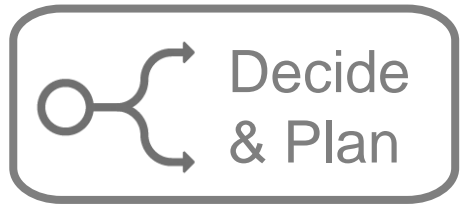
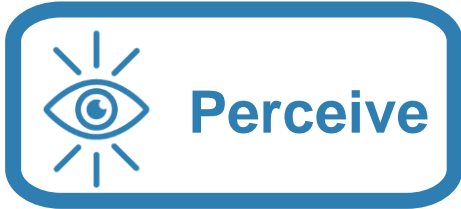
- Simulation
- Public repositories
- In the lab
- In the field
- Internet of Things (IoT)



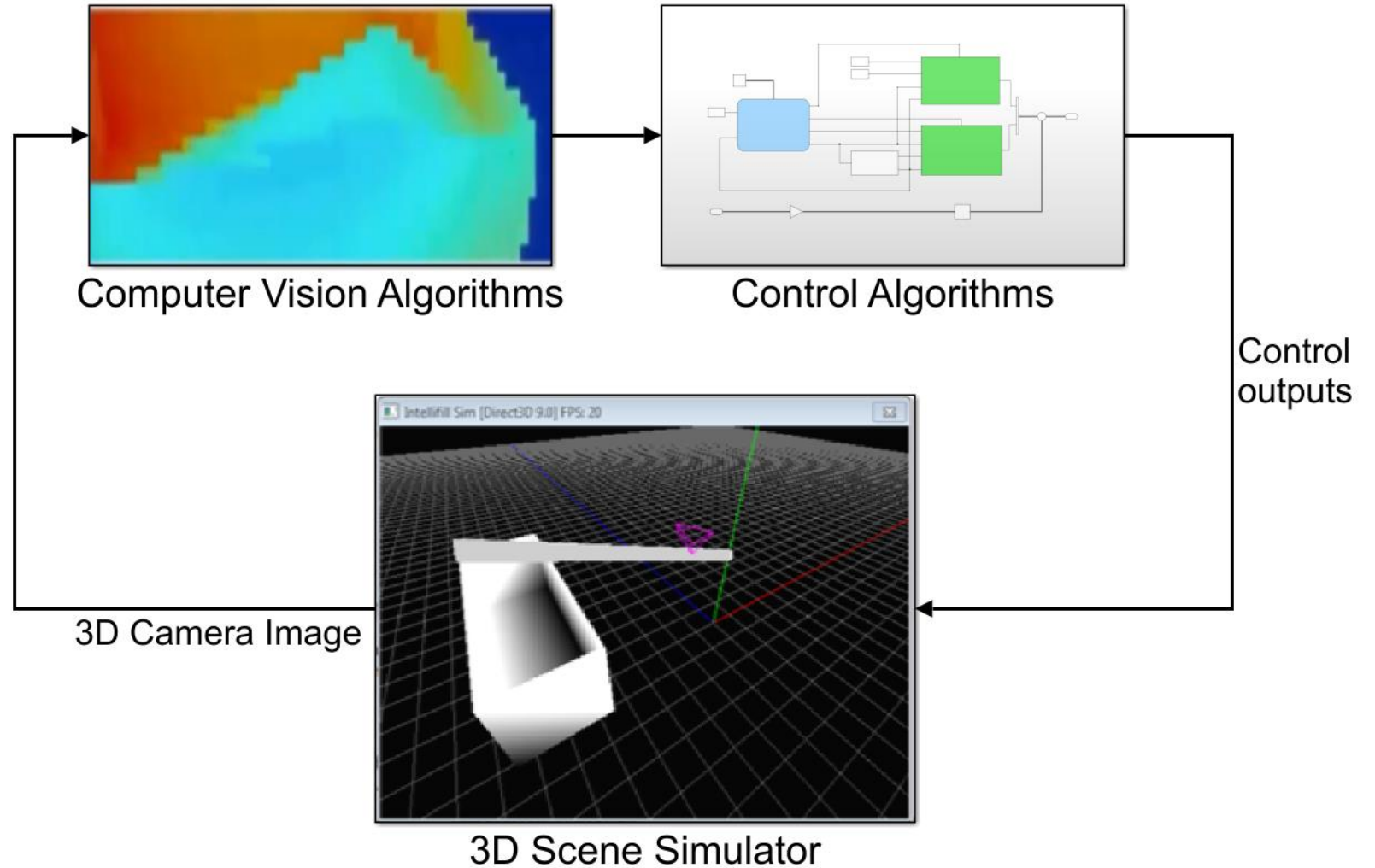


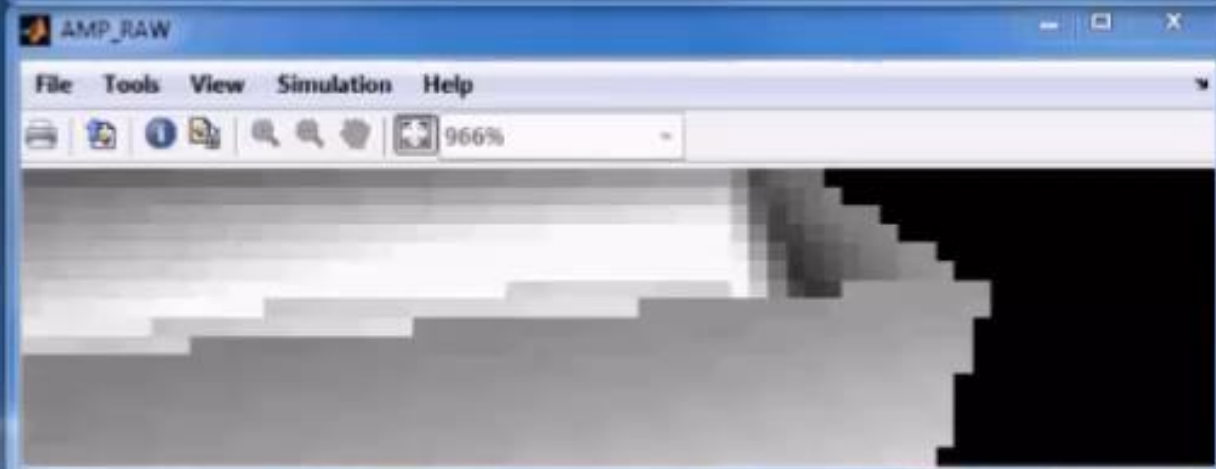
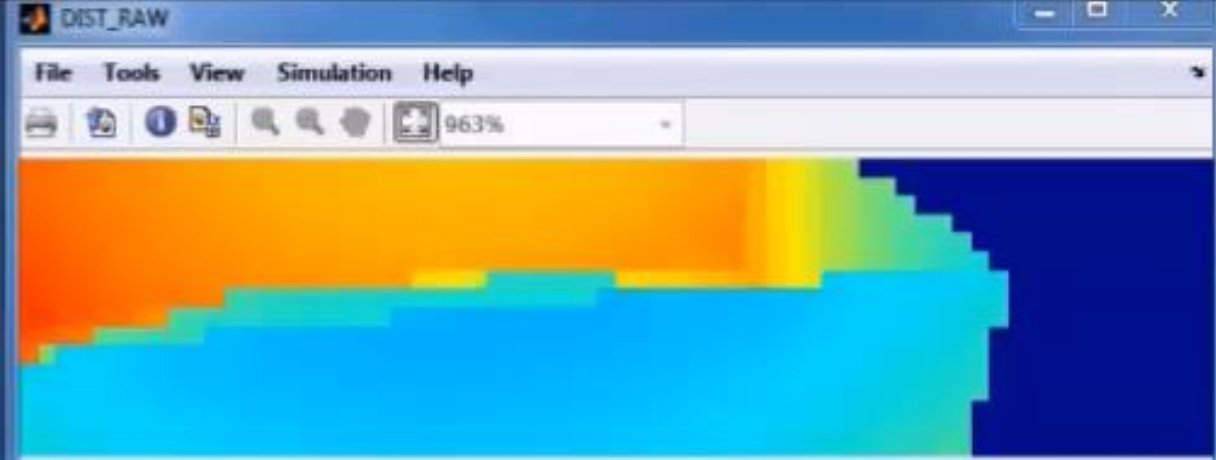
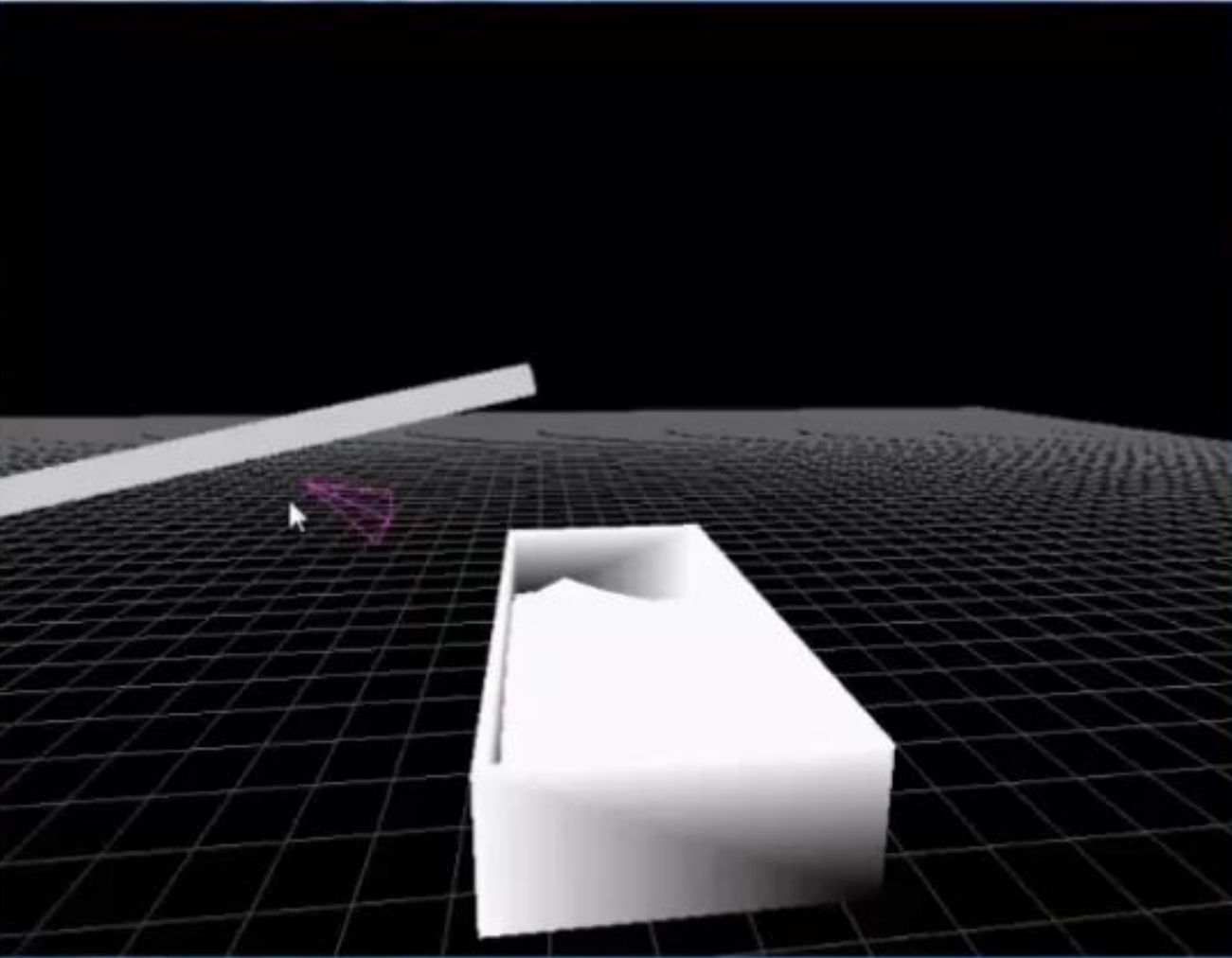


Autonomous Trailer Filling

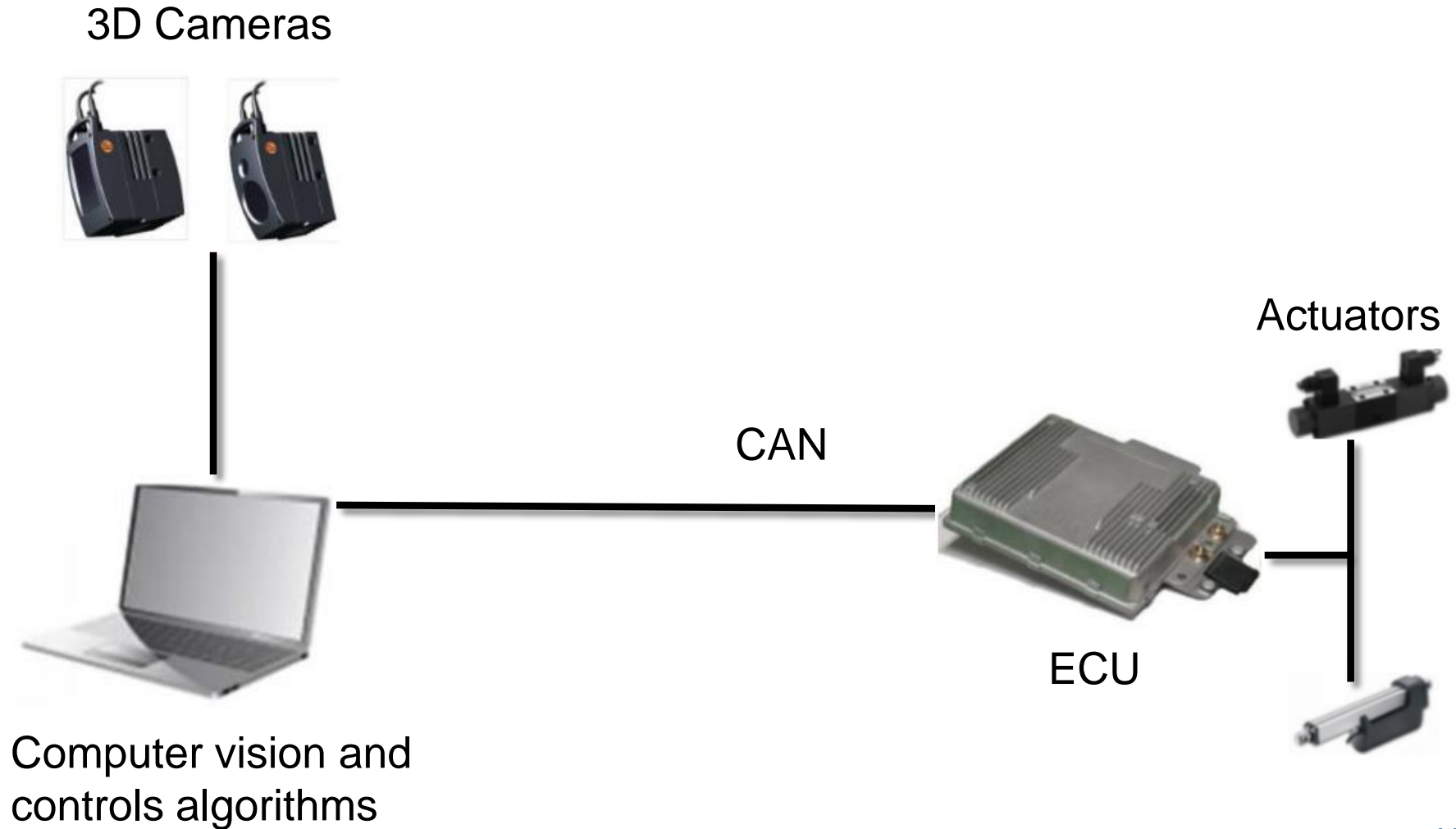
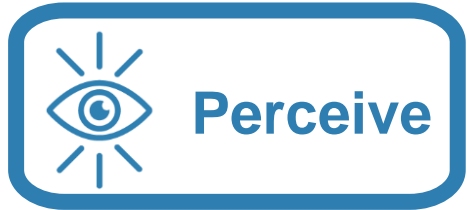


Autonomous Trailer Filling

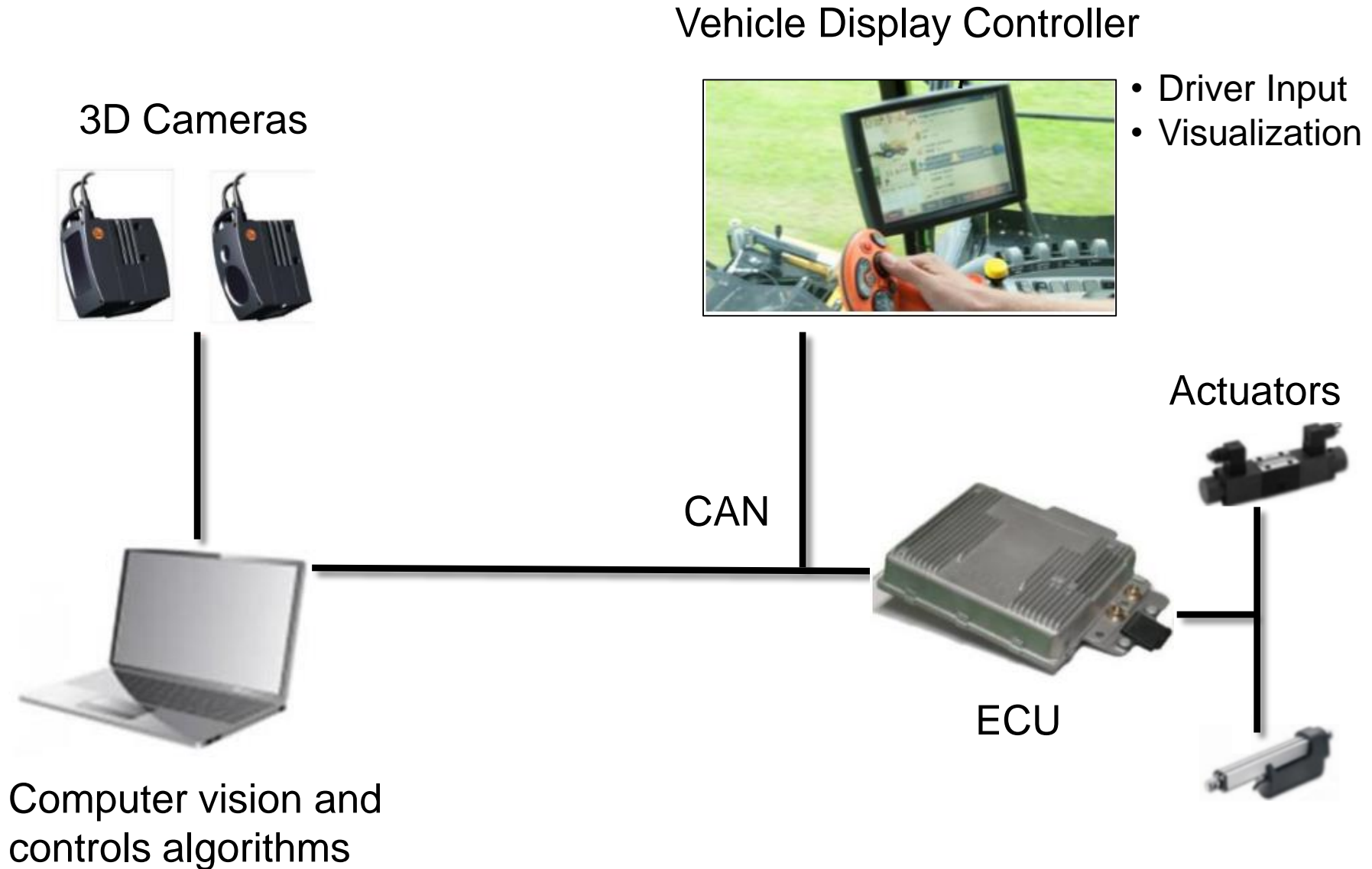
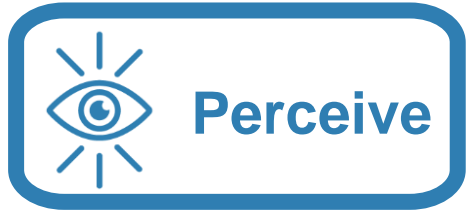




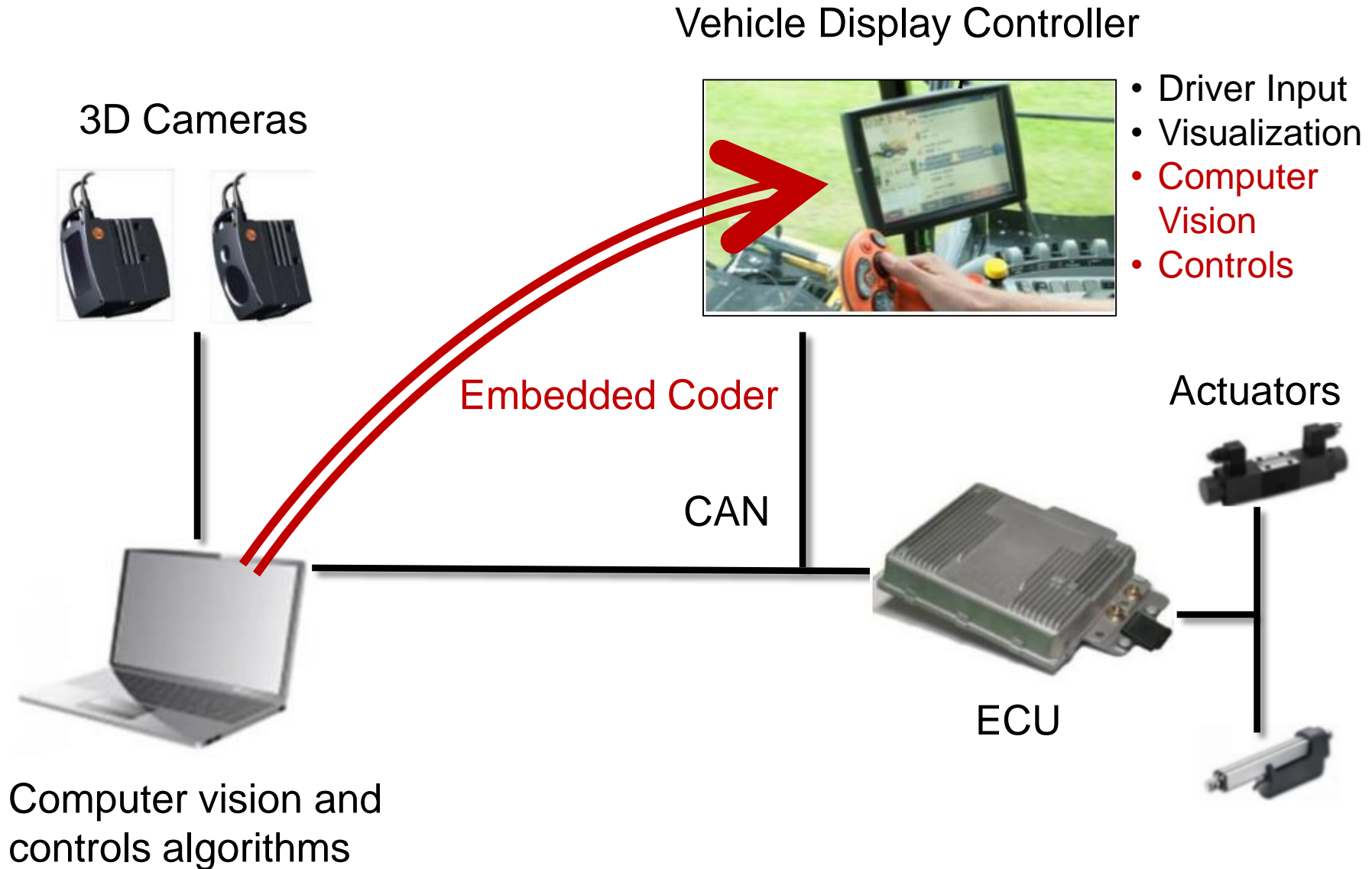
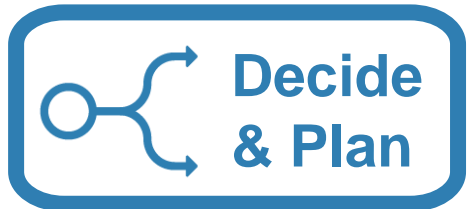
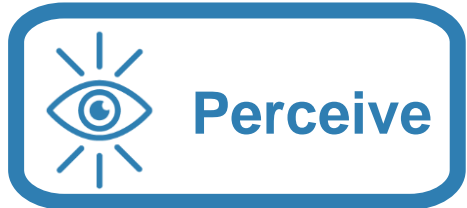
Autonomous Trailer Filling



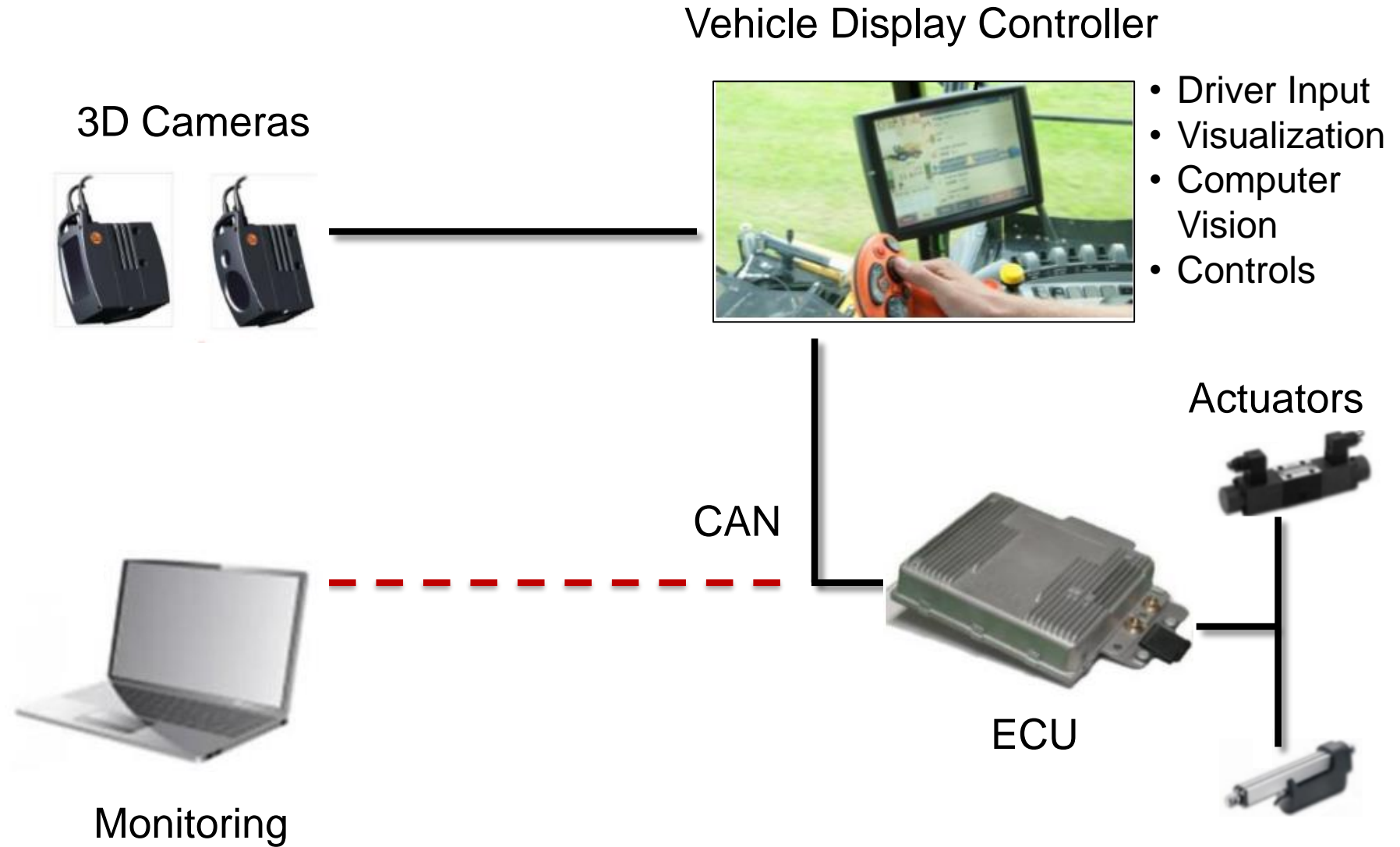
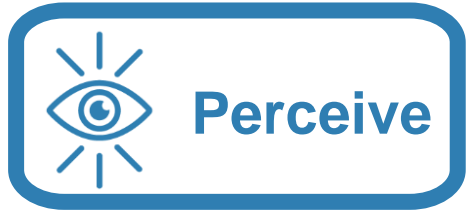
Autonomous Trailer Filling



Autonomous Trailer Filling



Autonomous Trailer Filling



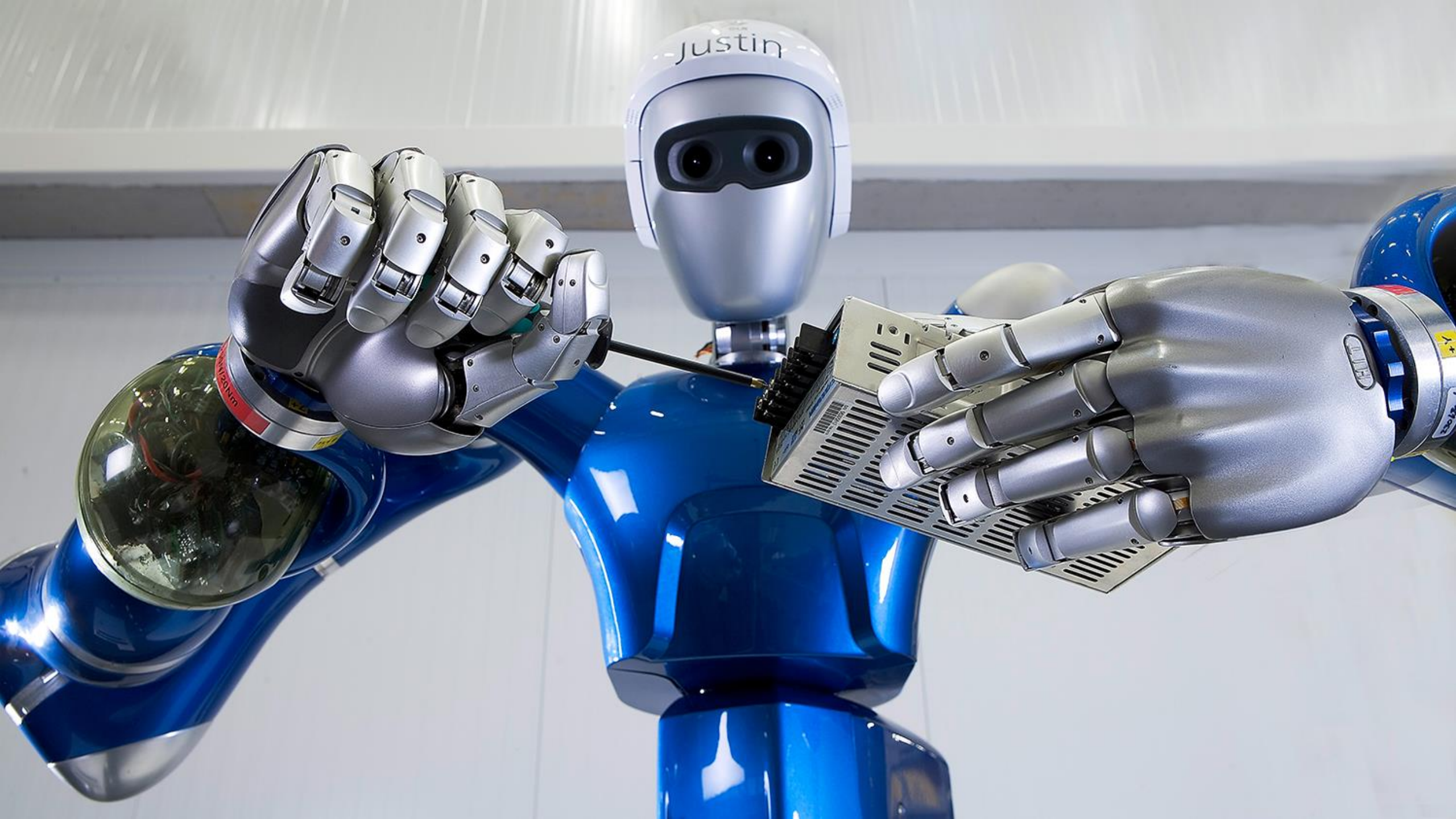
How will you put it into production?

- System Architecture
- Embedded systems
- Enterprise systems
- HMIs

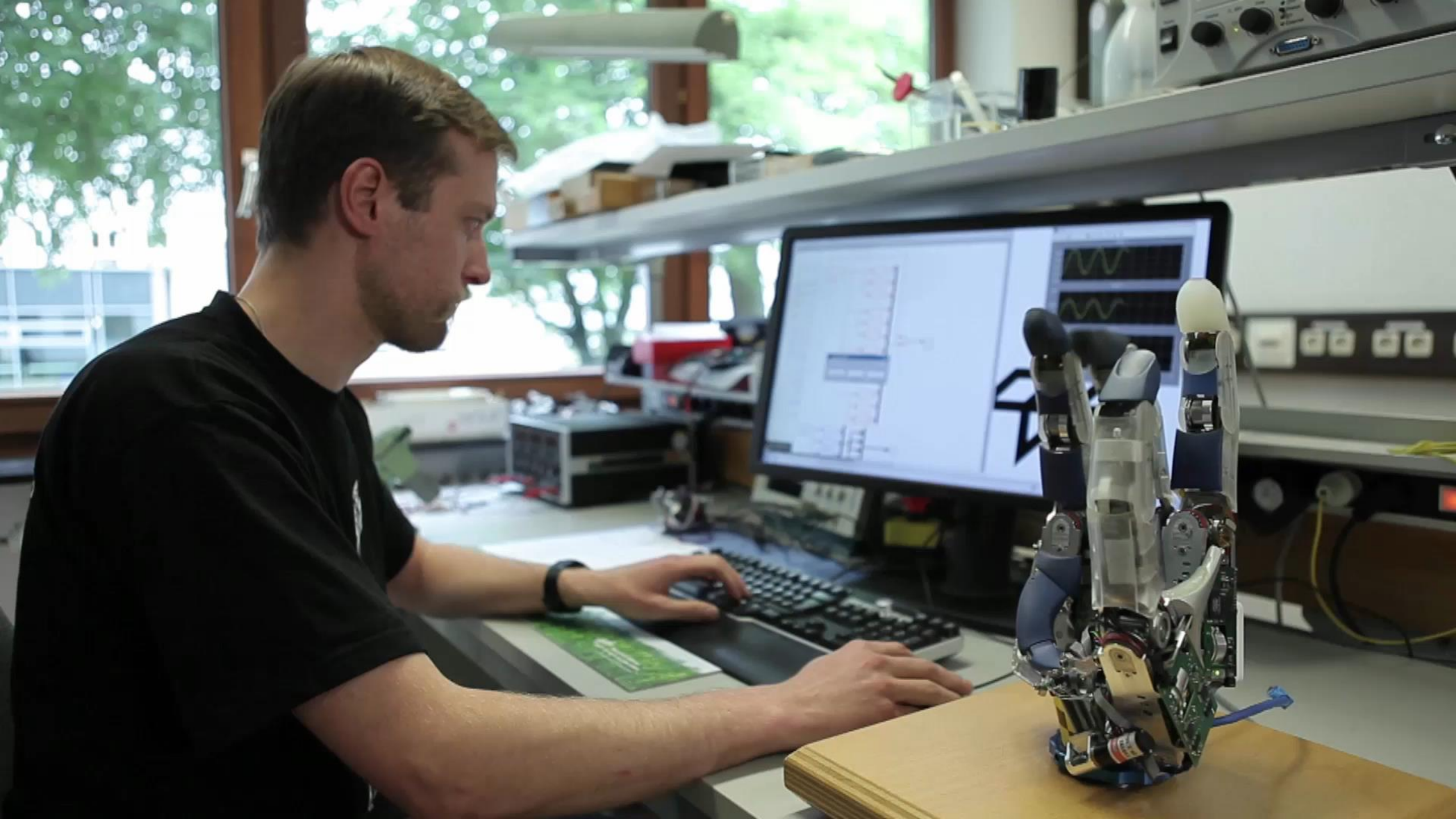


The screenshot displays a complex software interface for process control. On the left, a sidebar lists various process units (M151 to M275). The main area contains several time-series plots for different parameters over a 24-hour period. A red banner at the bottom of the plots reads "Abstellen nach Vielfachen von 3200m!". To the right, a status panel shows "Status ONLINE" and a table of accuracy metrics. Below that, a parameter table lists values for various process points. At the bottom right, there are two small maps showing spatial data distributions.

Parameter	Label	Value
10001	Betriebspunkt	
10004	Stippe mit Loch	
	Fertigungsauftrag	
	Rollen Nr.	
	Massedruck A:	239
	Massedruck A: Steigung	5
	Massedruck A: Schwankung	6
	Massedruck B:	252
	Massedruck B: Steigung	3
	Massedruck B: Schwankung	4
	Massedruck C:	233
	Massedruck C: Steigung	7
	Massedruck C: Schwankung	8







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

Go to Production

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?

