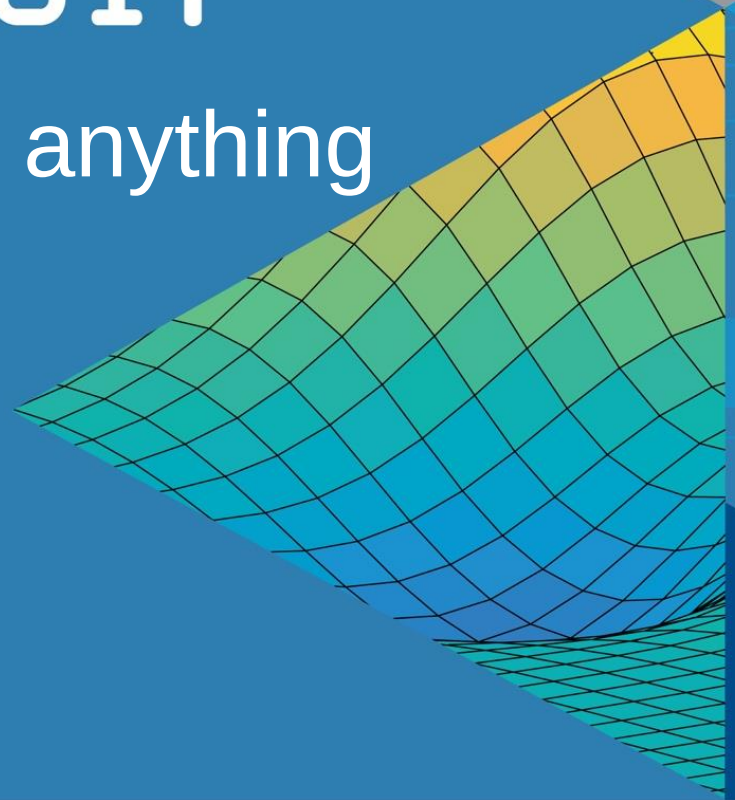
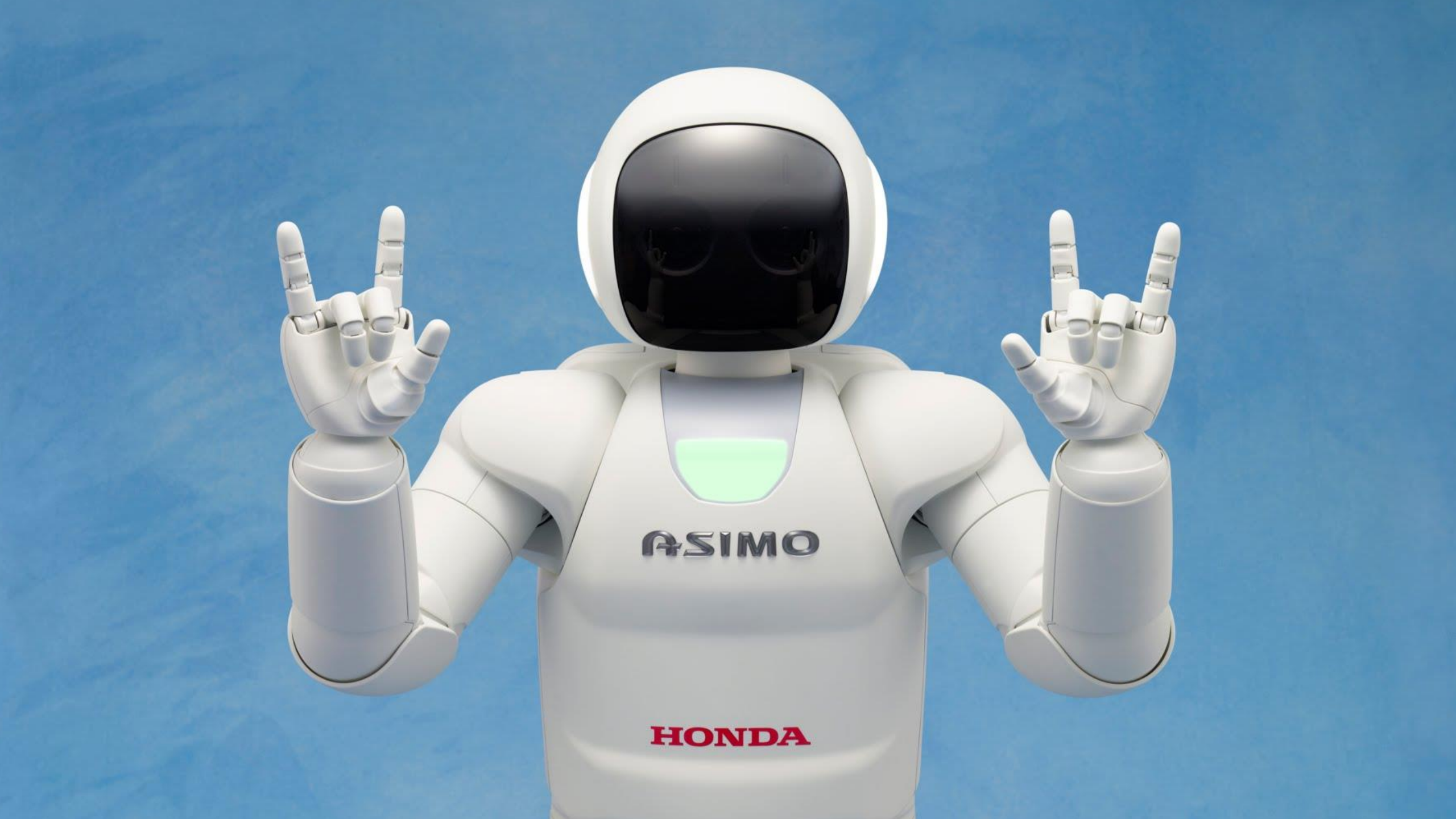
MATLAB EXPO 2017

How to build an **autonomous** anything



Jim Tung
jim@mathworks.com


ASIMO
HONDA

amazon

5" 12,000 PSI
5" 12,000 PSI
BAKER HUGHES

127 mg/dl
189 mg/dl
97 mg/dl
Well, hello Sunshine. What's for breakfast?
CGM

Autonomous Technology

Autonomy

Having the power for self-governance

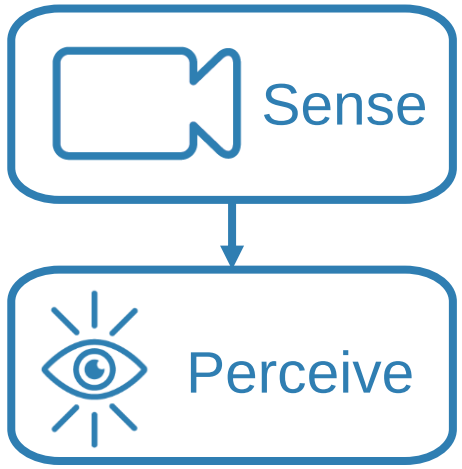
Autonomous Technology

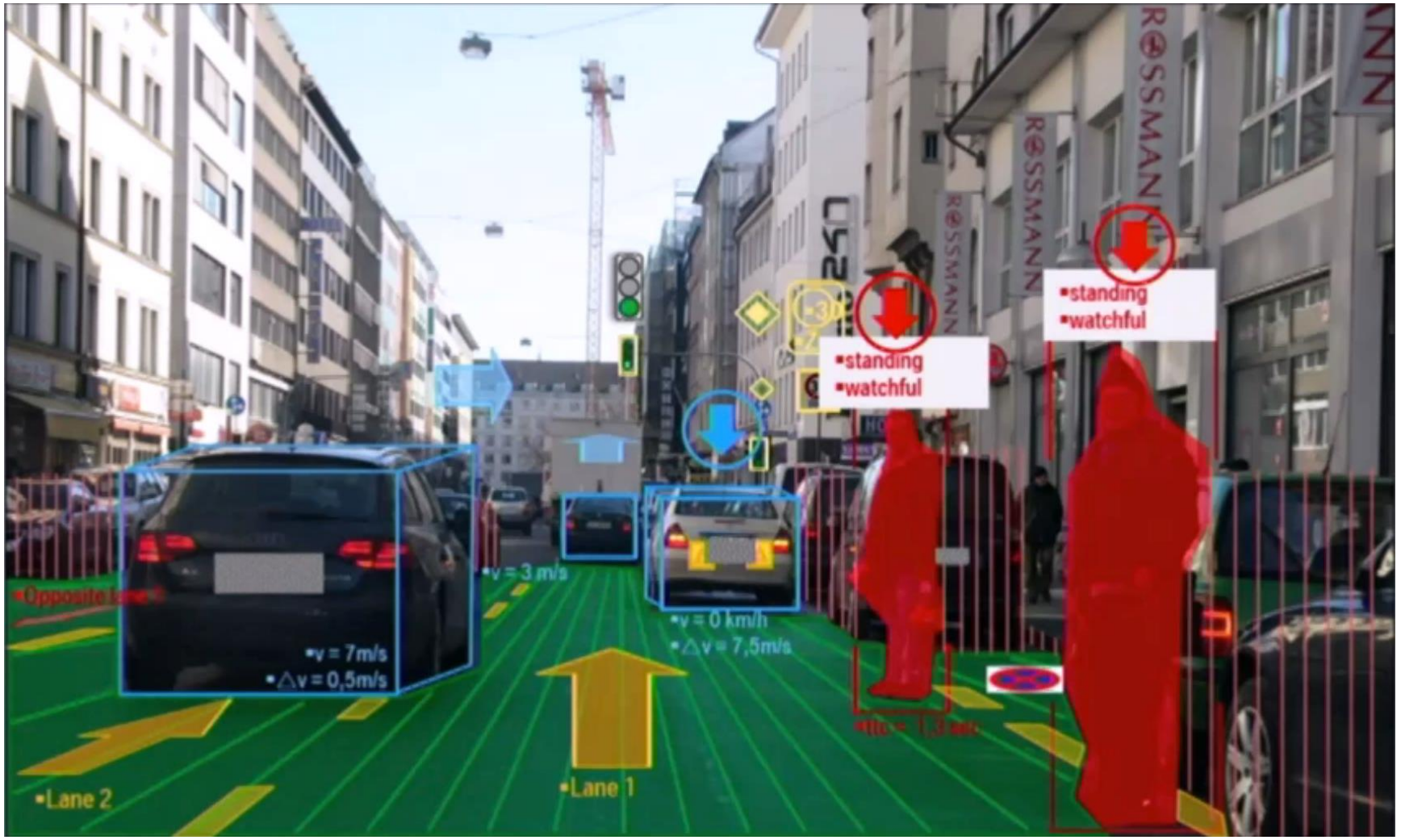
Provides the ability of a system to act independently of direct human control under unrehearsed conditions

Capabilities of an Autonomous System

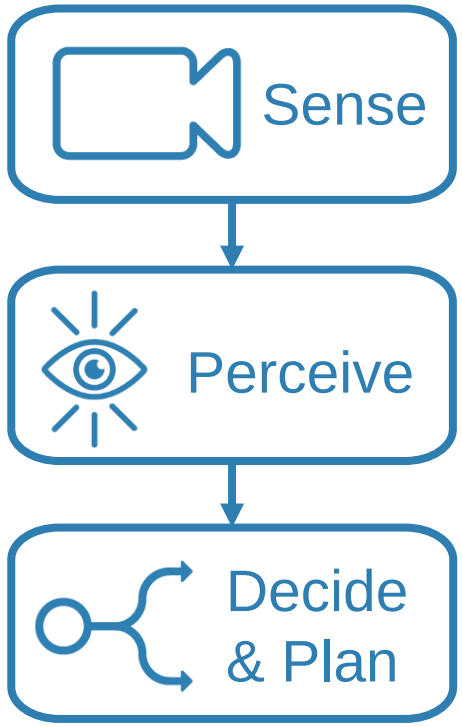
Sense

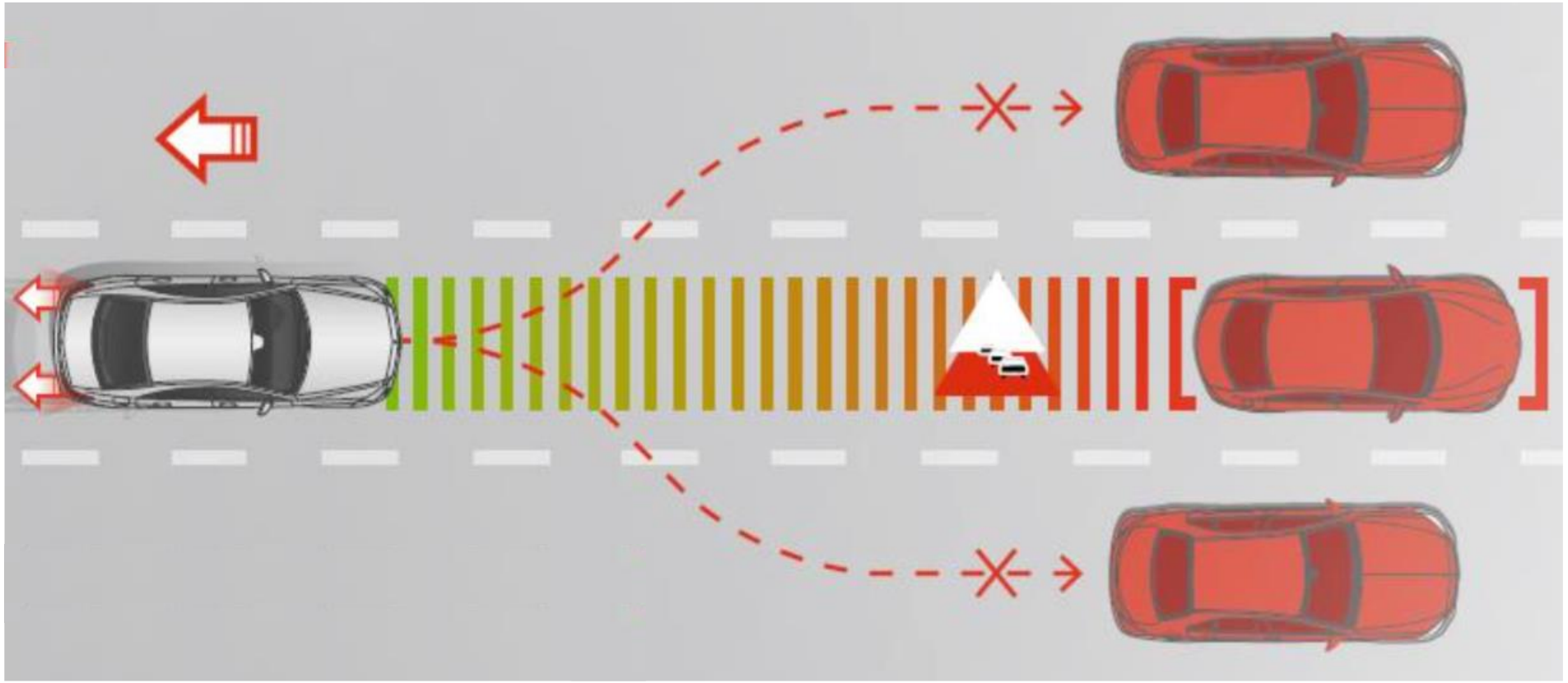
Capabilities of an Autonomous System



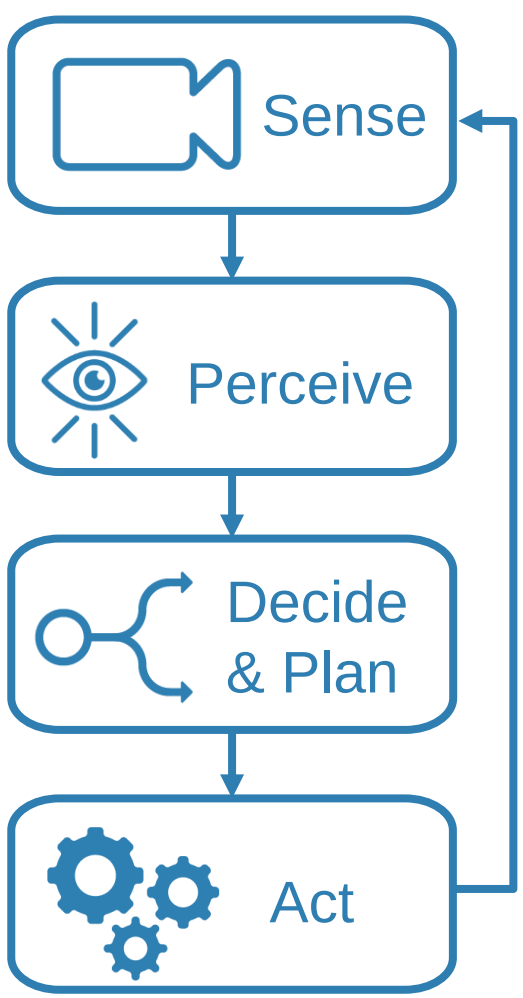


Capabilities of an Autonomous System

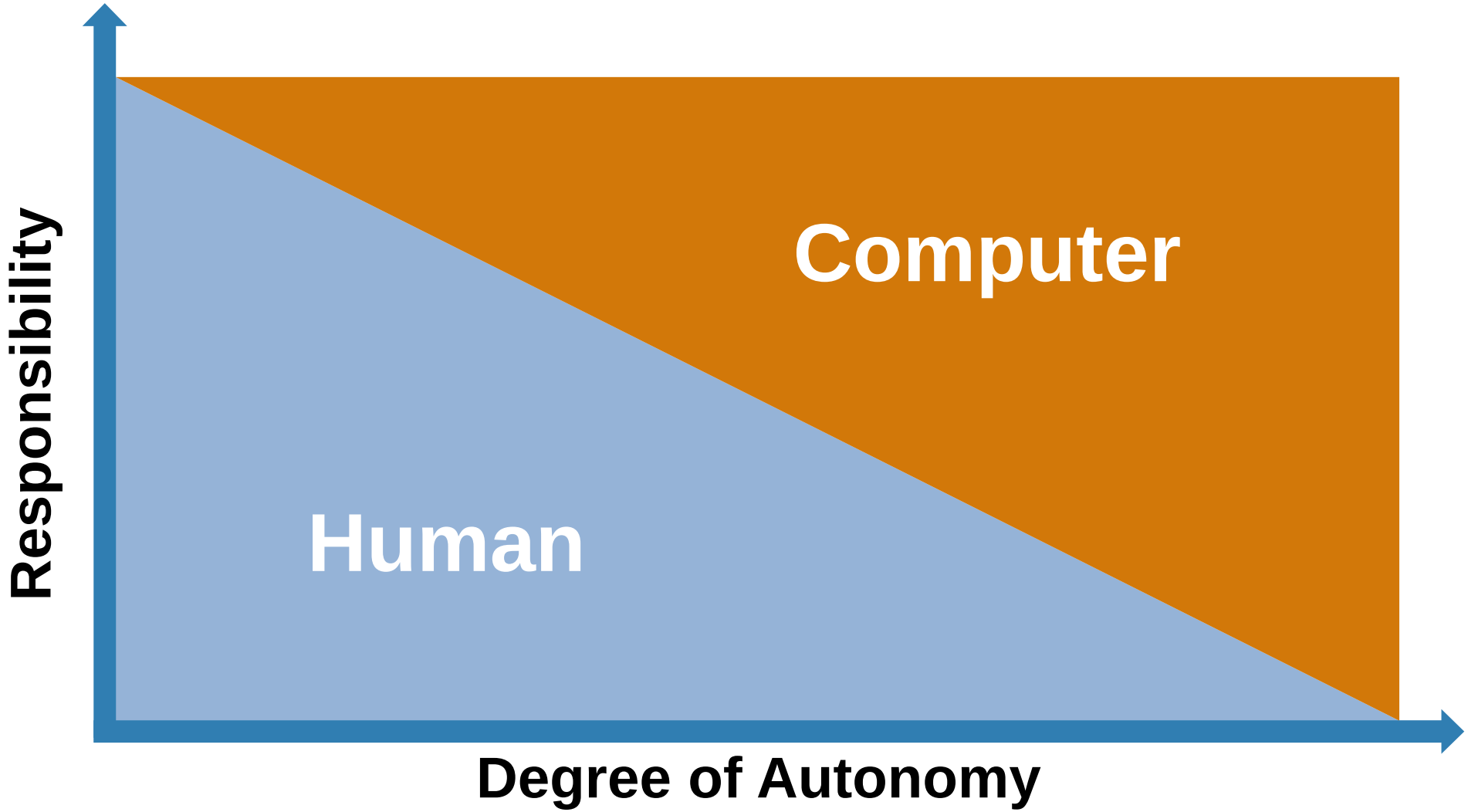


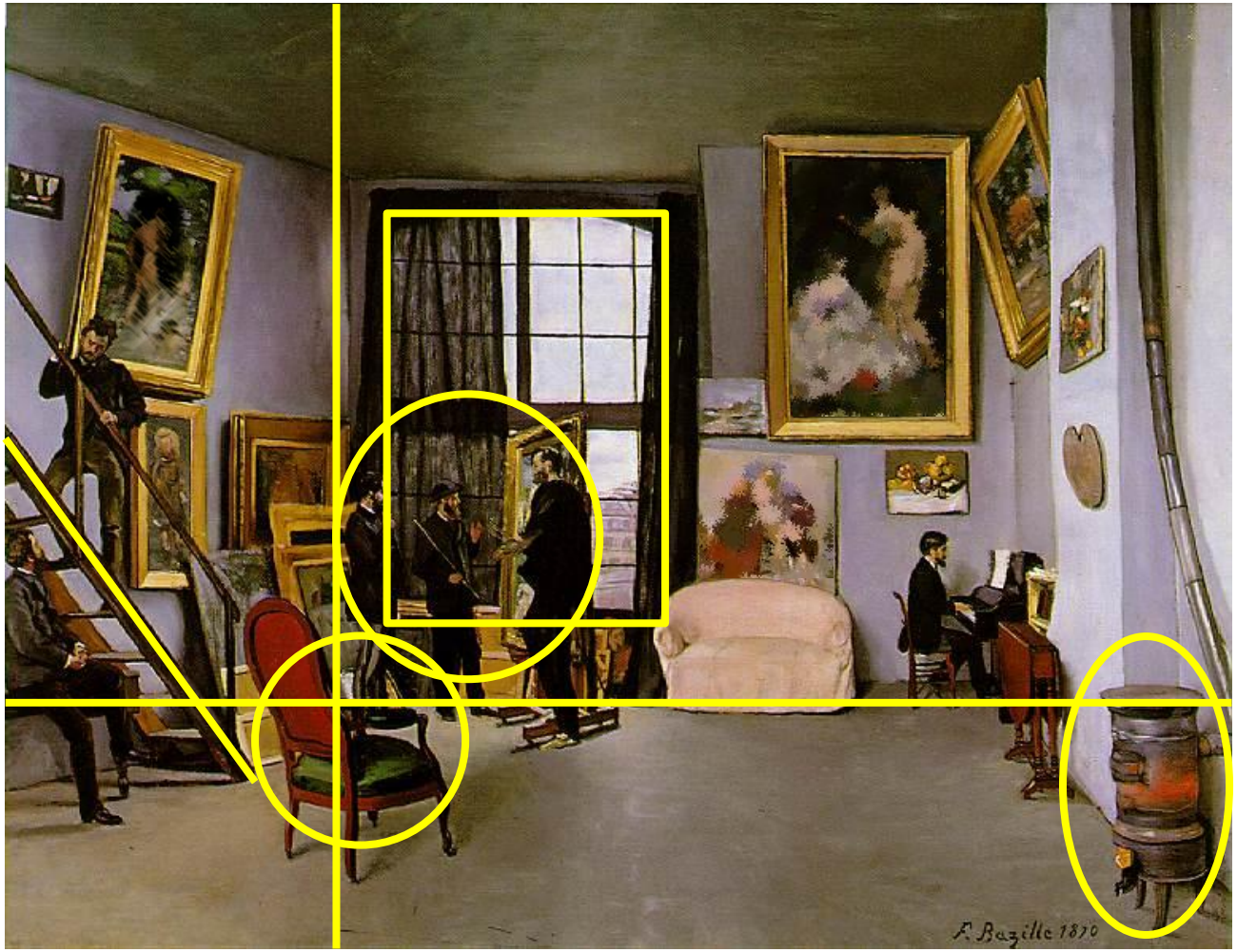


Capabilities of an Autonomous System



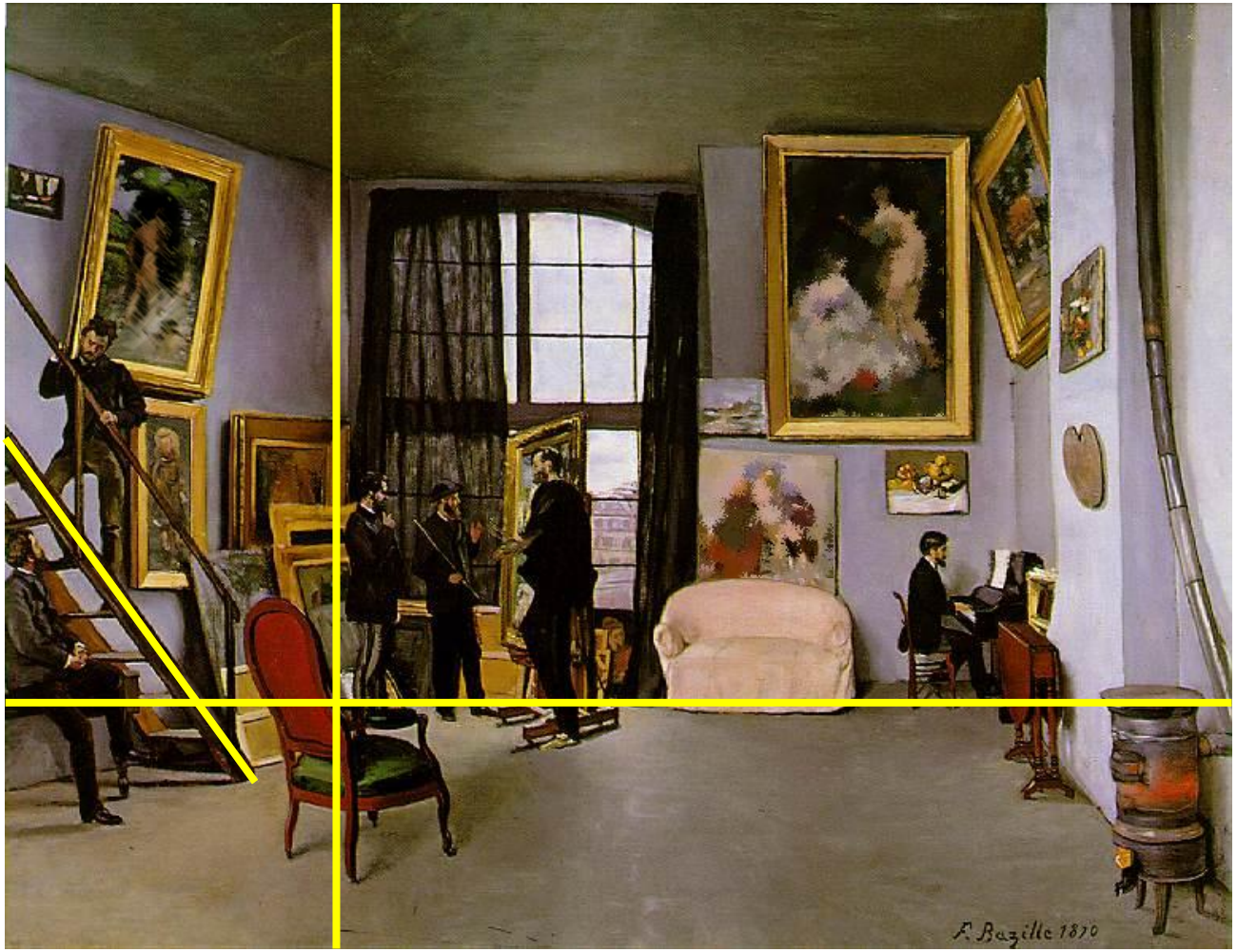
Autonomous Technology Transfers Responsibility to Computers



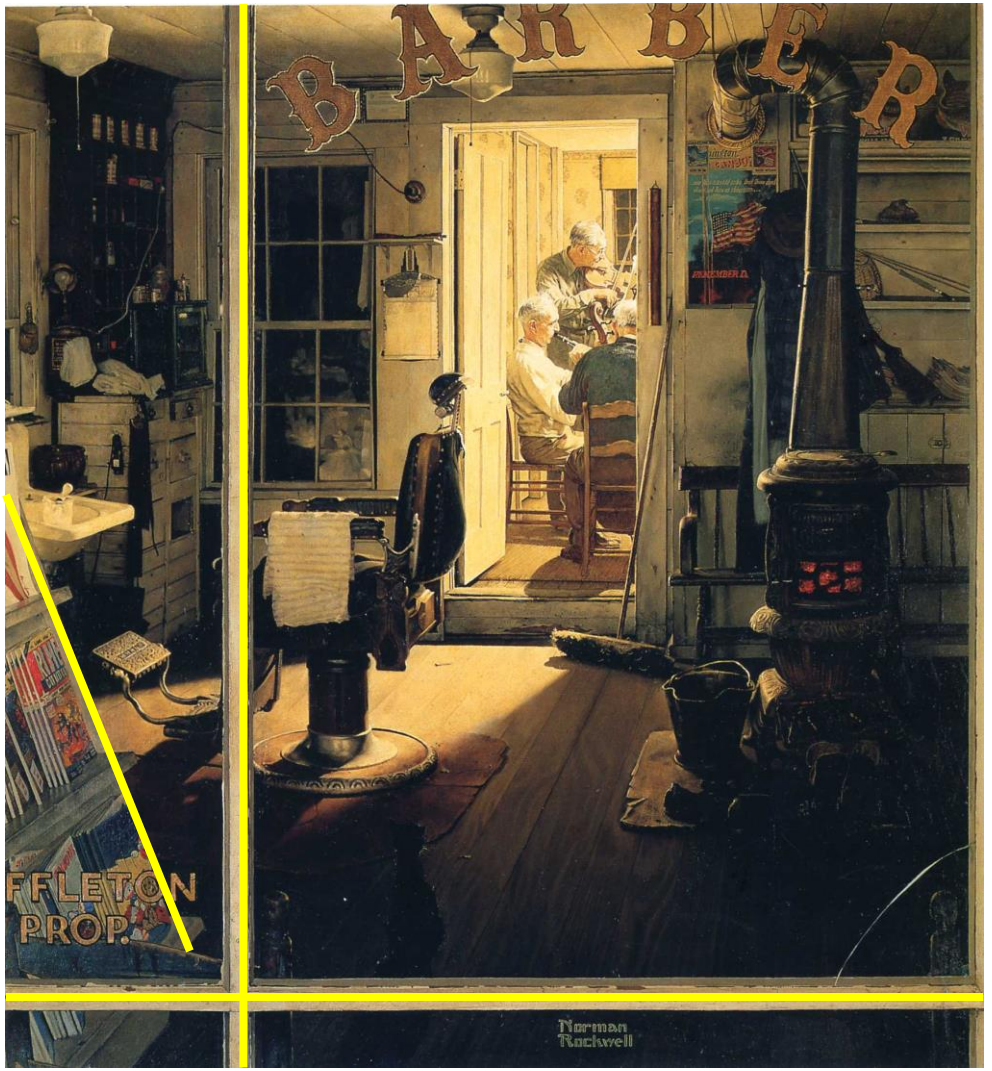


Bazille's Studio
Frederic Bazille (Paris, 1870)

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

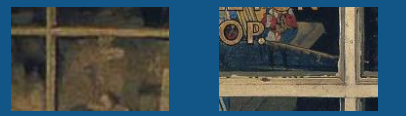
Sense

Perceive

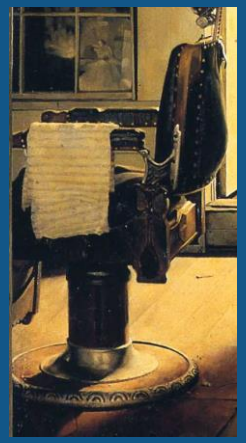
Decide & Plan

Act

Image Feature Extraction



Visual Features



Machine Learning Classification

Style Classifier (SVM)

Style: Regionalism

Genre Classifier (SVM)

Genre: Interior

Artist Classifier (SVM)

Artist: Rockwell

Where to add autonomy with perception?

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

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
5" 12,000 PSI
5" 12,000 PSI
BAKER HUGHES

Autonomous Service for Predictive Maintenance

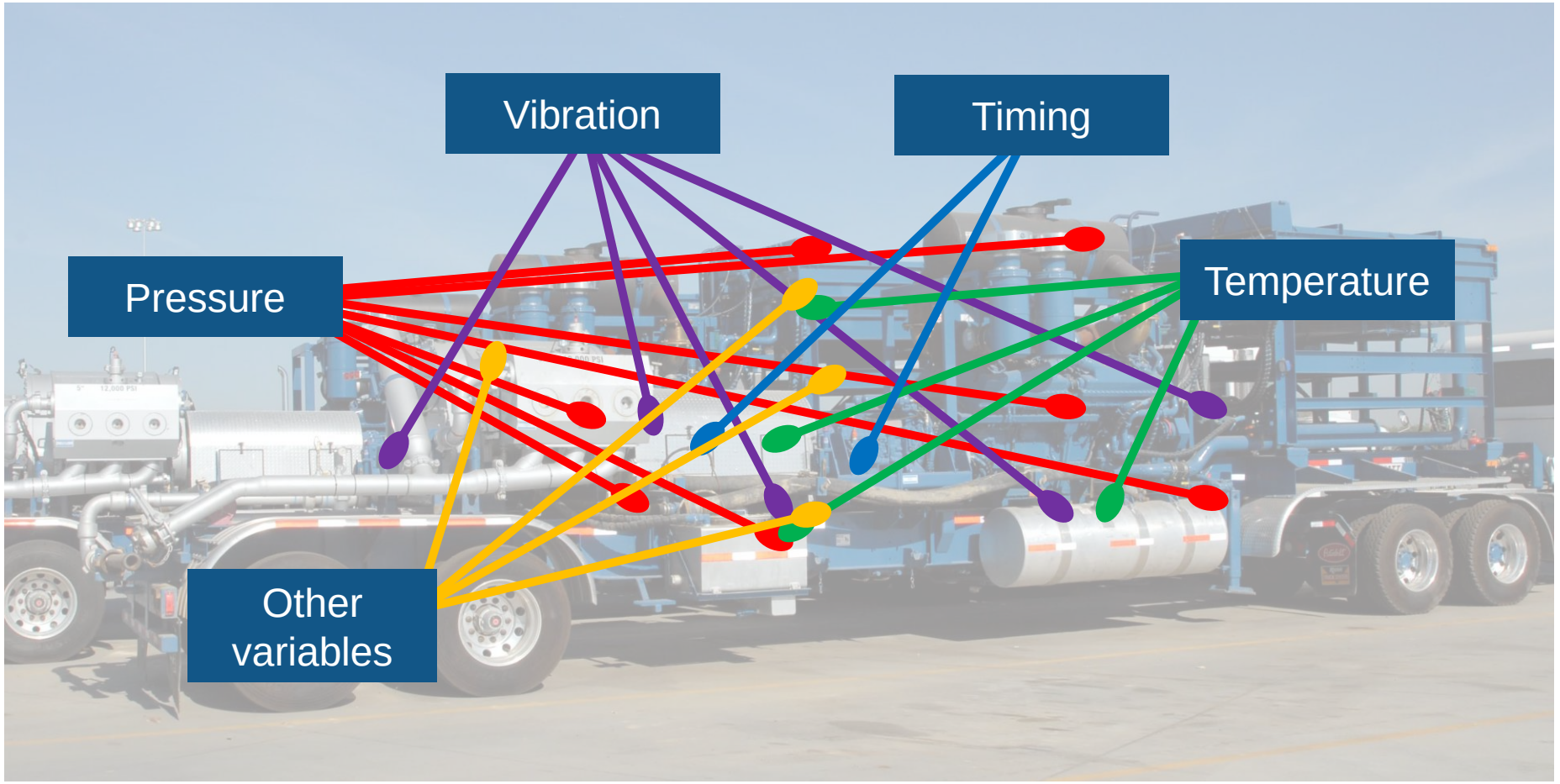
Sense

Perceive

Decide & Plan

Act

Which sensor values should they use?



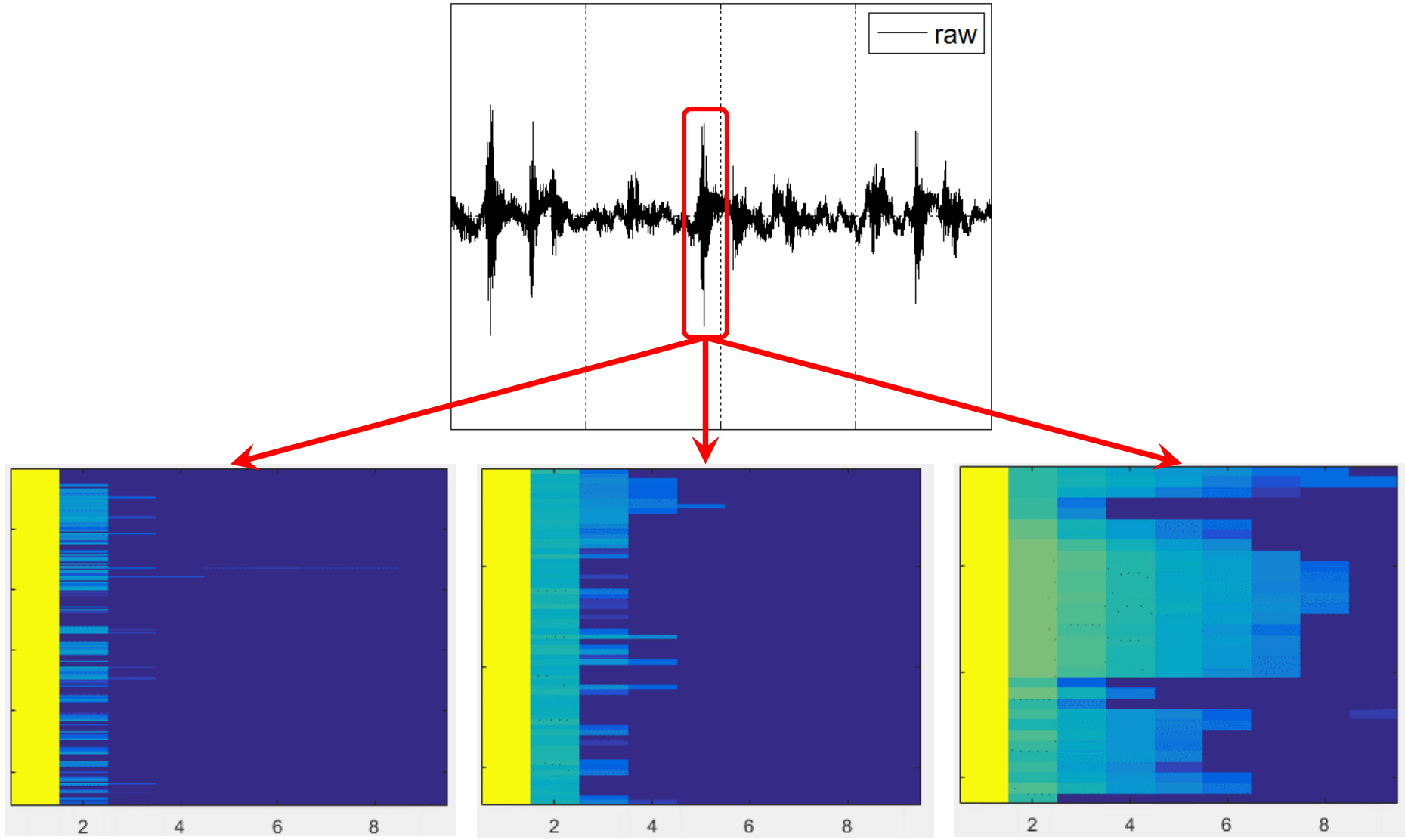
Autonomous Service for Predictive Maintenance

Sense

Perceive

Decide & Plan

Act



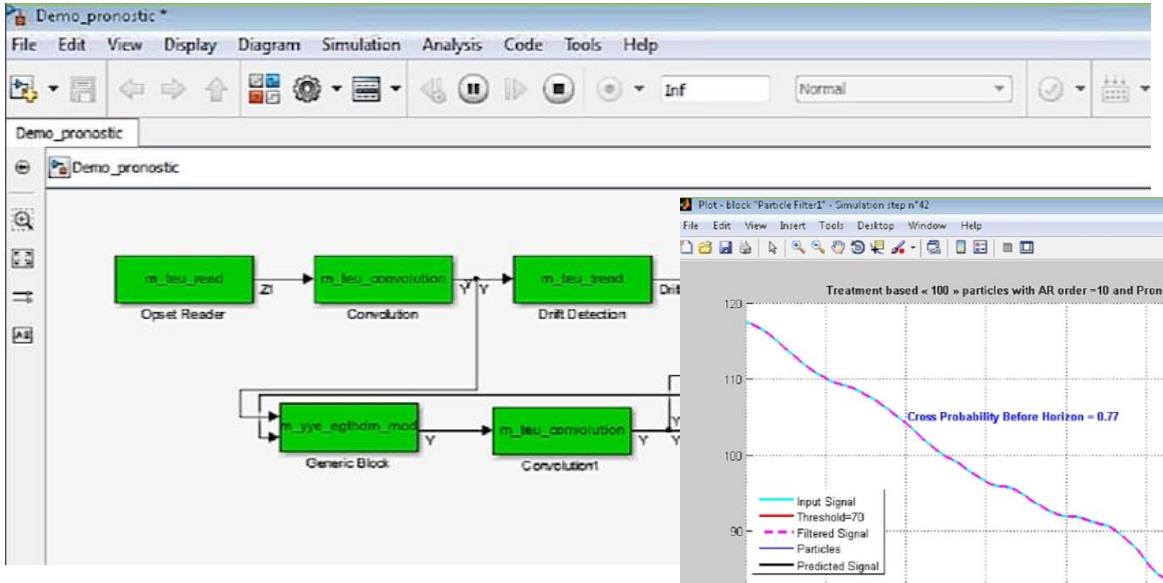
Normal Operation | Monitor Closely | Maintenance Needed

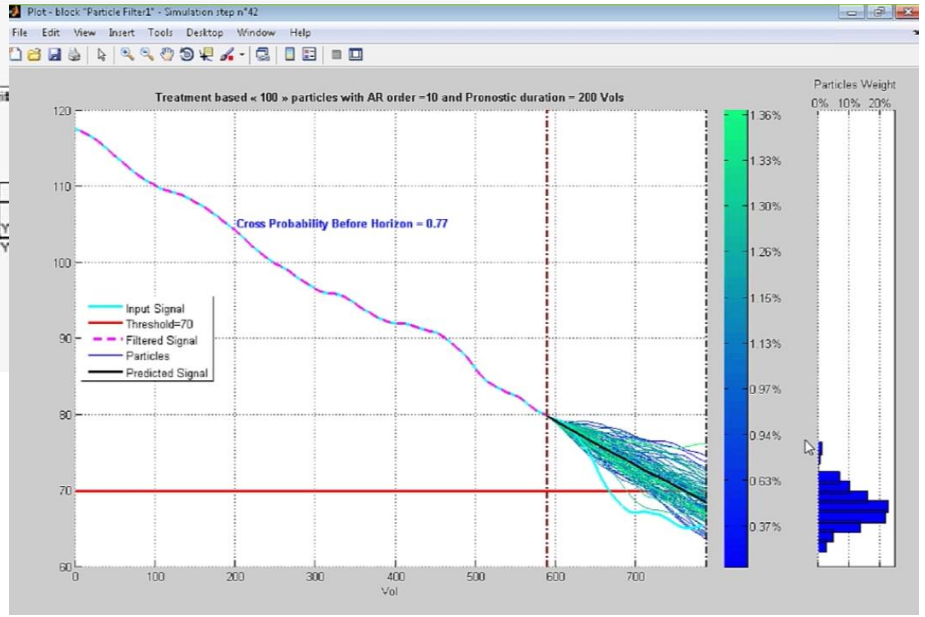
What are the best predictors?

- Data-driven
- Model-driven

Jet Engine Monitoring

SAFRAN
Snecma





Autonomous Glucose Level Management

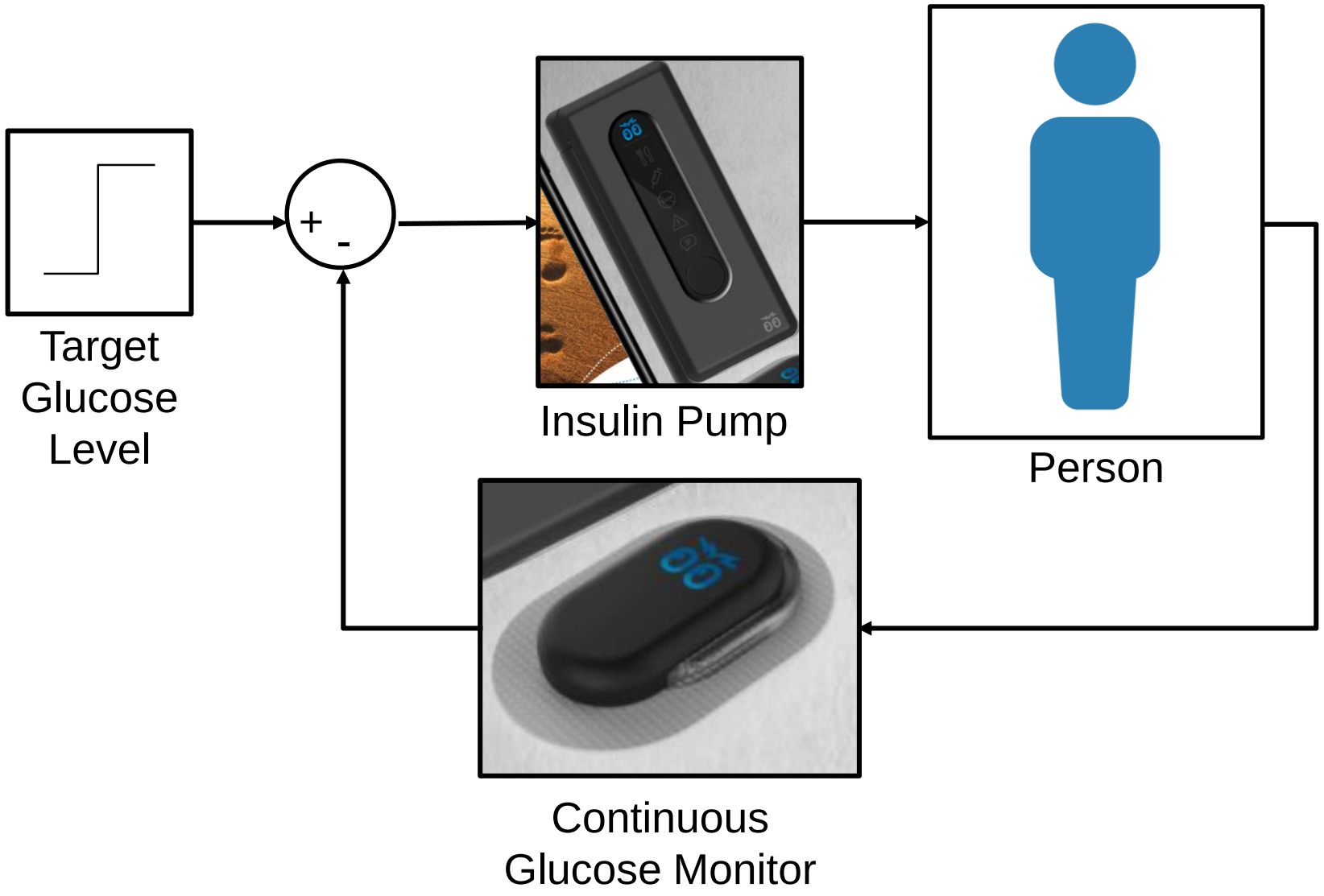
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Perceive

Decide & Plan

Act



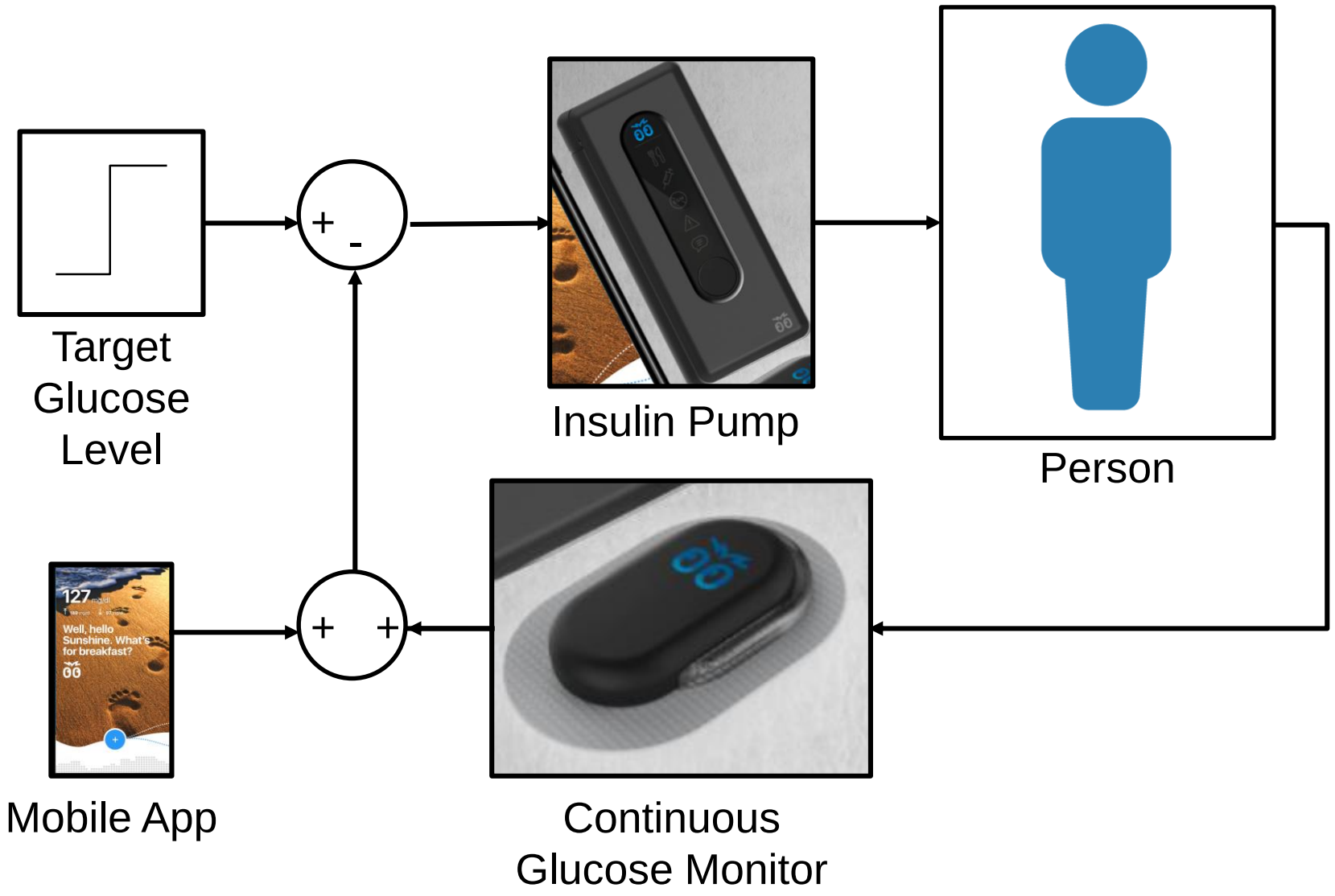
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Perceive

Decide & Plan

Act



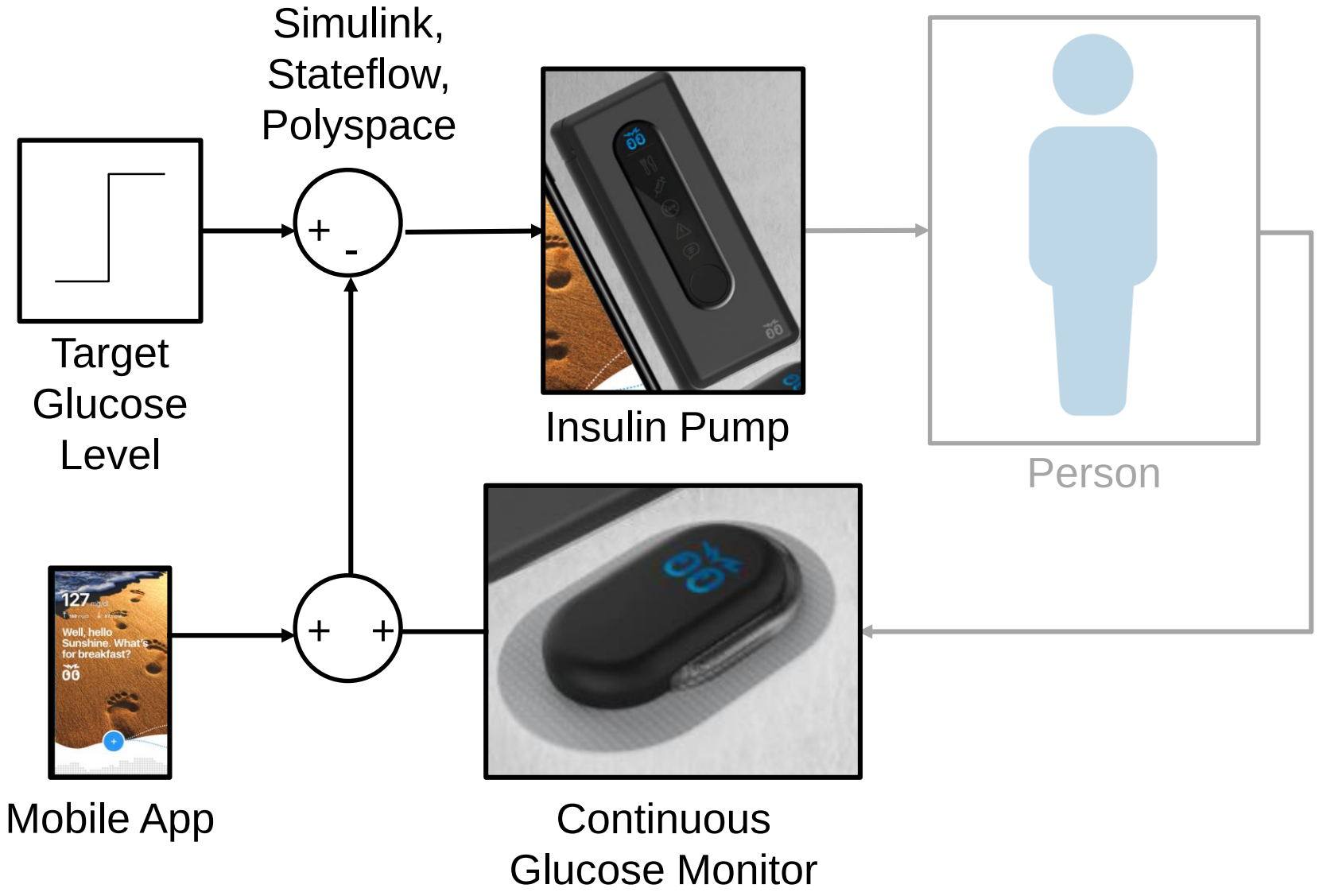
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Perceive

Decide & Plan

Act



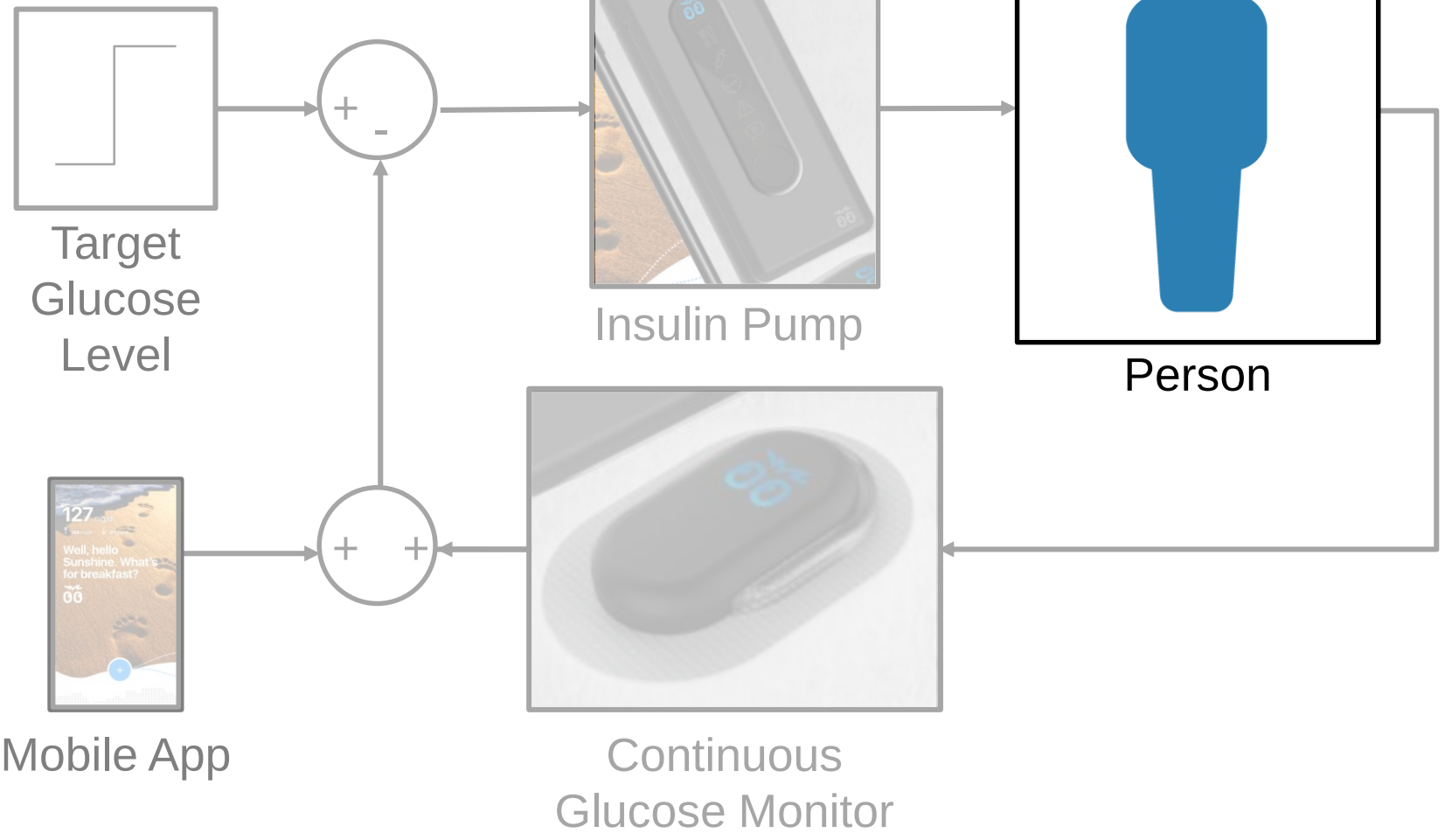
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Perceive

Decide & Plan

Act



Autonomous Glucose Level Management
Bigfoot Biomedical

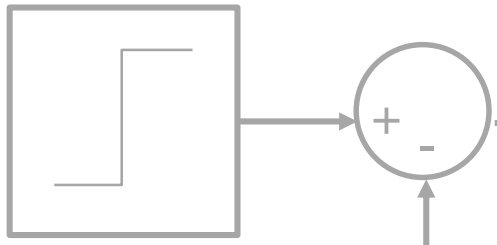
Sense

Perceive

Decide & Plan

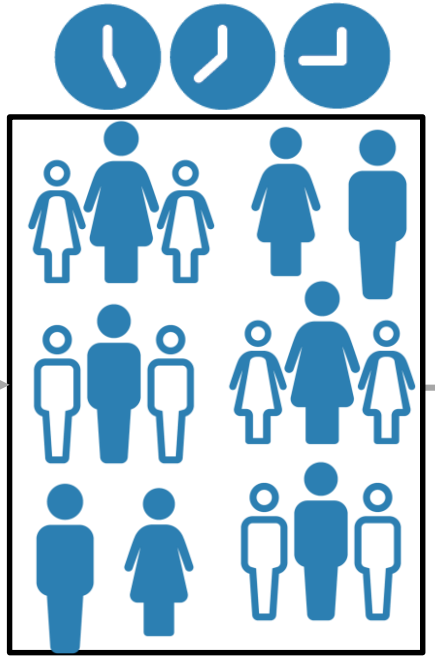
Act

Virtual Clinic
MATLAB, Toolboxes

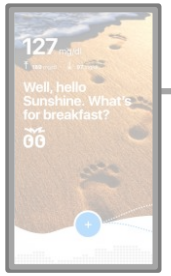


Target Glucose Level

Insulin Pump



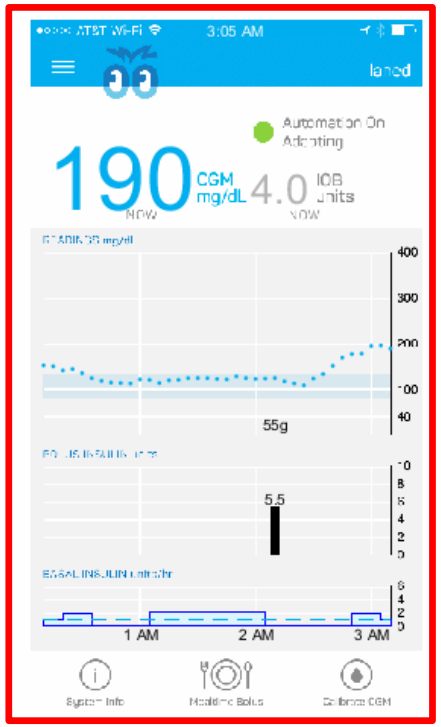
Person

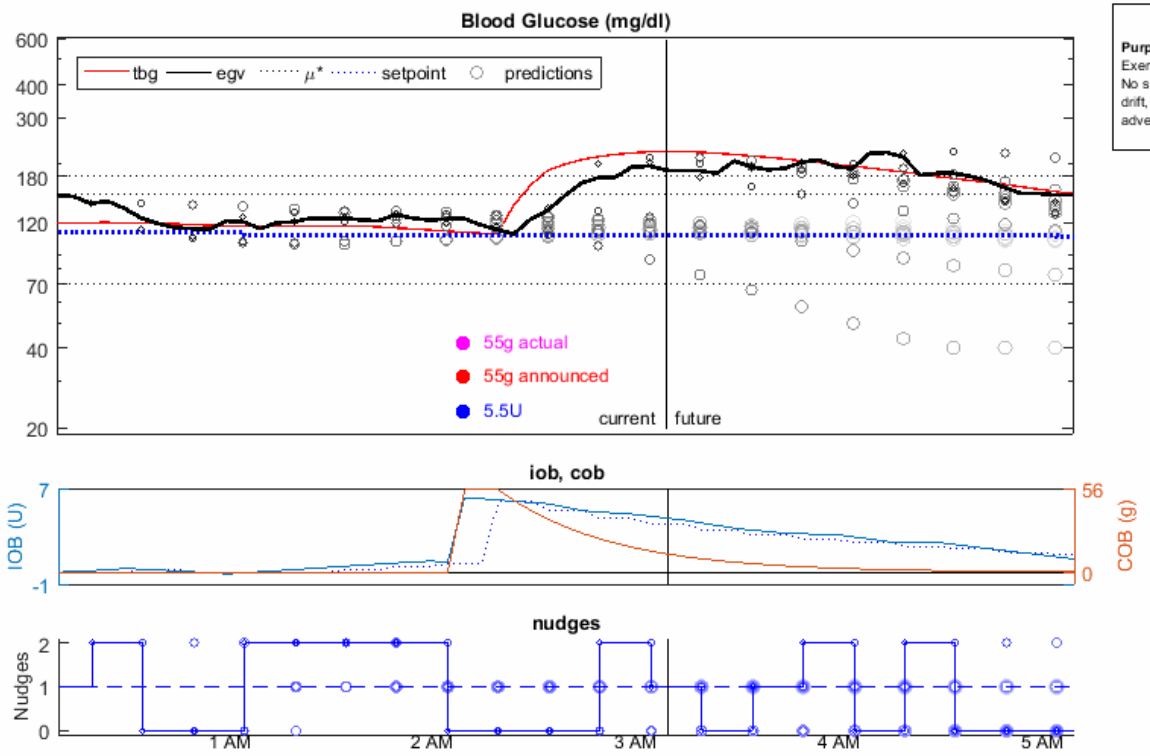


Mobile App

Continuous Glucose Monitor

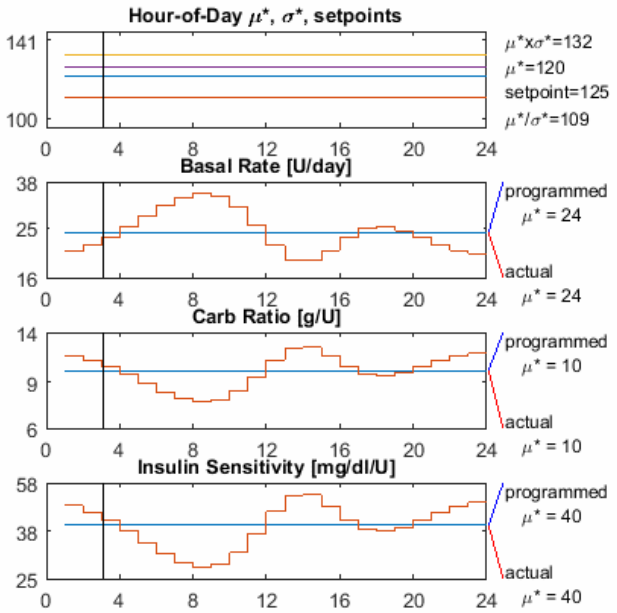
Virtual Clinic
Generating data through simulation

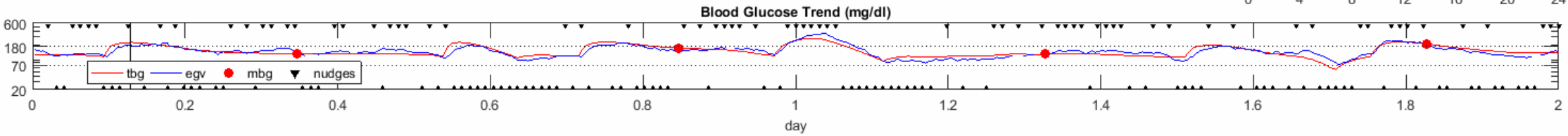




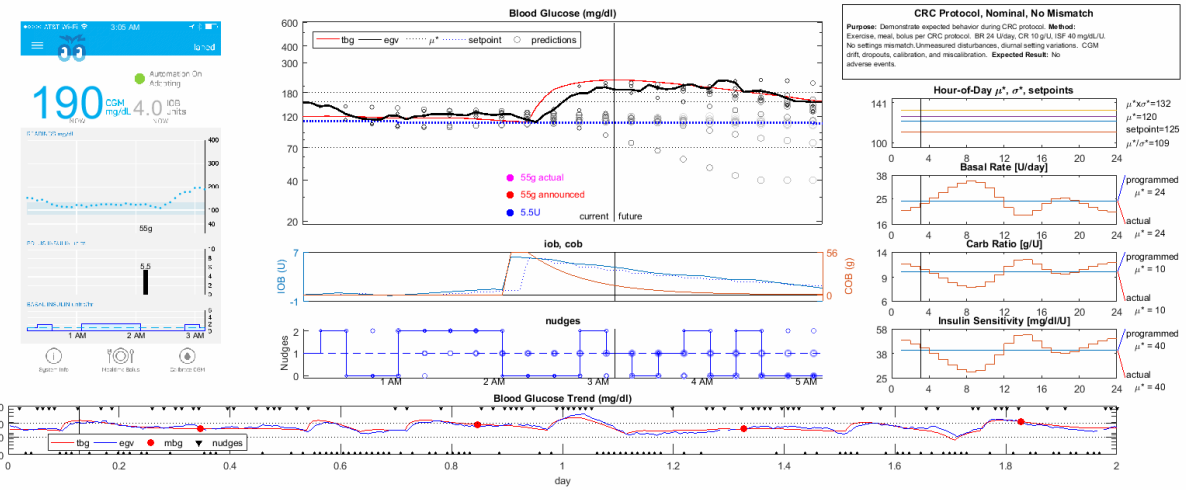
CRC Protocol, Nominal, No Mismatch

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



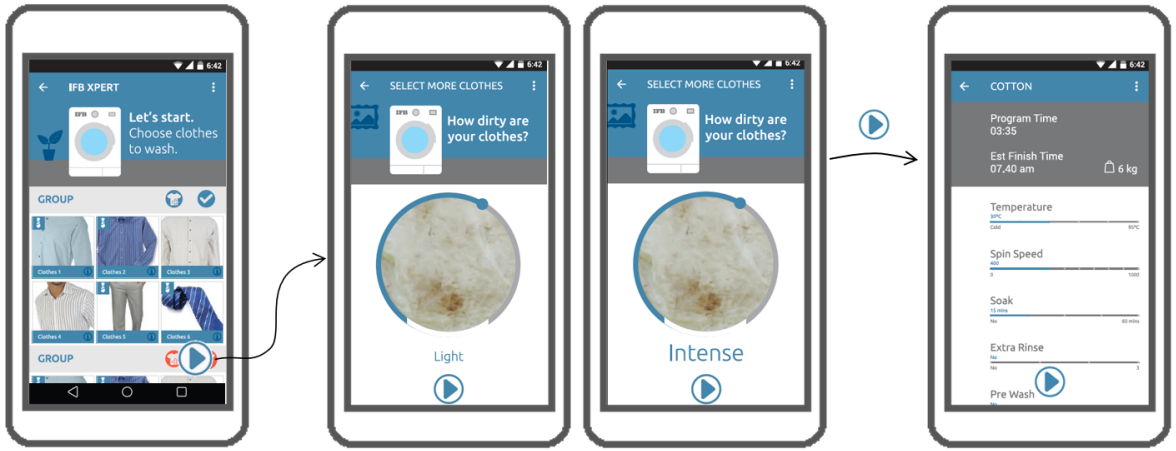
IFB Industries Limited, Goa

Development of decision support system for connected washing machine

Results Achieved

IFB
www.ifbappliances.com

- 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."

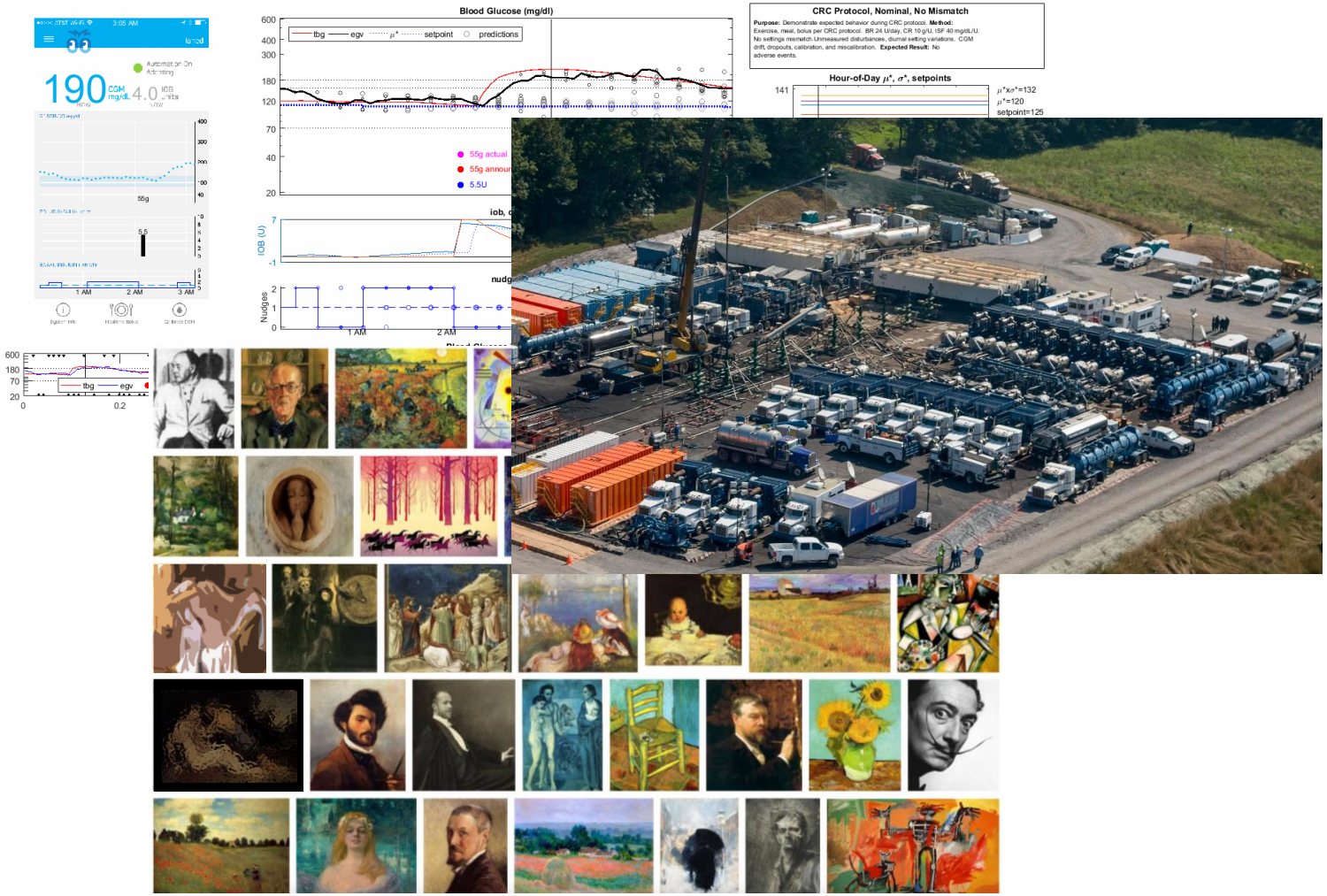
"the app feels like it is designed for me."

"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."

© 2017 IFB Industries Ltd. - Confidential

Where will you get your data?

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



Autonomous Trailer Filling

Sense

Perceive

Decide & Plan

Act

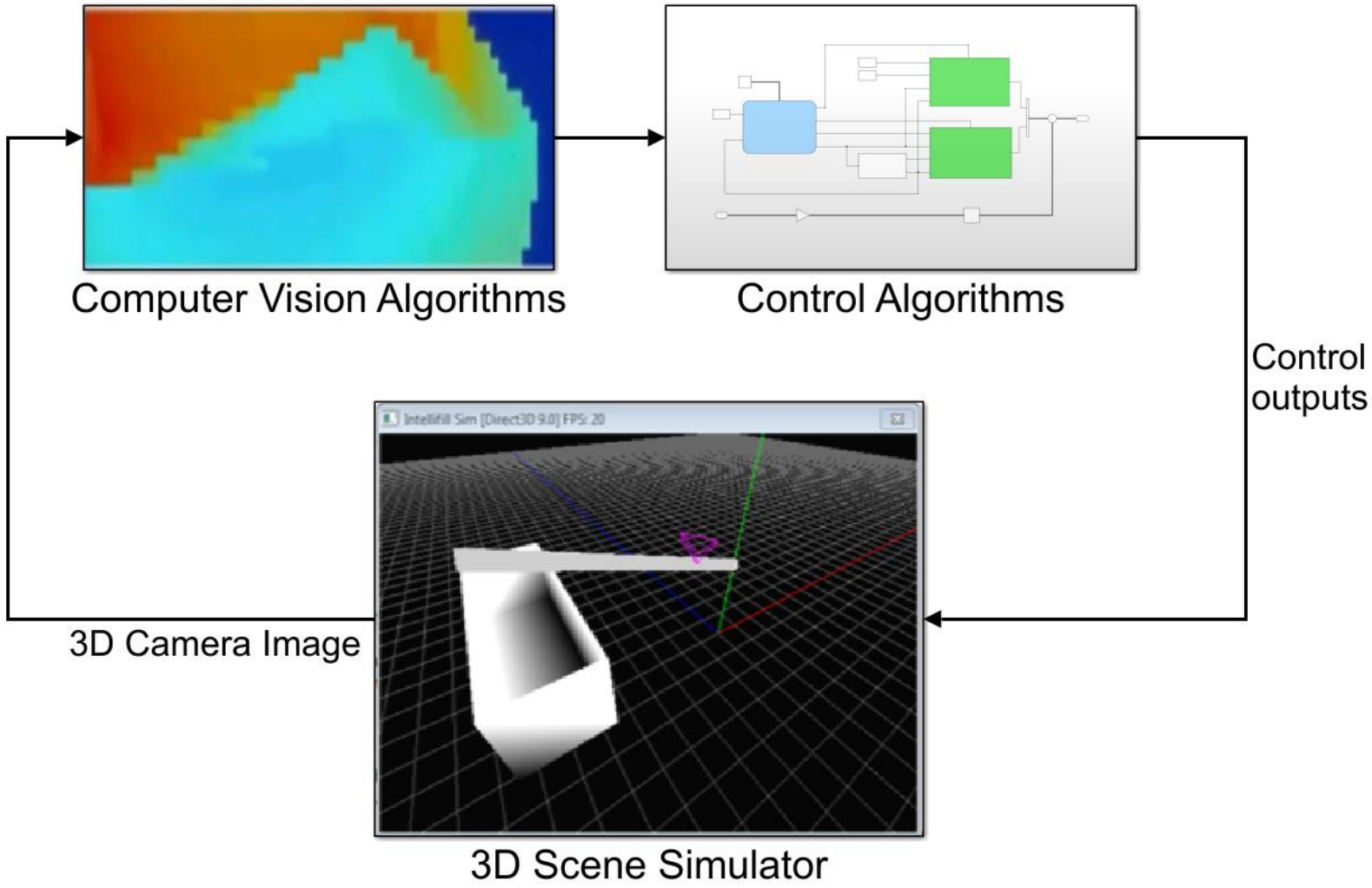
Autonomous Trailer Filling

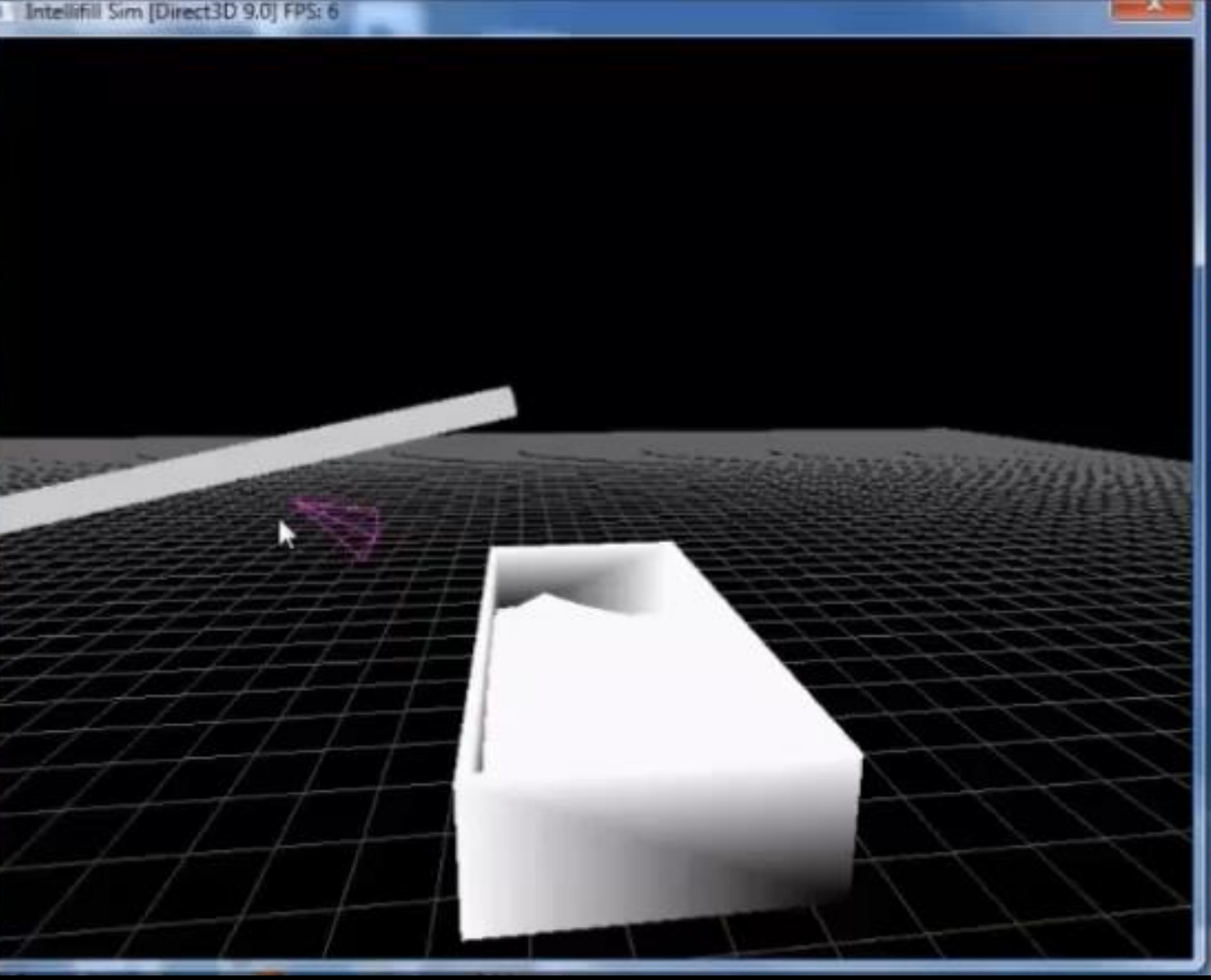
Sense

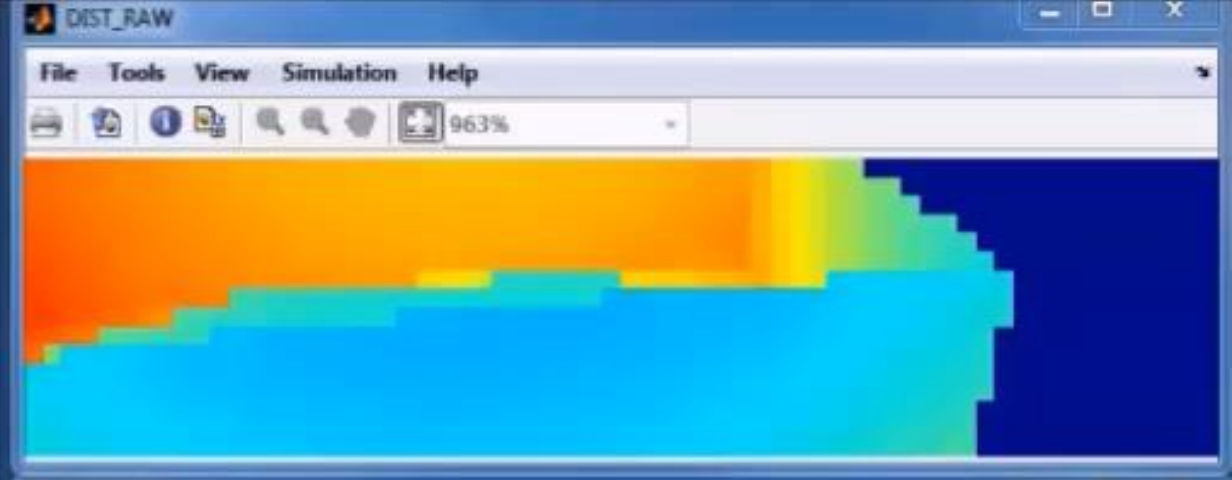
Perceive

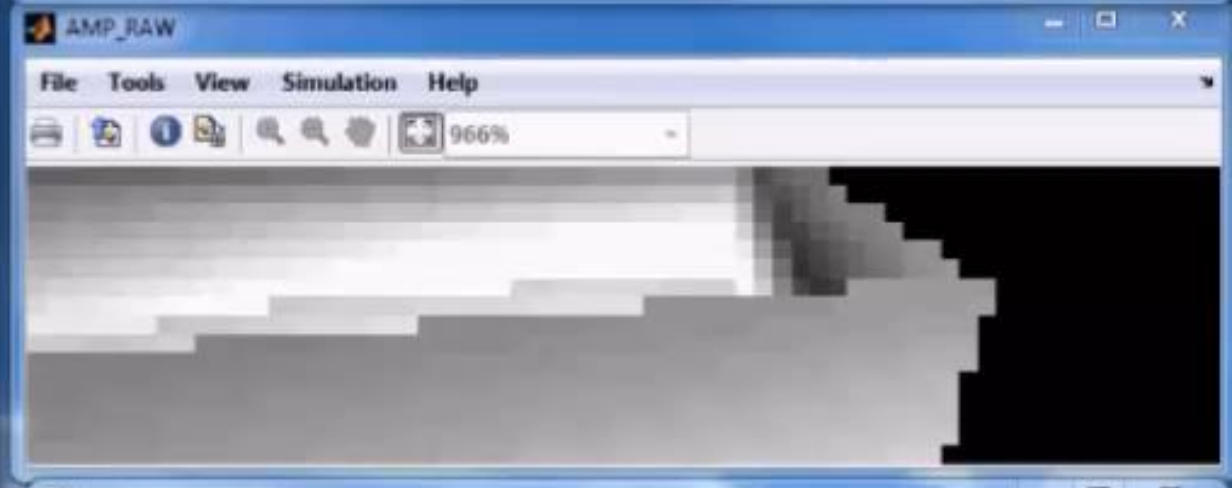
Decide & Plan

Act




Intellifill Sim [Direct3D 9.0] FPS: 6


DIST_RAW
File Tools View Simulation Help
963%


AMP_RAW
File Tools View Simulation Help
966%

Overlay_Dist_image
File Tools View Simulation Help
236%
0133
LW
0150
0150
0150
0000
0142
RW
CCW
0279

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

Vehicle Display Controller

- Driver Input
- Visualization

CAN

ECU

Actuators

Computer vision and controls algorithms

Autonomous Trailer Filling

Sense

Perceive

Decide & Plan

Act

Vehicle Display Controller

- Driver Input
- Visualization
- Computer Vision
- Controls

3D Cameras

Embedded Coder

CAN

Actuators

ECU

Computer vision and controls algorithms

Autonomous Trailer Filling

Sense

Perceive

Decide & Plan

Act

Vehicle Display Controller

- Driver Input
- Visualization
- Computer Vision
- Controls

3D Cameras

CAN

Monitoring

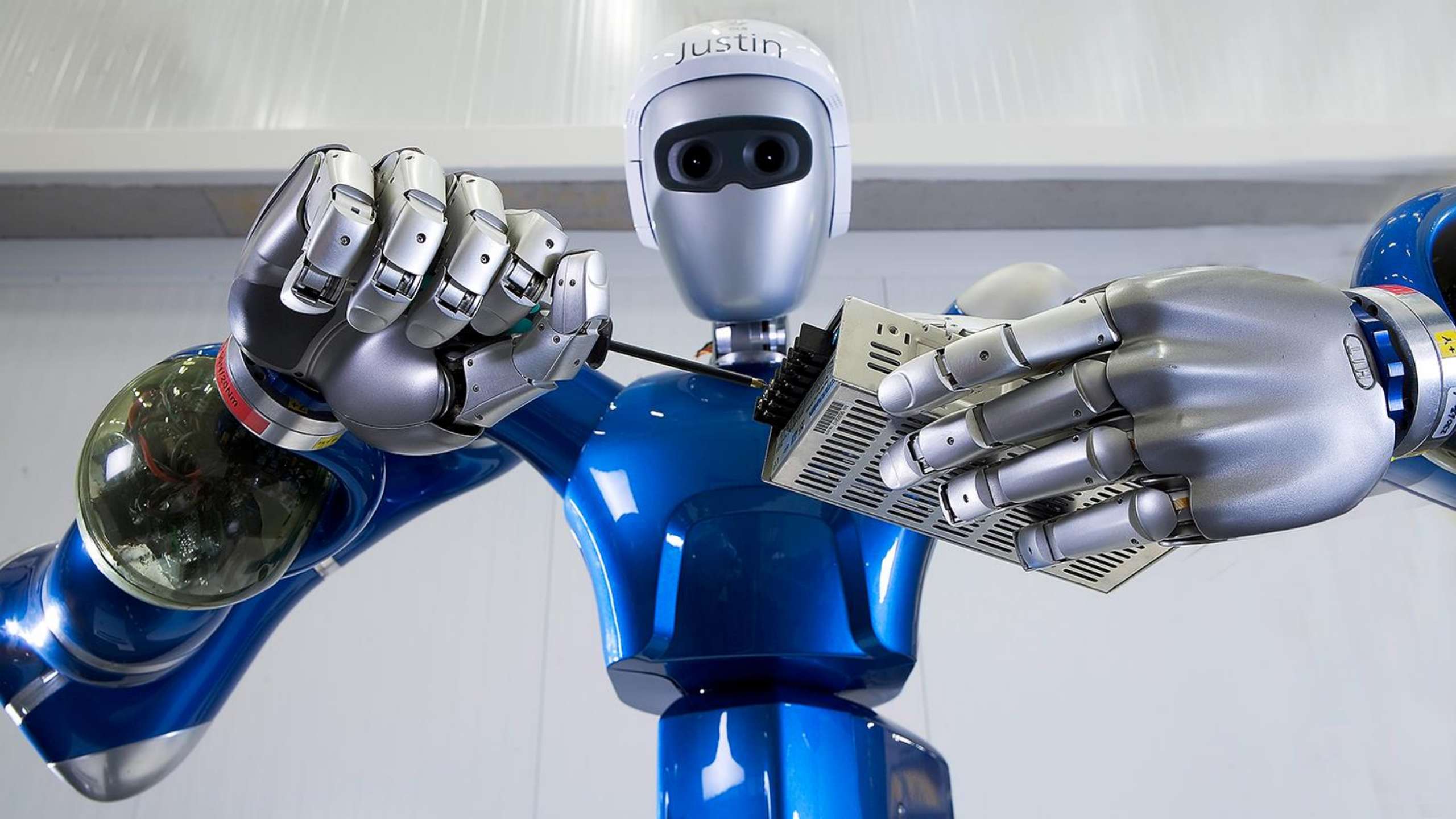
ECU

Actuators

How will you put it into production?

- System Architecture

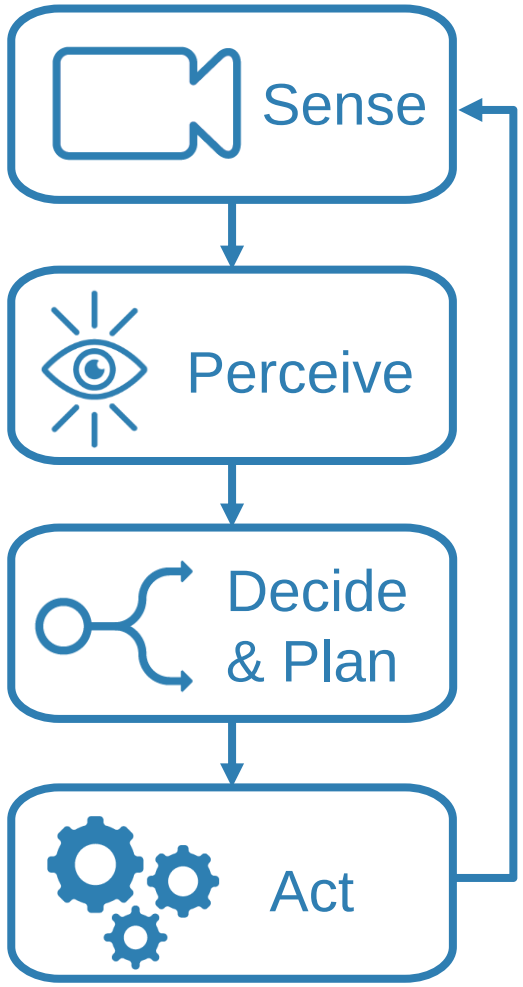
- Embedded systems
- Enterprise systems
- HMIs


Justin

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

How to build an autonomous anything



Rise PRIZE Driverless Car Challenge

What is ***your***
autonomous anything?