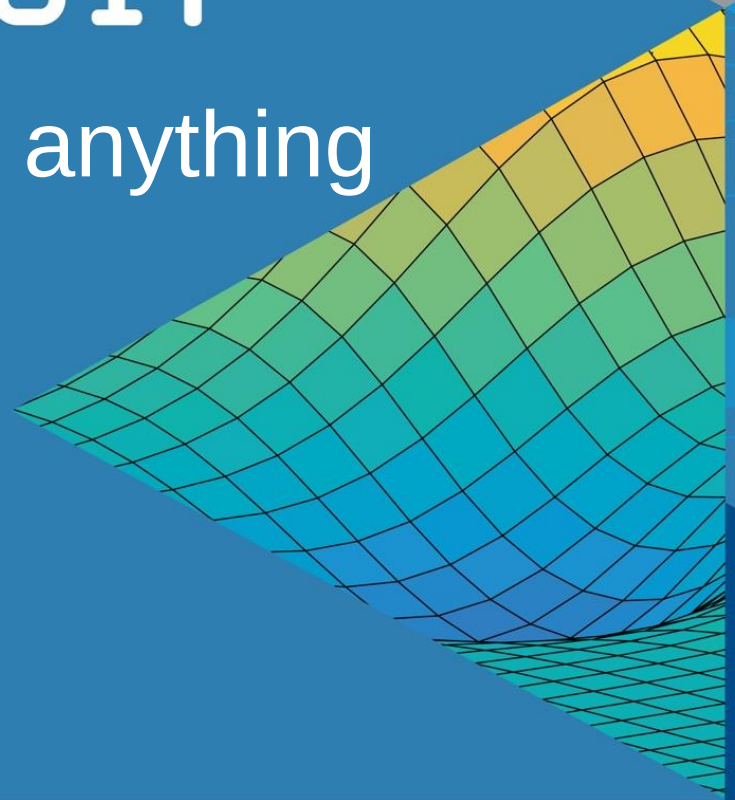
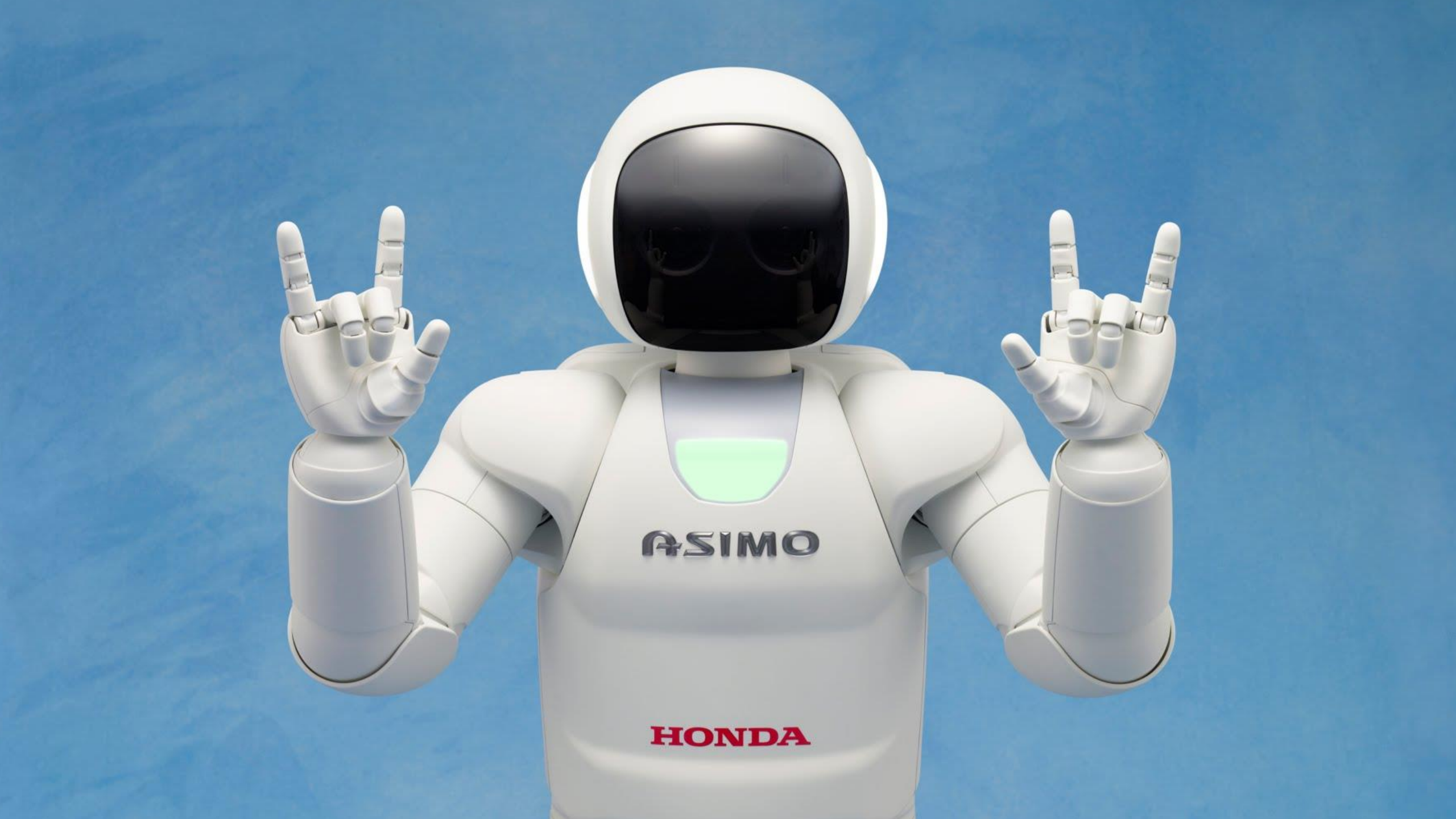
MATLAB EXPO 2017

How to build an **autonomous** anything



Richard Rovner
VP Marketing
MathWorks


WAYMO


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

Autonomous

Acting independently

Autonomous Technology

Autonomous Technology

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

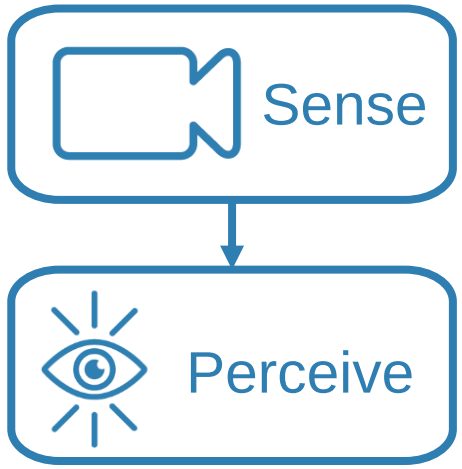
Autonomous Technology

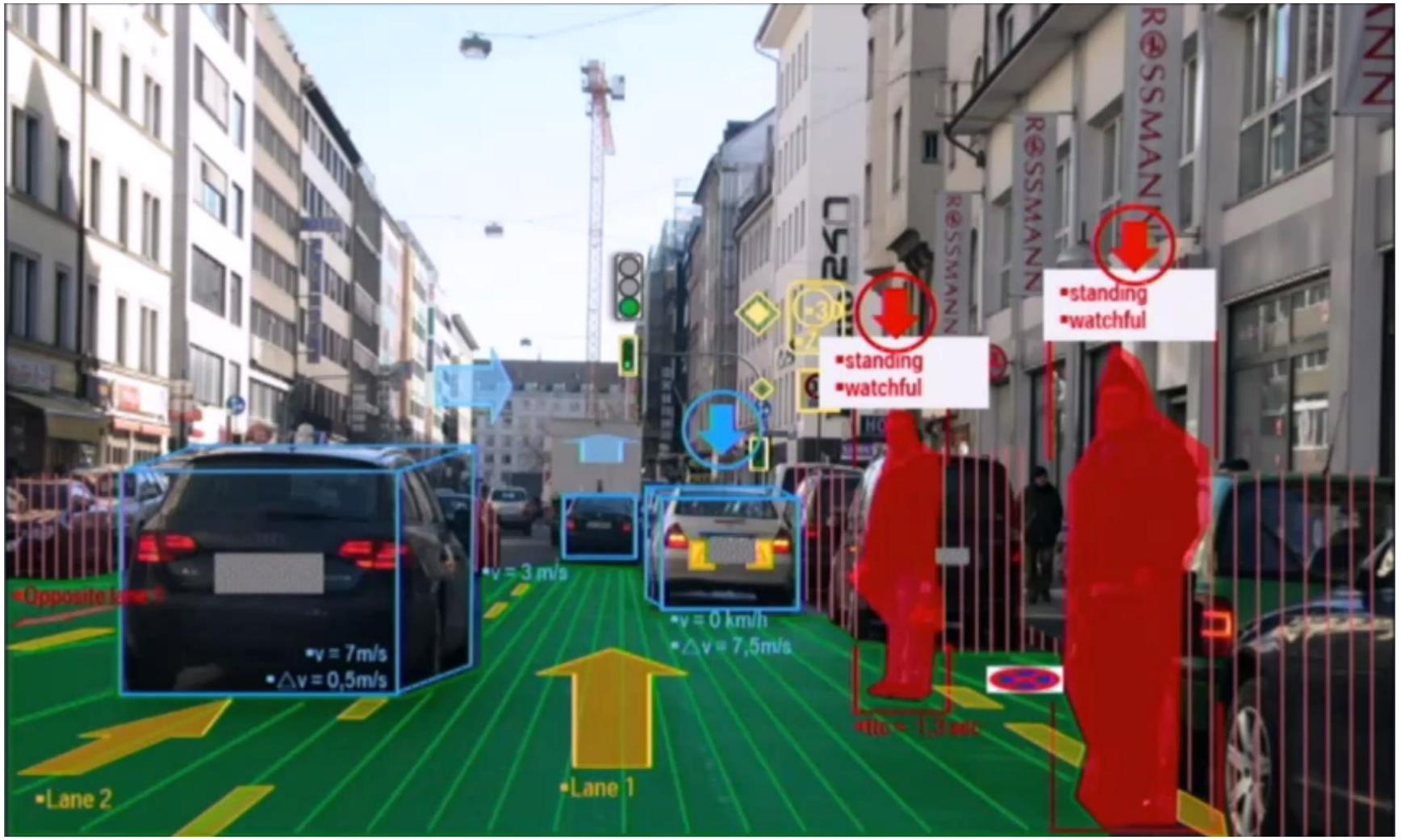
Provides the ability of a system to act independently of direct human control under unrehearsed conditions

Capabilities of an Autonomous System

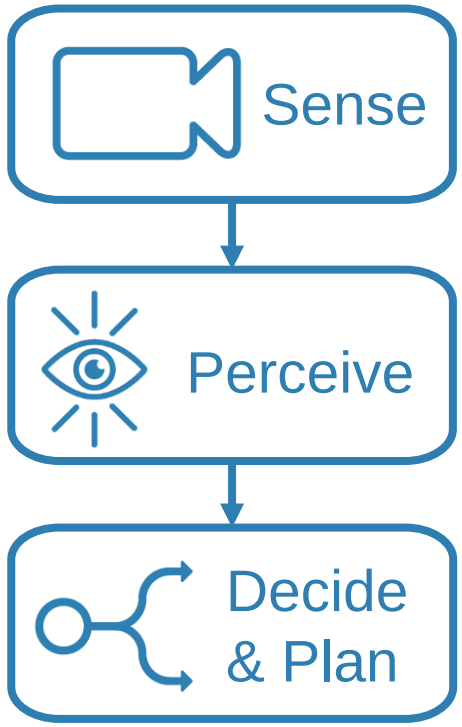
Sense

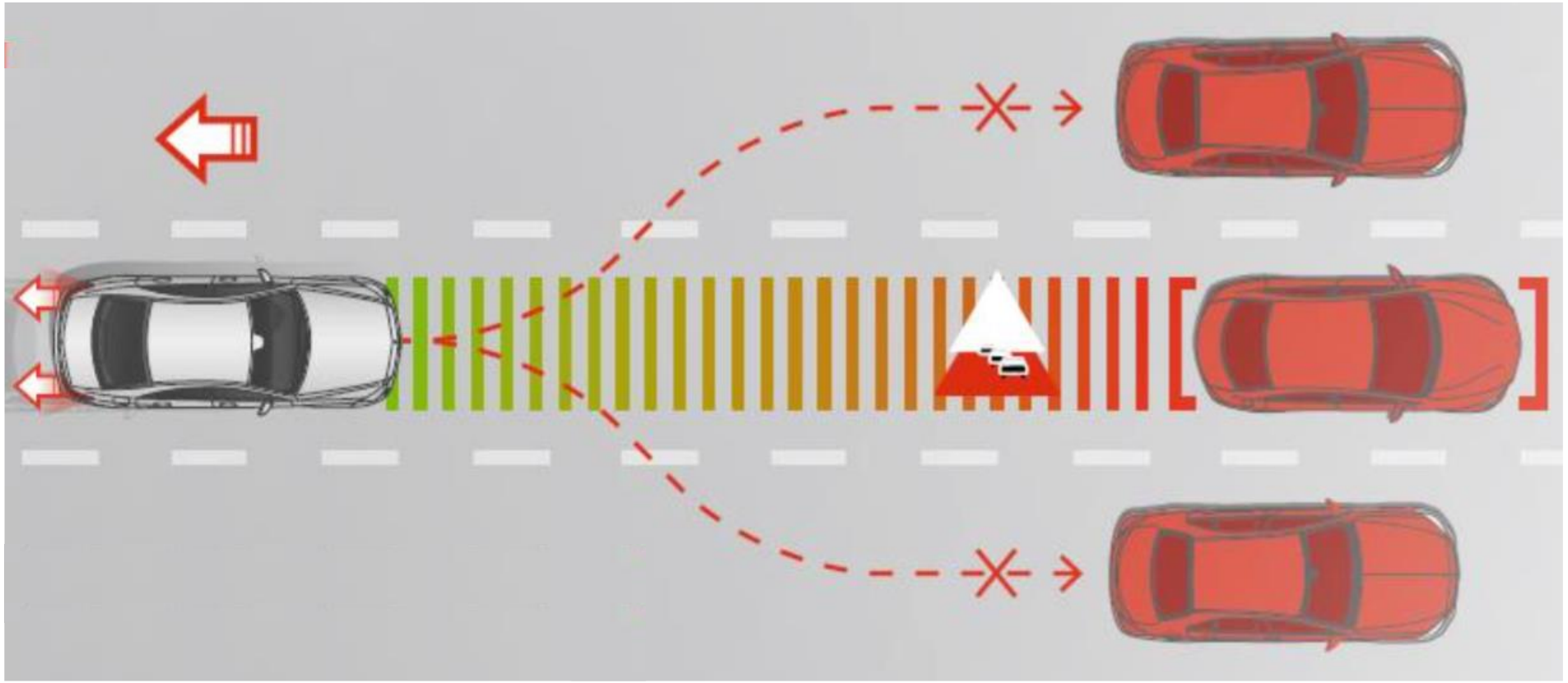
Capabilities of an Autonomous System



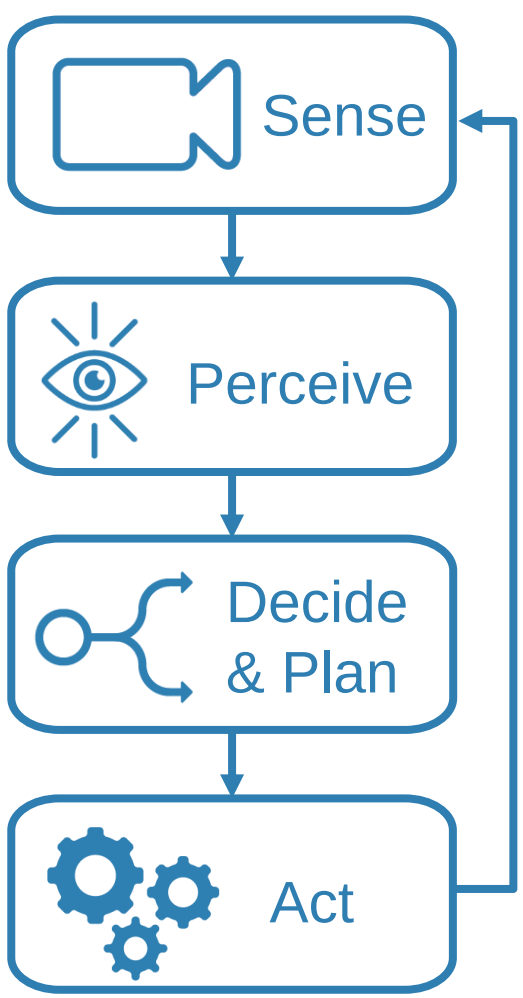


Capabilities of an Autonomous System

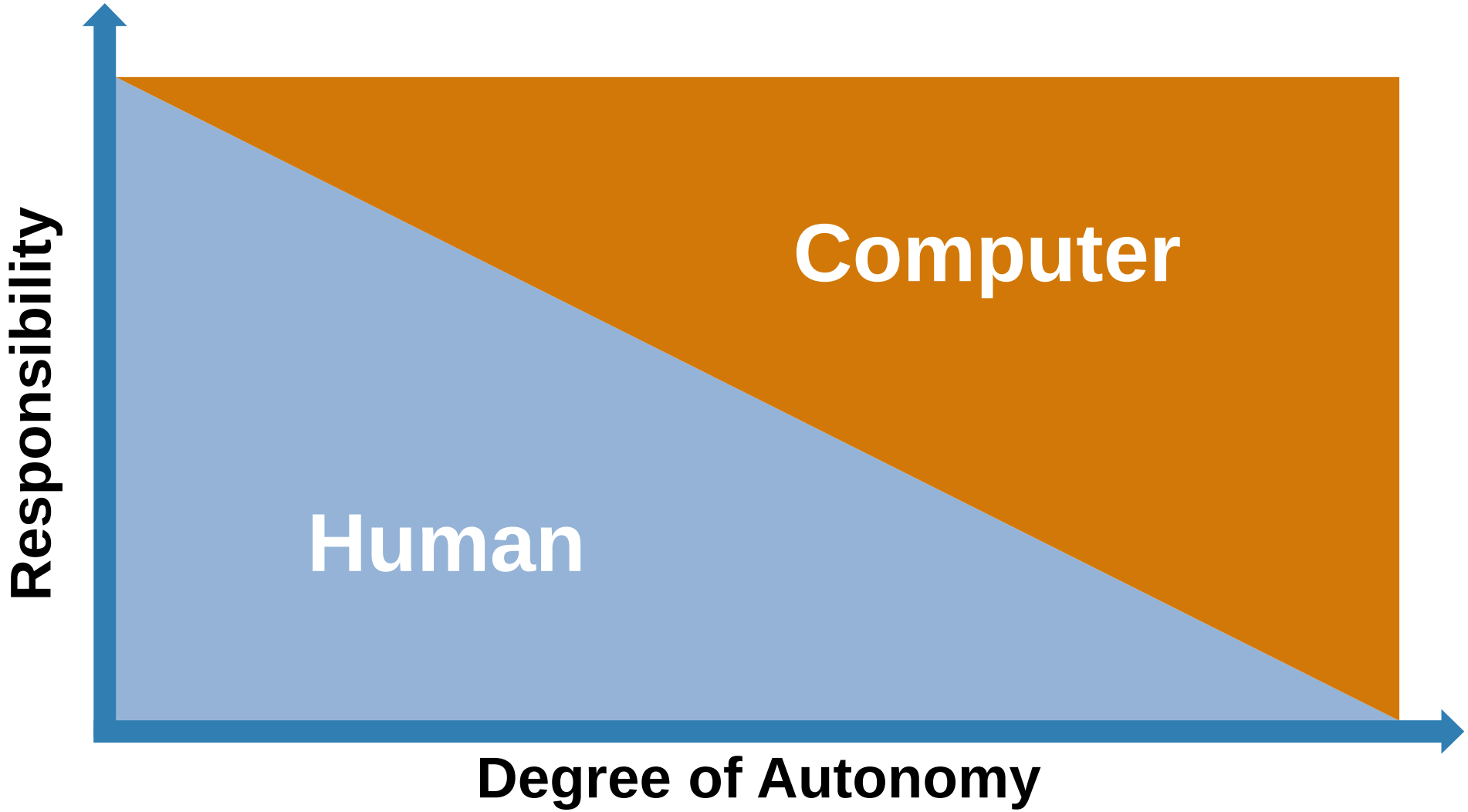


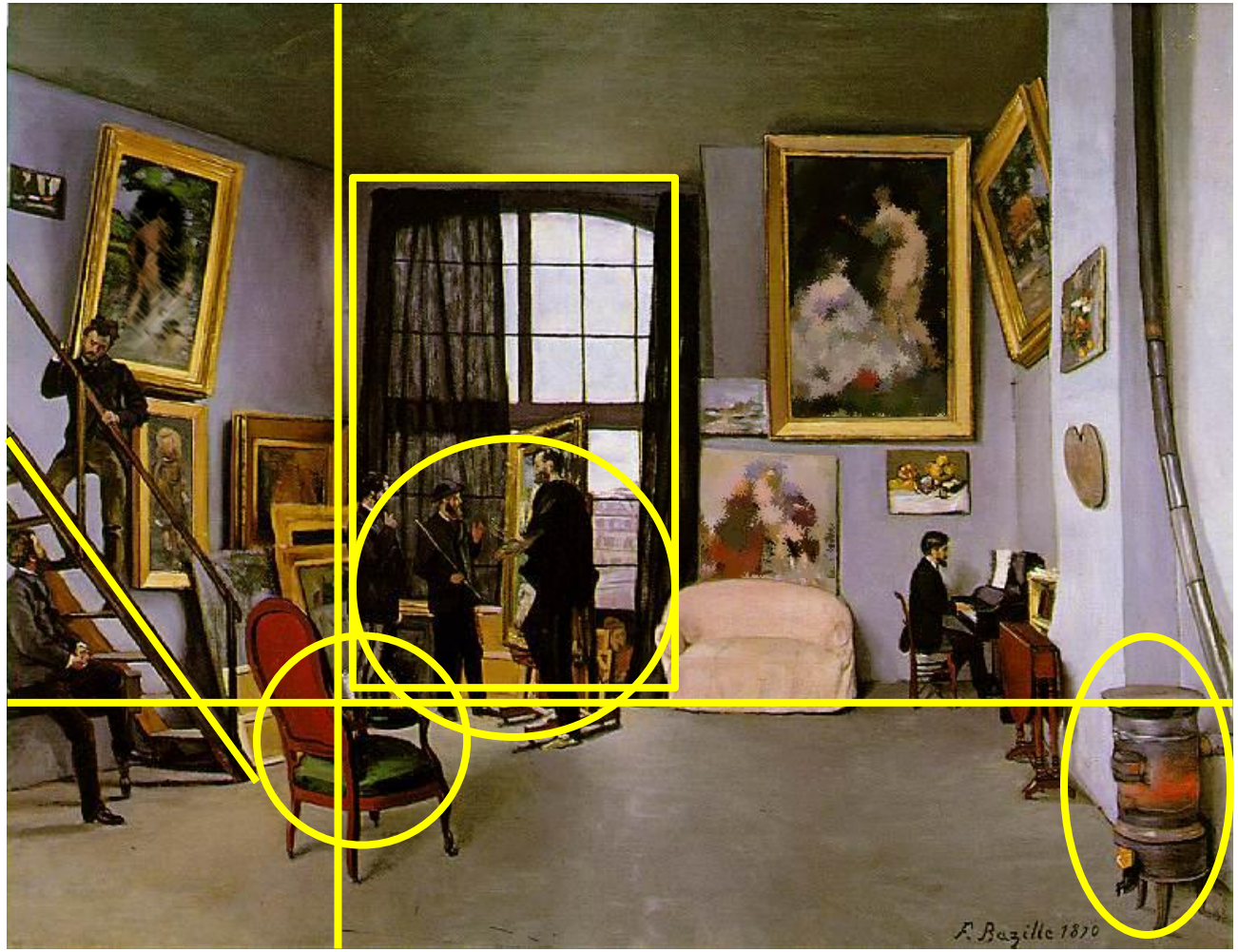


Capabilities of an Autonomous System



Autonomous Technology – Balancing Responsibility





Bazille's Studio
Bazille 1870

Shuffleton's Barbershop
Rockwell 1950

Autonomous Artistic Style Classification
Rutgers University

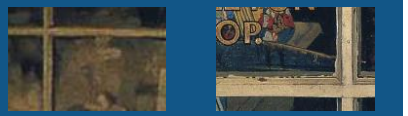
Sense

Perceive

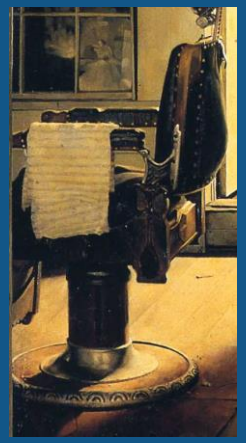
Decide & Plan

Act

Image Feature Extraction



Visual Features



Machine Learning Classification

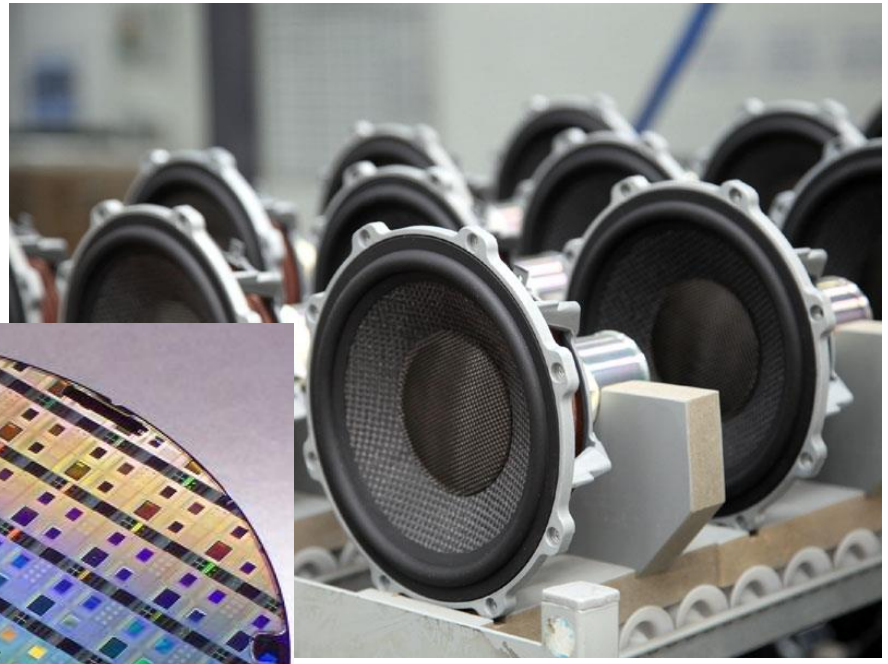
Style Classifier (SVM) → **Style:** Regionalism

Genre Classifier (SVM) → **Genre:** Interior

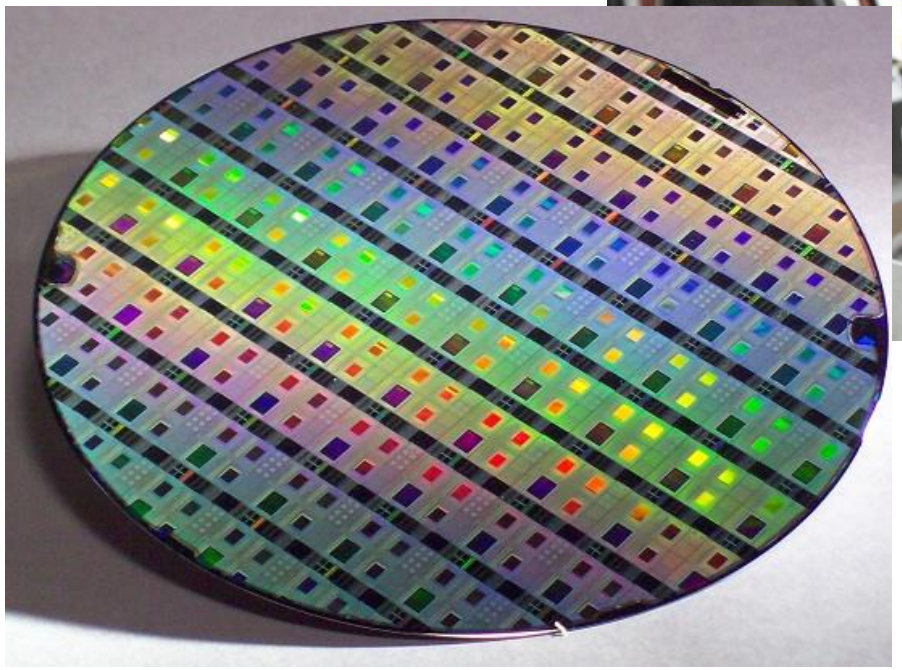
Artist Classifier (SVM) → **Artist:** Rockwell

Where to add autonomy with perception?

- Analyze more data
- Reduce bias
- Improve measurement quality
- Save time
- Improve performance



Determine Loudspeaker Quality



Virtual Semiconductor Manufacturing Calibration


Cost of rig: $1,000,000+
Repair cost: $100,000
Cost of valve: $200
5" 12,000 PSI
5" 12,000 PSI
BAKER HUGHES

Autonomous Service for Predictive Maintenance

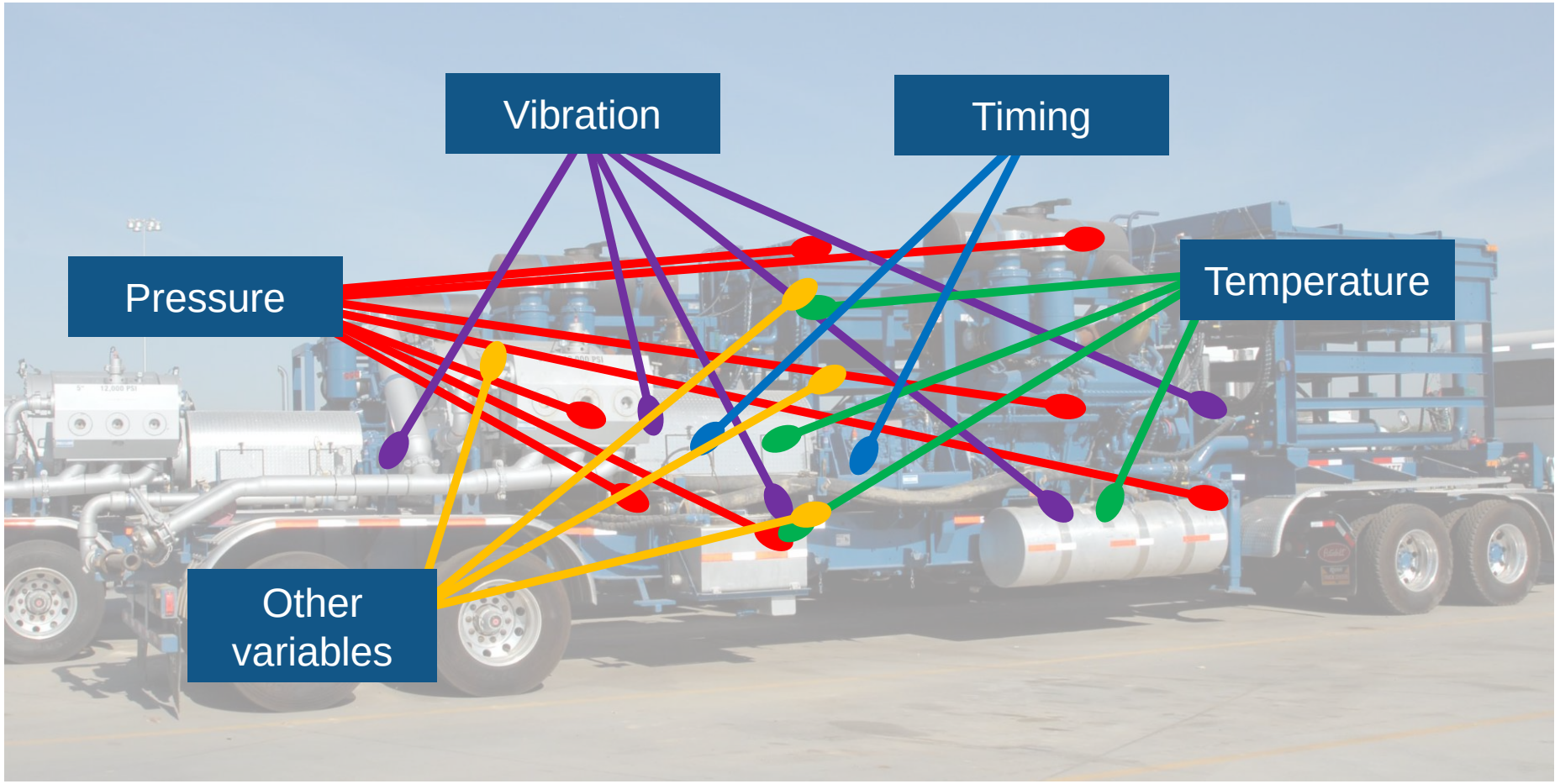
Sense

Perceive

Decide & Plan

Act

Which sensor values should they use?



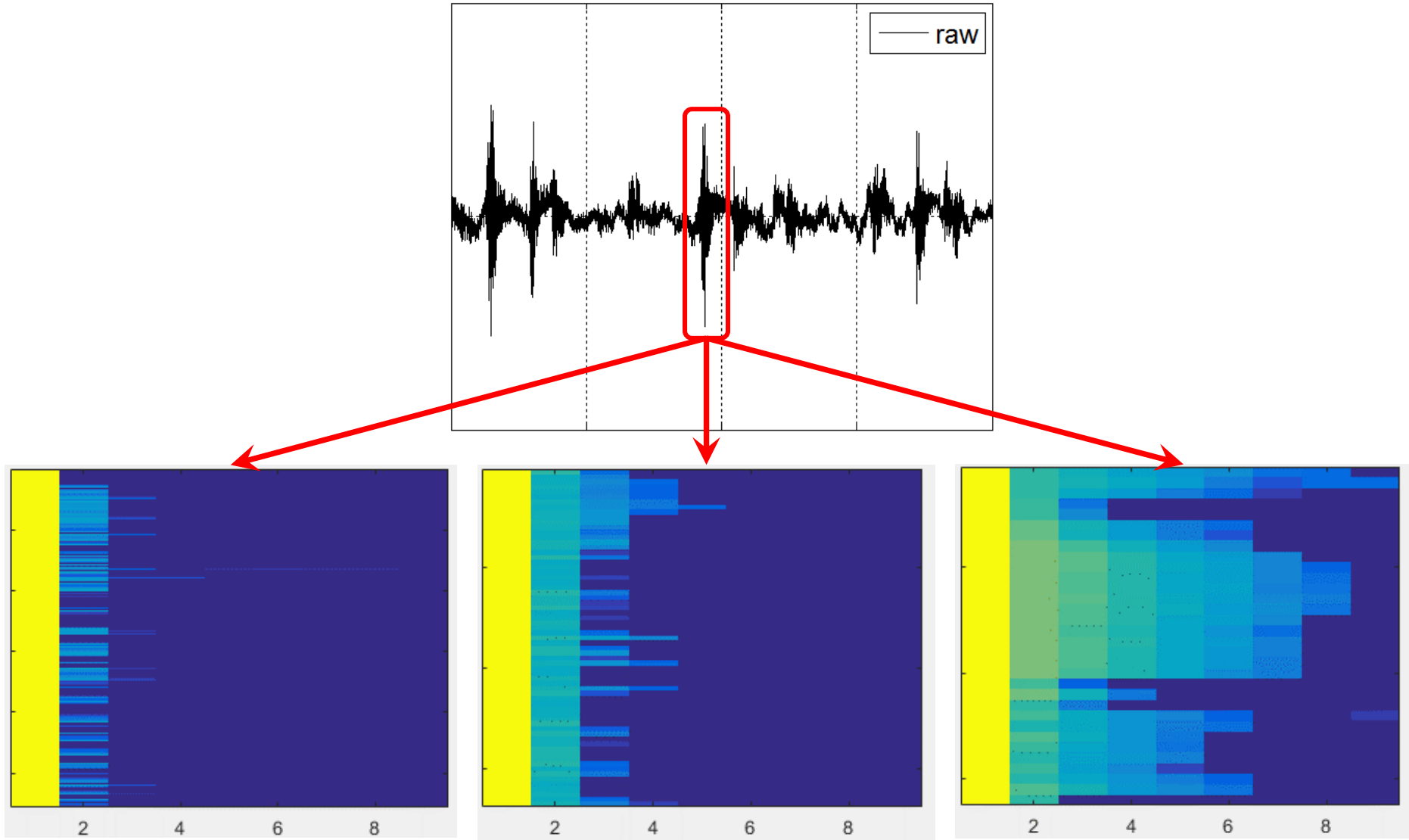
Autonomous Service for Predictive Maintenance

Sense

Perceive

Decide & Plan

Act



Normal Operation | Monitor Closely | Maintenance Needed

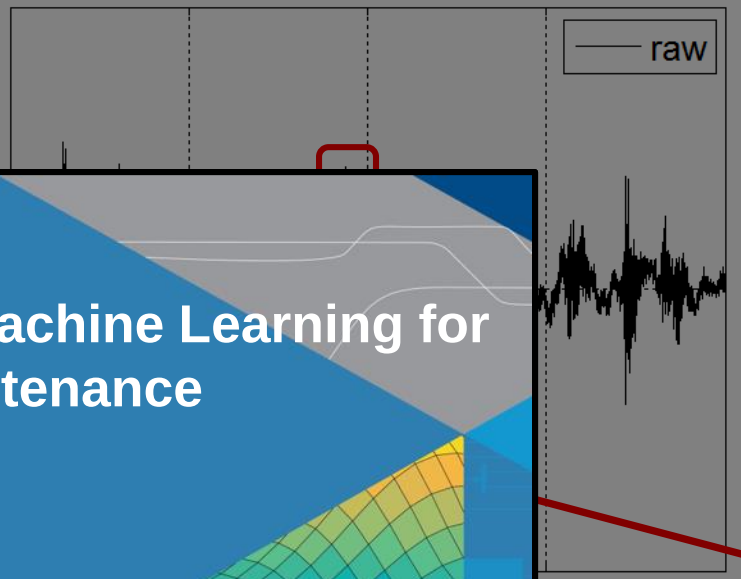
Autonomous Service for Predictive Maintenance

Sense

Perceive

Decide & Plan

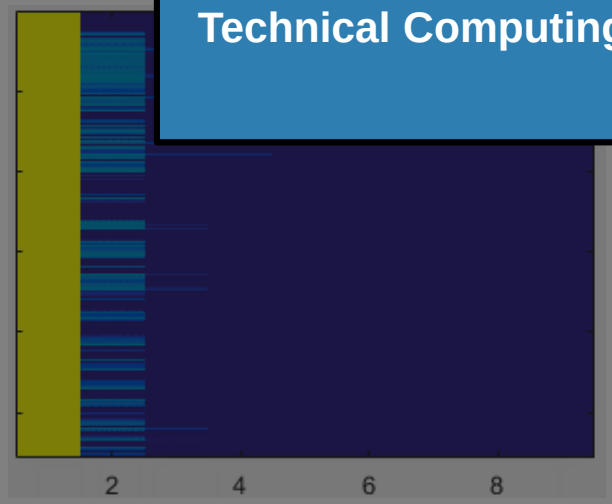
Act



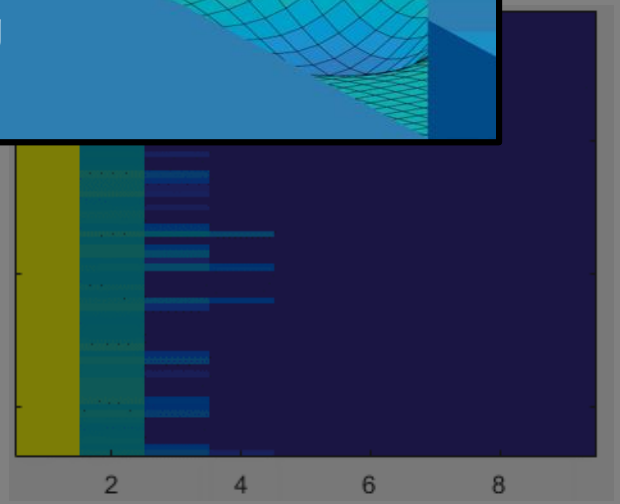
Find out more:
Big Data and Machine Learning for Predictive Maintenance

Paul Peeling

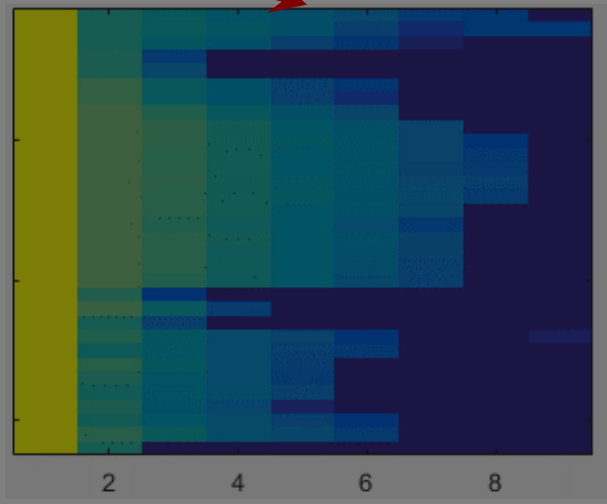
Technical Computing



Normal Operation



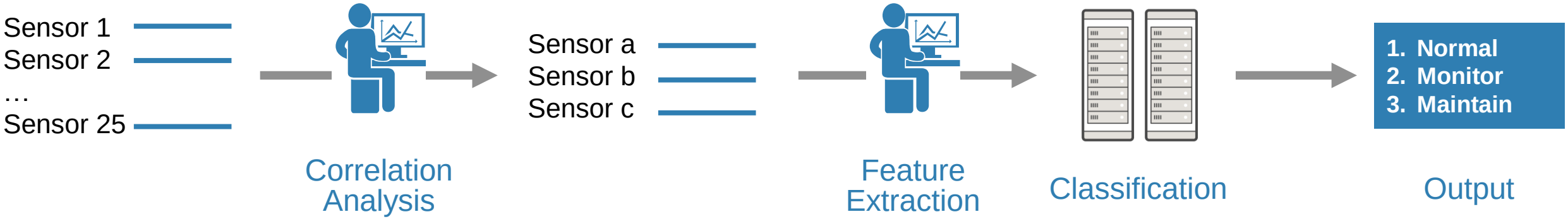
Monitor Closely



Maintenance Needed

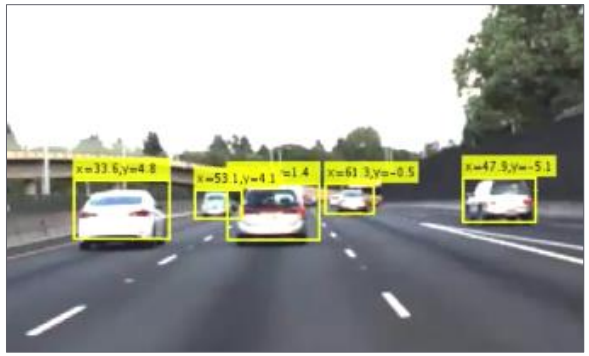
Machine Learning or Deep Learning?

Machine Learning Approach



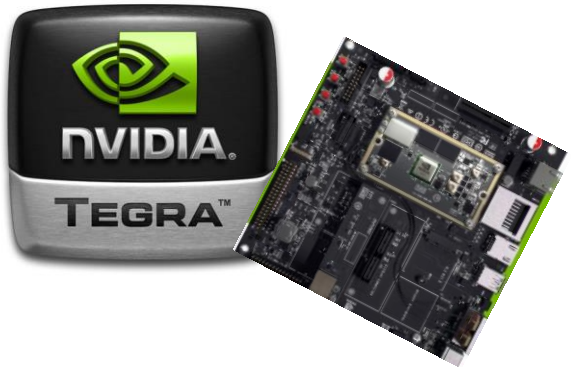
Deep Learning Approach

R2017b Mega Release of Deep Learning Capabilities



Design Deep Learning
& Vision Algorithm

Accelerate and Scale
Training



High Performance
Embedded Implementation

Deep learning design is easy in MATLAB

Apps for Ground Truth Labeling, Pixel Labeling
Pre-trained **model importer**
Training Visualization

Parallel Computing Toolbox

7x faster than pyCaffe
2x faster than TensorFlow

GPU Coder

14x faster than pyCaffe
4x faster than TensorFlow
1.6x faster than C++ Caffe

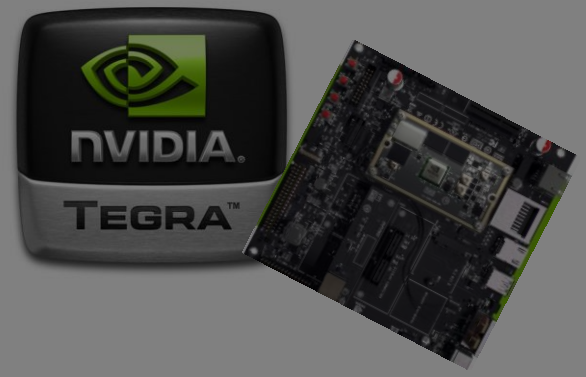
R2017b Mega Release of Deep Learning Capabilities

Design Deep Learning
& Vision Algorithm

Find out more:
Introduction to Machine Learning and Deep Learning

Conor Daly

Getting Started with MATLAB and Simulink



High Performance
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Pre-trained **model importer**

Parallel Computing Toolbox

7x faster than pyCaffe
2x faster than TensorFlow

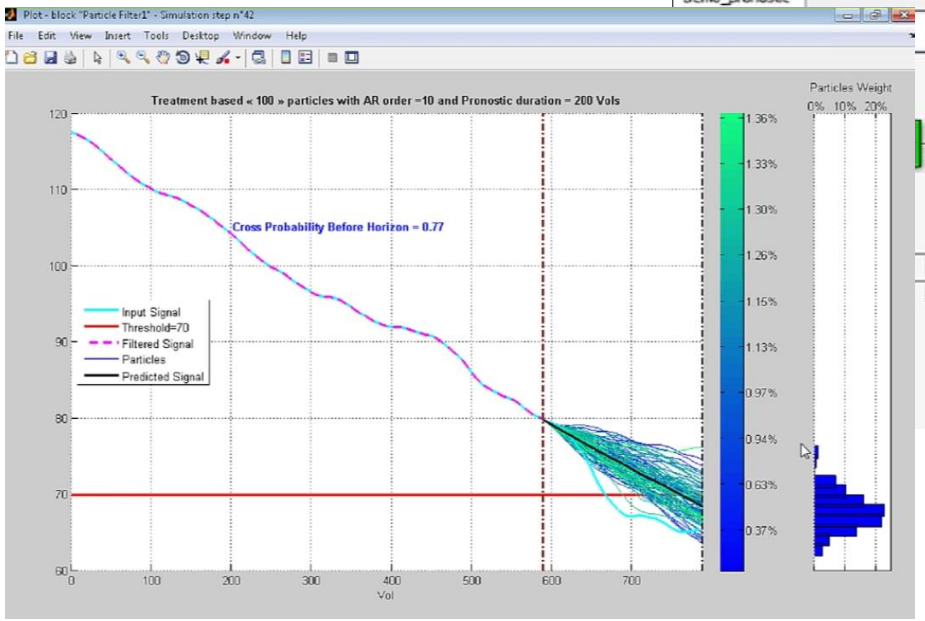
GPU Coder

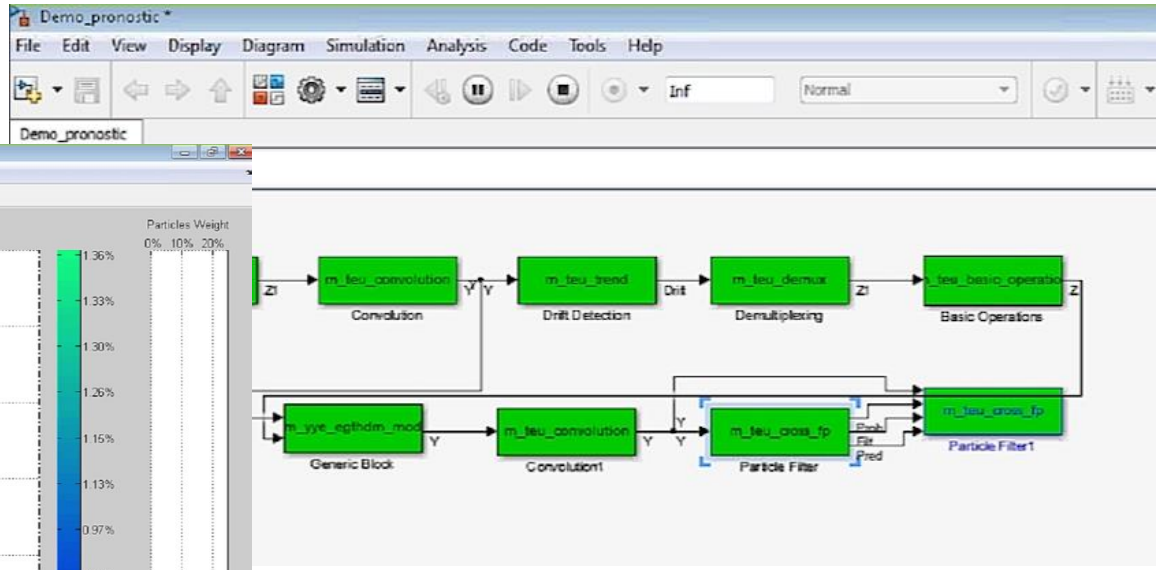
14x faster than pyCaffe
4x faster than TensorFlow
1.6x faster than C++ Caffe

What are the best predictors?

- Data-driven
- Model-driven

SAFRAN
Snecma





Jet Engine Monitoring

Autonomous Glucose Level Management

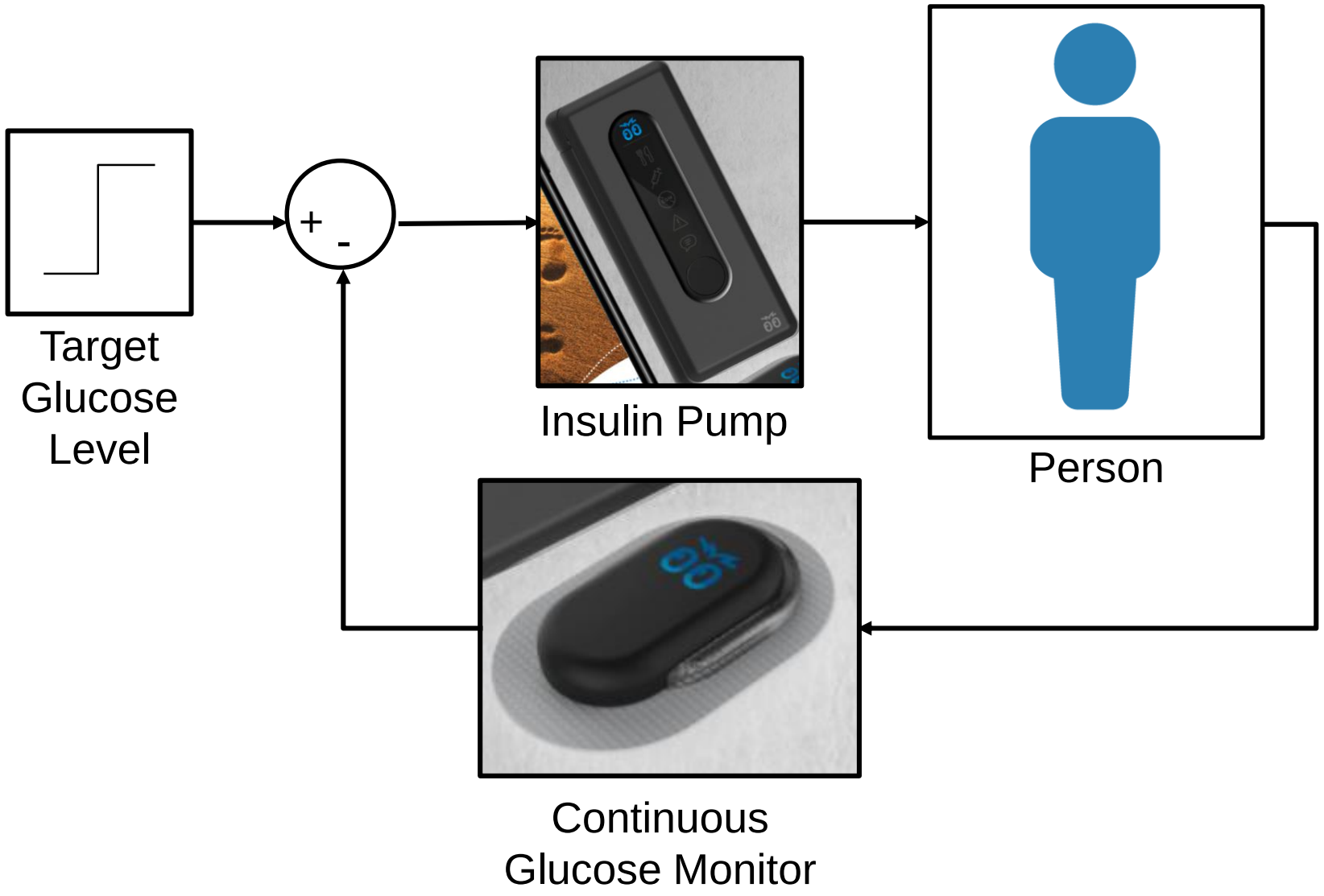
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

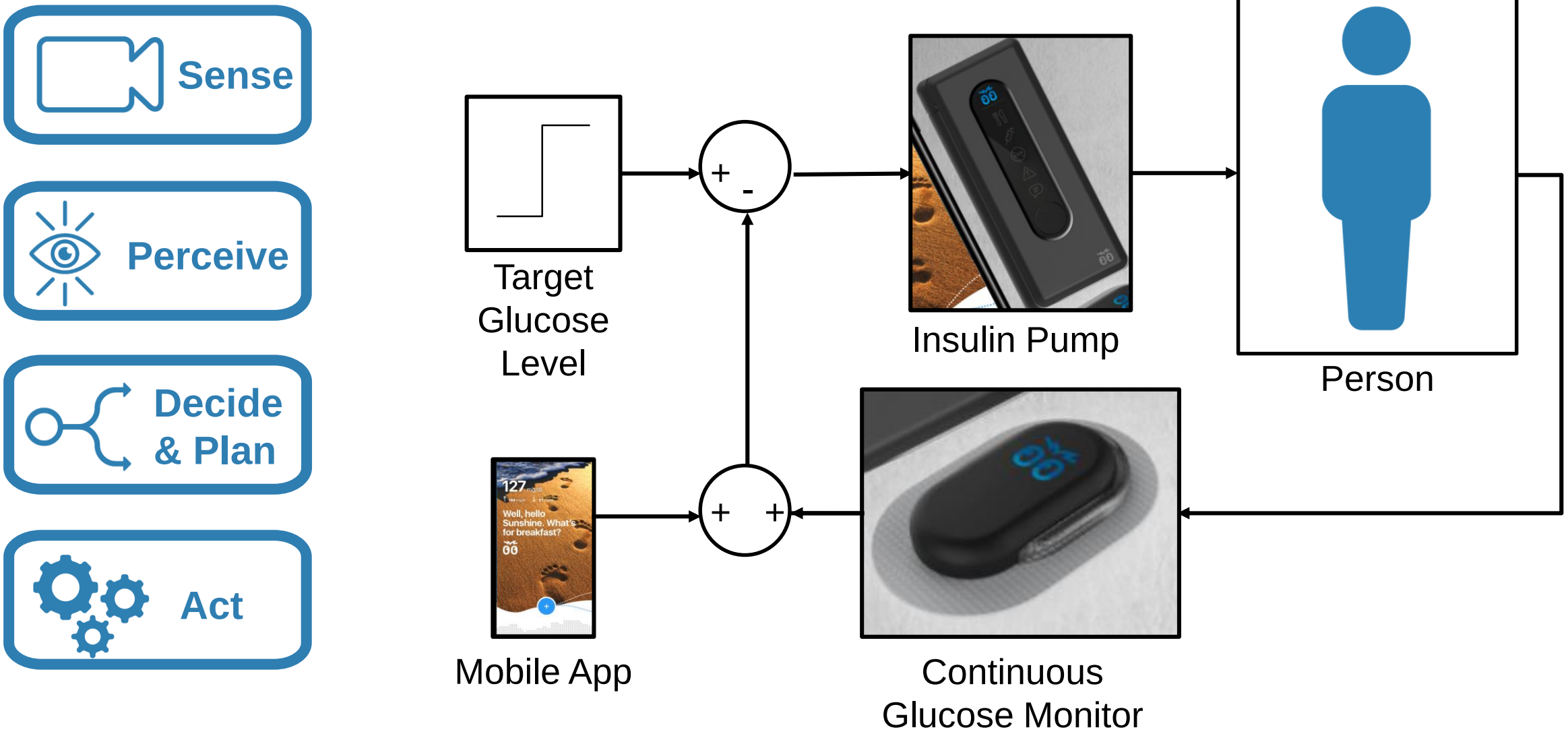
Perceive

Decide & Plan

Act



Autonomous Glucose Level Management
Bigfoot Biomedical



Autonomous Glucose Level Management
Bigfoot Biomedical

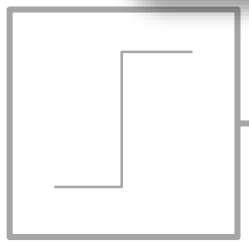
Virtual Lab
Simulink, Stateflow
Polyspace

Sense

Perceive

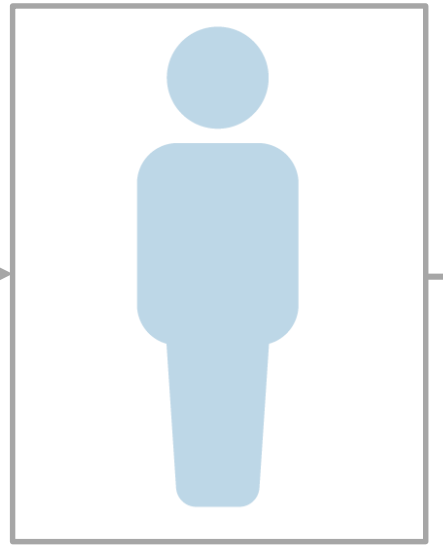
Decide & Plan

Act

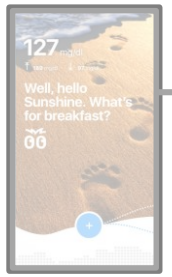


Target Glucose Level

Insulin Pump



Person



Mobile App

Continuous Glucose Monitor

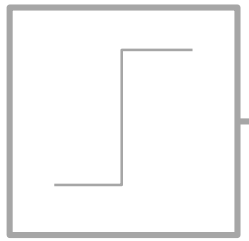
Autonomous Glucose Level Management
Bigfoot Biomedical

Sense

Perceive

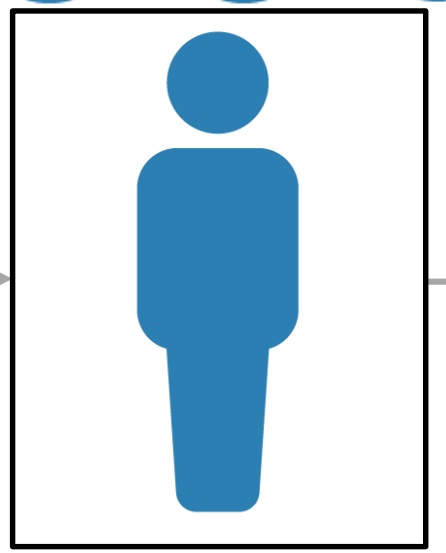
Decide & Plan

Act

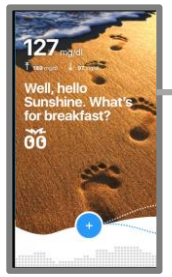


Target Glucose Level

Insulin Pump



Person



Mobile App

Continuous Glucose Monitor

Autonomous Glucose Level Management
Bigfoot Biomedical

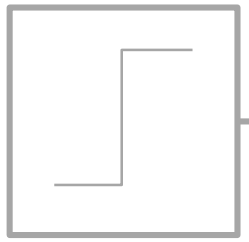
Virtual Clinic
MATLAB, Toolboxes

Sense

Perceive

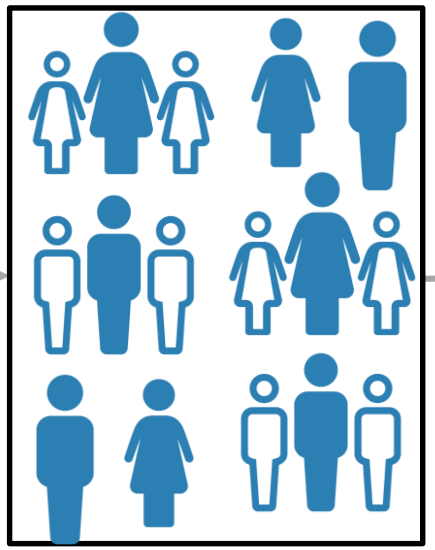
Decide & Plan

Act

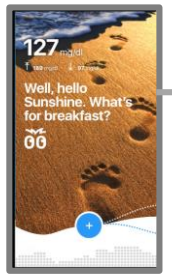


Target Glucose Level

Insulin Pump



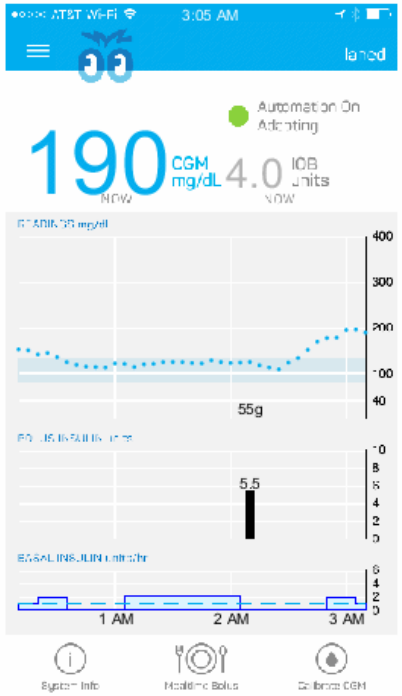
Person

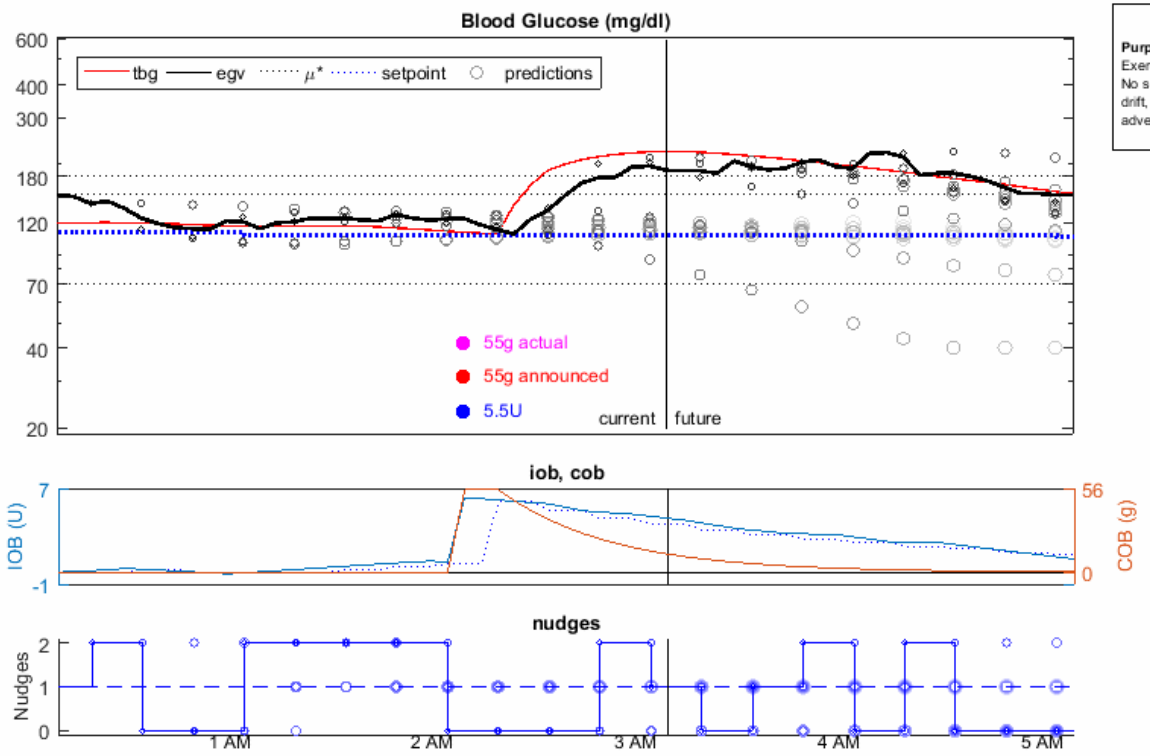


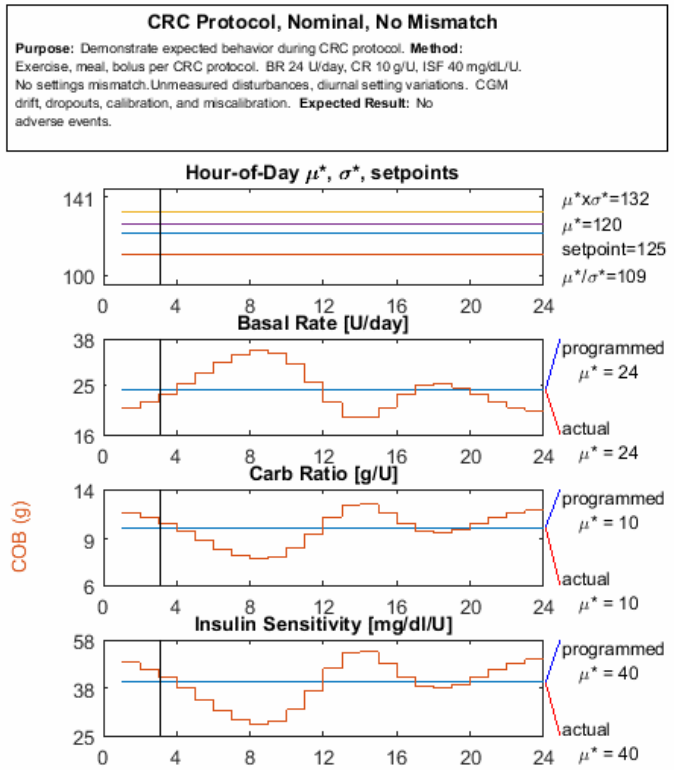
Mobile App

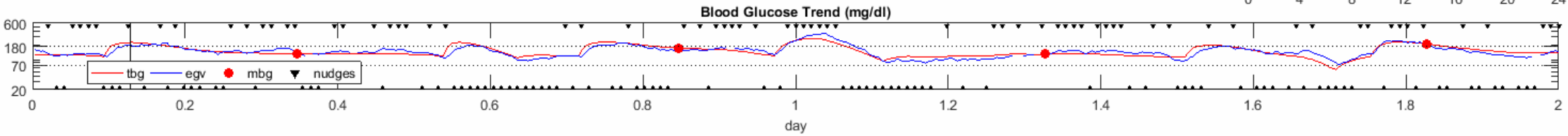
Continuous Glucose Monitor

Virtual Clinic
Generating data through simulation

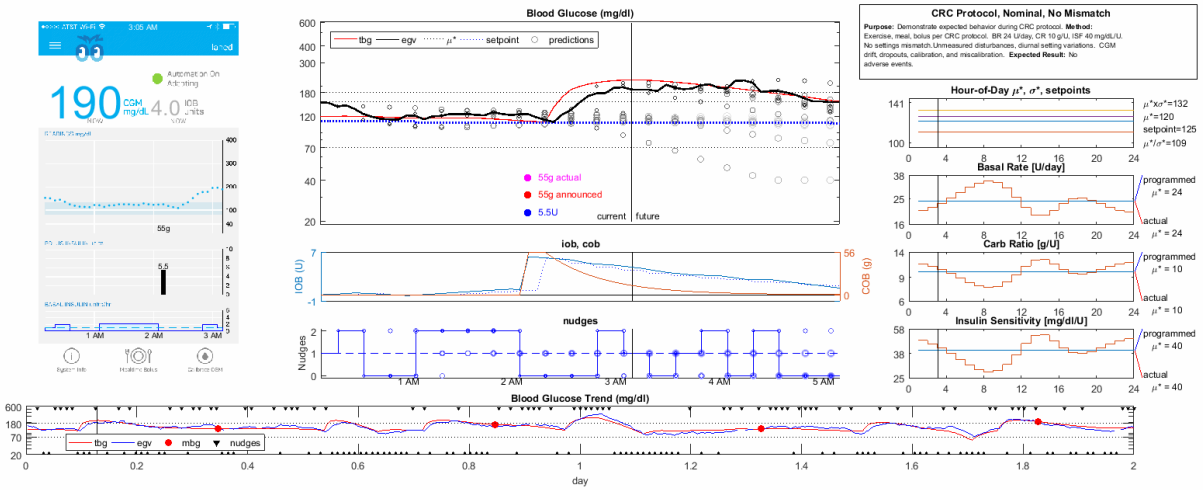








Virtual Clinic
Scaling computations to simulate 50 million patients a day



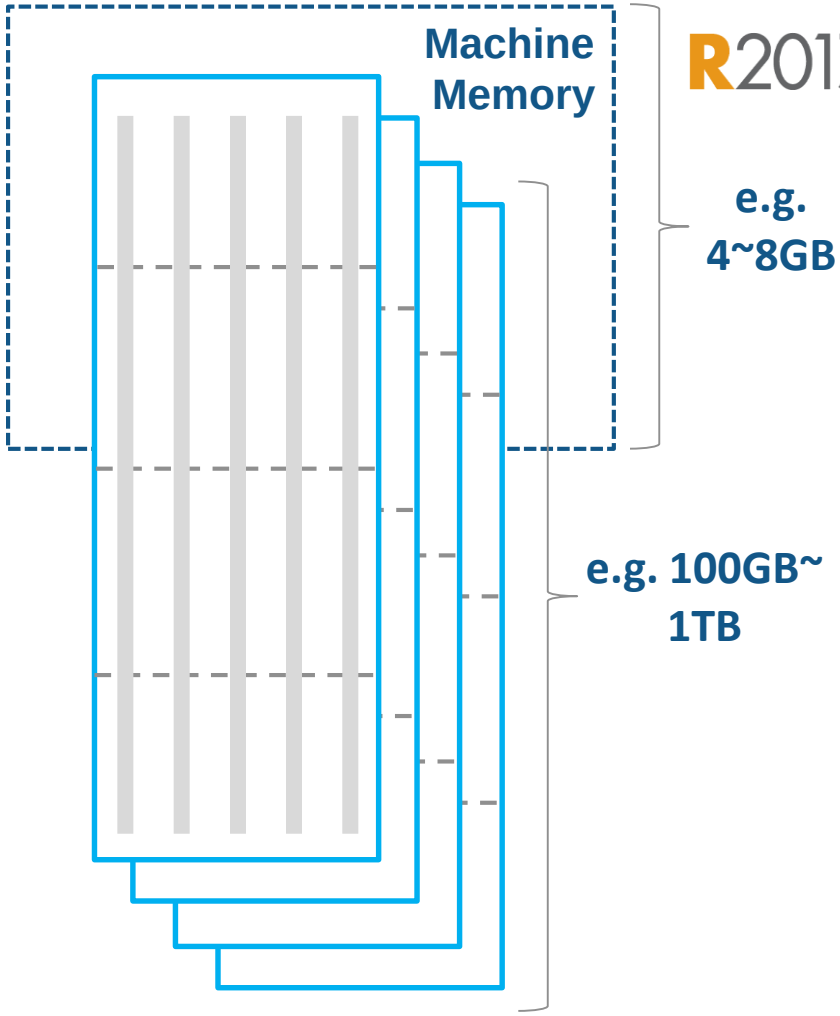
Where will you get your data?

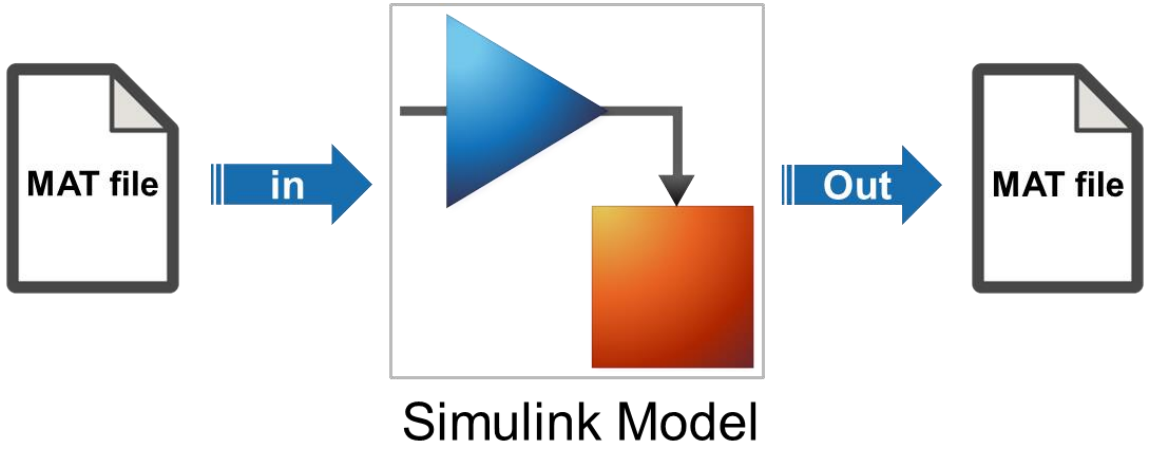
- Simulation
- Public repositories
- In the field
- In the lab
- Internet of Things (IoT)

Working with Big Data Just Got Easier

Tall arrays in MATLAB

R2016b
R2017a





Stream large input signals from MAT-files

R2017a

Autonomous Trailer Filling

Sense

Perceive

Decide & Plan

Act

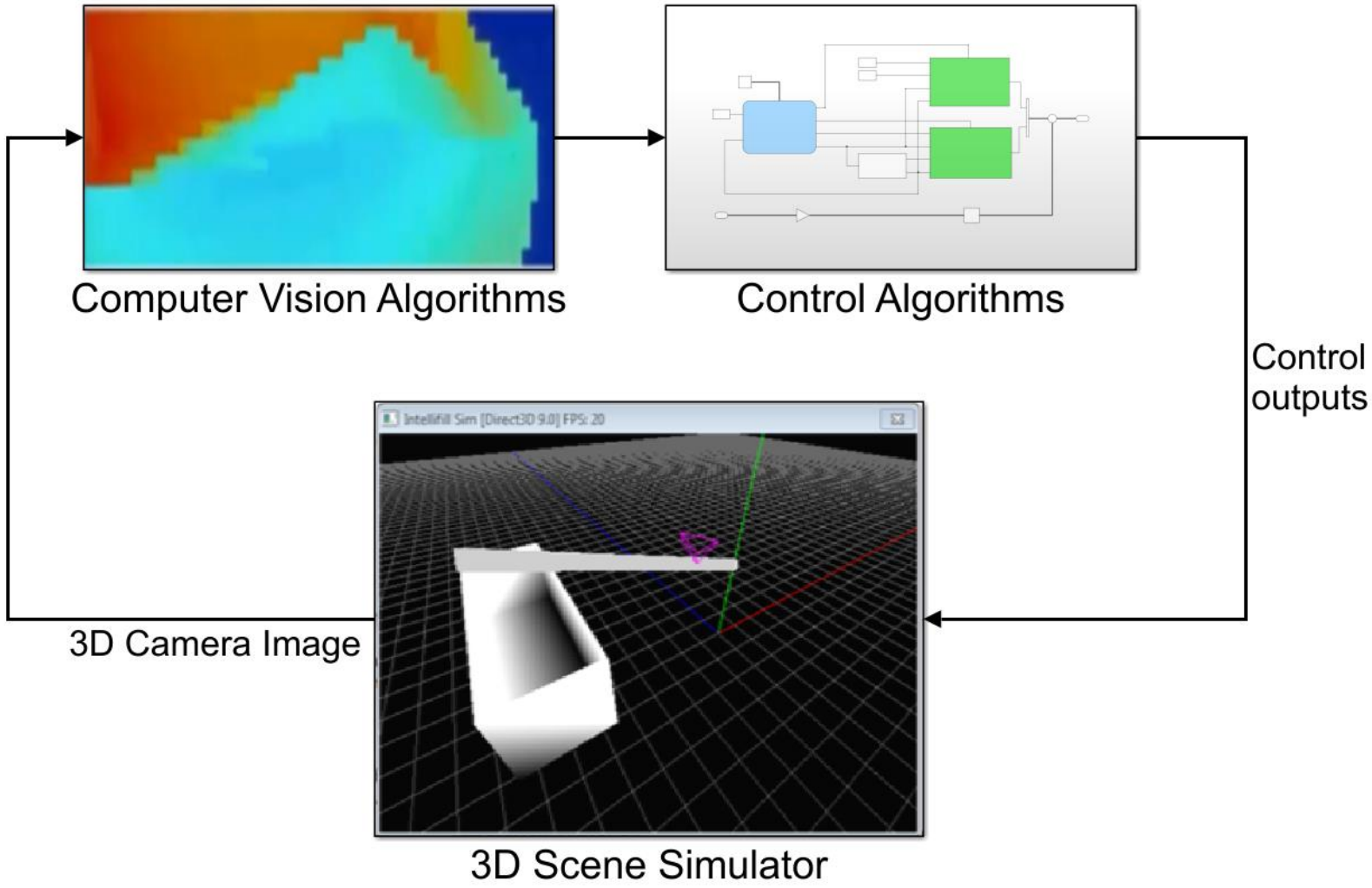
Autonomous Trailer Filling

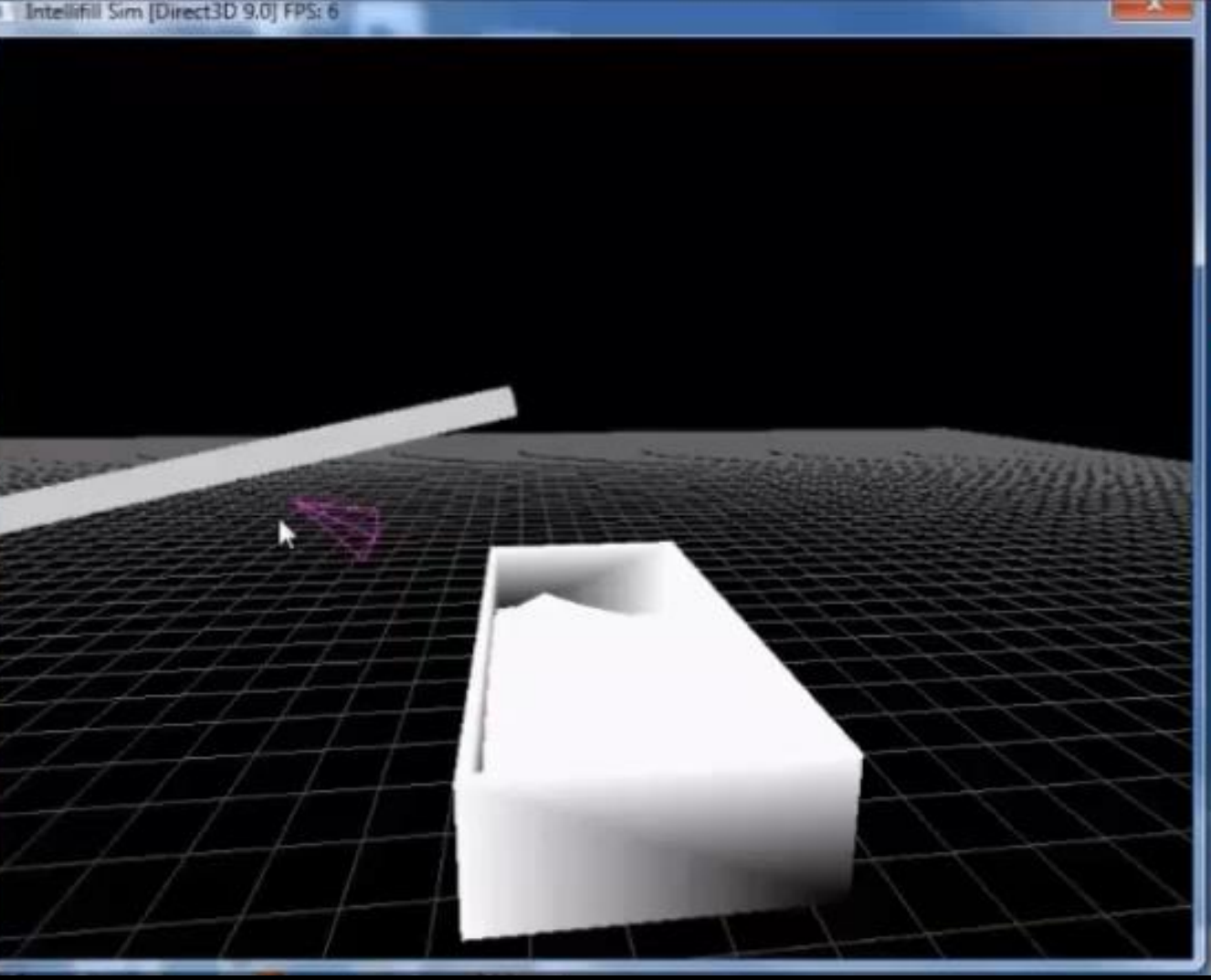
Sense

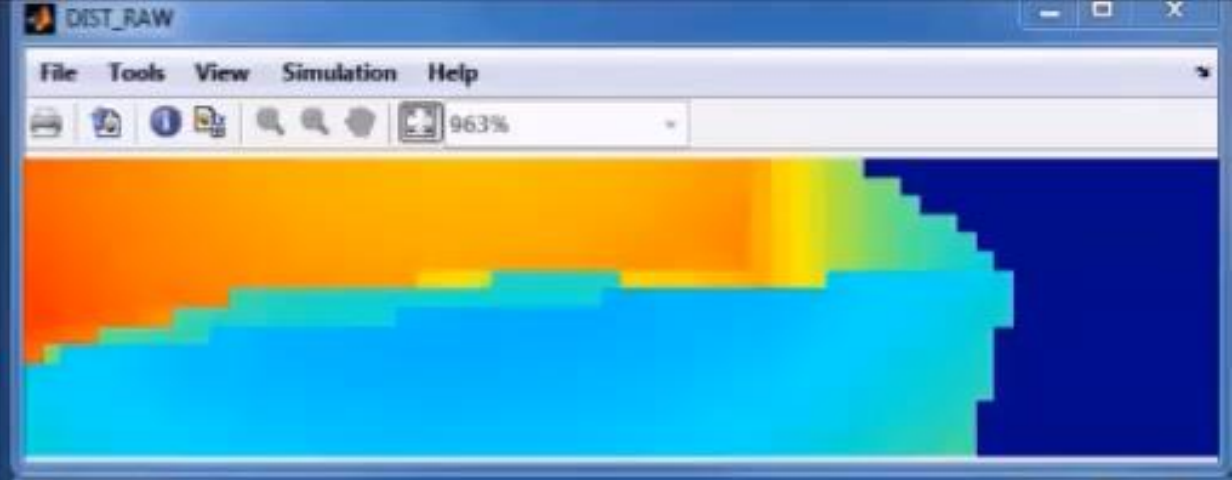
Perceive

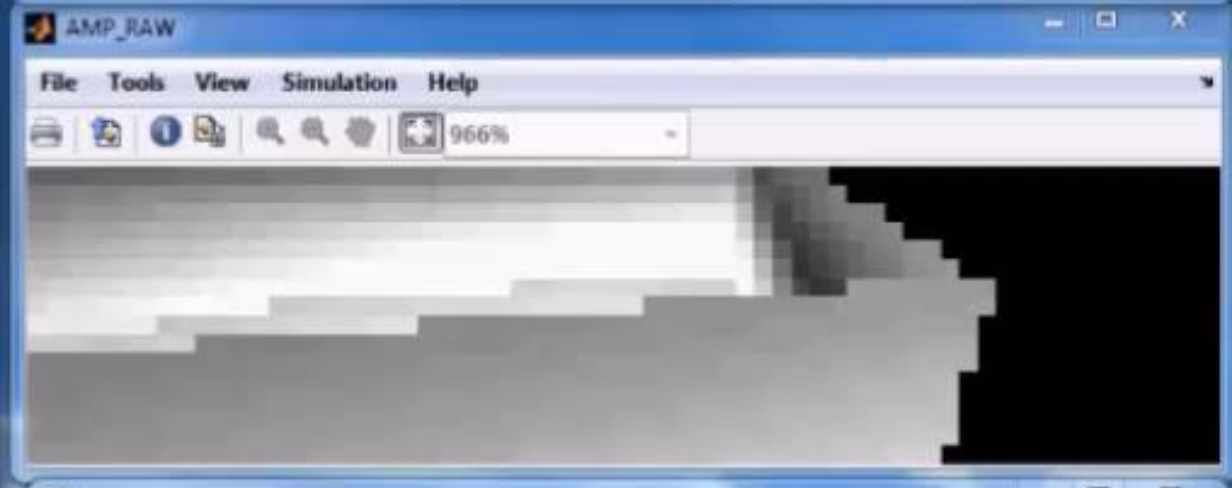
Decide & Plan

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 Camera

Embedded Platform
MPC5121e

- User Input
- Visualization

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

Embedded Coder

CAN

Actuators

ECU

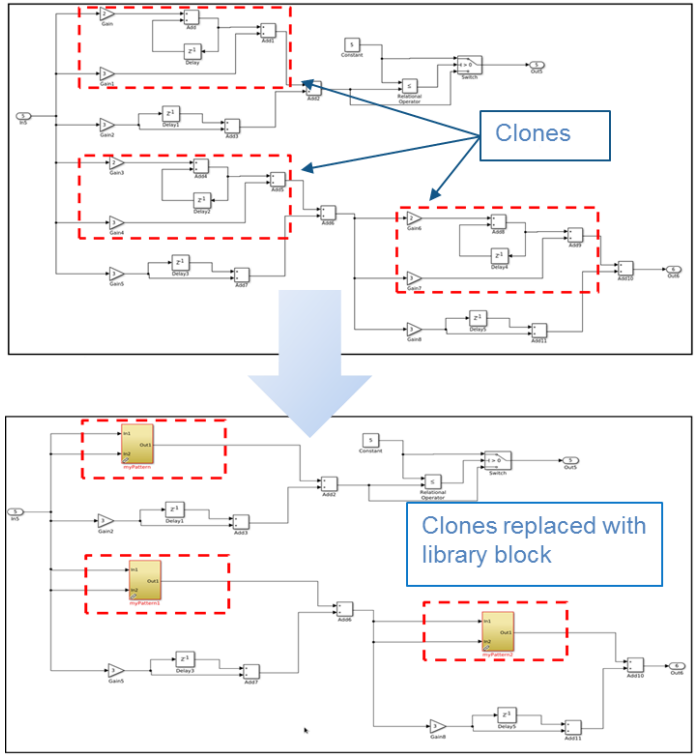
Computer vision and controls algorithms

How will you put it into production?

- Embedded Systems
- IT Systems
- Cloud
- Desktop Apps

Investments in Model-Based Design

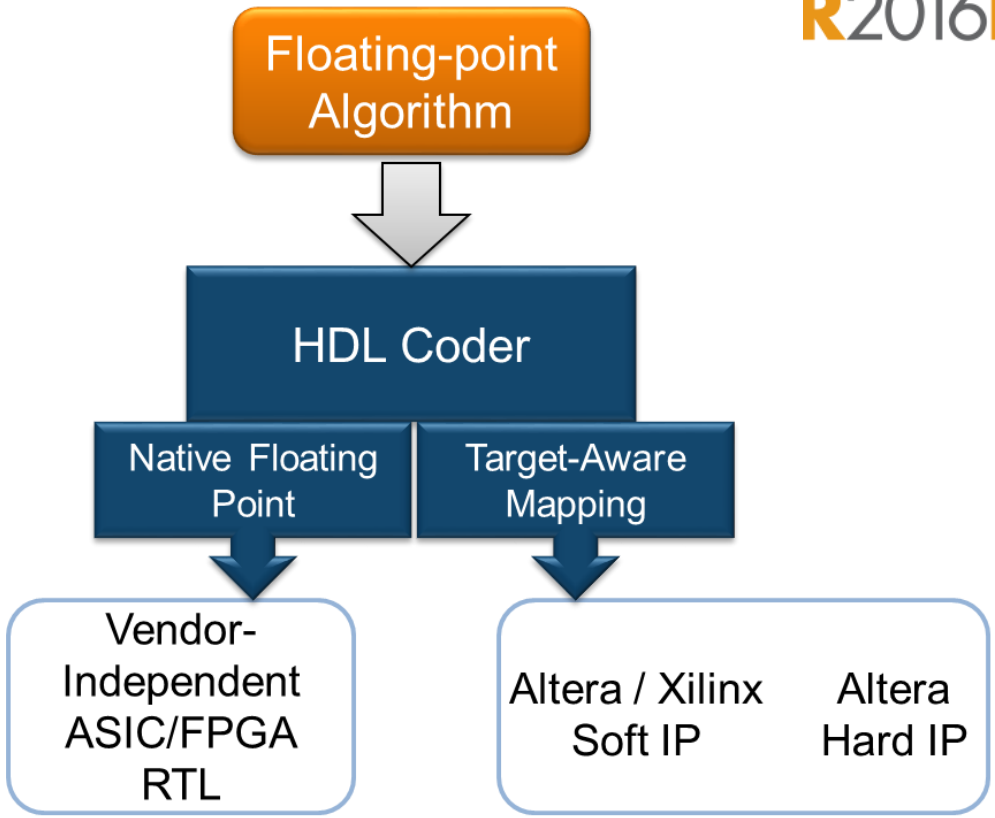
Efficient code generation



R2017a

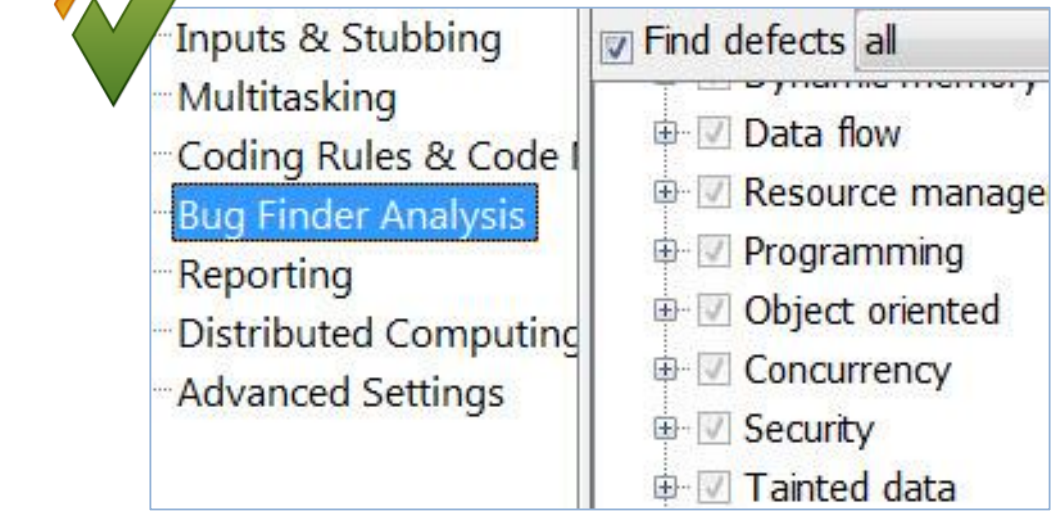
Floating-point HDL code generation

R2016b



Investments in Model-Based Design

Code verification in support of CERT C standard

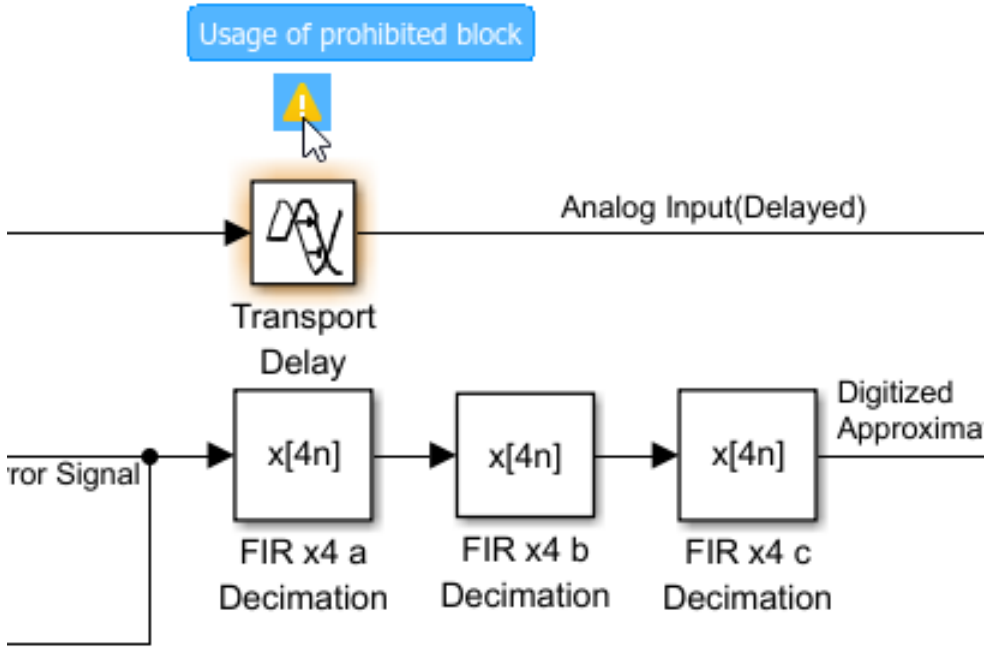



```
if (output_v7 >= 0) {
    saved_values[output_v7] = s8_ret;
    return s8_ret
}
return reset_temp
```

Assignment to element of static array (int 16): [-32 .. 112]
array size: 127
array index value: [0 .. 555]

CERT C	Description	Polyspace Code Prover
ARR30-C	Do not form or use out-of-bounds pointers or array subscripts	Array access out of bounds

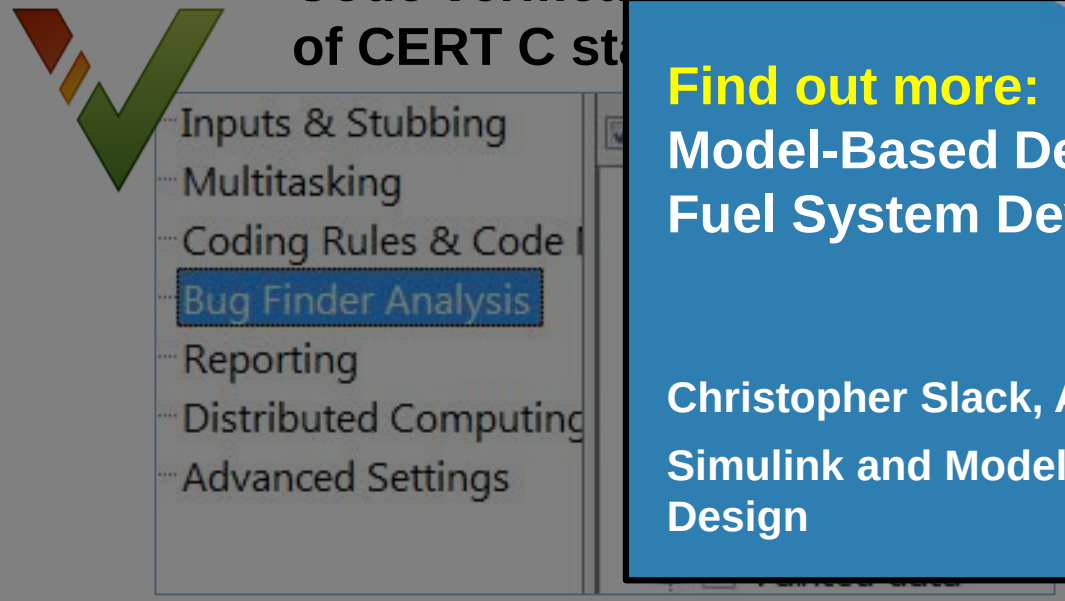
Detect and fix standards compliance issues at design time



R2016b

Investments in Model-Based Design

Code verification in support of CERT C st




```
if (output_v7 >= 0) {
    saved_values[output_v7] = s8_ret;
    return s8_ret
}
return reset_temp
```

Assignment to element of static array (int 16): [-32 .. 112]
array size: 127
array index value: [0 .. 555]

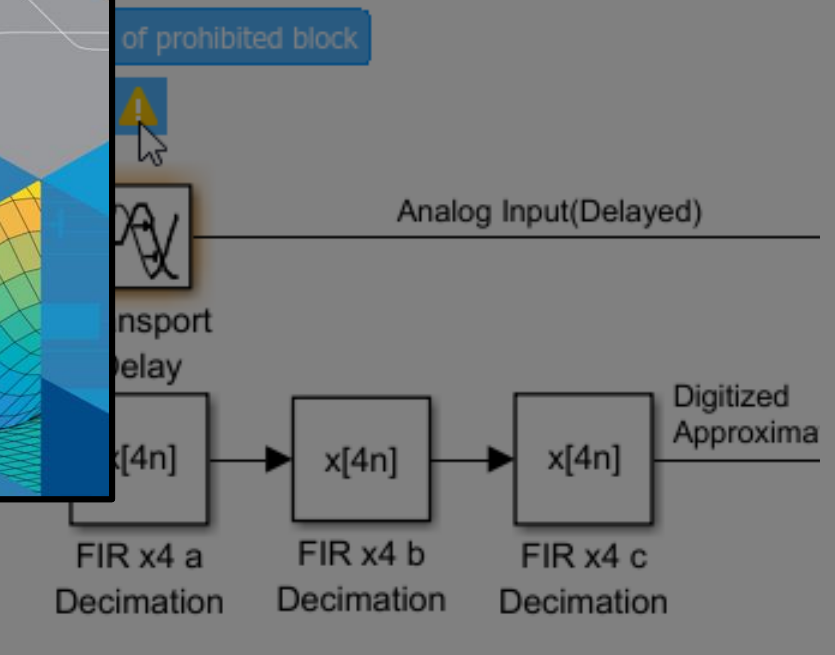
CERT C	Description	Polyspace Code Prover
ARR30-C	Do not form or use out-of-bounds pointers or array subscripts	Array access out of bounds

Find out more:
Model-Based Design for Fuel System Development

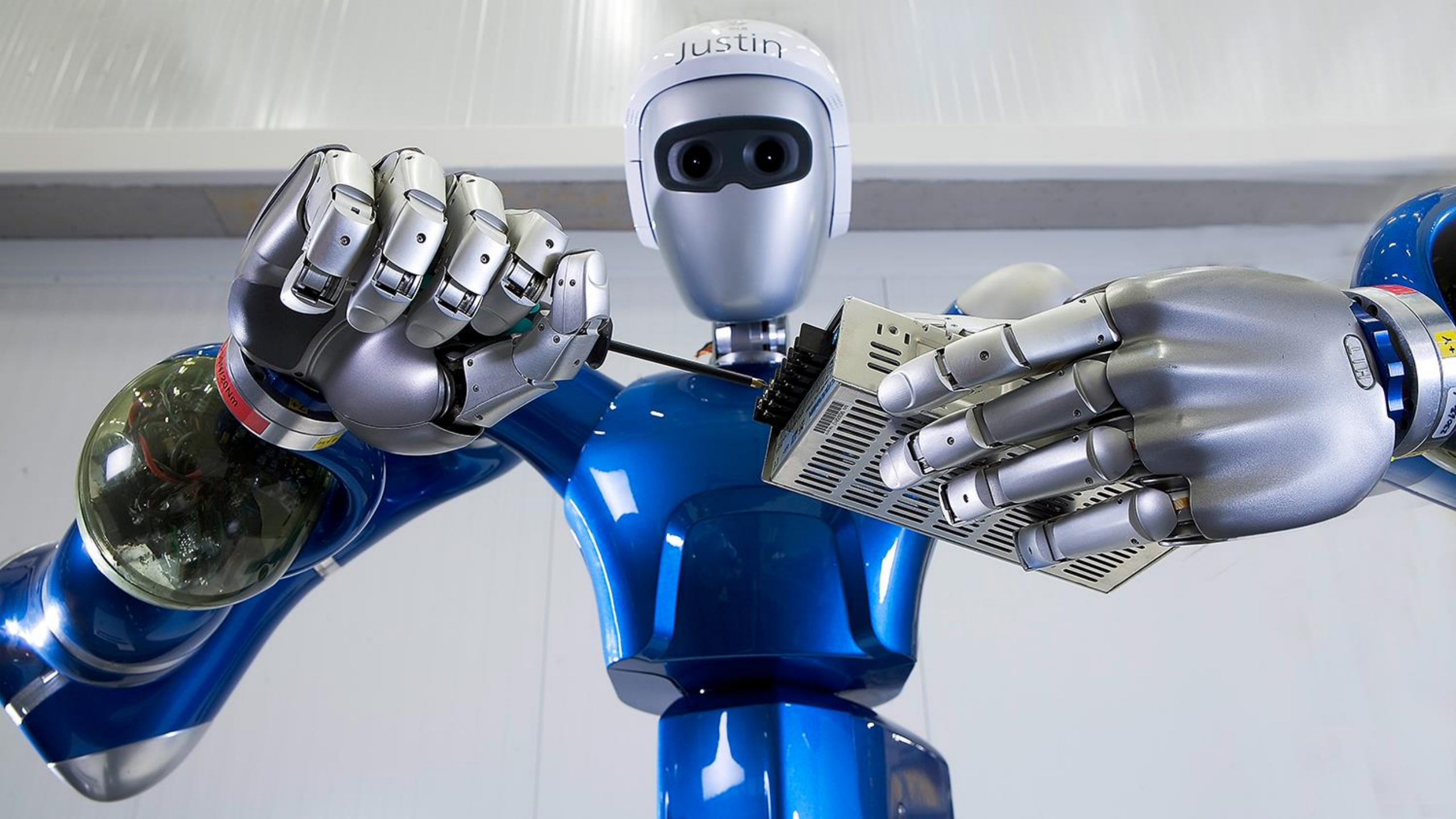
Christopher Slack, Airbus

Simulink and Model-Based Design

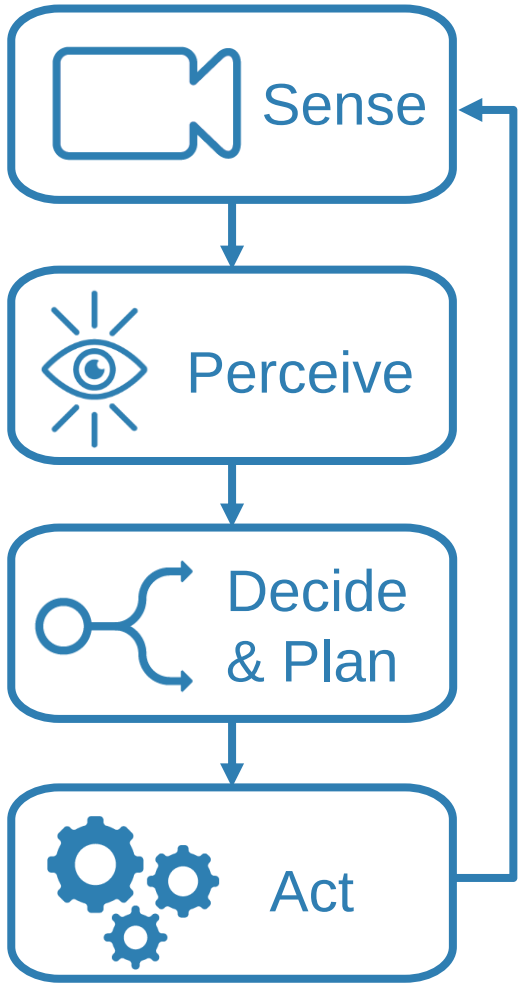
Detect and fix standards compliance design time

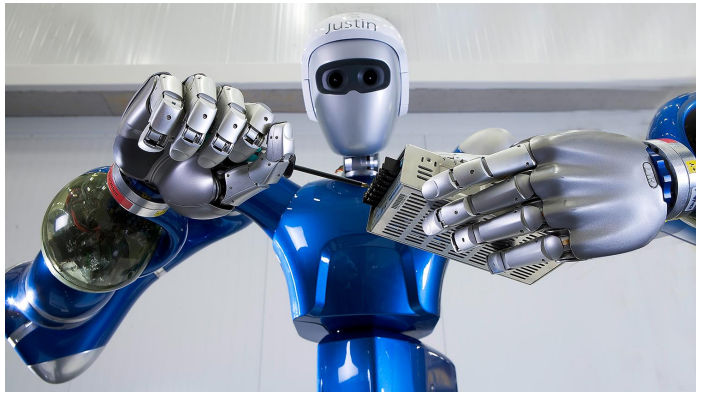


R2016b


Justin

Capabilities of an Autonomous System





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
Flow to Production	• Address the architecture • Leverage Model-Based Design for embedded • Automate integration with enterprise IT systems

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