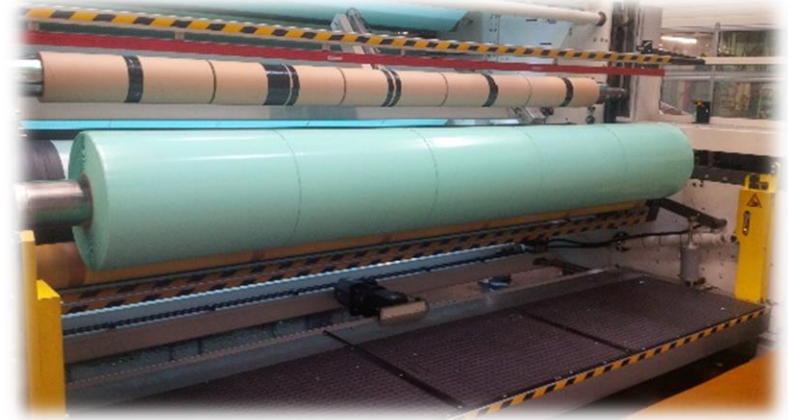


# MATLAB EXPO 2016

## The Rise of Engineering-Driven Analytics

*Phil Rottier*  
*MathWorks UK Consulting*





# The Rise of Engineering-Driven Analytics



# Analysis



Apply robust, statistically-motivated methods to data produced from complex systems to understand what has happened and why, predict what will happen

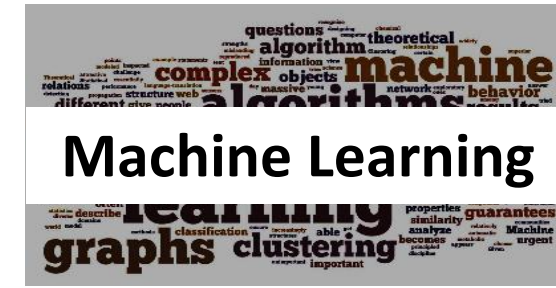
# Analytics



Apply robust, statistically-motivated methods to data produced from complex systems to understand what has happened and why, predict what will happen, suggest decisions or actions.

Decision  
Support

Decision  
Automation



## Analytics are pervasive – *Why Now?*

### We have data

- Engineering
- Business
- Transactional

### We have compute

- Desktop  
Multicore, GPU
- Clusters
- Cloud computing
- Hadoop with Spark

### We know how

- Neural Networks
- Classification
- Clustering
- Regression
- ...and much more...

# Analytics in e-commerce



**Engineering Data**



Images



**Business Data**

Social profile

Geolocation

Keystroke logs

Transactions

Use **Image Processing**

to add image data to the model,  
improving performance

**IMPROVED  
Predictive  
Model**

**Improved  
Offer to  
Customer**

# Consider the *Data* in Data Analytics



**Engineering Data**

Video

Audio

Images

Sensor



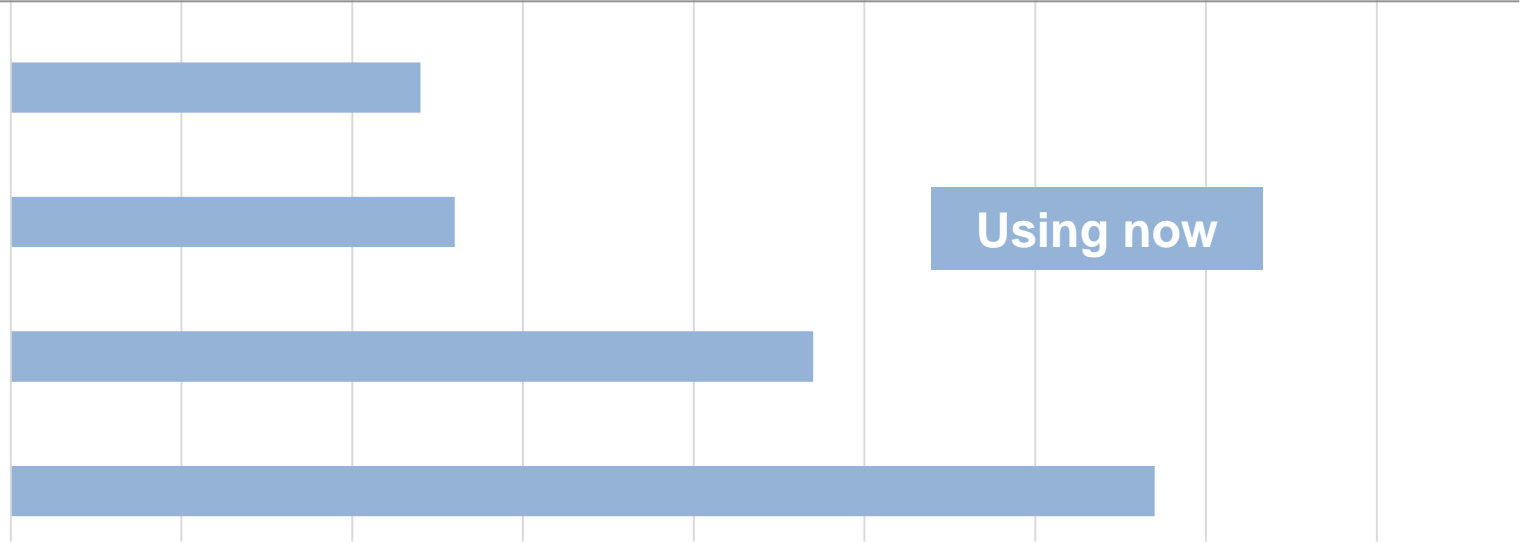
**Business Data**

Social profile

Geolocation

Keystroke logs

Transactions



**Using now**

*Level of Industry / User Adoption*

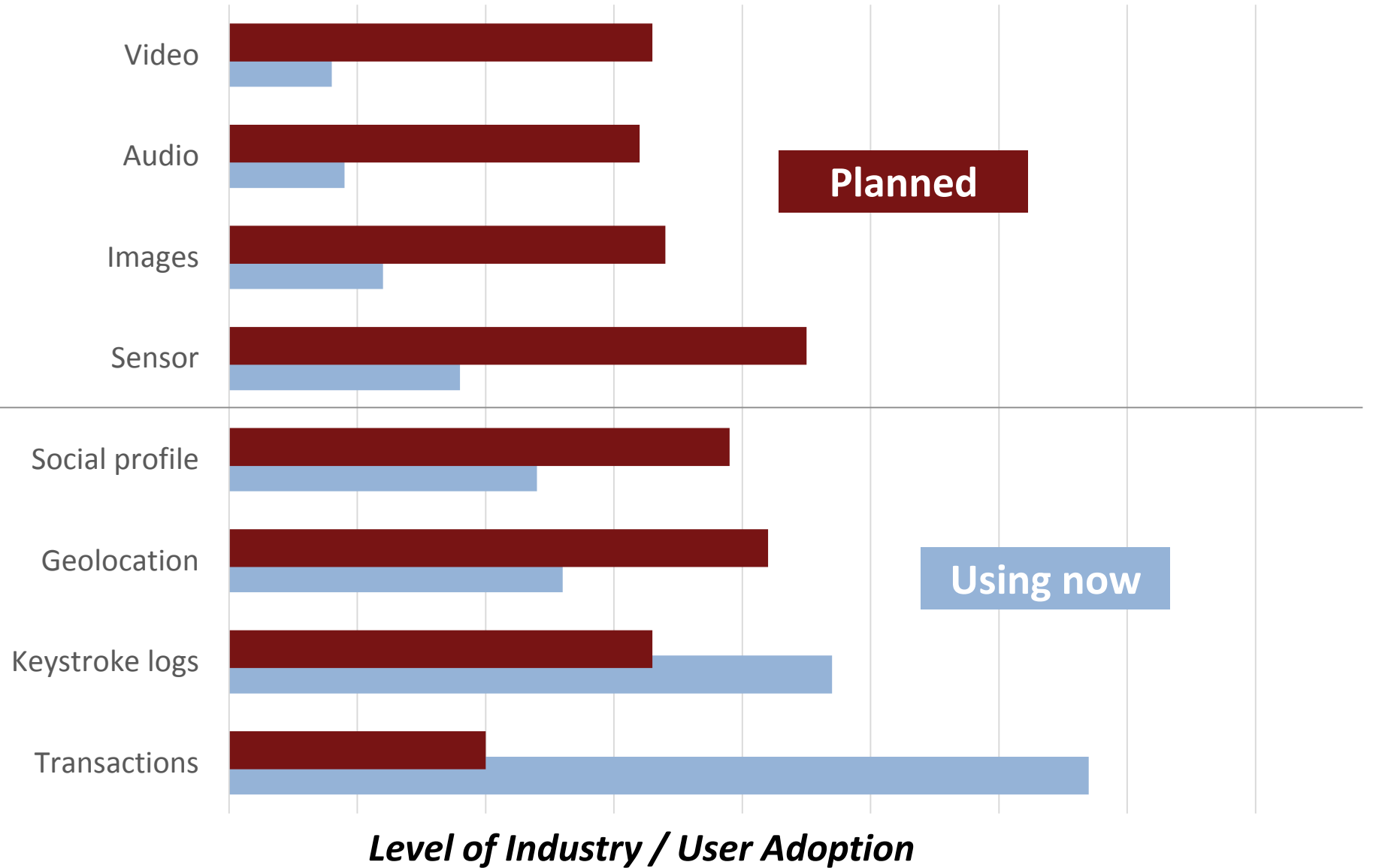
# Consider the *Data* in Data Analytics



**Engineering Data**



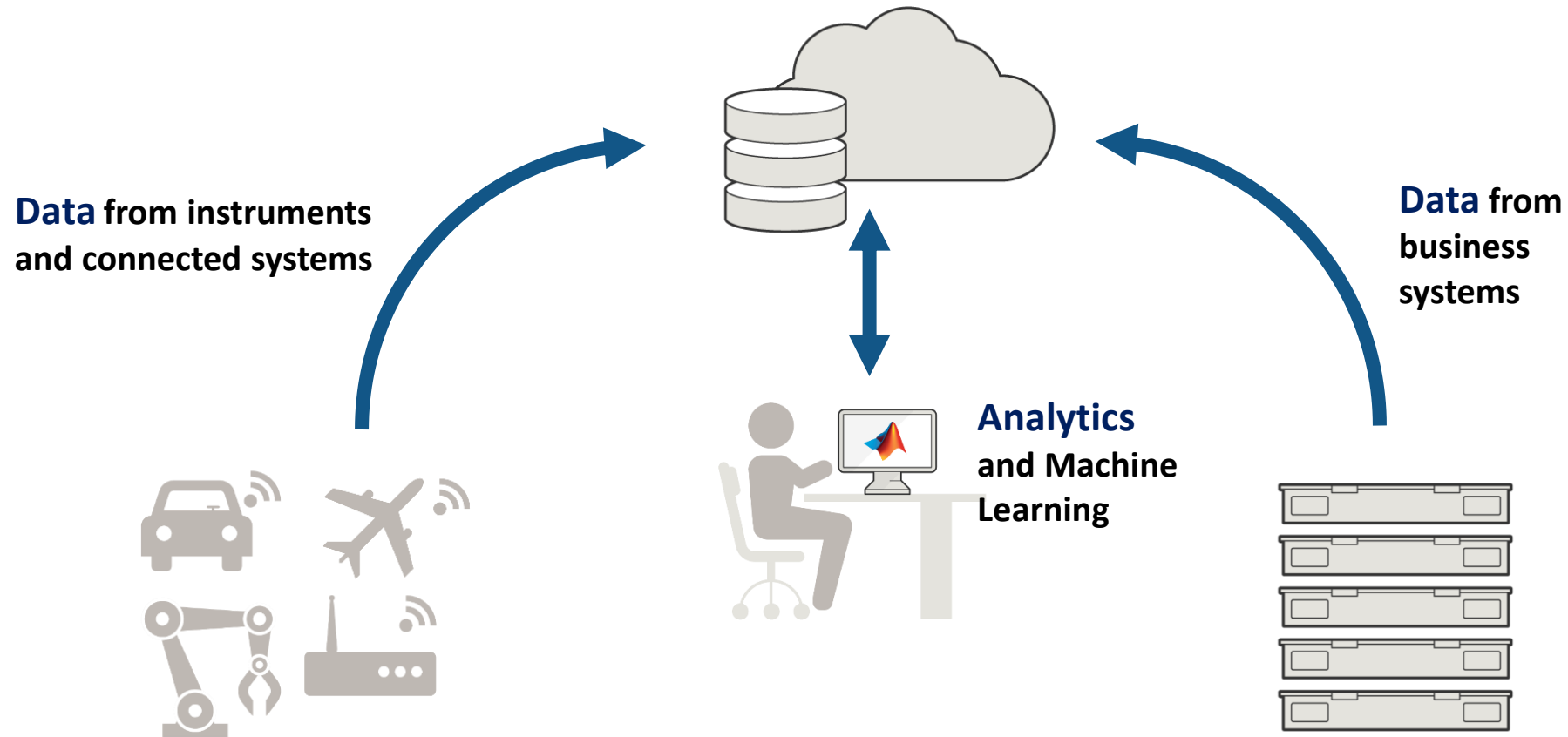
**Business Data**



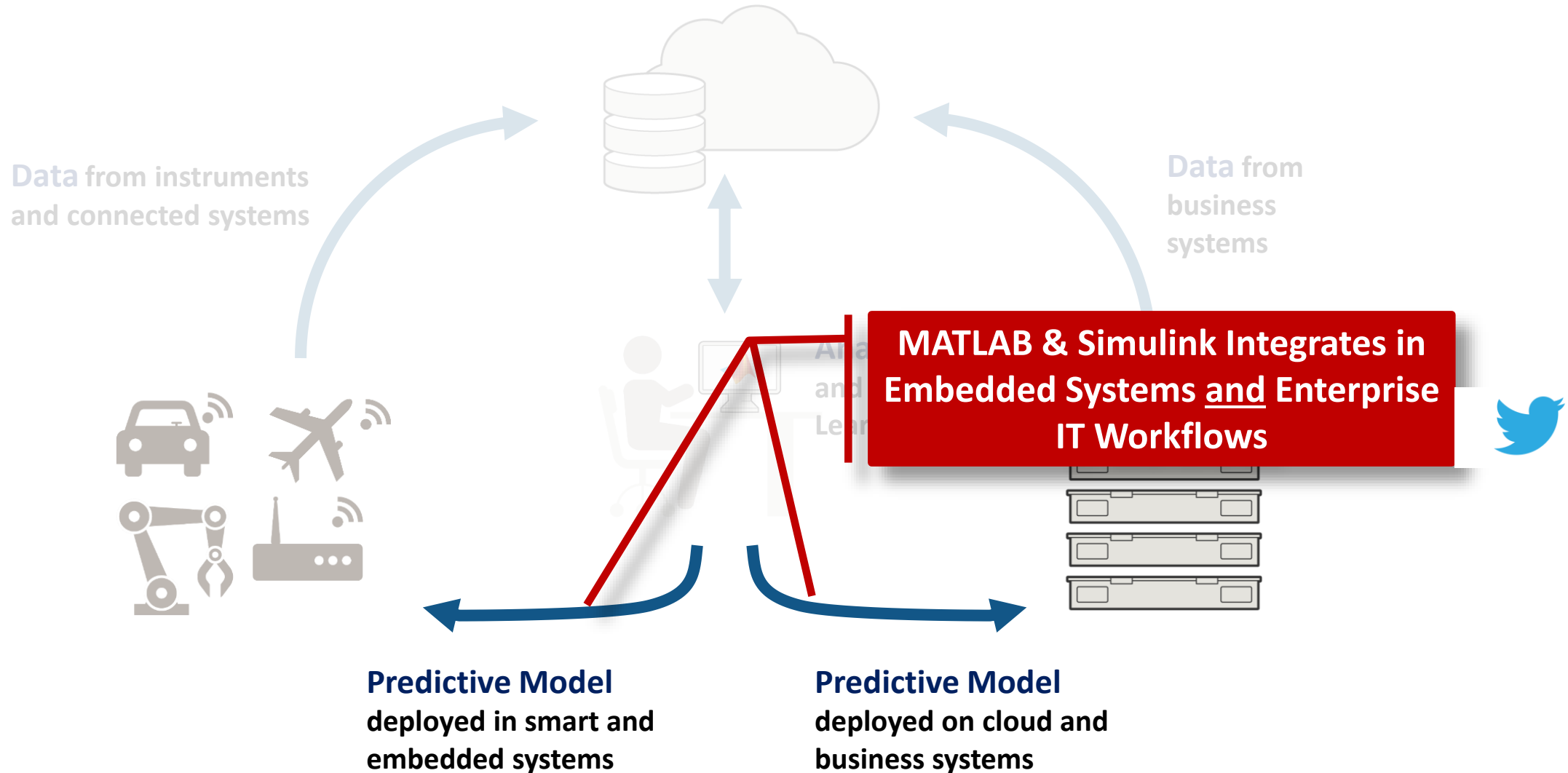


# The Rise of **Engineering-Driven Analytics**

# Architecture of an analytics system

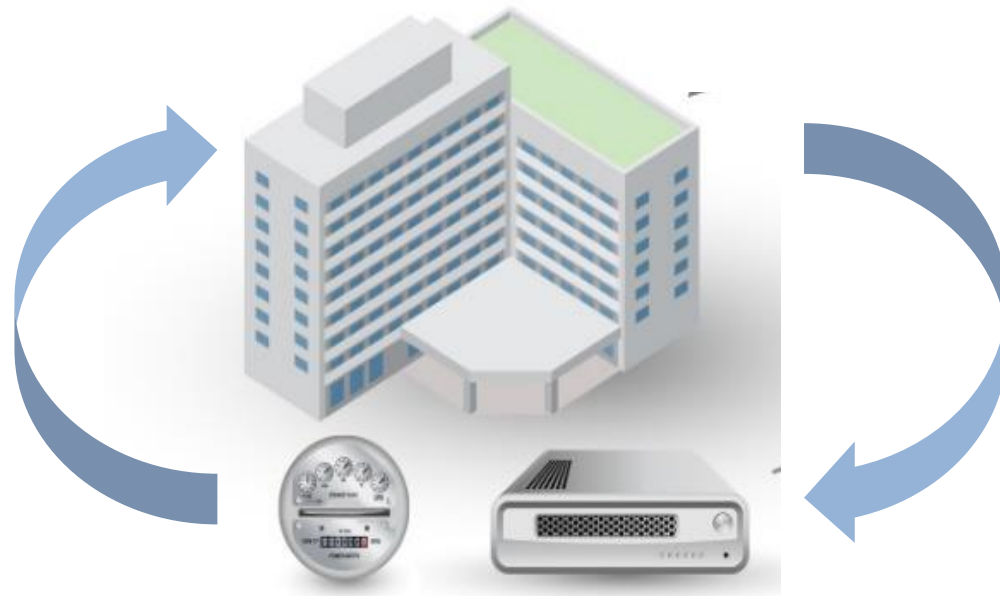


# Architecture of an analytics system



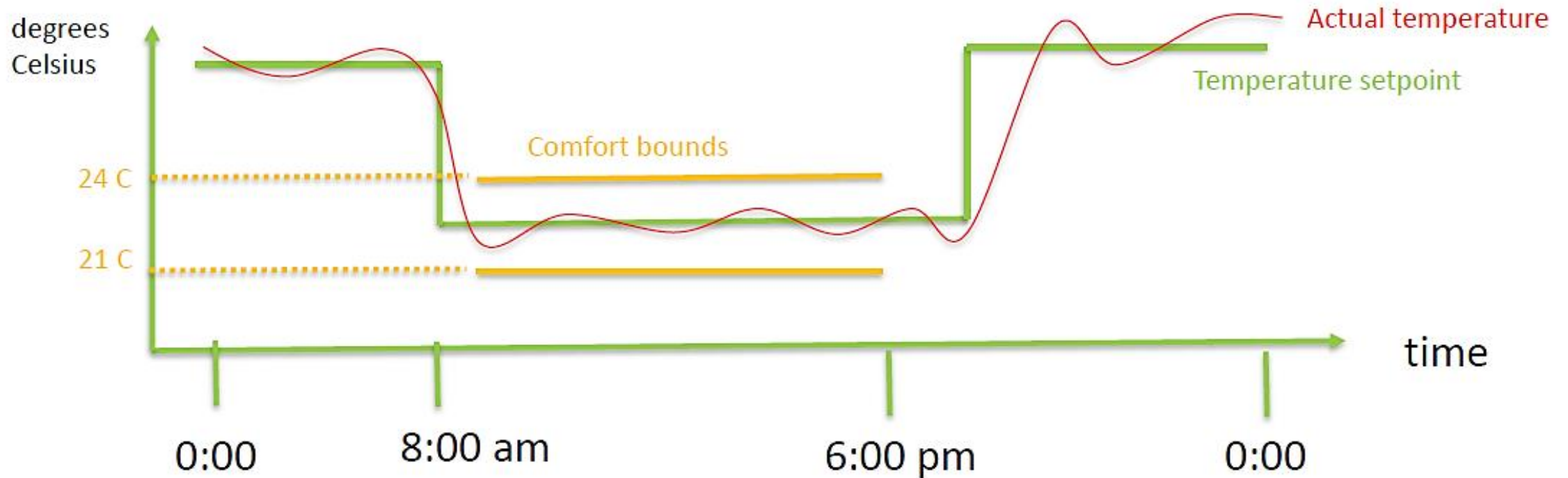
# Example – BuildingIQ

## Adaptive building energy management



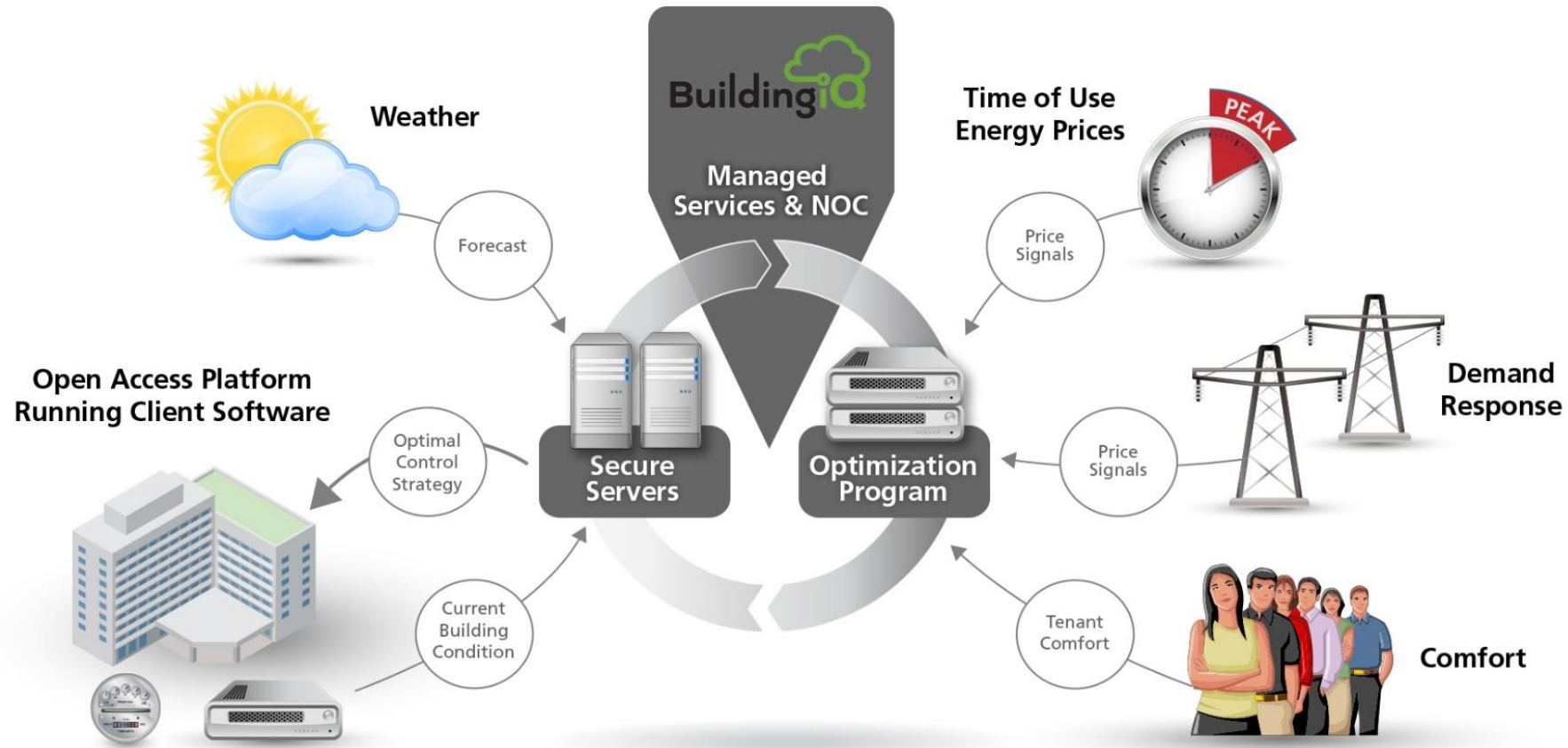
# Example – BuildingIQ

## Adaptive building energy management

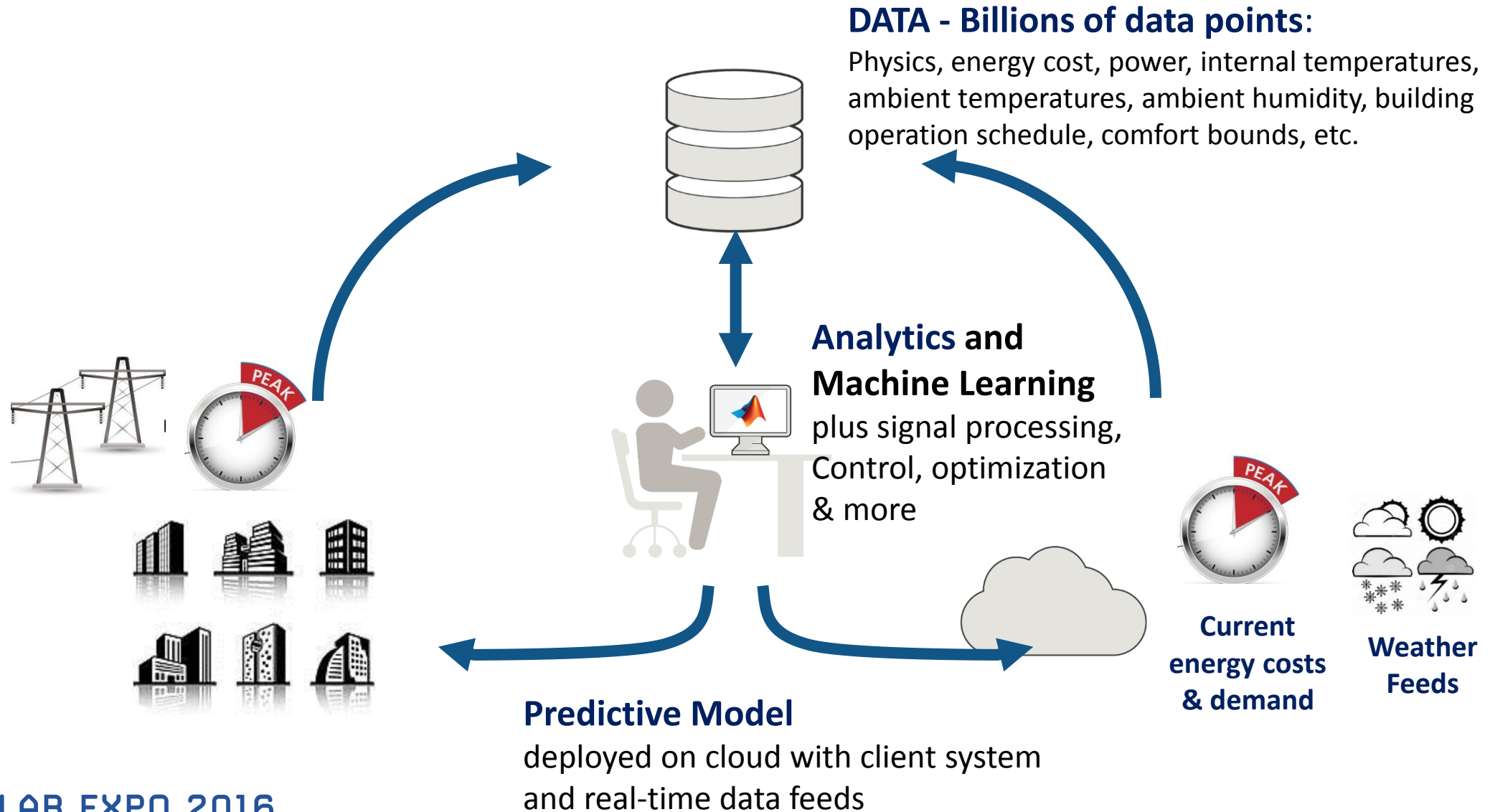


# Example – BuildingIQ

## Adaptive building energy management

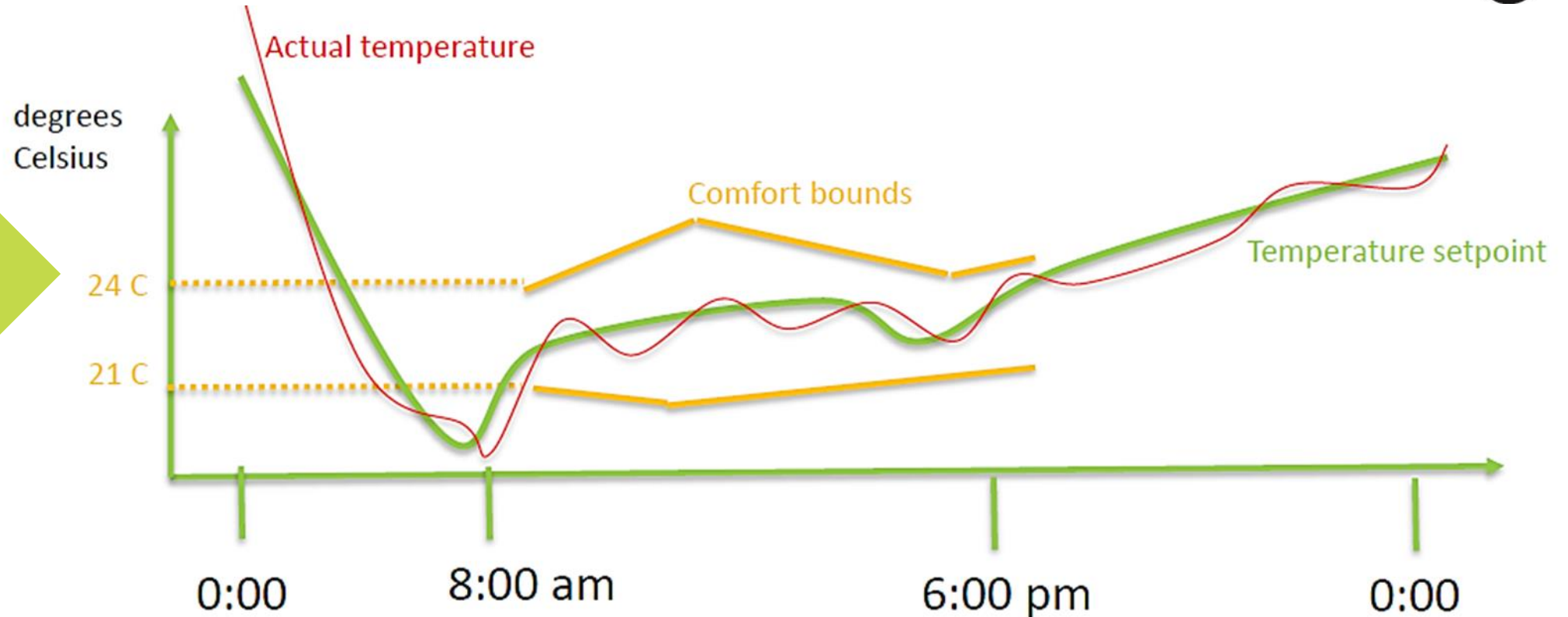


# Real-time, closed-loop optimization algorithms



# Example – BuildingIQ

## Adaptive building energy management



10% to 25%  
cost  
reduction



# Why MATLAB?

- **Robust numerical algorithms**
- Extensive visualization and analytics tools
- Industry-robust and **reliable mathematical optimization** routines
- Good object-oriented framework
- Ability to interface with Java (for backend work)
- Running MATLAB in the cloud in **production**
- Unit-testing framework



We could rapidly translate our prototypes into production algorithms that deal reliably with real-world noise and uncertainty

*Borislav Savkovic, BuildingIQ*

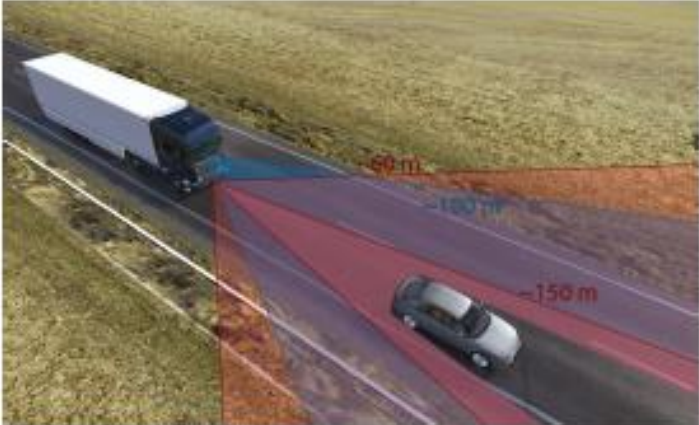
**50 km/h - sudden brake**



# Example – Scania

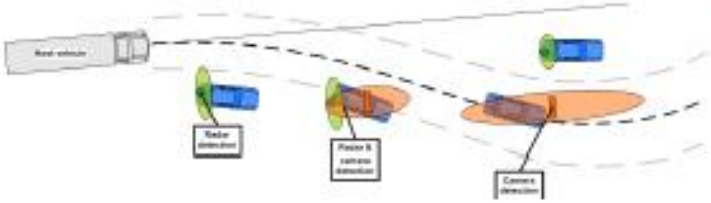
## Automatic emergency braking using sensor fusion and analytics

**Sensor fusion**  
**Two sensors -> One "truth"**




Sensors have different advantages

- Radar
  - + Range (longitudinal)
  - + Relative velocity
  - + Solid object reflection
  - No shapes
  - Lateral position
- Camera
  - + Object type
  - + Object width
  - + Lateral position
  - Range
  - Optical illusions

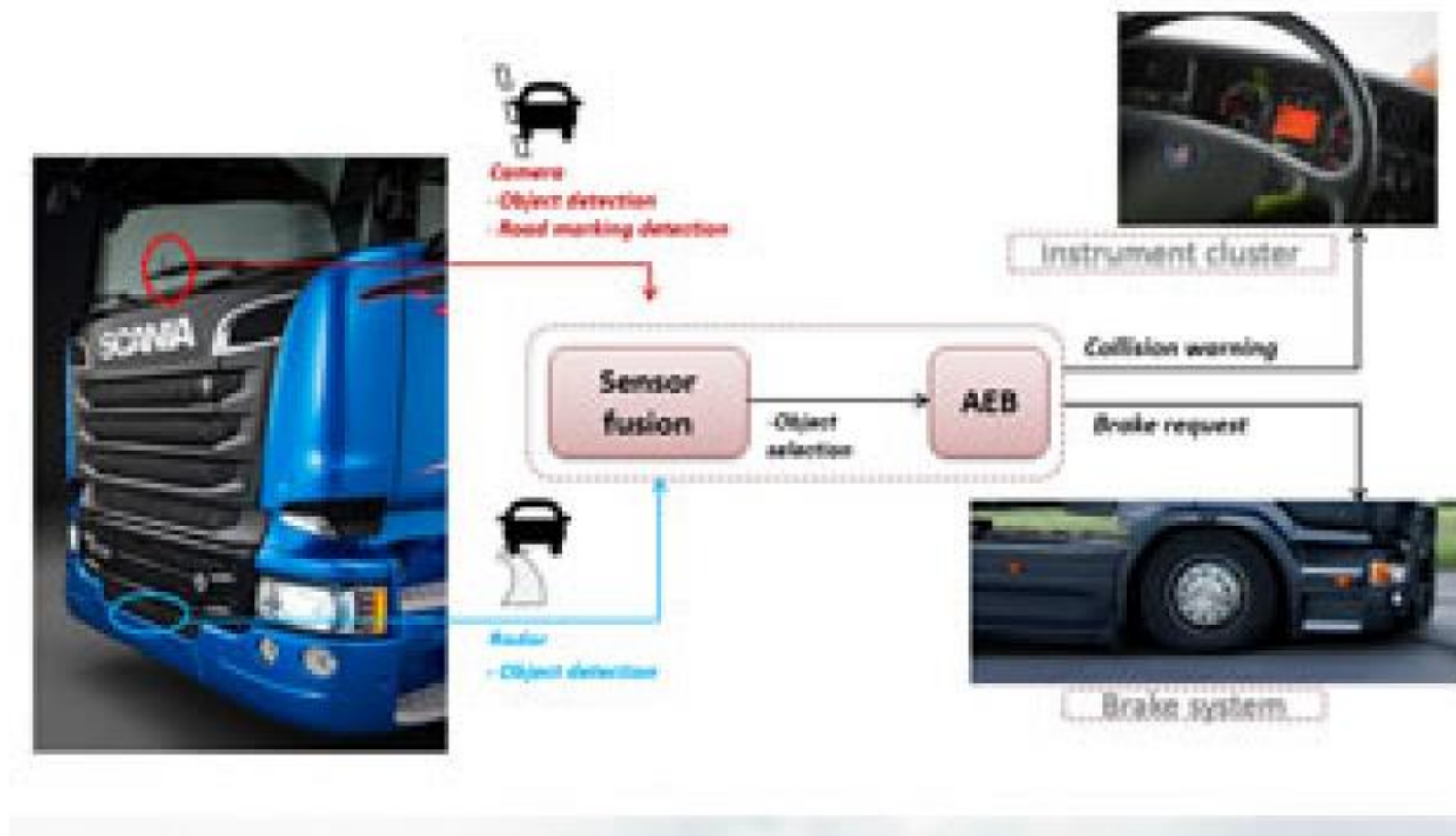


2015-09-24 Jonny Andersson



# Example – Scania

## Automatic emergency braking using sensor fusion and analytics

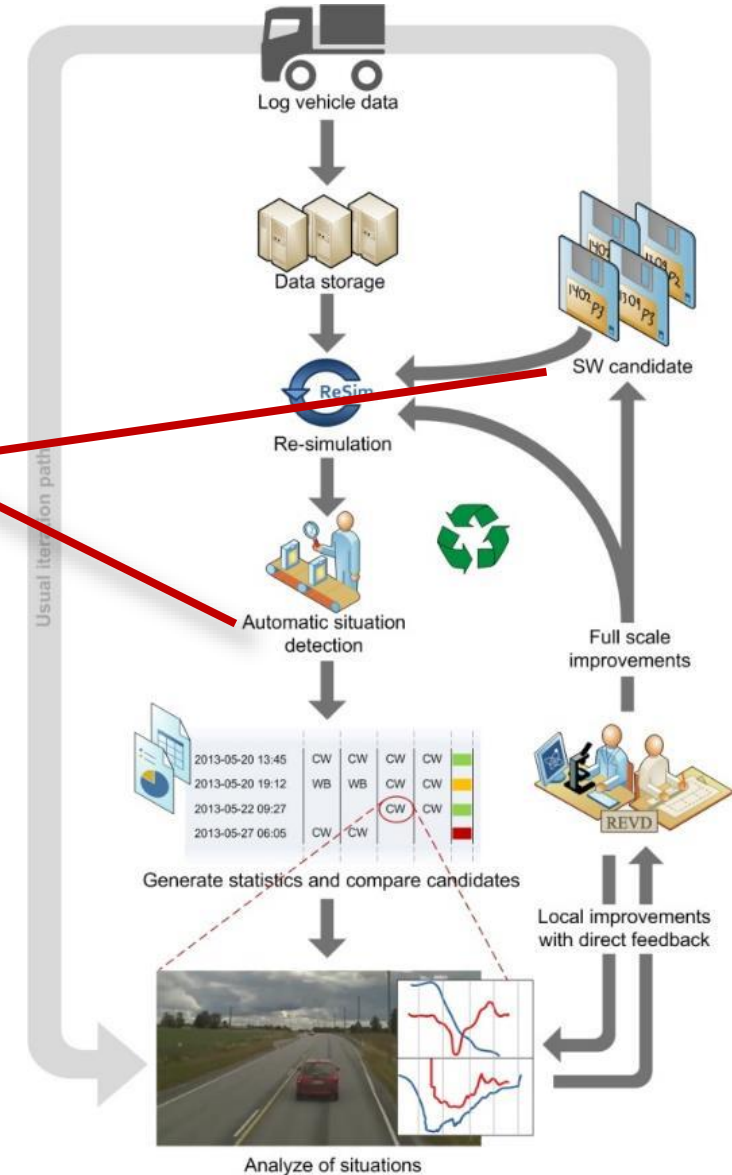


# Using Model-Based Design

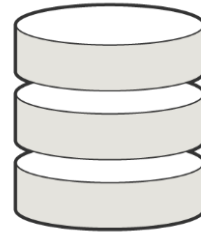
to build and deploy the analytics  
in an embedded control system



**MATLAB Integrates Analytics and Model-Based Design**



# Implementing Sensor Fusion at Scania



**Machine learning**  
to develop fusion algorithms  
for situation detection

2013-05-20 13:45	CW	CW	CW	CW	Green
2013-05-20 19:12	WB	WB	CW	CW	Yellow
2013-05-22 09:27	CW	CW	CW	CW	Green
2013-05-27 06:05	CW	CW	CW	CW	Red

Generate statistics and compare candidates



Analyze of situations

**Vehicle logs**  
of video and radar data

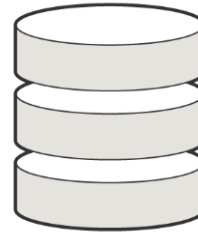
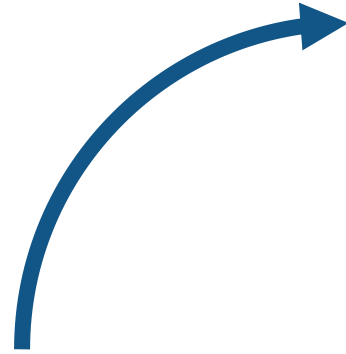


**Predictive Model**  
deployed on vehicle



# Predictive Maintenance for polymer-based production machines

Sensor Data (~1 minute)  
10s-100s sensors/machine  
Quality State (~40 minutes)



1 TIMESTAMP	2 PARAMETER										3 STATE
'2015-07-14 00:49:12.0'	160	160	160	160	1000	7	1000	9	33	32	1
'2015-07-14 00:50:12.0'	160	160	160	160	1000	8	1000	10	33	32	1
'2015-07-14 00:51:13.0'	160	160	160	160	1000	8	1000	10	33	32	1
'2015-07-14 00:52:12.0'	160	160	160	160	1000	8	1000	10	33	32	1
'2015-07-14 00:53:12.0'	160	160	160	160	1000	8	1000	11	33	32	2
'2015-07-14 00:54:12.0'	160	160	160	160	1000	8	1000	12	33	32	2
'2015-07-14 00:55:12.0'	160	160	160	160	1000	8	1000	10	33	32	2

## Classification using Statistics, Machine Learning, and Neural Networks

### Nearest Neighbor Classification

### Support Vector Machines (SVMs)

### Naive Bayes Classification

### Neural Networks

# Deployment – a MATLAB App used by machine operators



OK





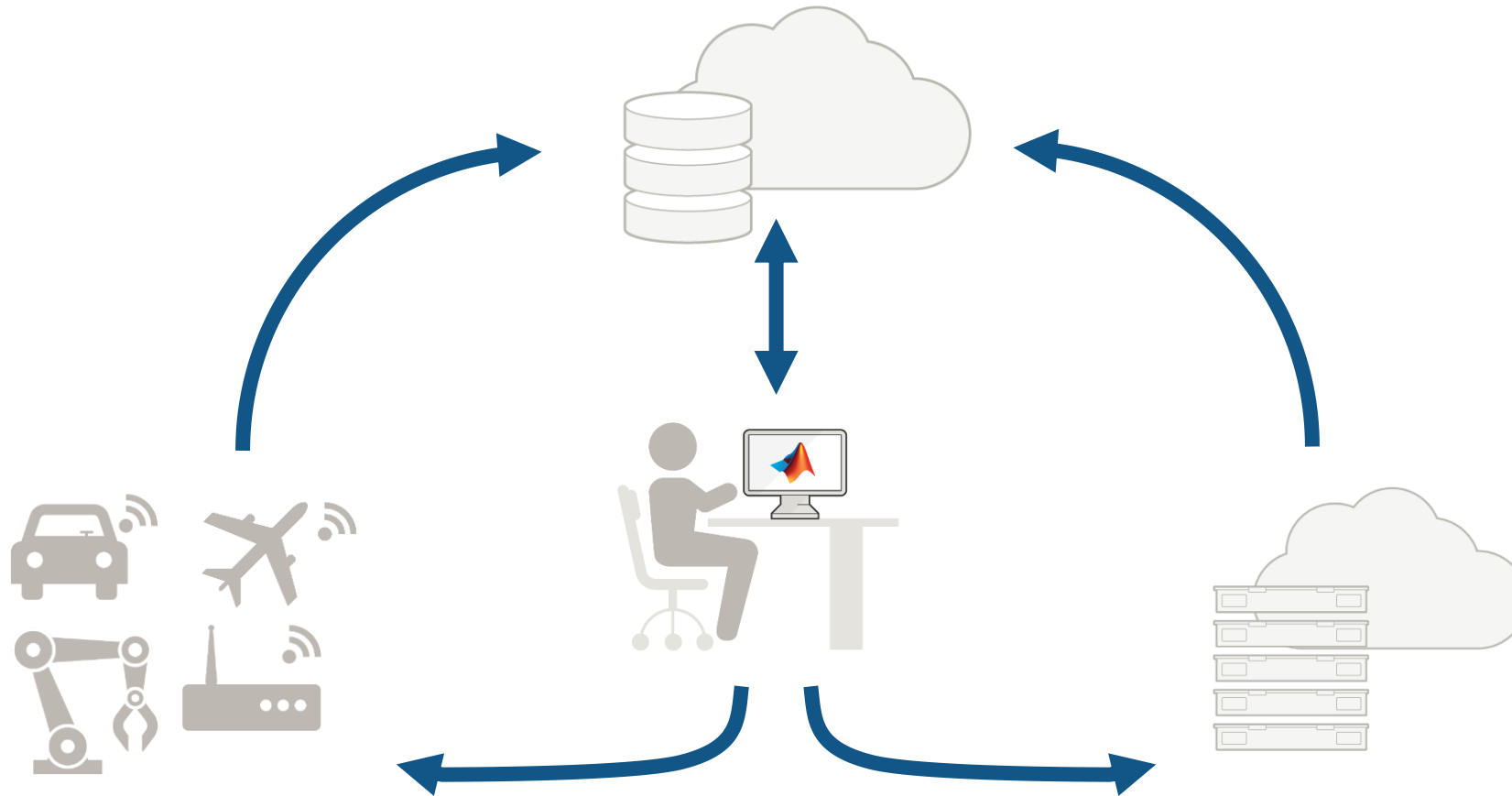
# Deployment – a MATLAB App used by machine operators

“Our financial control department determined that we are saving more than 50,000 euros per year by using MATLAB for predictive maintenance,” says Dr. Kohlert. “That total is based on just eight machines. We expect that to increase at least fourfold as we analyze the data from more of our machines.”

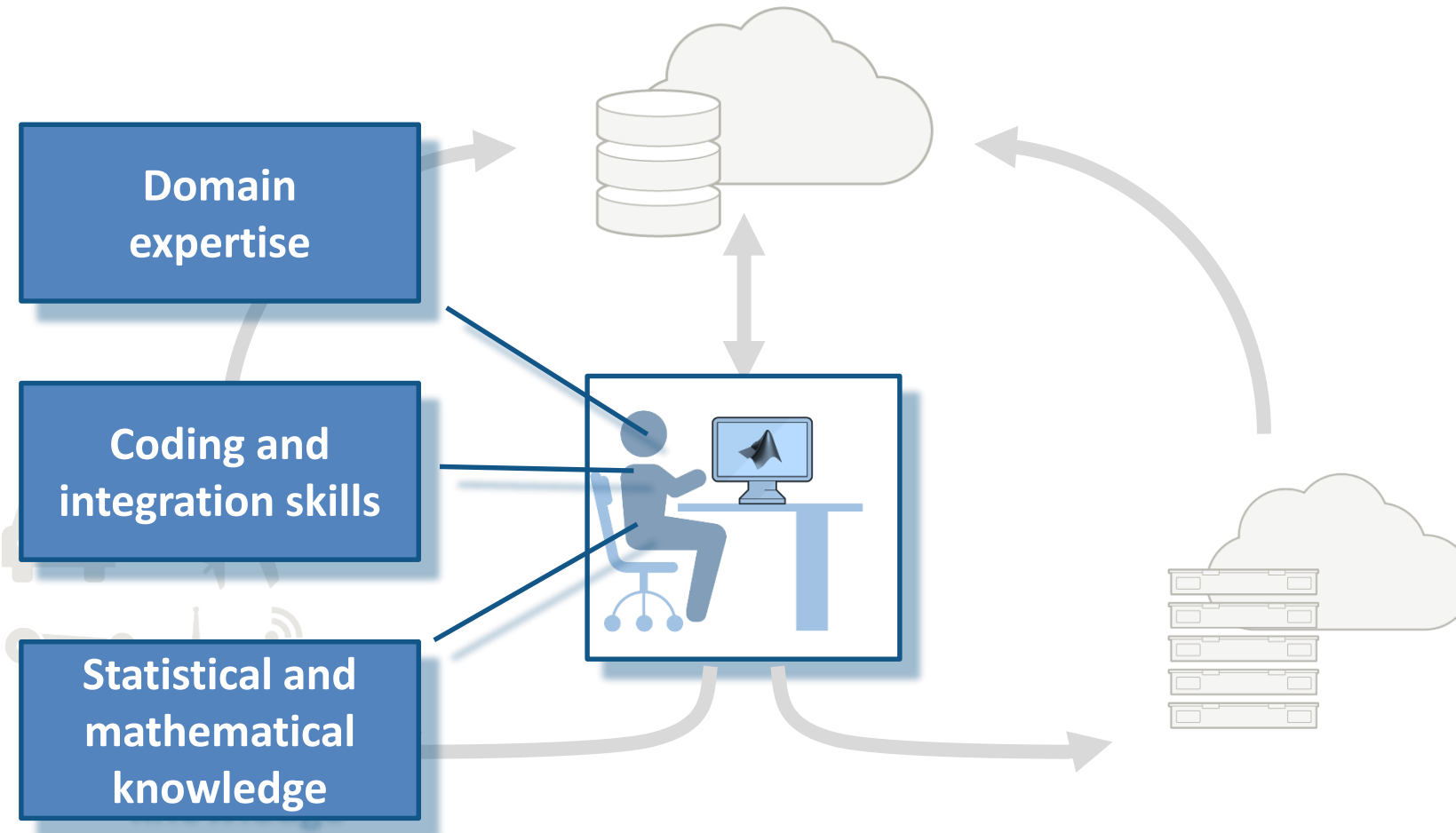


NOT OK

# Architecture of an analytics system



# The need for data scientists



**Essential Guide**

IoT analytics guide: Understanding Internet of Things data  
A comprehensive collection of articles, videos and more, hand-picked by our editors

## Shortage of data scientists, big data pros vexes IoT efforts

CRUNCH NETWORK

# How To Stem The Global Shortage Of Data Scientists

Posted Dec 31, 2015 by [Amy Gershkoff \(@amygershkoff\)](#)

## Big data talent shortage: How to bridge the gap?

By [Abhishek Raval](#) on May 29, 2015

### What they say

- Expand university programs
- Train existing analysts

**coursera** [Catalog](#)  [Institutions](#) [Log In](#) [Sign Up](#)

**HIGHER SCHOOL OF ECONOMICS**  
NATIONAL RESEARCH UNIVERSITY

## Core Concepts in Data Analysis

Learn both theory and application for basic methods that have been invented either for developing new concepts – principal components or clusters, or for finding interesting correlations – regression and classification. This is preceded by a thorough analysis of 1D and 2D data.

CALIFORNIA INSTITUTE OF TECHNOLOGY

## LEARNING FROM DATA

Machine Learning course - recorded at a live broadcast from Caltech

**HIGHLIGHTS**

A real Caltech course, not a watered-down version

**Featured on**

- [\[Home\]](#)
- [The lectures](#)
- [Homework](#)
- [Textbook](#)
- [Forum](#)

**coursera** [Catalog](#)  [Institutions](#) [Log In](#) [Sign Up](#)

## Machine Learning

Stanford University

[Course Info](#)

**coursera** [Catalog](#)  [Institutions](#) [Log In](#) [Sign Up](#)

**BD2K LINC DATA COORDINATION AND INTEGRATION CENTER**

## Big Data Science with the BD2K-LINCS Data Coordination and Integration Center

Learn various methods of analysis including: unsupervised clustering, gene-set enrichment analyses, Bayesian integration, network visualization, and supervised machine learning applications to LINCS data and other relevant Big Data from high content molecular and phenotype profiling of human cells.

**coursera** [Catalog](#)  [Institutions](#) [Log In](#) [Sign Up](#)

**UNIVERSITY of WASHINGTON**

## Computational Methods for Data Analysis

Exploratory and objective data analysis methods applied to the physical, engineering, and biological sciences.

# ThingSpeak IoT open data platform for students and makers

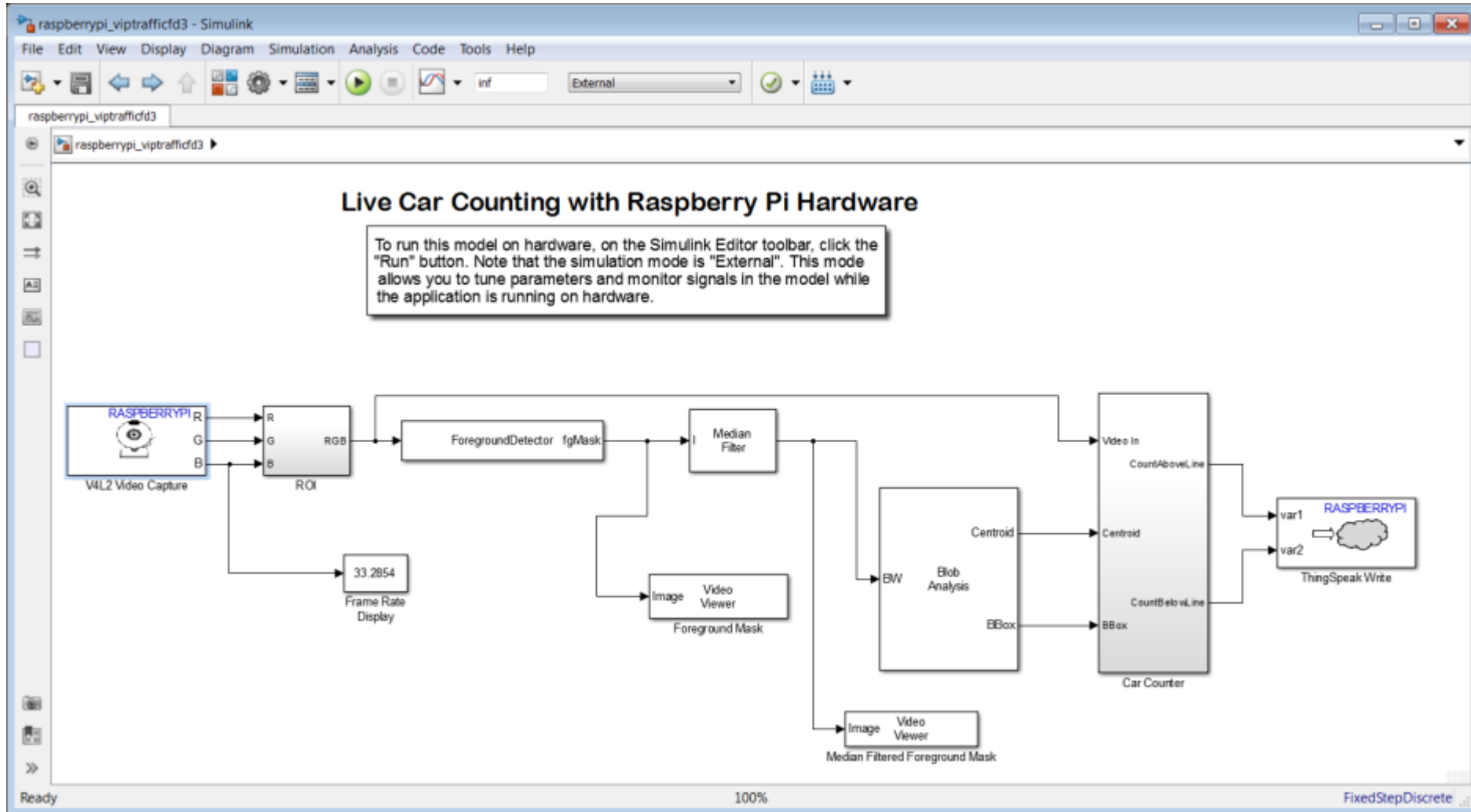
## Built-in MATLAB analysis

The screenshot shows the ThingSpeak website interface. The browser address bar displays `https://thingspeak.com/apps/matlab_analyses/templates`. The page title is "New MATLAB Analysis Templates". Under the "Templates:" section, there are four radio button options: "Custom (no starter code)", "Get data from a private channel", "Get data from a public channel", and "Get data from a webpage". A mouse cursor is hovering over the "Get data from a public channel" option. Below the templates, there is a section for "Examples: Sample code to analyze and transform data".

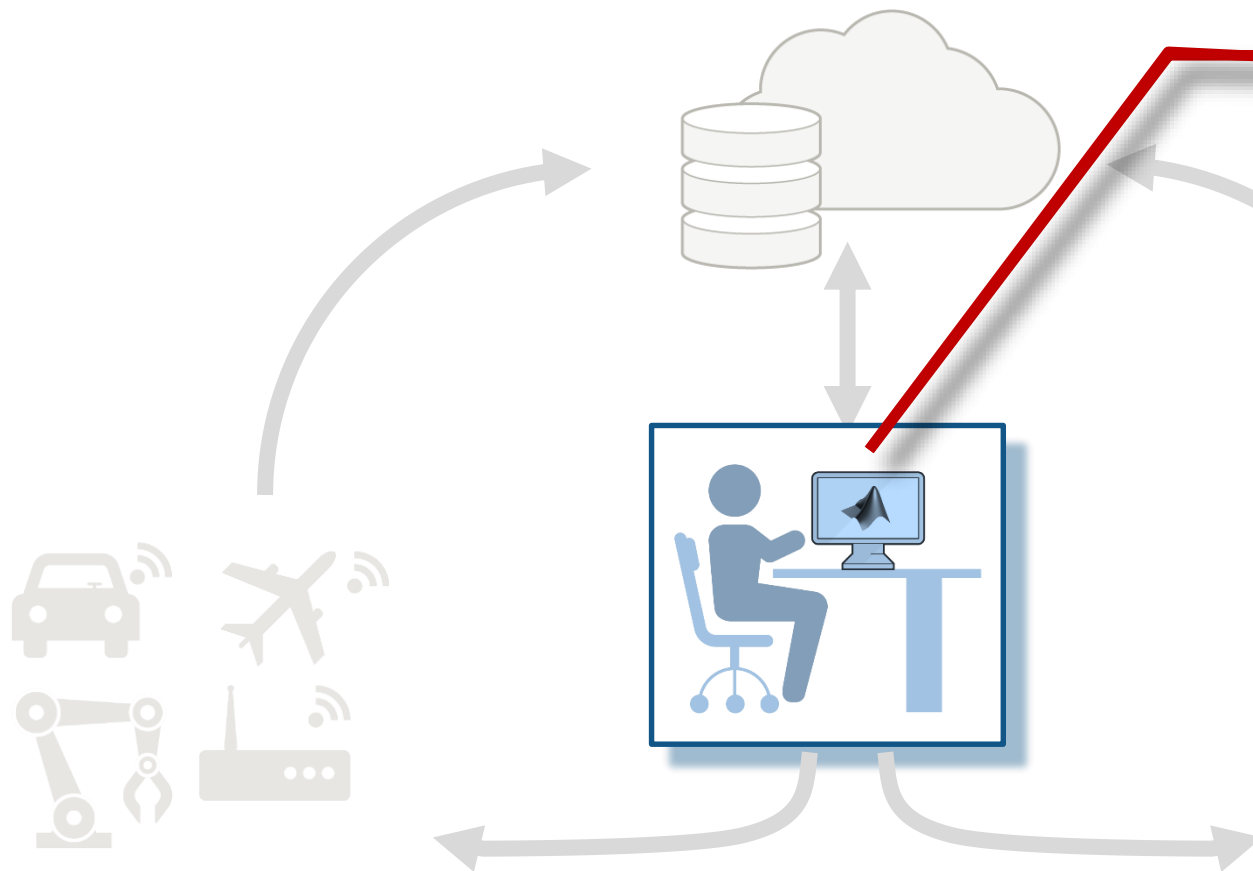
## Simulink support via Raspberry Pi

The screenshot shows a Simulink model titled "Live Car Counting with Raspberry Pi Hardware". The model is running on a Raspberry Pi. The diagram includes several blocks: "VCL2 Video Capture", "ROI", "ForegroundDetector (gibson)", "Median Filter", "Image Viewer", "Foreground Mask", "Sub-Analysis", "Car Counter", and "Raspberry Pi". A text box in the model provides instructions: "To run this model on hardware, on the Simulink Editor toolbar, click the 'Run' button. Note that the simulation mode is 'External'. This mode allows you to tune parameters and monitor signals in the model while the application is running on hardware." The output of the model is connected to a "ThingSpeak Write" block.

# ThingSpeak IoT open data platform for students and makers



# MATLAB lets you be your own data scientist



**“As a manufacturing company we don’t have data scientists with machine learning expertise, but MathWorks provided the tools and technical knowhow that enabled us to develop a production preventative maintenance system in a matter of months,”**

**Dr. Michael Kohlert, head of information management and process automation at Mondi.**

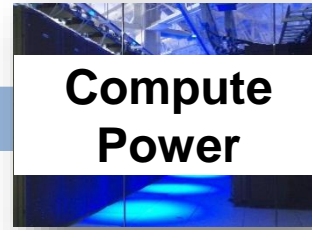


Limited users, scope, & technology



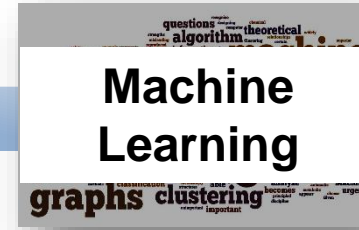
## Big Data

- Engineering
- Business
- Transactional
- Native support for engineering data
- Database interfaces
- Streaming



## Compute Power

- Desktop - Multicore, GPU
- Clusters
- Cloud computing
- Hadoop with Spark



## Machine Learning

- Neural Networks
- Classification
- Clustering
- Regression
- ...and much more...

Pervasive users, scope, & technology

In MATLAB

## NEW for MATLAB

**Audio System Toolbox** R2016a

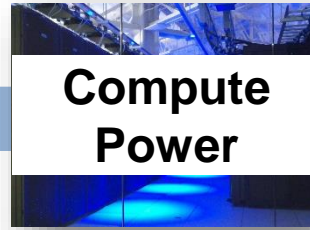
**Vision HDL Toolbox** R2015a

Limited users, scope, & technology



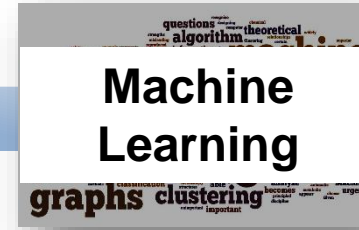
## Big Data

- Engineering
- Business
- Transactional
- Native support for engineering data
- Database interfaces
- Streaming
- Datastore  
text, image, video, Excel files
- **Timetable, string, and tall arrays 2016b**



## Compute Power

- Desktop - Multicore, GPU
- Clusters
- Cloud computing
- Hadoop with Spark



## Machine Learning

- Neural Networks
- Classification
- Clustering
- Regression

Pervasive users, scope, & technology

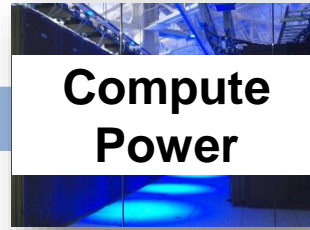
In MATLAB

Limited users, scope, & technology



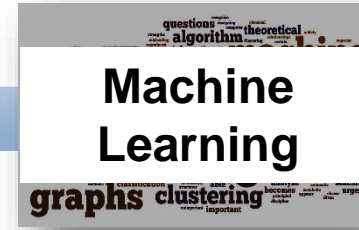
## Big Data

- Engineering
- Business
- Transactional
- Native support for engineering data
- Database interfaces
- Streaming
- Datastore  
text, image, video, Excel files
- **Timetable, string, and tall arrays 2016b**



## Compute Power

- Desktop -  
Multicore, GPU
- Clusters
- Cloud computing
- Hadoop with Spark
- Multicore & GPU
- MATLAB Distributed Computing Server and EC2 Support
- **Hadoop with Spark support R2016b**
- MATLAB Production Server



## Machine Learning

- Neural Networks
- Classification
- Clustering
- Regression

Pervasive users, scope, & technology

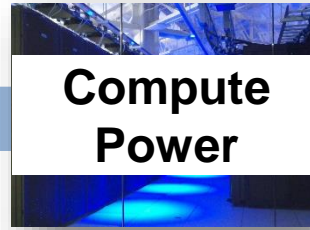
In MATLAB

Limited users, scope, & technology



## Big Data

- Engineering
- Business
- Transactional
- Native support for engineering data
- Database interfaces
- Streaming
- Datastore  
text, image, video, Excel files
- **Timetable, string, and tall arrays** 2016b



## Compute Power

- Desktop -  
Multicore, GPU
- Clusters
- Cloud computing
- Hadoop with Spark
- Multicore & GPU
- MATLAB Distributed Computing Server and EC2 Support
- **Hadoop with Spark support** R2016b
- MATLAB Production Server



## Machine Learning

- Neural Networks
- Classification
- Clustering
- Regression
- Statistics and Machine Learning Toolbox
- **Classification Learner App** R2015a
- Neural Network Toolbox
- **CNNs for Deep learning** R2016a
- Machine learning with code generation

Pervasive users, scope, & technology

In MATLAB

# MATLAB Apps for Data Analytics

Classification Learner

Distribution Fitting

System Identification

Signal Analysis

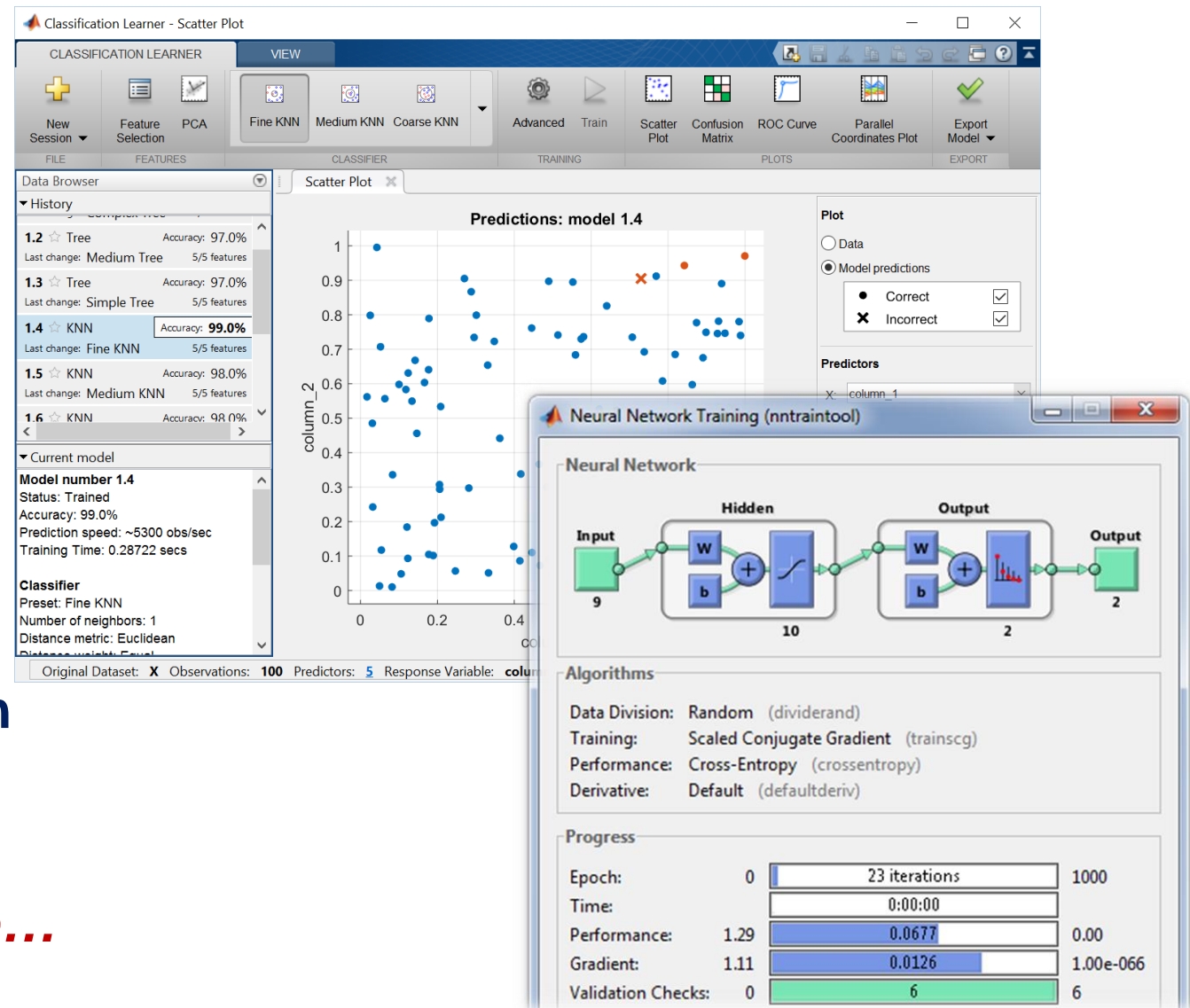
Wavelet Design and Analysis

Neural Net Fitting

Neural Net Pattern Recognition

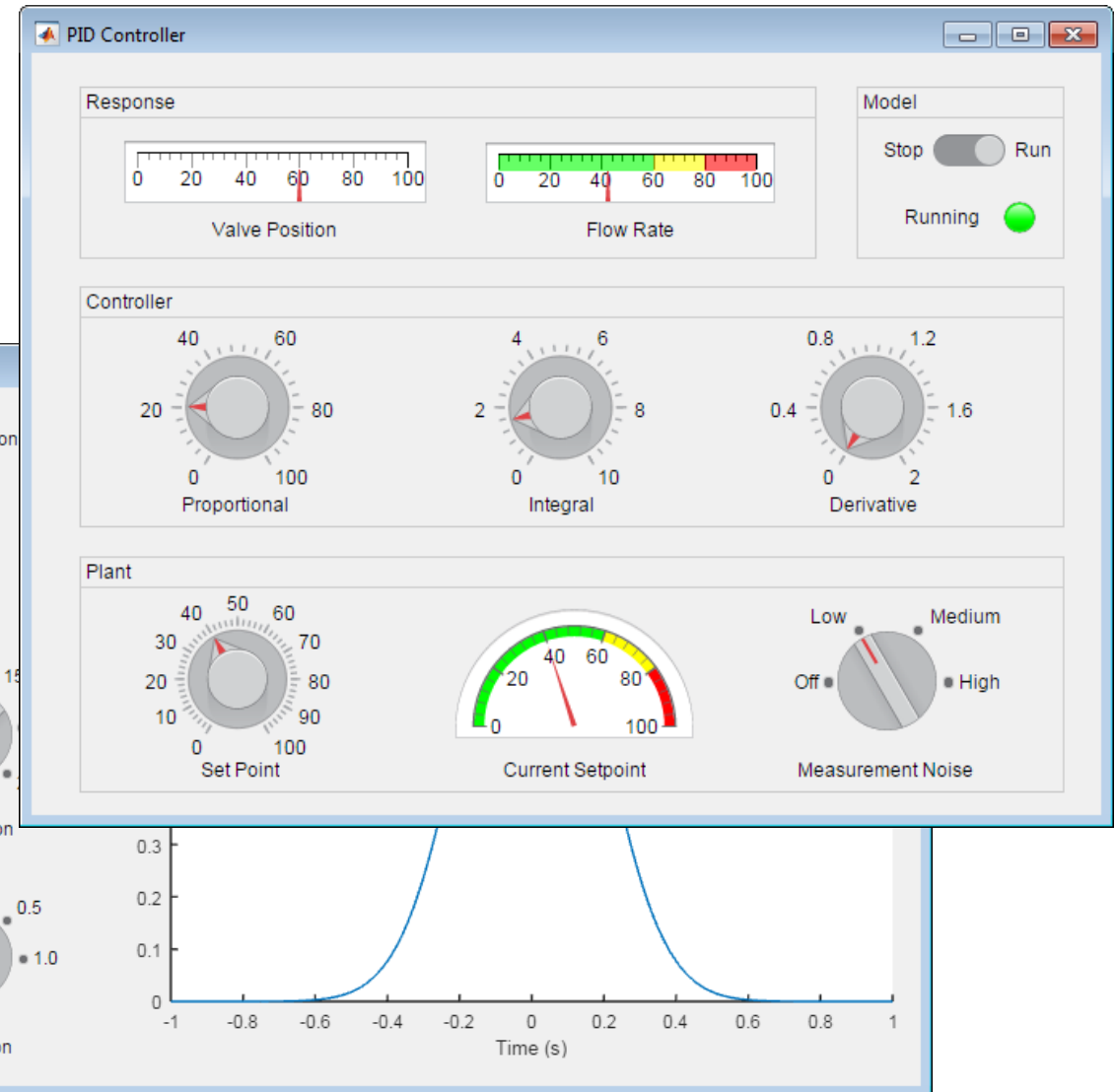
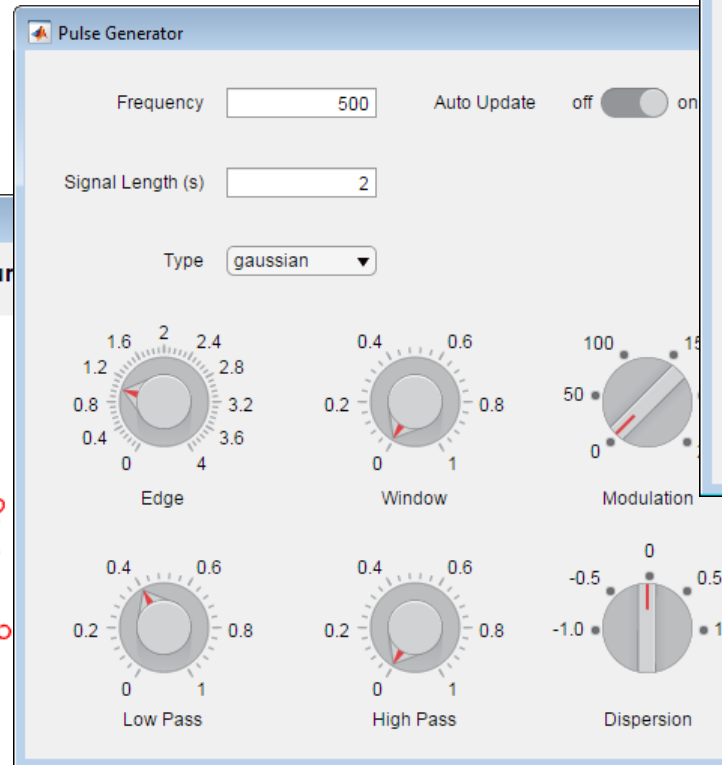
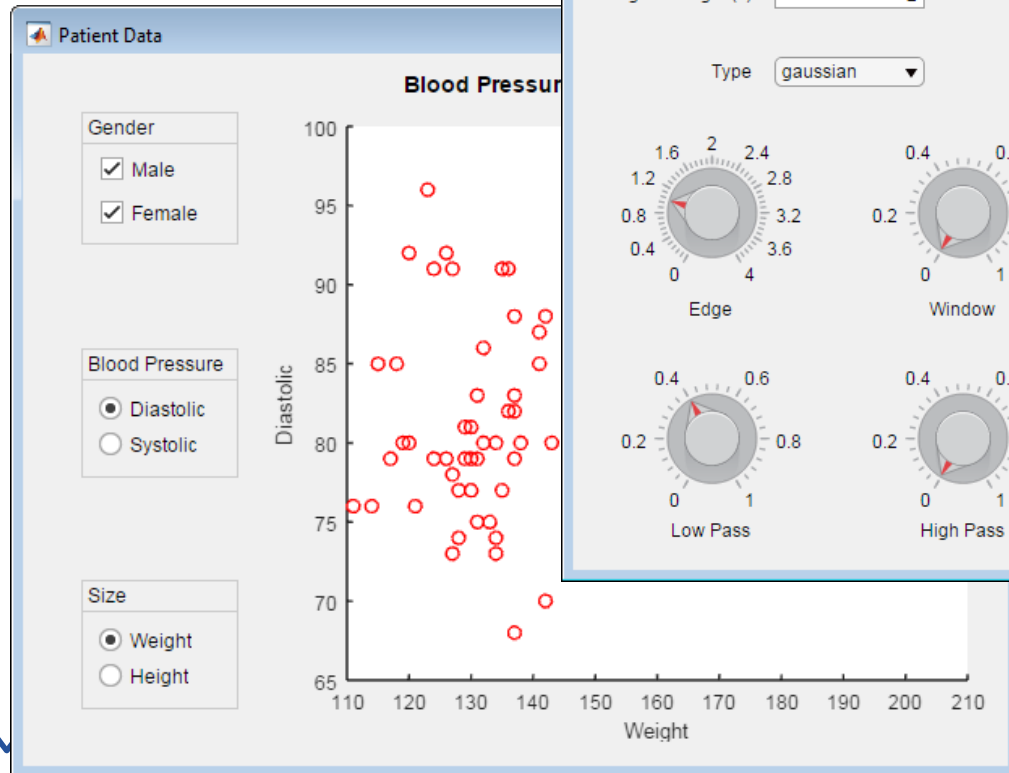
Training Image Labeler

*and many more...*

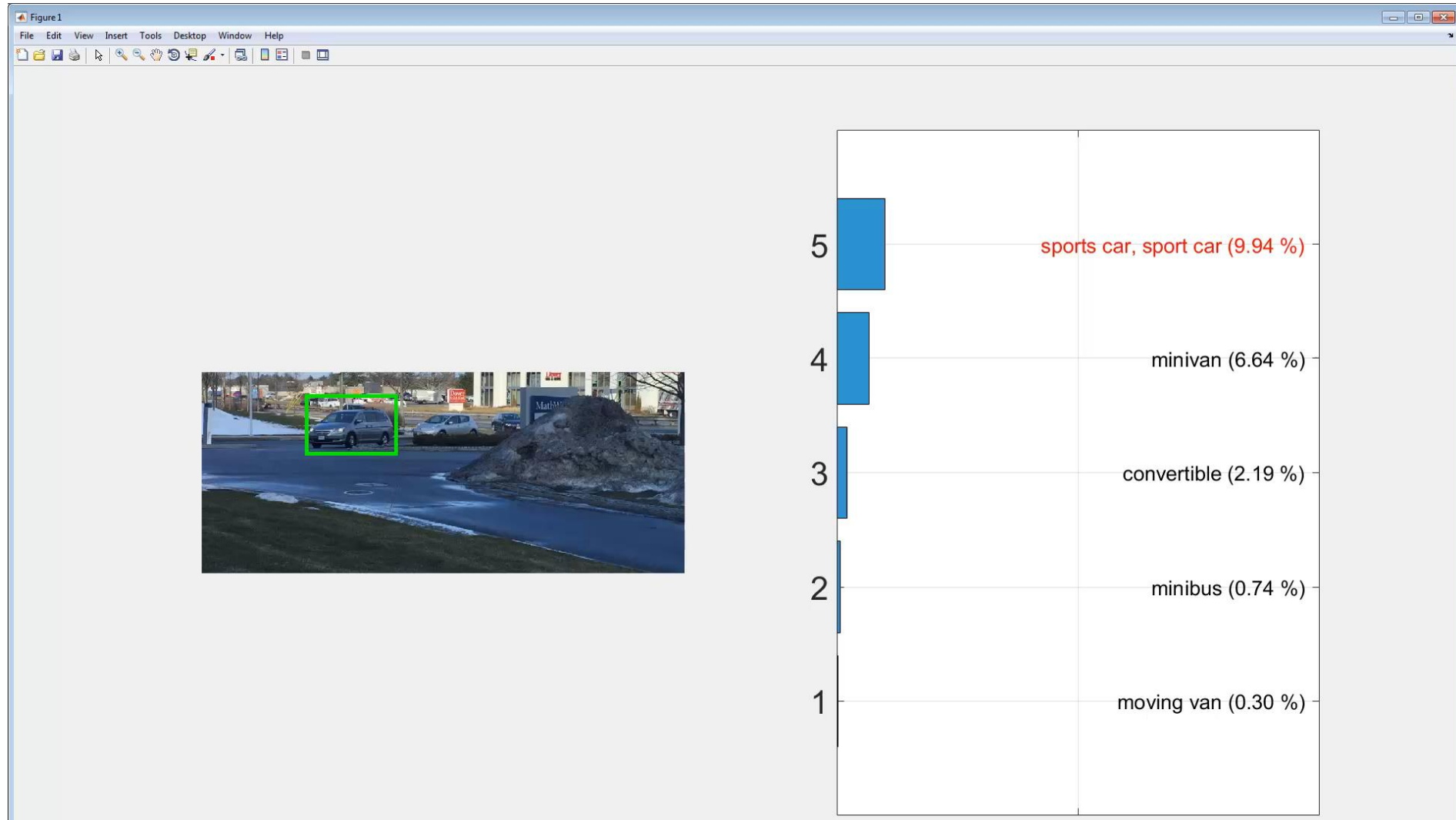


# Using MATLAB R2016a

## App Designer



# Deep Learning with Neural Network Toolbox - New in R2016a



# The Rise of Engineering-Driven Analytics

Limited  
users, scope,  
& technology

Big Data

Compute  
Power

Machine  
Learning

Pervasive  
users, scope,  
& technology

Be your own Data Scientist! 



# More details in ...

	Application Track 1	Application Track 2	Introductory Sessions	Master Classes
11:15	<b>Big Data</b>	<b>What's New in Simulink Release R2016a and R2016b</b>	<b>Introduction to MATLAB</b>	<b>Signal Processing</b>
11:45	<b>MATLAB and Advanced Analytics at Shell</b>	<b>Fast-Paced Development in F1 Control and Analysis Systems</b>		
12:15	<b>Machine Learning and Deep Learning</b>	<b>New Capabilities in Testing</b>	<b>Introduction to Parallel Computing</b>	<b>Hardware-in-the-Loop: Real-Time Simulation</b>
12:45	<b>Lunch</b>			
13:15	<b>Lunchtime Talk - Science Capital</b>			
14:00	<b>The Adoption of MATLAB Apps and Toolboxes at Jaguar Land Rover</b>	<b>Physical Modelling Integration and Cosimulation in a Real-Time Environment</b>	<b>Introduction to Simulink and Stateflow</b>	<b>Simulink for Teams: High-Productivity Workflows</b>
14:30	<b>Developing and Sharing MATLAB Apps and Toolboxes</b>	<b>Connecting to Hardware and Rapid Prototyping</b>		
15:15	<b>Break</b>			
15:45	<b>MATLAB Algorithm Development and Verification for Eurofighter Typhoon Praetorian</b>	<b>Applying MathWorks Tools to Automotive Embedded Software Development</b>	<b>Modelling Physical Systems in Simscape</b>	<b>Developing Robust MATLAB Code and Apps</b>
16:15	<b>Modelling and Simulating RF Sensor Systems</b>	<b>Verification of Automatically Generated Code</b>		

# The Rise of Engineering-Driven Analytics

Limited  
users, scope,  
& technology

Big Data

Compute  
Power

Machine  
Learning

Pervasive  
users, scope,  
& technology

Thankyou

## More details on ...

- BuildingIQ: Adaptive building energy management
  - [http://uk.mathworks.com/company/user\\_stories/buildingiq-develops-proactive-algorithms-for-hvac-energy-optimization-in-large-scale-buildings.html?s\\_tid=srchtitle](http://uk.mathworks.com/company/user_stories/buildingiq-develops-proactive-algorithms-for-hvac-energy-optimization-in-large-scale-buildings.html?s_tid=srchtitle)
- Scania: Automatic emergency braking using sensor fusion and analytics
  - [http://uk.mathworks.com/company/newsletters/articles/developing-advanced-emergency-braking-systems-at-scania.html?s\\_tid=srchtitle](http://uk.mathworks.com/company/newsletters/articles/developing-advanced-emergency-braking-systems-at-scania.html?s_tid=srchtitle)
- Mondi: Predictive Maintenance for polymer-based production machines
  - [http://uk.mathworks.com/company/user\\_stories/mondi-implements-statistics-based-health-monitoring-and-predictive-maintenance-for-manufacturing-processes-with-machine-learning.html?s\\_tid=srchtitle](http://uk.mathworks.com/company/user_stories/mondi-implements-statistics-based-health-monitoring-and-predictive-maintenance-for-manufacturing-processes-with-machine-learning.html?s_tid=srchtitle)