

Machine Learning with MATLAB

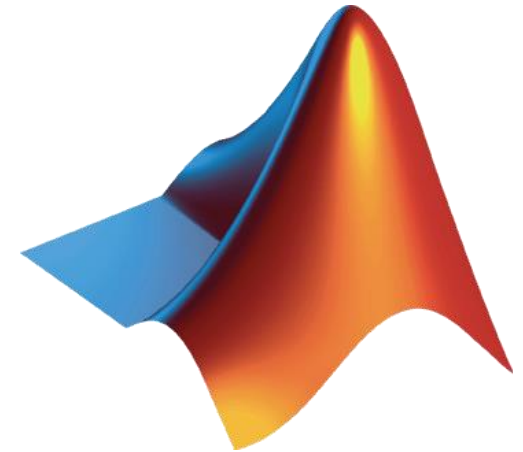
This session will start at 12:00 PM PST (3:00 PM EST)

If you are having audio issues, please join audio by phone:

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Access code: 719565187



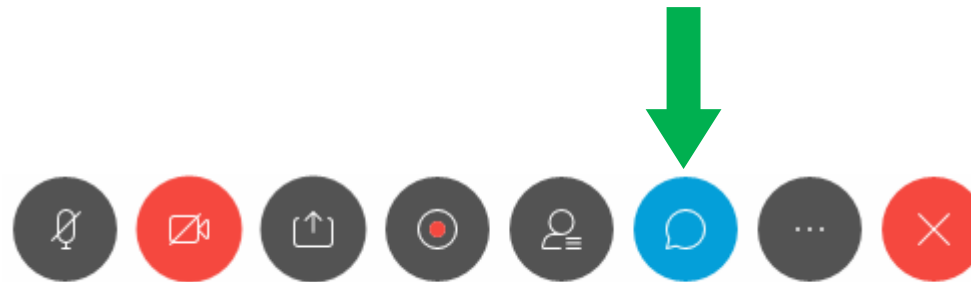
MathWorks Customer Success
education@mathworks.com

Bo Luan
Application Engineer
boluan@mathworks.com





June 18, 2020

If you have questions/participation to the polls

- Please use “**Q&A**” or “**Chat**” and direct your questions to “**Panelists**”
- Please **participate in the polls**, presenter will adjust the presentation to the responses



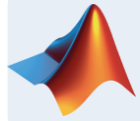
June 18 MATLAB Day Webinars (PST)

-  10:00 AM – 11:00 AM: **Data Analysis and Visualization with MATLAB for Beginners**
-  12:00 PM – 1:00 PM: **Machine Learning with MATLAB**
-  3:00 PM – 4:00 PM: **Deep Learning with MATLAB**
-  4:30 PM – 5:00 PM: **Learning MATLAB and Career Paths**

Agenda

- **What is Machine Learning?**
- **Demo: Building a Classification Model**
- **Sharing and Deploying Machine Learning Algorithms**
- **Resources and Support**

Agenda

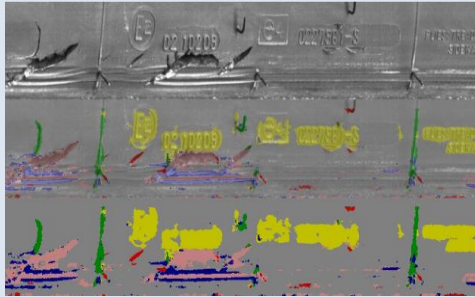


What is Machine Learning?

- **Demo: Building a Classification Model**
- **Sharing and Deploying Machine Learning Algorithms**
- **Resources and Support**

Machine Learning is Everywhere

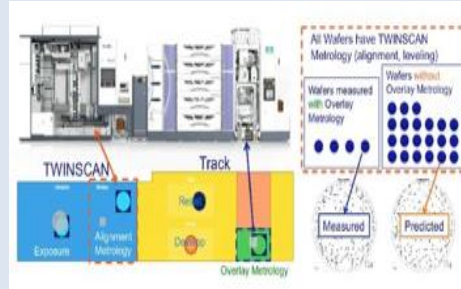
Automobile



Tire Wear

BRIDGESTONE

Industrial Automation



Overlay metrology improvement

ASML

CES & Aero Defense



Telecom customer churn prediction

Cognizant

Energy & Finance



Forecasting & Risk Analysis



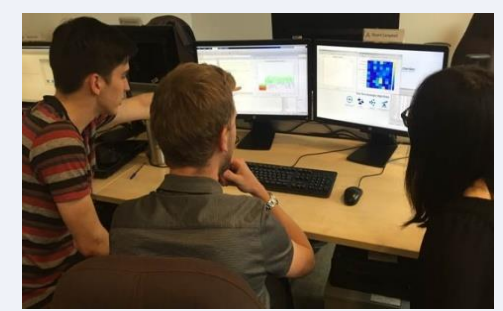
Detect Oversteer



Building energy use optimization



Engine Health
(Predictive Maintenance)



Portfolio Allocation



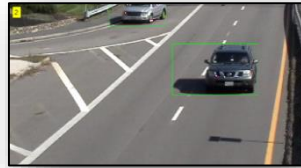
What is Machine Learning?

Ability to learn from data without being explicitly programmed

Solution is too complex for hand written rules or equations



Speech Recognition



Object Recognition



Engine Health Monitoring

learn complex non-linear relationships

Solution needs to adapt with changing data



Weather Forecasting



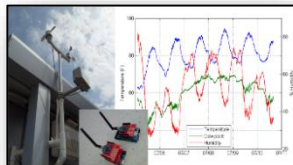
Energy Load Forecasting



Stock Market Prediction

update as more data becomes available

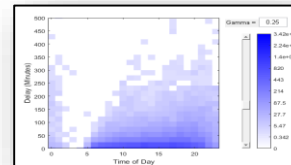
Solution needs to scale



IoT Analytics



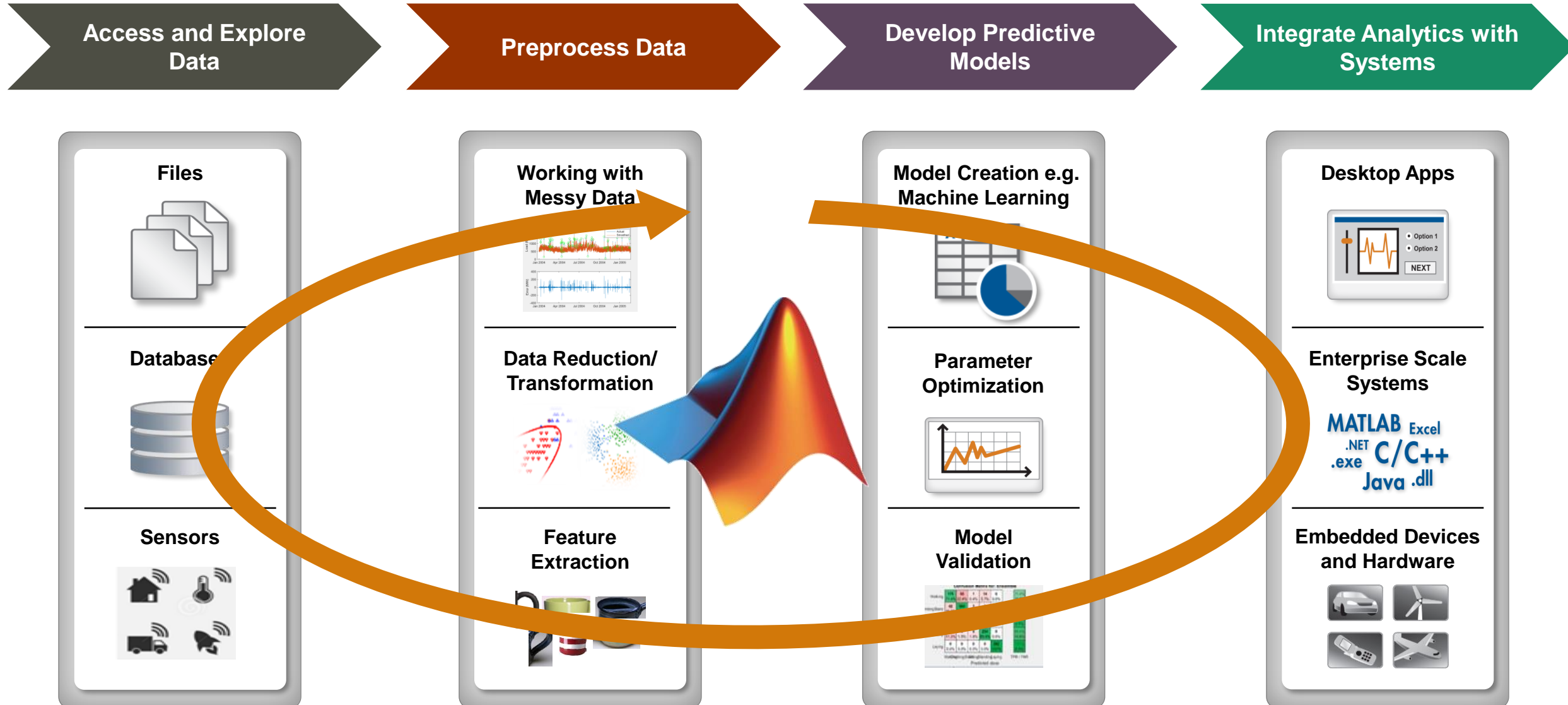
Taxi Availability



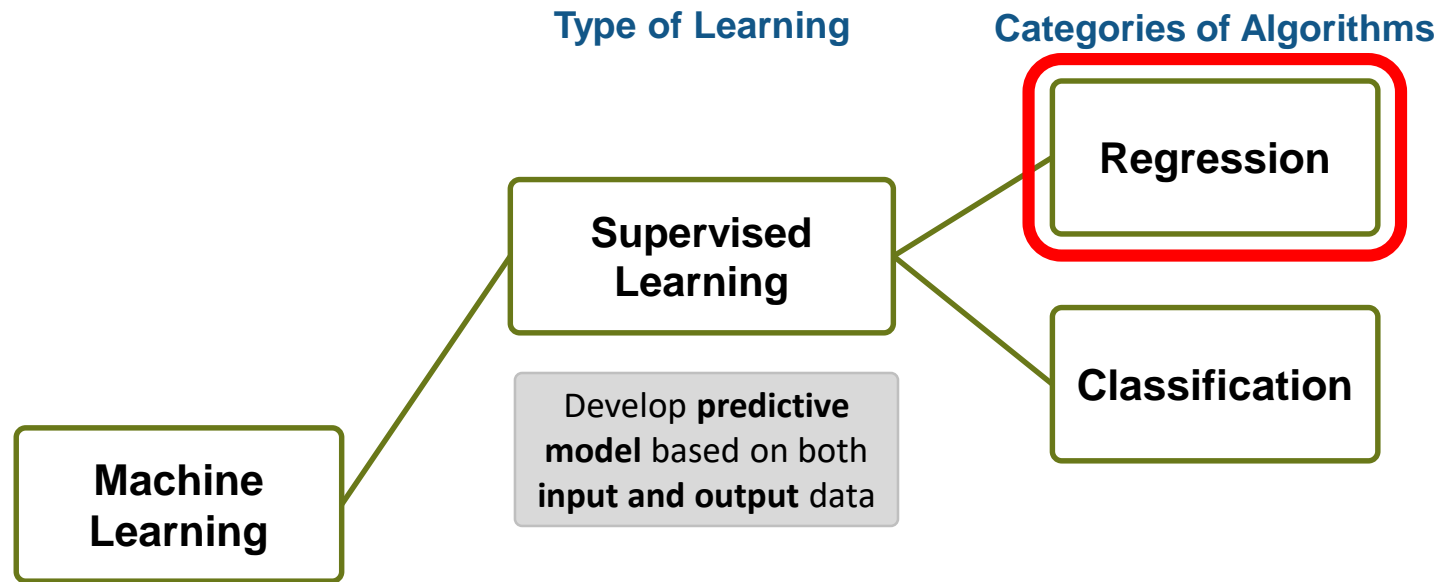
Airline Flight Delays

learn efficiently from very large data sets

Machine Learning Workflow

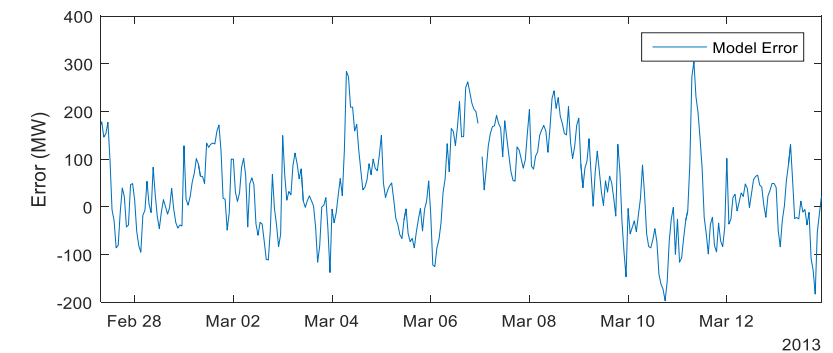
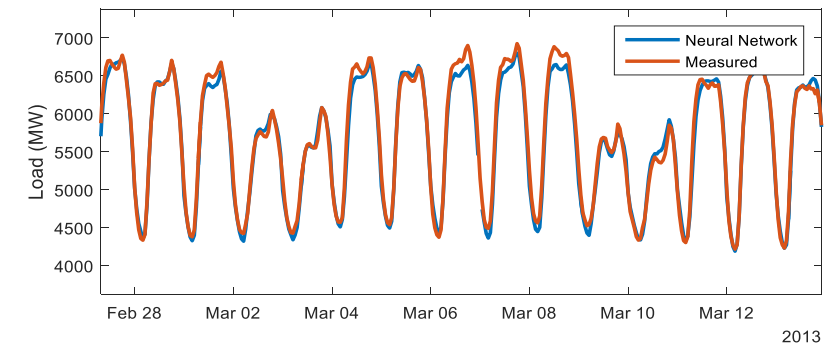


Types of Machine Learning

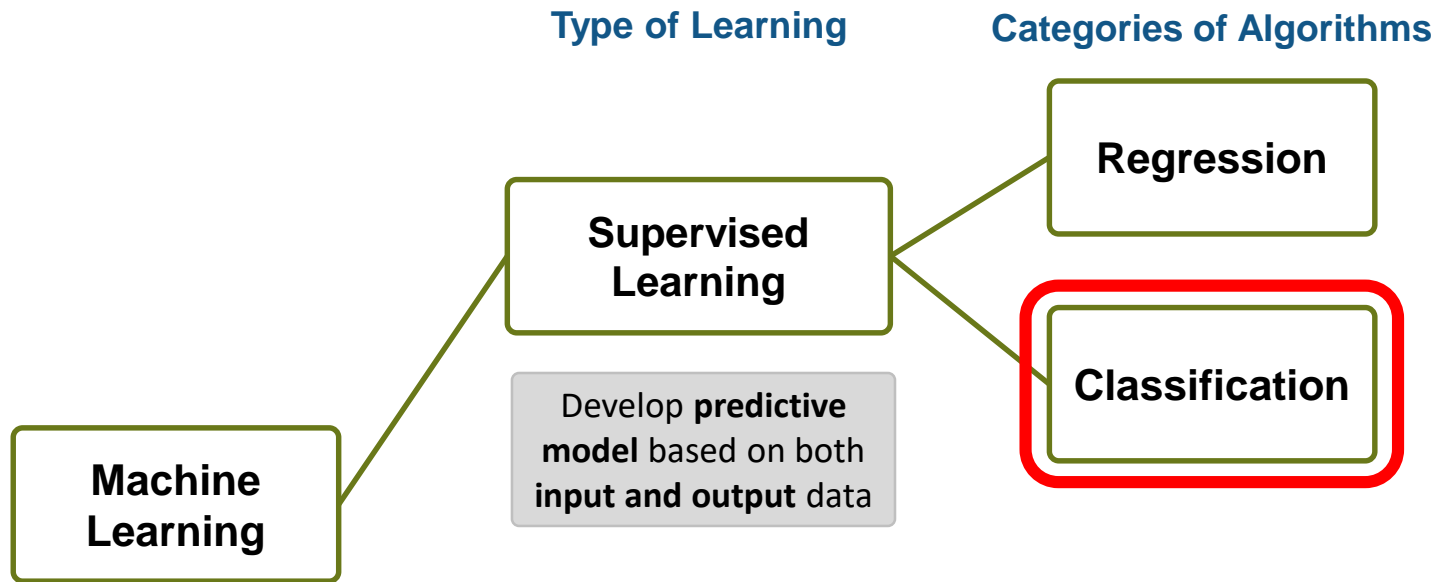


Objective:

Easy and accurate computation of day-ahead system load forecast





Types of Machine Learning



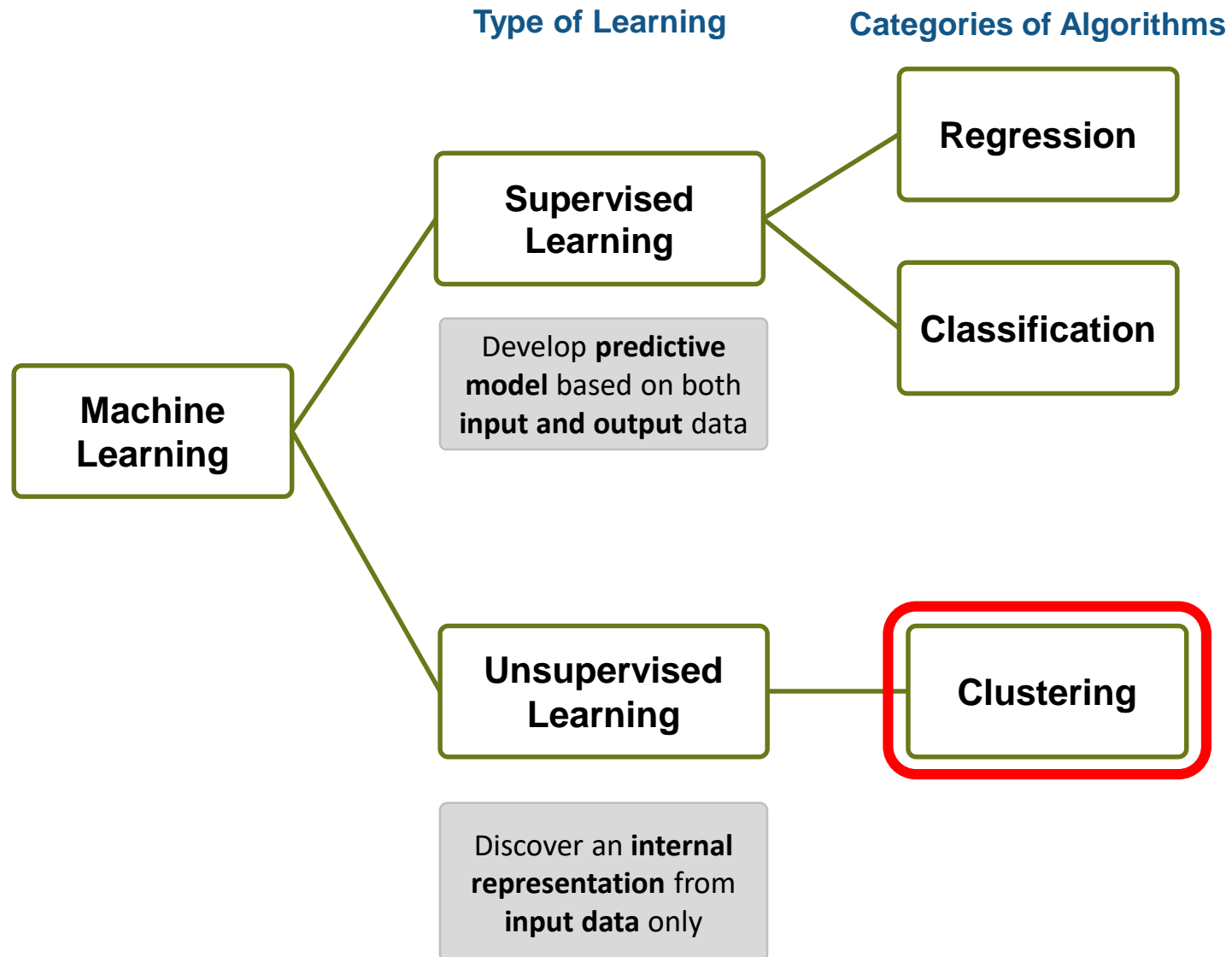
Objective:

Train a classifier to classify human activity from sensor data

Data:

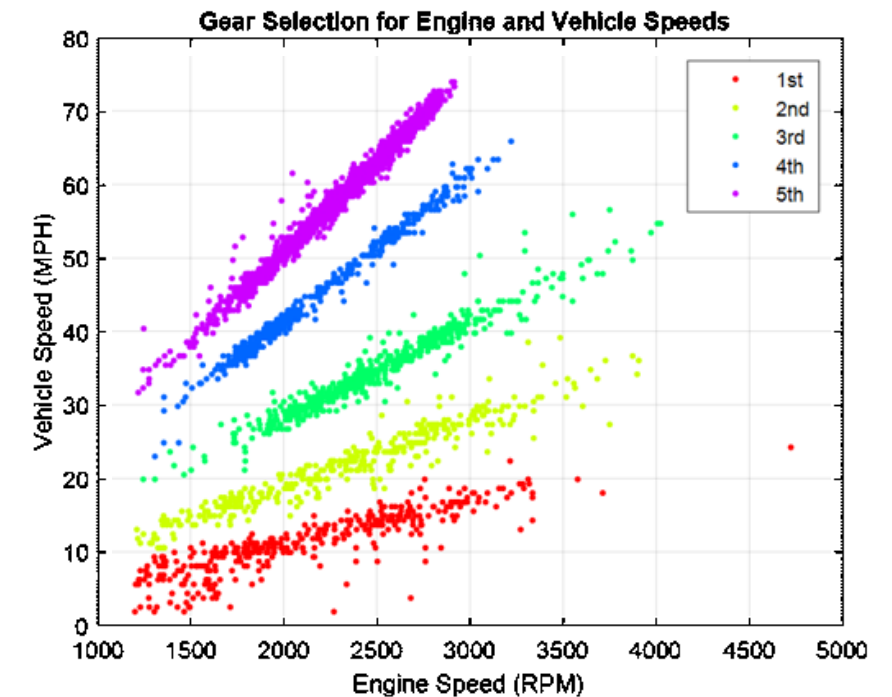
| | | |
|---------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Inputs | 3-axial Accelerometer 3-axial Gyroscope |  |
| Outputs |  | |

Types of Machine Learning

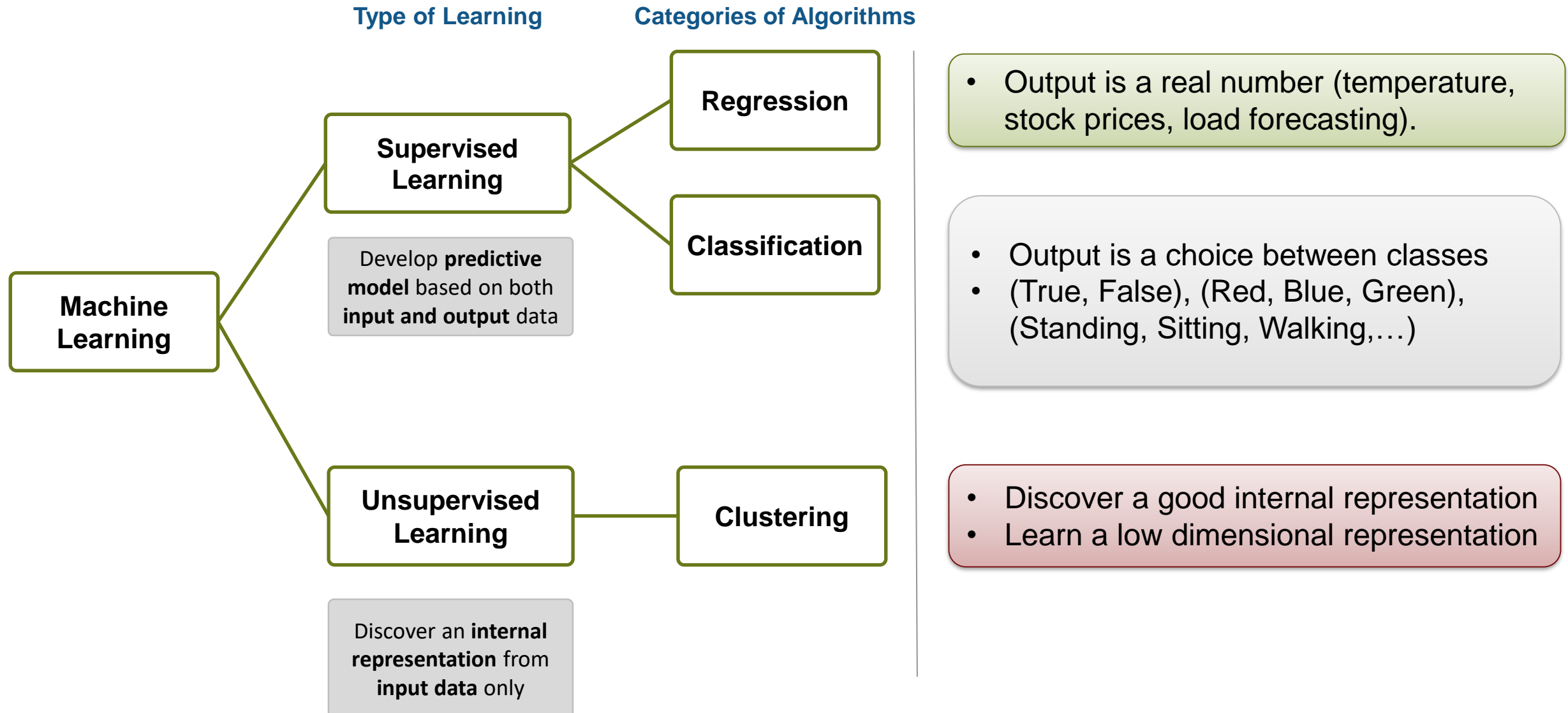


Objective:

Given data for engine speed and vehicle speed, identify clusters

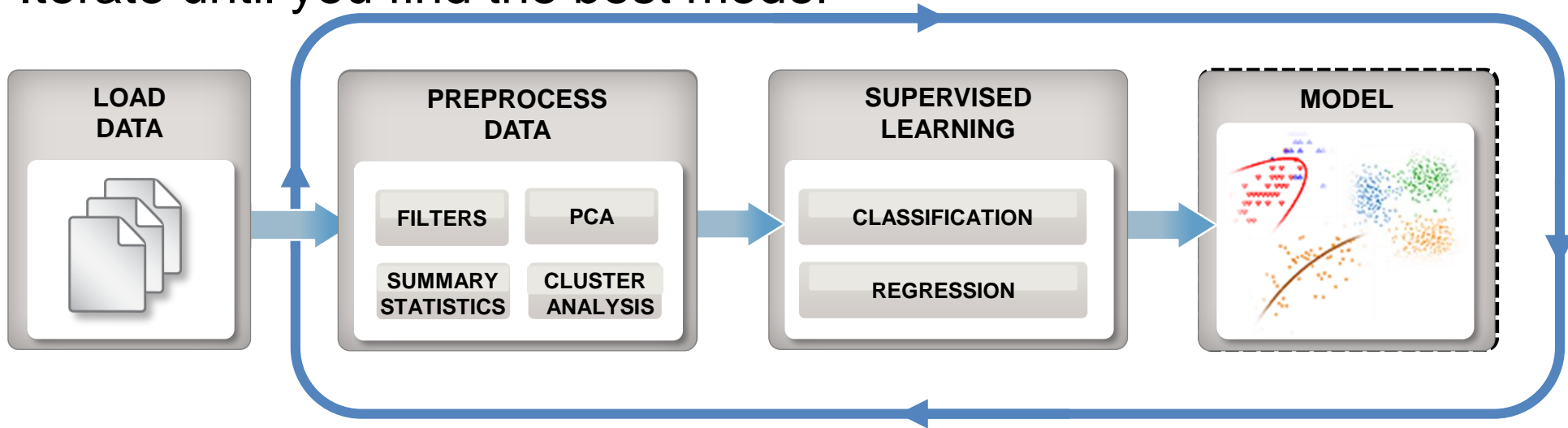


Different Types of Machine Learning

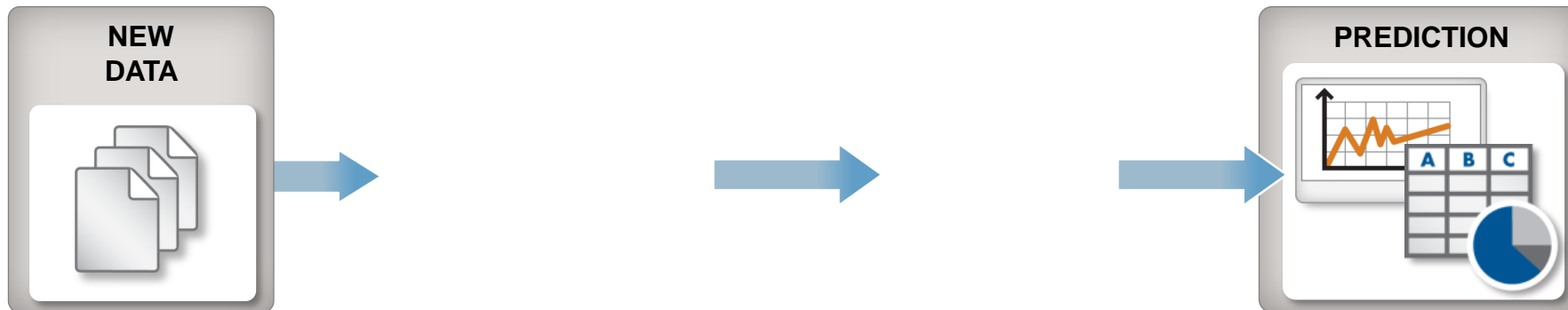


Supervised Learning Workflow

Train: Iterate until you find the best model

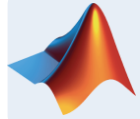


Predict: Integrate trained models into applications



Agenda

- **What is Machine Learning?**

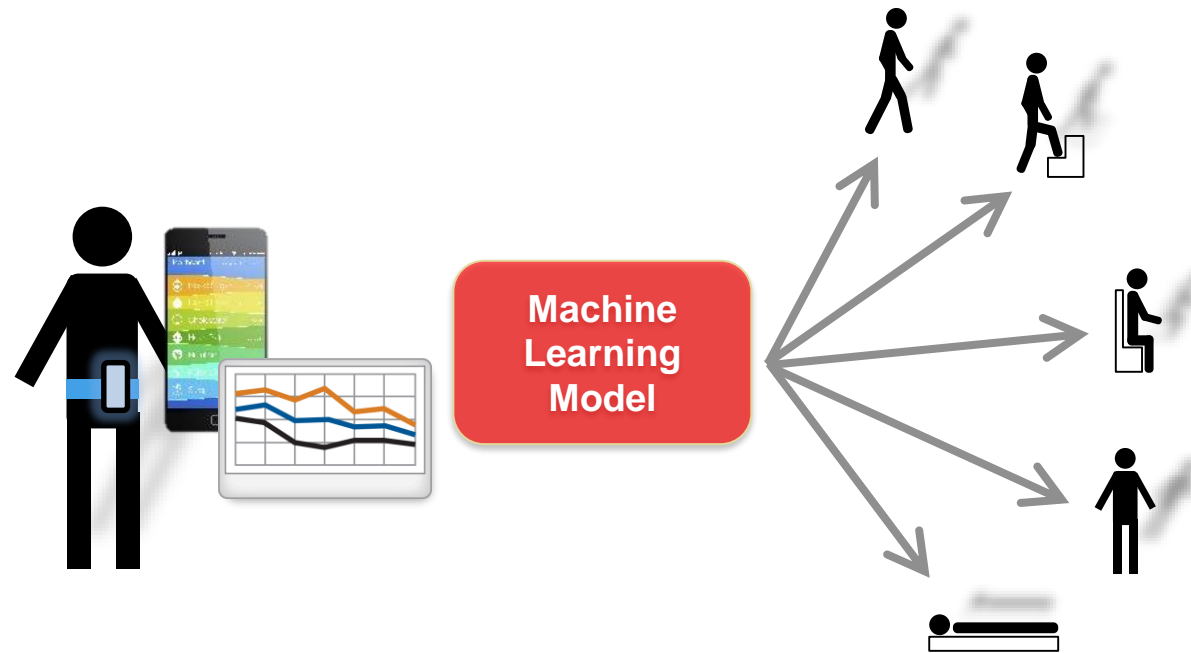


Demo: Building a Classification Model

- **Deploying Machine Learning Algorithms**
- **Resources and Support**

Example: Human Activity Recognition

Classification



Data:

- 3-axial Accelerometer data
- 3-axial Gyroscope data

Dataset courtesy of:


Davide Anguita, Alessandro Ghio, Luca Oneto, Xavier Parra and Jorge L. Reyes-Ortiz.
Human Activity Recognition on Smartphones using a Multiclass Hardware-Friendly Support Vector Machine.
International Workshop of Ambient Assisted Living (IWAAL 2012). Vitoria-Gasteiz, Spain. Dec 2012
<http://archive.ics.uci.edu/ml/datasets/Human+Activity+Recognition+Using+Smartphones>

Example: Human Activity Recognition

Classification

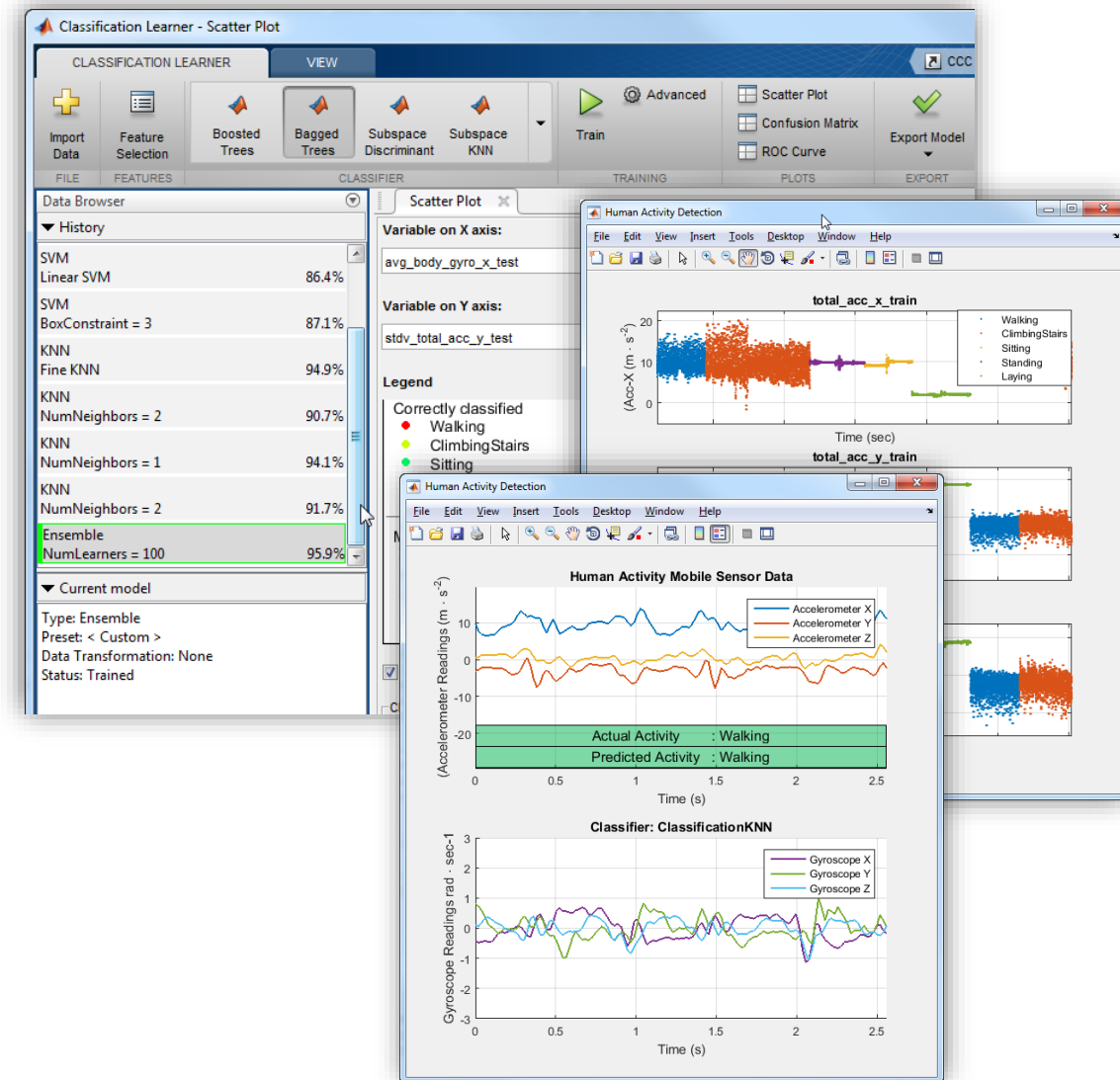
Goal: Train a model to classify human activity from sensor data

Data:

| | |
|------------|----------------------------------------------------------------------------------------------|
| Predictors | 3-axis Accelerometer and Gyroscope data |
| Response | Activity:  |

Approach:

- Extract features from raw sensor signals
- Train and compare classifiers
- Test results on new sensor data




Example: Human Activity Recognition

Classification

Goal: Train a model to classify human activity from sensor data

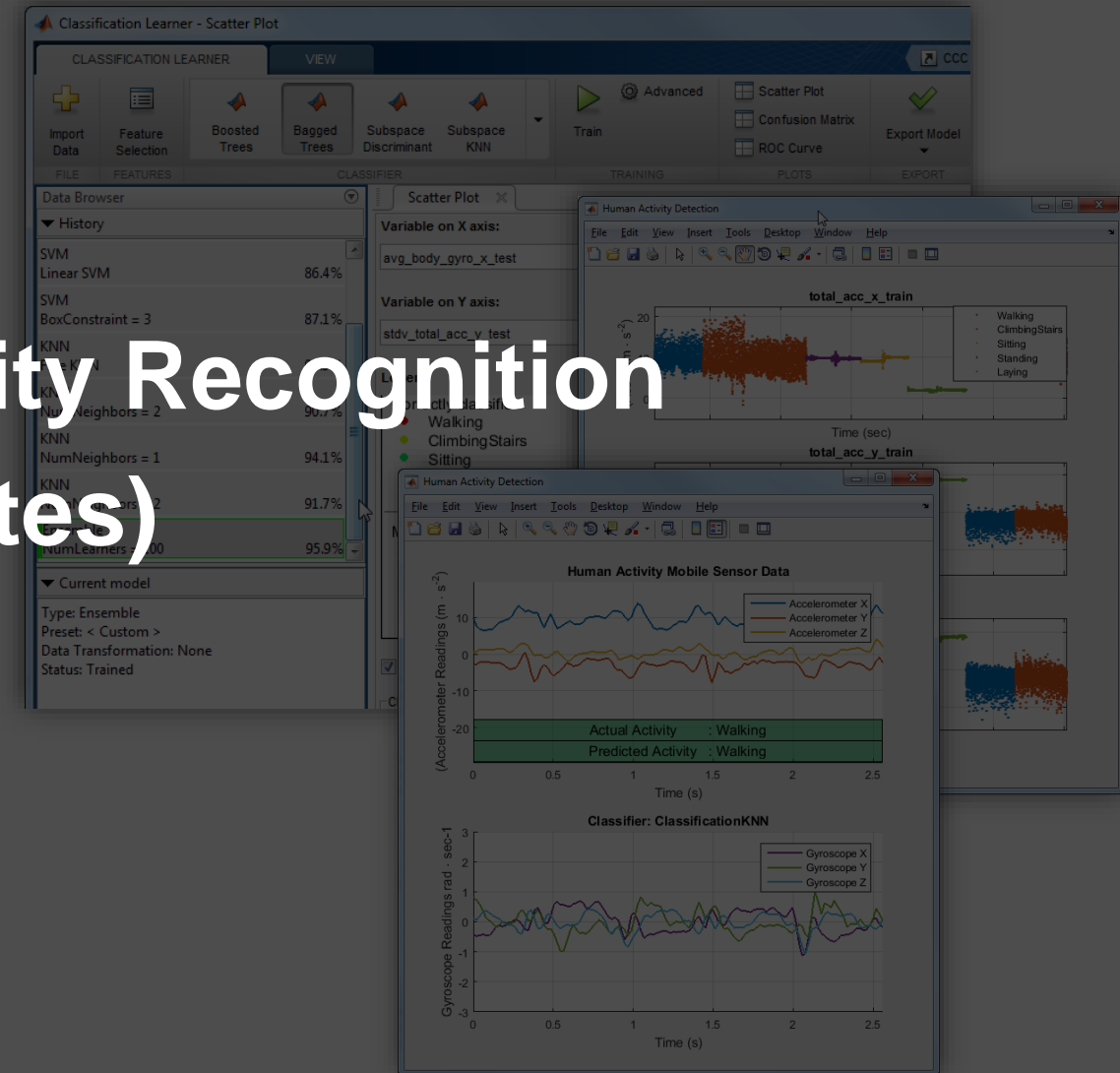
Data:

| | |
|------------|----------------------------------------------------------------------------------------------|
| Predictors | 3-axis Accelerometer and Gyroscope data |
| Response | Activity:  |

Demo: Human Activity Recognition (30 minutes)

Approach:

- Extract features from raw sensor signals
- Train and compare classifiers
- Test results on new sensor data



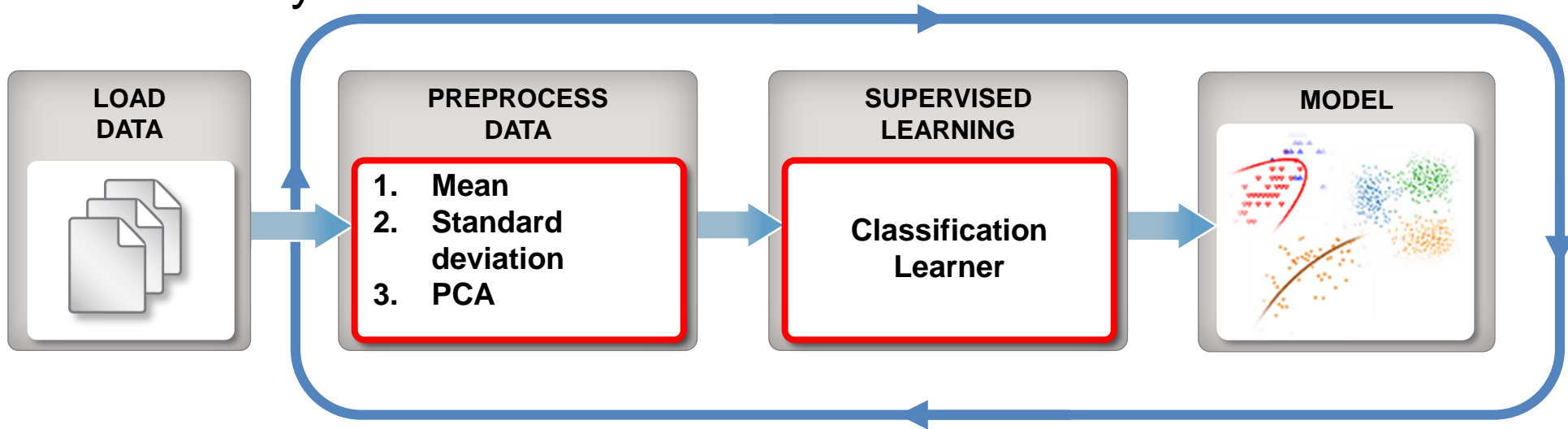


“Essentially, all models are **wrong,
but some are **useful**.”**

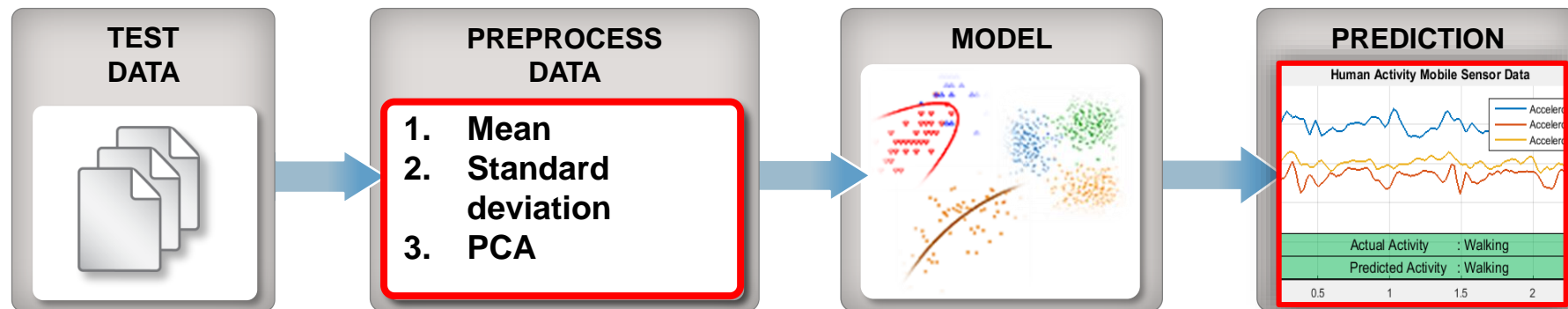
– George Box

Machine Learning Workflow for Classification Example

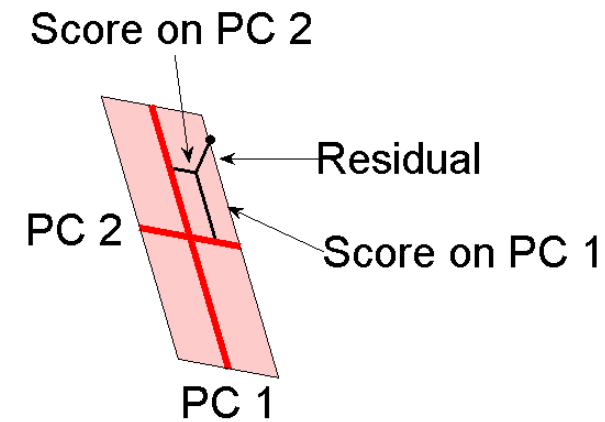
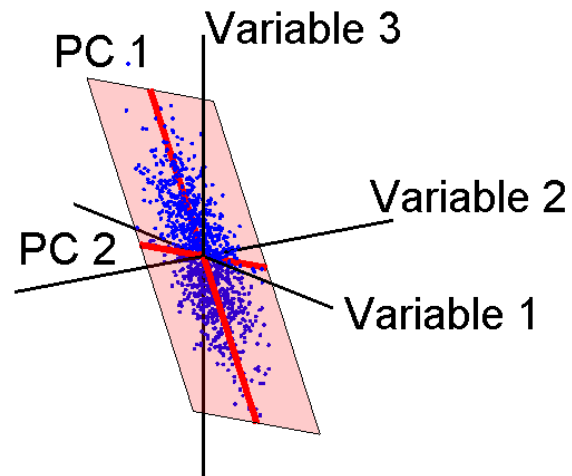
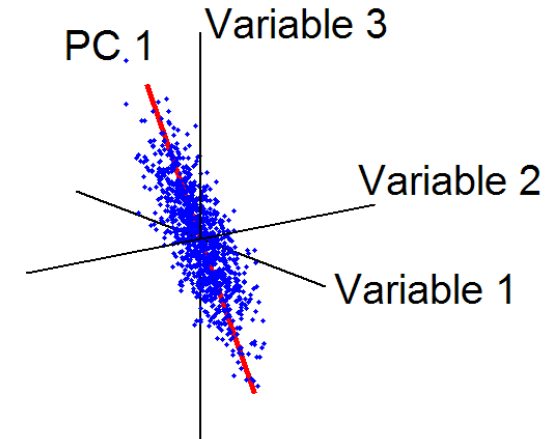
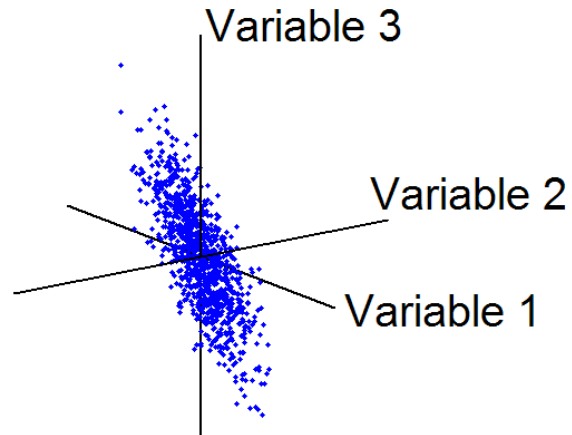
Train: Iterate until you find the best model



Predict: Integrate trained models into applications



Principal Components Analysis



Feature Engineering

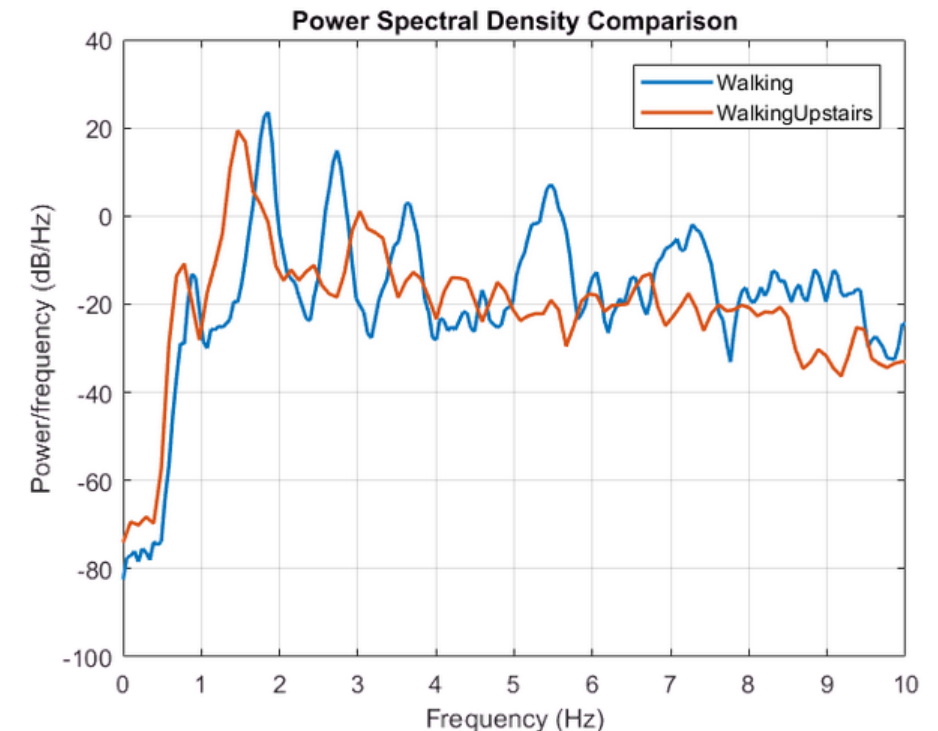
Using domain knowledge to create features for machine learning algorithms

Feature transformation: Reduce dimensionality

Feature selection: Choose subset of most relevant features

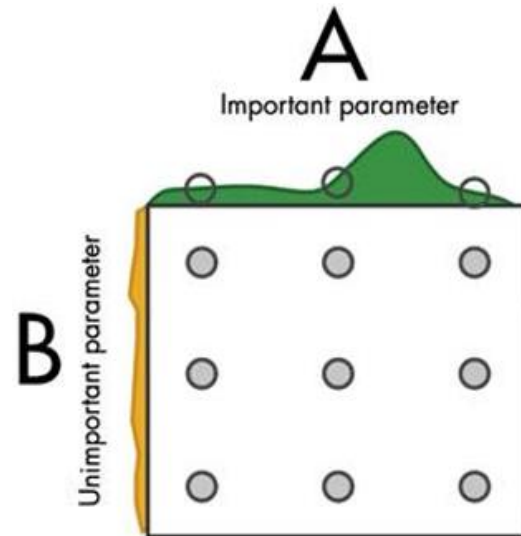
Possible feature engineering ideas:

- Additional statistics – PCA, NCA etc.
- Signal Processing Techniques – power spectral density, wavelets etc.
- Image Processing Techniques – bag of words, pixel intensity etc.
- Get creative!

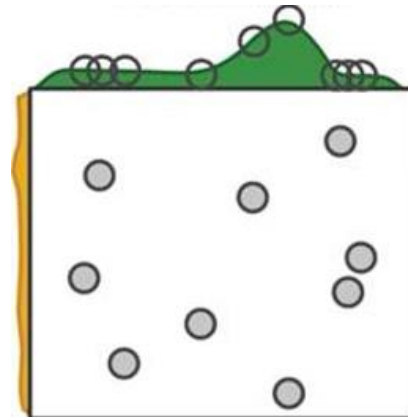


Hyperparameter Tuning

Standard:
Grid Search



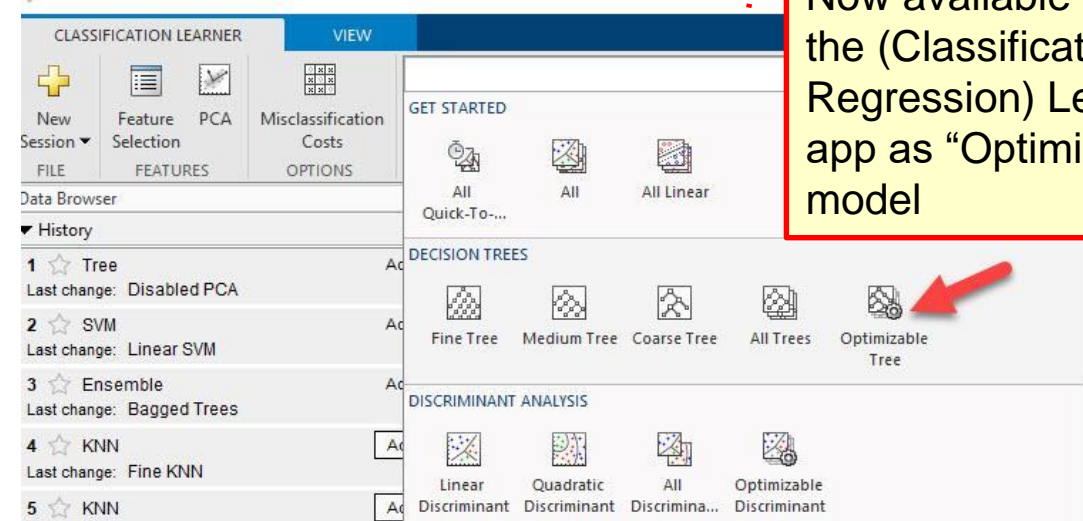
Maybe Better:
Random Search



Bayesian Optimization

- Bayesian model indicates impact of change
- Model picks “good” point to try next
- Much more efficient!
- Scale to multi-cores (using PCT) for larger datasets

Classification Learner - Confusion Matrix

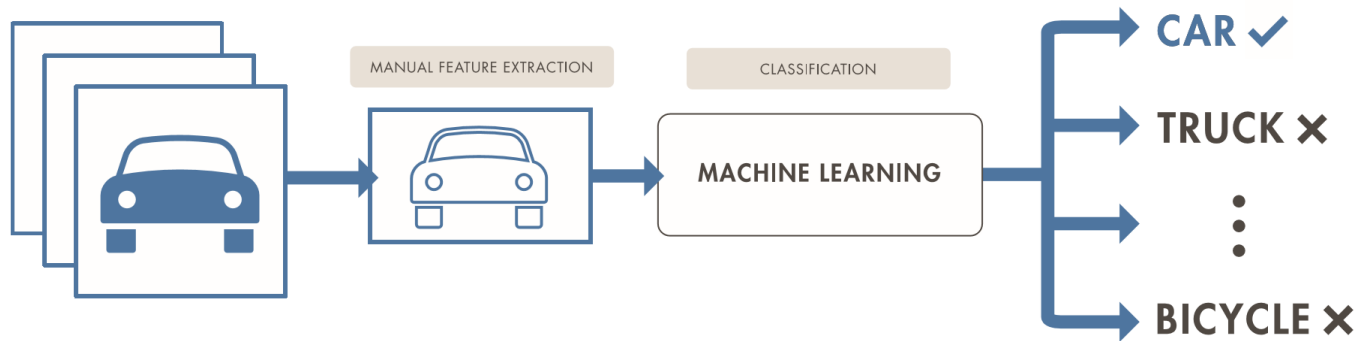


Now available inside the (Classification/Regression) Learner app as “Optimizable” model

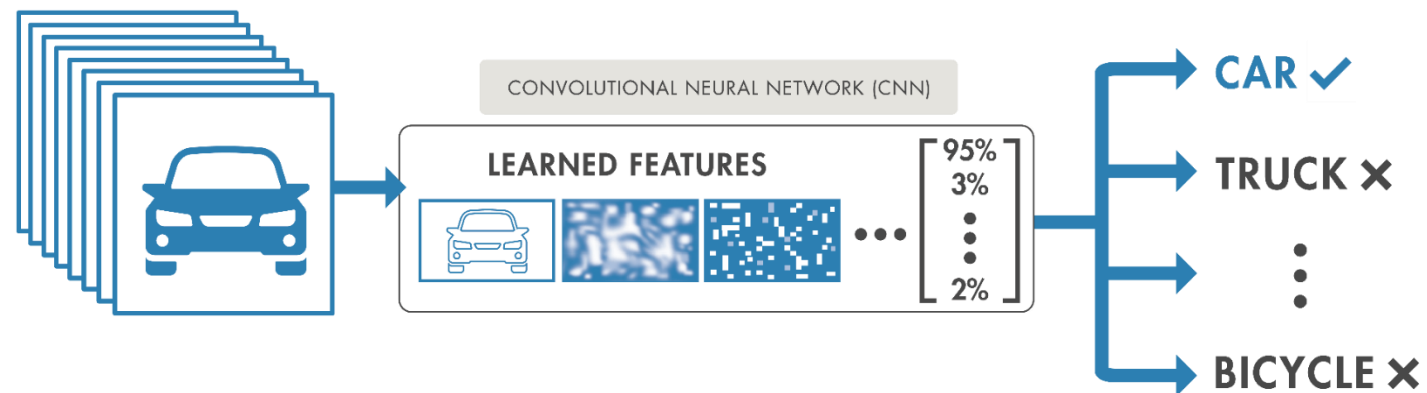
Machine Learning vs Deep Learning

Deep learning performs **end-to-end learning** by learning **features, representations and tasks** directly from **images, text and sound**

Machine Learning

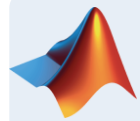


Deep Learning



Agenda

- **Machine Learning Introduction**
- **Demo: Building a Classification Model**

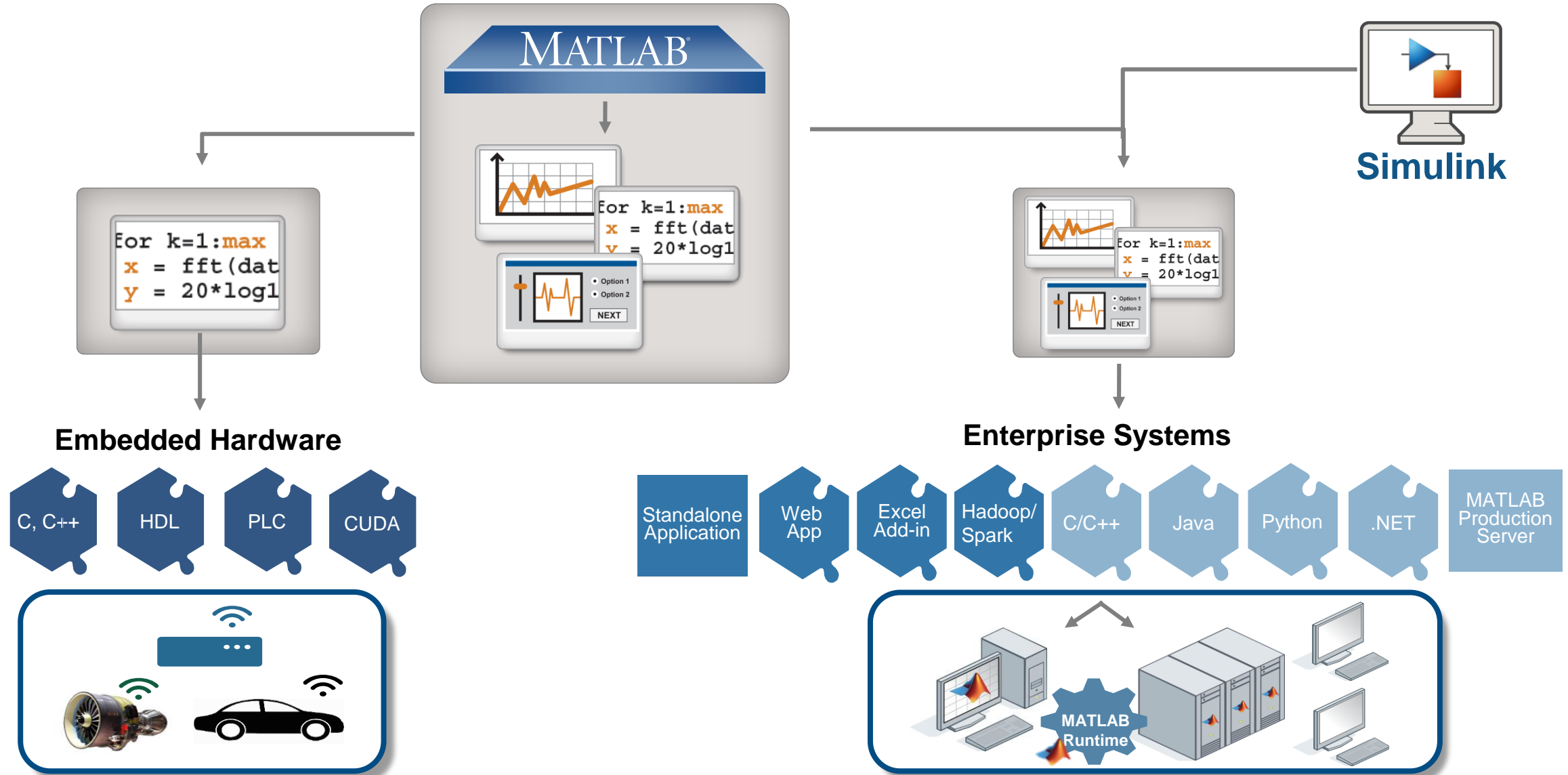


Sharing and Deploying Machine Learning Algorithms

- **Resources and Support**

Deploying Algorithms and Models

MATLAB Analytics
run anywhere



Machine Learning for Edge Analytics and Code Deployment

Deploy trained models as standalone C/C++ code

- Apply algorithms to out-of-memory data using tall arrays
- Generate C/C++ code for predictive models
- Generate fixed-point C/C++ code for SVM models, decision trees, and ensembles of decision trees
- Update deployed models without regenerating code

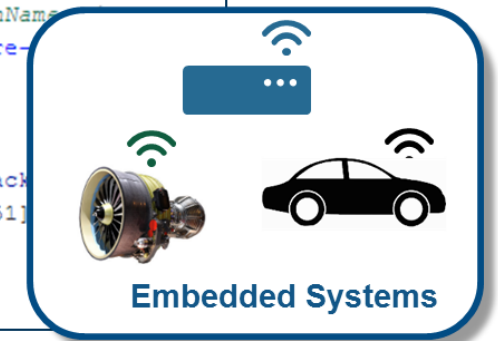
MATLAB code

```
function label = classifyIonosphere(X) %#codegen
%classifyIonosphere Classify Ionosphere based on pre-trained SVM model
mdl = loadCompactModel( 'SVMIonosphere' );
label = predict( mdl, X );
end
```

saveCompactModel loadCompactModel

C code

```
14 /* Variable Definitions */
15 static emlrtRSInfo emlrtRSI = { 4, /* lineNo */
16     "classifyIonosphere", /* fcnName */
17     "C:\\Users\\jcherrie\\Sandbox\\temp\\feature-
18 };
19
20 /* Function Definitions */
21 void classifyIonosphere(classifyIonosphereStack
22     const real_T X[11934], cell_wrap_0 label[351]
23 {
24     real_T t0_Alpha[90];
25     real_T expl_temp[34];
```



Using MATLAB with Other Languages

Calling Libraries Written in Another Language From MATLAB



- Java
 - Python
 - C
 - C++
 - Fortran
 - COM components and ActiveX® controls
 - RESTful, HTTP, and WSDL web services
- Execute Python functions out of process **R2019b**
- Call C++ libraries directly from MATLAB **R2019a**

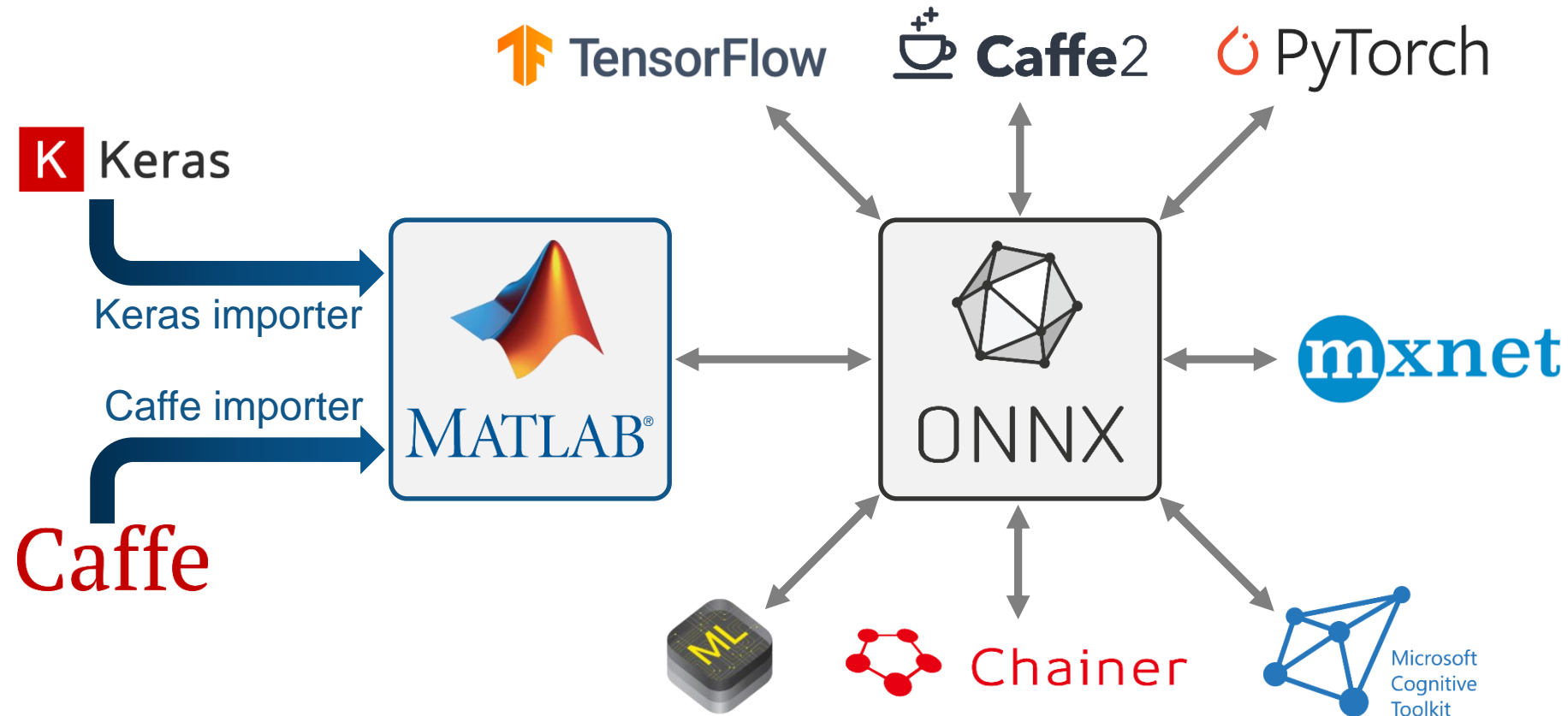
Calling MATLAB from Another Language



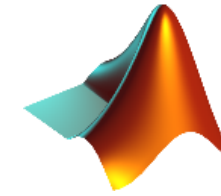
- Java
- Python
- C/C++
- Fortran
- COM Automation server

MATLAB interoperates with other frameworks

Supports ONNX and can exchange models with PyTorch, TensorFlow, and other frameworks.



Summary: Complete Machine Learning Workflow



Access and
explore data

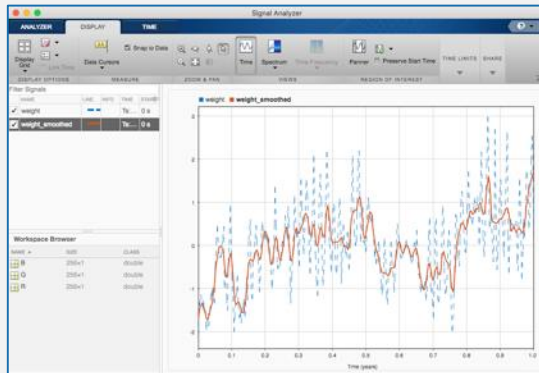
Preprocessing

Feature
Engineering

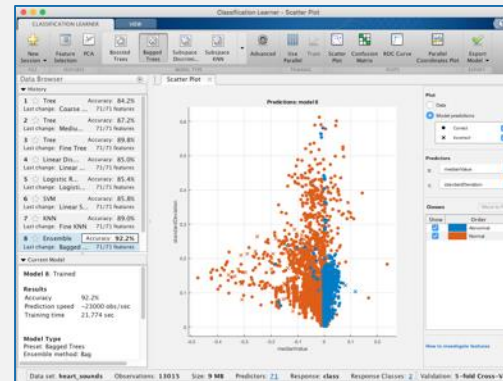
Model
Training

Model
Tuning

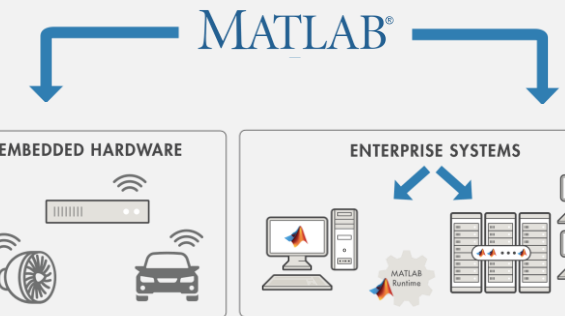
Integrate
Analytics



Datatypes and tools for missing data, outliers, time-alignment, etc.



Machine Learning apps



C/C++ Code Generation and Enterprise IT Integration

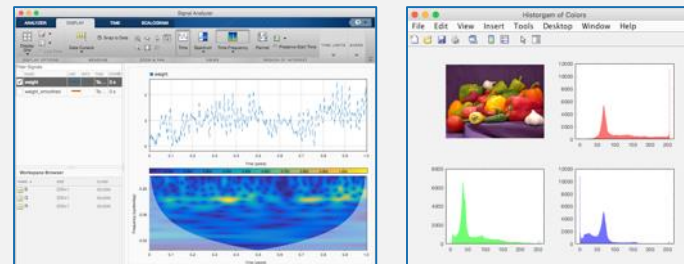
Import - (Applications\MATLAB_2019b\app\toolbox\matlab\import\outages.csv)

Column delimiter: Range: A1:F1469 Output Type: Table

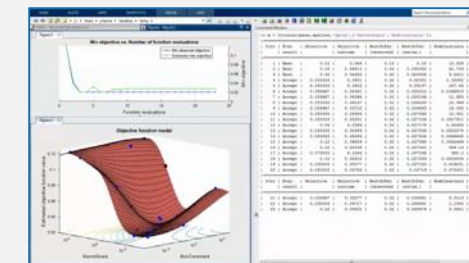
Fixed Width: Delimiter: ; Variable Names Row: 1 Text Options: Import Selection: Import

| | Region | OutageTime | Loss | Customers | RestorationTime | Cause |
|---|-----------|------------------|-------------|-------------|------------------|---------------------------------------|
| 1 | Region | OutageTime | Loss | Customers | RestorationTime | Cause |
| 2 | SouthWest | 2002-02-01 12:18 | 418.9772218 | 182019.482 | 2002-02-07 18:50 | winter storm |
| 3 | SouthEast | 2003-01-23 00:49 | 510.1199497 | 212015.3001 | 2003-02-07 18:50 | winter storm |
| 4 | SouthEast | 2003-02-07 21:15 | 289.4035493 | 142918.6282 | 2003-02-17 08:14 | winter storm |
| 5 | West | 2004-04-06 05:44 | 414.8053124 | 340171.0818 | 2004-04-06 06:10 | equipment fault |
| 6 | MidWest | 2002-03-18 06:18 | 186.4367788 | 212754.0 | 0 | Converted To Type: Number. Value: 0.0 |
| 7 | West | 2003-06-18 02:49 | 0 | 0.0 | 2003-06-18 10:54 | attack |
| 8 | West | 2004-06-20 14:39 | 211.2947226 | | 2004-06-20 19:16 | equipment fault |

Text files, spreadsheets, databases, binary files, data feeds, web, cloud storage



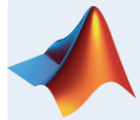
Domain-specific techniques for Signals, Images, Video, Audio, and Text



Automated Parameter Tuning

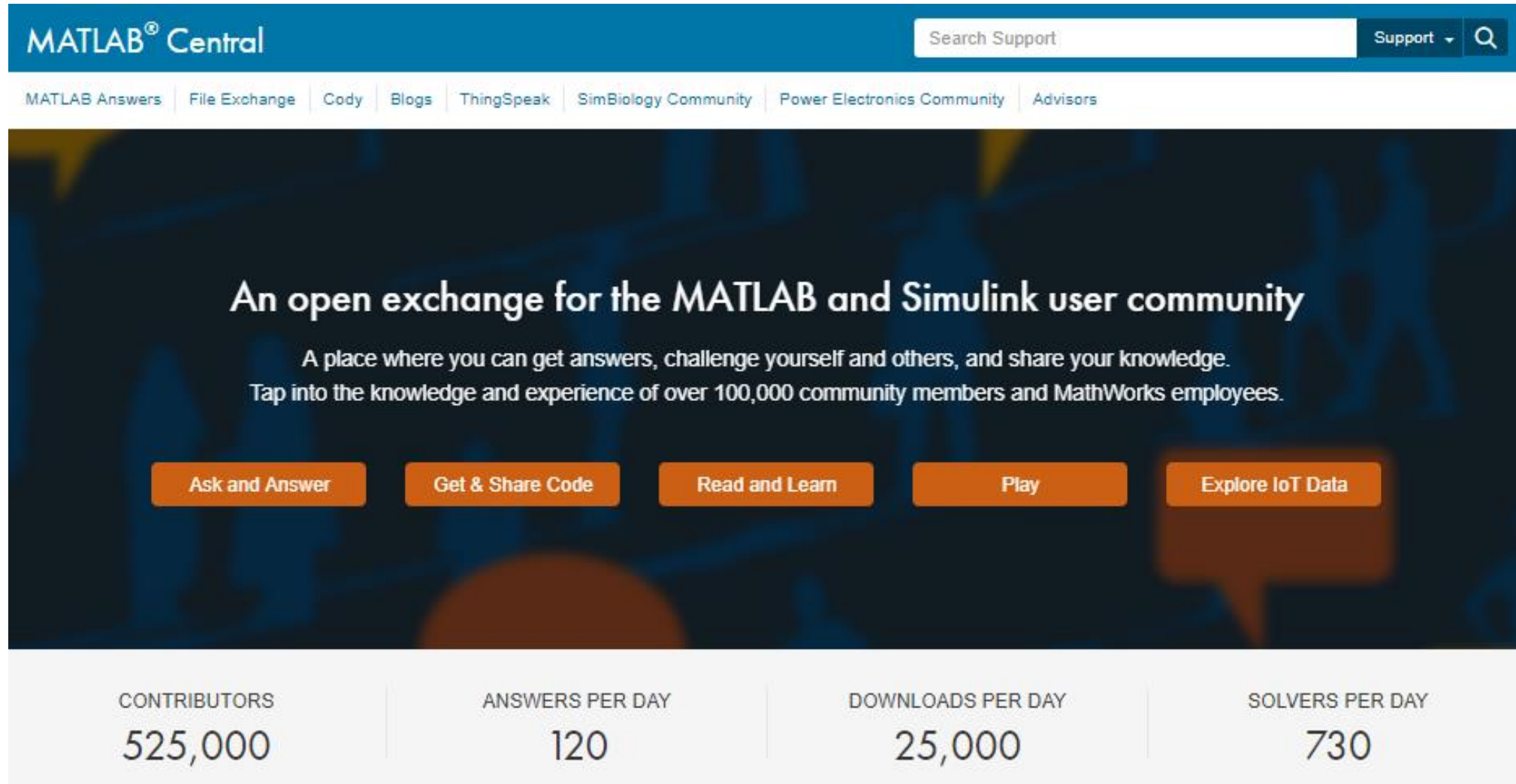
Agenda

- **Machine Learning Introduction**
- **MATLAB Demo: Fuel Economy Analysis**
- **Sharing and Deploying Machine Learning Algorithms**

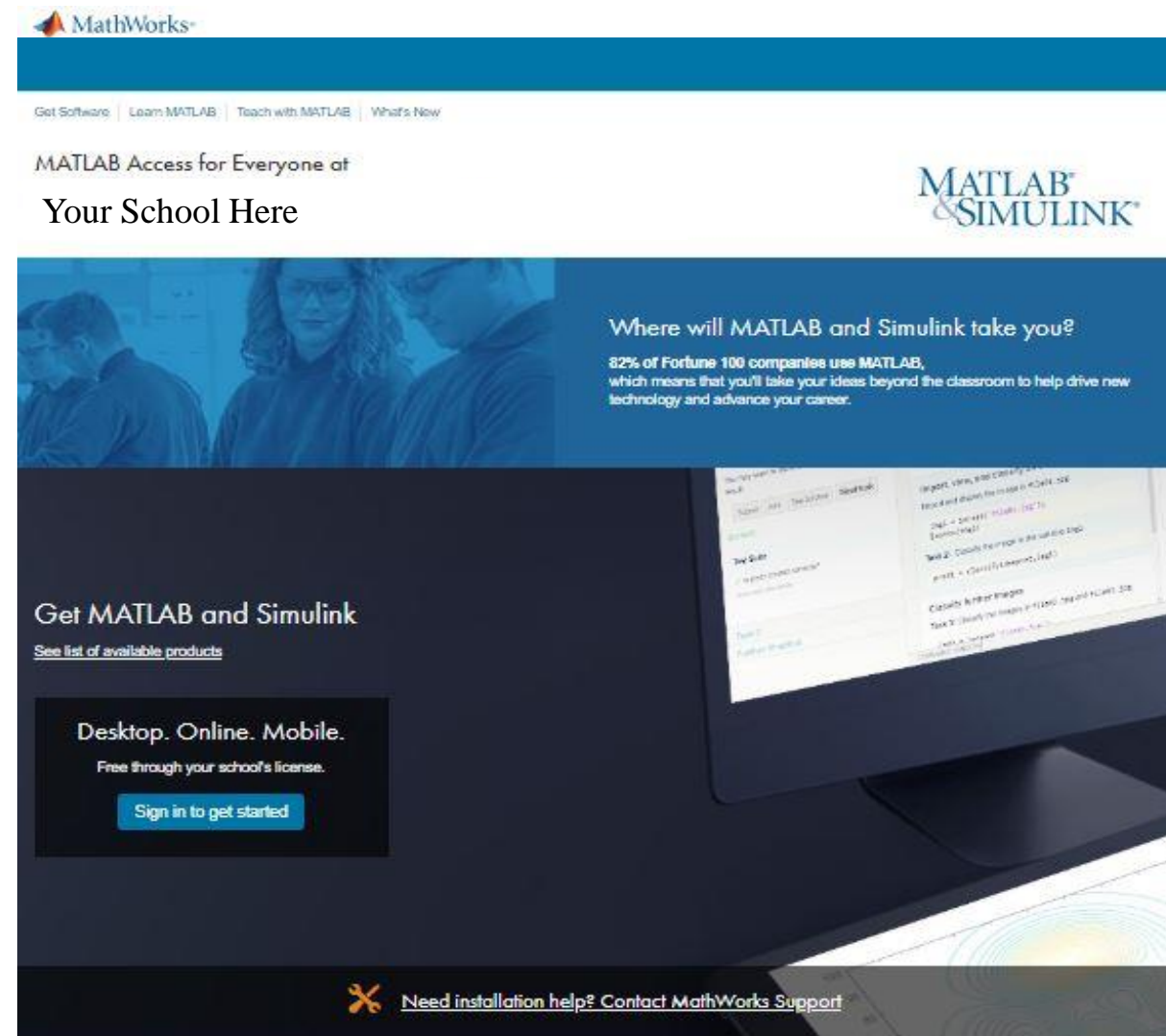


Resources and Support

MATLAB Central

The image shows the MATLAB Central homepage. At the top is a blue header with the MATLAB Central logo on the left, a search bar labeled 'Search Support' in the center, and a 'Support' dropdown menu with a magnifying glass icon on the right. Below the header is a navigation bar with links to 'MATLAB Answers', 'File Exchange', 'Cody', 'Blogs', 'ThingSpeak', 'SimBiology Community', 'Power Electronics Community', and 'Advisors'. The main content area has a dark blue background with a pattern of faint MATLAB logos. It features a large white heading 'An open exchange for the MATLAB and Simulink user community', followed by two lines of white text: 'A place where you can get answers, challenge yourself and others, and share your knowledge.' and 'Tap into the knowledge and experience of over 100,000 community members and MathWorks employees.' Below this text are five orange buttons with white text: 'Ask and Answer', 'Get & Share Code', 'Read and Learn', 'Play', and 'Explore IoT Data'. At the bottom is a white section with four columns, each containing a label and a large number: 'CONTRIBUTORS 525,000', 'ANSWERS PER DAY 120', 'DOWNLOADS PER DAY 25,000', and 'SOLVERS PER DAY 730'.

Campus-wide access



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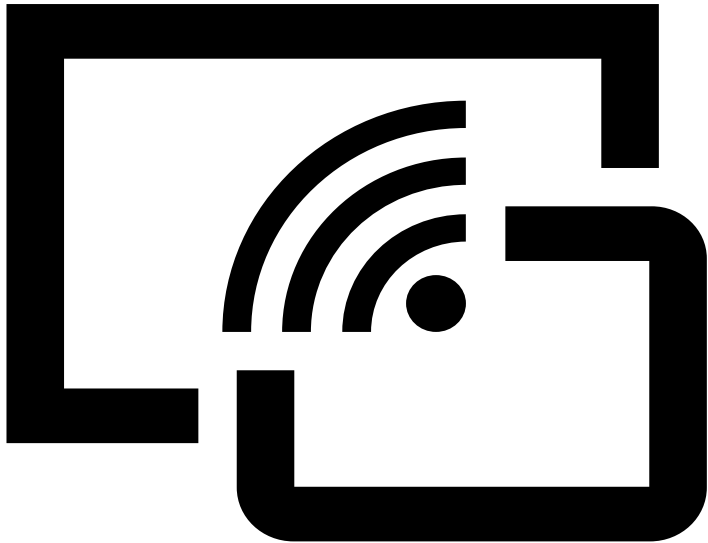
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Machine Learning Onramp
Deep Learning Onramp

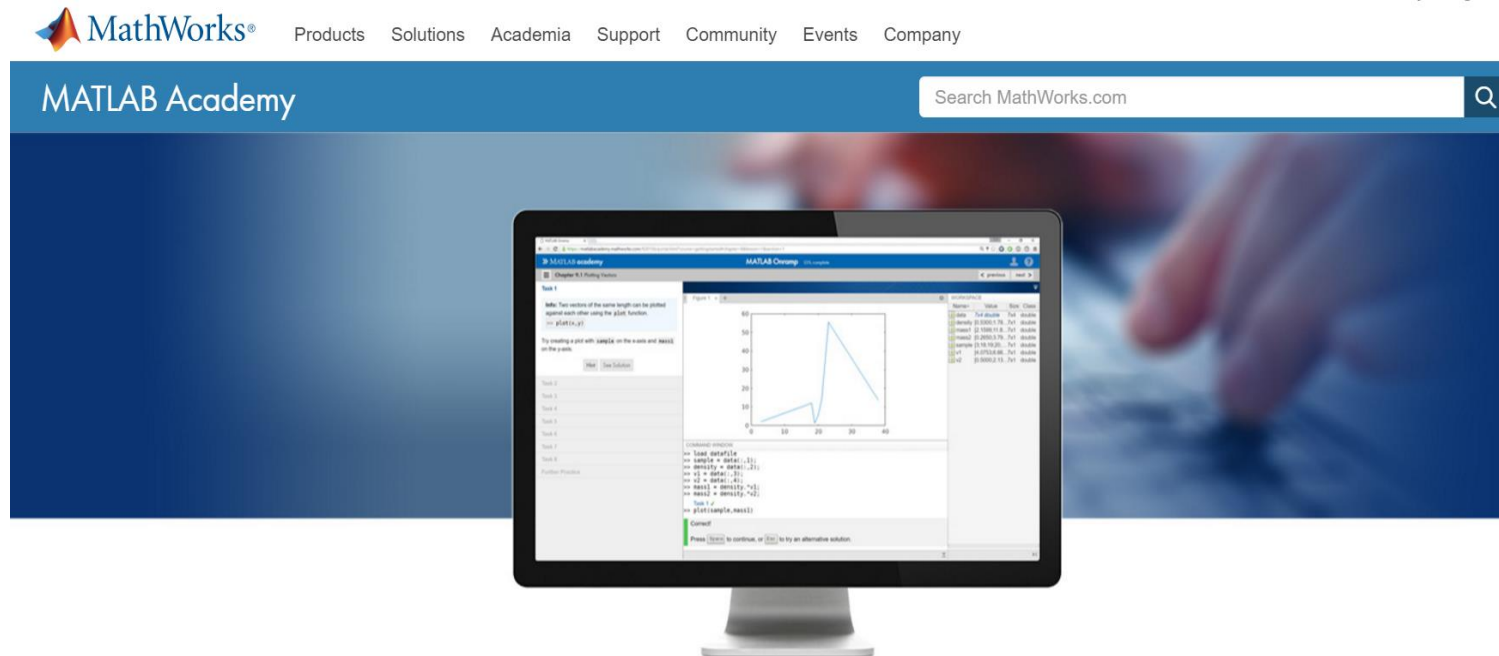
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MATLAB Fundamentals
MATLAB Programming Techniques
MATLAB for Financial Applications
MATLAB for Data Processing and Viz
Machine Learning with MATLAB
Deep Learning with MATLAB

COMPUTATIONAL MATH COURSES (2-3 hours)

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Solving Ordinary Differential Equations
Introduction to Statistical Methods
Solving Non-Linear Equations
Introduction to Symbolic Math




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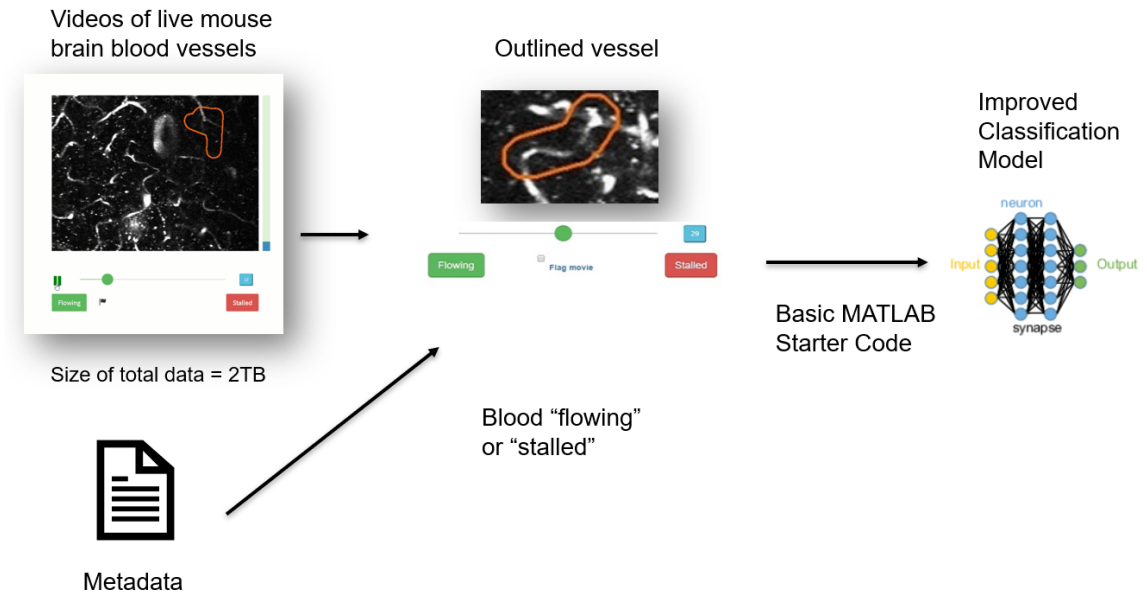
Enroll for Free
Starts Jun 16

Financial aid available

6,318 already enrolled

Advance Alzheimer's Research Data Science Challenge

- Online data science competition hosted by [DrivenData](https://www.drivendata.org) and supported by MathWorks
- No Eligibility Criteria
 - Open to students, professors, employers and at-home
 - Participate Individually or in a Team
 - Submit multiple entries
 - Online and around the globe
- Prizes worth \$10K
- MathWorks support:
 - [MATLAB benchmark code](#)
 - [Complimentary licenses](#)
 - [Technical assistance](#)



Open to all until **August 3, 2020**

Register at : <https://www.drivendata.org/competitions/65/clog-loss-alzheimers-research/>

Resources

[Teaching Data Science with MATLAB](#)

[Machine Learning Onramp](#) (2-hour online introduction)

Machine Learning with MATLAB:

- [Quick Start Guide](#)
- [Machine Learning Intro](#) (Tech talk videos)
- [Mastering Machine Learning](#) (eBook)
- [Practical Data Science with MATLAB](#) (Coursera Specialization)
- [Try the Classification Learner App in a browser](#)

Machine and Deep Learning

- [Deep vs. Machine Learning: Choosing the Best Approach](#) (eBook)
- [Deep learning Onramp](#) (2-hour online introduction)

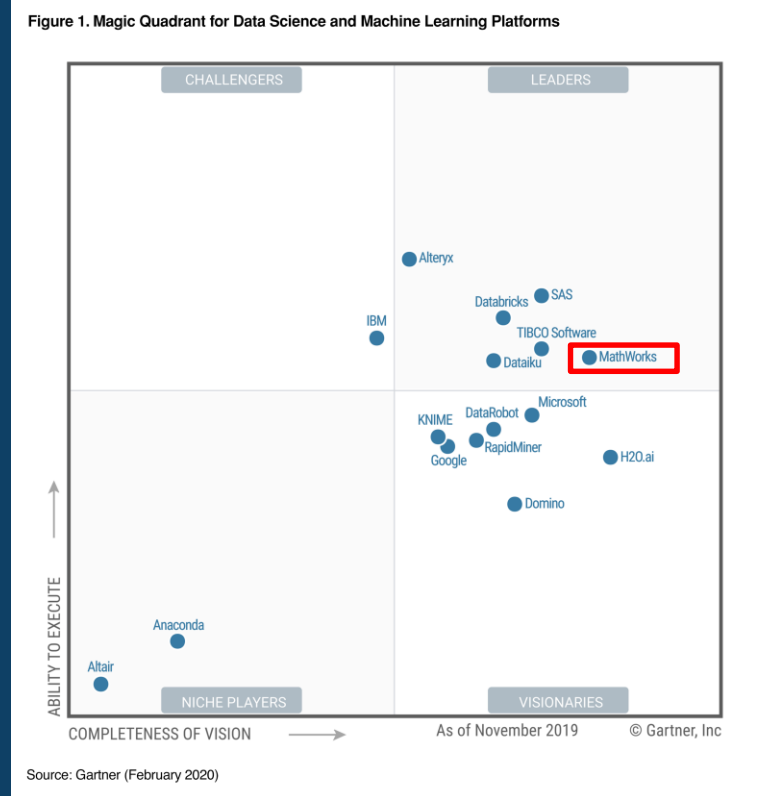


is a **Leader** in the Gartner Magic Quadrant for 2020 Data Science and Machine Learning Platforms

MathWorks has the furthest completeness of vision in the Leaders quadrant

We believe this recognition demonstrates our ability to:

- Empower your team, including those with limited AI or data science experience
- Provide complete workflows for data preparation, AI modeling, system design, and production
- Deploy AI models on embedded devices, edge, enterprise systems, and the cloud
- Use Simulink to tackle integration challenges and reduce risk in designing AI-driven systems



*Gartner Magic Quadrant for Data Science and Machine Learning Platforms, Peter Krensky, Erick Brethenoux, Jim Hare, Carlie Idoine, Alexander Linden, Svetlana Sicular, 11 February 2020 .

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consult with faculty and researchers to support them with their STEM initiatives,
including integrating computational or systems thinking into their curriculum.





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