

Introduction to MATLAB

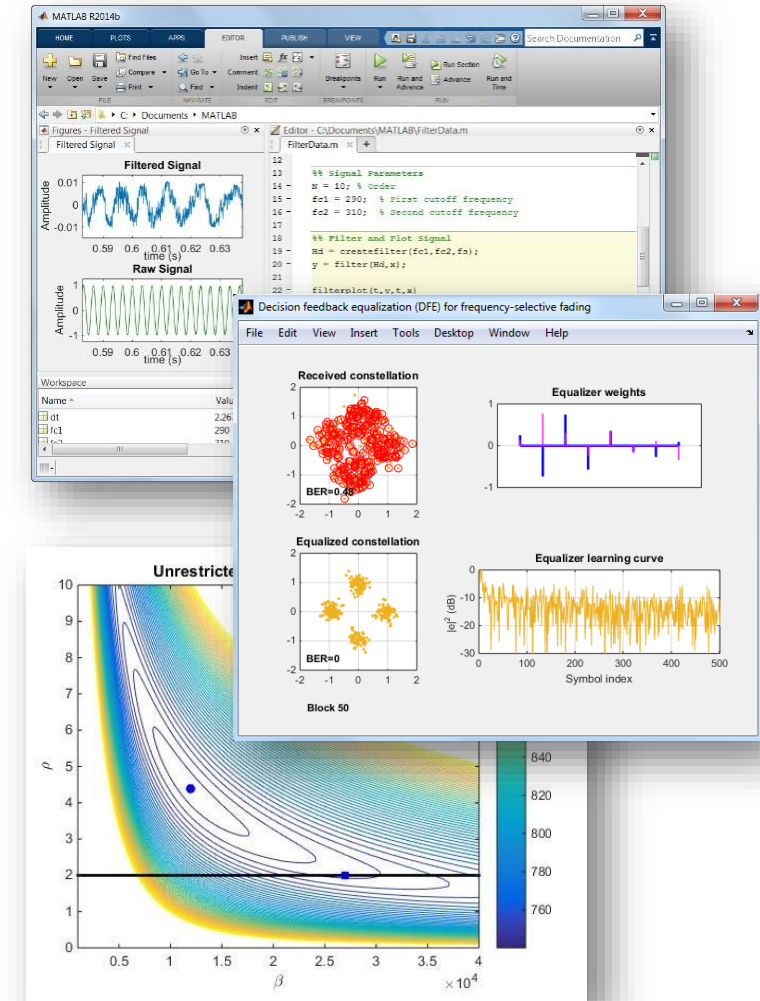
M M Zafar

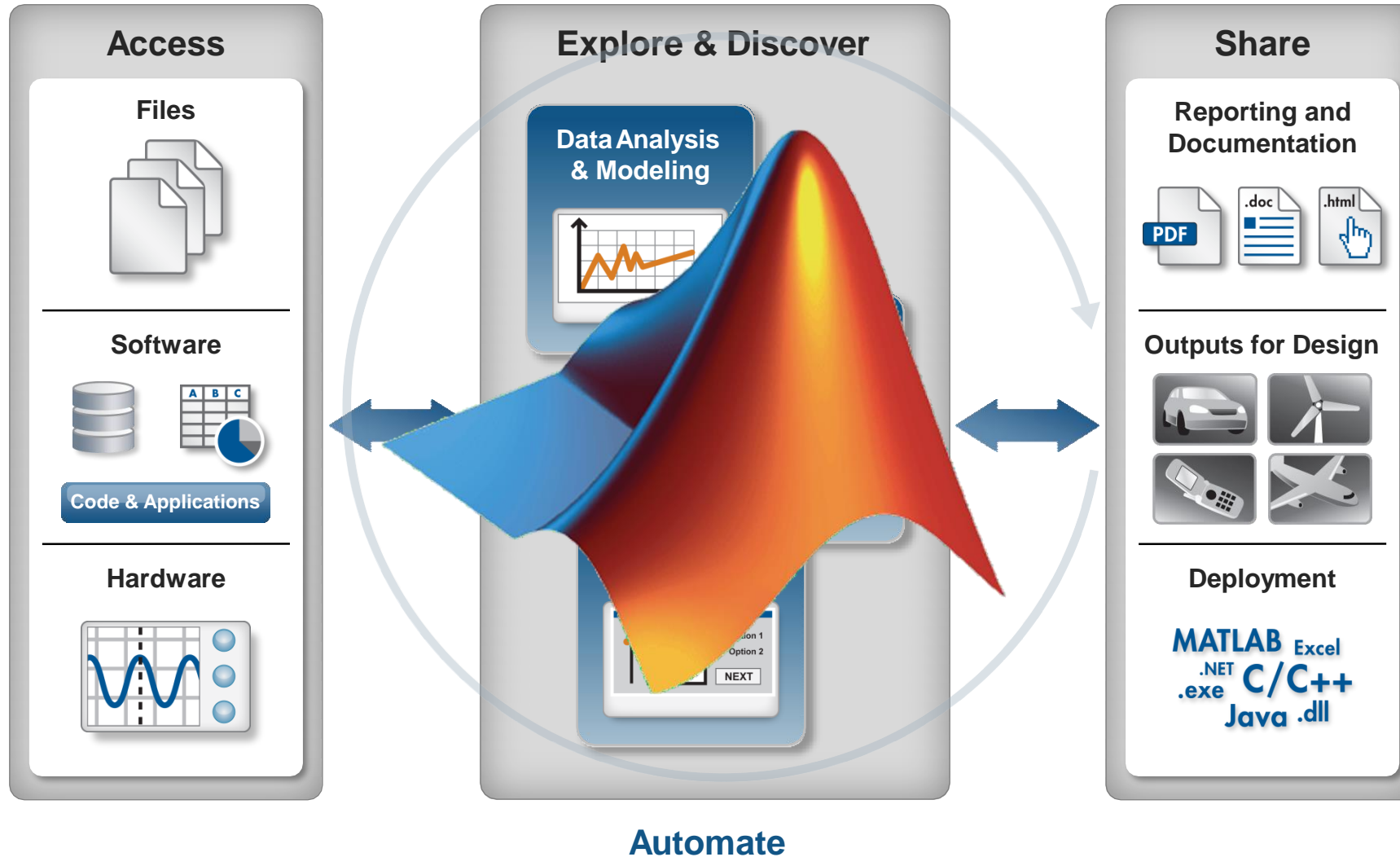
mahmooduz.zafar@designtechsys.com

- Overview of MATLAB
- Using Live Editor
- Example:
 - Demo
- Summary

What is MATLAB?

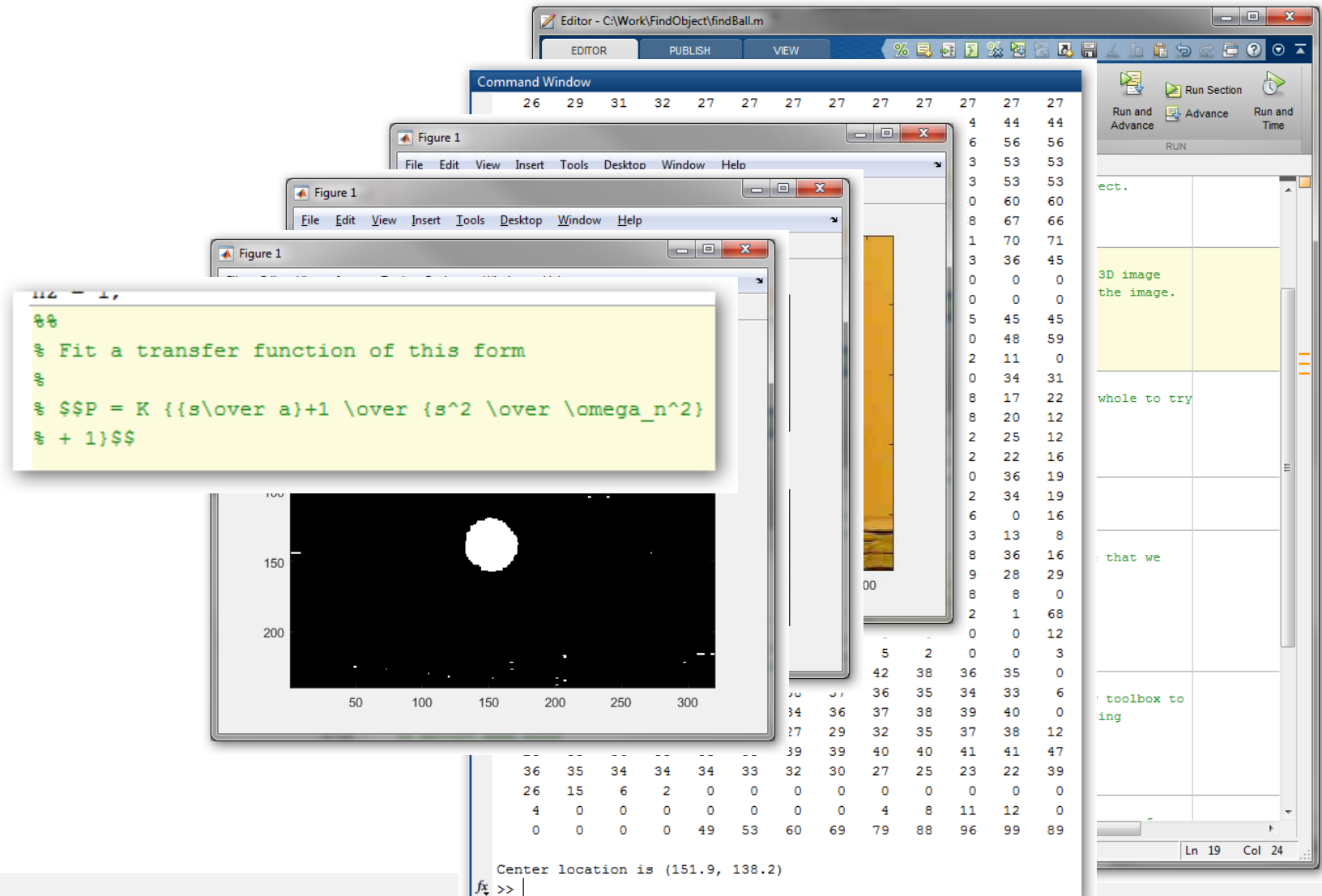
- High-level language
- Interactive development environment
- Used for:
 - Numerical computation
 - Data analysis and visualization
 - Algorithm development and deployment





Editing and Running MATLAB Code Today

- Plain-text editing
- Output goes to Command Window
- Multiple figure windows appear
- Equations, images, and hyperlinks only appear if published



Using the Live Editor

- Accelerate Exploratory Programming
- Create an Interactive Narrative
- Teach with Live Scripts

Live Editor - C:\MATLAB\Live Editor\RootsOfOne.mlx

LIVE EDITOR VIEW

The Roots of One

What does it mean to find the n^{th} root of 1?

Today we're going to talk about finding the roots of 1. What does it mean to find the n^{th} root of 1? The n^{th} roots of 1 are the solutions to the equation $x^n - 1 = 0$.

For square roots, this is easy. The values are $x = \pm \sqrt{1} = \pm 1$. For higher-order roots, it gets a bit more difficult. To find the cube roots of 1 we need to solve the equation $x^3 - 1 = 0$. We can factor this equation to get

$$(x - 1)(x^2 + x + 1) = 0.$$

So the first cube root is 1. Now we can use the quadratic formula to get the second and third cube roots.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Calculate the Cube Roots

In our case a , b , and c are all equal to 1. The other two roots are calculated from these formulas:

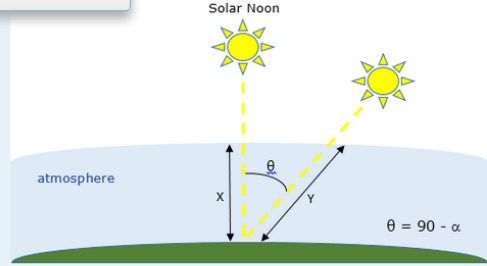
Live Editor - C:\MATLAB\Live Editor\SolarPower.mlx

LIVE EDITOR VIEW

Air Mass and Solar Radiation

As light from the sun passes through the earth's atmosphere, some of the solar radiation will be absorbed. The [air mass](https://en.wikipedia.org/wiki/Air_mass) is a function of solar elevation (α). As shown in the diagram below, it is a measure of the length of the path of light through the atmosphere (Y) relative to the shortest possible path (X).

https://en.wikipedia.org/wiki/Air_mass
Ctrl+Click to follow link



The larger the air mass, the less radiation reaches the ground. The air mass can be calculated from the equation

$$AM = \frac{1}{\cos(90 - \alpha) + 0.5057(6.0799 + \alpha)^{-1.6364}}.$$

Then the solar radiation (in Kw/m²) reaching the ground can be calculated from the empirical equation

$$sRad = 1.353 * 0.7^{AM^{0.678}}.$$

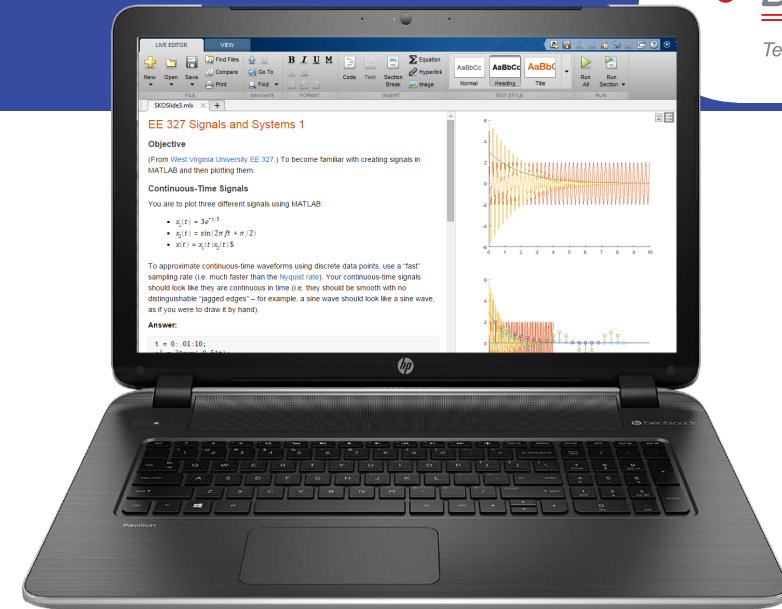
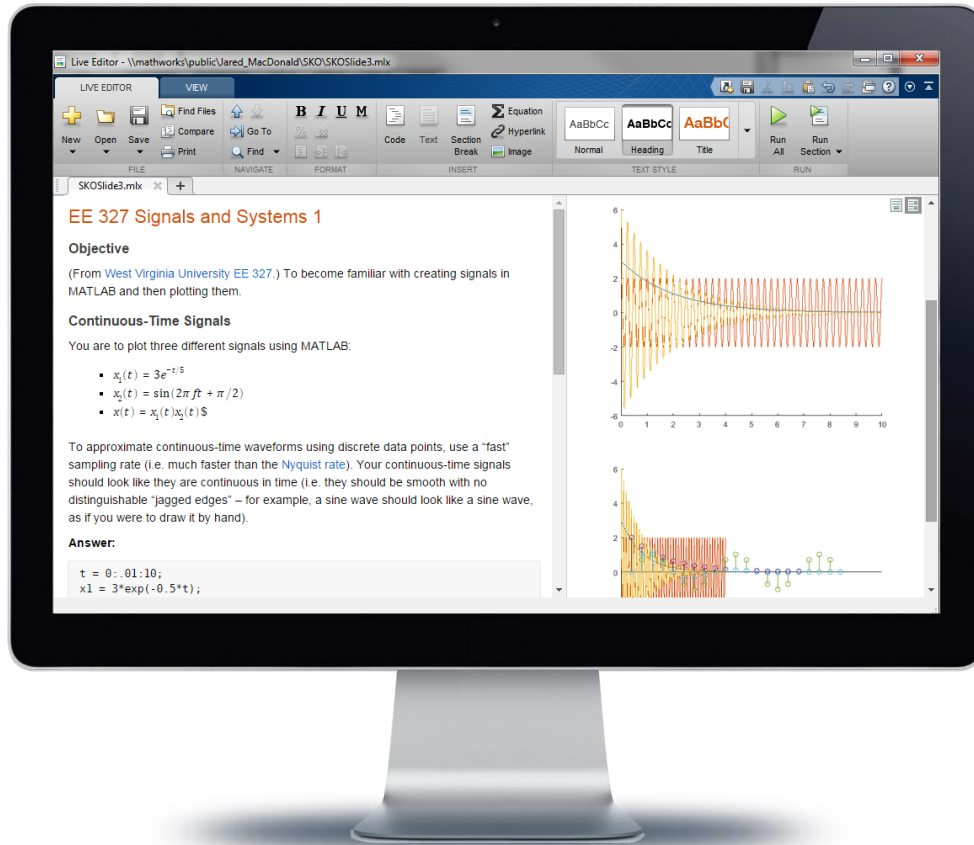
```
AM = 1/(cosd(90-alpha) + 0.5057*(6.07955+alpha)^-1.6354);
sRad = 1.353*0.7^(AM^0.678); % kW/m^2
disp(['Air Mass = ' num2str(AM) ' Solar Radiation = ' num2str(sRad) ' kW/m^2'])
```

Air Mass = 1.0688 Solar Radiation = 0.93164 kW/m²

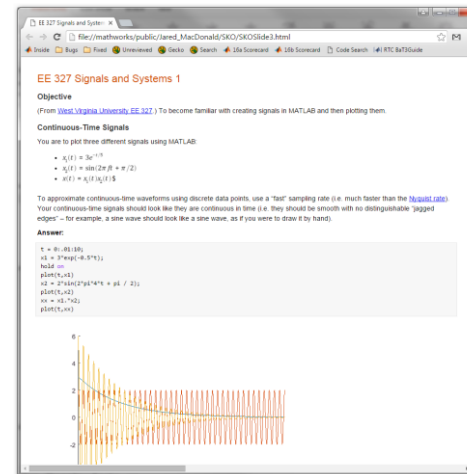
Solar Radiation on Fixed Panels

Panels installed with a [solar tracker](#) can move with the sun and receive 100% of the sun's radiation as the sun moves across the sky. However, most [solar cell](#) installations have panels set at a fixed azimuth and tilt. Therefore the actual radiation reaching the panel will also depend on the sun's

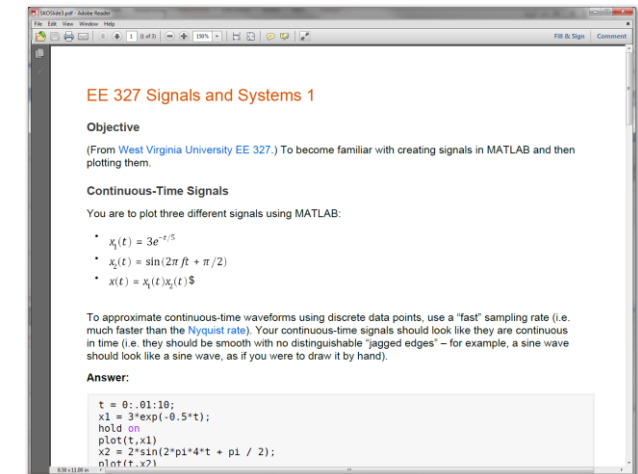
Sharing Live Scripts



Colleague with MATLAB



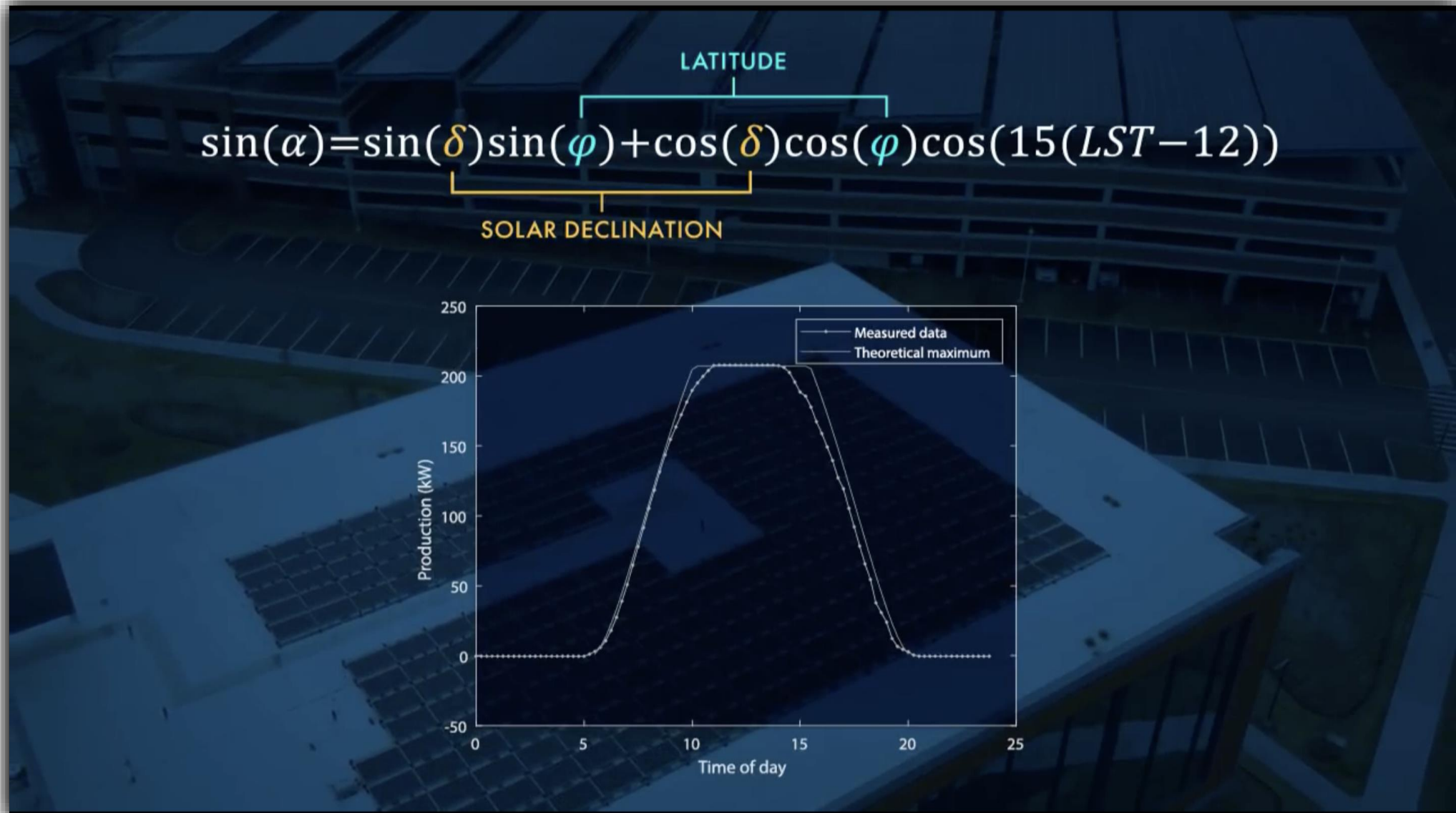
HTML



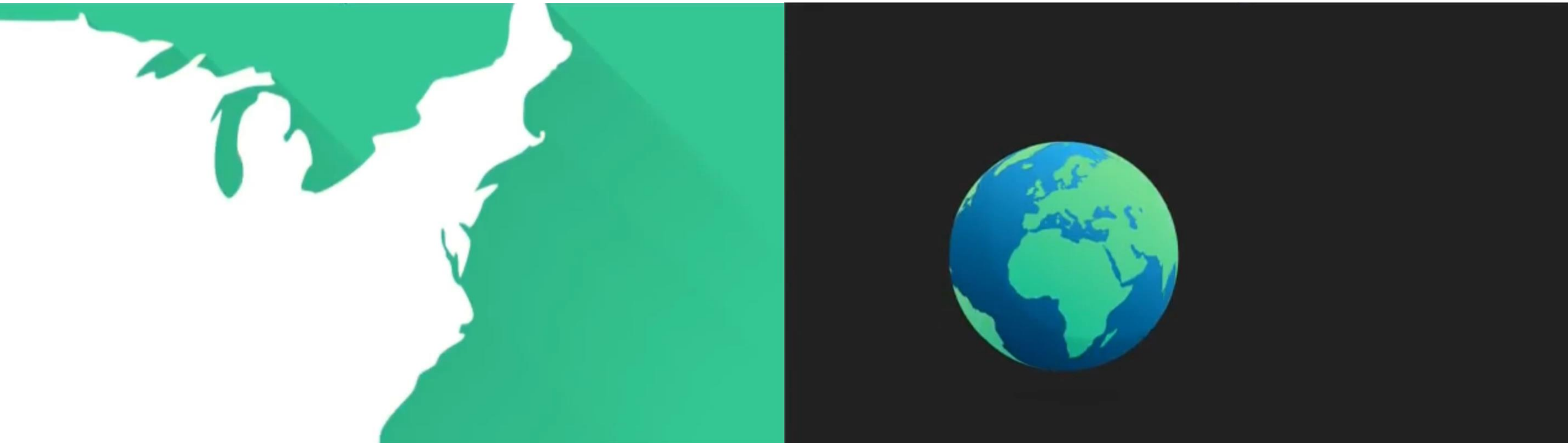
PDF

Demo: Solar Electricity Production

Demo: Solar Electricity Production



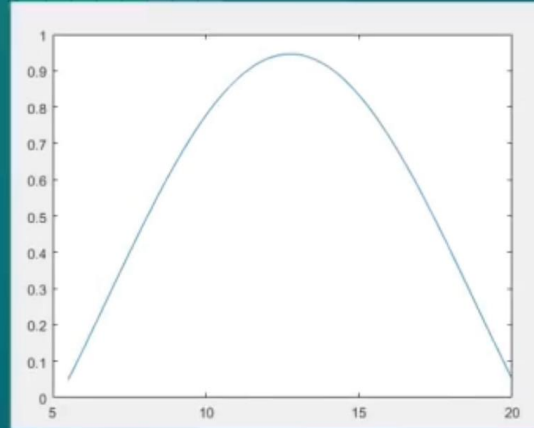
Demo: Solar Electricity Production



$$\sin(\alpha) = \sin(\delta)\sin(\varphi) + \cos(\delta)\cos(\varphi)\cos(15(\textcolor{brown}{LST} - 12))$$

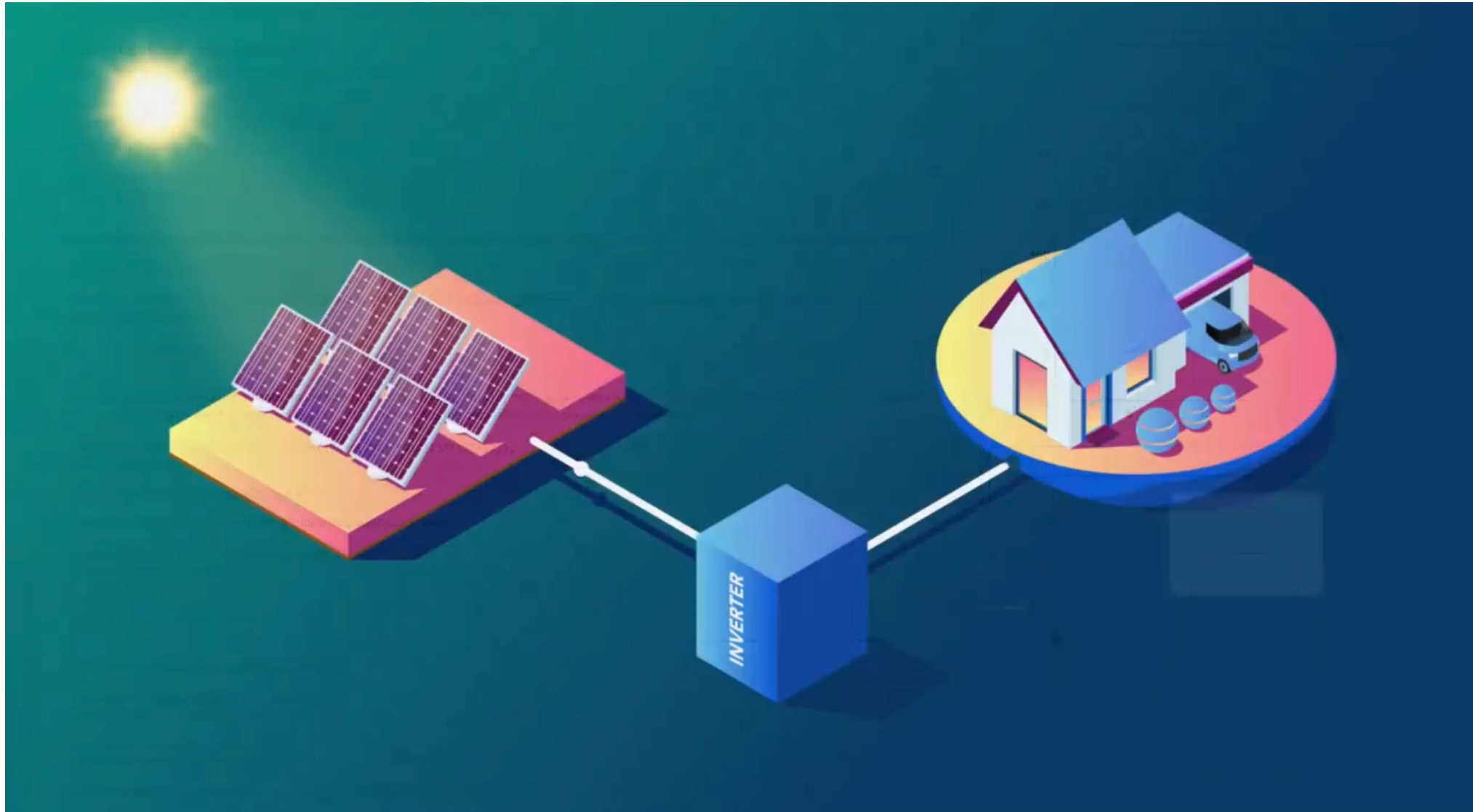
|
LOCAL SOLAR TIME

Demo: Solar Electricity Production



Demo: Solar Electricity Production

Demo: Solar Electricity Production

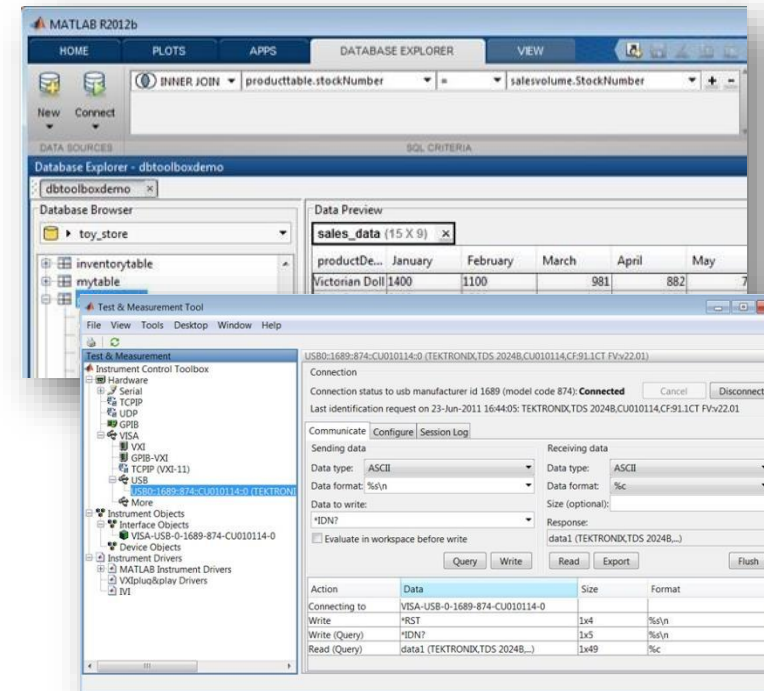


Access

Explore & Discover

Share

- Files
 - Excel, text, or binary
 - Audio and video, image
 - Scientific formats and XML
- Web Services
 - JSON, CSV, and image data
- Applications and languages
 - C/C++, Java, FORTRAN, Python
 - COM, .NET, shared libraries
 - Databases (*Database Toolbox*)
- Measurement hardware
 - Data acquisition hardware (*Data Acquisition Toolbox*)
 - Stand-alone instruments and devices (*Instrument Control Toolbox*)

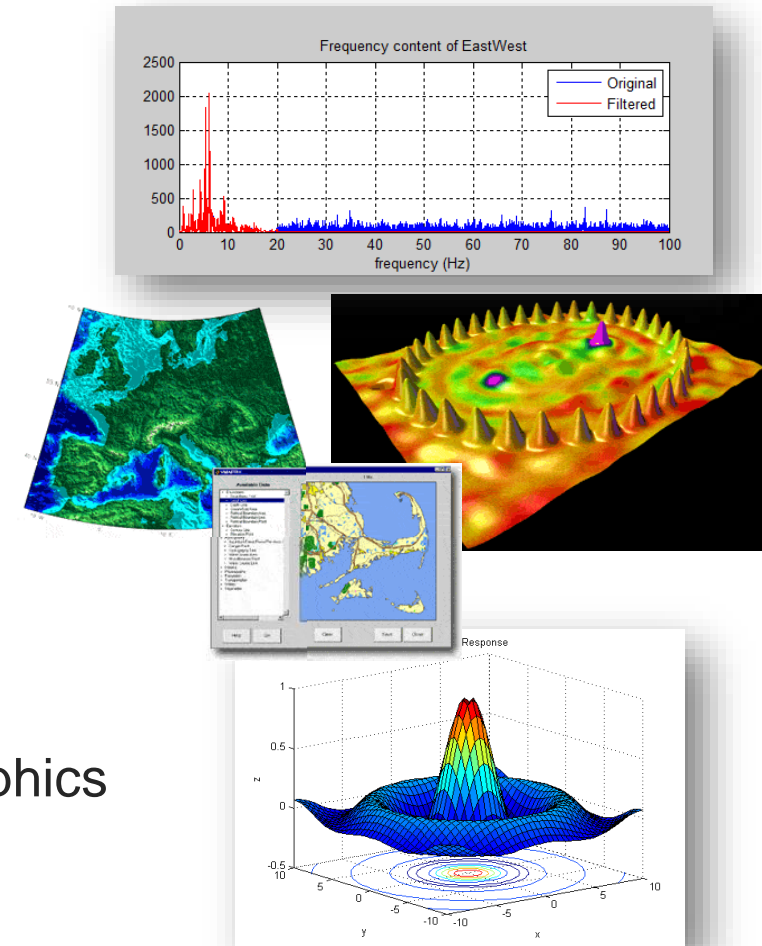


Access

Explore & Discover

Share

- Data analysis
 - Manipulate, preprocess, and manage data
 - Fast, accurate analysis with pre-built math and engineering functions
- Visualization
 - Built in graphics functions for engineering and science (2D, 3D, VolViz)
 - Interactive tools to annotate and customize graphics

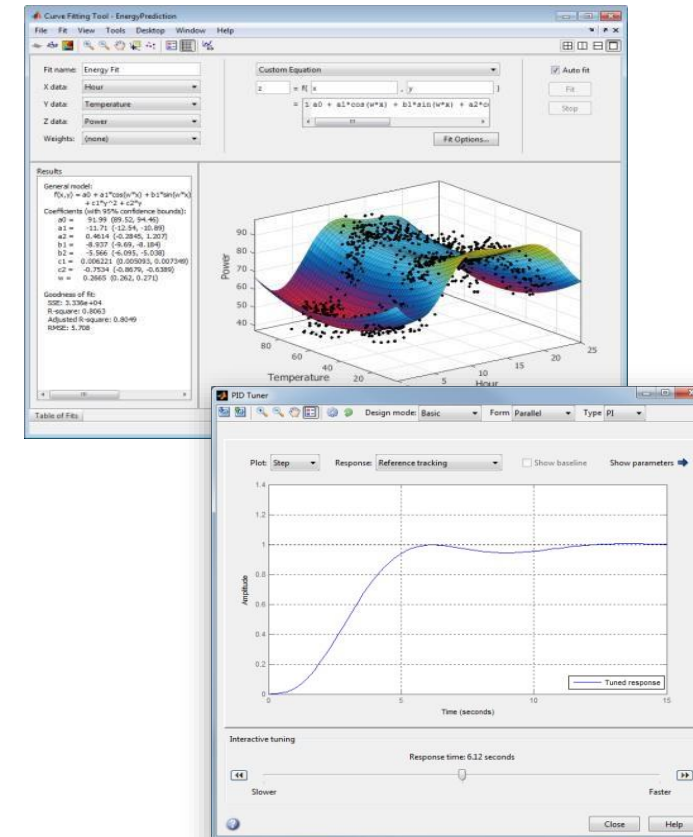


Access

Explore & Discover

Share

- MathWorks add-on tools for:
 - Math, statistics, and optimization
 - Control system design and analysis
 - Signal processing and communications
 - Image processing and computer vision
 - Parallel computing and more...
- Partner products provide:
 - Additional interfaces
 - Domain-specific analysis
 - Support for niche applications



Access

Explore & Discover

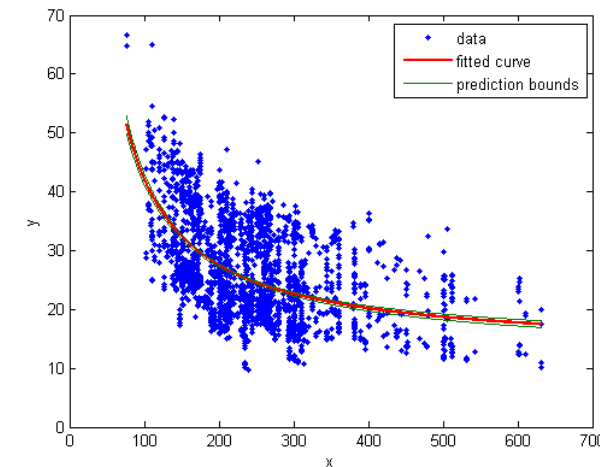
Share

- Automatically generate reports
 - Publish MATLAB files
 - Customize reports using MATLAB Report Generator
- Package as an app
- Deploy applications to other environments

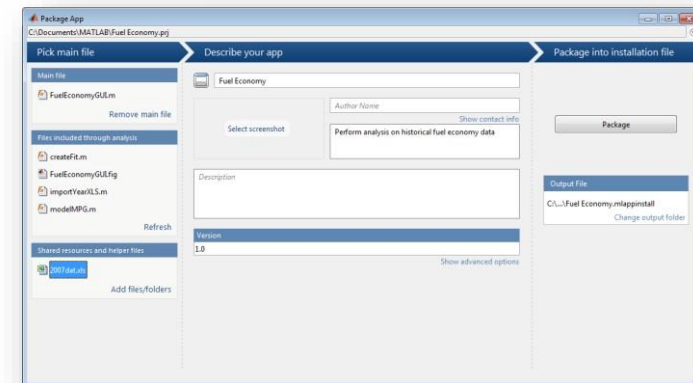
Plot Data and Model

The result from the Curve Fitting Toolbox has a `plot` method for displaying the result graphically. We can choose to display the prediction bounds for the fit.

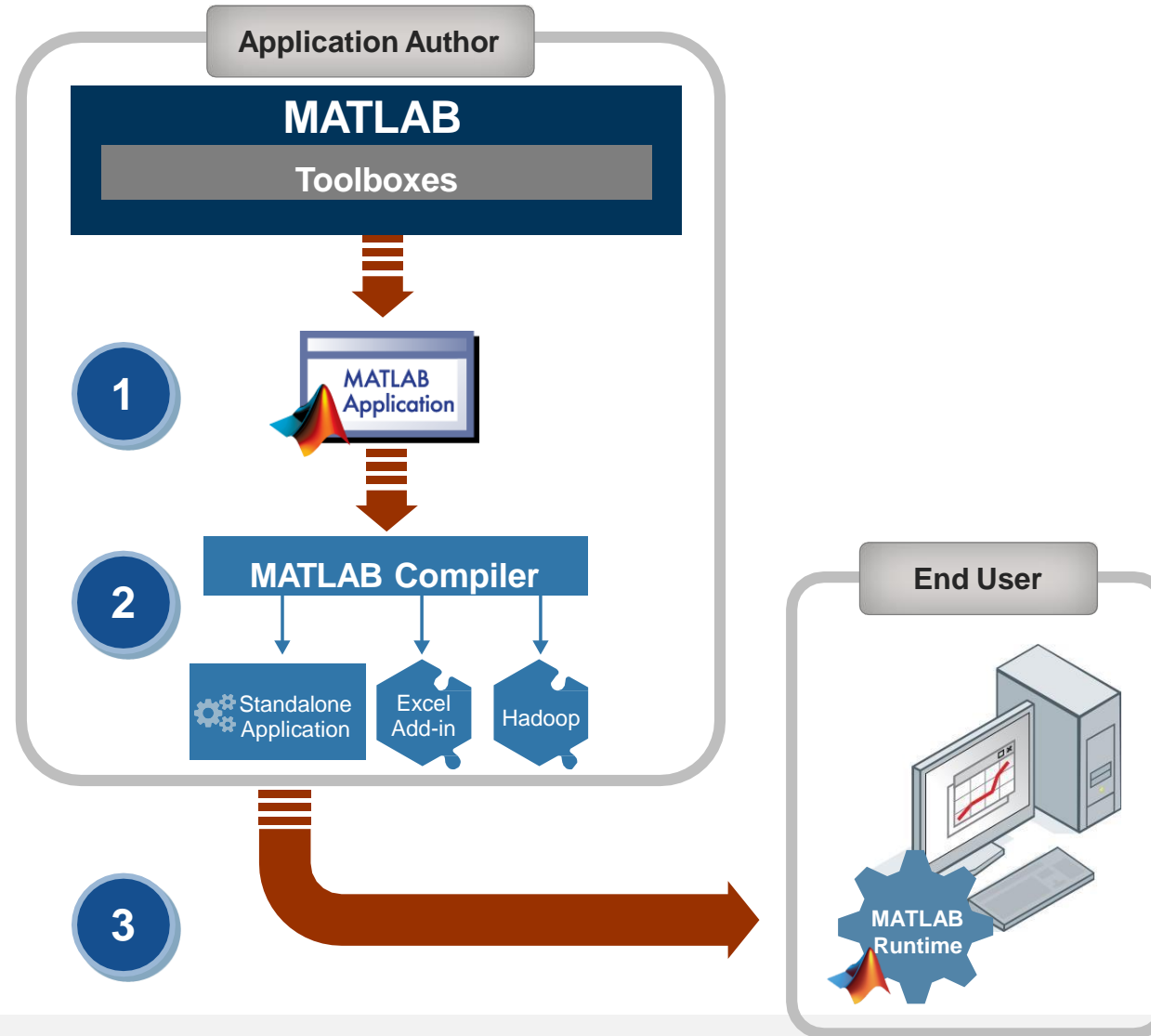
```
figure;  
hh = plot(cf, 'r', carDataDS.RatedHP, carDataDS.MPG, 'predfunc', 0.95);  
set(hh(2), 'LineWidth', 2);  
set(hh(3:4), 'LineStyle', '-', 'Color', [0 .5 0]);
```



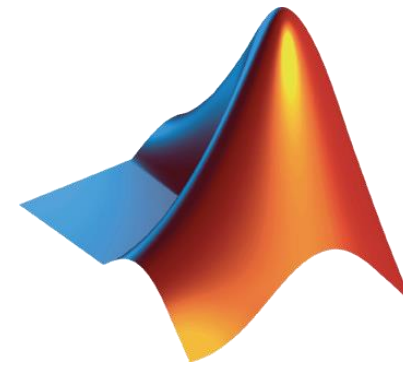
- MATLAB apps
 - Interactive applications to perform technical computing tasks
 - Displayed in apps gallery
- Included in many MATLAB products
- Package your own app
 - Create single file for distribution and installation into gallery
 - Packaging tool:
 - Automatically includes all necessary files
 - Documents required products



Sharing Standalone Applications

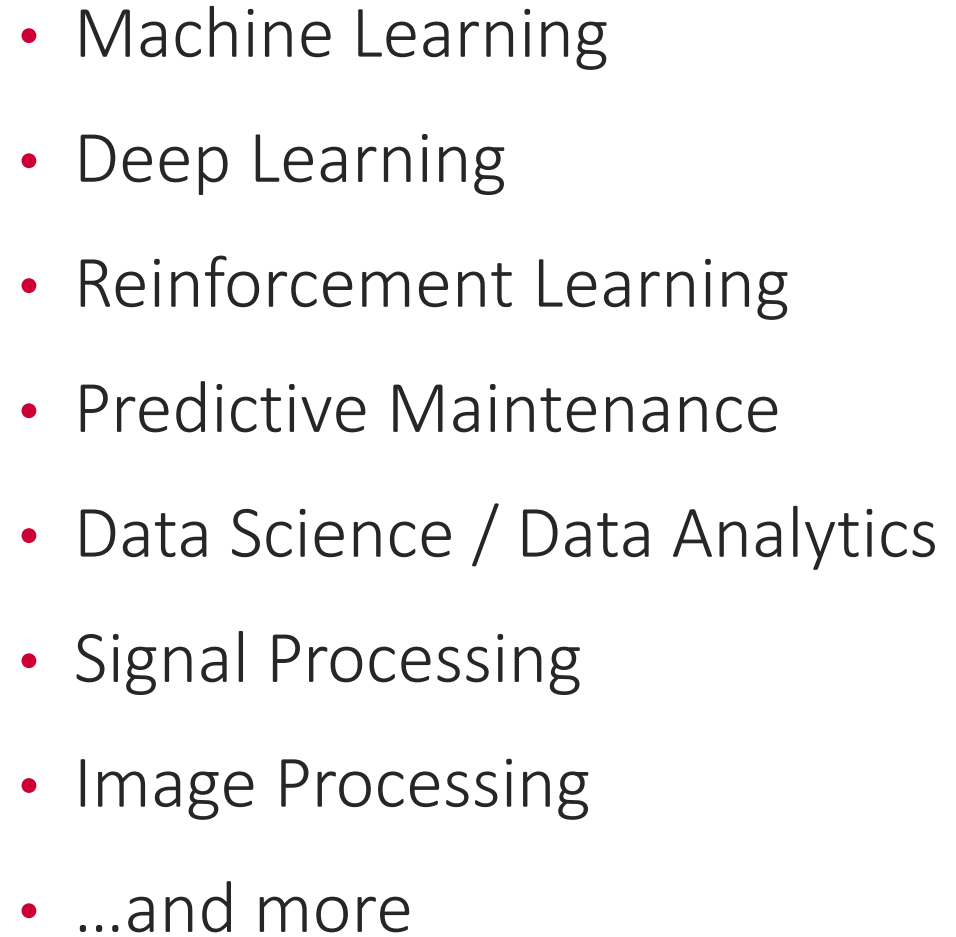


- High-level language
 - Native support for vector and matrix operations
 - Built-in math and visualization functions
- Development environment
 - Interactive and easy to get started
 - Ideal for iterative exploration and design
- Technical computing platform
 - Add-on products for a range of application areas
(*e.g., signal processing and communications, image and video processing, control systems, test and measurement*)



Break

Essential Tools for Machine Learning

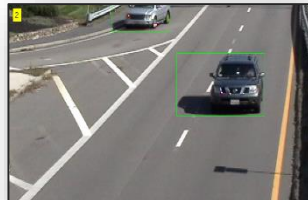


Machine Learning is Everywhere

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



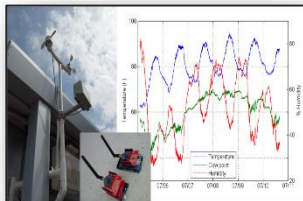
Energy Load Forecasting



Stock Market Prediction

update as more data becomes available

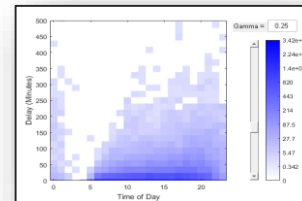
Solution needs to scale



IoT Analytics



Taxi Availability



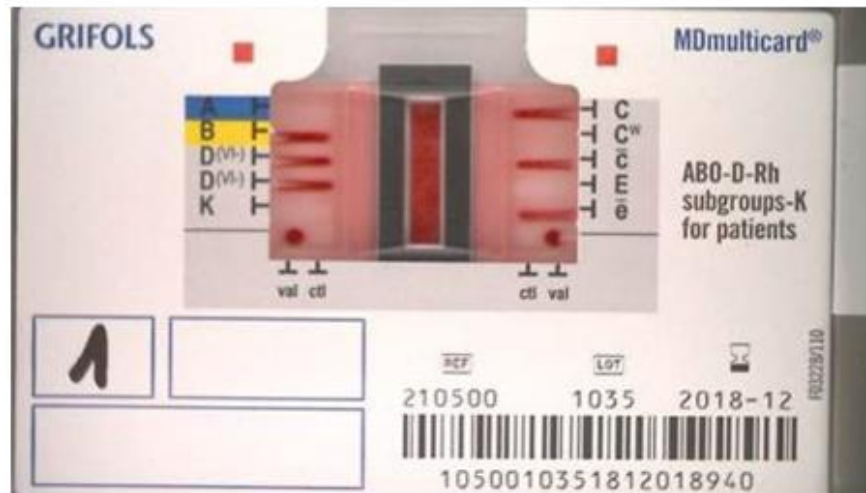
Airline Flight Delays

learn efficiently from very large data sets

IDNEO Develops Embedded Computer Vision and Machine Learning Algorithms for Interpreting Blood Type Results

"With the time we saved by generating code with Embedded Coder, we were able to experiment with new features and complete additional iterations in MATLAB, incorporating customer feedback on the early prototypes."

— Marc Blanch, IDNEO



The Grifols MDmulticard.

Challenge

Automate the visual interpretation of cards used by hospital staff to determine patient blood antigenic typing

Solution

Use MATLAB to develop, test, and generate embedded code for image analysis and machine learning algorithms

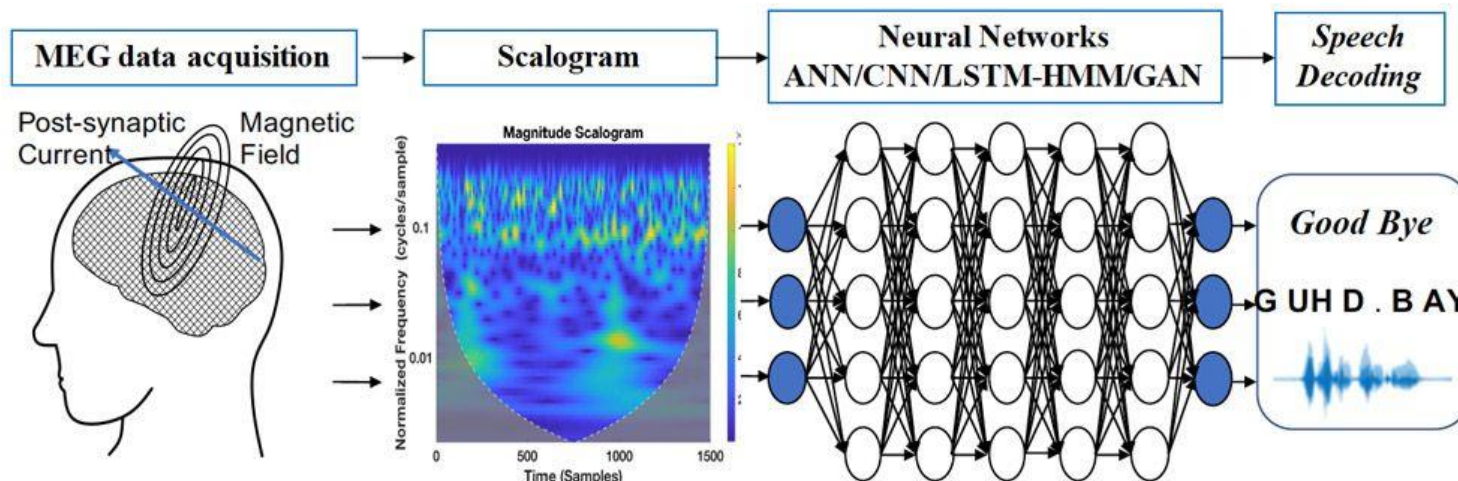
Results

- Accuracy requirements exceeded
- Project completion time halved
- Optimized system delivered

UT Austin Researchers Convert Brain Signals to Words and Phrases Using Wavelets and Deep Learning

“MATLAB is an industry-standard tool, and one that you can trust. It is easier to learn than other languages, and its toolboxes help you get started in new areas because you don’t have to start from scratch.”

— Dr. Jun Wang, UT Austin



Challenge

Create a speech-driven brain-computer interface to enable ALS patients to communicate by imagining the act of speaking specific phrases

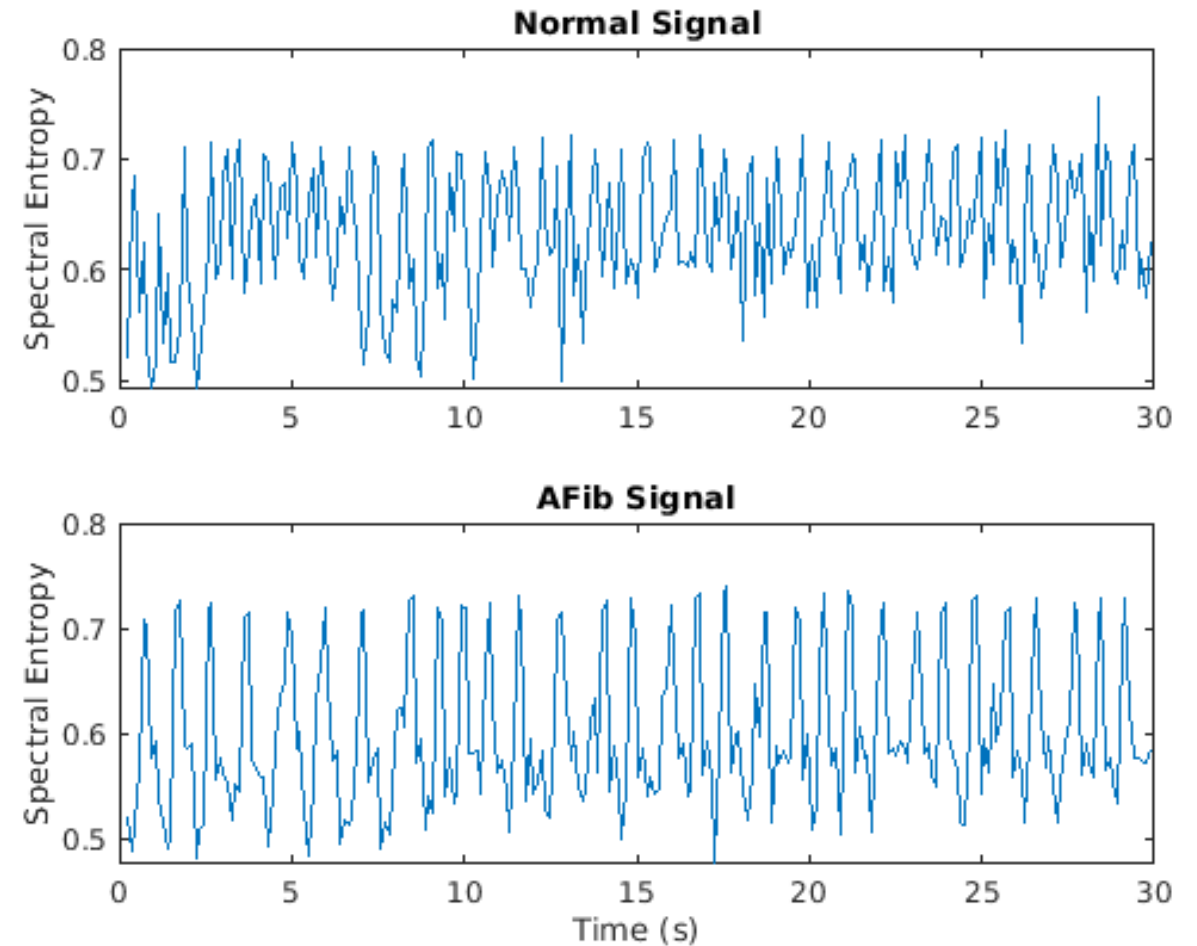
Solution

Use wavelet scalograms of MEG signals to train deep neural networks

Results

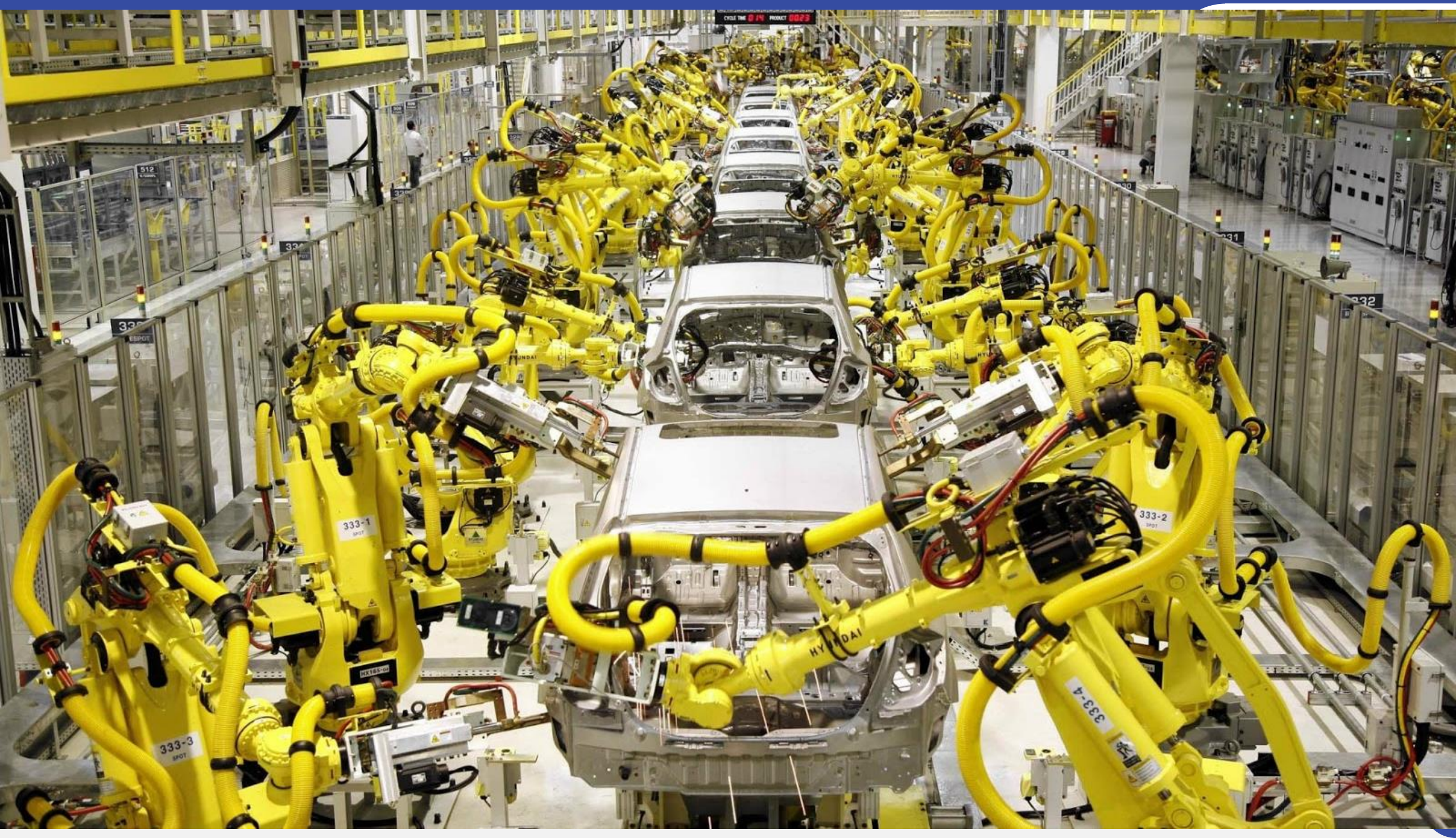
- Classification accuracy of 96% achieved
- Wavelets and deep learning networks quickly combined
- Training times accelerated by a factor of 10

- Machine Learning
 - Overview and workflow
- Example:
 - Basic example to get start
 - ECG Classification
- Deep Learning
 - Overview and resources
- Summary
 - Recap and key takeaways



Do you need AI?





Artificial Intelligence

The capability of a machine to imitate intelligent human behavior

Artificial Intelligence

The capability of a machine to match or exceed intelligent human behavior

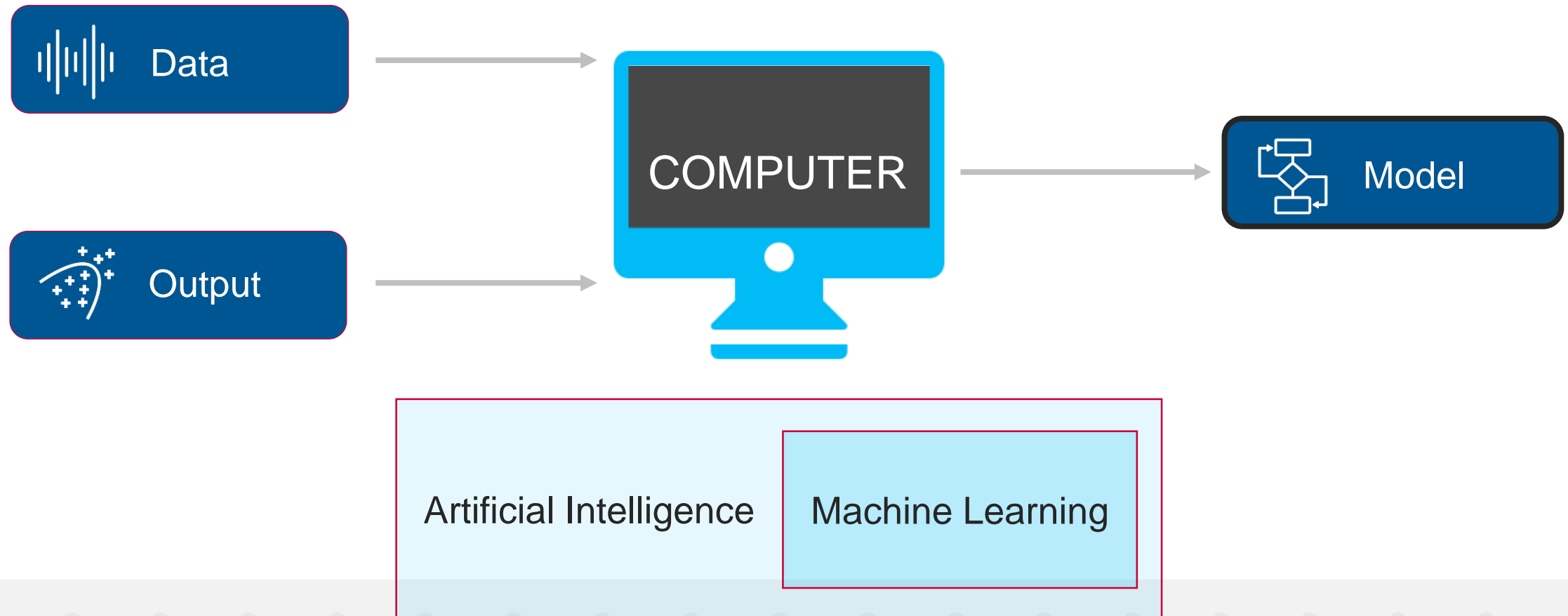
There are two ways to get a computer to do what you want



There are two ways to get a computer to do what you want



There are two ways to get a computer to do what you want



Are you ready for AI?

Data



Output



Model



Are you ready for AI?



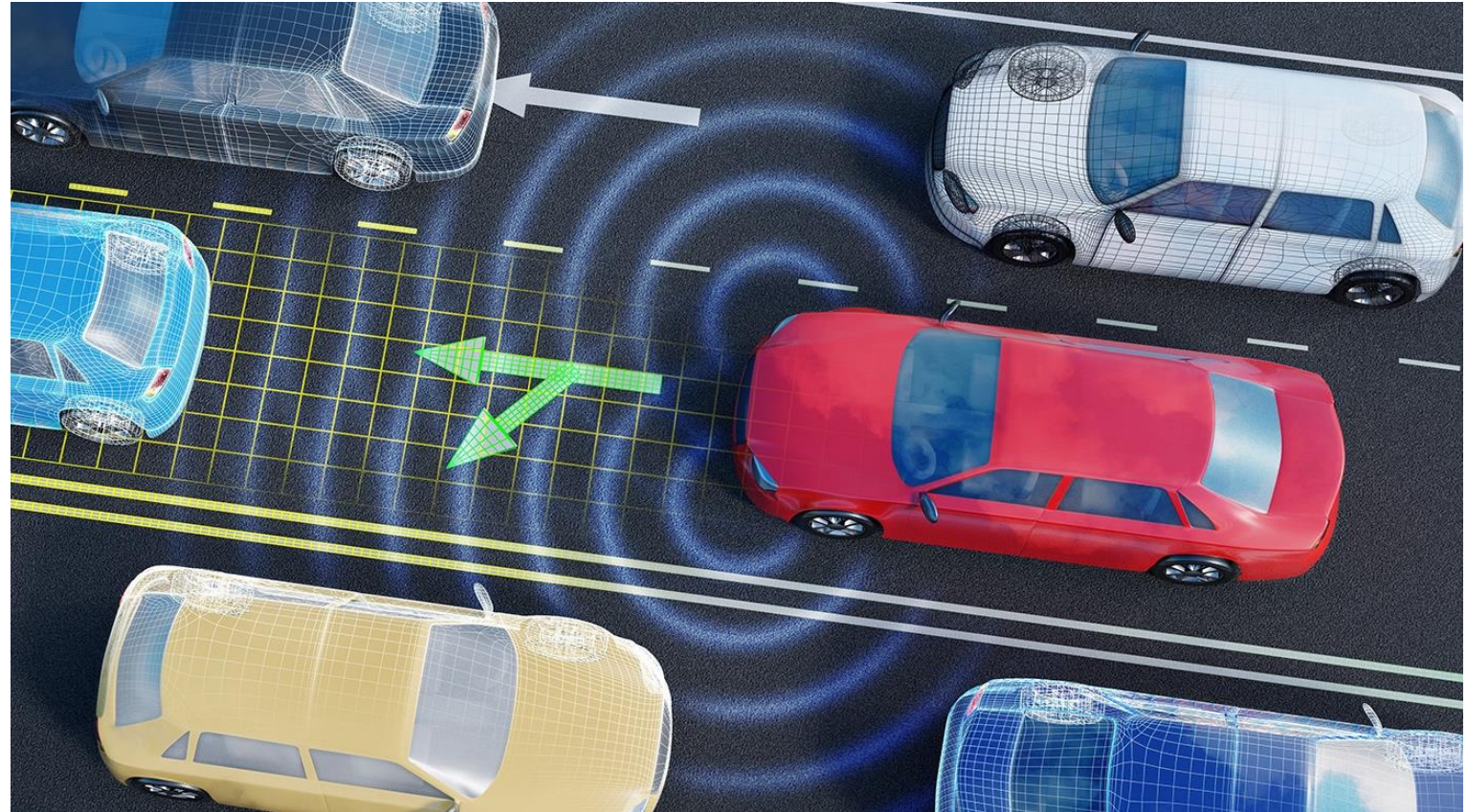
Data



Output



Model



Are you ready for AI?

Access Data

Analyze Data



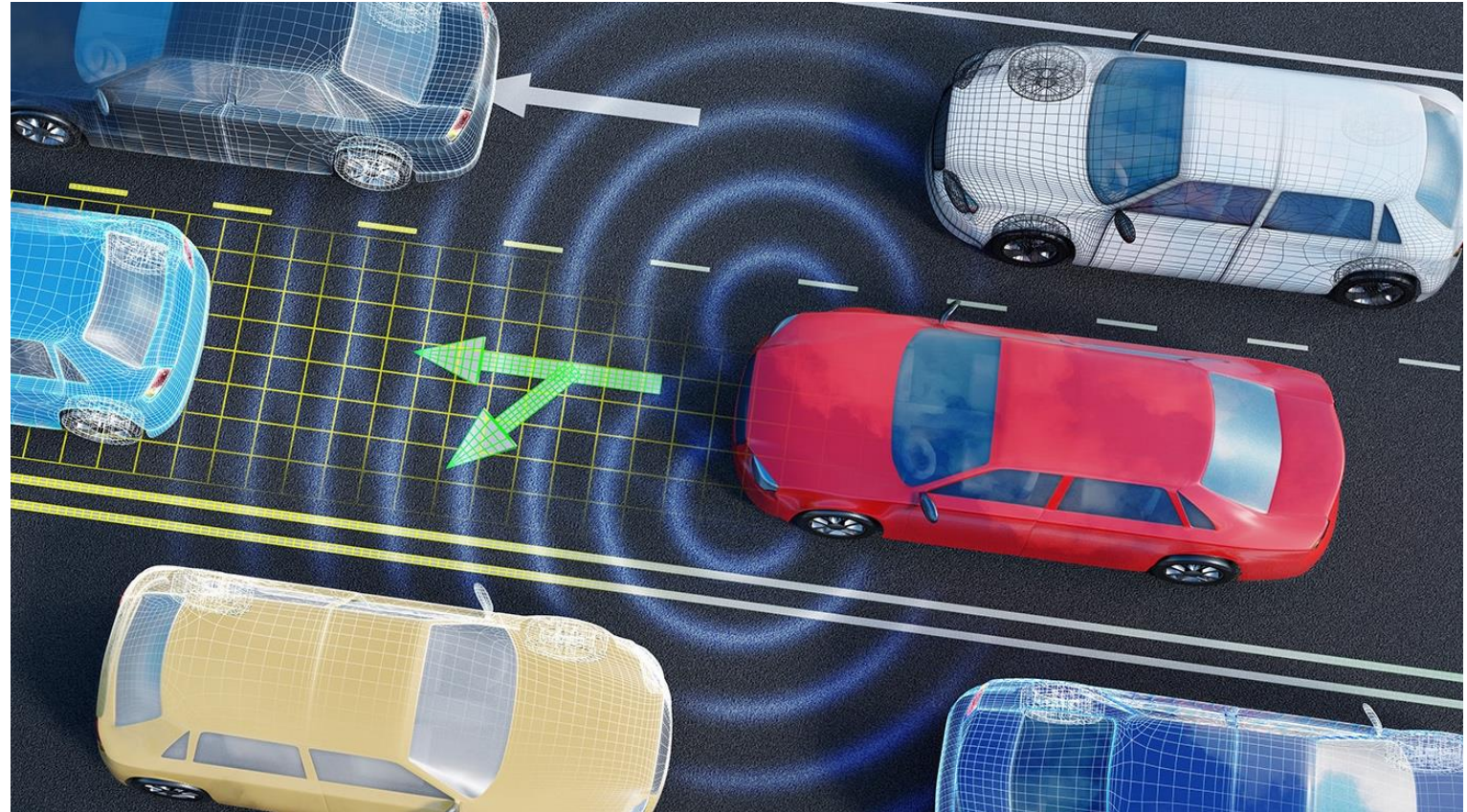
Data



Output



Model



Are you ready for AI?

Access Data

Analyze Data

Develop

Deploy



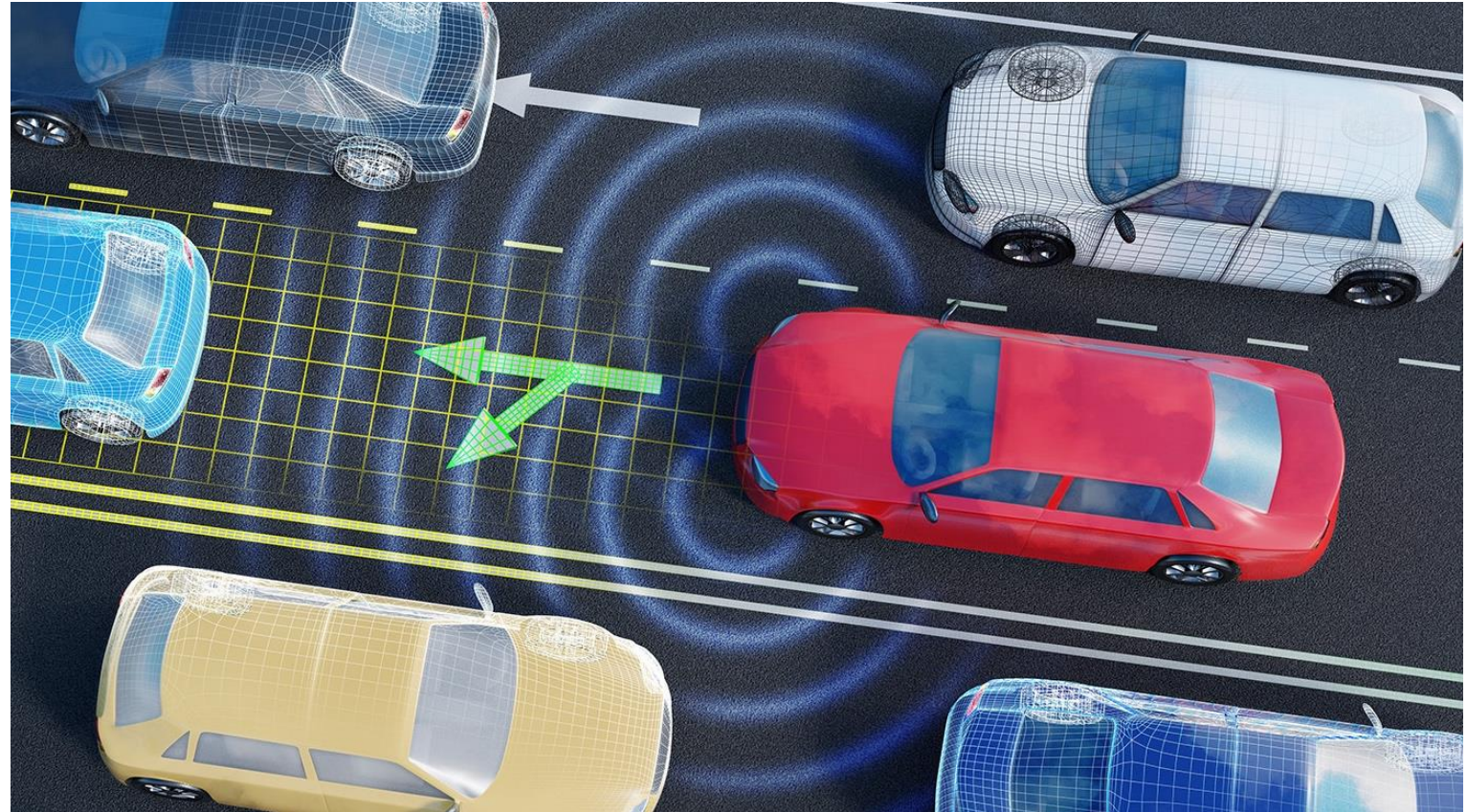
Data



Output



Model



Are you ready for AI?

Access Data

Analyze Data

Develop



AI model



Algorithm development



Modeling & simulation

Deploy

Are you ready for AI?

Access Data



Sensors



Files



Databases

Analyze Data



Data exploration



Preprocessing



Domain-specific algorithms

Develop



AI model



Algorithm development



Modeling & simulation

Deploy

Are you ready for AI?

Access Data



Sensors



Files



Databases

Analyze Data



Data exploration



Preprocessing



Domain-specific algorithms

Develop



AI model



Algorithm development



Modeling & simulation

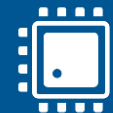
Deploy



Desktop apps

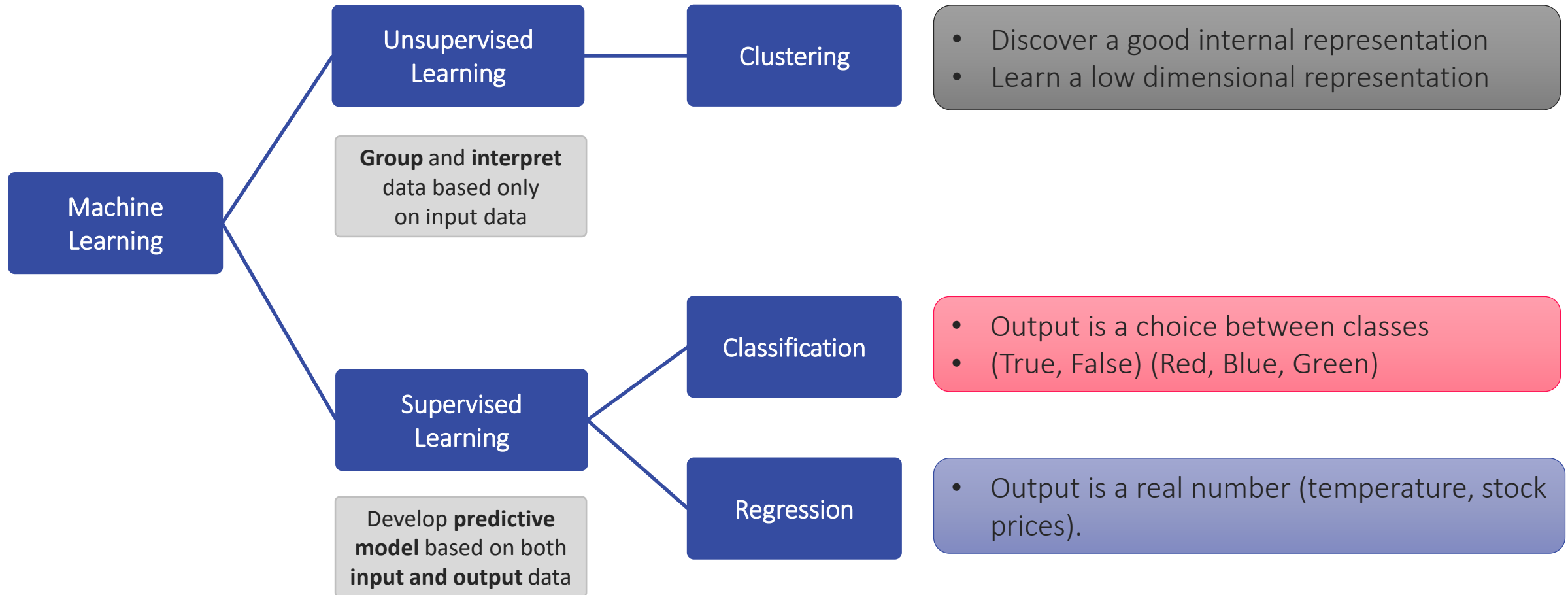


Enterprise systems



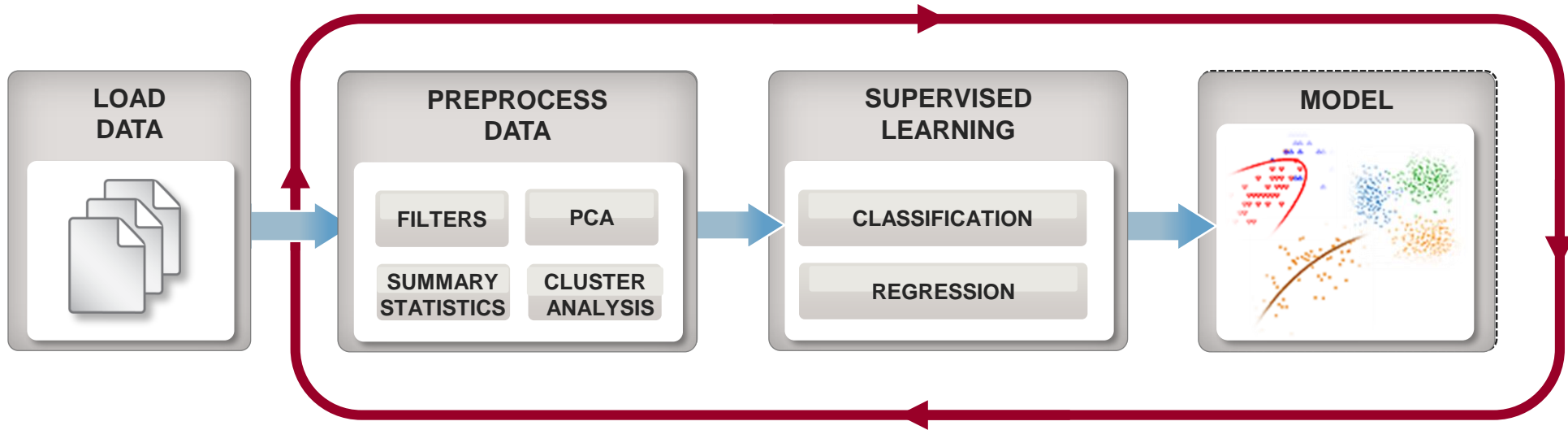
Embedded devices

Different Types of Machine Learning

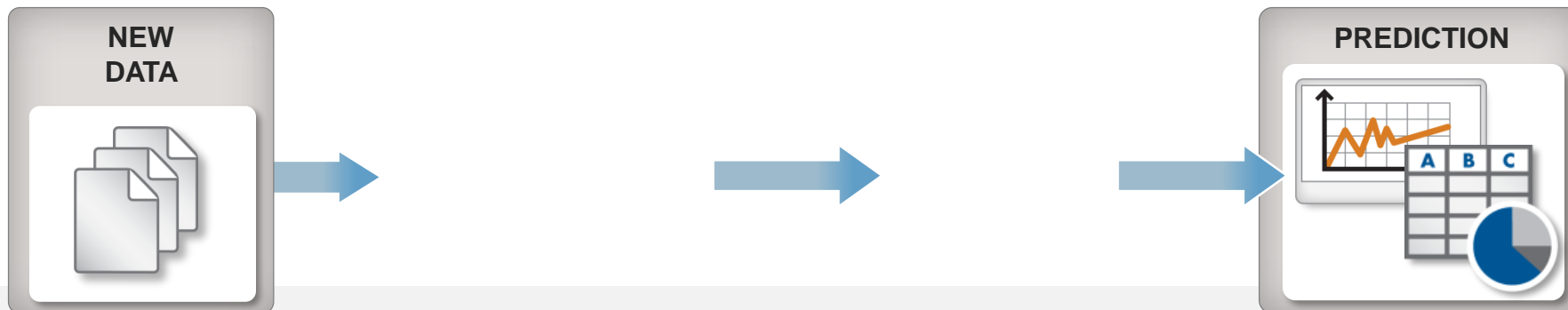


Machine Learning Workflow

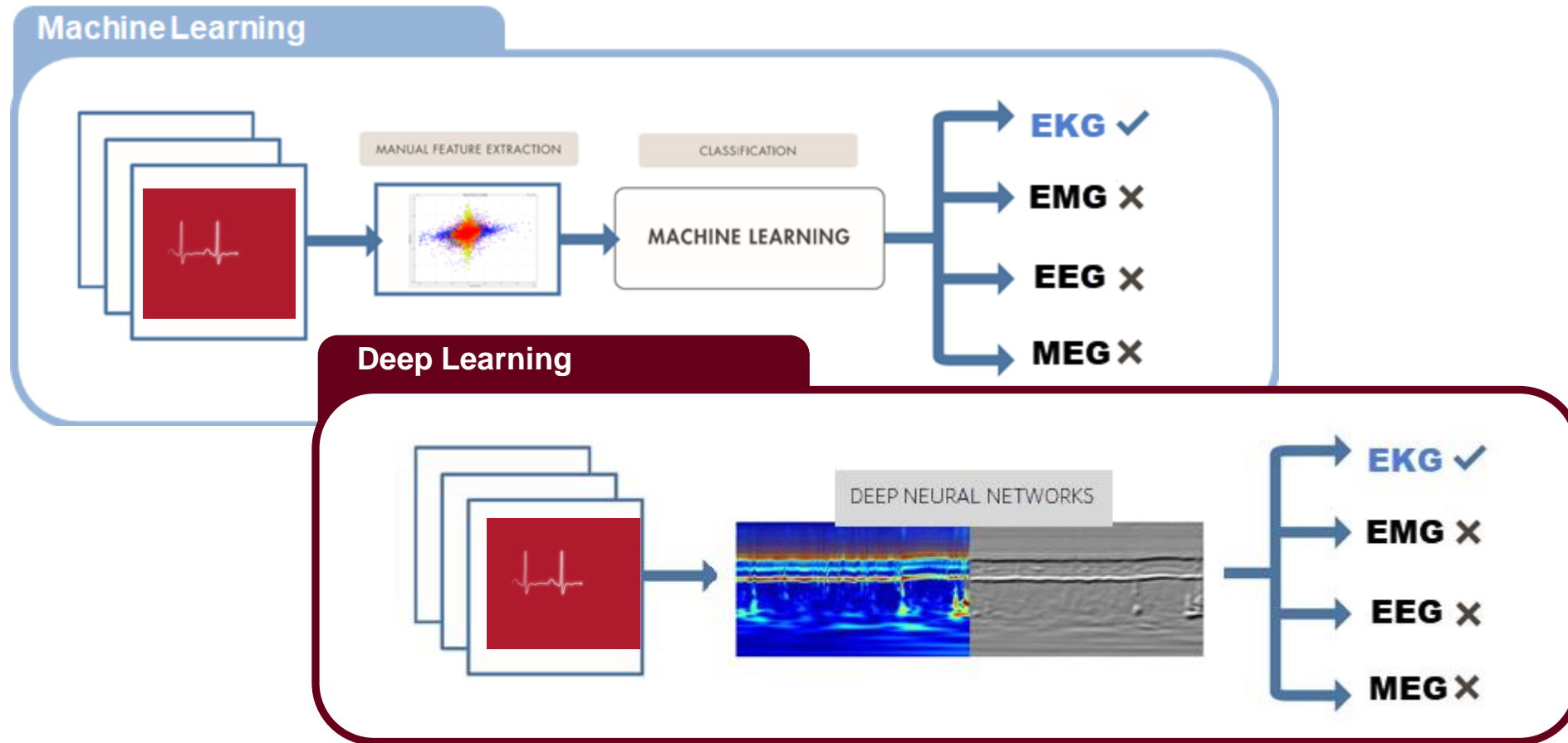
Train: Iterate till you find the best model



Predict: Integrate trained models into applications



Machine Learning vs Deep Learning



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

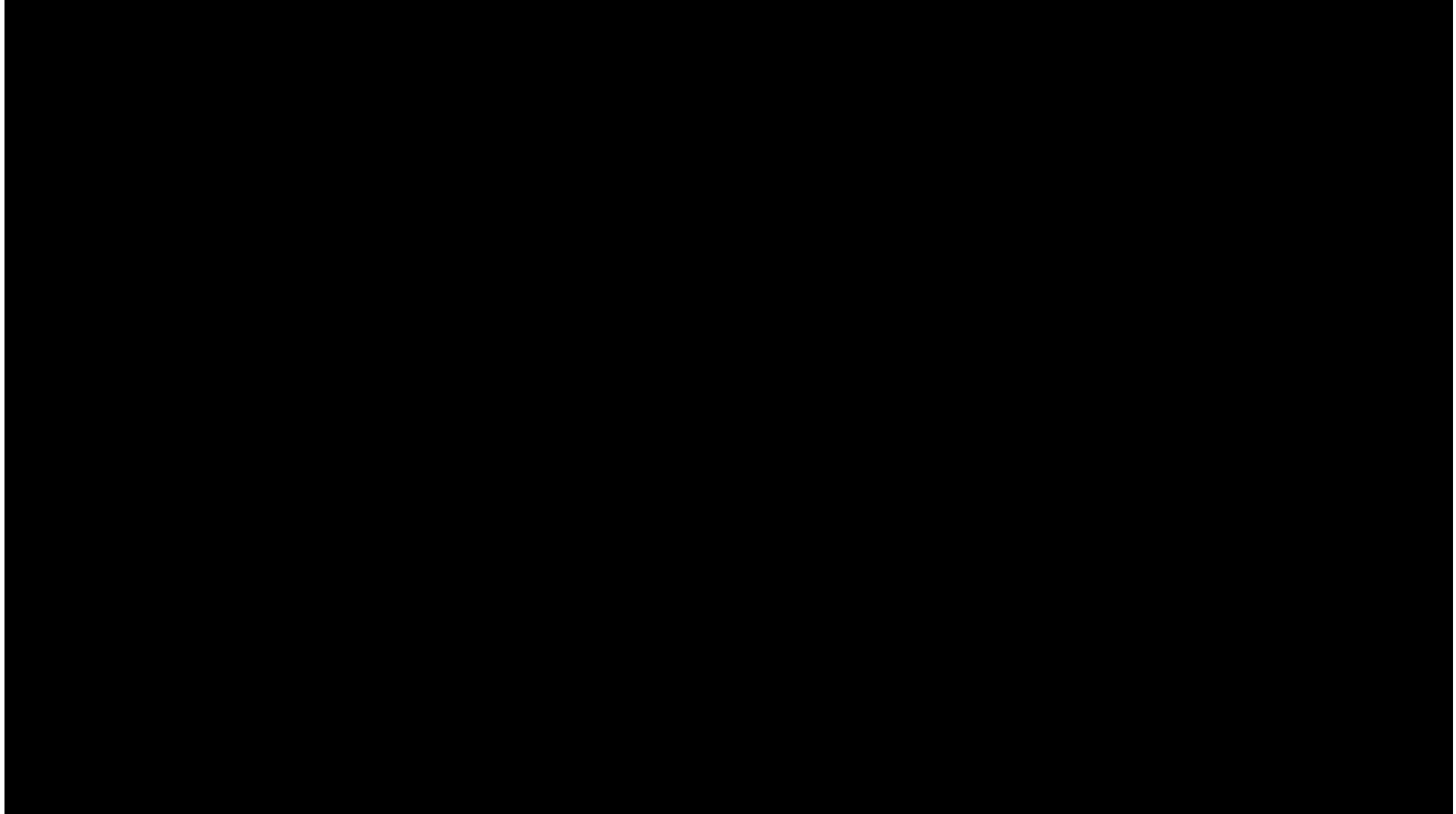
Deep Learning in 10 lines of MATLAB code

```
camera = webcam; % Connect to the camera
nnet = alexnet; % Load the neural net

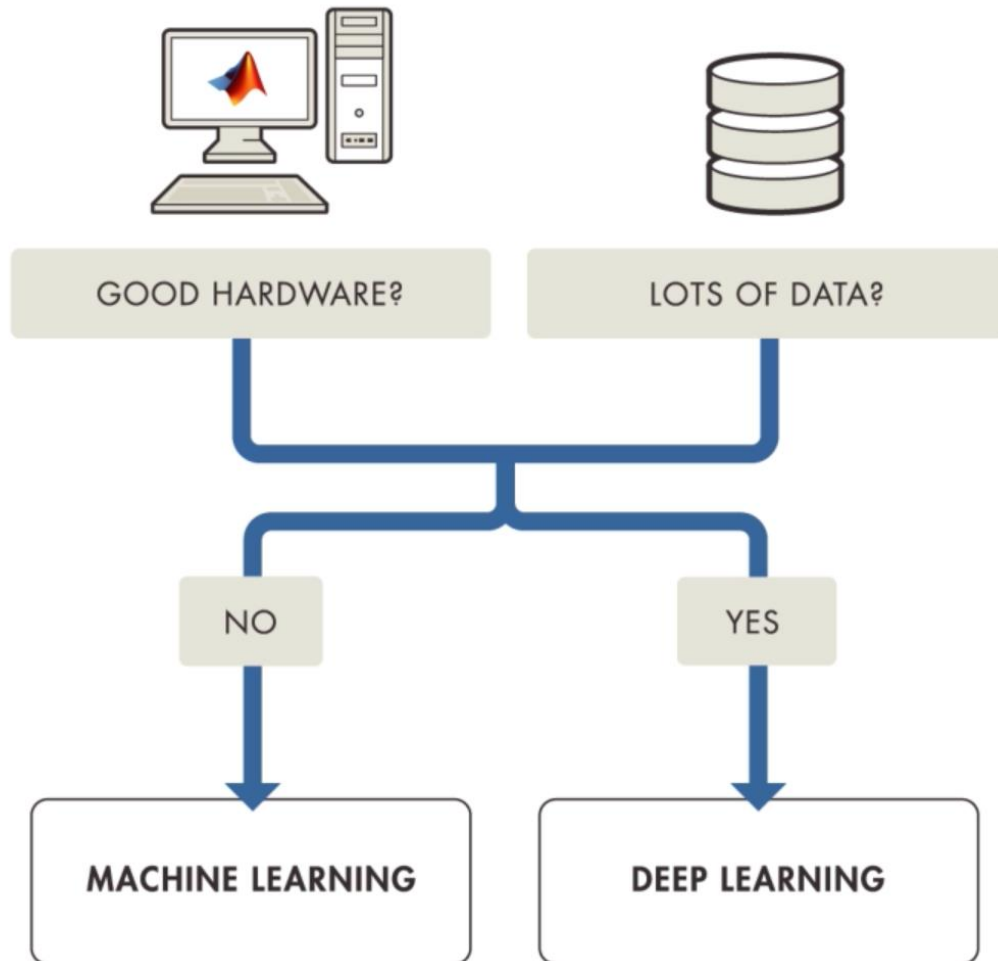
while true
    picture = camera.snapshot; % Take a picture
    picture = imresize(picture,[227,227]); % Resize the picture

    label = classify(nnet, picture); % Classify the picture

    image(picture); % Show the picture
    title(char(label)); % Show the label
    drawnow;
end
```

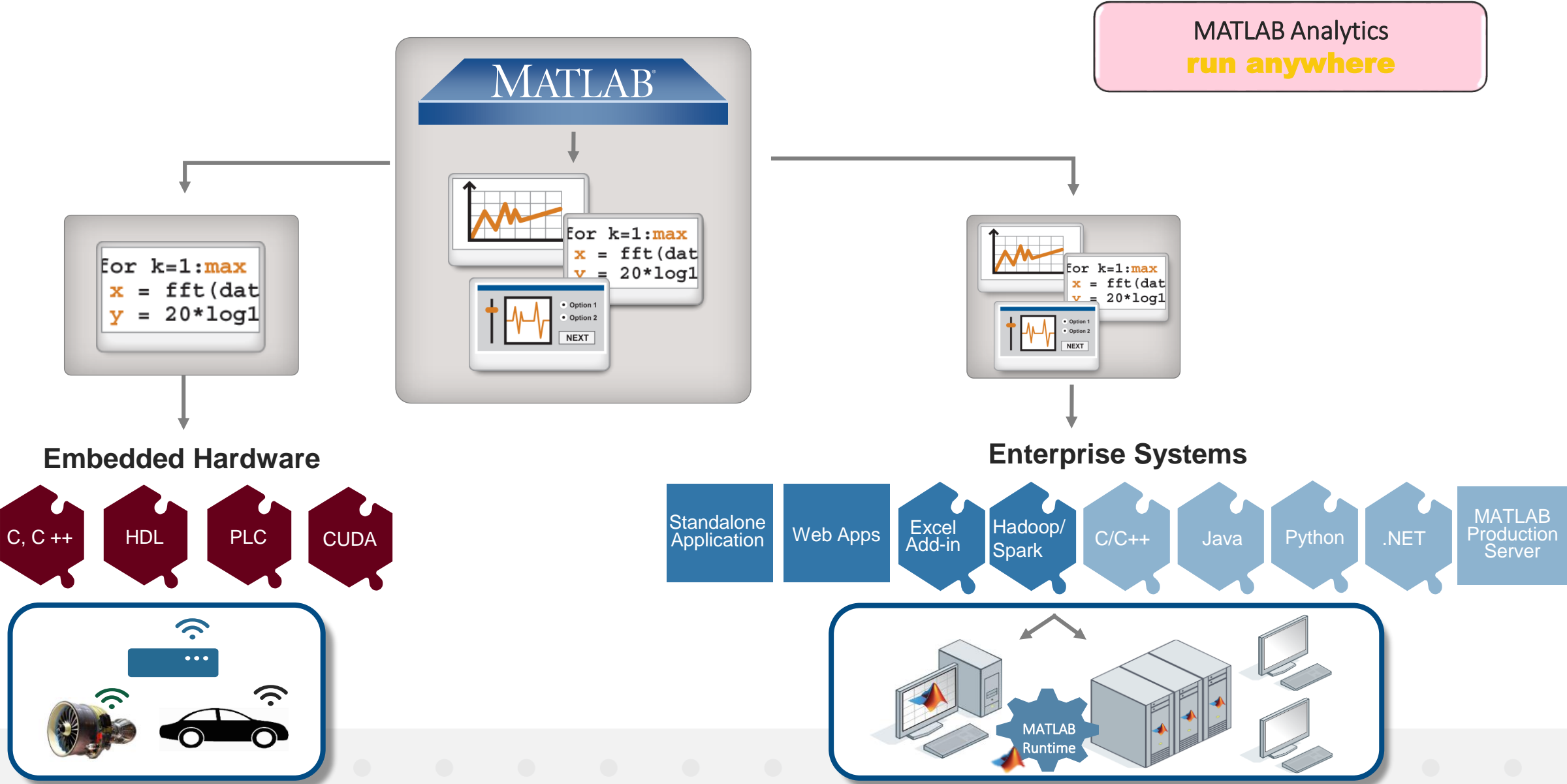


Machine Learning vs Deep Learning



	Machine Learning	Deep Learning
Training dataset	Small	Large
Choose your own features	Yes	No
# of classifiers available	Many	Few
Training time	Short	Long

Integrate Analytics with Systems



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

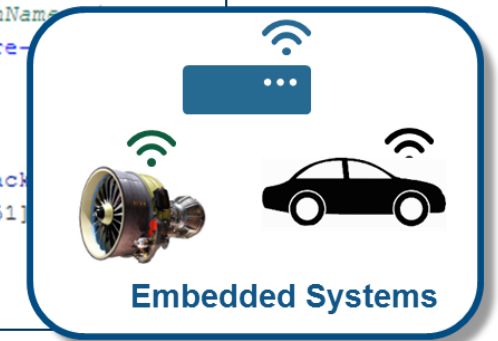
MATLAB code

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

saveCompactModel loadCompactModel

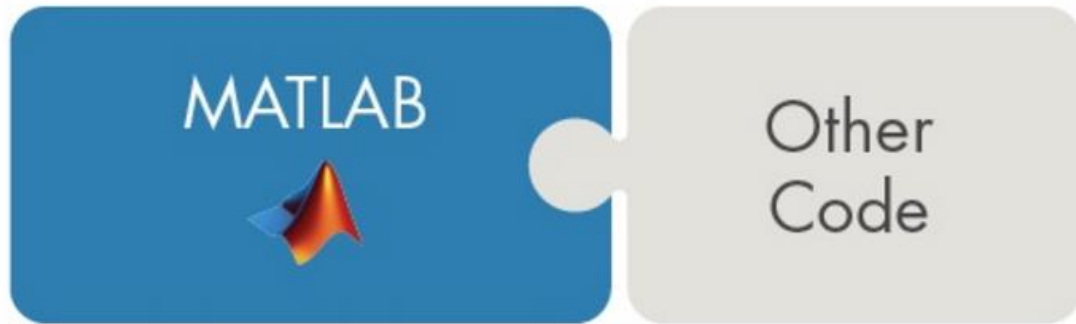
C code

```
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 → Call Python libraries directly from MATLAB **R2022a**
- C
- C++ → Call C++ libraries directly from MATLAB **R2019a**
- Fortran
- COM components and ActiveX® controls
- RESTful, HTTP, and WSDL web services

- Calling MATLAB from Another Language




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

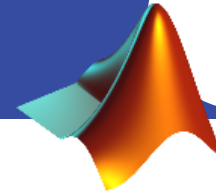
Challenges in Machine Learning

Steps	Challenge
Access and Explore data	Data diversity Numeric, Images, Signals, Text – not always tabular
Preprocess Data	Lack of domain tools Filtering and feature extraction Feature selection and transformation
Develop Predictive Models	Time consuming Train and compare several models to find the “best” Select optimal parameters and avoid overfitting
Integrate Analytics with Systems	Platform diversity Translate analytics to production Deploy on different target platforms
Iterate	

MATLAB Strengths for Machine Learning

Challenge	Solution
Data diversity	Extensive data support Work with signal, images, financial, textual, and others formats
Lack of domain tools	High-quality libraries Industry-standard algorithms for Finance, Statistics, Signal, Image processing & more
Time consuming	Interactive, app-driven workflows Focus on machine learning, not programing Select best model and easily fine-tune model parameters
Platform diversity	Run analytics anywhere Code generation for embedded targets Deploy to broad range of enterprise system architectures
	Flexible architecture for customized workflows Complete machine learning platform

Summary: Complete Machine Learning Workflow



Access and
explore data

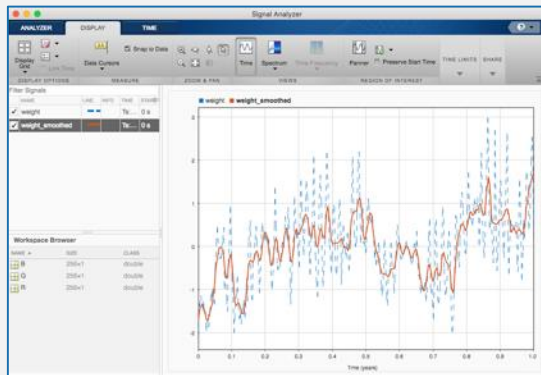
Preprocessing

Feature
Engineering

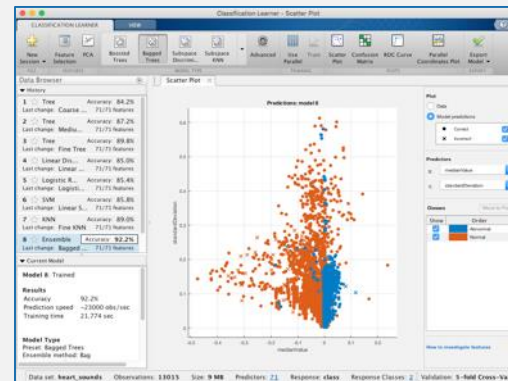
Model
Training

Model
Tuning

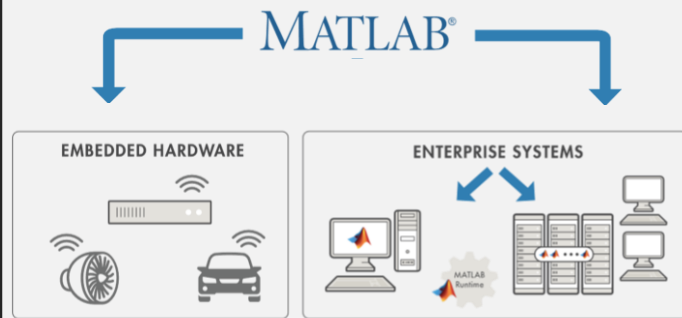
Integrate
Analytics



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



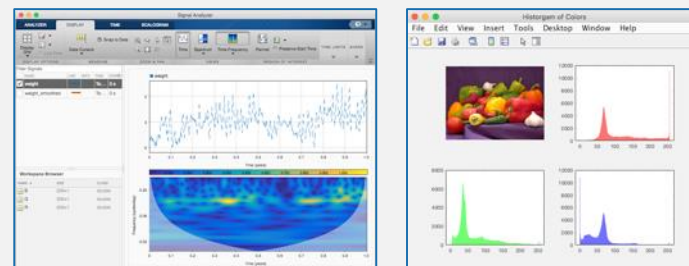
Machine Learning apps



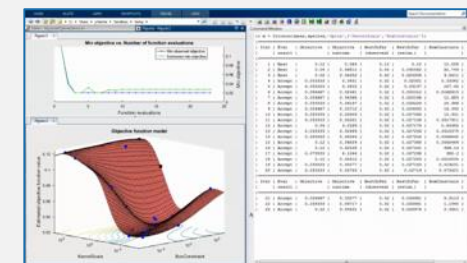
C/C++ Code Generation and
Enterprise IT Integration

Region	OutageTime	Loss	Customers	RestorationTime	Cause
SouthWest	2002-02-01 12:18	418.9772218	1820159.482	2002-02-07 16:50	winter storm
SouthEast	2003-01-23 00:49	510.1399497	212015.3001	2003-02-17 08:14	winter storm
SouthEast	2003-02-07 21:15	289.4035493	142938.6282	2003-02-17 08:14	winter storm
West	2004-04-06 05:44	414.8053524	340371.0338	2004-04-06 06:10	equipment fault
MidWest	2002-03-16 06:18	186.4367788	212754.0	2003-06-18 10:54	spring storm
West	2003-06-18 02:49	0	0.0	2003-06-18 10:54	attack
West	2004-06-20 14:39	211.2947226	0.0	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

- [Overview](#)
- [Cheat sheet](#)
- [Introductory eBook](#)
- [Mastering Machine Learning eBook](#)
- [Machine Learning Tech Talks](#)
- [Try the Classification Learner App in a browser](#)



Part 1: Machine Learning Fundamentals

Explore the fundamentals behind machine learning, focusing on unsupervised and supervised learning. Learn about the common techniques, including clustering, classification, and regression.



Part 2: Unsupervised Machine Learning

Get an overview of unsupervised machine learning, which looks for patterns in datasets that don't have labeled responses. This approach lets you explore your data when you're not sure what information the data contains.



Part 3: Supervised Machine Learning

Learn how to use supervised machine learning to train a model to map inputs to outputs and predict the response for new inputs.



Part 4: Getting Started with Machine Learning

Walk through a machine learning workflow step by step, and get insight into several key decision points along the way. The example workflow shows how to use machine learning to develop a cell phone health-monitoring app.

MathWorks can help you do Machine Learning

Free resources:

- Guided evaluations with a MathWorks machine learning engineer
- Proof-of-concept projects
- Seminars and technical deep dives
- Hands-on workshops

More options:

- Technical support
- Advanced customer support
- Installation, enterprise, and cloud deployment
- Consulting services
- Onsite or online training



MATLAB Campus-Wide License model

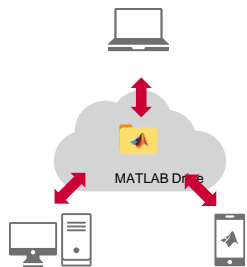
Ideal for Online mode of education



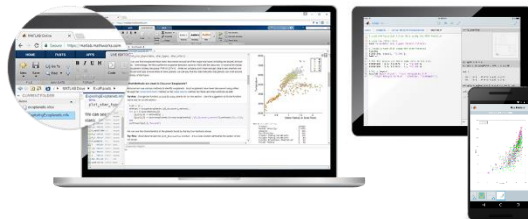
College & Lab computers



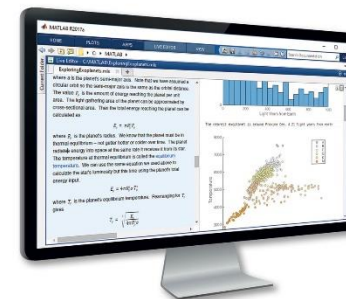
Online access via browser



Cloud Storage & Sharing

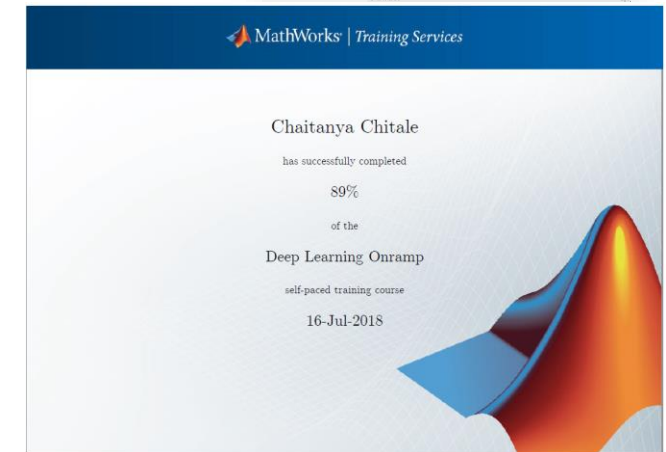
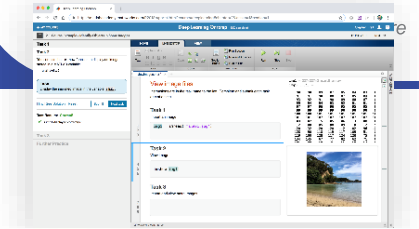


Laptops, Personal Computers & Mobile Devices



Teaching with MATLAB Live Editor

- ✓ Annual term license
- ✓ Any num of installations in college computers & Labs
- ✓ **Flexible access to use - anytime anywhere on- or off-network and self serve web free portal**
- ✓ Access to all MATLAB and Simulink products available for academic use
- ✓ Covers all faculty, staff, students and their devices



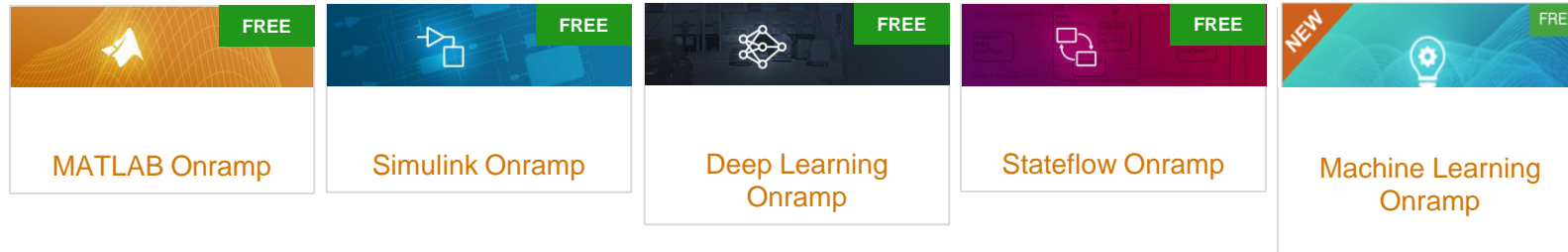
Online training and self paced learning with certificates



Project based learning with Low-cost hardware support

Available Online Training Courses

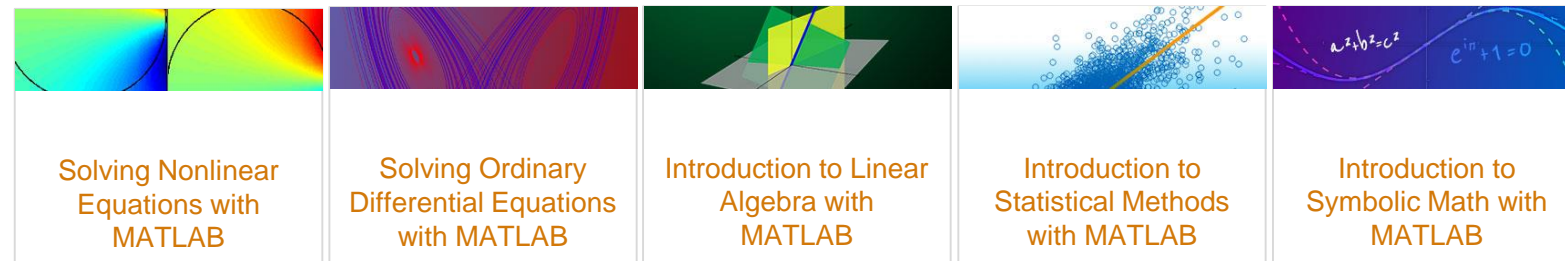
Get started – basic onramp courses



24 hours of FREE content –
available for everyone

Computational Mathematics

*Available only to users at universities that offer campus-wide training access.

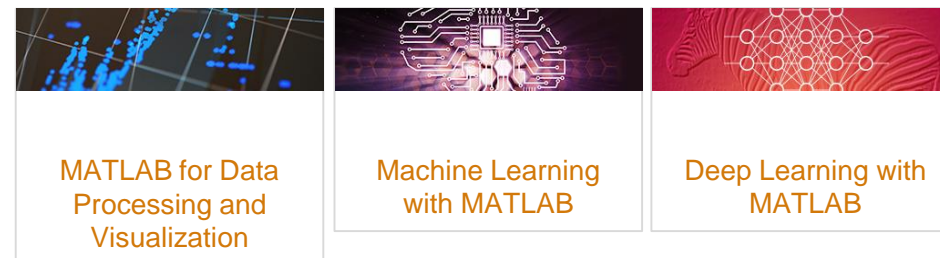


9 hours of short courses on
computational mathematics topics

Core MATLAB



Data Science



Over 80 hours of
comprehensive
MATLAB learning
content



Technology for designing the future

A blue-tinted background image showing a design studio environment. It includes a laptop on the left, architectural blueprints spread across a desk, and several interlocking gears in the foreground and background, symbolizing technology and design.

Thank You