TECHSOURCE
Dynamic Solutions Precise Results

UNIVERSITI MALAYSIA PERLIS
MATLAB SEMINAR

What's New in MATLAB

R2013b

R2019a

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Application Engineer

Supported by

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Southeast Asia's sole distributor of

MATLAB® & SIMULINK®

TIME	TOPIC
9:00 – 10:30	**Topic 1: What's New in MATLAB (Duration: 1.5 hours)**
10.30-10.45	*Quick Break*
10.45-12.15	**Topic 2: Demystifying deep learning: A practical approach in MATLAB (Duration: 1.5 hours)**
12.45-13.00	**Wrap Up & Networking /Visit & Lunch**

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Agenda

	**MATLAB Foundation**
	Data Handling & Language Enhancements
	Building & Sharing Apps
	Hardware Support
	New Features in Toolboxes & New Toolboxes
	Summary and Wrap-up

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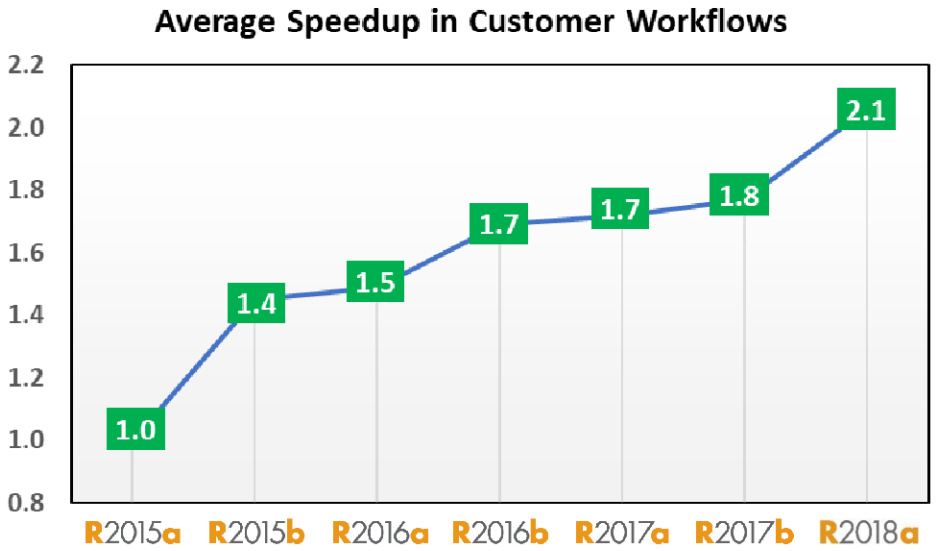
Increased Performance

R2015b

- Run MATLAB code faster with redesigned execution engine
  - All MATLAB code is now JIT compiled



R2016a – R2017a

- Execute loops with scalar math faster
- Construct objects and set properties faster
- Improved script and try/catch performance
- Render plots with large numbers of markers faster using less memory

R2017b

- Upgraded Java SE 8

R2018a R2018b

- Increased speed of MATLAB startup

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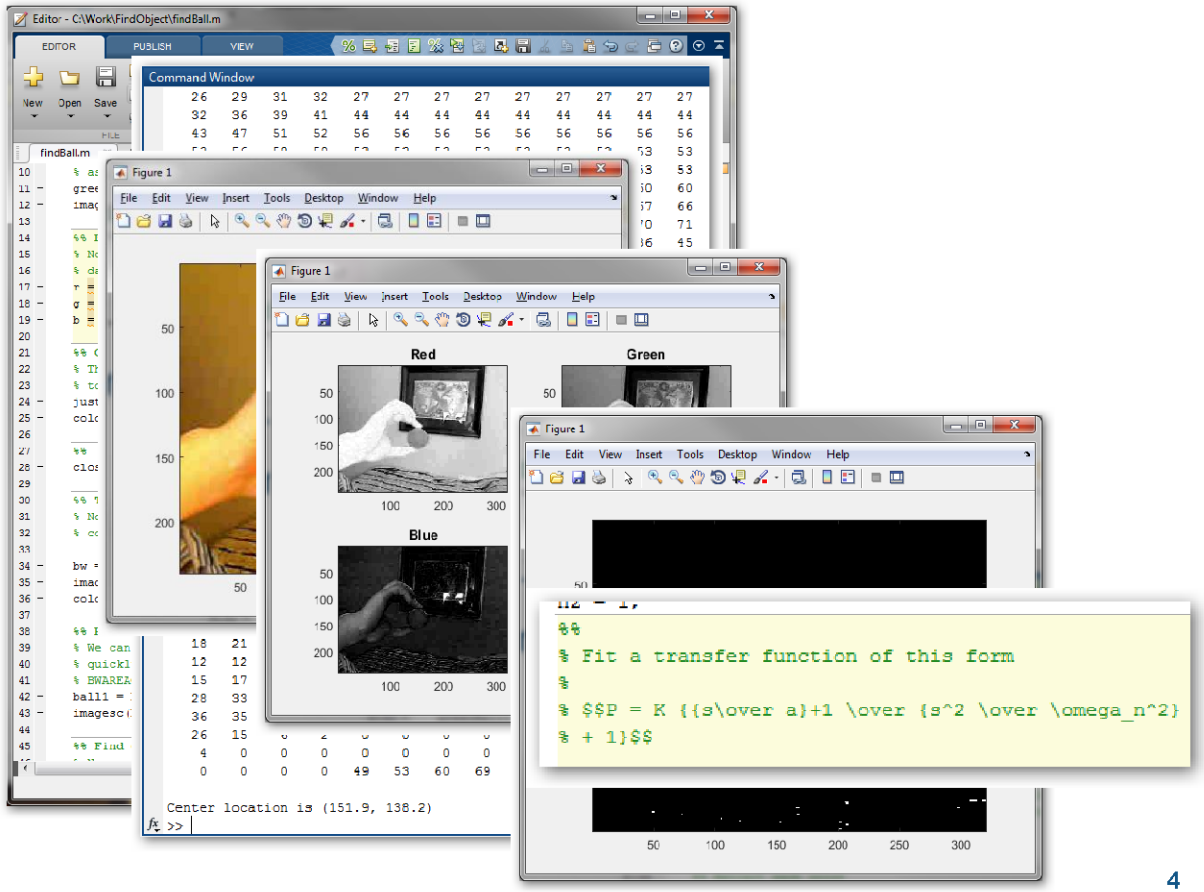
Editing and Running MATLAB Code Pre-16a

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



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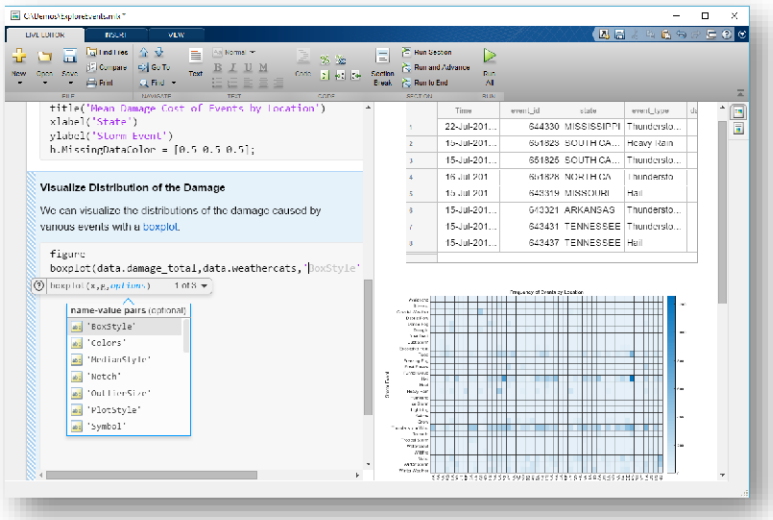
Live Editor

R2016a

- Explore and analyze problems in a single, interactive environment
  - See results inline or side-by-side
  - Interactively explore and customize plots, with automatic MATLAB code generation

R2017b
  - Use context-aware coding guides

R2018a
  - Debug functions and scripts
  - Use interactive controls to modify values in a script



- Turn your code into formatted, executable documents that tell your story
  - Add rich text formatting, images, and hyperlinks
  - Interactively enter equations

R2017b
  - Save directly to PDF, HTML, and LaTeX
  - Display high-resolution plots in PDF output

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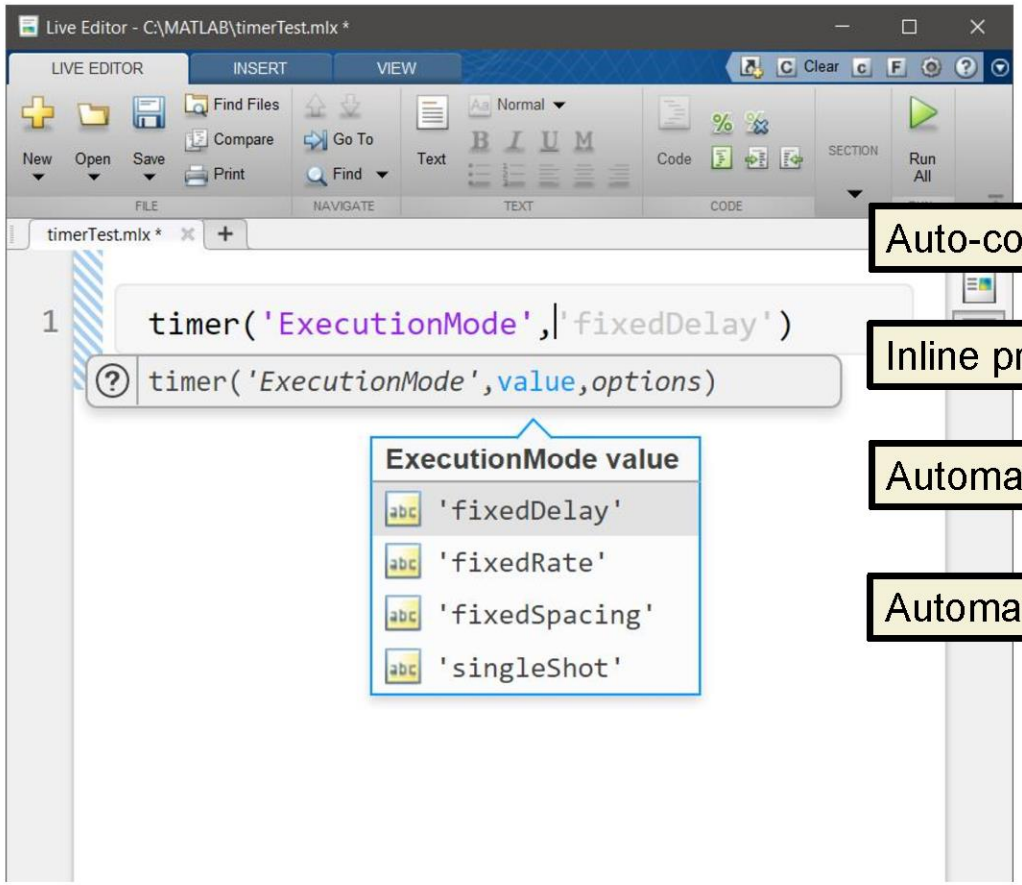
R2017b

Context-Aware Coding Guides



Auto-complete suggestions without using Tab

Inline preview of tab-complete text

Automatic closing parenthesis

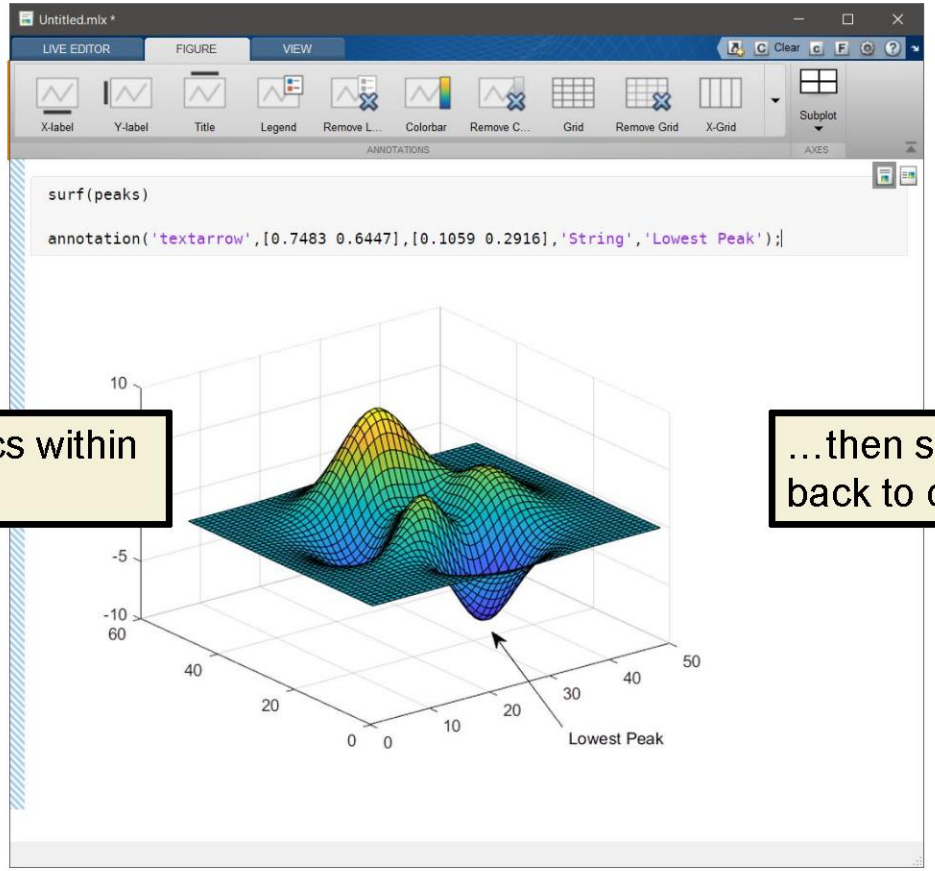
Automatic Name/Value pair suggestions

MathWorks

R2016b

Interactive Graphics

Interact with graphics within your live script…



…then save your interactions back to code

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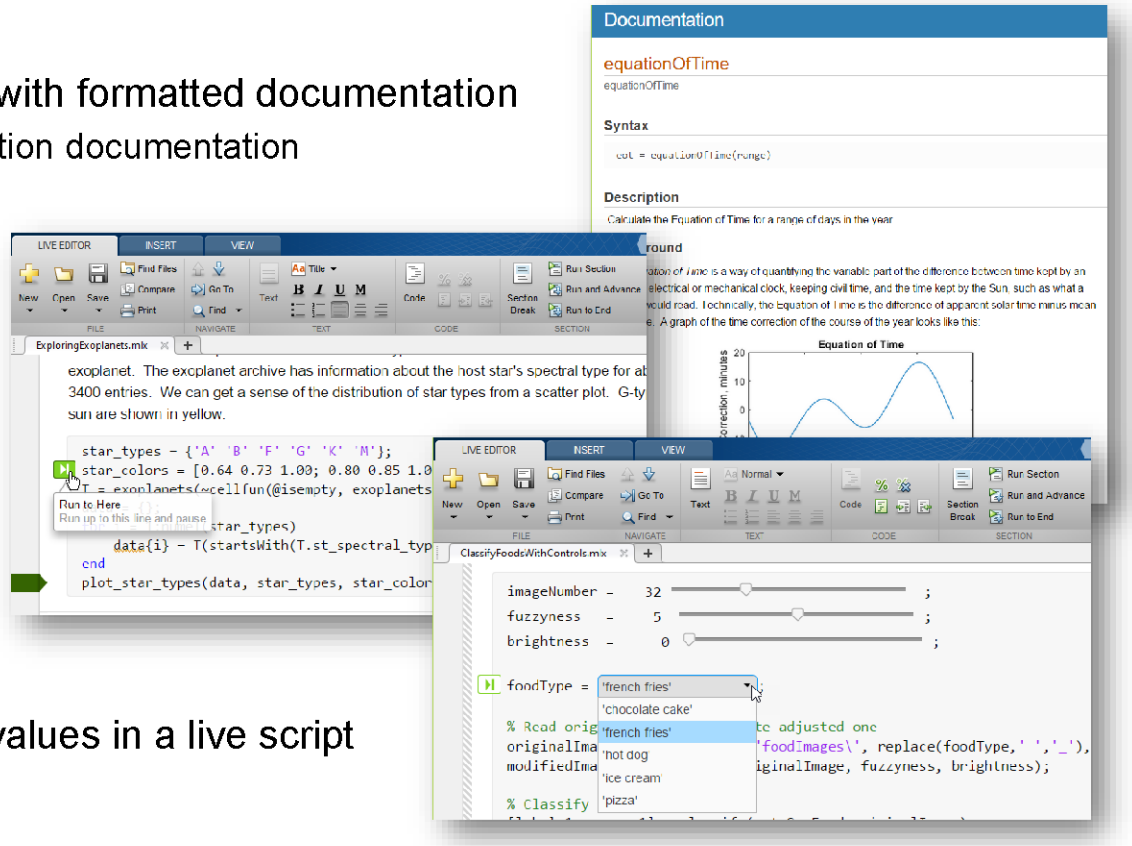
R2018a

Live Editor Updates

- Create functions in the Live Editor with formatted documentation
  - Use the Help Browser to view function documentation
- Debug functions and scripts
  - Run to here
  - Set breakpoints
  - Step into functions
- Use interactive controls to control values in a live script
  - Sliders and combo boxes



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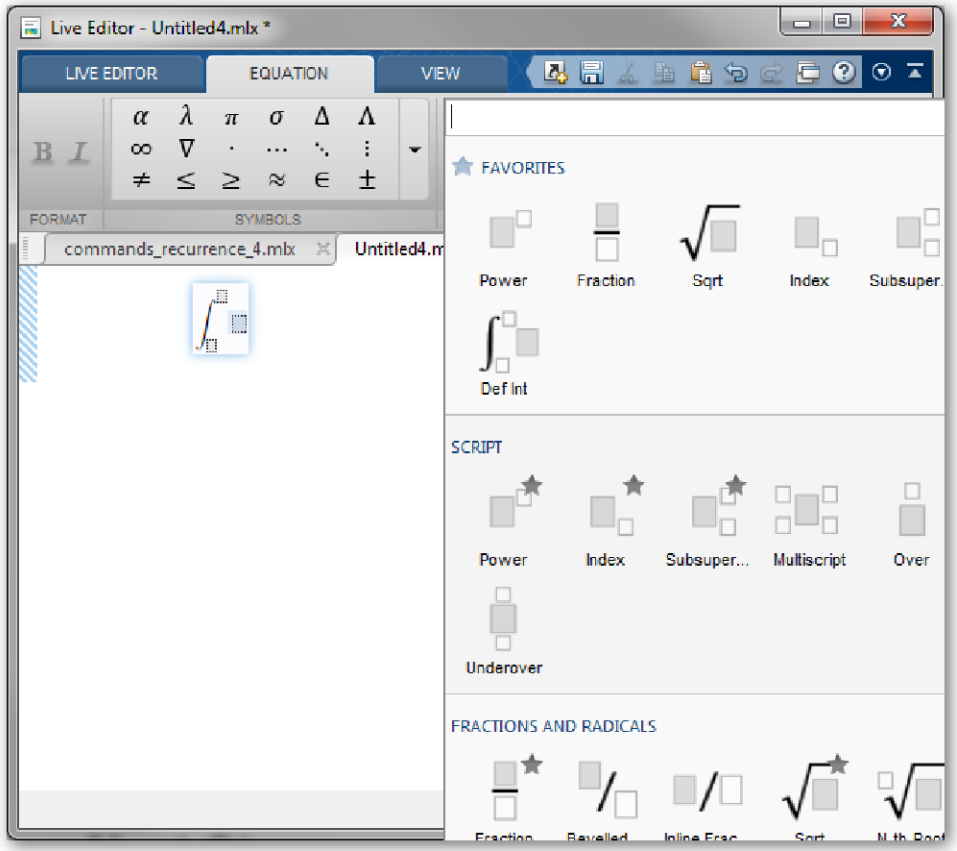
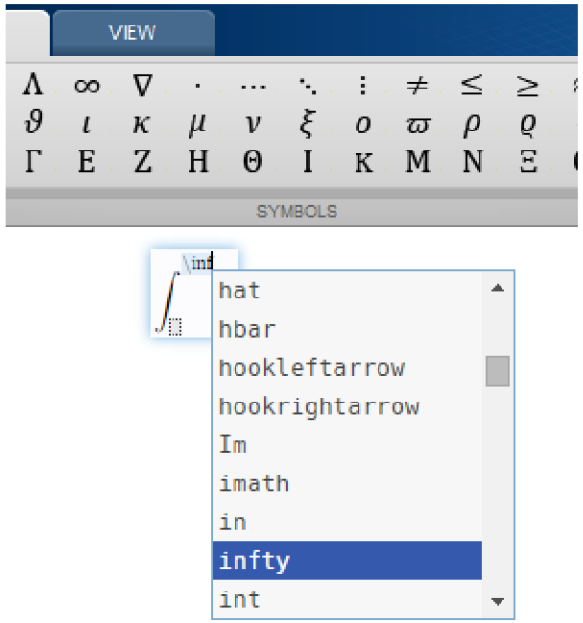
R2016b

Interactive Equation Editing





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Live Editor Keyboard Shortcuts

R2016b

- Format as you type

Formatting Style	Keyboard Shortcut	Autoformatting sequence
Title	**Ctrl + Alt + L**	*# text* + **Enter**
Heading	**Ctrl + Alt + H**	*## text* + **Enter**
Section break	**Ctrl + Alt + Enter**	%% + **Enter** --- + **Enter** *** + **Enter**
Bulleted list	**Ctrl + Alt + U**	** text* *- text* *+ text*
Numbered list	None	*number. text*
LaTeX equation	**Ctrl + Alt + G**	$*LaTeX*$
Hyperlink	**Ctrl + K**	*URL* + **Space** or **Enter** <*URL*> [*Label*](*URL*)
Toggle between code and text input	**Ctrl + E**	

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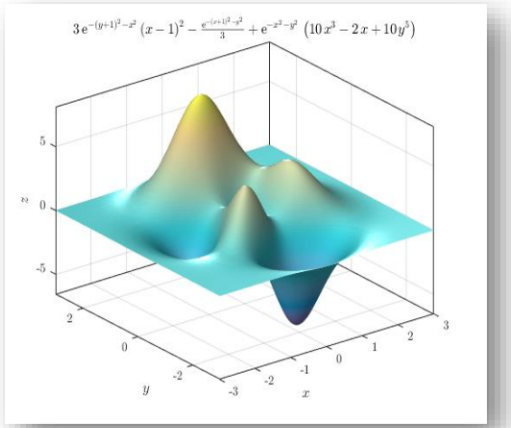
R2014b

Graphics System Updates

- New look and feel
  - New default colormap and line colors
  - Anti-aliased fonts and lines



- Enhanced control and manipulations
  - Access and change properties using dot-notation

```
>> p = plot(x,y);
>> p.Color = 'red';
```

R2018a – Minimize/maximize figures programmatically

R2018b – Axes interactions *(panning, zooming, data tips, and 3-D rotation)* enabled by default

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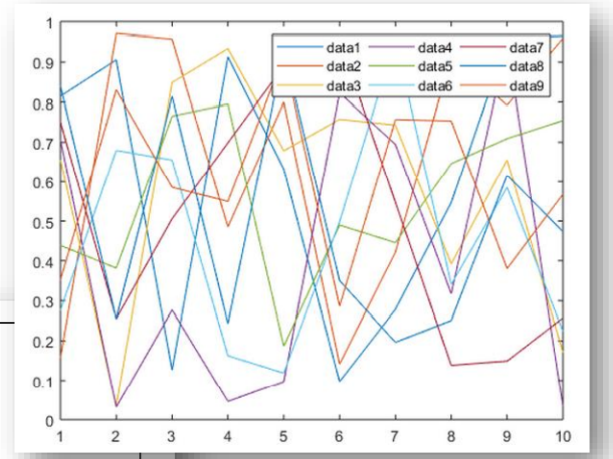
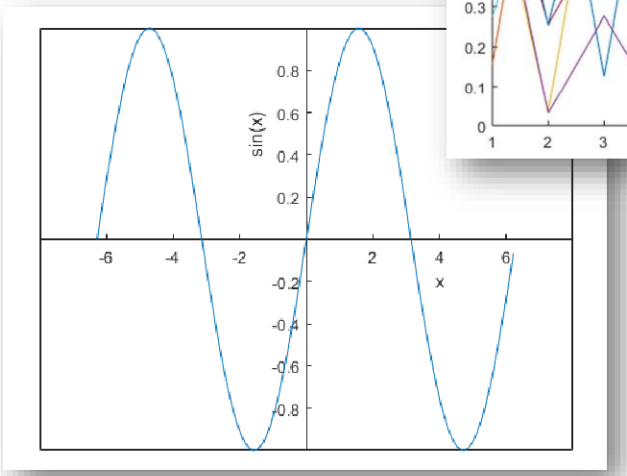
R2014b

Graphics System Updates

- Enhanced plot customizations
  - Automatic updating of datetime tick labels
  - Rotatable tick labels
  - Multiple colormaps per figure
  - Multilingual text and symbols
  - Dynamic legends and legends with multiple columns





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New and Updated Visualizations

- Updated polar plots and dual-axes support
- Animated lines
- Bivariate histograms
- Heat maps
- Word cloud
- Big data (`tall`) support
- Geographic plots
  - Geographic bubble chart R2017b
  - Line, scatter, and point density plots on interactive maps R2018b
- Stacked plot R2018b
- Scatter histogram R2018b

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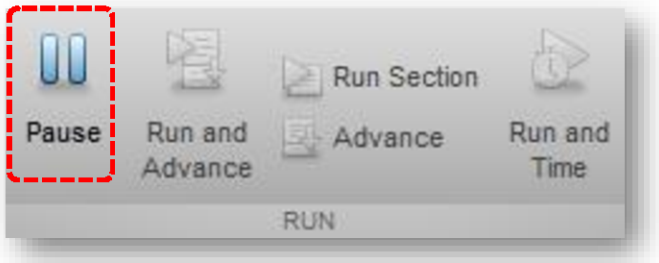
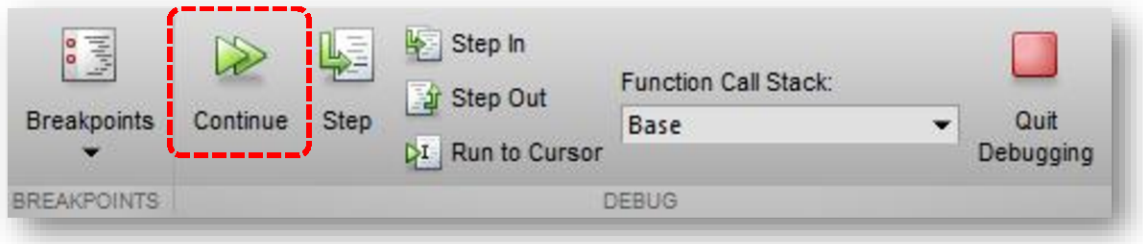
Pause or Add Breakpoints During Code Evaluation

R2016a

- New feature allows you to troubleshoot problems without specifying breakpoints in advance
  - Pause execution of a program from the Editor
  - Enter debug mode
  - Resume program execution





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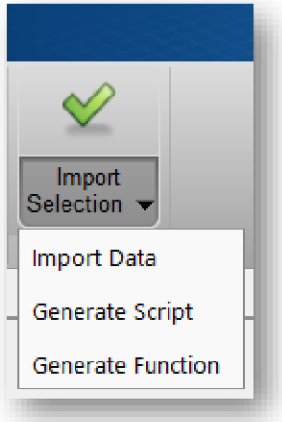
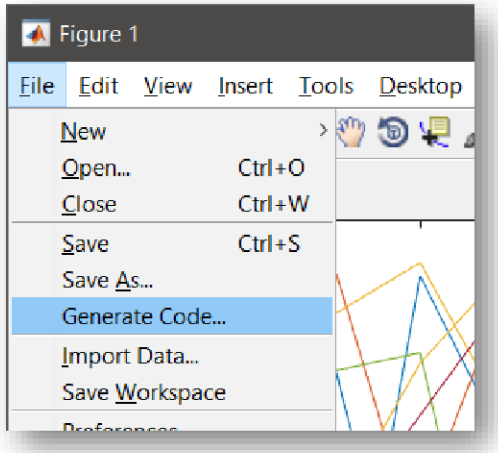
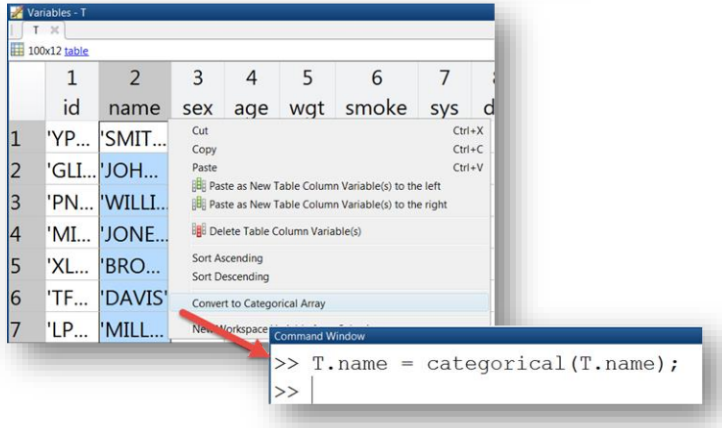
Automatic MATLAB Code Generation

- Customized data import
- Recreate customized plots
  - Directly from figures
  - Within Live Editor
  - Plot Gallery
- Variable Editor actions
- Apps in Toolboxes generate code for more complex workflows







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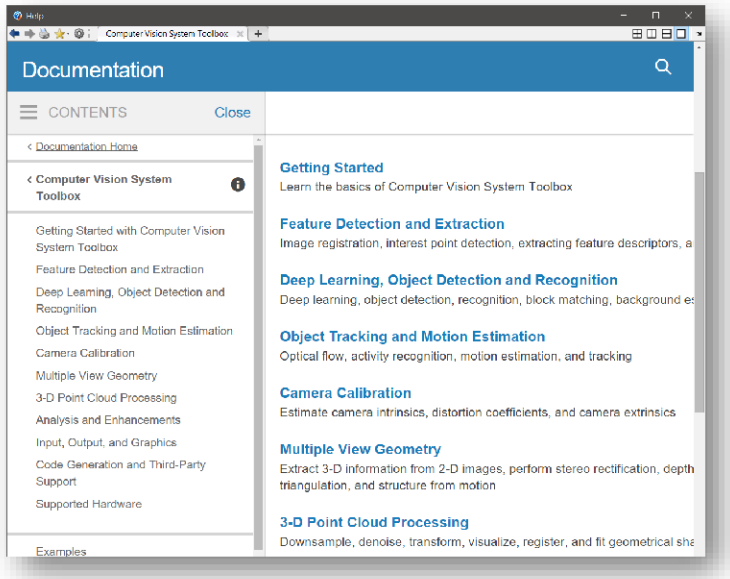
Redesigned Documentation



- More examples
- More domain-specific information
- Improved discoverability
- Release Notes filtering
  - More easily find changes across releases
  - Highlight only changes that have incompatibility considerations

R2015b to R2016a

Compatibility Considerations

Incompatibilities Only

Functionality	Result	Use This Instead	Compatibility Considerations
`plotyy` function	Still runs	`yyaxis`	Replace all instances of `plotyy` with `yyaxis`.
`polar` function	Still runs	`polarplot`	Replace all instances of `polar` with `polarplot`.
`ezplot` function	Still runs	`fplot`	Replace all instances of `ezplot` with `fplot`.
`ezplot3` function	Still runs	`fplot3`	Replace all instances of `ezplot3` with `fplot3`.

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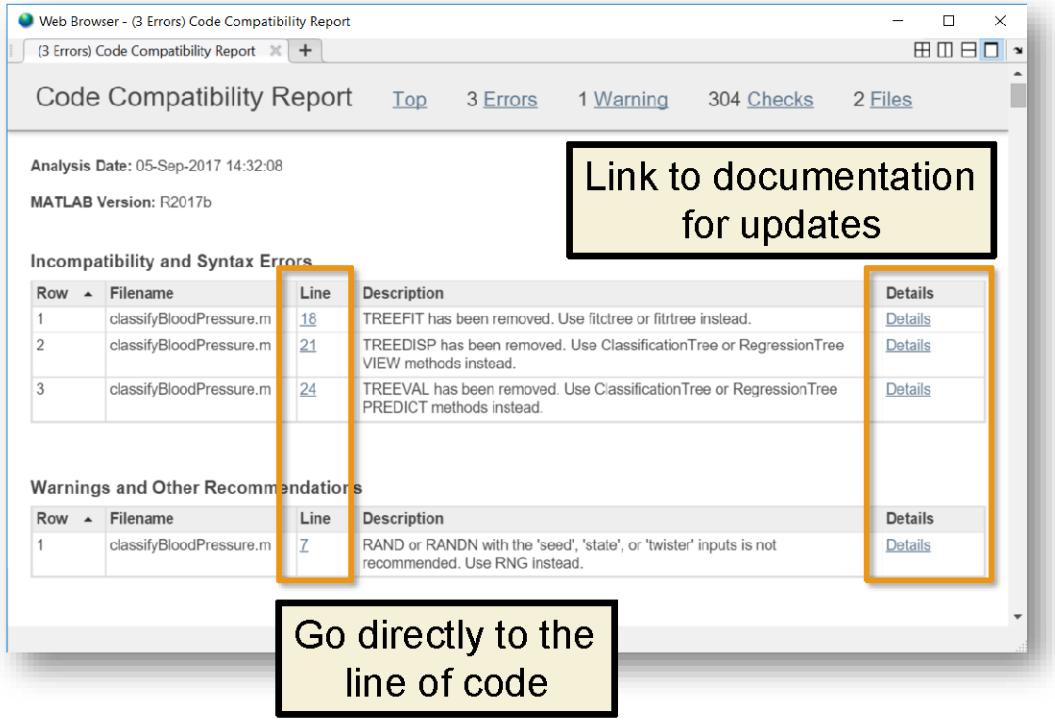
R2017b

Code Compatibility Report

- Tool to help upgrade code to latest and greatest
- Identifies potential compatibility issues
- Hundreds of checks for incompatibilities, errors, and warnings
- More features coming!



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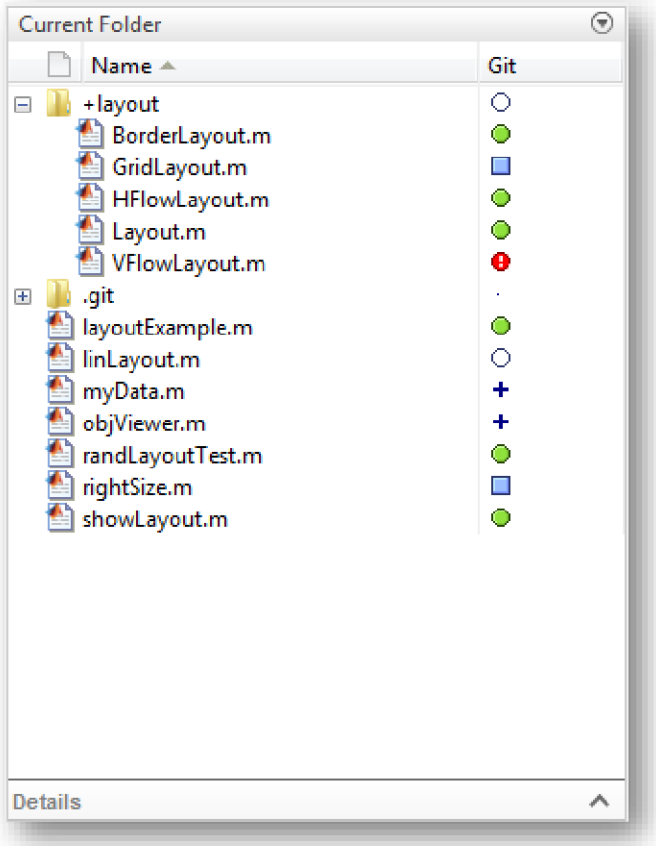
R2014b

Source Control Integration

- Manage your code from within the MATLAB Desktop
- Leverage modern source control capabilities
  - GIT and Subversion integration in Current Folder browser
- Use Comparison Tool to view and merge changes between revisions



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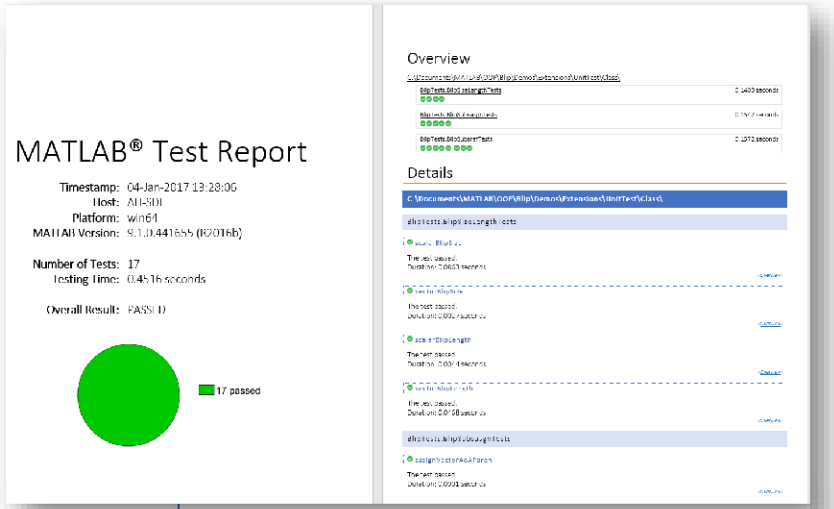
Test Frameworks

- MATLAB Unit Testing Framework
  - Test your code early and often
  - xUnit style framework
  - Script / function / class based testing
  - Works with continuous integration servers
  - Automatic reporting
  - Mocking framework R2017a
  - Run tests from the MATLAB Editor toolstrip R2018a
- Performance Testing Framework
  - Time MATLAB code automatically
  - Track performance over time
- App Testing Framework R2018a
  - Author automated test for App Designer apps




```
results =
  1×17 TestResult array with properties:

    Name
    Passed
    Failed
    Incomplete
    Duration
    Details
Totals:
   17 Passed, 0 Failed, 0 Incomplete.
   1.0937 seconds testing time.
```

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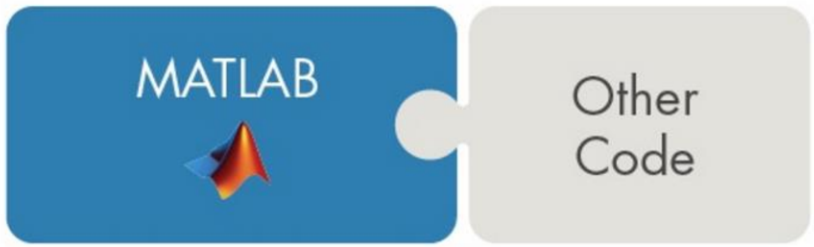
External Interfaces

Calling Libraries Written in Another Language From MATLAB



- Java
- Python R2014b
- C/C++
- Fortran
- COM components and ActiveX® controls
- RESTful, HTTP, and WSDL web services

Calling MATLAB from Another Language

- Java R2016b
- Python R2014b
- C/C++
  - Updated C++ API R2017b
- Fortran
- COM Automation server

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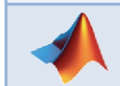
Agenda

	MATLAB Foundation
	**Data Handling & Language Enhancements**
	Building & Sharing Apps
	Hardware Support
	New Features in Toolboxes & New Toolboxes
	Summary and Wrap-up

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MATLAB Language Enhancements

Expressing basic math more naturally

```
        % Remove mean of each column:
1986:   [nr,nc] = size(A)
        A = A - ones(nr,1)*mean(A)

1996:   A = A - repmat(mean(A),nr,1)

2006:   A = bsxfun(@minus,A,mean(A))

2016:   A = A - mean(A)
```

R2016b

http://blogs.mathworks.com/loren/2016/10/24/matlab-arithmetic-expands-in-r2016b/

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MATLAB Language Enhancements

Programming flexibility

- Functions in scripts R2016b
  - Define local functions in scripts for improved code reuse and readability

```
x = 1:10;
n = length(x);
avg = mymean(x,n);
med = mymedian(x,n);

function a = mymean(v,n)
% MYMEAN Example of a local function.
    a = sum(v)/n;
end
```

- Property validation for classes R2017a
  - Easily control a property's size, class, and value

```
classdef ValidatorFunction
   properties
      Data(:,1) double {mustBePositive, mustBeFinite} = [1 2 3]
      Interp {mustBeMember(Interp,{'linear','spline'})} = 'linear'
   end
end
```

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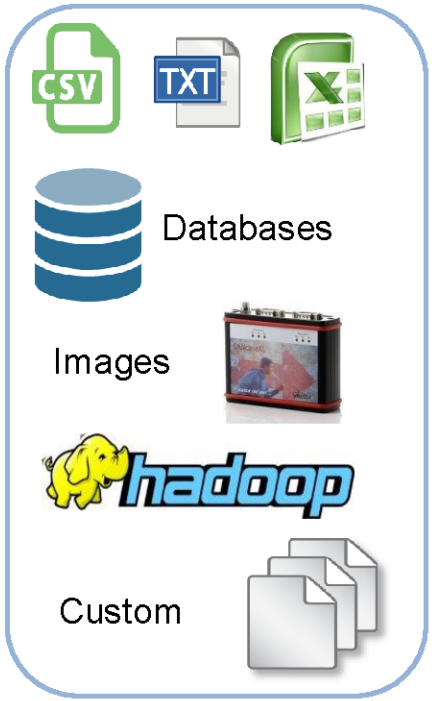
Importing and Exporting Data

- Access online data
  - RESTful, JSON, HTTP, CSV, text, and image data
  - Data sources like Amazon Web Services and Microsoft Azure Blob Storage R2018b
- Import improvements
  - Improved performance
  - Improved format detection in `readtable` and `datastore`
  - Advanced control over import with `detectImportOptions`
  - `datetime` by default R2016b
- Datastore R2017b
  - Text, spreadsheet, image, and custom format datastores



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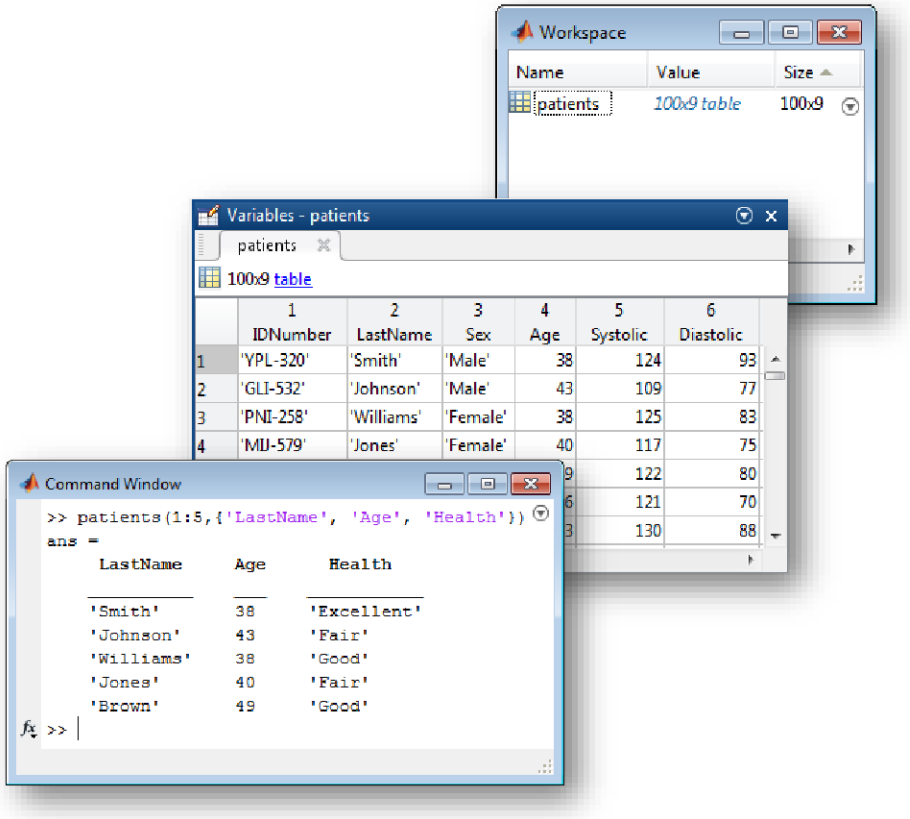
R2013b

Tables

Simplifying data management

- For mixed-type tabular data
  - Holds both data and metadata
- Supports flexible indexing
- Built-in functionality (merge, sort, etc.)
- Database-like functionality
  - Join
  - Stack / Unstack



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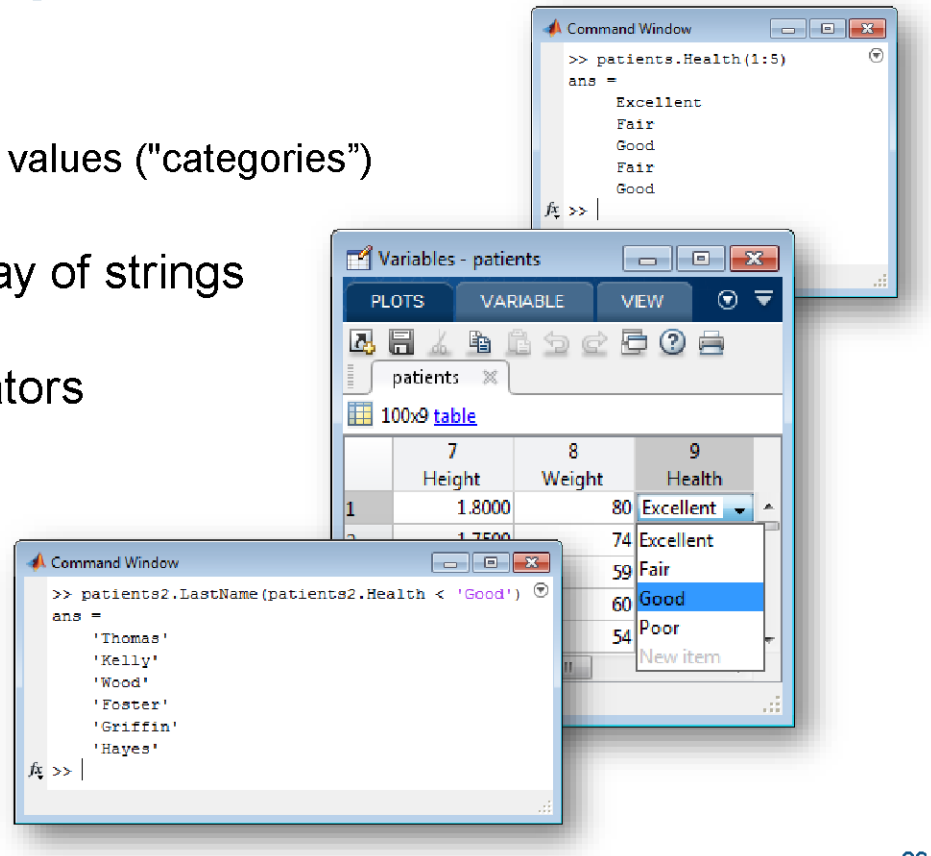
R2013b

Categorical Arrays

Storing data with values from finite set of categories

- For discrete non-numeric data
  - Values drawn from a finite set of possible values ("categories")
- More memory efficient than a cell array of strings
- Can be compared using logical operators
  - Similar to numeric arrays
- Allows for ordered categories
  - Mathematical compare categories



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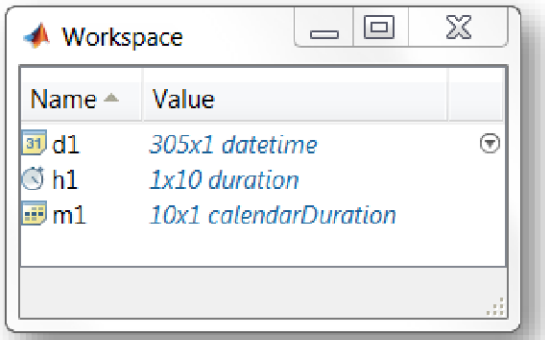
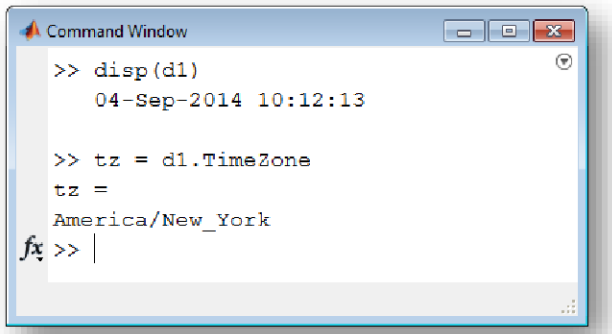
R2014b

Date and Time Arrays

Manage time more effectively

- `datetime` for representing a point in time
- `duration`, `calendarDuration` for representing elapsed time
- Same data type for computation and display
  - Add, subtract, sort, compare, and plot
  - Customize display formats
  - Nanosecond precision
- Support for time zones and leap seconds
  - Accounts for daylight saving time





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R2016b

Timetables

Time-stamped tabular data

- Manage time-stamped tabular data with time-based indexing and synchronization
- Store column-oriented data variables that have different data types
- Use dedicated functions to manage timetables
  - Reorganize data
  - Evenly space data by time
  - Align multiple data sets
- Use any table function with timetables

Time	Day	Total	Westbound	Eastbound
06/24/2015 00:00:00	Wednesday	13	9	4
06/24/2015 01:00:00	Wednesday	3	3	0
06/24/2015 02:00:00	Wednesday	1	1	0
06/24/2015 03:00:00	Wednesday	1	1	0
06/24/2015 04:00:00	Wednesday	1	1	0
06/24/2015 05:00:00	Wednesday	7	3	4
06/24/2015 06:00:00	Wednesday	36	6	30
06/24/2015 07:00:00	Wednesday	141	13	128
06/24/2015 08:00:00	Wednesday	327	44	283
06/24/2015 09:00:00	Wednesday	184	32	152

MathWorks

R2016b

Strings

The better way to work with text

- Manipulate, compare, and store text data efficiently

```
>> "image" + (1:3) + ".png"
```

R2017a

```
1×3 string array
  "image1.png"   "image2.png"   "image3.png"
```

- Simplified text manipulation functions
  - Example: Check if a string is contained within another string
    - Previously: `if ~isempty(strfind(textdata,"Dog"))`
    - Now: `if contains(textdata,"Dog")`
- Performance improvement
  - Up to 50x faster using **`contains`** with **`string`** than **`strfind`** with **`cellstr`**
  - Up to 2x memory savings using **`string`** over **`cellstr`**

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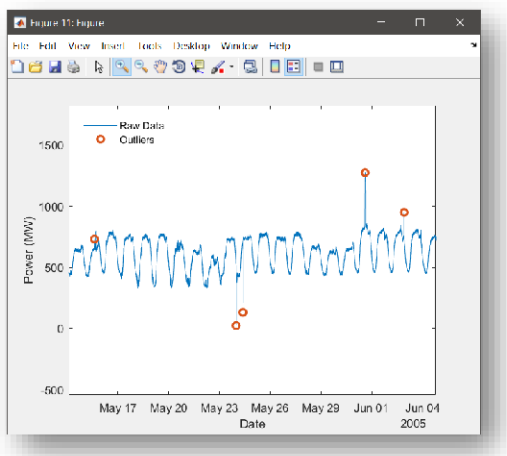
Data Preprocessing

Easier ways to clean up messy data

R2016b

- Find, fill, and remove missing data using `*missing` functions
- Options to ignore "NaNs" with cumulative statistic functions
- Easier text manipulation with `replace`, `contains`, `endsWith`, and more…
- Smooth noisy data with filtering or local regression using `smoothdata` R2017a
- More easily deal with outliers with
  - `isoutlier` and `filloutliers` R2017a
  - `rmoutliers` R2018b



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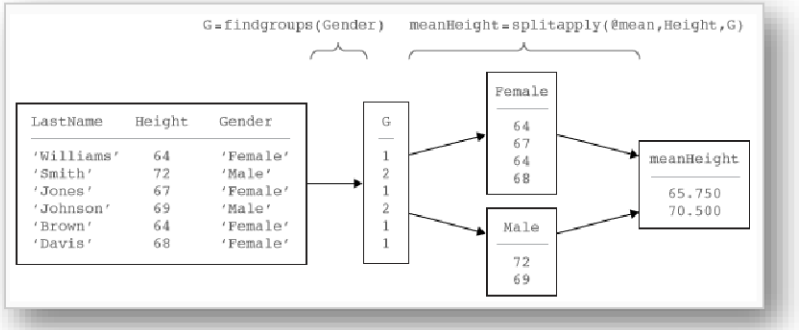
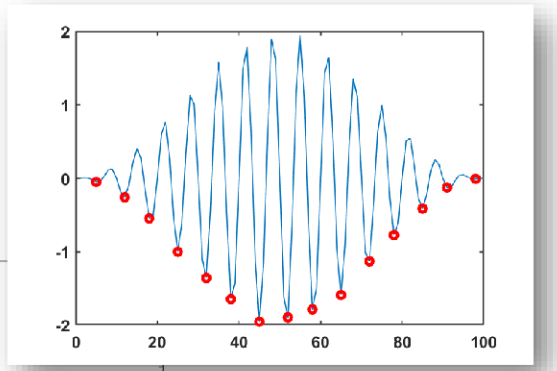
Analyze Data

Intuitive data processing

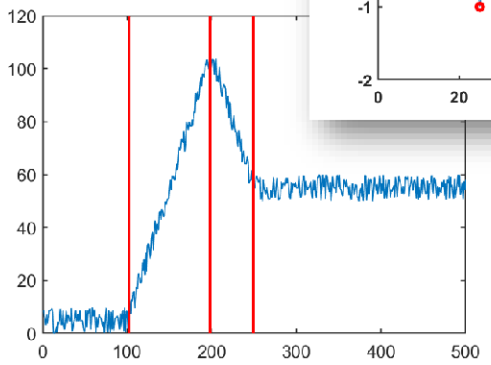


- Split-Apply-Combine Workflow **R2015b**
  - `findgroups` – splits the data into groups
  - `splitapply` – applies a function to each group and combines the results

- Detect local minima and maxima **R2017b** using `islocalmin` and `islocalmax`



- Detect abrupt changes in data with `ischange` **R2017b**



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R2015b

Graphs and Directed Graphs

Data connectivity

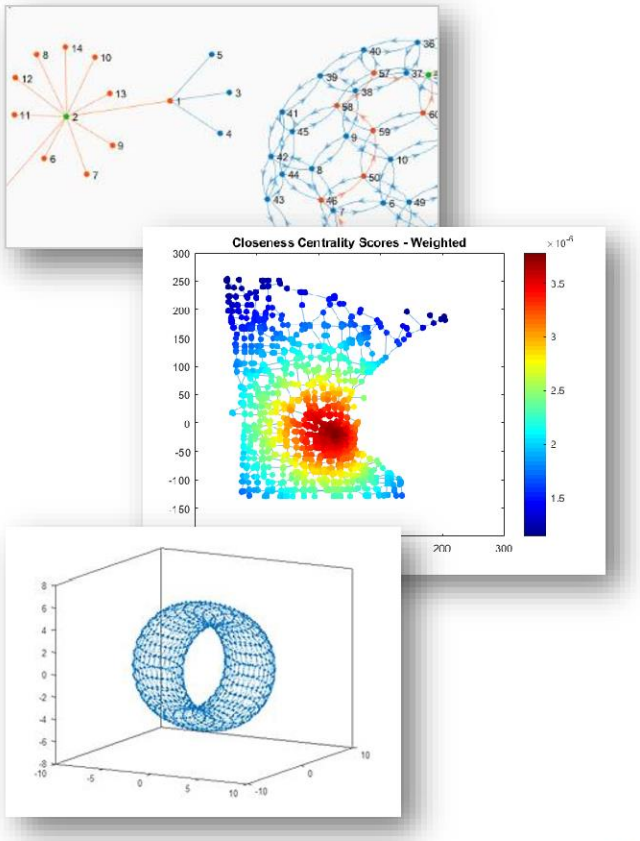
Create graph

```
G = digraph(lhstotal,rhstotal,'OmitSelfLoops');
G.Nodes = pagenames;

cleve = shortestpath(G,'Kevin_Bacon','Cleve_Moler');
jack = shortestpath(G,'Kevin_Bacon','John_N._Little');
```

Show graph

```
plot(G)
```



- 3D visualization
- Connected components R2016b
- Isomorphism

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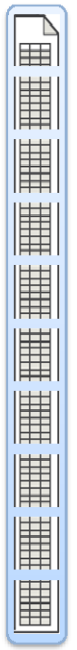
Got Big Data?

Working with it just got easier in MATLAB.

MathWorks

`tall` arrays R2016b

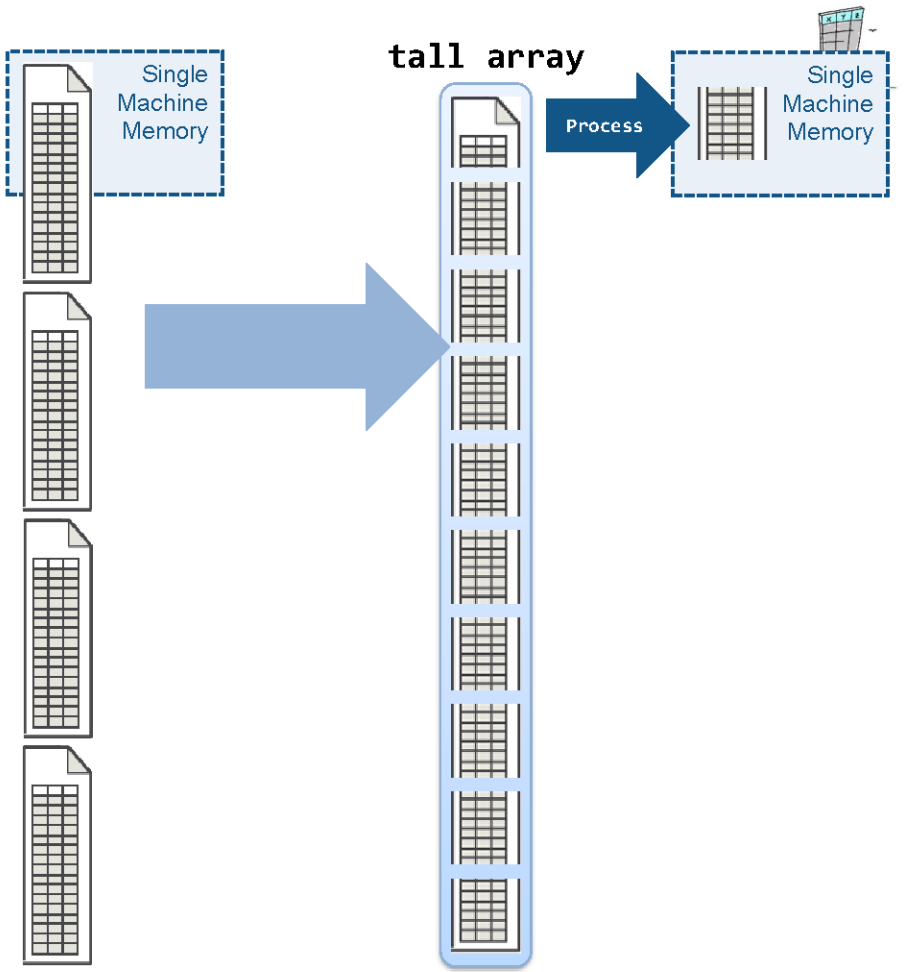


- New data type designed for data that doesn't fit into memory
- Lots of observations (hence "tall")
- Looks like a normal MATLAB array
  - Supports numeric types, tables, datetimes, strings, etc…
  - Supports several hundred functions for basic math, stats, indexing, etc.
  - **Statistics and Machine Learning Toolbox** support (clustering, classification, etc.)

MathWorks

`tall` arrays R2016b

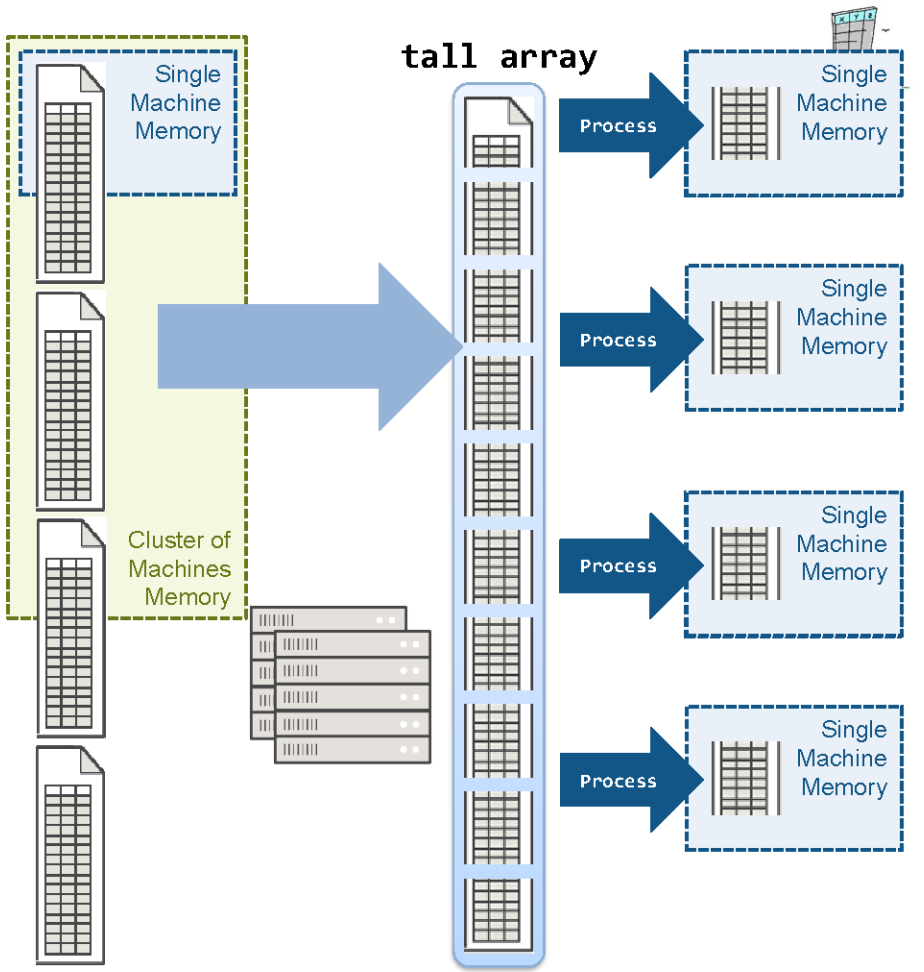
- Automatically breaks data up into small “chunks” that fit in memory
- Tall arrays scan through the dataset one “chunk” at a time
- Processing code for tall arrays is the same as ordinary arrays



MathWorks

`tall` arrays R2016b

- With Parallel Computing Toolbox, process several “chunks” at once
- Can scale up to clusters with MATLAB Distributed Computing Server
- Support for Spark and Hadoop



MathWorks

Tall Arrays – Example

- How many times do we need to access the disk for this calculation?

```
a = tt.Month;
b = tt.DayofMonth;
c = mean(tt.DayofMonth);
d = std(tt.DayOfWeek);
e = numel(tt.AirTime);
f = fillmissing(tt.TaxiOut,'constant',0);
g = smoothdata(f,1,'movmean',10);

calc3 = (a + b).*c + d.*f.*g;

calc3_result = gather(calc3);
```

```
- Pass 1 of 2: Completed in 3 sec
- Pass 2 of 2: Completed in 3 sec
Evaluation completed in 7 sec

e =
  tall double
    ?
Preview deferred. Learn more.
```

MATLAB performs a dependency analysis and does not compute results that are unnecessary

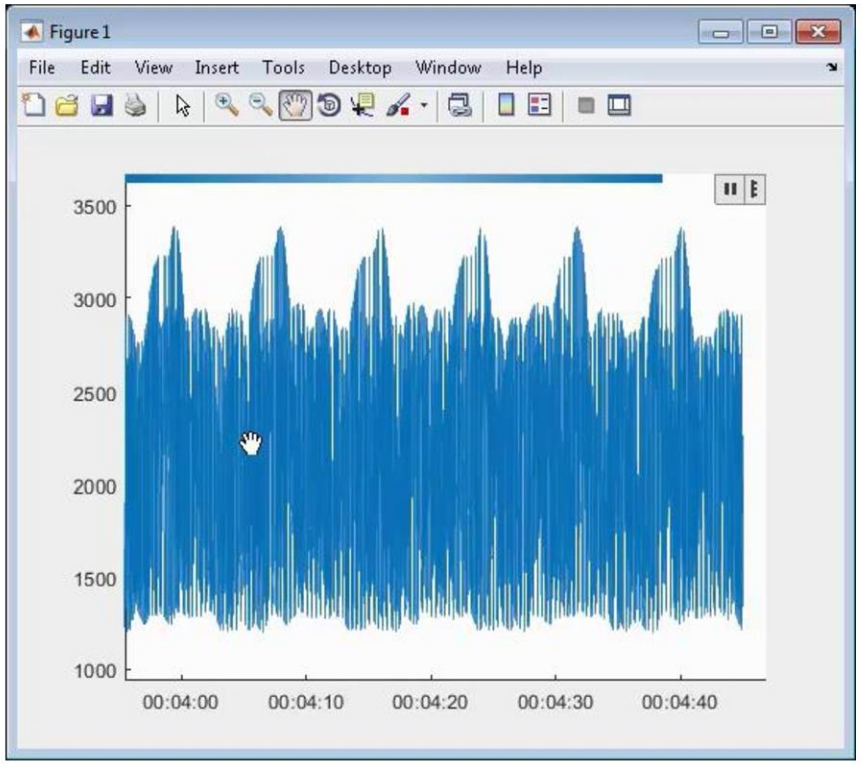
MathWorks

Visualizing Big Data Using `tall`

- Support for:
  - `histogram`
  - `histogram2`
  - `ksdensity`
  - `plot`
  - `scatter`
  - `binscatter`

R2017b

- Support will continue to grow!



MathWorks

`tall` arrays

Customization support for the entire workflow

- **Import**
  - Custom datastore R2018a
- **Process**
  - Out-of-box (`groupsummary`,`islocalmin`, ...)
  - Custom functions R2018b

```
tall_output1 = matlab.tall.transform(@fcn,tall_input);
tall_output2 = matlab.tall.reduce(@fcn,@reducefun,tall_input);
```

- **Export**
  - Custom write capabilities R2018b

```
write("OutputFolder",tt,"FileType","text")
write("OutputFolder",tt,"FileType","spreadsheet")
write("OutputFolder",tt,"WriteFcn",@myWriteFcn)
```

MathWorks

Agenda

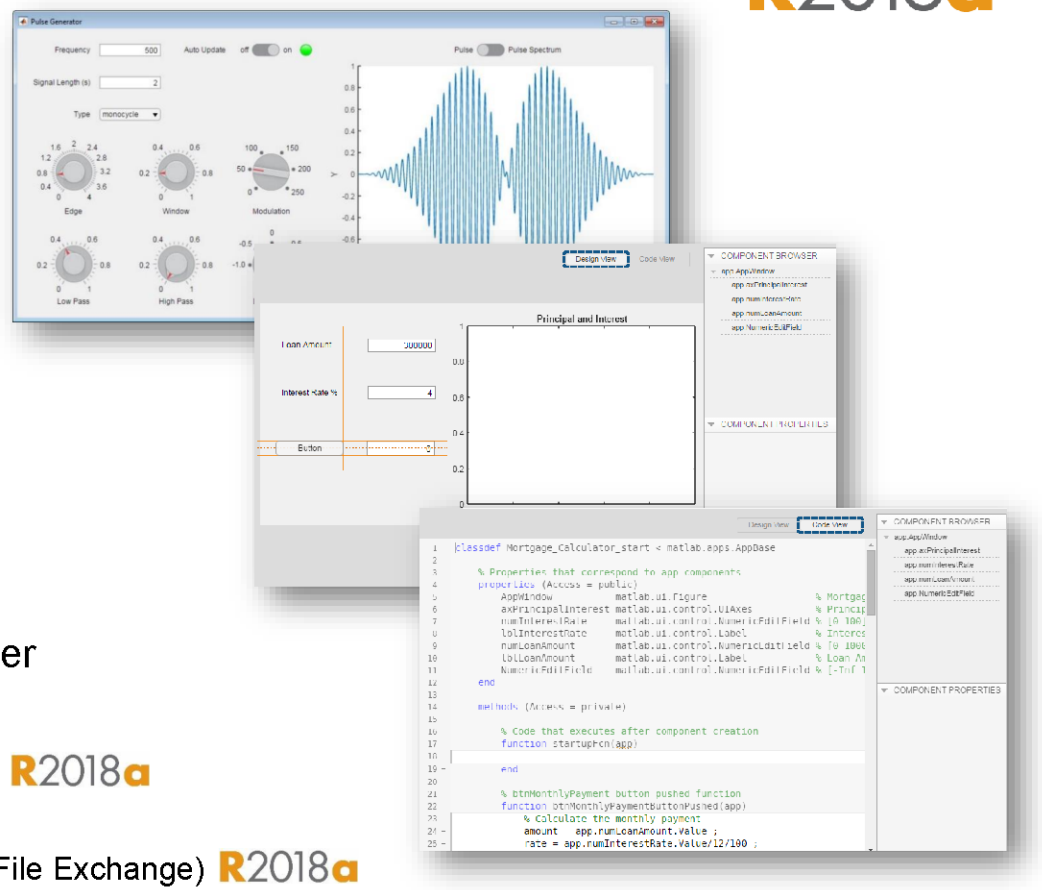
	MATLAB Foundation
	Data Handling & Language Enhancements
	**Building & Sharing Apps**
	Hardware Support
	New Features in Toolboxes & New Toolboxes
	Summary and Wrap-up

MathWorks

R2016a

App Designer

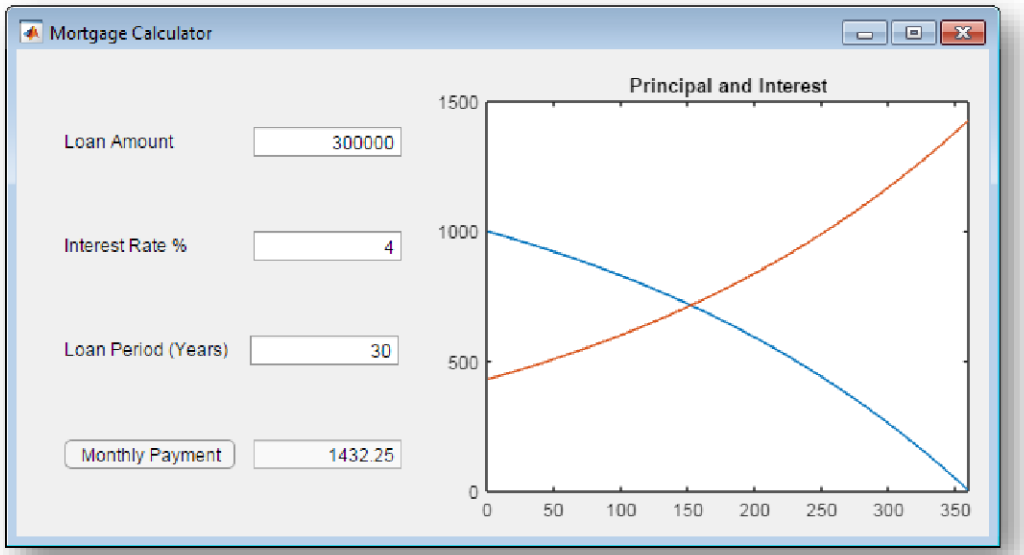
- Enhanced design environment
  - Component alignment guides
  - Simpler property inspectors
  - Intuitive menu bar interface R2017b
- Expanded UI component set
  - Gauges, dials, tabs, date picker, and more…
- Improved code and coding tools
  - Object-based code format
  - Property and method management
  - Code refactoring
- Run App Designer apps in a web browser
  - Run apps in MATLAB Online R2017b
  - Package apps using MATLAB Compiler and host them using MATLAB Web App Server R2018a
- GUIDE to App Designer transition tool (File Exchange) R2018a



MathWorks

App Designer

R2016a



MathWorks

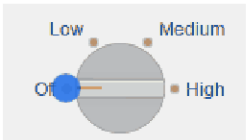
App Testing Framework

Write automated tests for App Designer apps

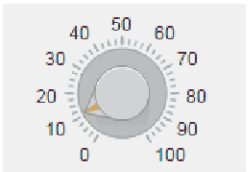
- Verify app behavior with tests that programmatically perform gestures on a UI component

```
testCase.press(myApp.checkbox)
```

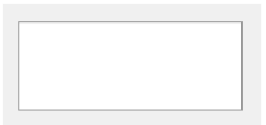

```
testCase.choose(myApp.discreteKnob, "Medium")
```




```
testCase.drag(myApp.continuousKnob, 10, 90)
```



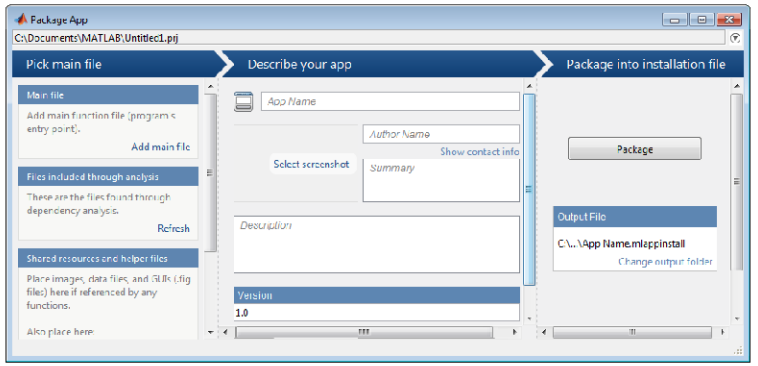

```
testCase.type(myApp.editfield, myTextVar)
```



MathWorks

Packaging Apps and User-Created Toolboxes

- App Packaging
  - Automatically includes all necessary files
  - Documents required products
  - Creates single installation file for easy distribution and installation into the MATLAB apps gallery



- Toolbox Packaging R2014b
  - Create your own toolbox of custom functions and package it as a single installer file
  - Contains all of the code, folders, data, apps, documentation, and examples
  - View details and uninstall toolboxes with Manage Add-on Toolboxes dialog box
  - Documents required products
  - Easily create a "Getting Started Guide" for your toolbox R2017b

MathWorks

Agenda

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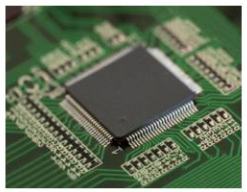
MathWorks

Hardware: Breadth and Depth









Data & RF | Embedded | Imaging | Specialty

- Serial
- I2C
- SPI
- Bluetooth
- IVI
- VISA
- VXIplug&play
- MODBUS R2017a
- GigE Vision
- USB3 Vision R2016a
- DCAM
- Camera Link
- CAN
- J1939
- OPC standards

and more…

Standards

MathWorks

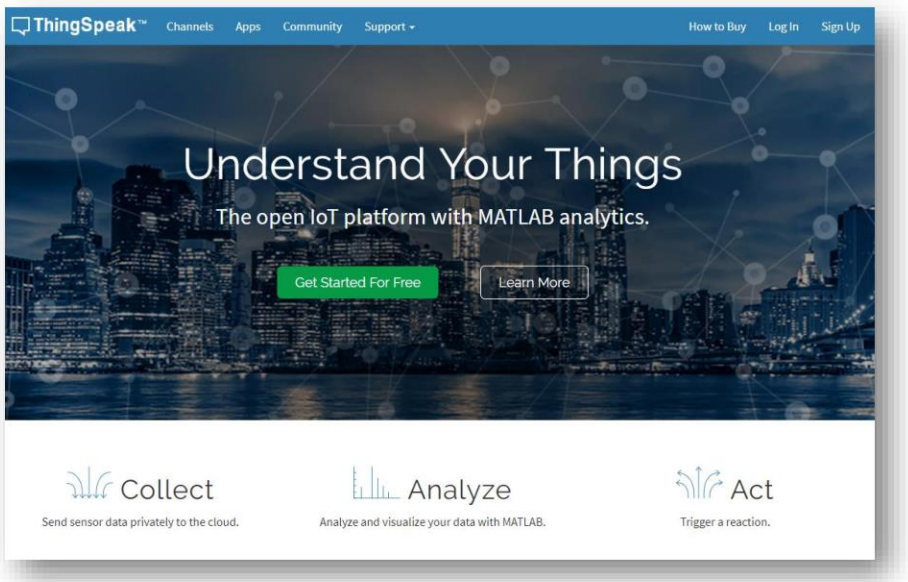
Low-Cost Hardware Prototyping

- Breadth of devices
  - Robotics: Arduino, Raspberry Pi, BeagleBone Black, LEGO EV3
  - Mobile: iPhone sensors, Android sensors
  - Imaging: webcams, IP cameras
- Connectivity options
  - Connect to MATLAB over USB, Ethernet, Wi-Fi, or Bluetooth
  - Connect to hardware from MATLAB Online (webcam and Raspberry Pi) R2018a
  - Log mobile sensor data to the cloud R2016b
  - Log mobile sensor data locally when device is offline R2018a
- Execution modes
  - Interactive communication from MATLAB
  - Deploy to Raspberry Pi for standalone execution R2018b

MathWorks

ThingSpeak

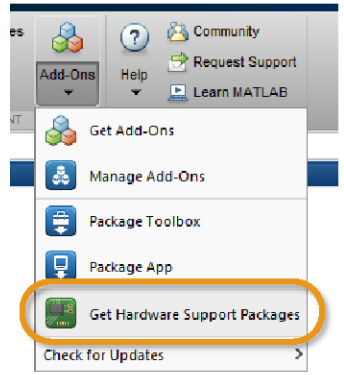
- Web service to aggregate, visualize and analyze live Internet of Things (IoT) data streams in the cloud
- Prototype and build proof of concept IoT systems
  - Collect data from IoT devices using REST or MQTT
  - Apply signal processing and machine learning algorithms to IoT data directly on the cloud
  - Share custom visualizations of live data privately with colleagues or clients



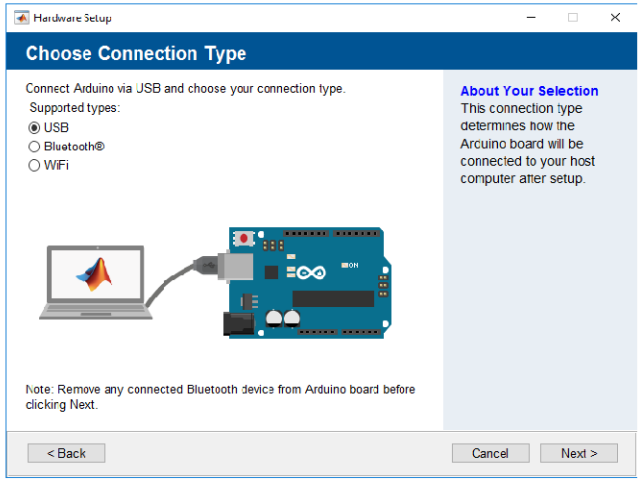
MathWorks

Hardware: Getting Up and Running Fast

- Hardware support packages in Add-On Explorer R2016b
  - Automates installation of hardware drivers



- Guided setup of Arduino connection R2017a

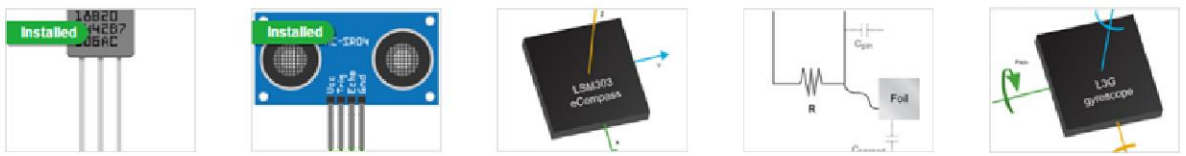


- Apps get you started quickly and automatically generate code
  - DAQ: Analog Input Recorder App R2017b

MathWorks

Hardware: Extensibility

- Interface designed for end users
- Custom Arduino libraries extend the Arduino support package



- SDKs allow developers to expand hardware support
  - Custom Arduino Libraries in MATLAB R2016a
  - Image Acquisition Toolbox SDK
  - Data Acquisition Toolbox SDK R2017a
  - Coder Products

Data Translation built their DAQ hardware support with the Data Acquisition SDK

MathWorks

Agenda

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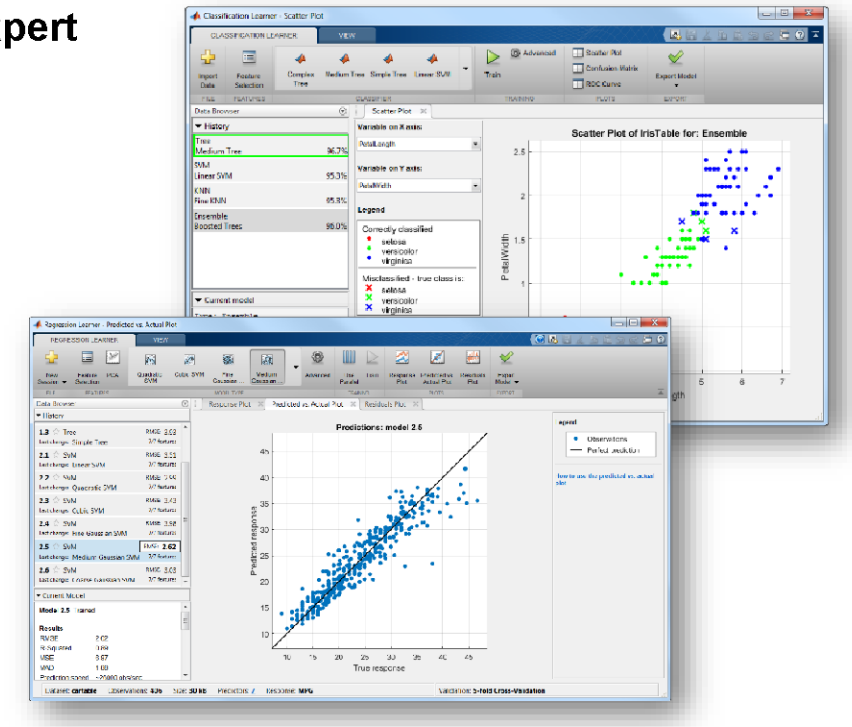
MathWorks

Machine Learning

"I would have never attempted machine learning if this app was not available."

MATLAB makes machine learning easy and accessible for everyone, even if you're not an expert

- Use apps to interactively explore data, choose algorithms to train and validate models, and compare results
  - Classification Learner app R2015a
  - Regression Learner app R2017a
- Apply algorithms to out-of-memory data using tall arrays R2016b +
- Generate C code for predictive models *(requires MATLAB Coder)* R2016b +

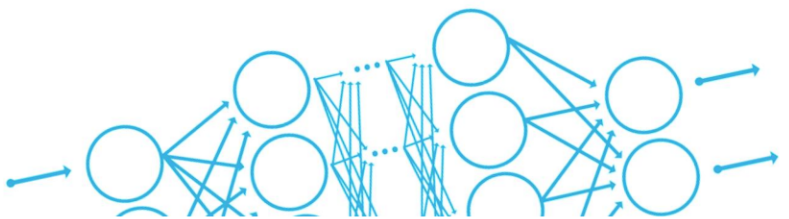


MathWorks

Deep Learning

Design, build, and visualize convolutional neural networks

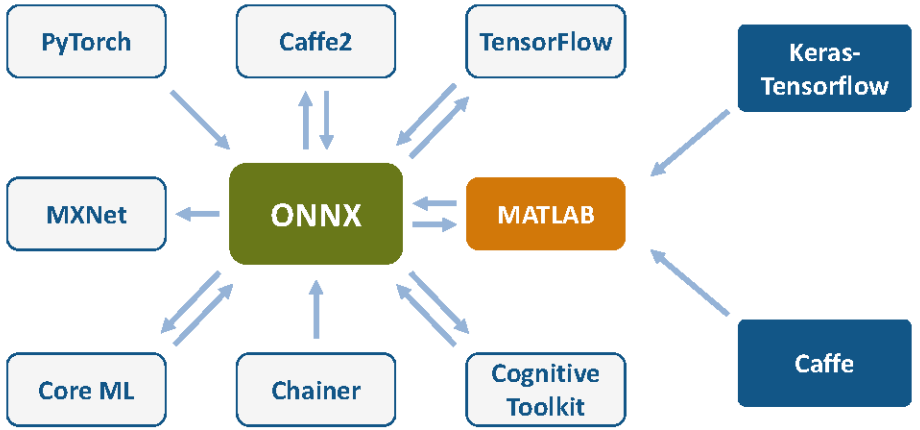
- Interoperability with deep learning frameworks
- Design and build your own models
  - R-CNN, Fast R-CNN, and Faster R-CNN algorithms
- Use NVIDIA GPUs to train your models R2017b +
- Automatically generate high-performance CUDA code for embedded deployment *(requires GPU Coder)* R2017b +
- Performance improvements for training and prediction on CPUs and GPUs R2018a +



MathWorks

Interoperability with Deep Learning Frameworks

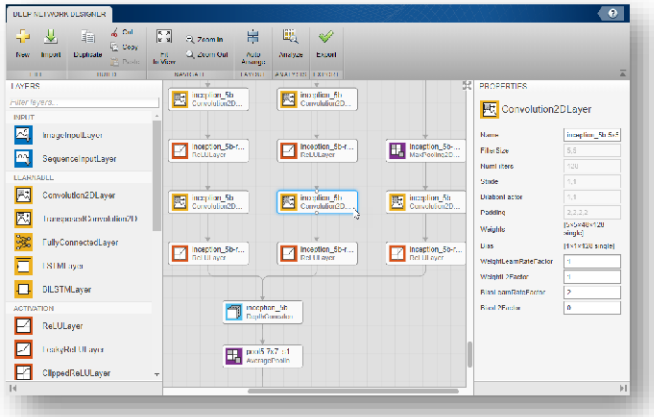
- Import and export models using the Open Neural Network Exchange (ONNX) format
- Model importers
  - Caffe
  - TensorFlow-Keras
- Access pretrained models with a single line of code

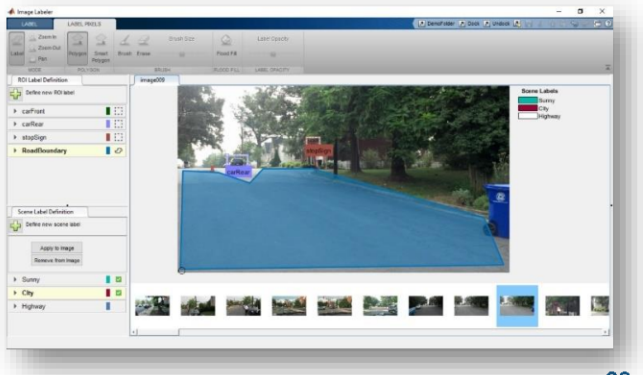


MathWorks

Designing and Building Deep Learning Models

- Edit and build deep networks (Deep Network Designer app) R2018b
- Visualize, analyze, and find problems in network architectures before training (Network Analyzer) R2018b
- Automate ground-truth labeling using apps
  - Image Labeler app R2017b+
  - Video Labeler app R2018b
  - Audio Labeler app
- Monitor training progress with plots for accuracy, loss, validation metrics, and more R2017b
- Visualize and debug deep learning models R2017b

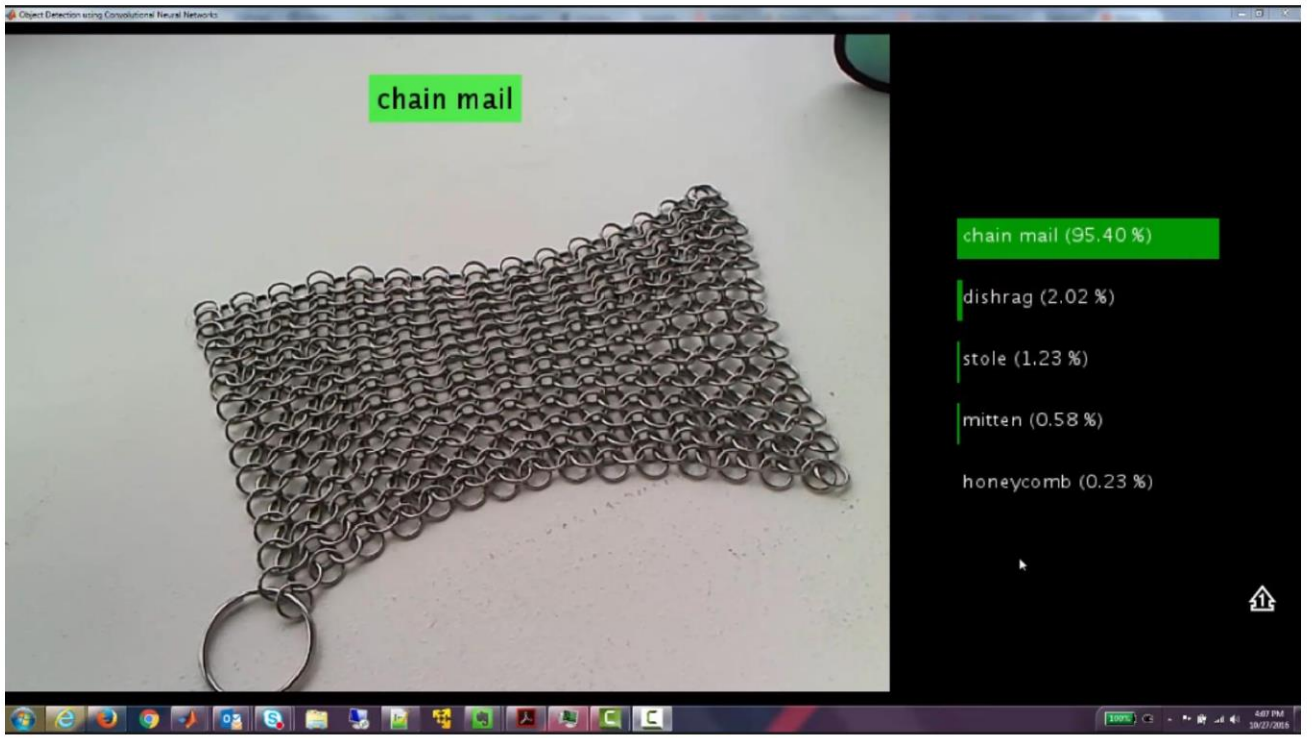




Deep Learning Toolbox
Computer Vision System Toolbox
Audio System Toolbox

MathWorks

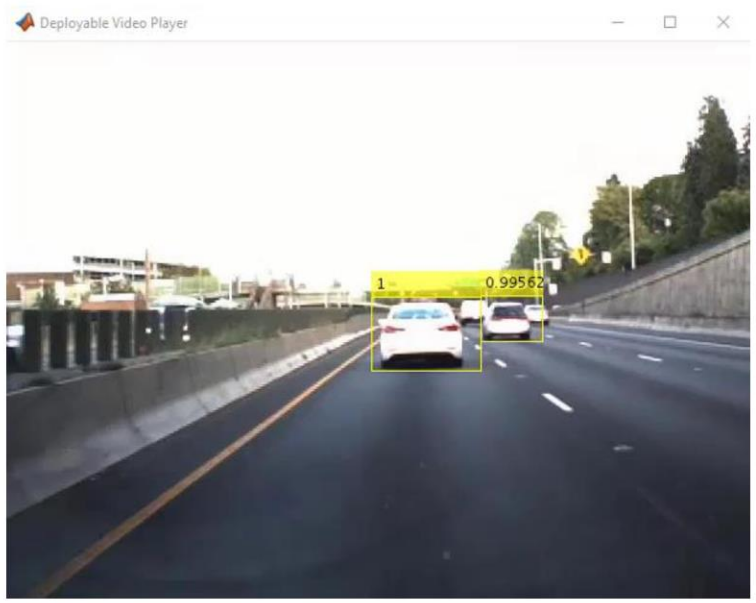
Example 1: Object recognition using deep learning



Training (GPU)	Millions of images from 1000 different categories
Prediction	Real-time object recognition using a webcam connected to a laptop

MathWorks

Example 2: Detection and localization using deep learning

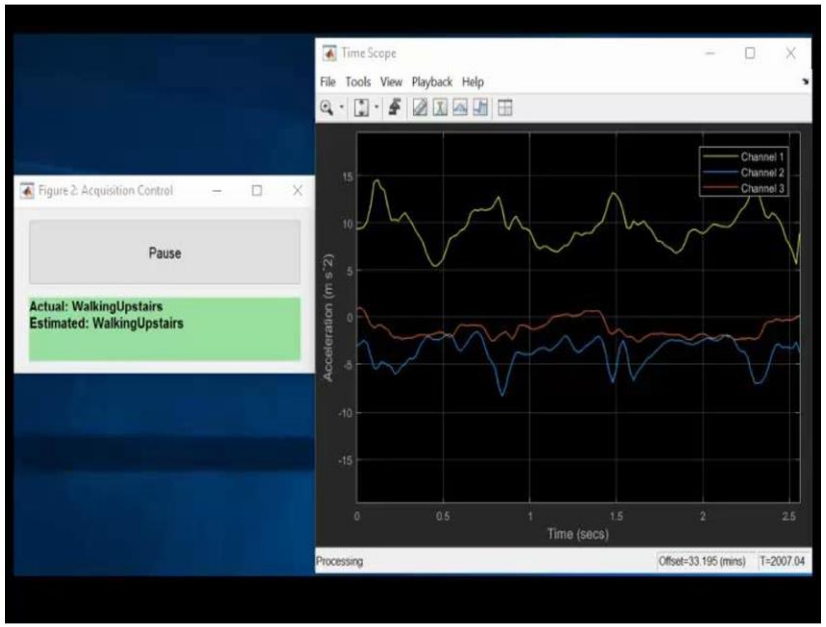


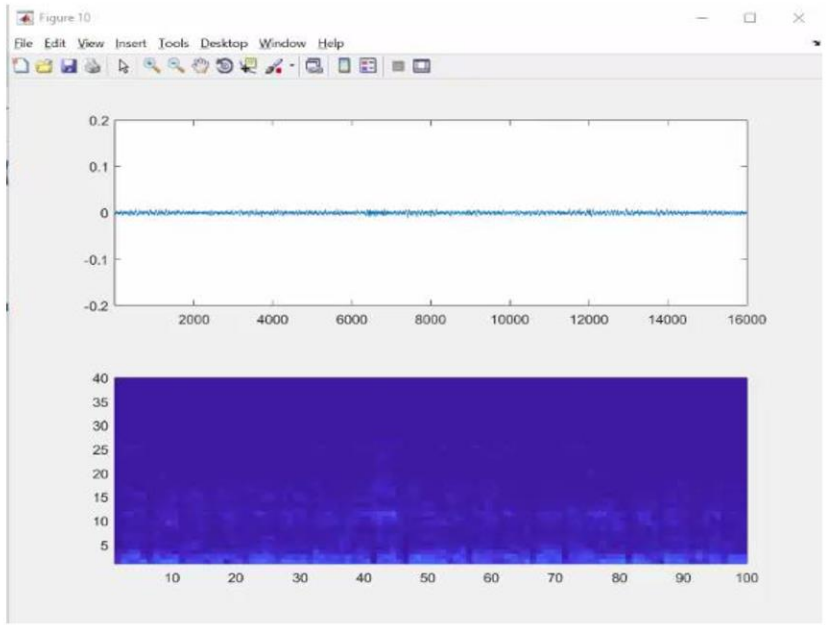
Regions with Convolutional Neural Network Features (R-CNN)

Semantic Segmentation using SegNet

MathWorks

Example 3: Analyzing signal data using deep learning





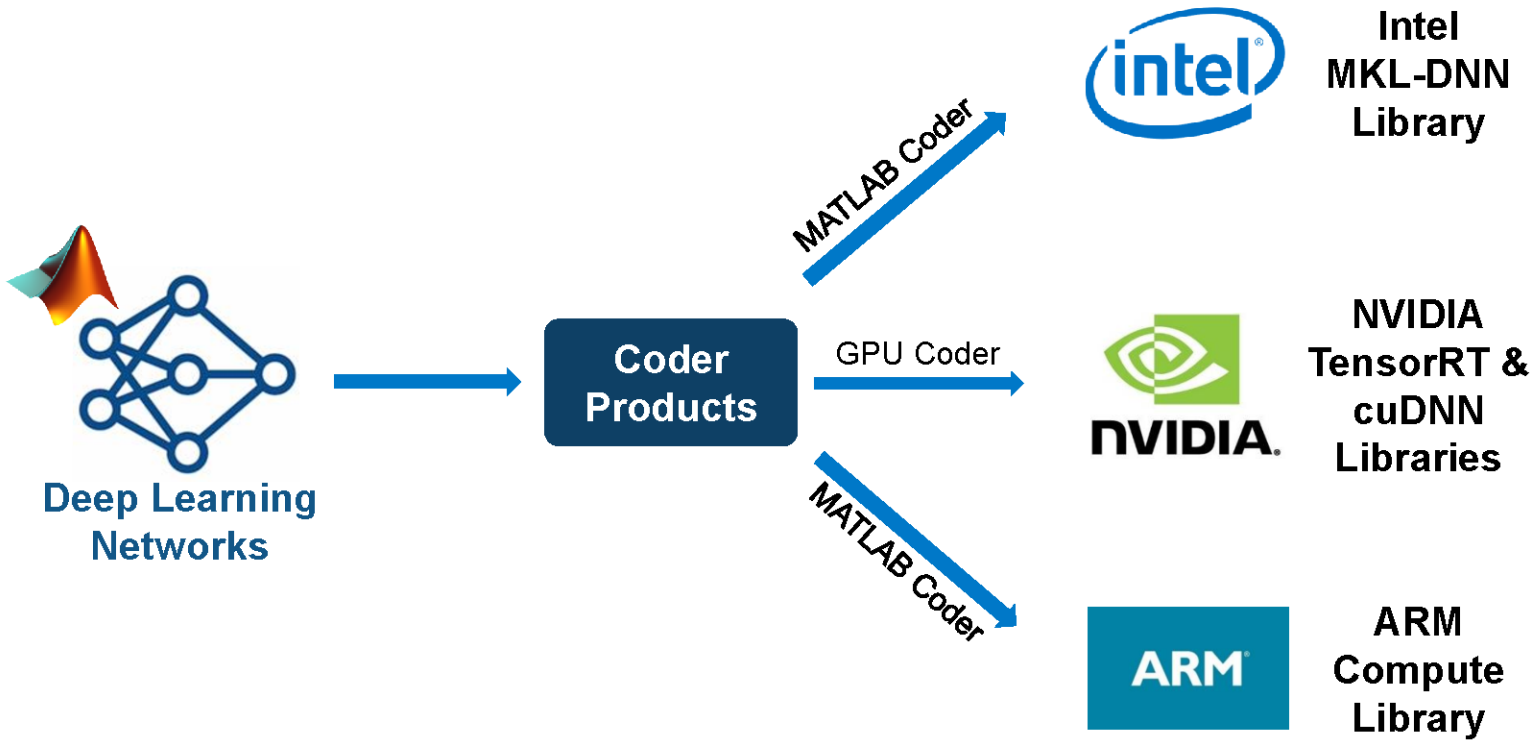
Signal Classification using LSTMs

Speech Recognition using CNNs

MathWorks

Deploying Deep Learning Models for Inference

R2017b+



MathWorks

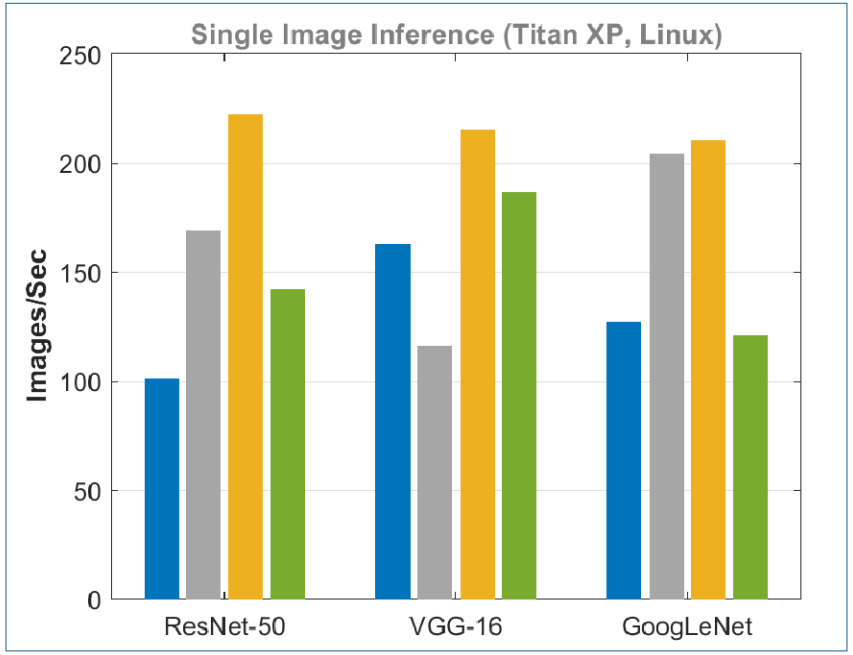
GPU Coder

Automatically generate CUDA code from MATLAB

- Support for networks in Deep Learning Toolbox
- Generate MEX functions for acceleration and verification
- Generated code can integrate with external CUDA code

Why is GPU Coder so fast?
- Code is lean, just prediction
- Invested 15 years in code gen
- Matrix-based calculations

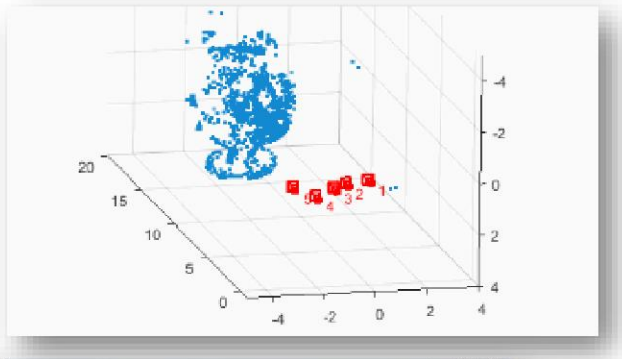
R2018b



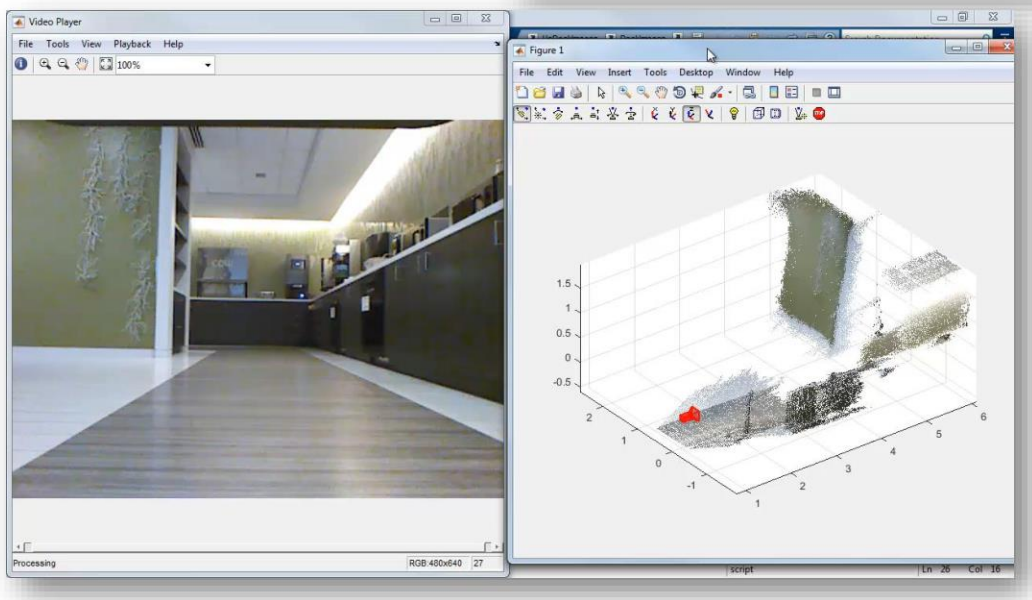
MathWorks

Image Processing and Computer Vision

- Structure from motion
  - Estimate the essential matrix and compute camera pose from 3-D to 2-D point correspondences



- Point cloud processing

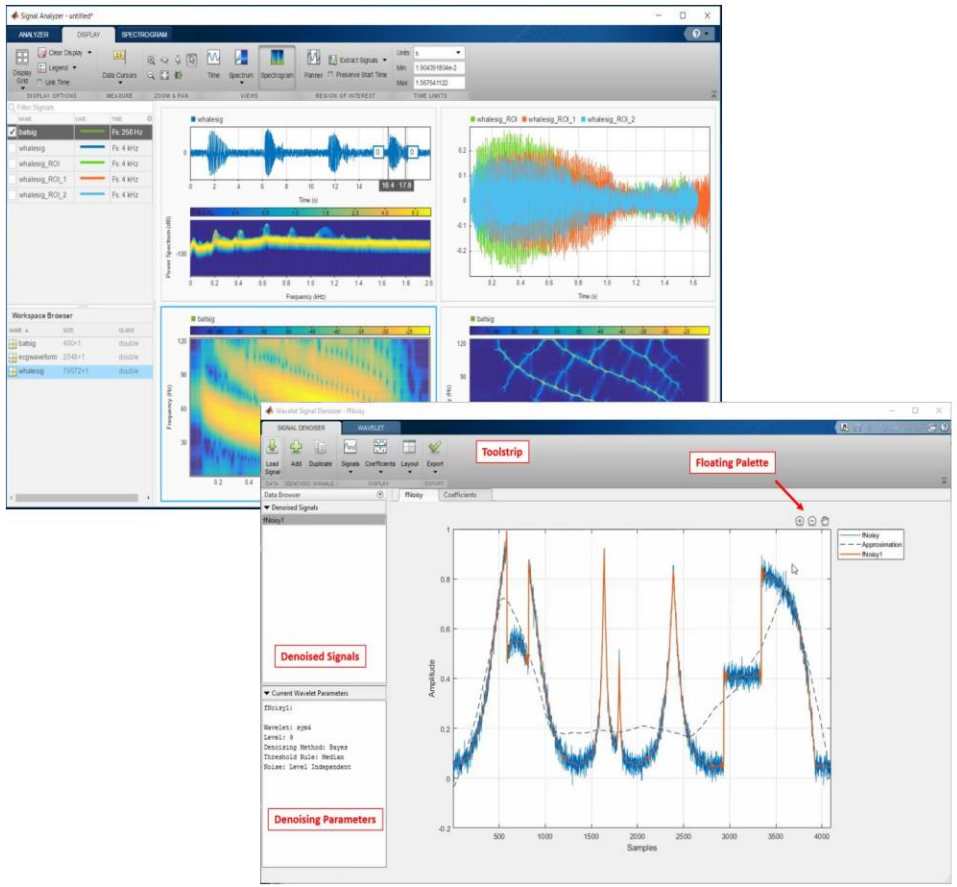


MathWorks

Signal Processing

- Signal Analyzer app R2016a
  - Visualize and compare multiple signals and spectra
  - Spectral analysis of signals
  - Time domain panning
  - Automatic MATLAB code generation R2017b
  - Preprocess signals by smoothing and filtering R2018a

- Wavelet Signal Denoiser App R2017b
  - Visualize and denoise time-series data
  - Automatic MATLAB code generation



Signal Processing Toolbox
Wavelet Toolbox

MathWorks

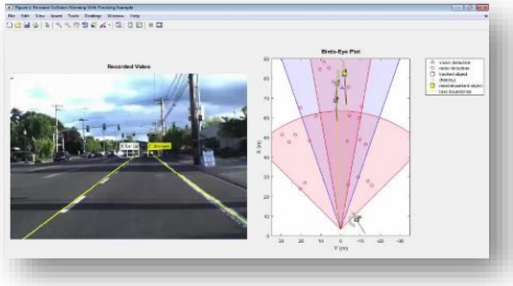
Automated Driving System Toolbox

R2017a

- Algorithm development
  - Sensor Fusion
  - Computer Vision
  - Deep learning
- Testing and verification
  - Ground Truth Labeling App
  - Traffic scenario generation
  - Euro NCAP and other prebuilt scenarios

R2018b

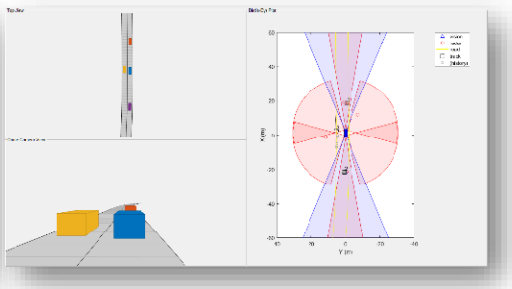
- Visualization tools



Sensor Fusion

Computer Vision & Deep Learning

Ground truth labeling



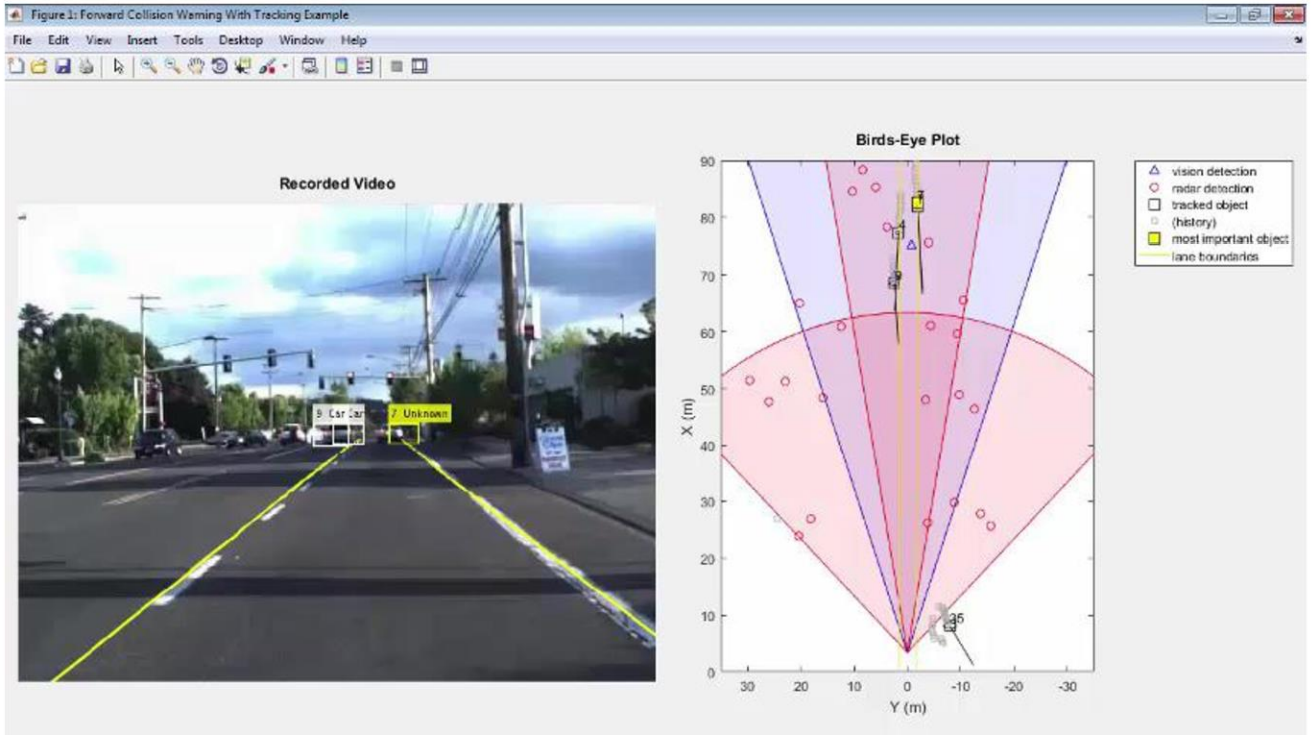
Scenario Generation

MathWorks

Automated Driving System Toolbox

Sensor Fusion and Visualization

R2017a



MathWorks

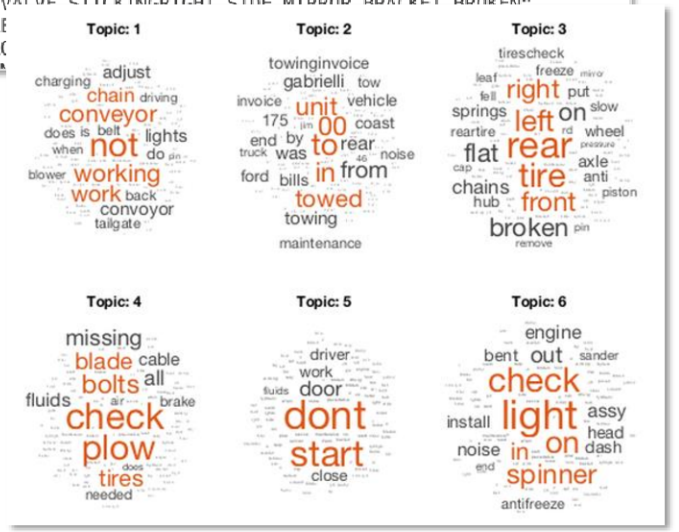
R2017b

Text Analytics Toolbox

Analyze and model text data

- Text extraction from PDF and Microsoft Word files
- Text preprocessing and normalization
- TF-IDF and word frequency statistics
- Machine learning algorithms, including Latent Dirichlet Allocation (LDA) and Latent Semantic Analysis (LSA)
- Word-embedding training, and pretrained model import with word2vec, FastText, and GloVe
- Word cloud and text scatter plots
- n-grams (create bags of multiword phrases) R2018a
- HTML text extraction R2018a +
- Japanese language support R2018b

```
repairNotes = 617×1 string array
    "PM SERVICE, CHECK TURN SIGNAL, CLUNKING NOISE WHEN DRIVING"
    "SERVICEROB,EXT,5604"
    "NEED 4 PLOW PINS"
    "INSTALL SPINNER ASSY"
    "DONT START"
    "DOG BONE PIN BROKEN"
    "NEED SERVICE, CHECK BRAKES"
    "HYD CAP CHECK ENGINE LIGHT ON"
    "TARP VALVE STICKINGRIGHT SIDE MIRROR BRACKET BROKEN"
    "HANDLE
    "NO PLC
```



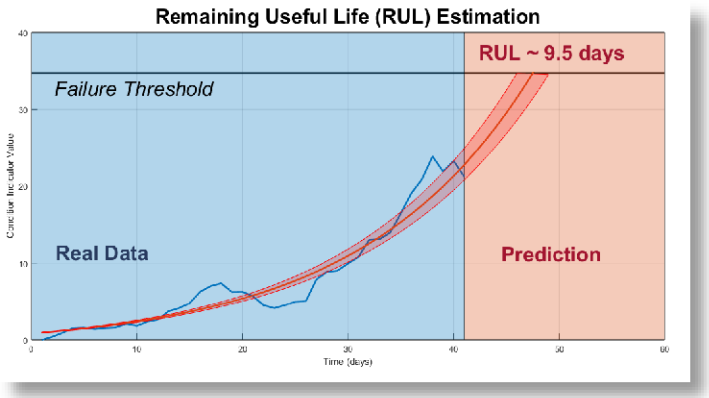
MathWorks

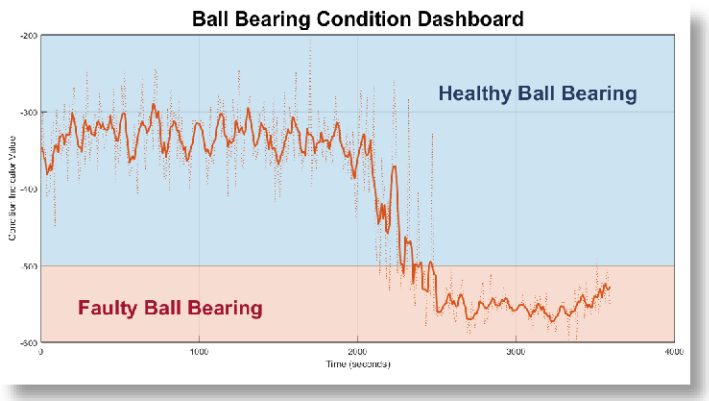
New Product: Predictive Maintenance Toolbox

R2018a

Design and test condition monitoring and predictive maintenance algorithms

- Survival, similarity, and time-series models for remaining useful life (RUL) estimation
- Time, frequency, and time-frequency feature extraction for designing condition indicators
- Import sensor data from Amazon S3, Windows Azure Blob Storage, and Hadoop HDFS
- Organize simulated machine data from Simulink models
- Examples for motors, gearboxes, batteries, and other machines





MathWorks

Support for the Latest Wireless Standards

Generate IEEE 802.11ad compliant waveforms and simulate 3GPP 5G radio technologies

- IEEE 802.11ad is a new Wi-Fi standard intended for high data rate short range communication
  - e.g., streaming video between a phone and a TV

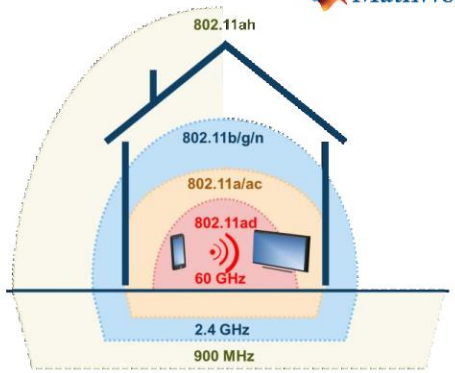
R2017a +

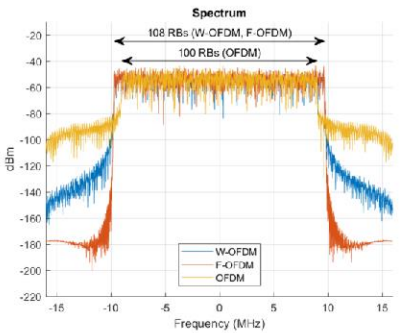
- A new product for simulating, analyzing, and testing the physical layer of 5G communication systems

R2018b

- LTE HDL Toolbox is a new product for modeling LTE communications subsystems for FPGAs and ASICs

R2017b





WLAN System Toolbox™
5G Toolbox™
LTE HDL Toolbox™

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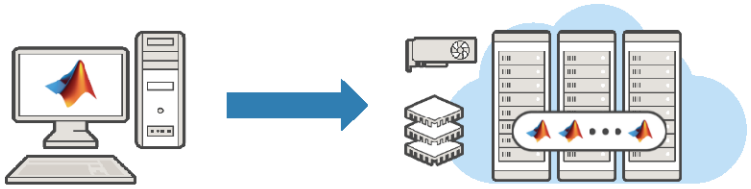
Parallel Computing



R2016b

- `tall` array support for big data and Spark
- Measure data sent to workers using `ticBytes` and `tocBytes`
- Cloud Center support for K80-equipped GPU instances

R2017a

- Simplified parallel Simulink simulations using `parsim`
- Send data to client using `DataQueue` and `PollableDataQueue`
- Train a single deep learning network with multiple CPUs or multiple GPUs

R2017b

- Train SVM models using GPUs
- Better monitoring tools for parallel Simulink simulations

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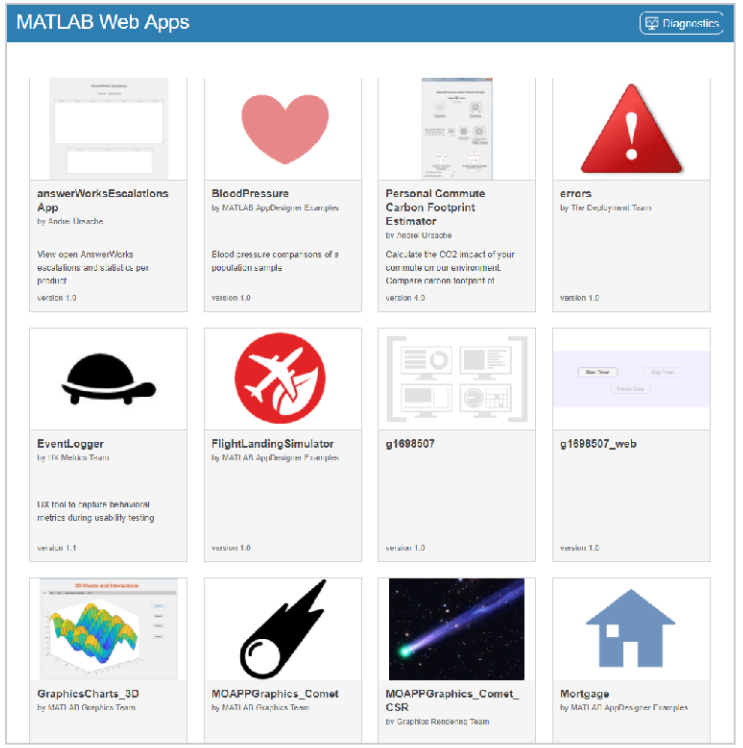
Application Deployment

Share MATLAB algorithms in desktop applications, language-specific libraries, or web applications

- Create MapReduce applications that run against Hadoop — R2014b
- Create MATLAB applications that run against an Apache Spark enabled cluster — R2016b
- Author and deploy App Designer applications as web apps that run in a web browser — R2018a
  - Upload and download files between the browser and the server-based deployed web app — R2018b



MATLAB Compiler
MATLAB Compiler SDK

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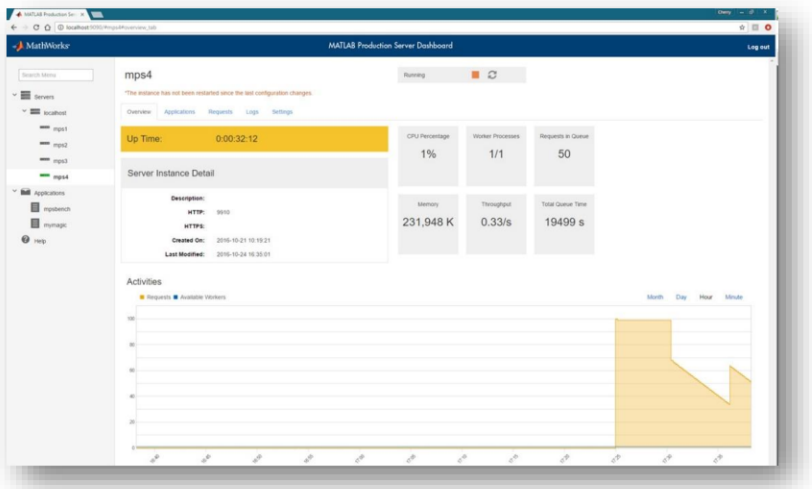
Integrate MATLAB Analytics into Enterprise Applications

Deploy MATLAB algorithms without recoding or creating custom infrastructure

- Develop clients for MATLAB Production Server in any programming language that supports HTTP using RESTful API and JSON — R2016a
- Configure and manage multiple server instances using a web-based interface — R2017a
- Discover the list of APIs provided by installed applications through a RESTful interface — R2018a



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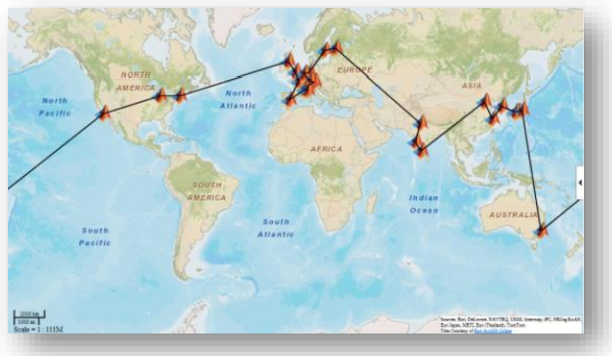
Other Toolbox Enhancements

- **Optimization Toolbox**
  - Mixed Integer Linear Programming
  - Simplified constraint and problem definition R2017b
  - Automatic solver selection R2017b
- **Global Optimization Toolbox**
  - Two new solvers R2018b
    - `surrogateopt` – for problems with time-consuming objective function evaluations
    - `paretosearch` – for multiobjective optimization problems
- **Mapping Toolbox**
  - Web map display with dynamic base maps



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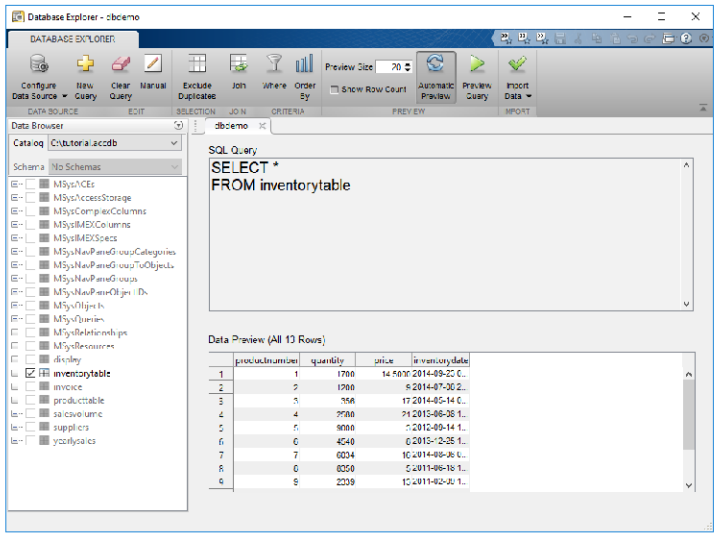
Other Toolbox Enhancements

- **Database Toolbox**
  - Analyze large data using a DatabaseDatastore and `tall` table capabilities
  - Retrieve graph data from Neo4j Graph Database
  - Updated Database Explorer App R2017b
  - Interface for Apache Cassandra database R2018b
  - Customize options for importing data from a database into MATLAB R2018b



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Other Toolbox Enhancements

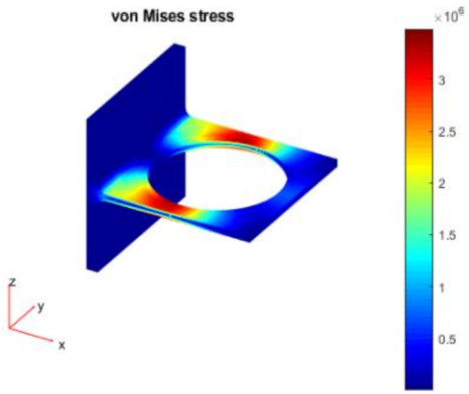
```
TotalLoad     = subs(q_t, Vars, Values)
```

TotalLoad =

$$\begin{cases} \frac{9375\left(\frac{X}{4}-\frac{66}{25}\right)}{104}\,\frac{\mathrm{N}}{\mathrm{m}}+\frac{328125\left(\frac{2X}{5}-\frac{3429}{125}\right)}{258064}\,\frac{\mathrm{N}}{\mathrm{m}}+\frac{1000000\sqrt{\frac{145161}{625}-X^2}}{16129\,\pi}\,\frac{\mathrm{N}}{\mathrm{m}} & \text{if } X \le \frac{12}{5} \\ \frac{328125\left(\frac{2X}{5}-\frac{3429}{125}\right)}{258064}\,\frac{\mathrm{N}}{\mathrm{m}}+\frac{1000000\sqrt{\frac{145161}{625}-X^2}}{16129\,\pi}\,\frac{\mathrm{N}}{\mathrm{m}} & \text{otherwise} \end{cases}$$

- **Symbolic Math**
  - Perform symbolic math using the MATLAB Live Editor and visualize results in mathematical typeset
  - Work with units and perform physical calculations R2017b

- **Econometrics Toolbox**
  - Bayesian Linear Regression
  - Vector Autoregressive Models (VAR) with Exogenous Inputs (VARX)
  - Econometric Modeler App *(time series analysis and modeling)* R2018a



- **Partial Differential Equations**
  - Supports 3D geometry from CAD in STL format R2015b
  - Heat transfer analysis for conduction-dominant problems R2017a
  - Structural analysis, including linear static, dynamic, and modal analysis R2018a

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New Toolboxes

- **Code Generation**
  - GPU Coder
  - Vision HDL Toolbox
- **Controls**
  - Robotics System Toolbox
- **Image Processing and Computer Vision**
  - Automated Driving System Toolbox
- **Signal Processing**
  - Audio System Toolbox
  - Sensor Tracking and Fusion Toolbox R2018b
  - 5G Toolbox R2018b
- **Math, Statistics, and Optimization**
  - Text Analytics Toolbox
  - Predictive Maintenance Toolbox
- **Computational Finance**
  - Risk Management Toolbox
- **Verification & Validation**
  - Simulink Test
  - Simulink Check
  - Simulink Coverage
  - Simulink Requirements
- **Physical Modeling**
  - Simscape Fluids
- **Wireless Communications**
  - WLAN System Toolbox
  - Antenna Toolbox
  - Phased Array System Toolbox
  - LTE System Toolbox
  - LTE HDL Toolbox

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Agenda

	MATLAB Foundation
	Data Handling & Language Enhancements
	Building & Sharing Apps
	Hardware Support
	New Features in Toolboxes & New Toolboxes
	**Summary and Wrap-up**

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MATLAB

is the **easiest** and
most **productive** environment
for **engineers** and **scientists**

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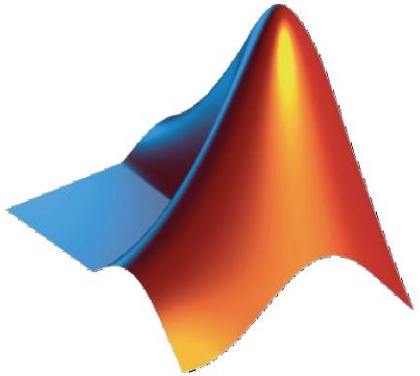

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MATLAB SEMINAR

Demystifying deep learning: A practical approach in

Siti Safwana
Application Engineer

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What deep learning is?

How it is used in the real world?

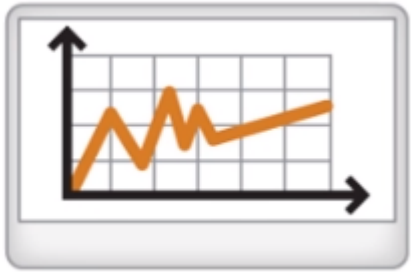
How you can get started?

DEEP LEARNING

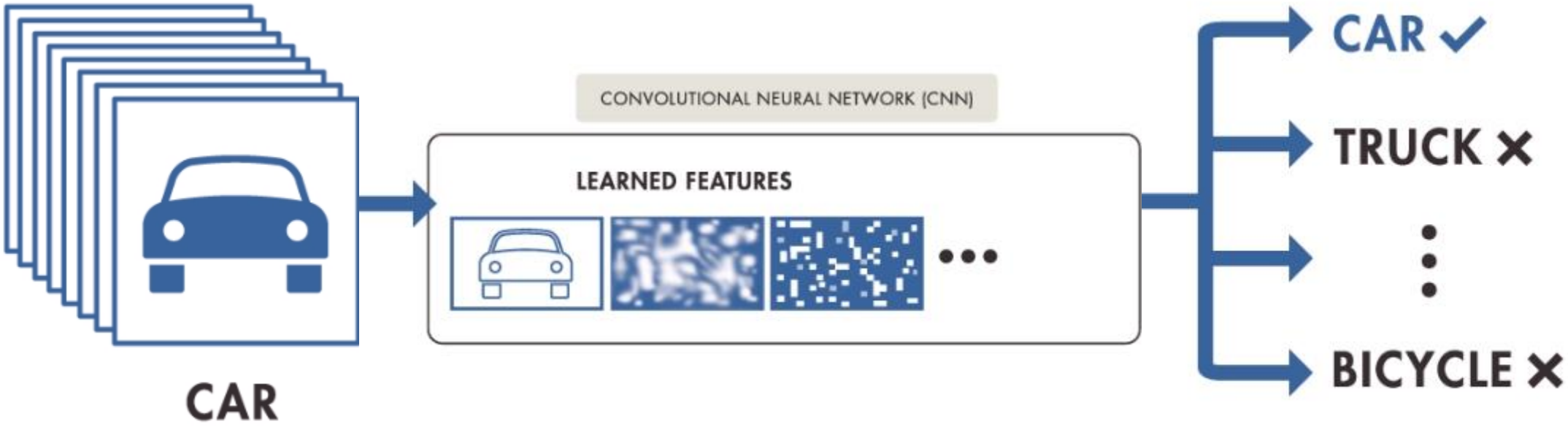
What's Deep Learning

Deep learning is a machine learning technique that learns **features and tasks** directly from data.

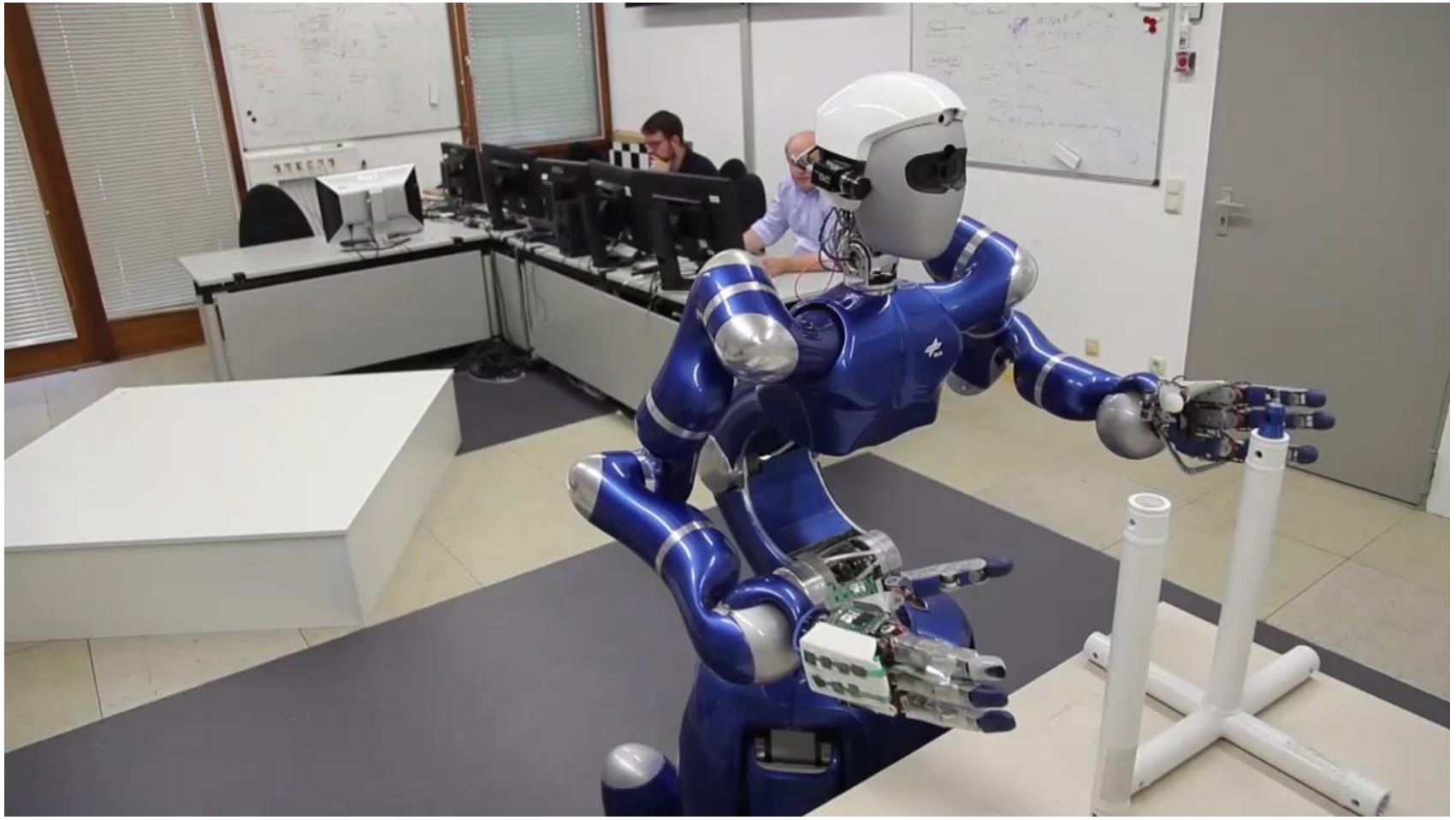
Data can be **images**, **text**, or **sound**.



Deep Learning perform **end-to-end learning** because the task is learned directly from the data

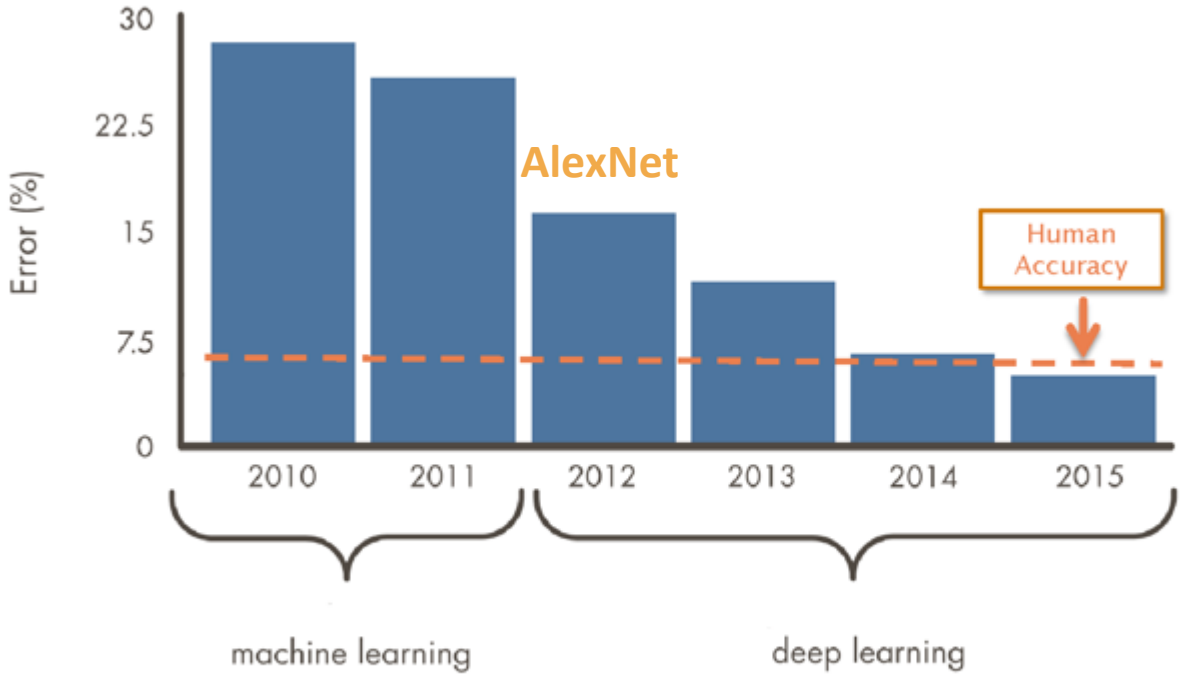


Example



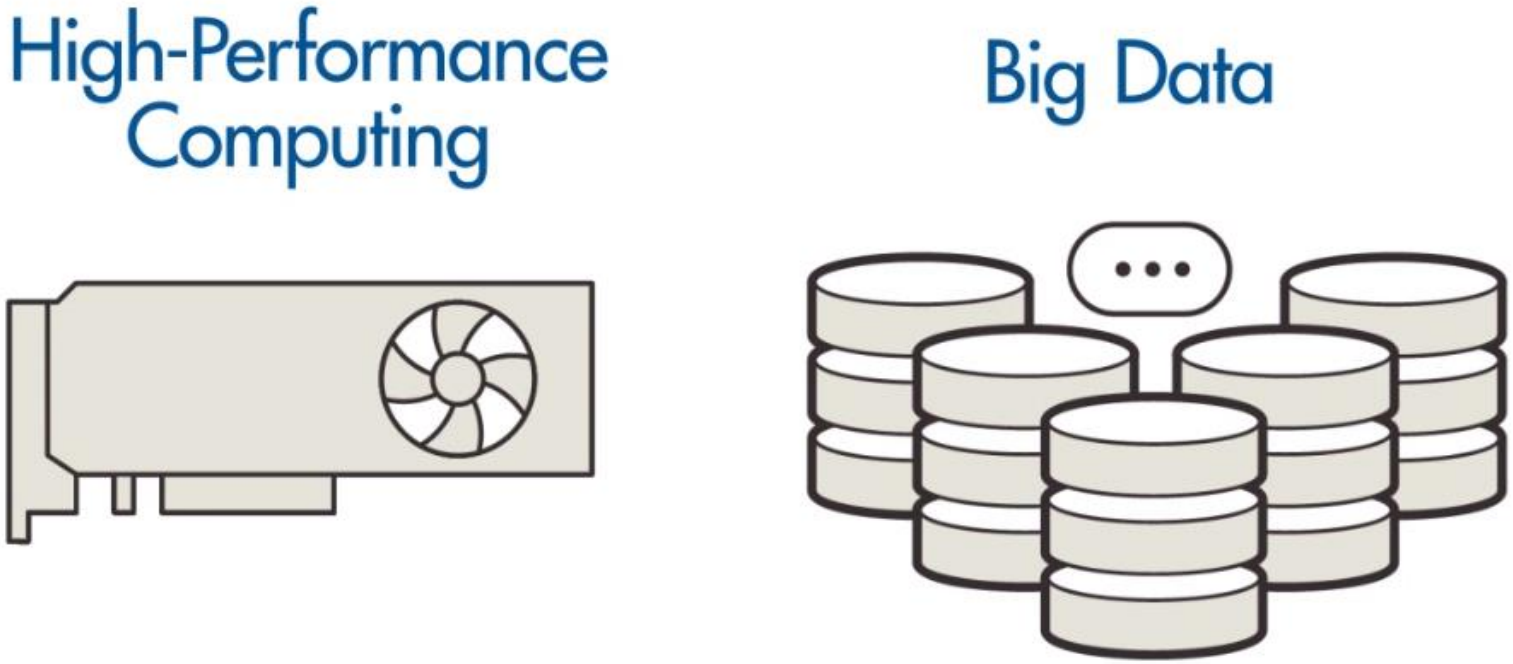
Why deep learning so popular now?

- Deep learning methods are now more accurate than people are at classifying images.



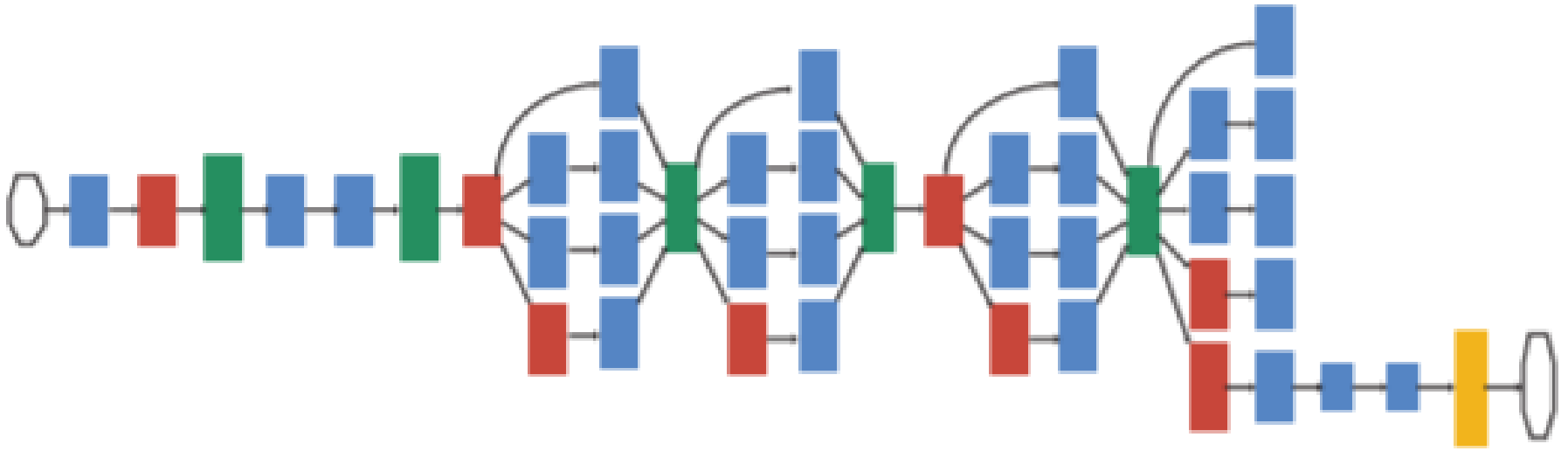
Source: ILSVRC Top-5 Error on ImageNet

- GPUs enable us to now train deep networks in less time.



- Large amounts of labeled data required for deep learning has become accessible over the last few years.

- Pretrained models built by experts



  - Alexnet, VGG16, VGG19, Squeezenet. Googlenet, Inceptionv3, Densenet201, Restnet18, Resnet50, Resent101, Inceptionrestnetv2

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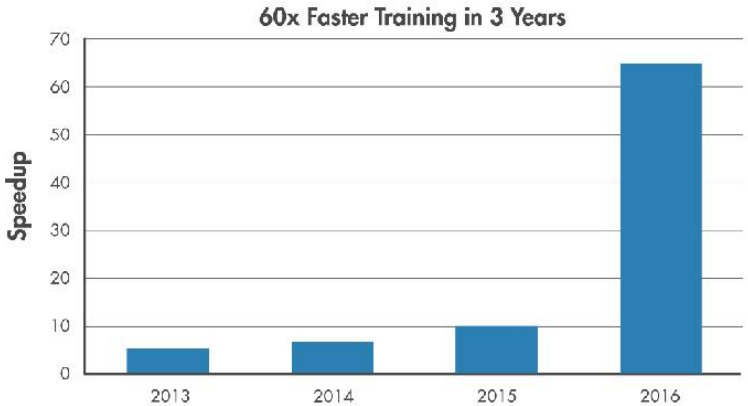
Deep Learning Enablers

- Increased GPU acceleration



- World-class models

AlexNet
PRETRAINED MODEL

VGG-16
PRETRAINED MODEL

ResNet-50
PRETRAINED MODEL

ONNX Converter
MODEL CONVERTER

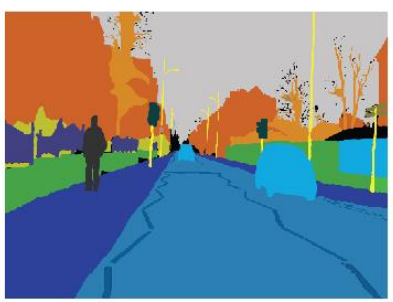
Caffe
IMPORTER

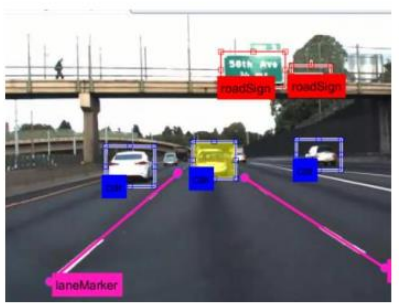
GoogLeNet
PRETRAINED MODEL

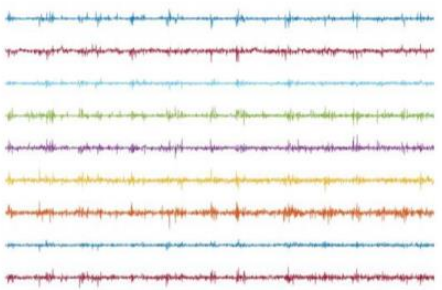
TensorFlow-Keras
IMPORTER

Inception-v3
MODELS

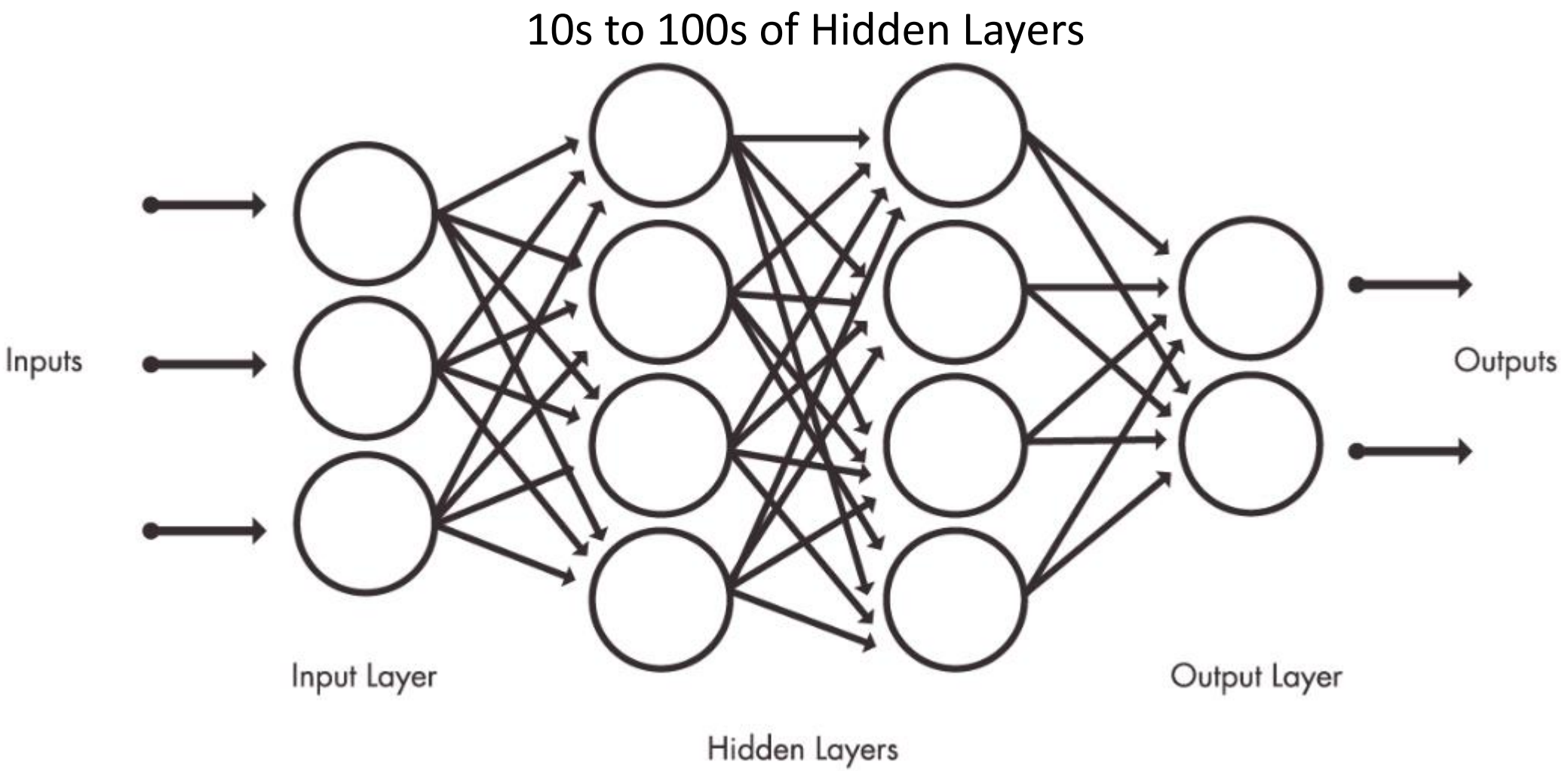
- Labeled public datasets



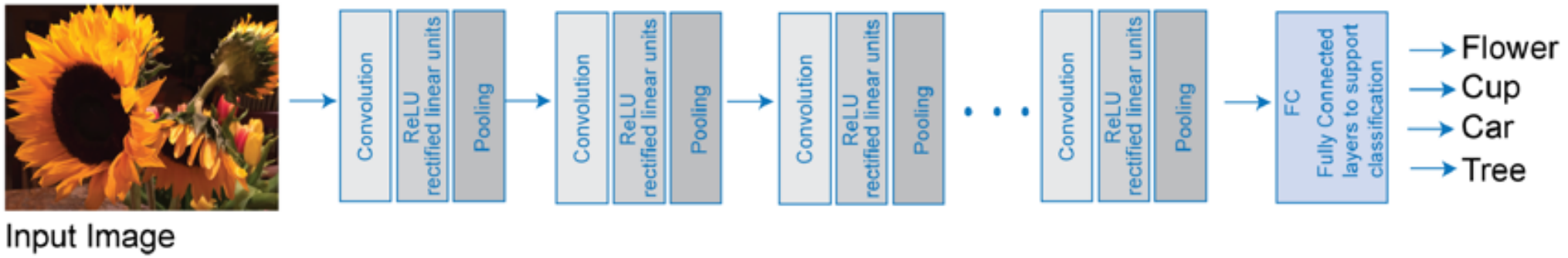




Inside a Deep Neural Network

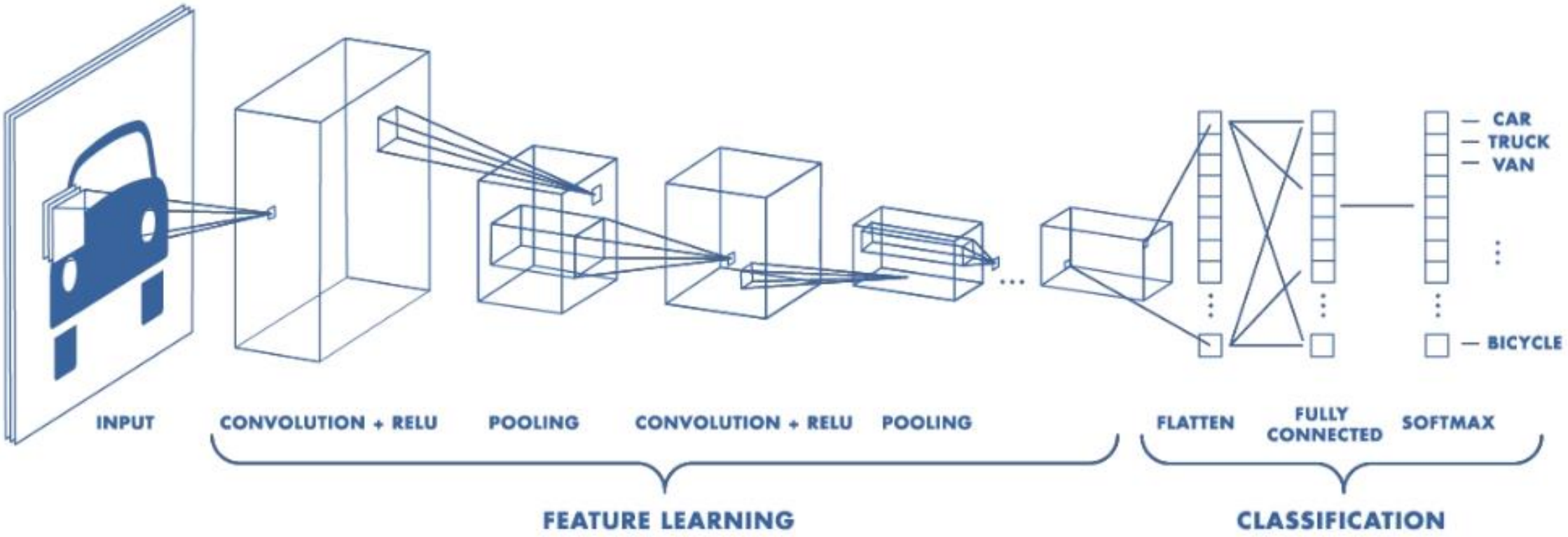


How A Deep Neural Network Learns

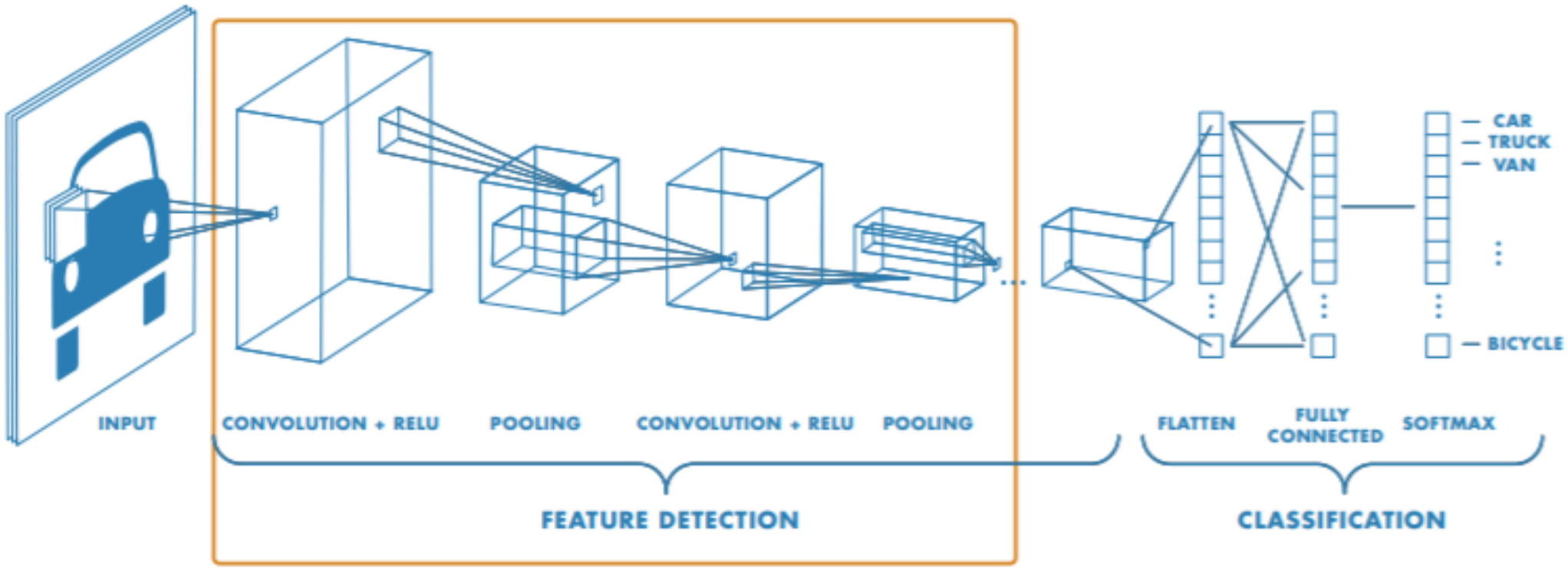


"Deep" in deep learning refers to number of layers

Convolutional Neural Network



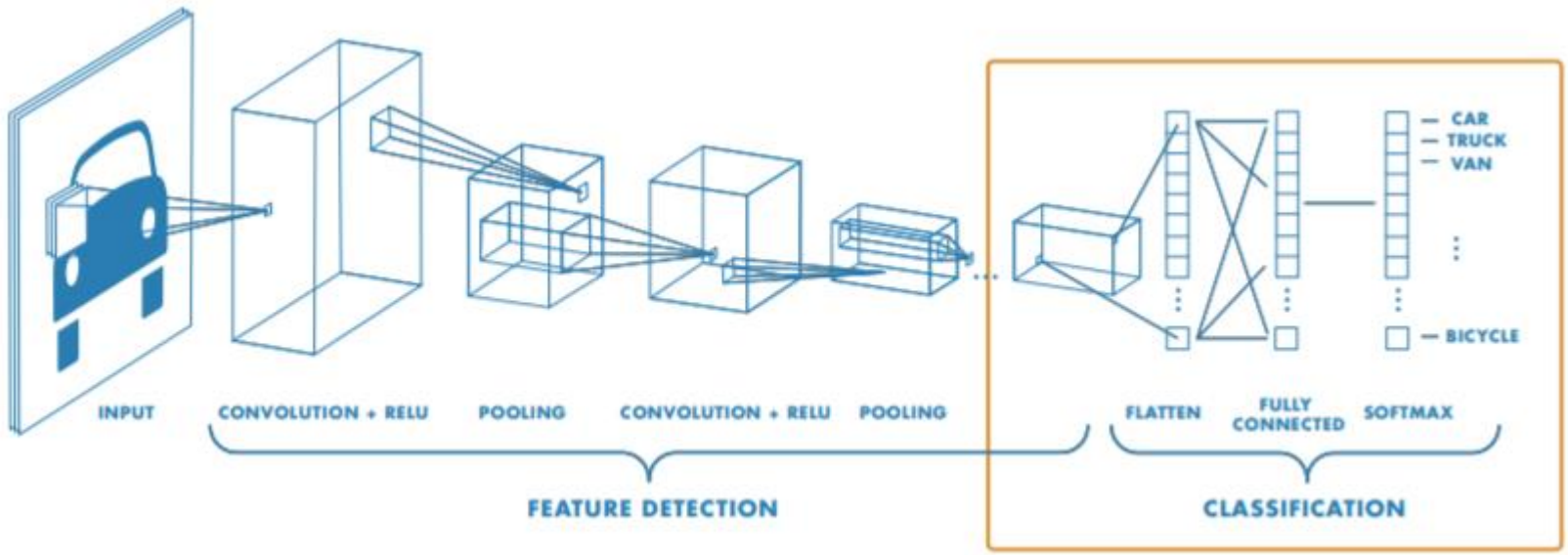
Feature Detection Layers



- These layers perform one of three types of operations on the data:
  - **convolution** puts the input images through a set of convolutional filters, each of which activates certain features from the images.
  - **Pooling** simplifies the output by performing nonlinear downsampling, reducing the number of parameters that the network needs to learn about.
  - **Rectified linear unit (ReLU)** allows for faster and more effective training by mapping negative values to zero and maintaining positive values.
- These three operations are repeated over tens or hundreds of layers, with each layer learning to detect different features.

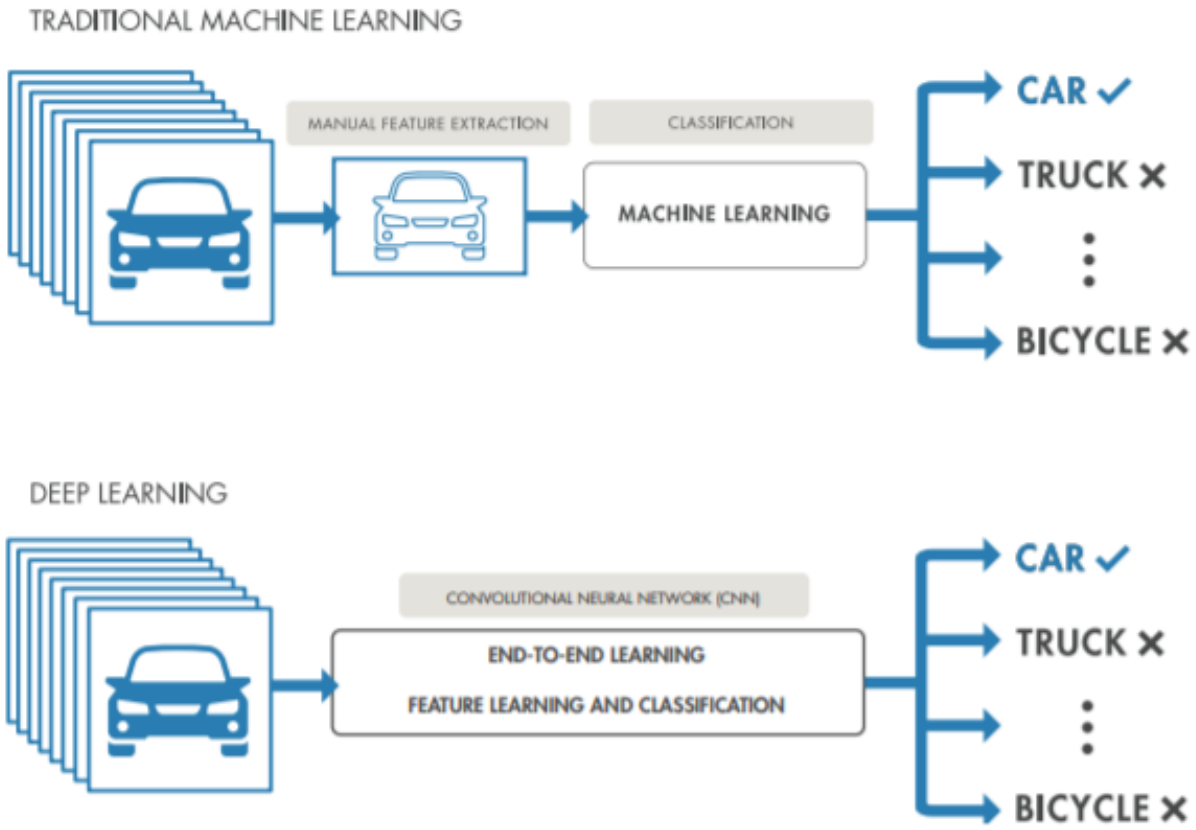
Classification Layers

There is no exact formula for selecting layers. The best approach is to try a few and see how well they work—or to use a pretrained network.



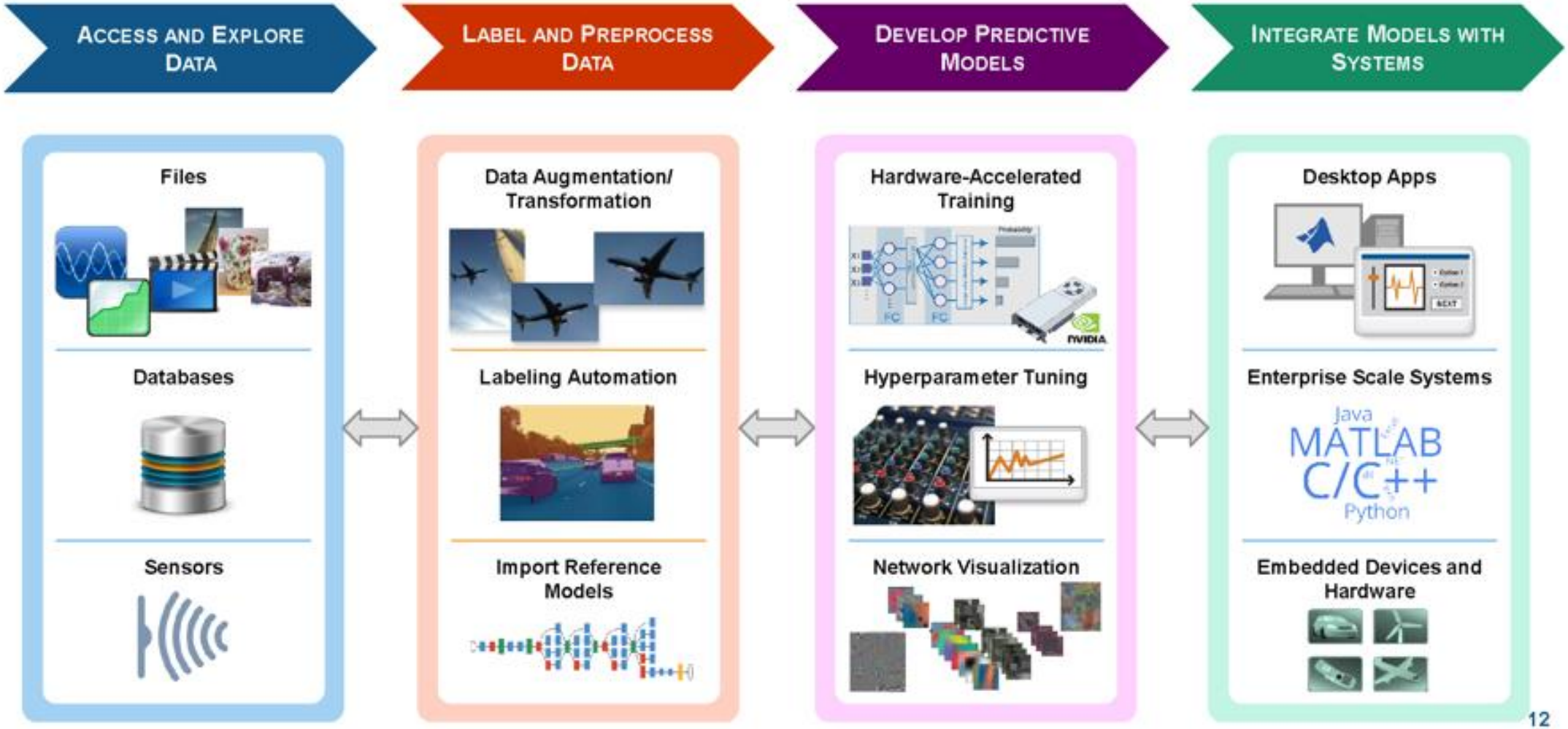
- The next-to-last layer is a **fully connected layer (FC)** that outputs a vector of K dimensions where K is the number of classes that the network will be able to predict. This vector contains the probabilities for each class of any image being classified.
- The final layer of the CNN architecture uses a **softmax** function to provide the classification output

What is the Difference Between Deep Learning and Machine Learning?



Machine Learning	Deep Learning
+ Good results with small data sets	— Requires very large data sets
+ Quick to train a model	— Computationally intensive
— Need to try different features and classifiers to achieve best results	+ Learns features and classifiers automatically
— Accuracy plateaus	+ Accuracy is unlimited

Deep Learning Workflow



AGENDA

- Demystifying Deep Learning: A practical approach in MATLAB
  - Manage extremely large sets of images
  - Perform classification and pixel-level semantic segmentation on images
  - Import training data sets from networks such as GoogLeNet, ResNet and VGG16
  - Visualize networks and gain insight into the black box nature of deep networks
  - Import and use pre-trained models from TensorFlow and Caffe
  - Speed up network training with parallel computing on a cluster
  - Automate manual effort required to label ground truth

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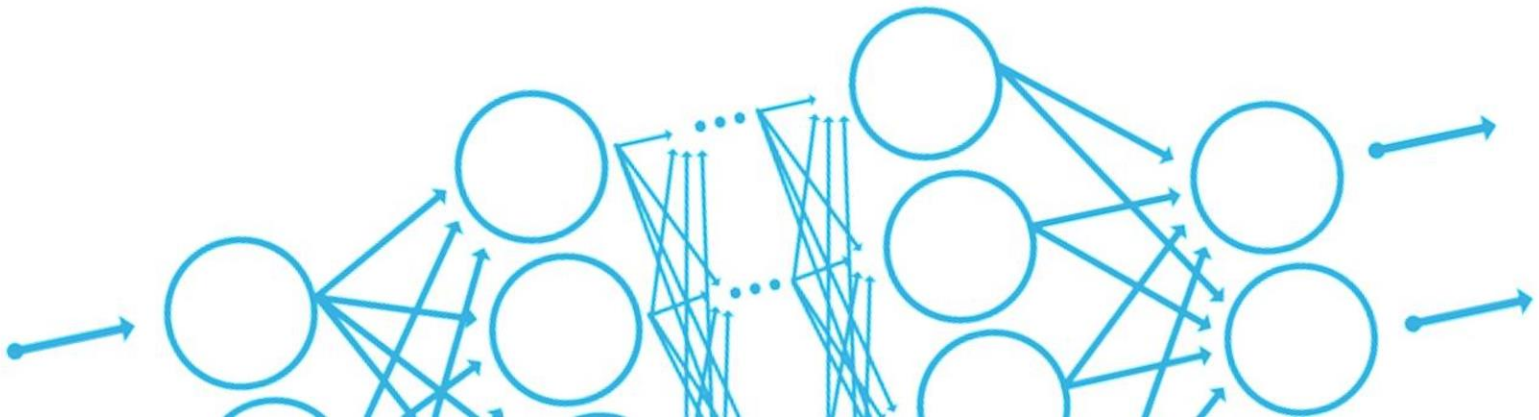
What is semantic segmentation?



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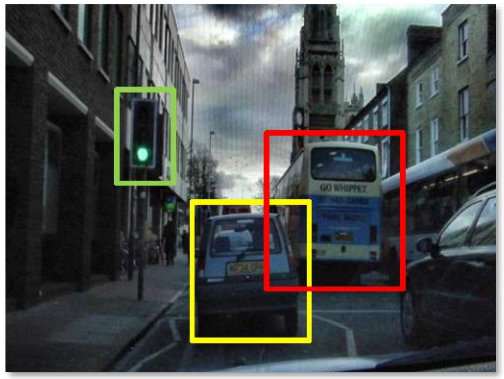
Original Image

ROI detection



Pixel classification

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Semantic Segmentation

CamVid Dataset

1. Segmentation and Recognition Using Structure from Motion Point Clouds, ECCV 2008
2. Semantic Object Classes in Video: A High-Definition Ground Truth Database ,Pattern Recognition Letters

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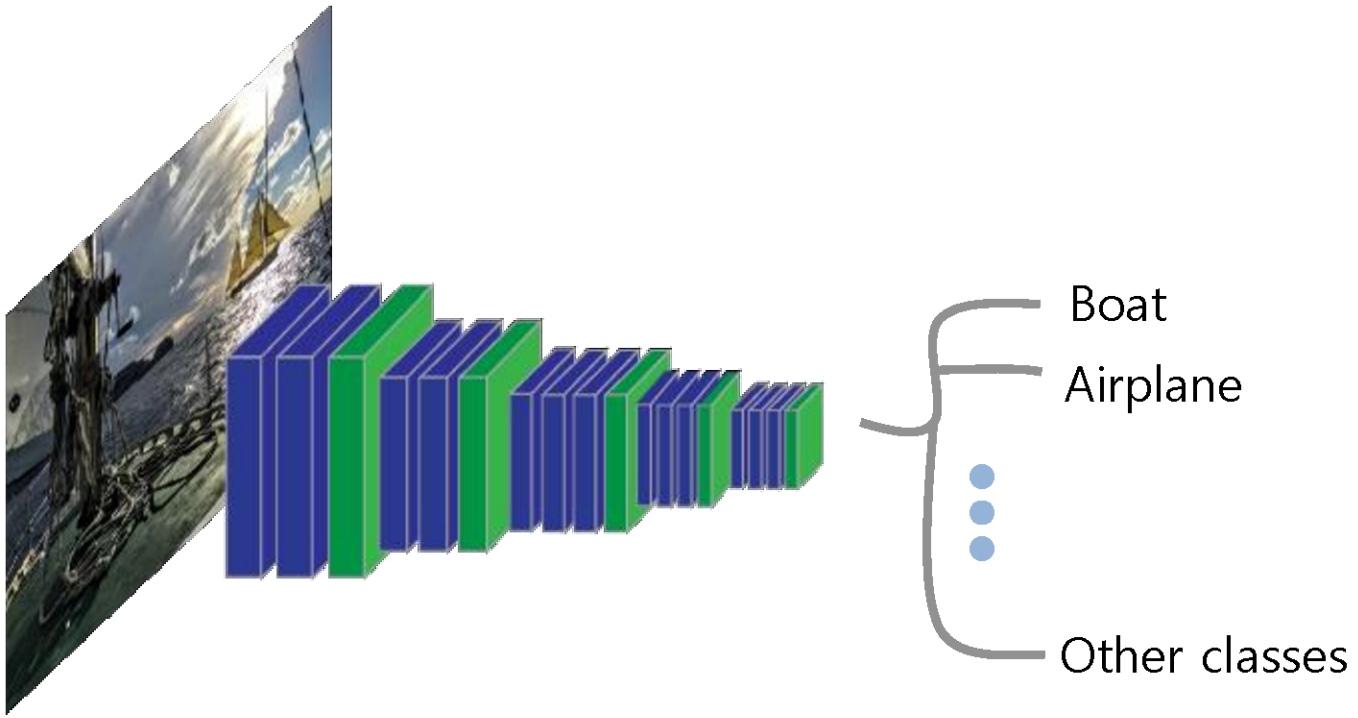
Semantic Segmentation Network



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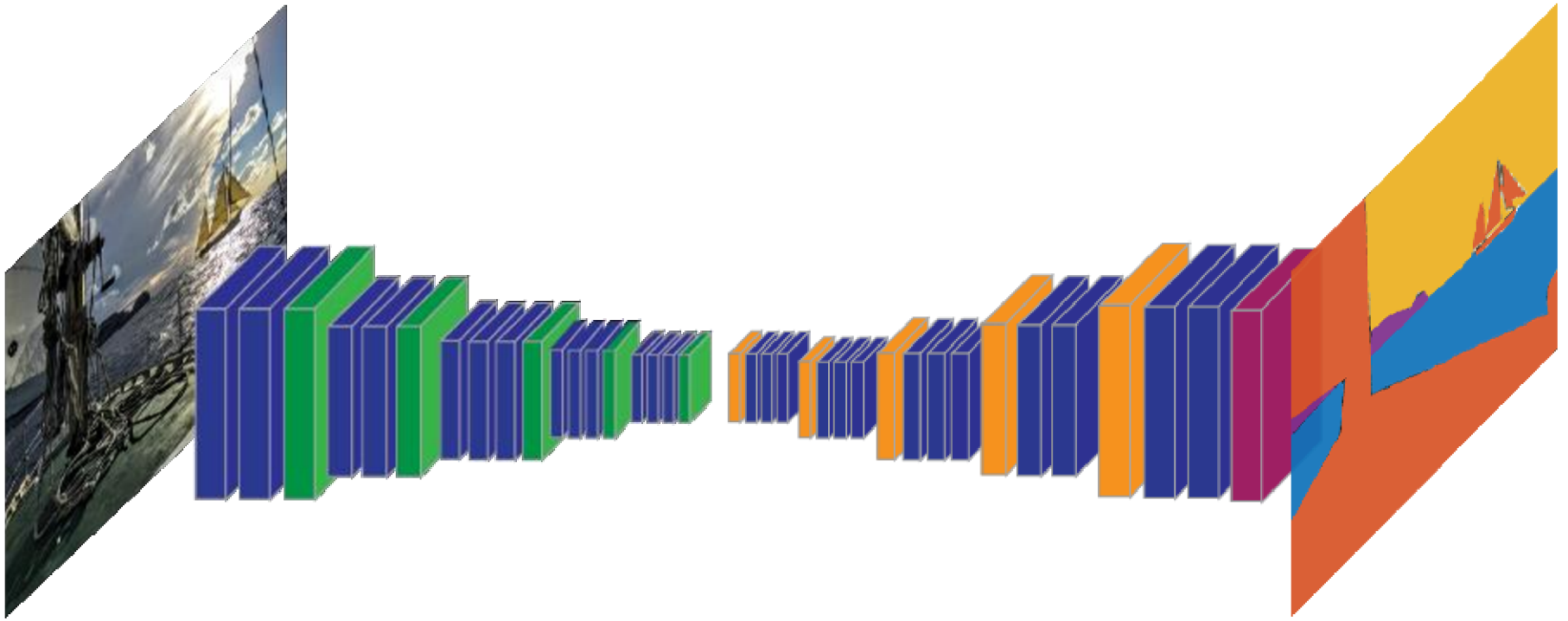
Semantic Segmentation Network



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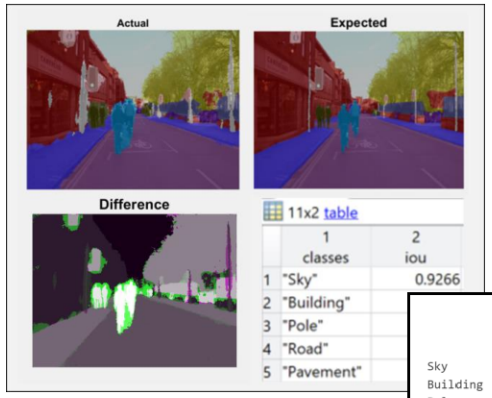
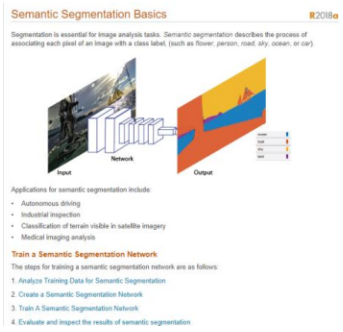
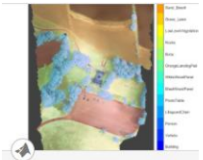
Useful Tools for Semantic Segmentation

- **Automatically create network structures**
  - Using `segnetLayers` and `fcnLayers`
- **Handle pixel labels**
  - Using the `pixelLabelImageDatastore` and `pixelLabelDatastore`
- **Evaluate network performance**
  - Using `evaluateSemanticSegmentation`
- **Examples and tutorials to learn concepts**



	Accuracy	IoU	MeanBFScore
Sky	0.93544	0.89279	0.88239
Building	0.79978	0.75543	0.59861
Pole	0.73166	0.18361	0.51426
Road	0.93644	0.90663	0.7086
Pavement	0.90624	0.72932	0.70585
Tree	0.86587	0.73694	0.67097
SignSymbol	0.76118	0.35339	0.44175
Fence	0.83258	0.49648	0.50265
Car	0.90961	0.75263	0.64837
Pedestrian	0.83751	0.35409	0.46796
Bicyclist	0.84156	0.5472	0.46933





Semantic Segmentation of Multispectral Images Using Deep Learning

Train a U-Net convolutional neural network to perform semantic segmentation of a multispectral image with seven channels: three

Transfer Learning with CNNs

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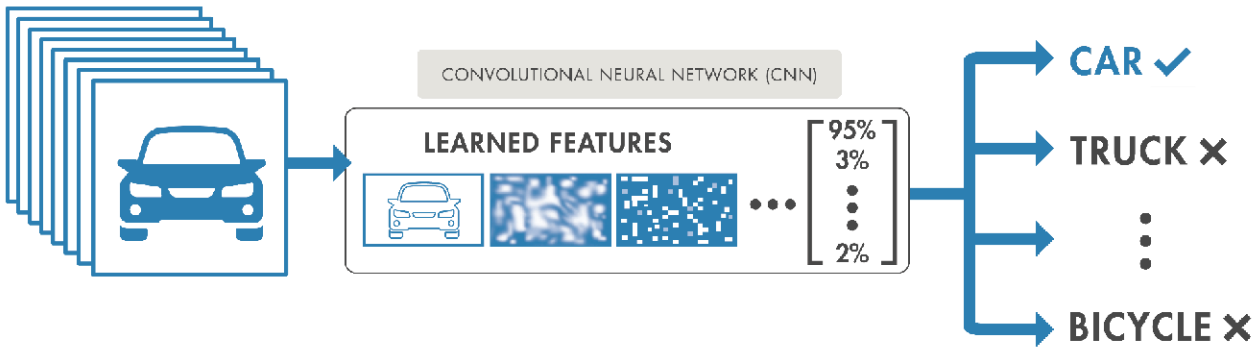
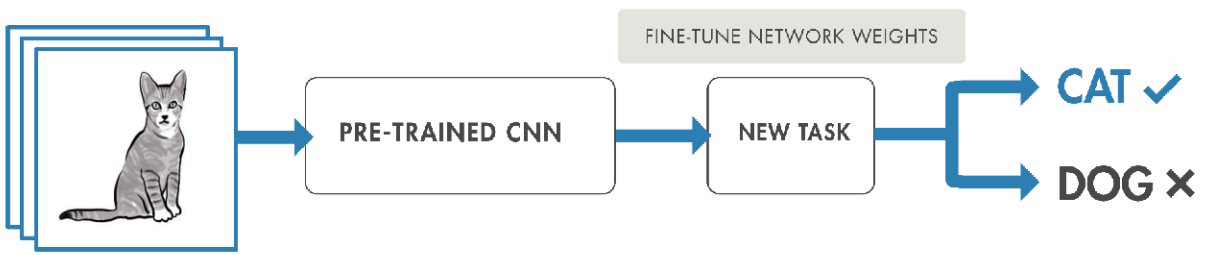
Two Approaches for Deep Learning

1. Train a Deep Neural Network from Scratch



2. Fine-tune a pre-trained model (transfer learning)



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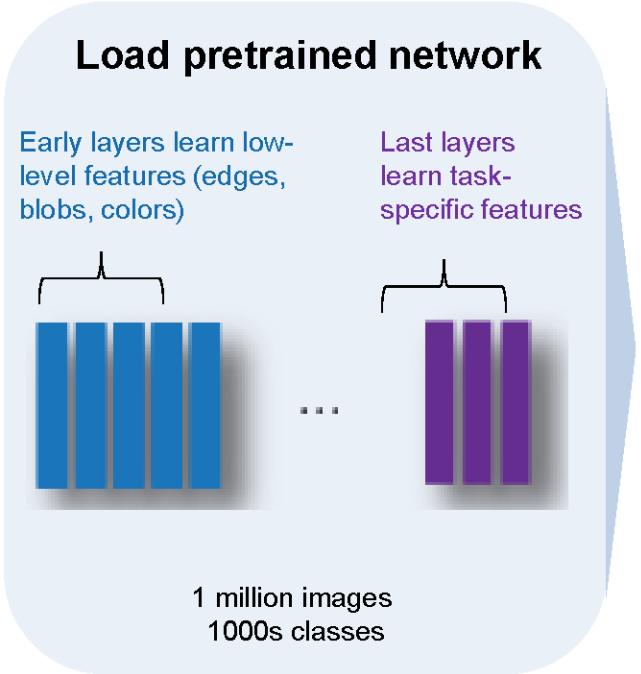
Transfer Learning Workflow



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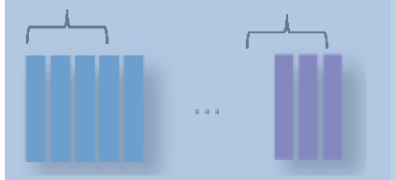
Transfer Learning Workflow

Load pretrained network

Early layers that learned low-level features (edges, blobs, colors)

Last layers that learned task specific features



1 million images
1000s classes

Replace final layers

New layers learn features specific to your data

Fewer classes
Learn faster

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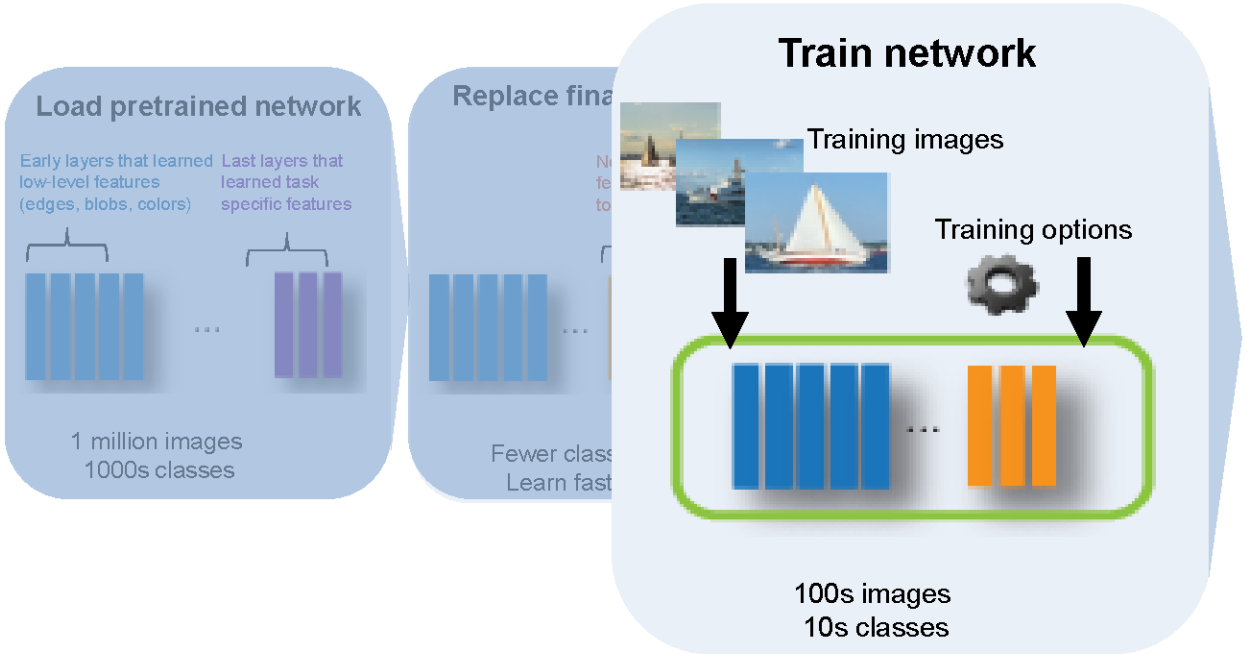
Transfer Learning Workflow



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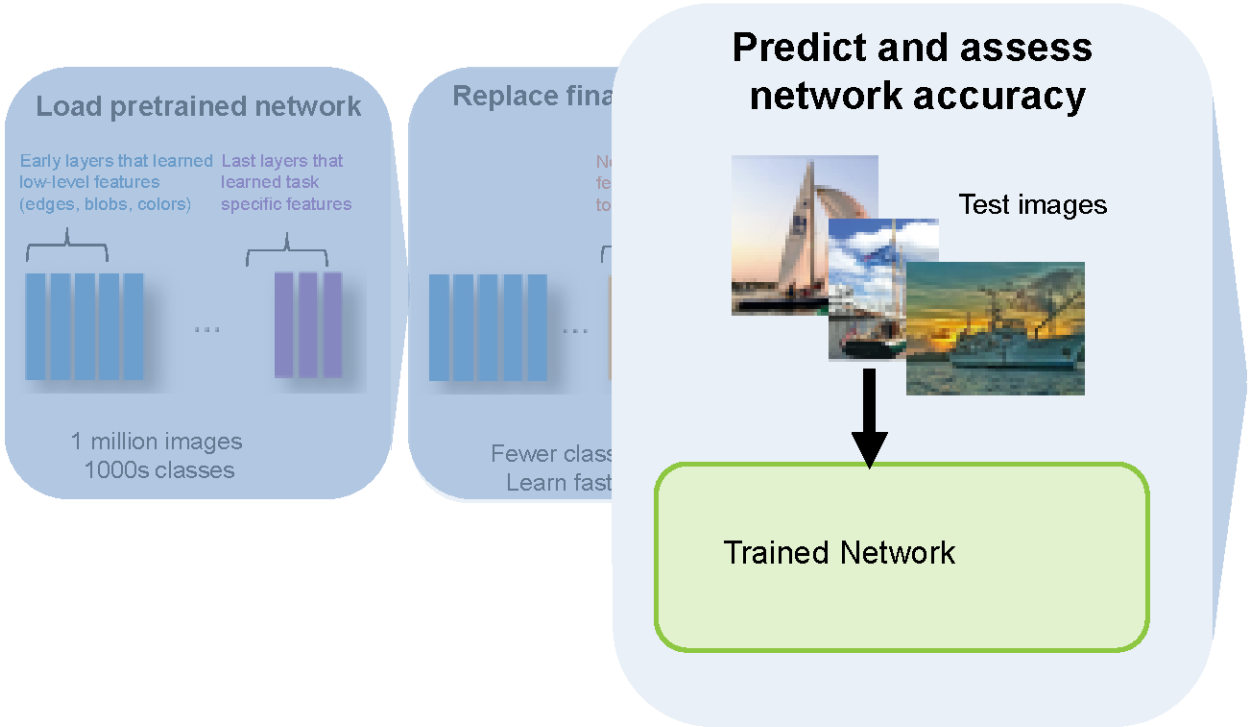
Transfer Learning Workflow



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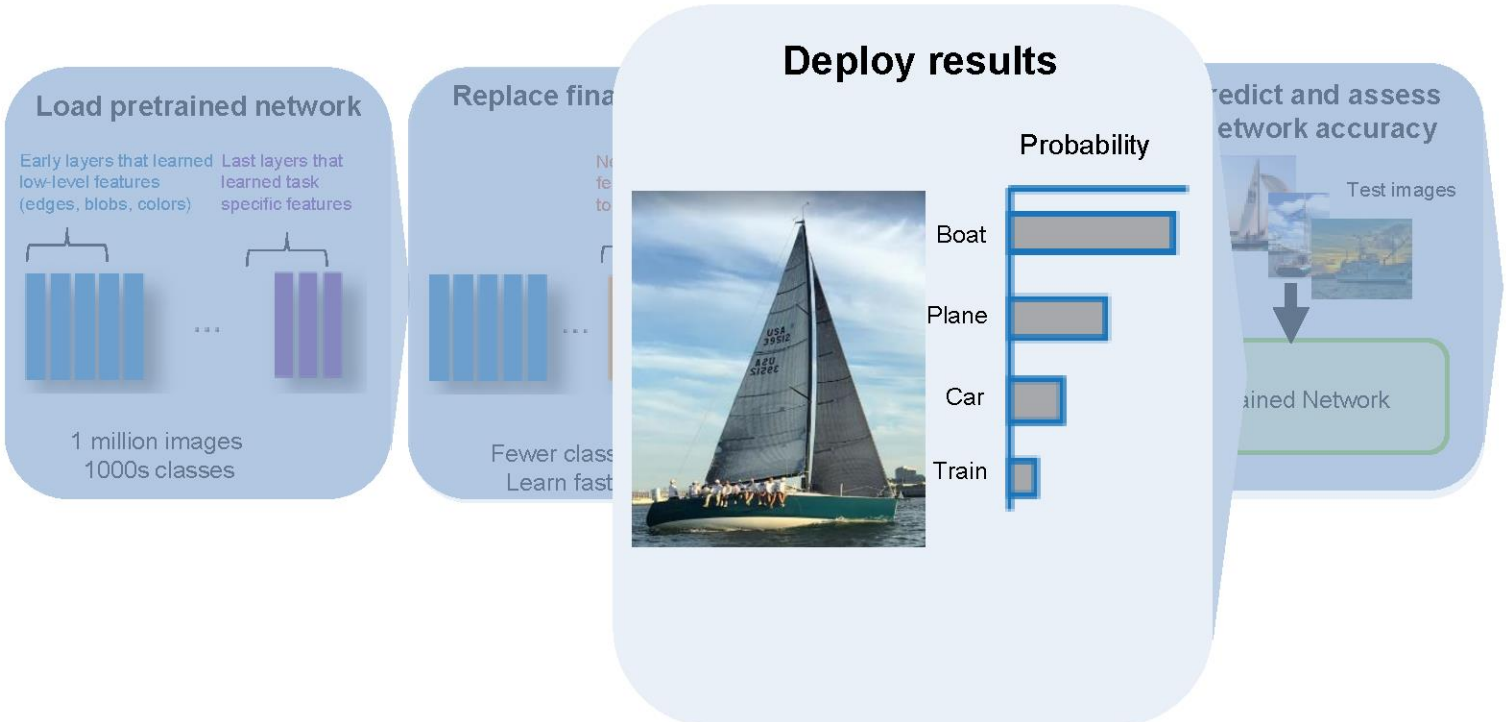
Transfer Learning Workflow



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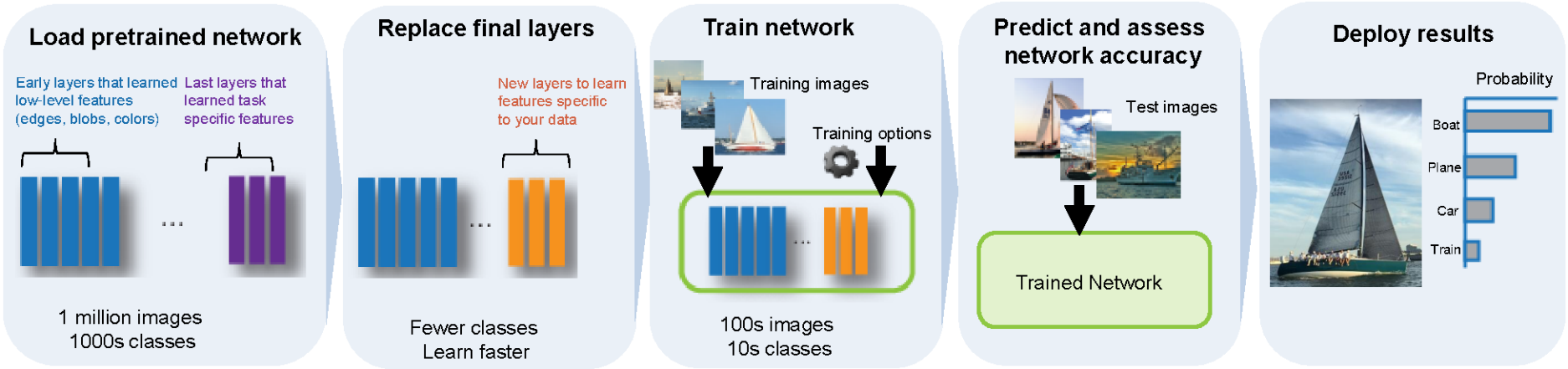
Transfer Learning Workflow



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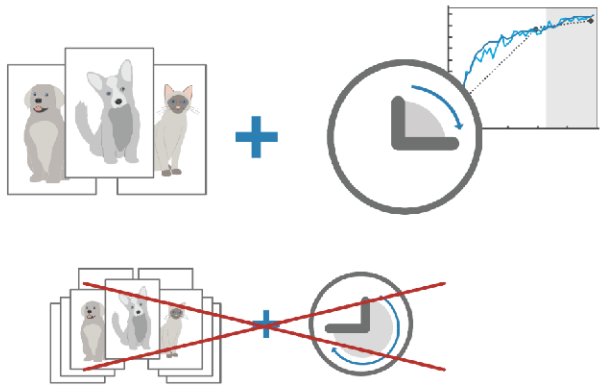
Why Perform Transfer Learning

- Requires less data and training time
- Reference models (like AlexNet, VGG-16, VGG-19, Inception-v3) are great feature extractors
- Leverage best network types from top researchers
  (list of all models)



AlexNet
PRETRAINED MODEL

VGG-16
PRETRAINED MODEL

ResNet-50
PRETRAINED MODEL

ONNX Converter
MODEL CONVERTER

Caffe
IMPORTER

GoogLeNet
PRETRAINED MODEL

TensorFlow-Keras
IMPORTER

Inception-v3
MODELS

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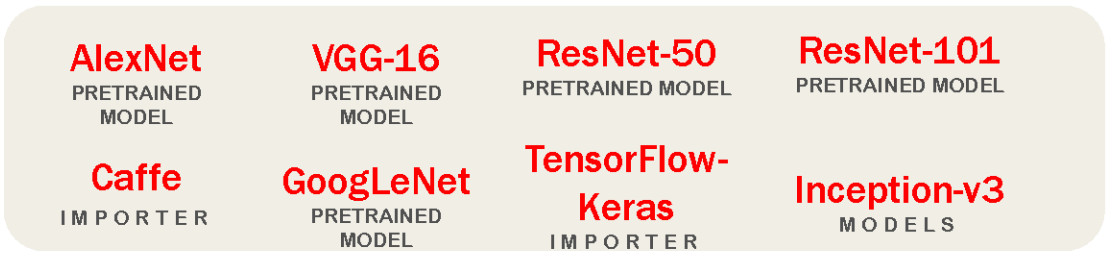
Import the Latest Models for Transfer Learning

Pretrained Models*

- AlexNet
- VGG-16
- VGG-19
- GoogLeNet
- Inception-v3
- ResNet-18
- ResNet-50
- ResNet-101
- Inception-resnet-v2
- SqueezeNet
- DenseNet-201

Import Models from Frameworks

- Caffe Model Importer
- TensorFlow-Keras Model Importer
- ONNX Converter (Import and Export)



* single line of code to access model

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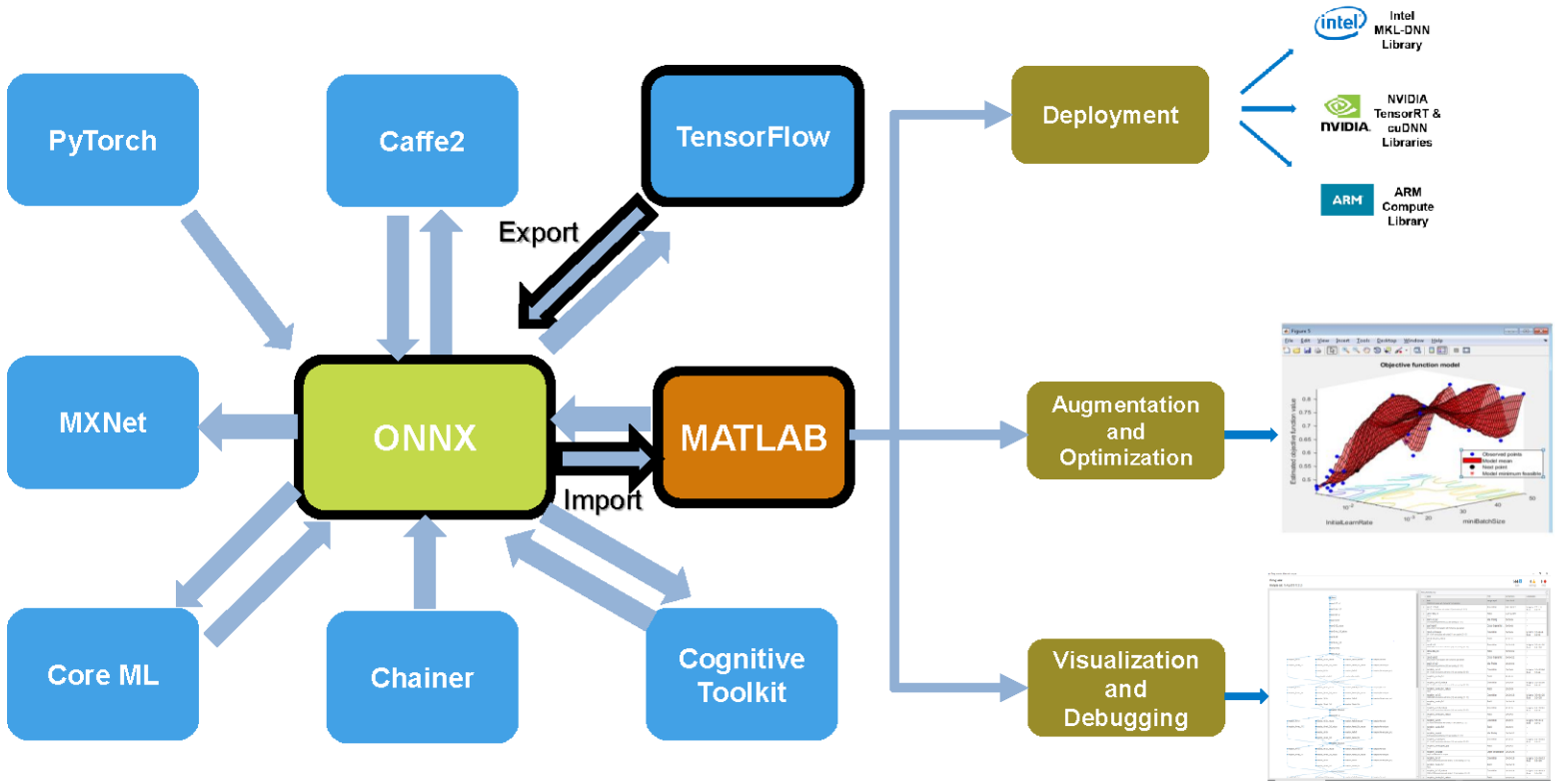
Integration with Other Frameworks



AGENDA

- Demystifying Deep Learning: A practical approach in MATLAB
  - Manage extremely large sets of images
  - Perform classification and pixel-level semantic segmentation on images
  - Import training data sets from networks such as GoogLeNet, ResNet and VGG16
  - Visualize networks and gain insight into the black box nature of deep networks
  - Import and use pre-trained models from TensorFlow and Caffe
  - Speed up network training with parallel computing on a cluster
  - Automate manual effort required to label ground truth

“I love to label and preprocess my data”

~ Said no engineer, ever.

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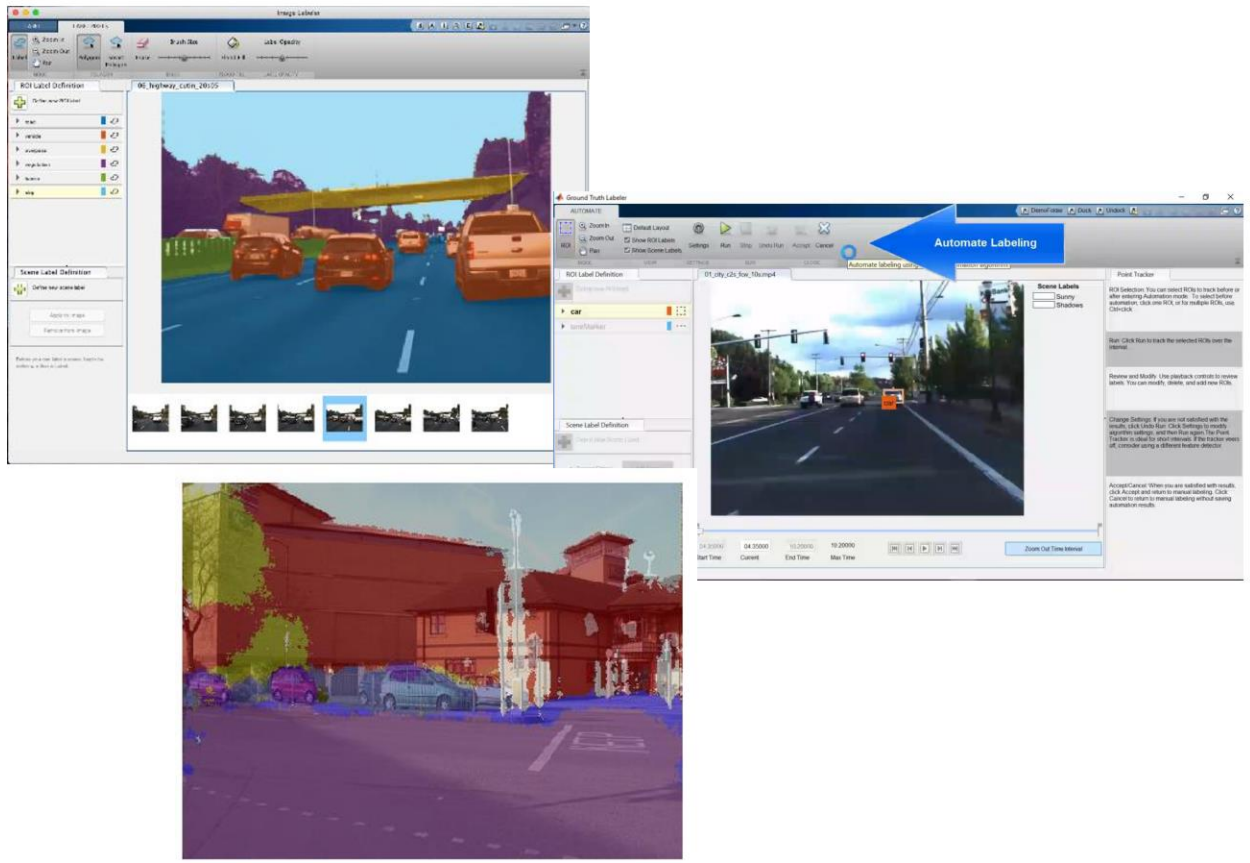
Ground truth Labeling

"How do I *label* my data?"

New App for Ground Truth Labeling

Label pixels and regions for semantic segmentation



Data

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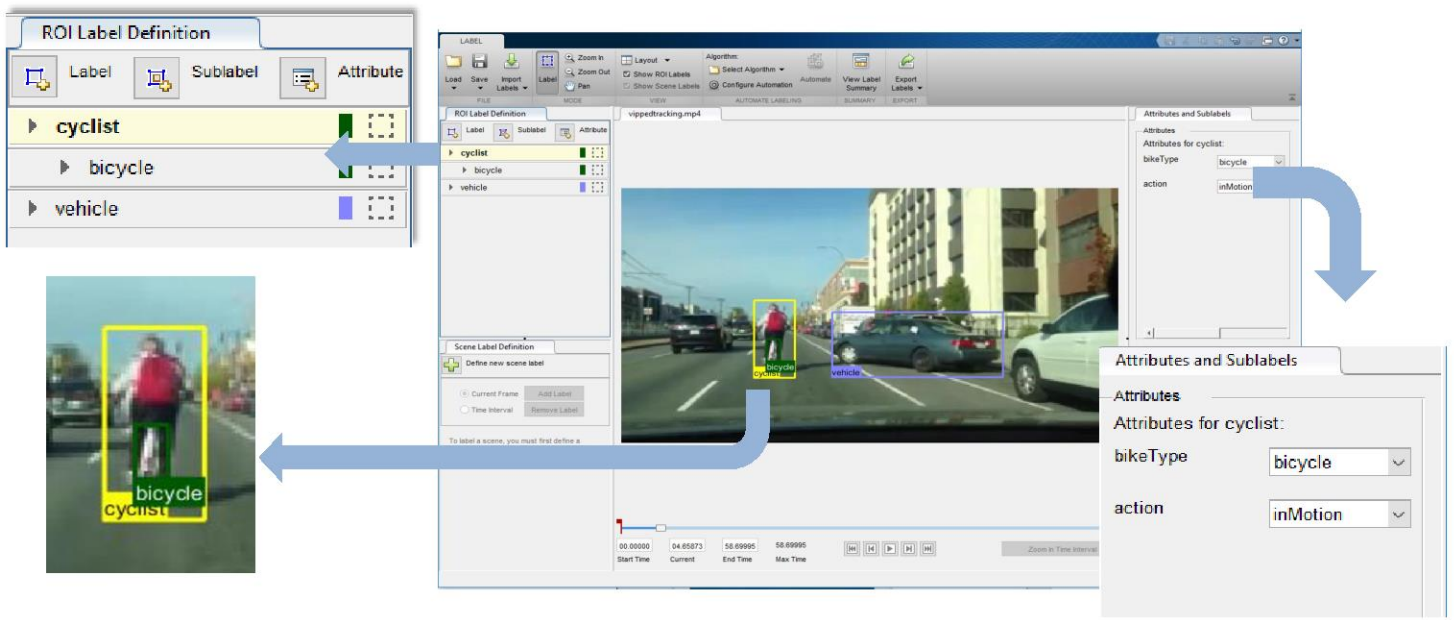
Attributes and Sublabels

NEW in R2018a



Deep Learning for Image Classification From Scratch

Background
Configure Example Settings
Download and Prepare the Data Set
Explore a Few Images
Classify an Example Image
Not Sure Where to Start? Check the Documentation!
Prepare the CNN
Deep Network Designer
Attempt 1: Set Training Options and Train Network
Attempt 2: Change the Learning Rate
Evaluate Accuracy
Attempt 3: Change the Network Architecture
Evaluate Accuracy
(Optional Aside) Why Change Learning Rate?
Demonstration Summary

Demonstration Summary

This demo introduced the following ideas:

- Creating and training a CNN from scratch
- Adjusting training options (hyperparameters)
- Evaluating network accuracy

Anything else in Deep Learning…

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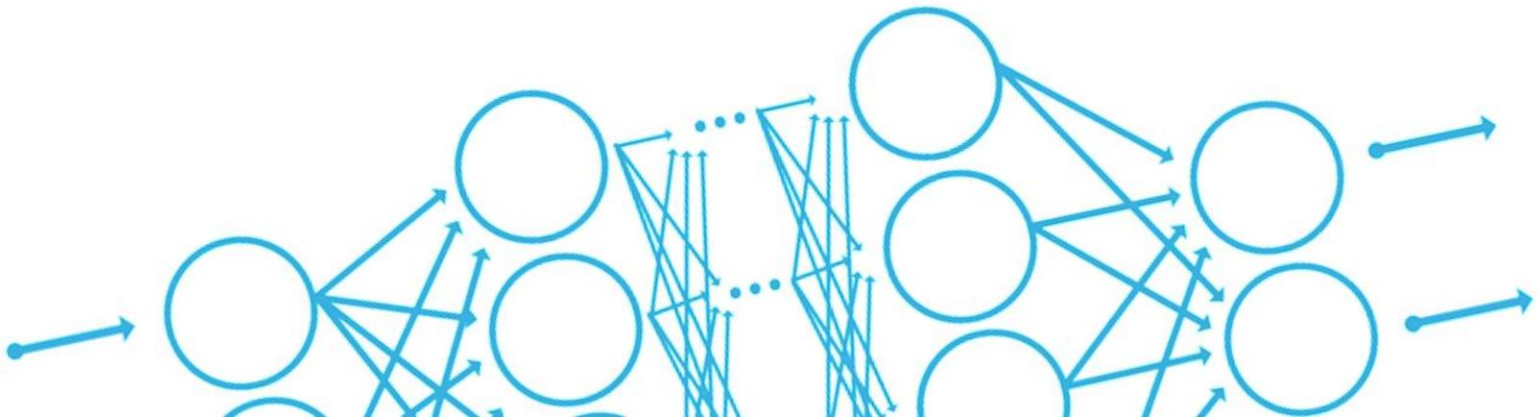
Training Performance and Scalability



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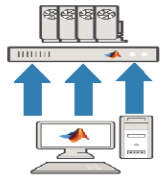
Deep Learning on CPU, GPU, Multi-GPU and Clusters

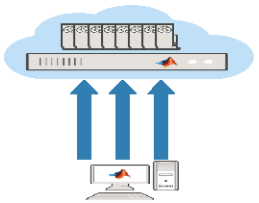
Single CPU

Single CPU
Single GPU

Single CPU, Multiple GPUs



On-prem server with GPUs



Cloud GPUs (AWS)

HOW TO TARGET?

```
opts = trainingOptions('sgdm', ...
    'MaxEpochs', 100, ...
    'MiniBatchSize', 250, ...
    'InitialLearnRate', 0.00005, ...
'ExecutionEnvironment', 'auto' );
```

```
opts = trainingOptions('sgdm', ...
    'MaxEpochs', 100, ...
    'MiniBatchSize', 250, ...
    'InitialLearnRate', 0.00005, ...
'ExecutionEnvironment', 'multi-gpu' );
```

```
opts = trainingOptions('sgdm', ...
    'MaxEpochs', 100, ...
    'MiniBatchSize', 250, ...
    'InitialLearnRate', 0.00005, ...
'ExecutionEnvironment', 'parallel' );
```

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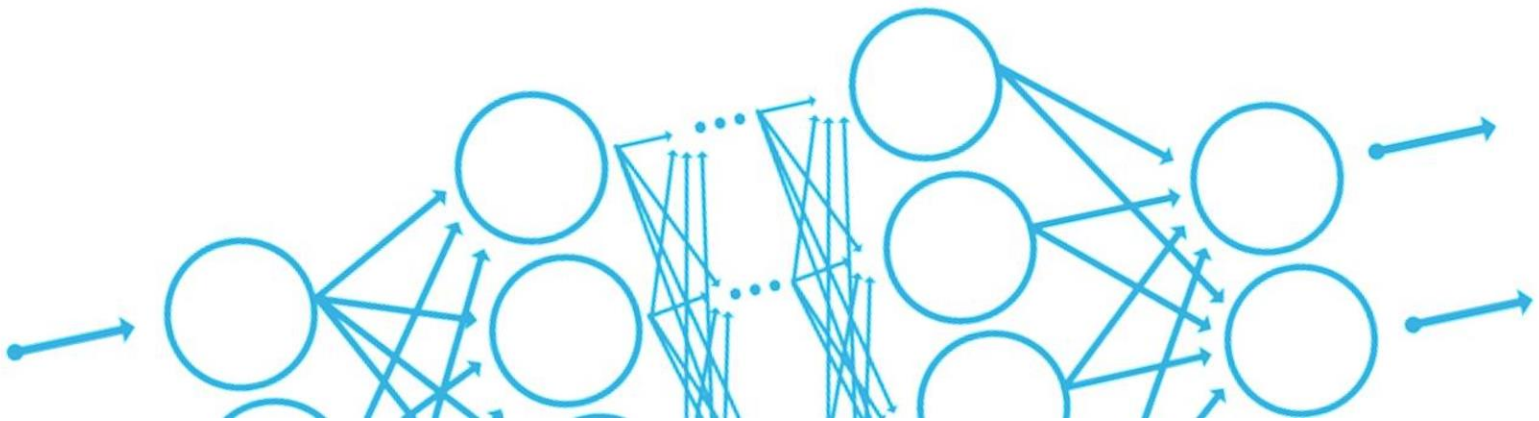
Inference Performance and Deployment



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Using Coder Products with Deep Learning

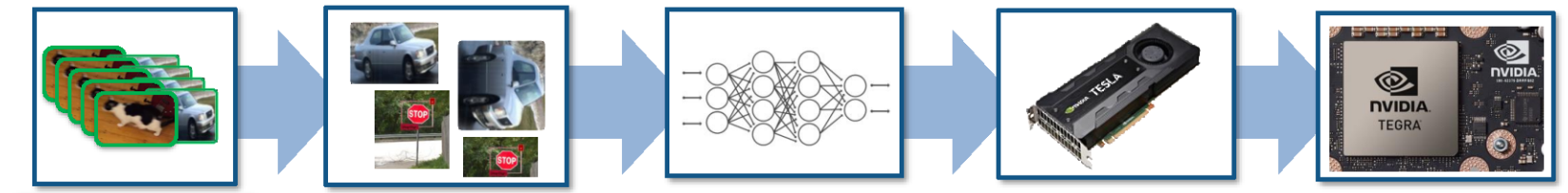

Image Acquisition Toolbox

Image Processing Toolbox

Computer Vision System Toolbox

Deep Learning Toolbox

Parallel Computing Toolbox

Coder Products

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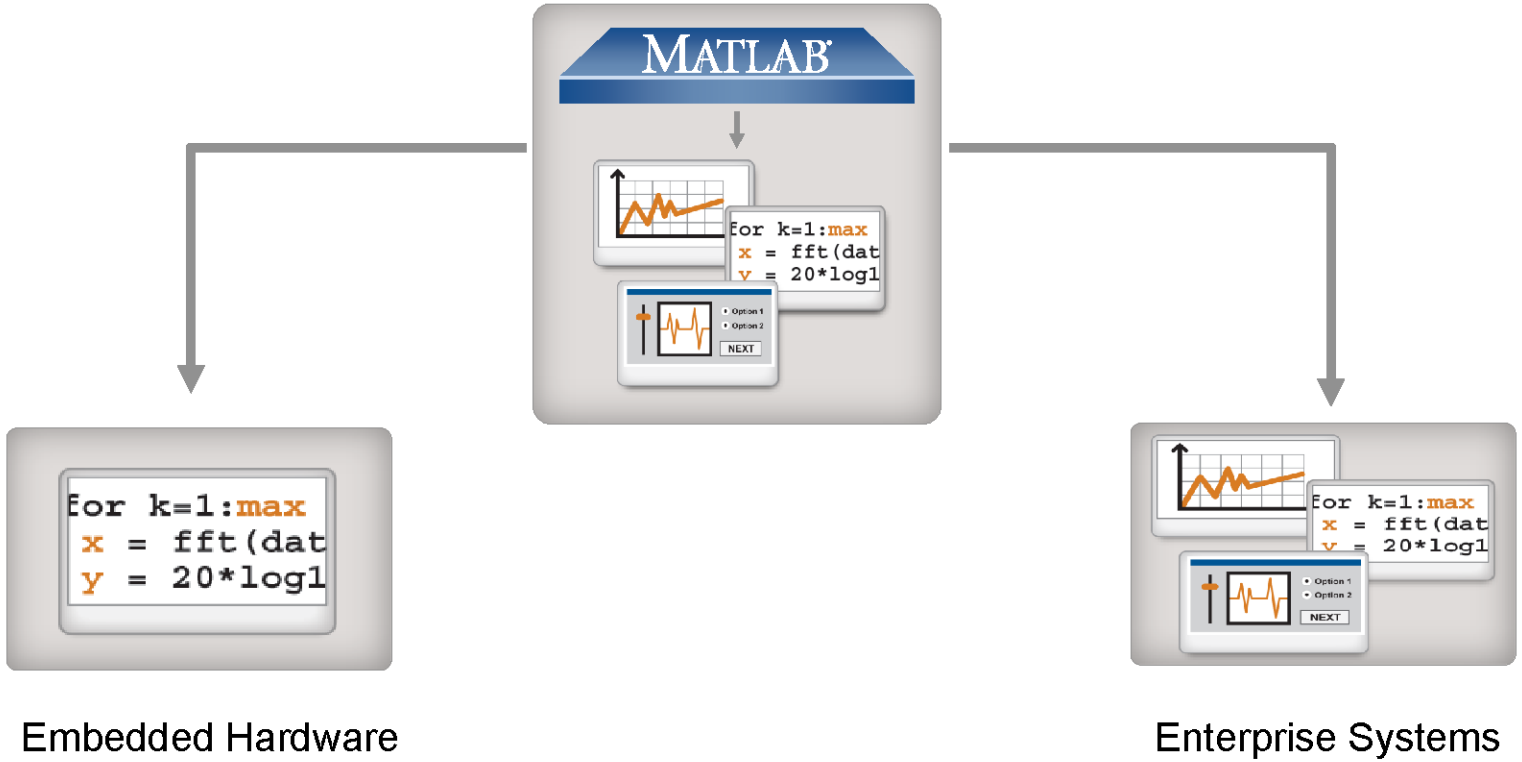
Integrate Deep Learning within Systems



Embedded Hardware

Enterprise Systems

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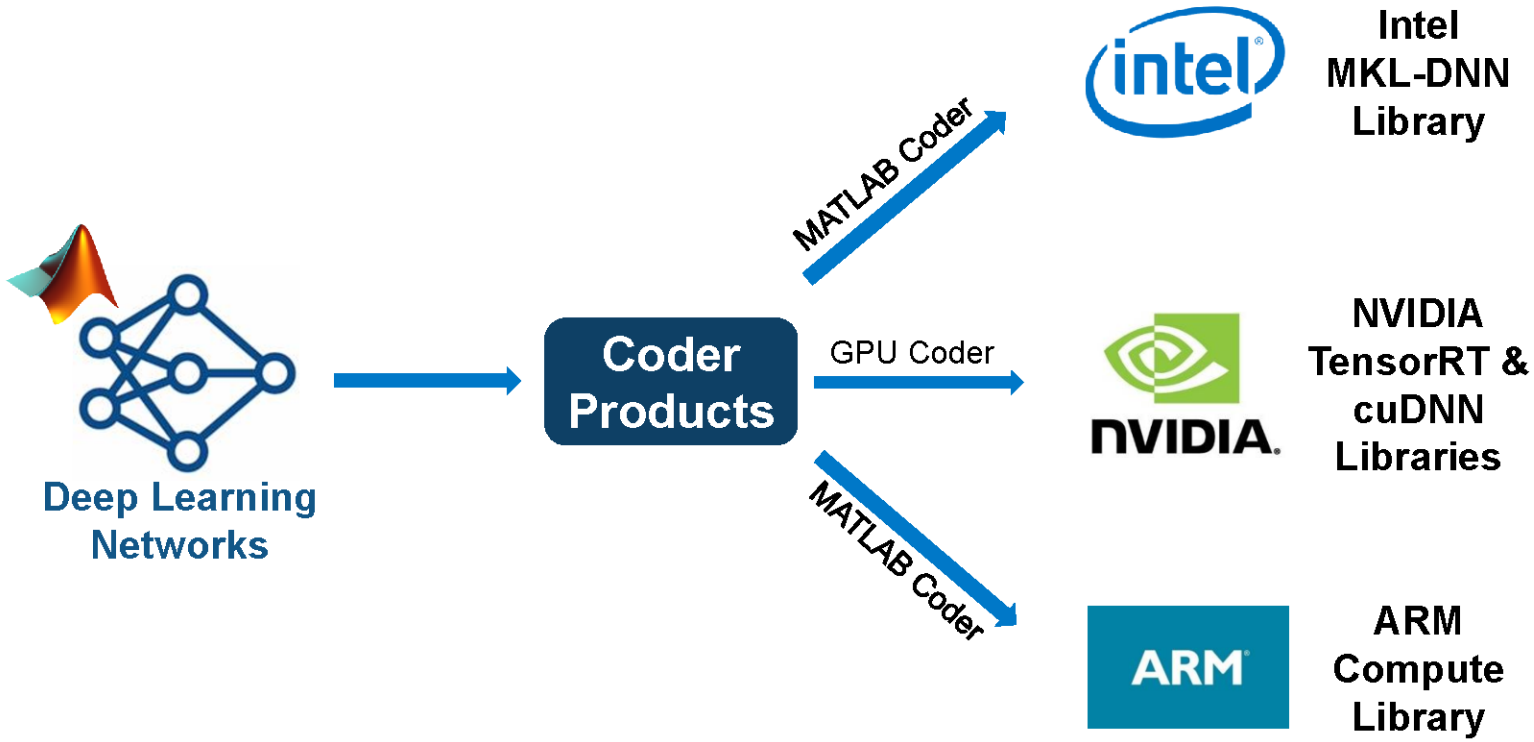
Deploying Deep Learning Models for Inference



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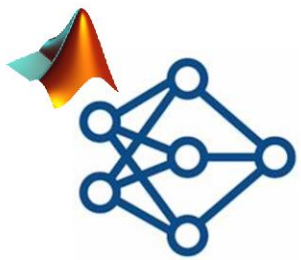
R2018a

Deploying to Various Targets



Deep Learning Networks

Coder Products

MATLAB Coder

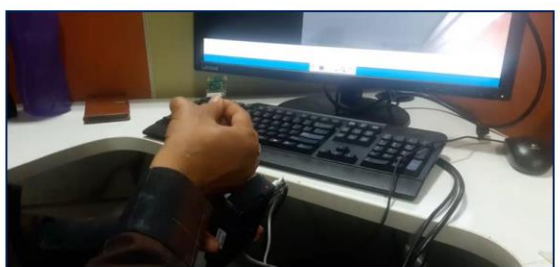
Desktop CPU

GPU Coder

NVIDIA

NVIDIA TensorRT & cuDNN Libraries

MATLAB Coder



Raspberry Pi board

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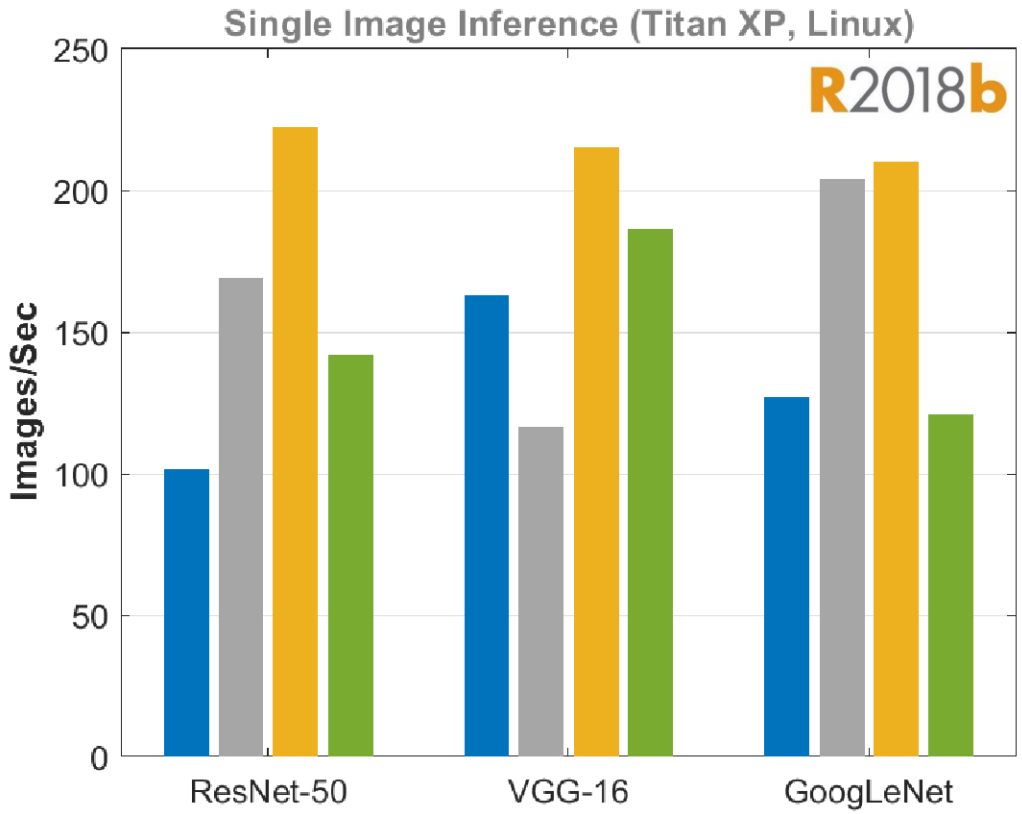
With GPU Coder, MATLAB is fast



Faster than TensorFlow,
MXNet, and PyTorch

Intel® Xeon® CPU 3.6 GHz - NVIDIA libraries: CUDA9 - cuDNN 7 - Frameworks: TensorFlow 1.8.0, MXNet 1.2.1, PyTorch 0.3.1

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Semantic Segmentation

Running in MATLAB

Generated Code from GPU Coder

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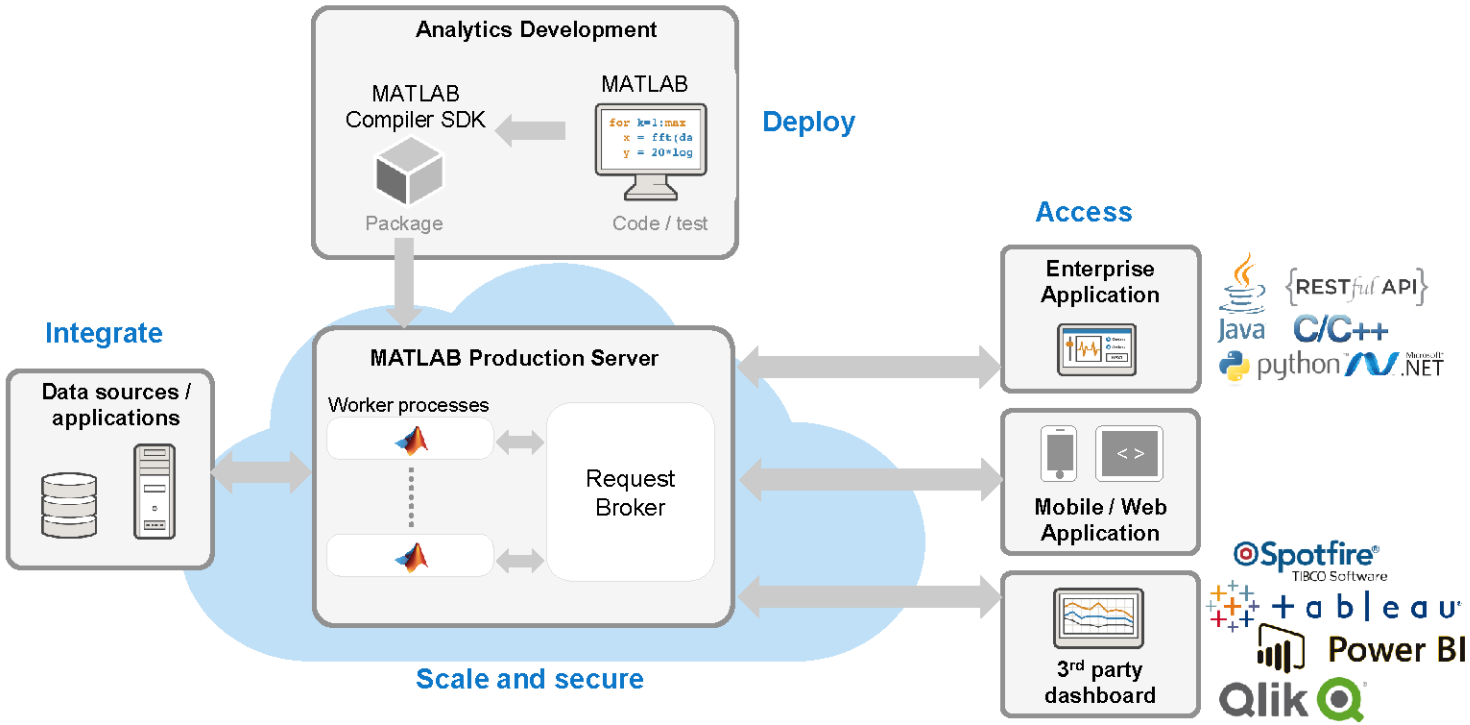
MATLAB Production Server is an application server that publishes MATLAB code as APIs that can be called by other applications



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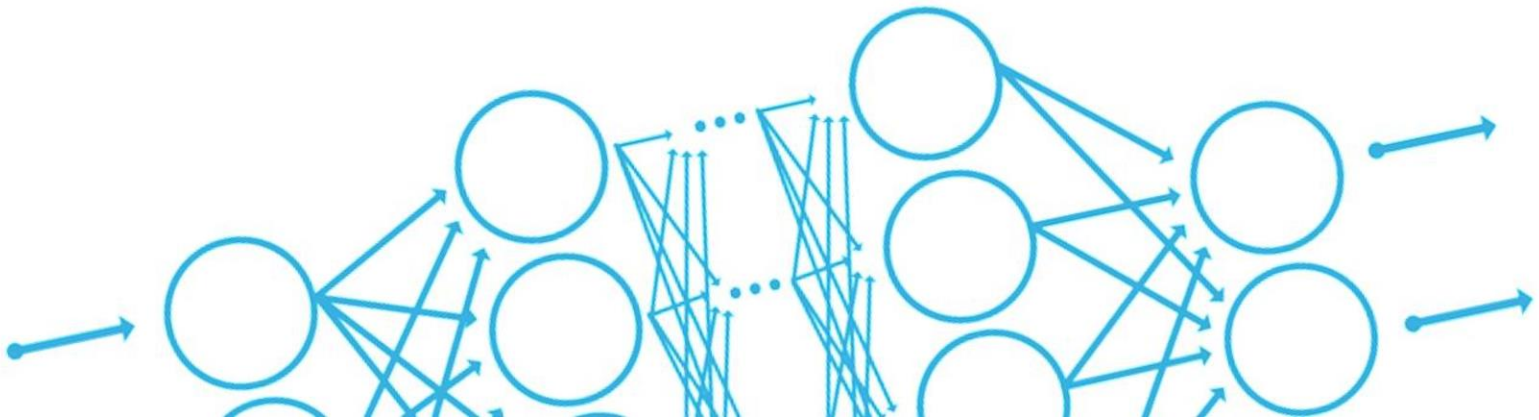
Other Features



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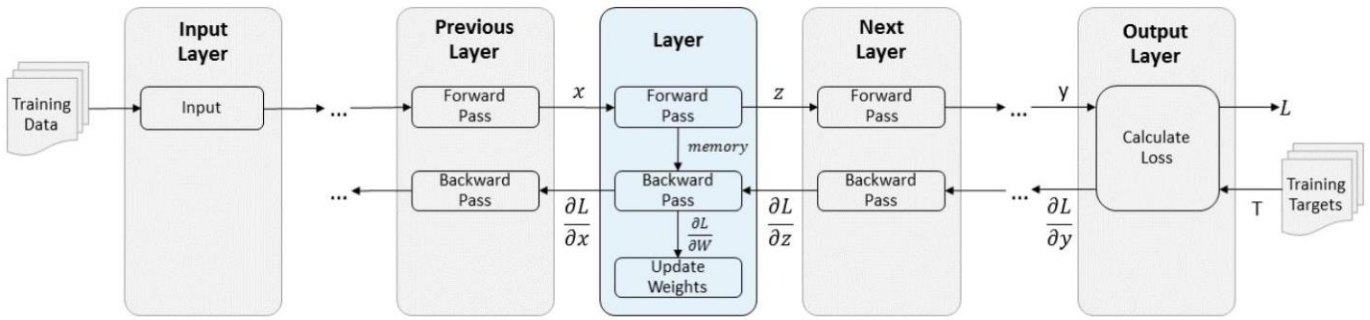
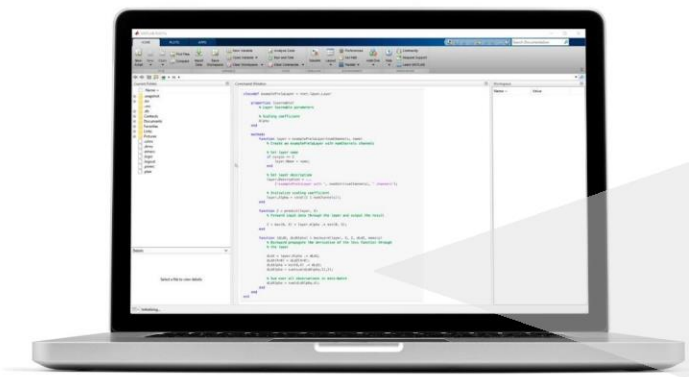
Define new deep neural network layers R2017b





```
function [dLdX, dLdAlpha] = backward(layer, X, Z, dLdZ, memory)
    % Backward propagate the derivative of the loss function through
    % the layer

    dLdX = layer.Alpha .* dLdZ;
    dLdX(X>0) = dLdZ(X>0);
    dLdAlpha = min(0,X) .* dLdZ;
    dLdAlpha = sum(sum(dLdAlpha,1),2);
```

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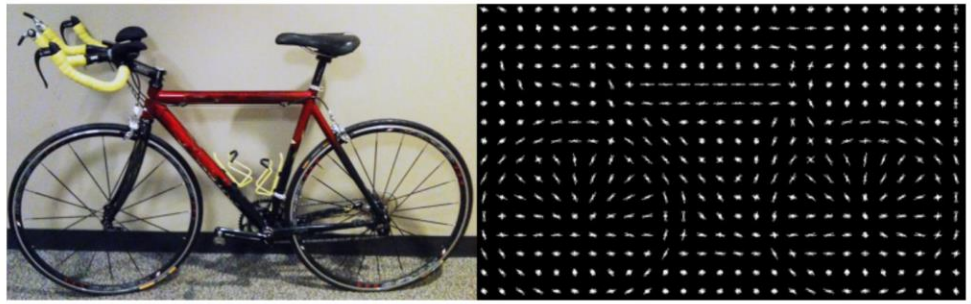
Object Detection Frameworks

R2017a

- Single line of code to train a detector
- Includes:
  - R-CNN
  - Fast R-CNN
  - Faster R-CNN



Create Custom Object Detectors

`trainACFObjectDetector`	Train ACF object detector
`trainCascadeObjectDetector`	Train cascade object detector model
`trainFastRCNNObjectDetector`	Train a Fast R-CNN deep learning object detector
`trainFasterRCNNObjectDetector`	Train a Faster R-CNN deep learning object detector
`trainImageCategoryClassifier`	Train an image category classifier
`trainRCNNObjectDetector`	Train an R-CNN deep learning object detector

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Deep learning features overview

- Classification
- Regression *
- Semantic segmentation
- Object detection *
- Scalability *
  - Multiple GPUs
  - Cluster or cloud
- Custom network layers *
- Import models *
  - Caffe
  - Keras/TensorFlow
- Data augmentation *
- Hyperparameter tuning *
  - Bayesian optimization
- Python ⟷ MATLAB interface *
- LSTM networks *
  - Time series, signals, audio
- Custom labeling *
  - API for ground-truth labeling automation
  - Superpixels
- Data validation *
  - Training and testing

** We can cover in more detail outside this presentation*

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MATLAB products for deep learning

Required products

- Deep Learning Toolbox
- Parallel Computing Toolbox
- Image Processing Toolbox
- Computer Vision System Toolbox

Optional products

- Statistics and Machine Learning Toolbox
- Signal Processing Toolbox
- Text Analytics Toolbox
- Wavelet Toolbox
- MATLAB Coder
- GPU Coder
- Automated Driving System Toolbox