MathWorks®

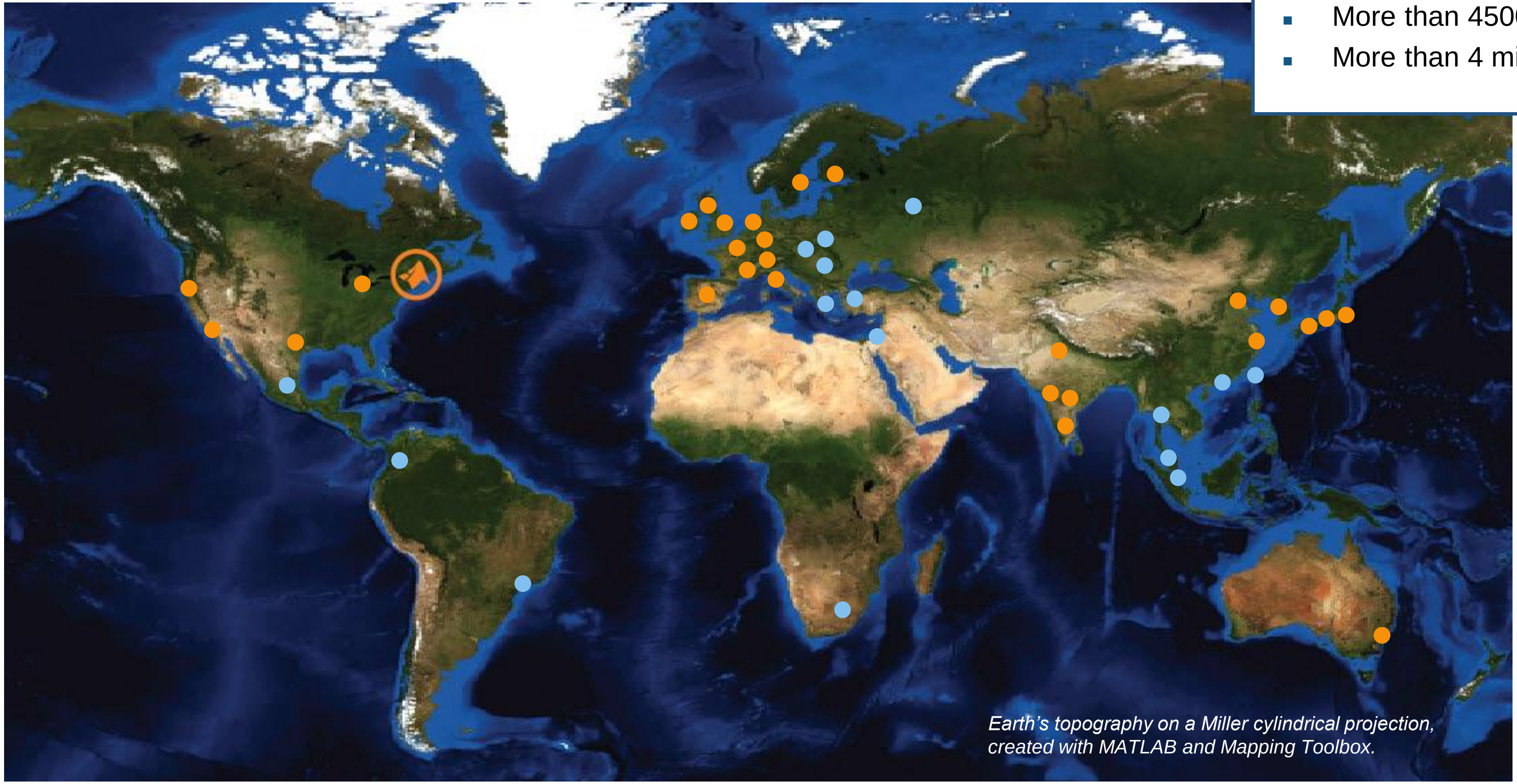
What’s new in MATLAB

FHI Berlin, 22.05.19
Dr. Philip Laserstein

R2019a

MathWorks at a Glance

- Privately held
- More than 4500 employees worldwide
- More than 4 million users in 185 countries



Earth's topography on a Miller cylindrical projection, created with MATLAB and Mapping Toolbox.

● Office locations ● Distributors serving 16 countries

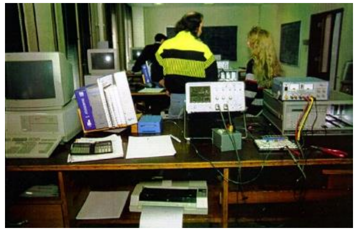
Deeply Rooted in Education

- 6500+ universities around the world
- 2000+ MATLAB and Simulink based books
- Academic support for research, fellowships, student competitions, and curriculum development

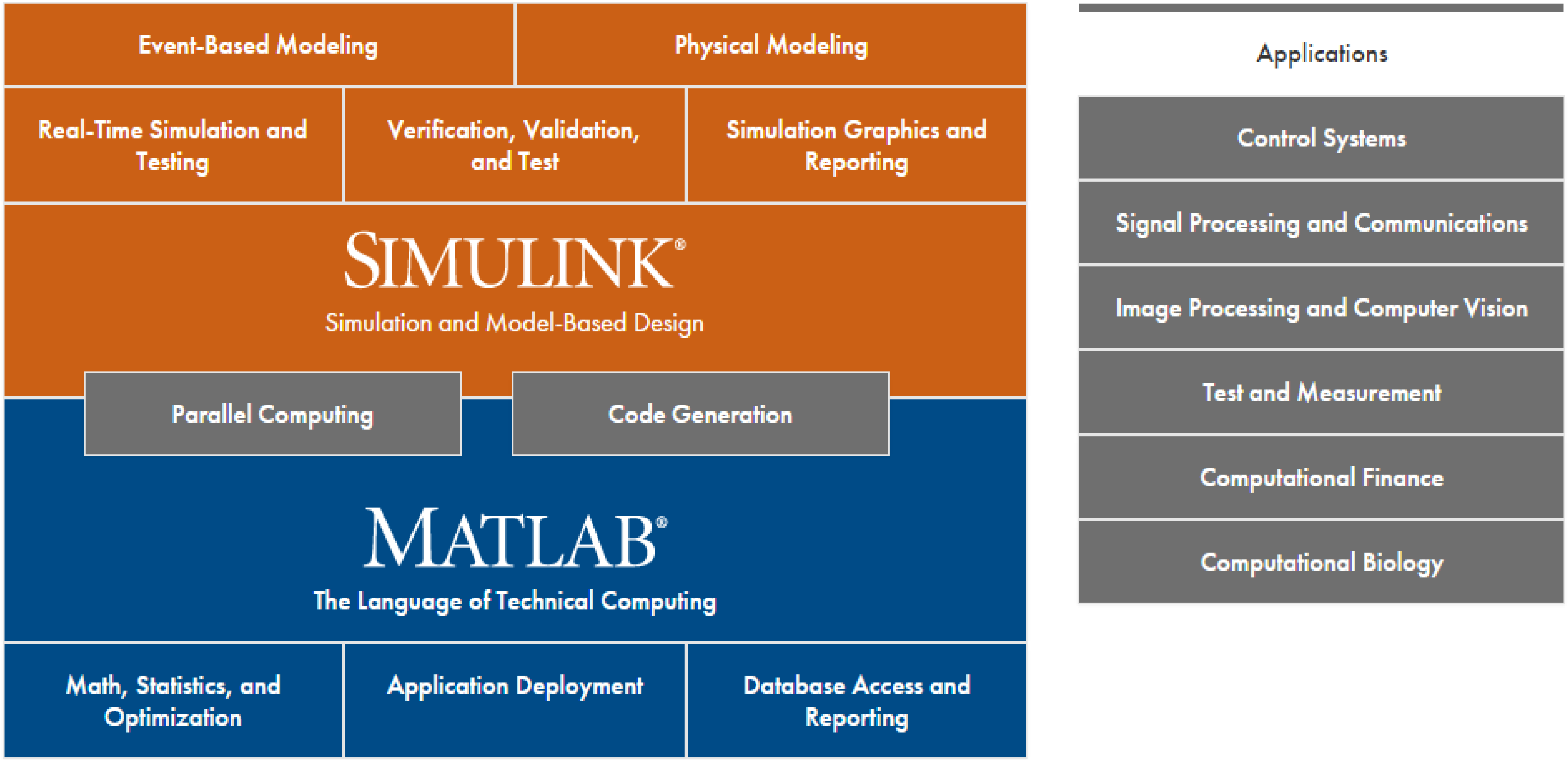
> “Everyone that comes in as a new hire already knows MATLAB, because they all had it in college. The learning curve is significantly lessened as a result.”
>
> **Jeff Corn,**
> **Chief of Engineering Projects Section,**
> **U.S. Air Force**

Benefits for Industry

- Every year, tens of thousands of engineers enter the workforce with MATLAB and Simulink product skills and experience.
- Students learn theory and techniques while using MATLAB and Simulink.



MathWorks Product Overview



Event-Based Modeling

Physical Modeling

Real-Time Simulation and Testing

Verification, Validation, and Test

Simulation Graphics and Reporting

SIMULINK®

Simulation and Model-Based Design

Parallel Computing

Code Generation

MATLAB®

The Language of Technical Computing

Math, Statistics, and Optimization

Application Deployment

Database Access and Reporting

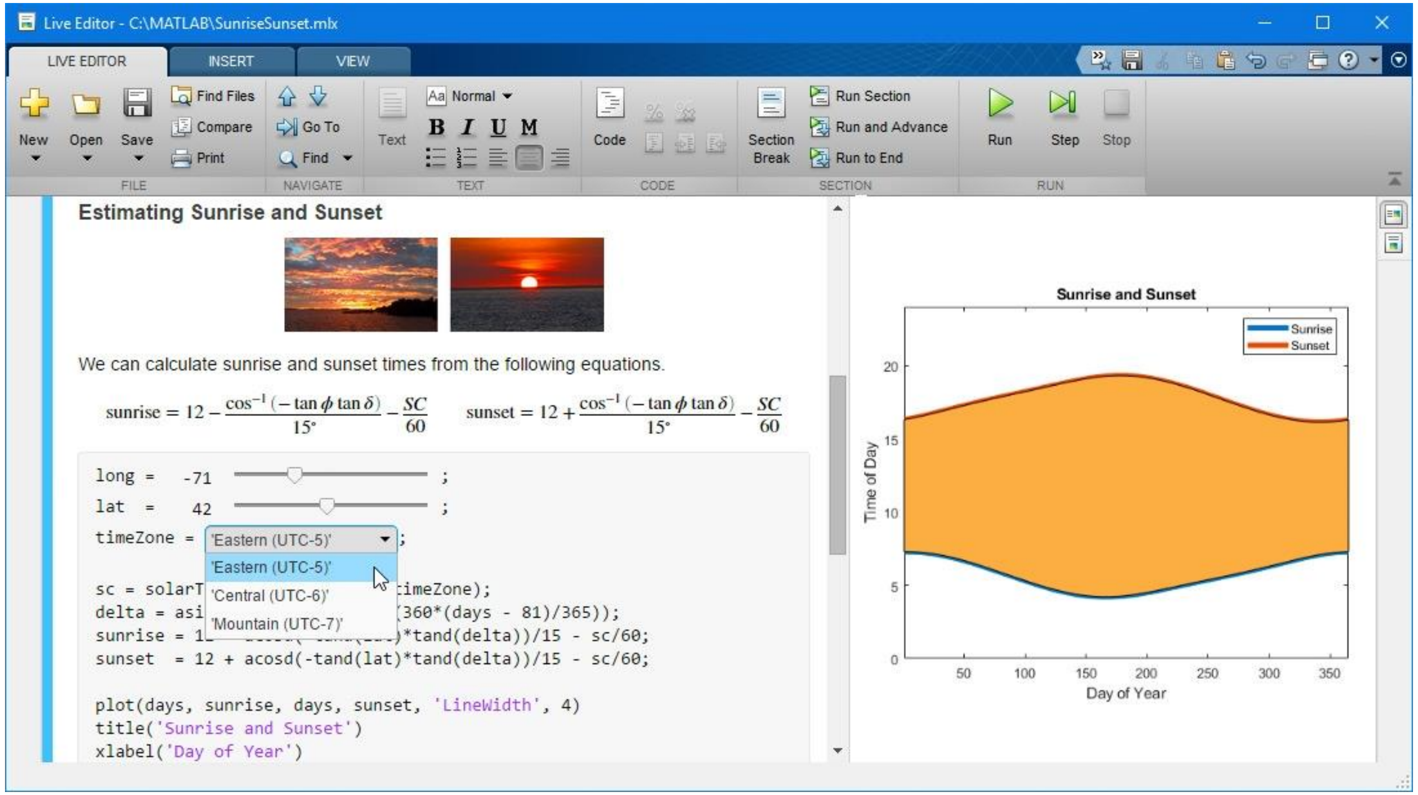
Applications

- Control Systems
- Signal Processing and Communications
- Image Processing and Computer Vision
- Test and Measurement
- Computational Finance
- Computational Biology

Access to all 90+ products via the MPG campus-wide license!

Agenda

- Desktop & Live Editor



Estimating Sunrise and Sunset

We can calculate sunrise and sunset times from the following equations.

$$\text{sunrise} = 12 - \frac{\cos^{-1}(-\tan\phi\tan\delta)}{15^\circ} - \frac{SC}{60} \qquad \text{sunset} = 12 + \frac{\cos^{-1}(-\tan\phi\tan\delta)}{15^\circ} - \frac{SC}{60}$$

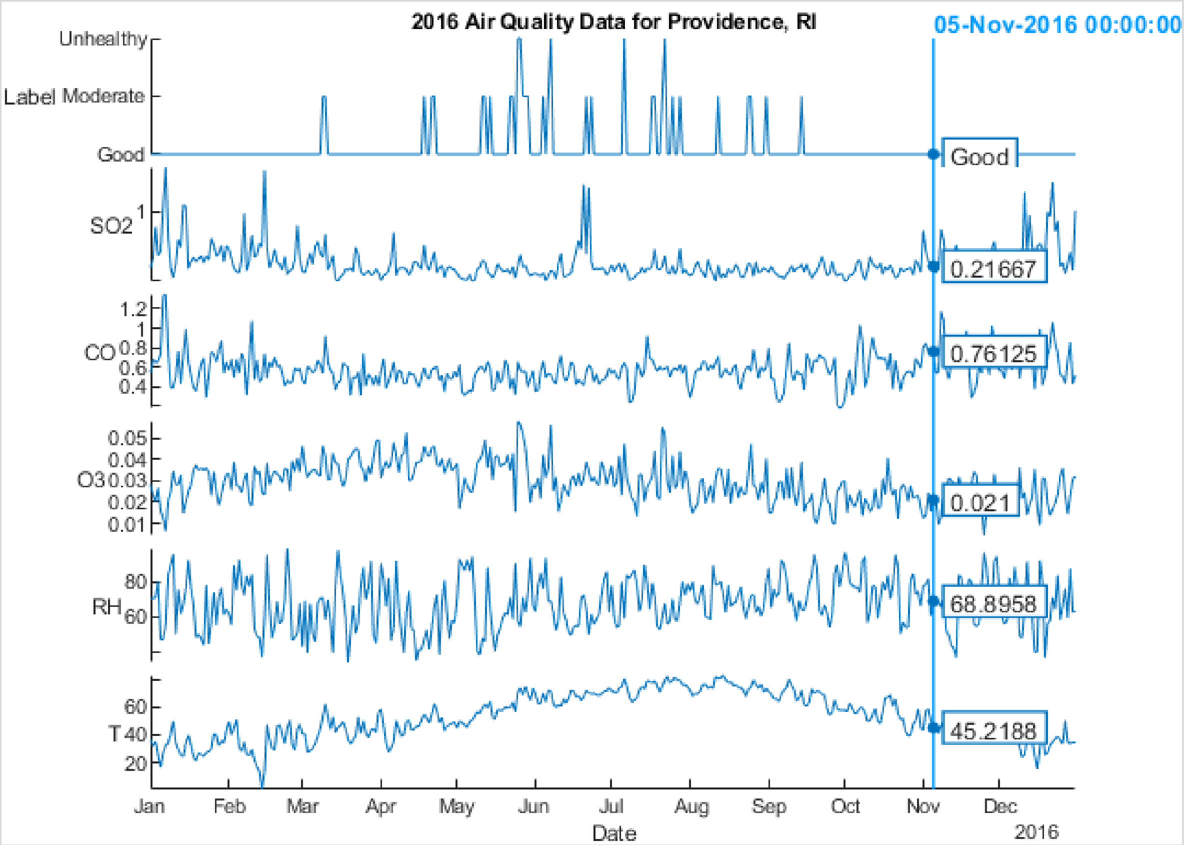
```
long =   -71                       ;
lat  =    42                       ;
timeZone = 'Eastern (UTC-5)'        ;
           'Eastern (UTC-5)'
sc = solarT'Central (UTC-6)'  timeZone);
delta = asi'Mountain (UTC-7)' (360*(days - 81)/365));
sunrise = 1                   )*tand(delta))/15 - sc/60;
sunset  = 12 + acosd(-tand(lat)*tand(delta))/15 - sc/60;

plot(days, sunrise, days, sunset, 'LineWidth', 4)
title('Sunrise and Sunset')
xlabel('Day of Year')
```

Agenda

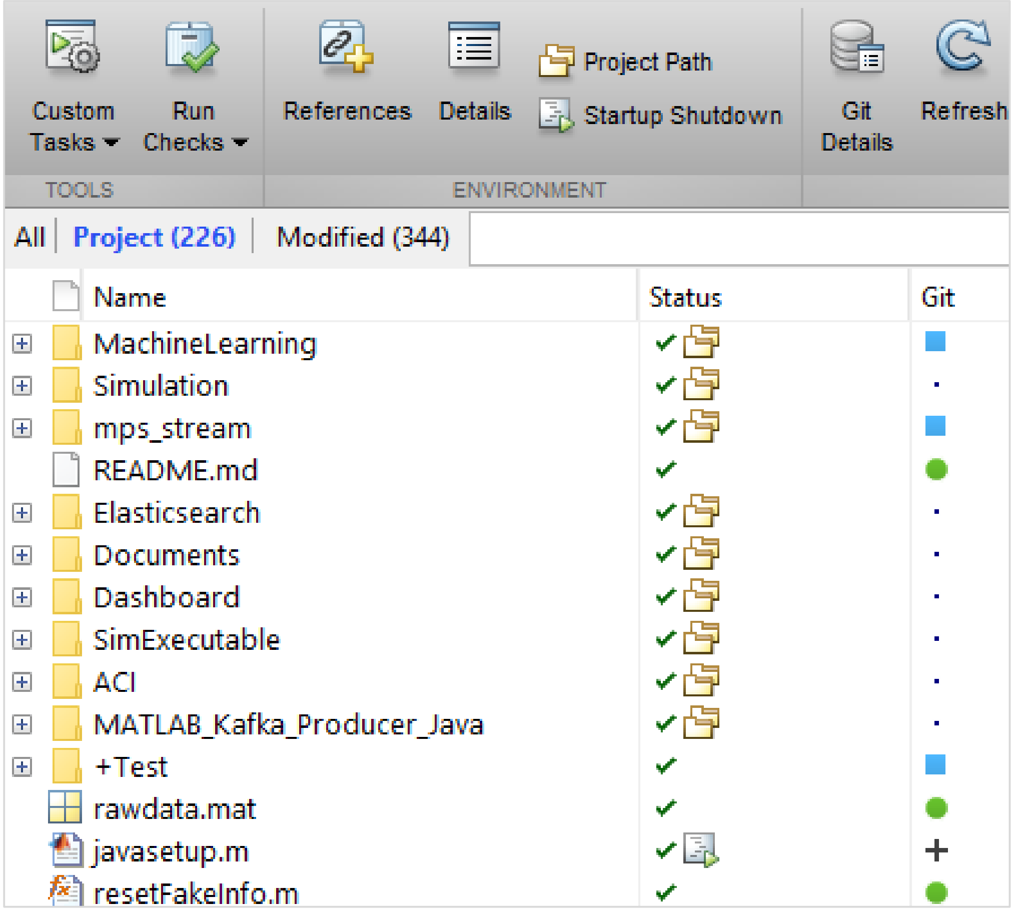
- Desktop & Live Editor

- Data Analysis & Visualization



Agenda

- Desktop & Live Editor
- Data Analysis & Visualization
- Language & Programming

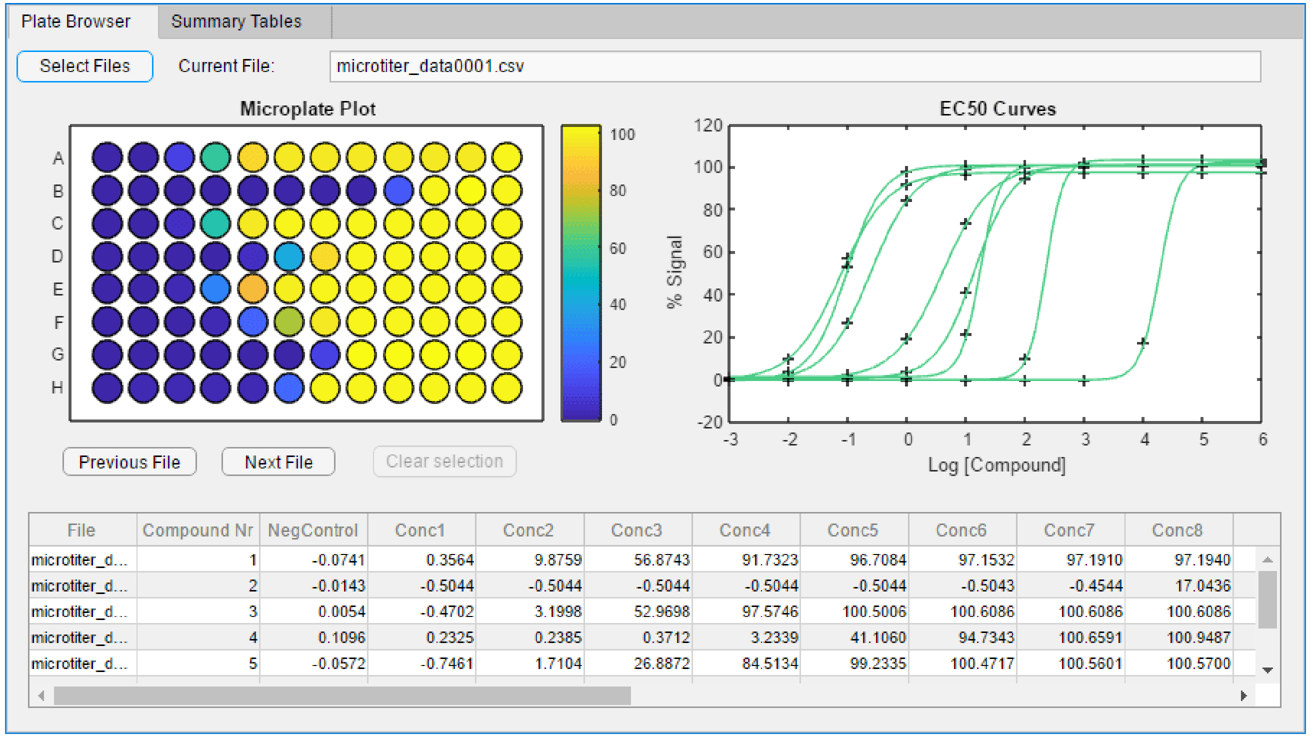


All | Project (226) | Modified (344)

Name	Status	Git
MachineLearning	✓	■
Simulation	✓	·
mps_stream	✓	■
README.md	✓	●
Elasticsearch	✓	·
Documents	✓	·
Dashboard	✓	·
SimExecutable	✓	·
ACI	✓	·
MATLAB_Kafka_Producer_Java	✓	·
+Test	✓	■
rawdata.mat	✓	●
javasetup.m	✓	+
resetFakeInfo.m	✓	●

Agenda

- Desktop & Live Editor
- Data Analysis & Visualization
- Language & Programming
- App Building & Sharing



File	Compound Nr	NegControl	Conc1	Conc2	Conc3	Conc4	Conc5	Conc6	Conc7	Conc8
microtiter_d...	1	-0.0741	0.3564	9.8759	56.8743	91.7323	96.7084	97.1532	97.1910	97.1940
microtiter_d...	2	-0.0143	-0.5044	-0.5044	-0.5044	-0.5044	-0.5044	-0.5043	-0.4544	17.0436
microtiter_d...	3	0.0054	-0.4702	3.1998	52.9698	97.5746	100.5006	100.6086	100.6086	100.6086
microtiter_d...	4	0.1096	0.2325	0.2385	0.3712	3.2339	41.1060	94.7343	100.6591	100.9487
microtiter_d...	5	-0.0572	-0.7461	1.7104	26.8872	84.5134	99.2335	100.4717	100.5601	100.5700

Agenda

- Desktop & Live Editor
- Data Analysis & Visualization
- Language & Programming
- App Building & Sharing
- Hardware Support

Data & RF

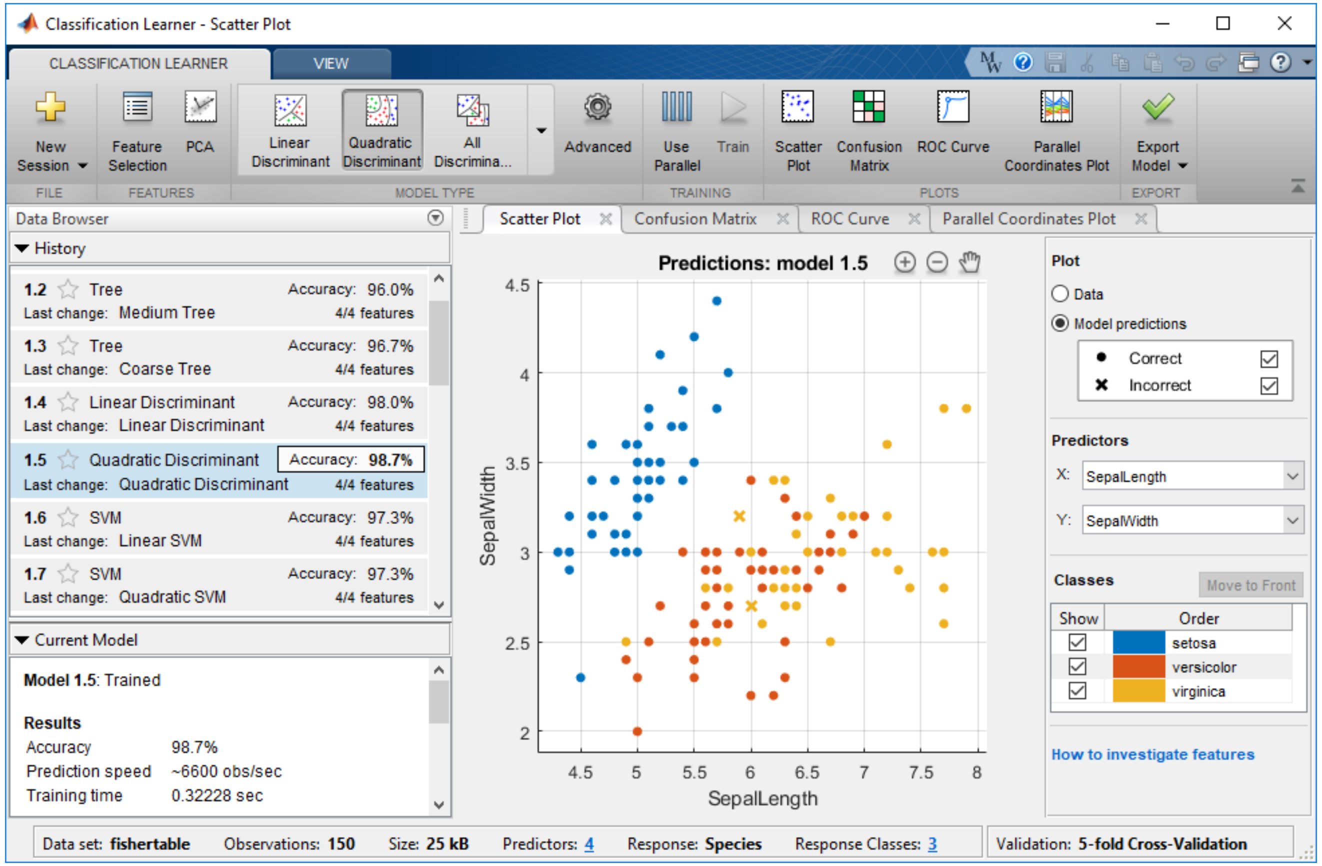
Embedded

Imaging

Specialty

Agenda

- Desktop & Live Editor
- Data Analysis & Visualization
- Language & Programming
- App Building & Sharing
- Hardware Support
- Toolbox Updates



1.2 ☆ Tree	Accuracy: 96.0%	Last change: Medium Tree	4/4 features
1.3 ☆ Tree	Accuracy: 96.7%	Last change: Coarse Tree	4/4 features
1.4 ☆ Linear Discriminant	Accuracy: 98.0%	Last change: Linear Discriminant	4/4 features
1.5 ☆ Quadratic Discriminant	Accuracy: 98.7%	Last change: Quadratic Discriminant	4/4 features
1.6 ☆ SVM	Accuracy: 97.3%	Last change: Linear SVM	4/4 features
1.7 ☆ SVM	Accuracy: 97.3%	Last change: Quadratic SVM	4/4 features

Model 1.5: Trained

Results

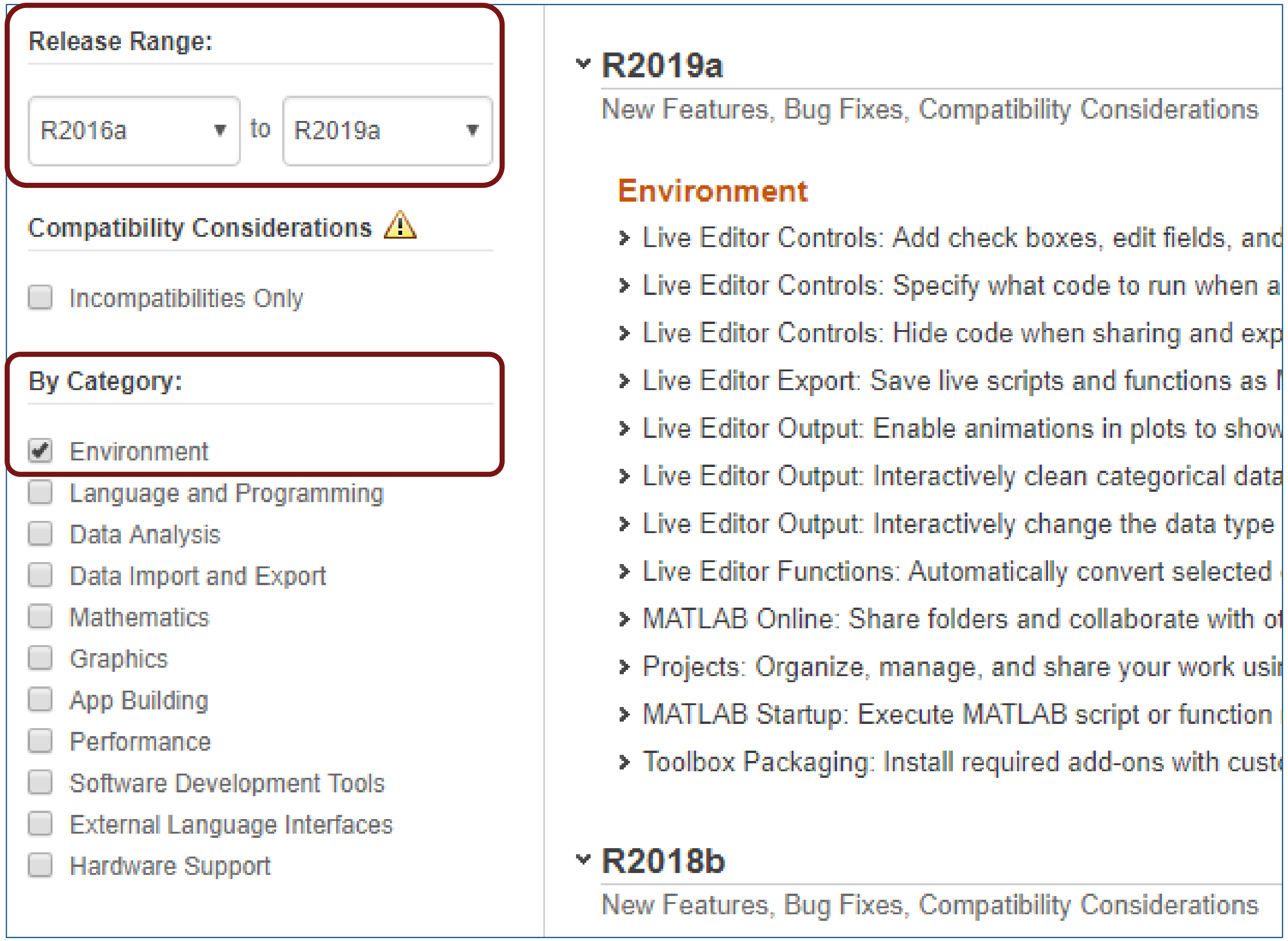
Accuracy	98.7%
Prediction speed	~6600 obs/sec
Training time	0.32228 sec

Show		Order
☑	🟦	setosa
☑	🟧	versicolor
☑	🟨	virginica

Data set: **fishertable** Observations: **150** Size: **25 kB** Predictors: 4 Response: **Species** Response Classes: 3 Validation: **5-fold Cross-Validation**

Full details are available in the documentation release notes

- Filter results by:
  - Release range
  - Category
  - Specific search terms



Release Range:

R2016a ▾ to R2019a ▾

Compatibility Considerations ⚠

□ Incompatibilities Only

By Category:

☑ Environment
□ Language and Programming
□ Data Analysis
□ Data Import and Export
□ Mathematics
□ Graphics
□ App Building
□ Performance
□ Software Development Tools
□ External Language Interfaces
□ Hardware Support

R2019a

New Features, Bug Fixes, Compatibility Considerations

Environment

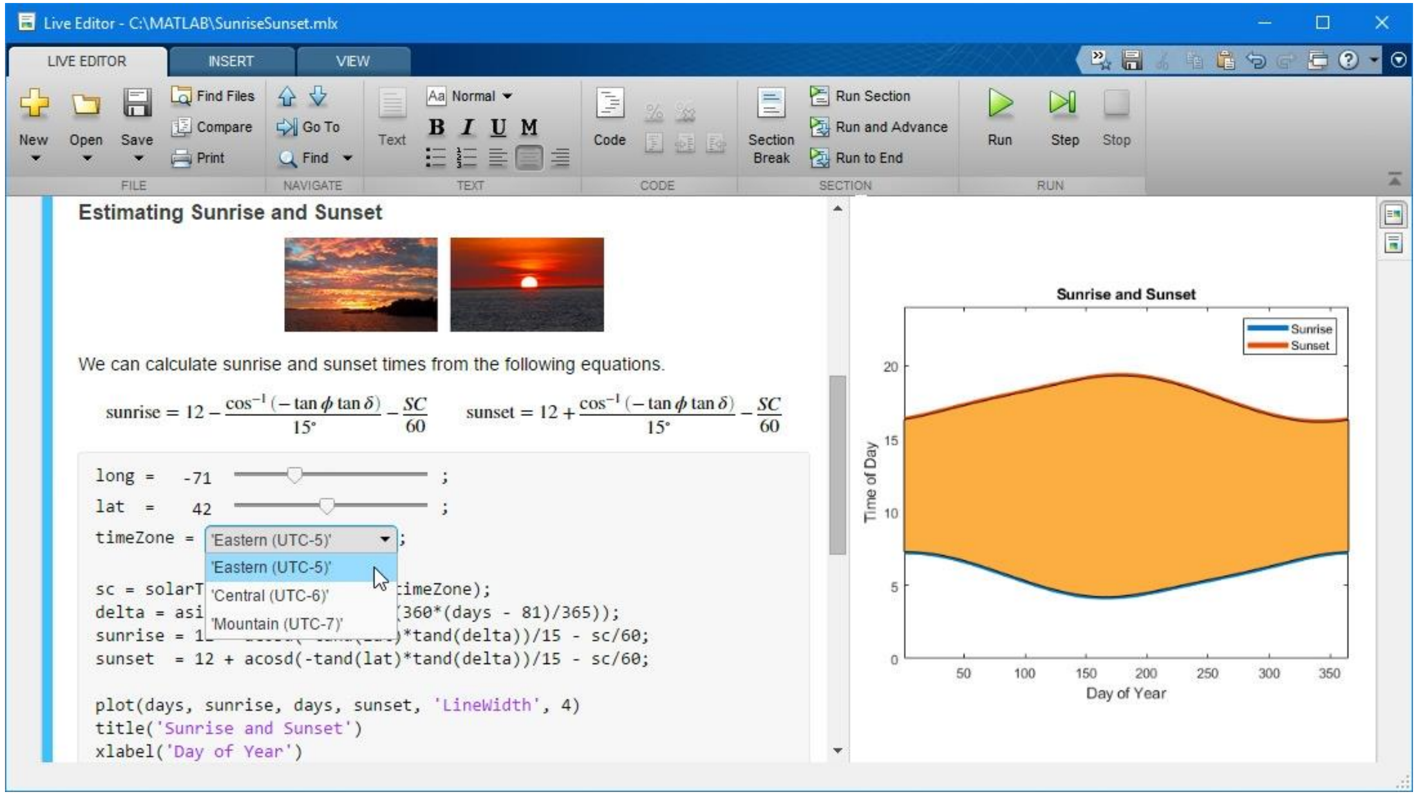
› Live Editor Controls: Add check boxes, edit fields, and
› Live Editor Controls: Specify what code to run when a
› Live Editor Controls: Hide code when sharing and exp
› Live Editor Export: Save live scripts and functions as I
› Live Editor Output: Enable animations in plots to show
› Live Editor Output: Interactively clean categorical data
› Live Editor Output: Interactively change the data type
› Live Editor Functions: Automatically convert selected
› MATLAB Online: Share folders and collaborate with ot
› Projects: Organize, manage, and share your work usi
› MATLAB Startup: Execute MATLAB script or function
› Toolbox Packaging: Install required add-ons with custo

R2018b

New Features, Bug Fixes, Compatibility Considerations

Agenda

- **Desktop & Live Editor**
- Data Analysis & Visualization
- Language & Programming
- App Building & Sharing
- Hardware Support
- Toolbox Updates



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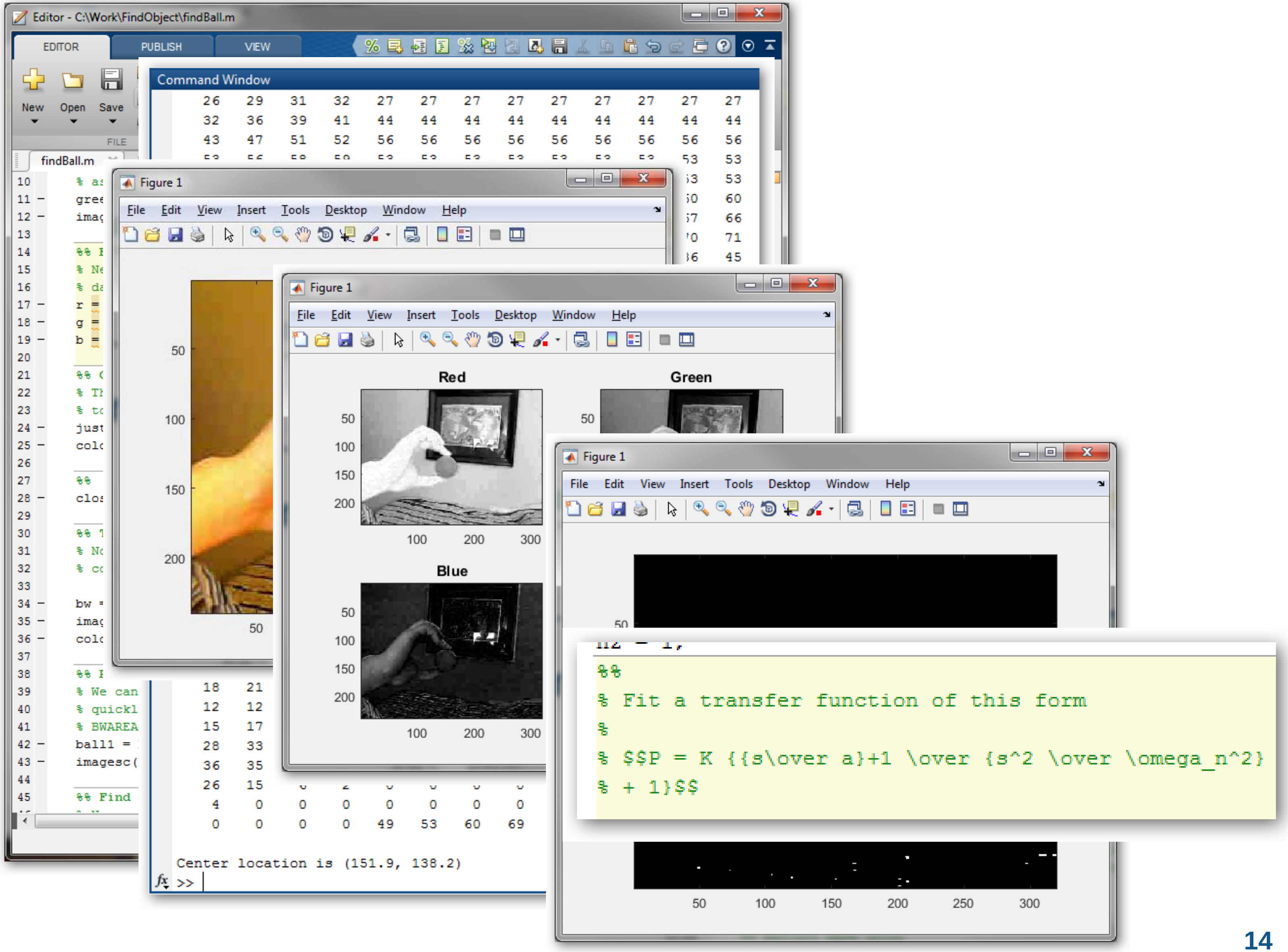
```
long =   -71                 ;
lat  =    42                 ;
timeZone = 'Eastern (UTC-5)' ;
            'Eastern (UTC-5)'
            'Central (UTC-6)'
            'Mountain (UTC-7)'

sc = solarT                  timeZone);
delta = asi                  (360*(days - 81)/365));
sunrise = 1                  )*tand(delta))/15 - sc/60;
sunset  = 12 + acosd(-tand(lat)*tand(delta))/15 - sc/60;

plot(days, sunrise, days, sunset, 'LineWidth', 4)
title('Sunrise and Sunset')
xlabel('Day of Year')
```

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


Editor - C:\Work\FindObject\findBall.m
EDITOR
PUBLISH
VIEW
New
Open
Save
FILE
findBall.m
Command Window
Figure 1
File Edit View Insert Tools Desktop Window Help
50
100
150
200
50
Figure 1
File Edit View Insert Tools Desktop Window Help
Red
Green
Blue
50
100
150
200
100
200
300
Figure 1
File Edit View Insert Tools Desktop Window Help
50
50
100
150
200
250
300

```
    % as
    gree
    imag

    %% F
    % Ne
    % da
    r =
    g =
    b =

    %% C
    % Th
    % to
    just
    colo

    %%
    clos

    %% T
    % No
    % co

    bw =
    imag
    colo

    %% F
    % We can
    % quickl
    % BWAREA
    ball1 =
    imagesc(

    %% Find
```

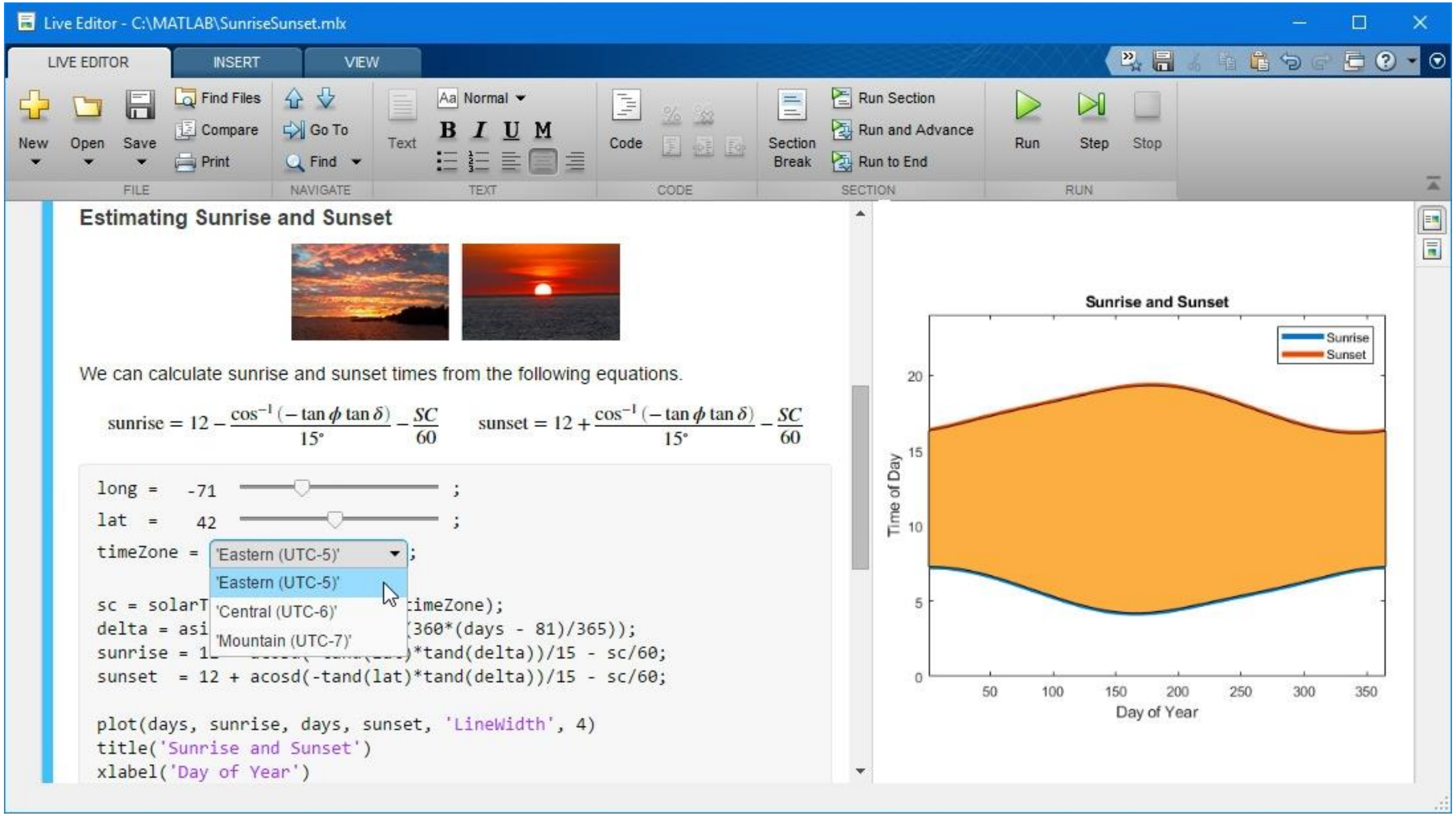
```
    26   29   31   32   27   27   27   27   27   27   27   27   27
    32   36   39   41   44   44   44   44   44   44   44   44   44
    43   47   51   52   56   56   56   56   56   56   56   56   56
                                                          53   53
                                                          53   53
                                                          50   60
                                                          57   66
                                                          70   71
                                                          36   45
    18   21
    12   12
    15   17
    28   33
    36   35
    26   15
     4    0    0    0    0    0    0    0
     0    0    0    0   49   53   60   69

Center location is (151.9, 138.2)
>>
```

```
%%
% Fit a transfer function of this form
%
% $$P = K {{s\over a}+1 \over {s^2 \over \omega_n^2}
% + 1}$$
```

Use the **Live Editor** to create scripts that combine code, output, and formatted text in an executable notebook.

R2016a



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long =  -71 ;
lat  =   42 ;
timeZone = 'Eastern (UTC-5)';
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           'Mountain (UTC-7)'
sc = solarT                  timeZone);
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sunrise = 1                  )*tand(delta))/15 - sc/60;
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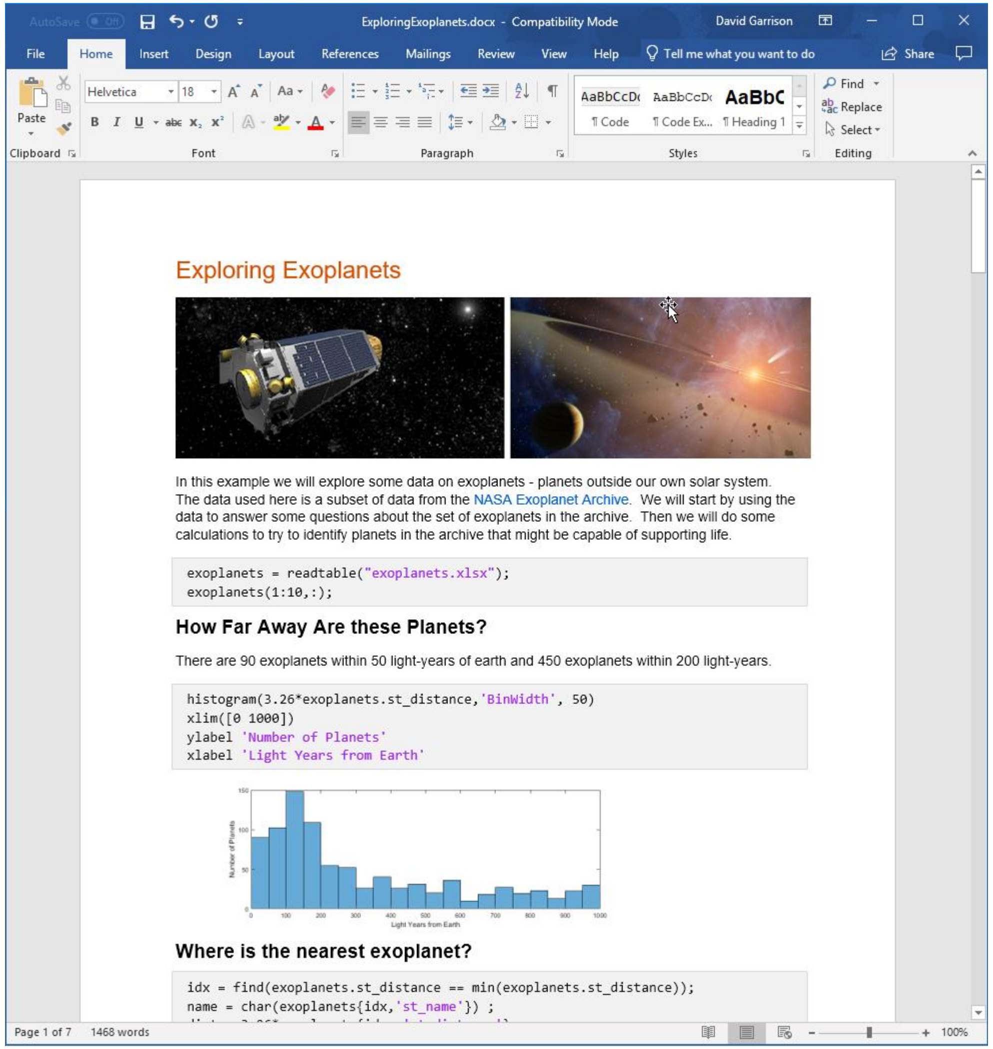
plot(days, sunrise, days, sunset, 'LineWidth', 4)
title('Sunrise and Sunset')
xlabel('Day of Year')
```

Live Editor Notebook Features

- Divide code into sections
- View output next to the code
- Add rich text formatting, equations, images, and hyperlinks
- Add interactive controls
- Enable animations in plots
- Save directly to PDF, HTML, Word, and LaTeX



Exploring Exoplanets

In this example we will explore some data on exoplanets - planets outside our own solar system. The data used here is a subset of data from the NASA Exoplanet Archive. We will start by using the data to answer some questions about the set of exoplanets in the archive. Then we will do some calculations to try to identify planets in the archive that might be capable of supporting life.

```
exoplanets = readtable("exoplanets.xlsx");
exoplanets(1:10,:);
```

How Far Away Are these Planets?

There are 90 exoplanets within 50 light-years of earth and 450 exoplanets within 200 light-years.

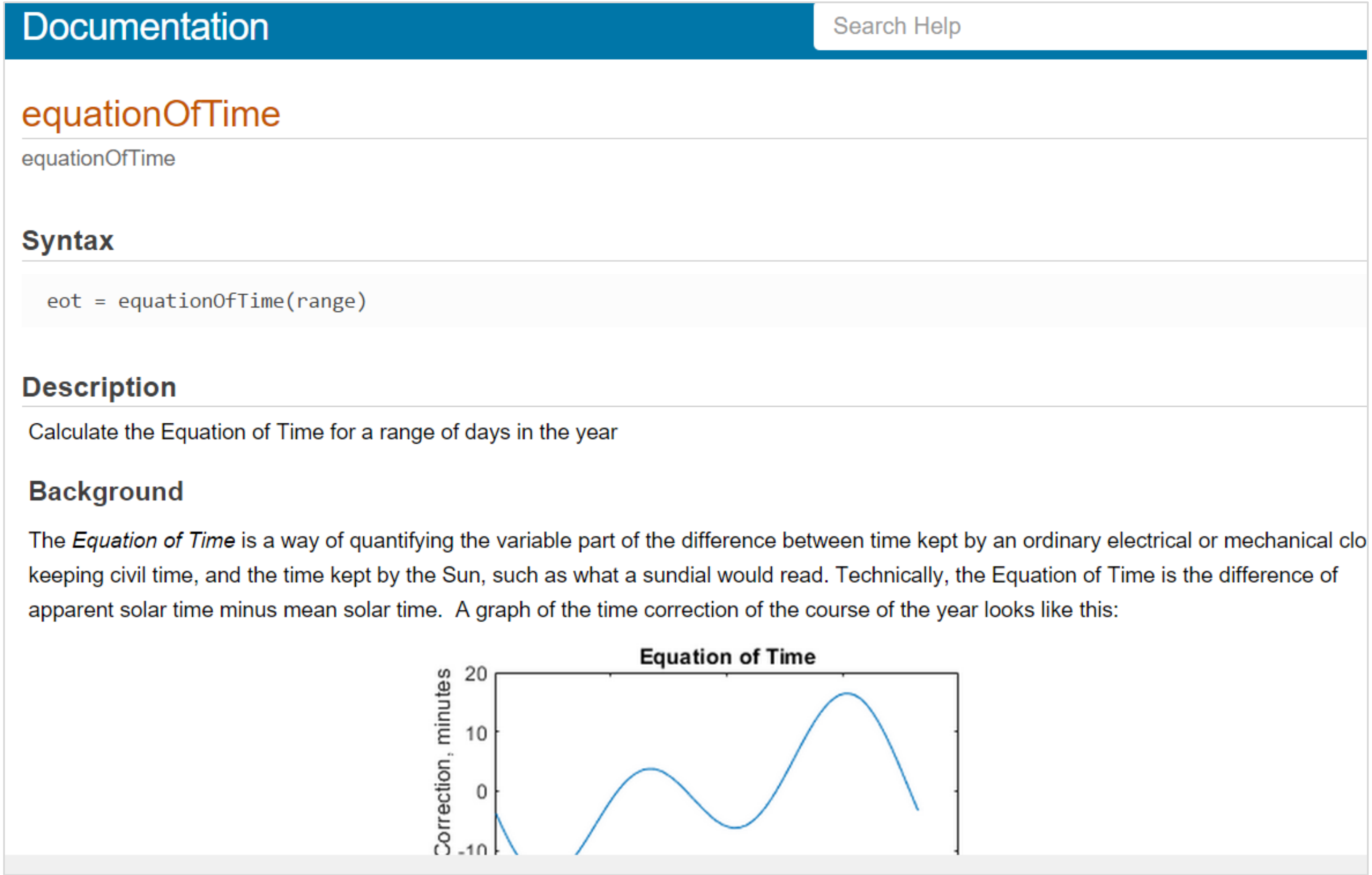
```
histogram(3.26*exoplanets.st_distance,'BinWidth', 50)
xlim([0 1000])
ylabel 'Number of Planets'
xlabel 'Light Years from Earth'
```

Where is the nearest exoplanet?

```
idx = find(exoplanets.st_distance == min(exoplanets.st_distance));
name = char(exoplanets{idx,'st_name'}) ;
```

Live Editor Coding Features

- Use contextual hints when calling functions
- Automatically generate code when interacting with plots and tables in the output
- Debug live scripts and functions
- Select and edit rectangular areas of code
- Refactor code into local or external functions
- Create formatted function reference documentation



equationOfTime

equationOfTime

Syntax

```
eot = equationOfTime(range)
```

Description

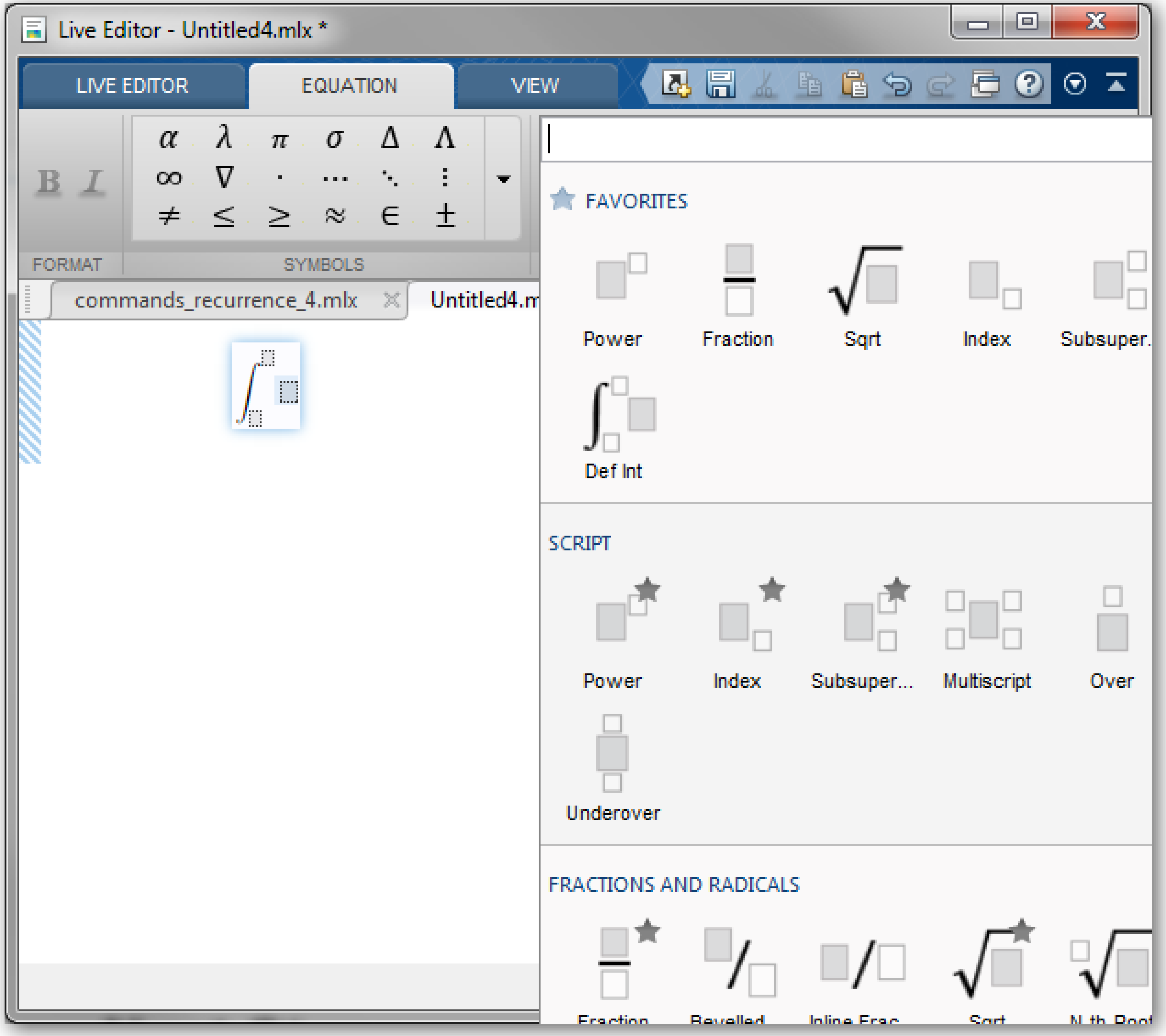
Calculate the Equation of Time for a range of days in the year

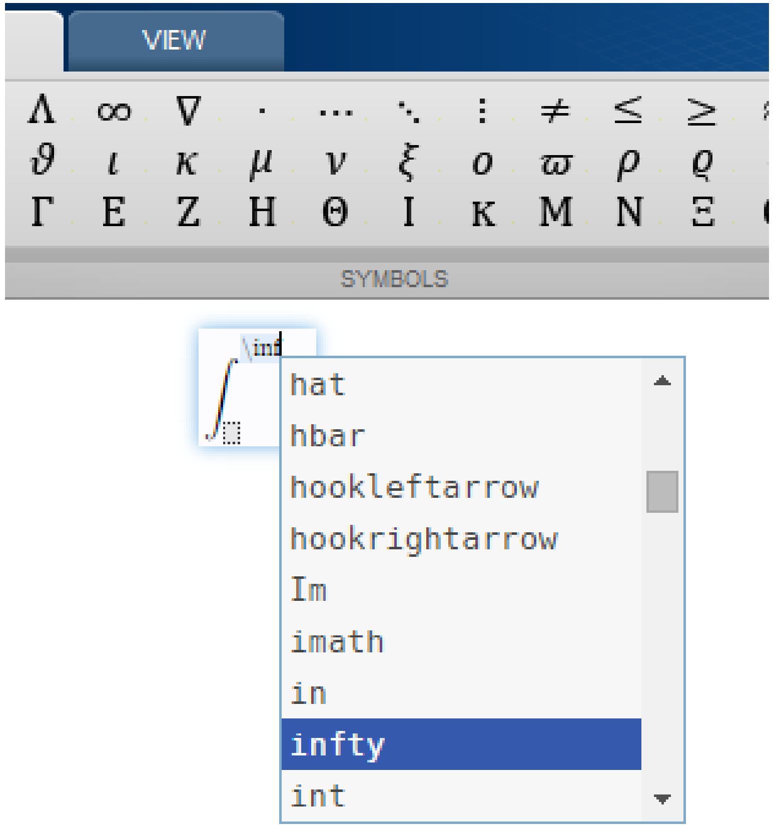
Background

The *Equation of Time* is a way of quantifying the variable part of the difference between time kept by an ordinary electrical or mechanical clo keeping civil time, and the time kept by the Sun, such as what a sundial would read. Technically, the Equation of Time is the difference of apparent solar time minus mean solar time. A graph of the time correction of the course of the year looks like this:

Interactive Equation Editing

R2016b





Live Editor Keyboard Shortcuts* let you format as you type

Formatting Style	Autoformatting Sequence	Keyboard Shortcut
Title	# text + Enter	Ctrl + Alt + L
Heading 1	## text + Enter	Ctrl + Shift + 1
Heading 2	### text + Enter	Ctrl + Shift + 2
Heading 3	#### text + Enter	Ctrl + Shift + 3
Section break	%% + Enter	Ctrl + Alt + Enter
	--- + Enter	
	*** + Enter	
Bulleted list	* text	Ctrl + Alt + U
	- text	
	+ text	
Numbered list	number. text	Ctrl + Alt + O
Italic	*text*	Ctrl + I
	text	
Bold	**text**	Ctrl + B
	__text__	
Underline	None	Ctrl + U
LaTeX equation	$LaTeX$	Ctrl + Shift + L

* This is a subset of available keyboard shortcuts. The full list can be found here: https://www.mathworks.com/help/matlab/matlab_prog/format-live-scripts.html#bvackht-1

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- Desktop & Live Editor
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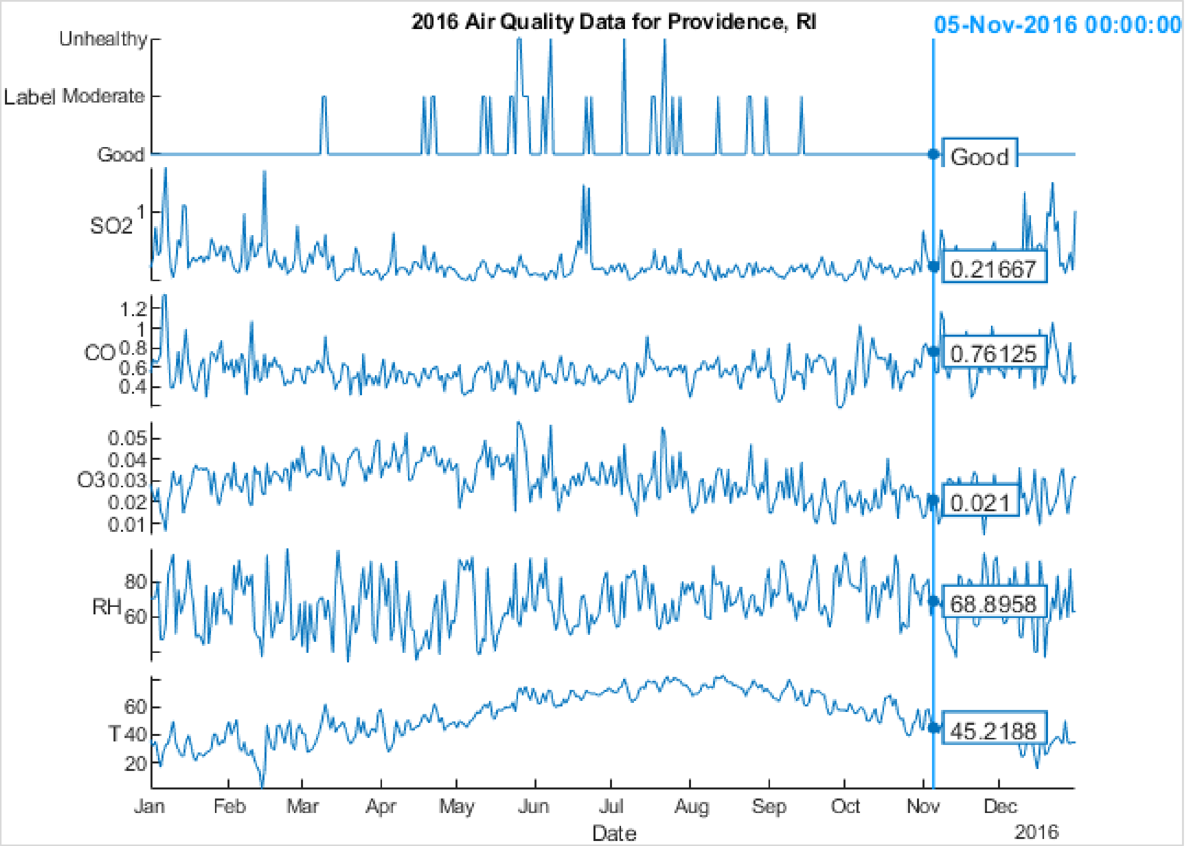
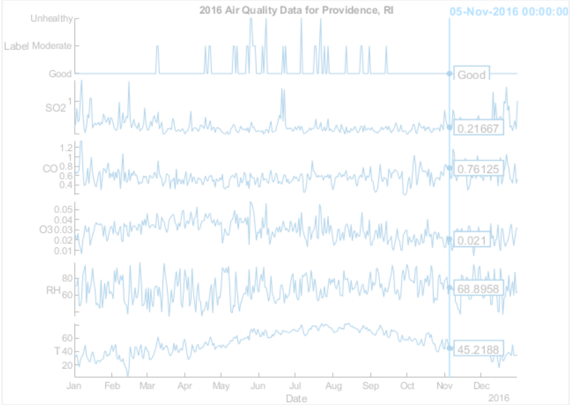
- Language & Programming
- App Building & Sharing
- Hardware Support
- Toolbox Updates

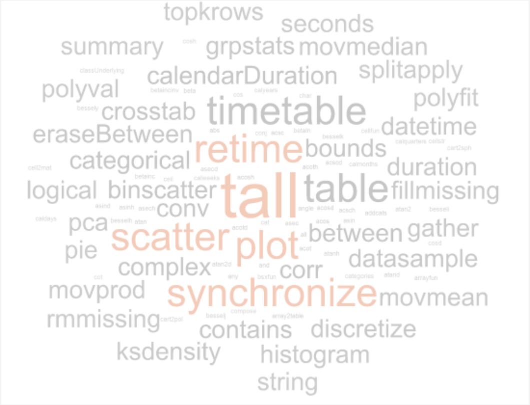


Data Analysis & Visualization

Access



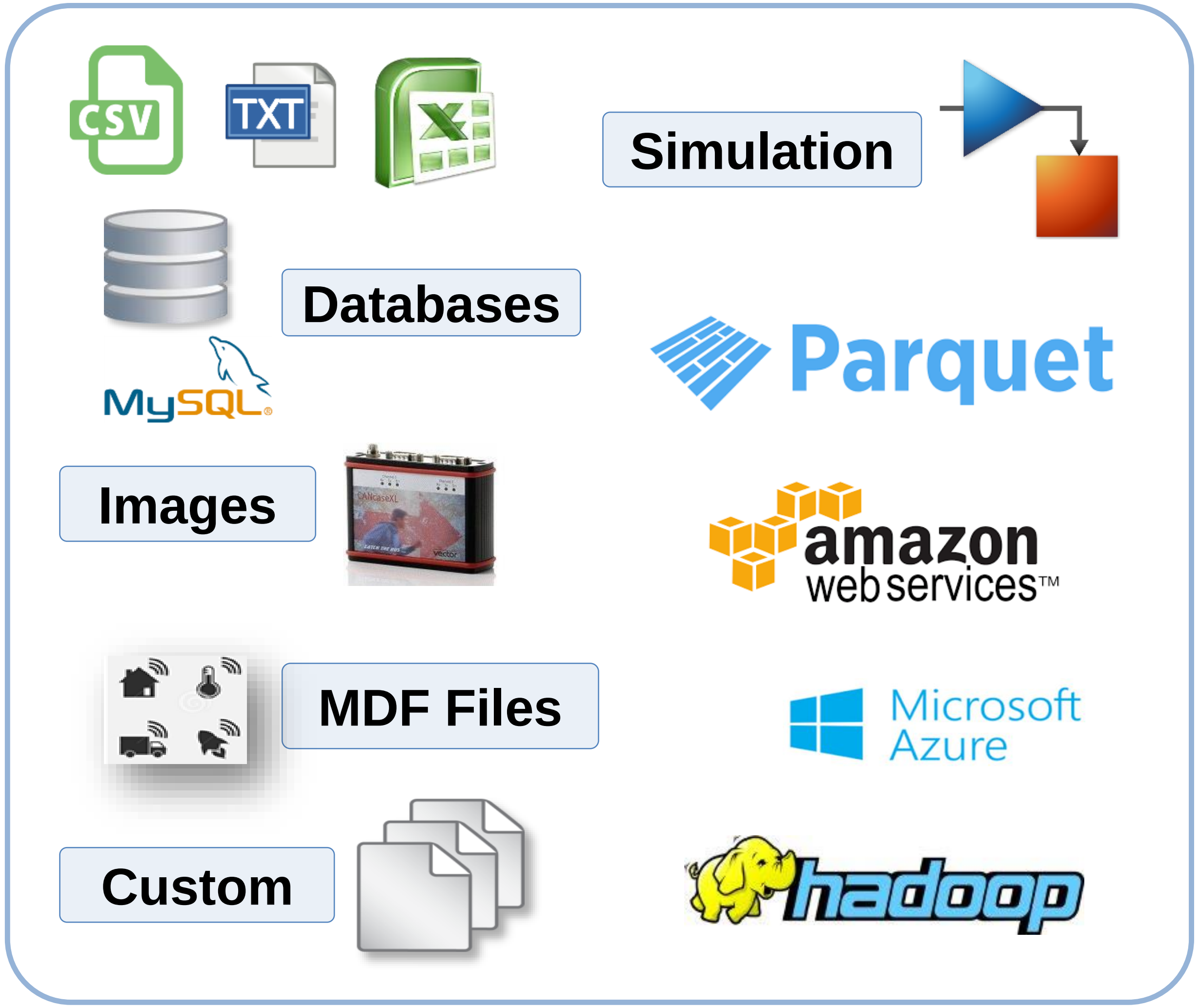
Analysis & Visualization



Big Data

Access data in many formats from many locations

- Type
- Structure
- Location



Simulation

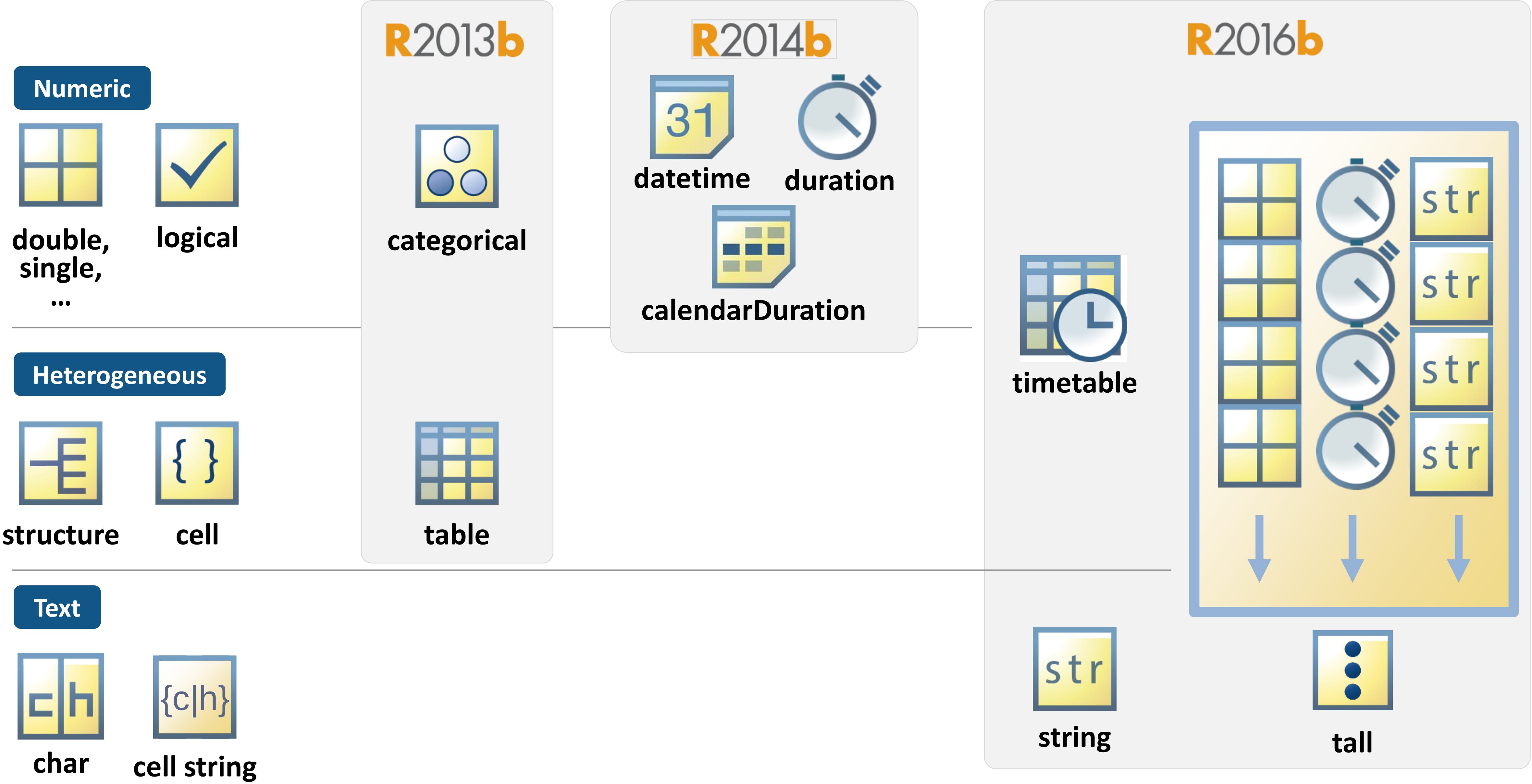
Databases

Images

MDF Files

Custom

New data types express more types of data naturally



R2013b

R2014b

R2016b

Numeric

double, single, …

logical

categorical

datetime

duration

calendarDuration

Heterogeneous

structure

cell

table

timetable

Text

char

cell string

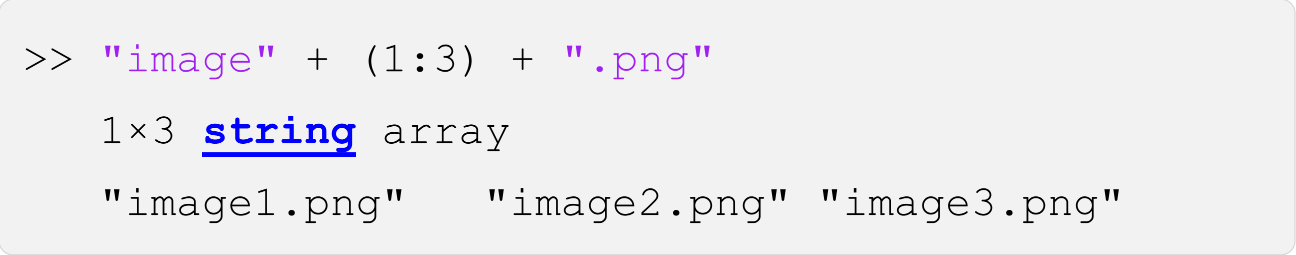
string

tall

Strings

R2016b

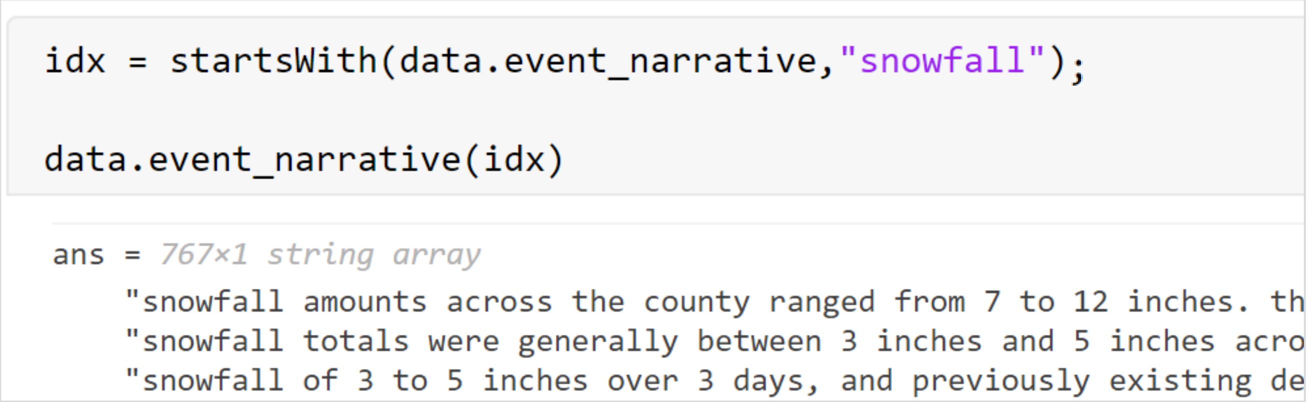
- **For:**
  - Text data
- **Provides:**
  - Improved execution speed and memory usage vs `cellstr`
  - Manipulate, compare, and store text data efficiently
  - Simplified text manipulation functions



```
>> "image" + (1:3) + ".png"
   1×3 string array
   "image1.png"    "image2.png"  "image3.png"
```

Previously: `if ~isempty(strfind(textdata,"Dog"))`

Now: `if contains(textdata,"Dog")`



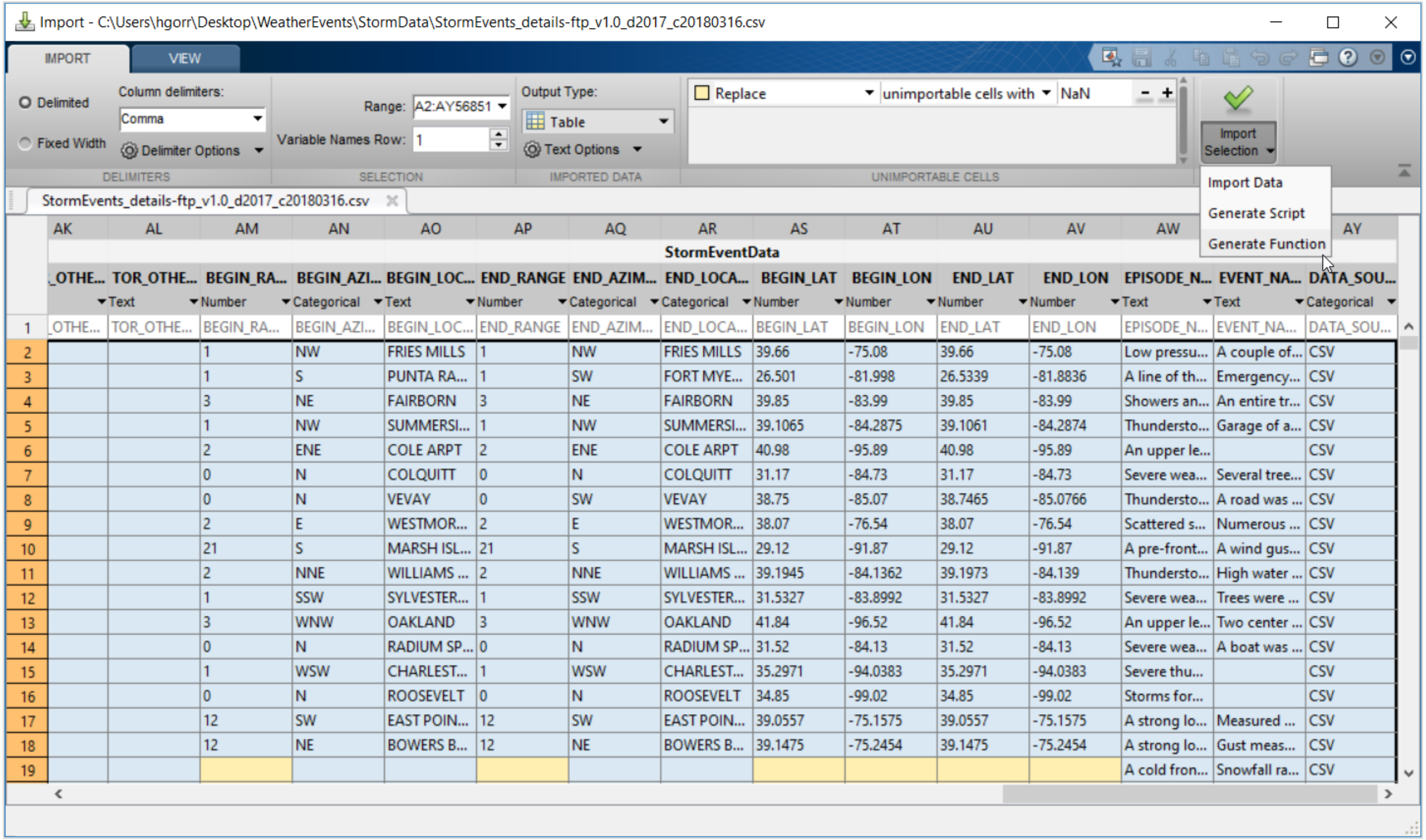
```
idx = startsWith(data.event_narrative,"snowfall");

data.event_narrative(idx)

ans = 767×1 string array
    "snowfall amounts across the county ranged from 7 to 12 inches. th
    "snowfall totals were generally between 3 inches and 5 inches acro
    "snowfall of 3 to 5 inches over 3 days, and previously existing de
```

Access data interactively using the Import Tool

- Select data types
- Choose what to do with missing data
- Generate MATLAB code



Import - C:\Users\hgorr\Desktop\WeatherEvents\StormData\StormEvents_details-ftp_v1.0_d2017_c20180316.csv

● Delimited ○ Fixed Width

Column delimiters: Comma

Range: A2:AY56851

Variable Names Row: 1

Output Type: Table

□ Replace unimportable cells with NaN

StormEvents_details-ftp_v1.0_d2017_c20180316.csv

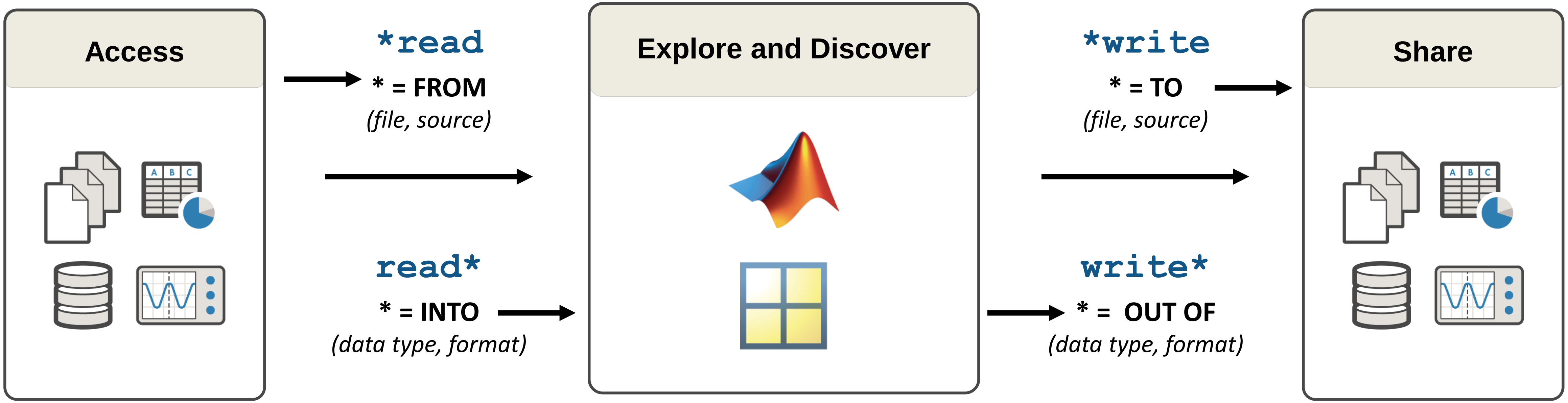
StormEventData

	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW		AY
	_OTHE...	TOR_OTHE...	BEGIN_RA...	BEGIN_AZI...	BEGIN_LOC...	END_RANGE	END_AZIM...	END_LOCA...	BEGIN_LAT	BEGIN_LON	END_LAT	END_LON	EPISODE_N...	EVENT_NA...	DATA_SOU...
		Text	Number	Categorical	Text	Number	Categorical	Categorical	Number	Number	Number	Number	Text	Text	Categorical
1	_OTHE...	TOR_OTHE...	BEGIN_RA...	BEGIN_AZI...	BEGIN_LOC...	END_RANGE	END_AZIM...	END_LOCA...	BEGIN_LAT	BEGIN_LON	END_LAT	END_LON	EPISODE_N...	EVENT_NA...	DATA_SOU...
2			1	NW	FRIES MILLS	1	NW	FRIES MILLS	39.66	-75.08	39.66	-75.08	Low pressu...	A couple of...	CSV
3			1	S	PUNTA RA...	1	SW	FORT MYE...	26.501	-81.998	26.5339	-81.8836	A line of th...	Emergency...	CSV
4			3	NE	FAIRBORN	3	NE	FAIRBORN	39.85	-83.99	39.85	-83.99	Showers an...	An entire tr...	CSV
5			1	NW	SUMMERSI...	1	NW	SUMMERSI...	39.1065	-84.2875	39.1061	-84.2874	Thundersto...	Garage of a...	CSV
6			2	ENE	COLE ARPT	2	ENE	COLE ARPT	40.98	-95.89	40.98	-95.89	An upper le...		CSV
7			0	N	COLQUITT	0	N	COLQUITT	31.17	-84.73	31.17	-84.73	Severe wea...	Several tree...	CSV
8			0	N	VEVAY	0	SW	VEVAY	38.75	-85.07	38.7465	-85.0766	Thundersto...	A road was ...	CSV
9			2	E	WESTMOR...	2	E	WESTMOR...	38.07	-76.54	38.07	-76.54	Scattered s...	Numerous ...	CSV
10			21	S	MARSH ISL...	21	S	MARSH ISL...	29.12	-91.87	29.12	-91.87	A pre-front...	A wind gus...	CSV
11			2	NNE	WILLIAMS ...	2	NNE	WILLIAMS ...	39.1945	-84.1362	39.1973	-84.139	Thundersto...	High water ...	CSV
12			1	SSW	SYLVESTER...	1	SSW	SYLVESTER...	31.5327	-83.8992	31.5327	-83.8992	Severe wea...	Trees were ...	CSV
13			3	WNW	OAKLAND	3	WNW	OAKLAND	41.84	-96.52	41.84	-96.52	An upper le...	Two center ...	CSV
14			0	N	RADIUM SP...	0	N	RADIUM SP...	31.52	-84.13	31.52	-84.13	Severe wea...	A boat was ...	CSV
15			1	WSW	CHARLEST...	1	WSW	CHARLEST...	35.2971	-94.0383	35.2971	-94.0383	Severe thu...		CSV
16			0	N	ROOSEVELT	0	N	ROOSEVELT	34.85	-99.02	34.85	-99.02	Storms for...		CSV
17			12	SW	EAST POIN...	12	SW	EAST POIN...	39.0557	-75.1575	39.0557	-75.1575	A strong lo...	Measured ...	CSV
18			12	NE	BOWERS B...	12	NE	BOWERS B...	39.1475	-75.2454	39.1475	-75.2454	A strong lo...	Gust meas...	CSV
19													A cold fron...	Snowfall ra...	CSV

New functions for reading and writing data

```
parquetread
thingSpeakRead
...
```

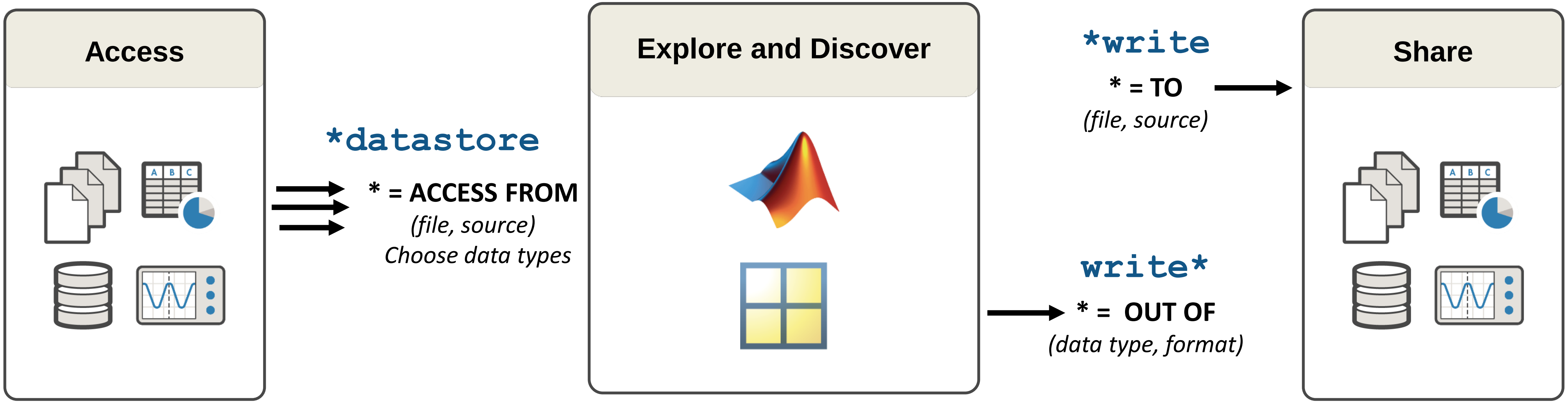
```
parquetwrite
thingSpeakWrite
...
```



```
readtimetable
readcell
readmatrix
readstruct
...
```

```
writetimetable
writecell
writematrix
writestruct
...
```

Use datastores for reading collections of files, or parts of a file/database a chunk at a time



Access

`*datastore`

* = ACCESS FROM

(file, source)

Choose data types

Explore and Discover

`*write`

* = TO

(file, source)

`write*`

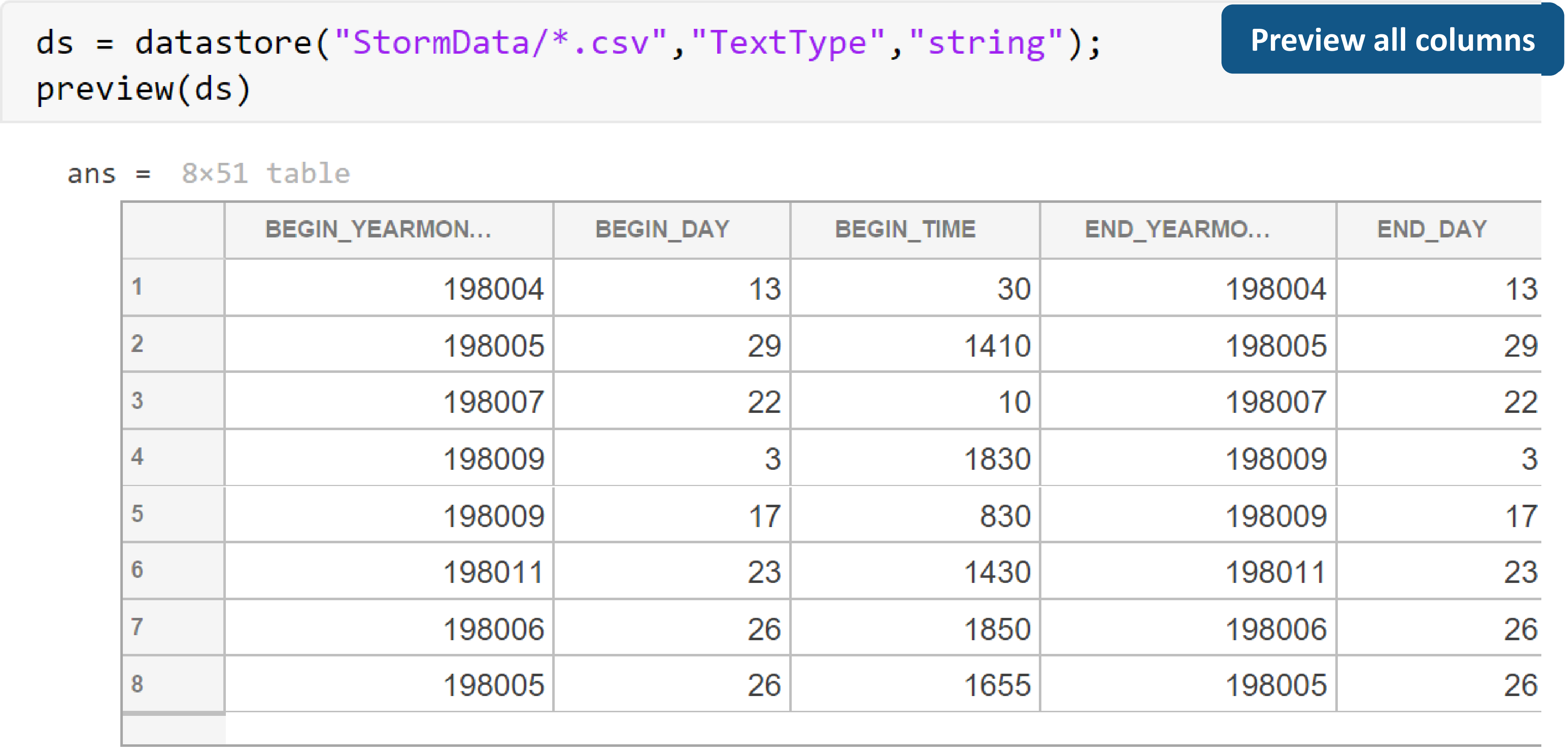
* = OUT OF

(data type, format)

Share

[Select Datastore for File Format or Application](#)

Preview and adjust properties to best represent the data



```
ds = datastore("StormData/*.csv","TextType","string");
preview(ds)
```

Preview all columns

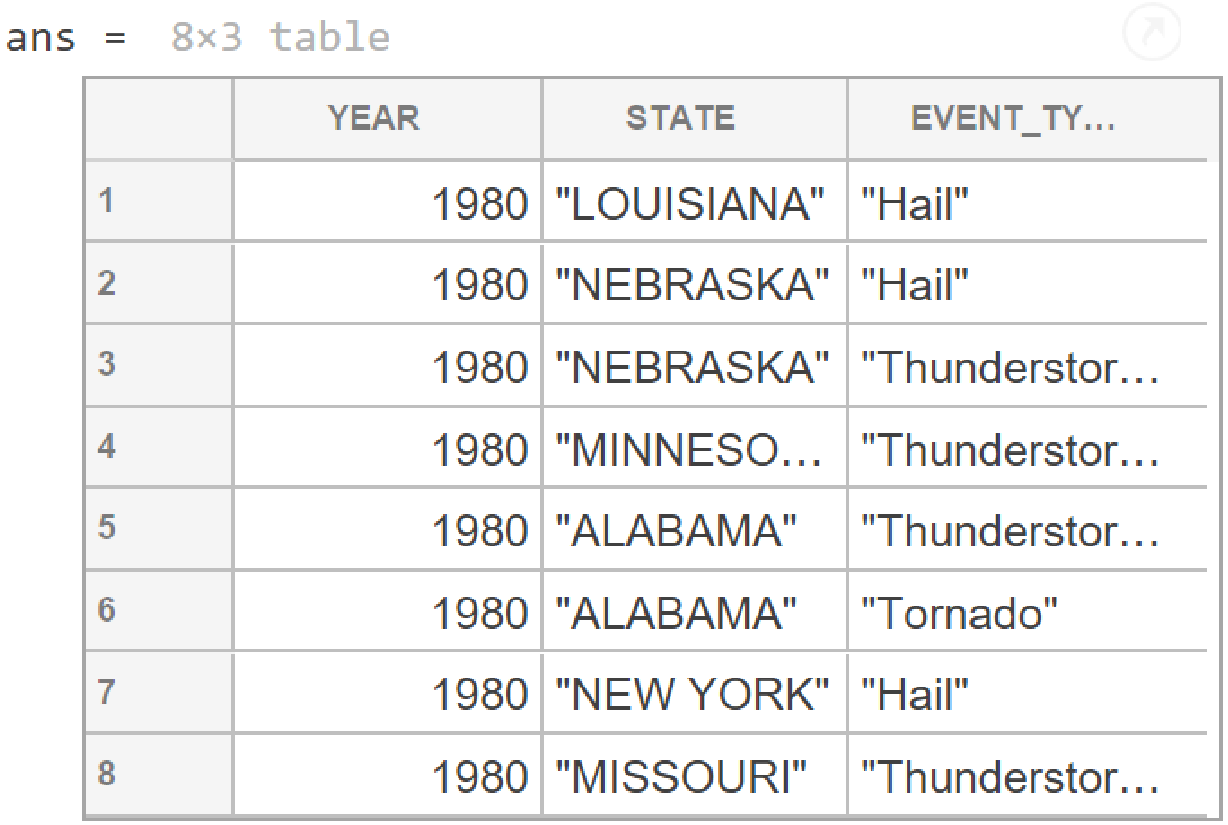
```
ans =  8×51 table
```

	BEGIN_YEARMON...	BEGIN_DAY	BEGIN_TIME	END_YEARMO...	END_DAY
1	198004	13	30	198004	13
2	198005	29	1410	198005	29
3	198007	22	10	198007	22
4	198009	3	1830	198009	3
5	198009	17	830	198009	17
6	198011	23	1430	198011	23
7	198006	26	1850	198006	26
8	198005	26	1655	198005	26

Preview and adjust properties to best represent the data

```
ds.SelectedVariableNames = ["YEAR","STATE","EVENT_TYPE"];
preview(ds)
```

Select subset



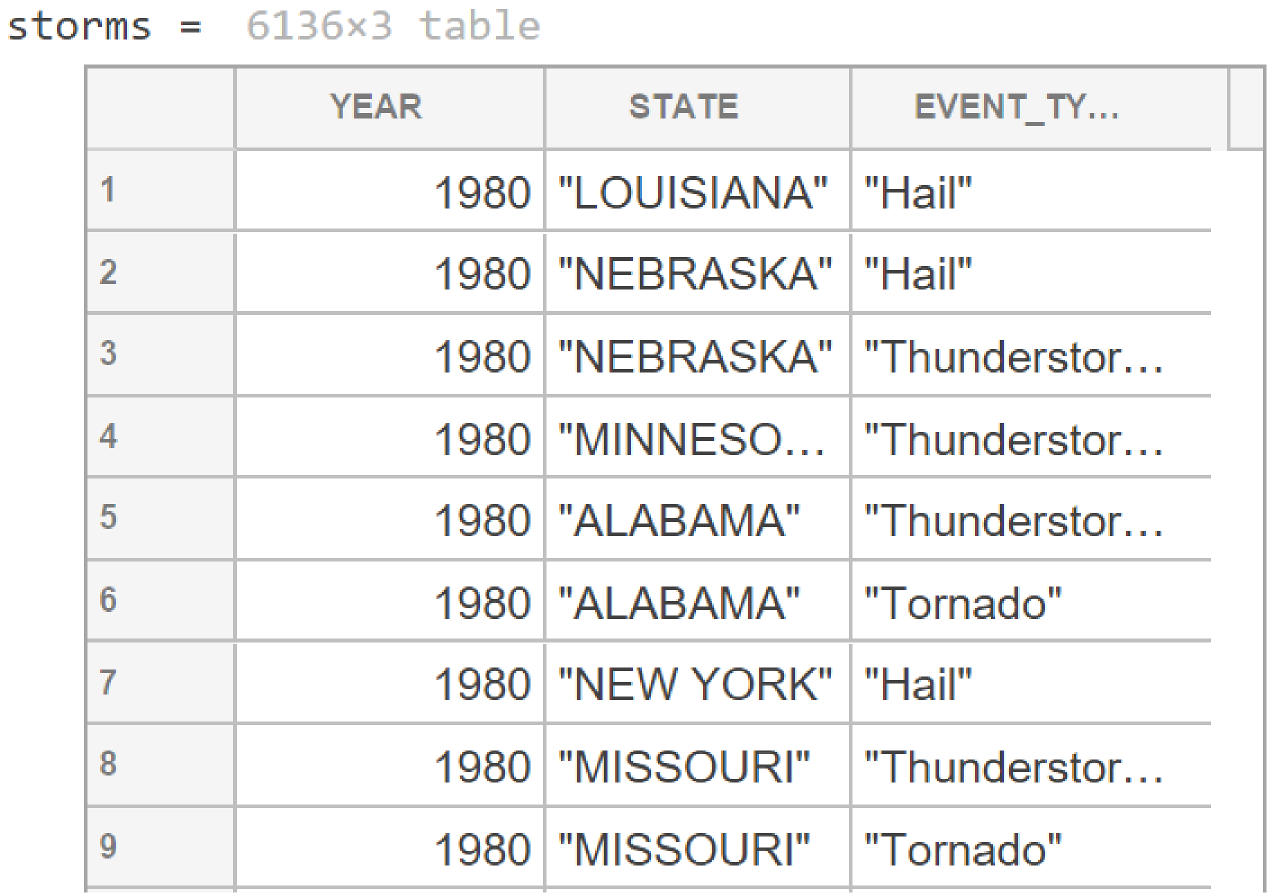
```
ans = 8×3 table
```

	YEAR	STATE	EVENT_TY...
1	1980	"LOUISIANA"	"Hail"
2	1980	"NEBRASKA"	"Hail"
3	1980	"NEBRASKA"	"Thunderstor...
4	1980	"MINNESO...	"Thunderstor...
5	1980	"ALABAMA"	"Thunderstor...
6	1980	"ALABAMA"	"Tornado"
7	1980	"NEW YORK"	"Hail"
8	1980	"MISSOURI"	"Thunderstor...

Preview and adjust properties to best represent the data

```
storms = read(ds)
```

Read first block

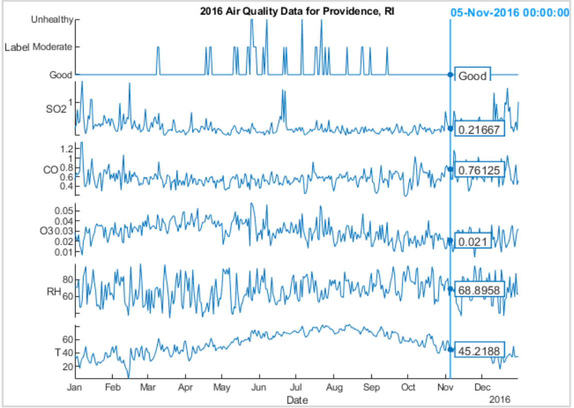


```
storms =  6136×3 table
```

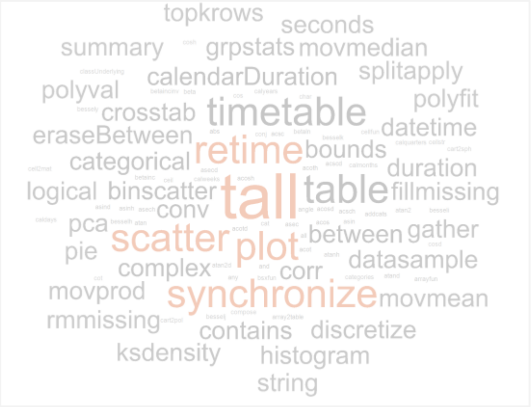
	YEAR	STATE	EVENT_TY...
1	1980	"LOUISIANA"	"Hail"
2	1980	"NEBRASKA"	"Hail"
3	1980	"NEBRASKA"	"Thunderstor…
4	1980	"MINNESO…	"Thunderstor…
5	1980	"ALABAMA"	"Thunderstor…
6	1980	"ALABAMA"	"Tornado"
7	1980	"NEW YORK"	"Hail"
8	1980	"MISSOURI"	"Thunderstor…
9	1980	"MISSOURI"	"Tornado"

Data Analysis & Visualization

Access

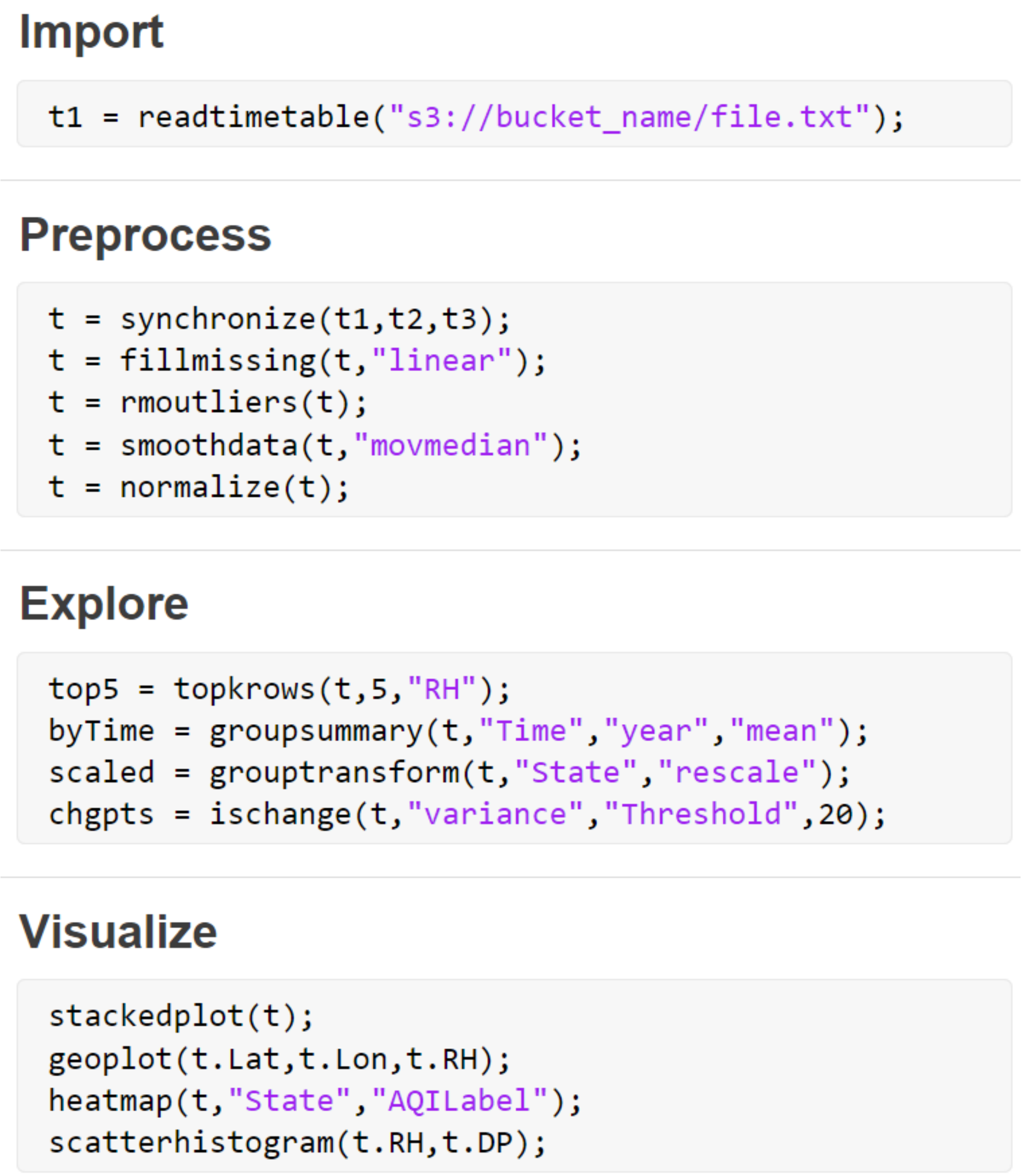


Analysis & Visualization



Big Data

Preprocessing and analyzing data is easier than ever



Import

```
t1 = readtimetable("s3://bucket_name/file.txt");
```

Preprocess

```
t = synchronize(t1,t2,t3);
t = fillmissing(t,"linear");
t = rmoutliers(t);
t = smoothdata(t,"movmedian");
t = normalize(t);
```

Explore

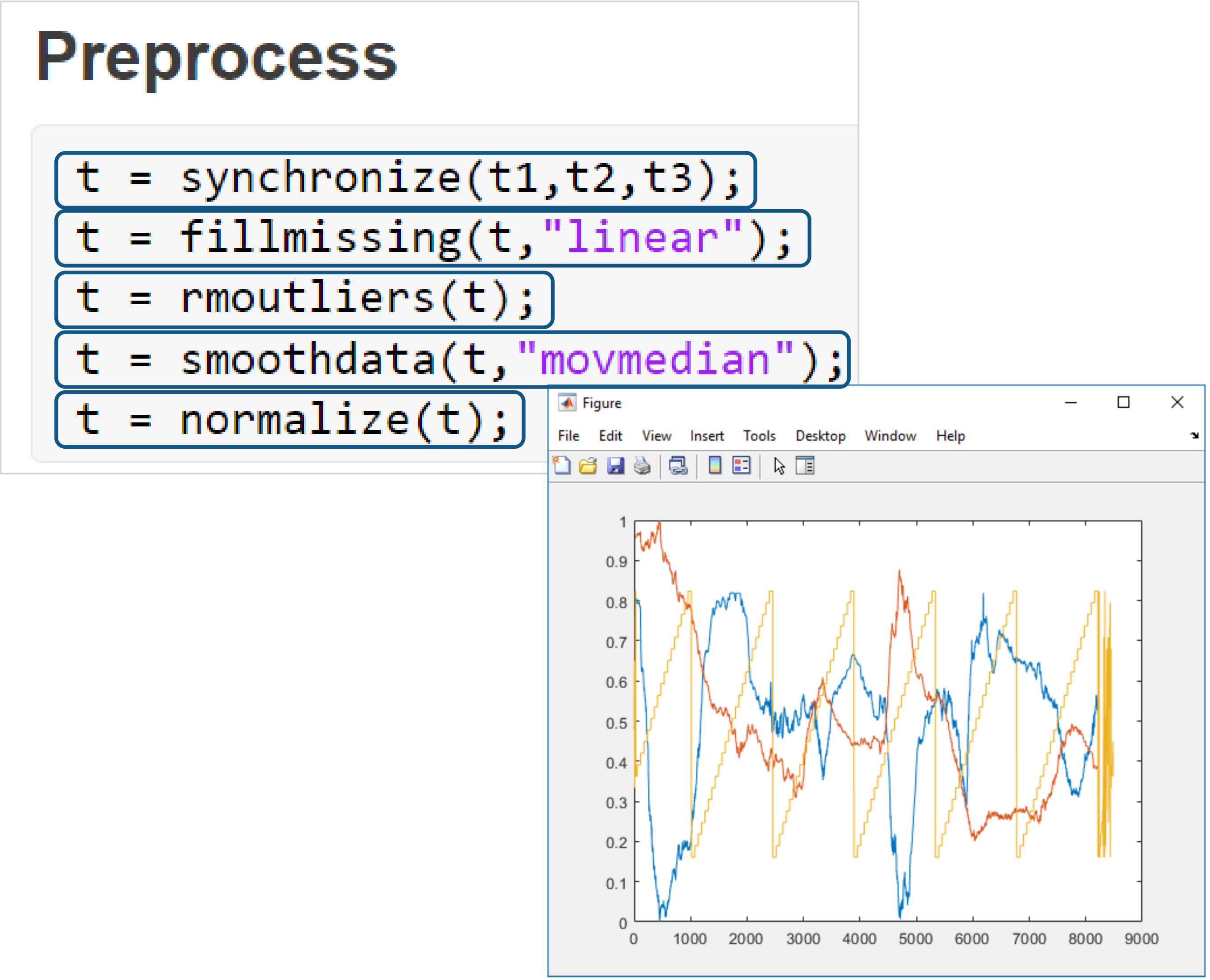
```
top5 = topkrows(t,5,"RH");
byTime = groupsummary(t,"Time","year","mean");
scaled = grouptransform(t,"State","rescale");
chgpts = ischange(t,"variance","Threshold",20);
```

Visualize

```
stackedplot(t);
geoplot(t.Lat,t.Lon,t.RH);
heatmap(t,"State","AQILabel");
scatterhistogram(t.RH,t.DP);
```

New functions for common preprocessing tasks

- Synchronize by time
- Find, fill, and remove missing
- Work with outliers
- Smooth noisy data
- Normalize, rescale data

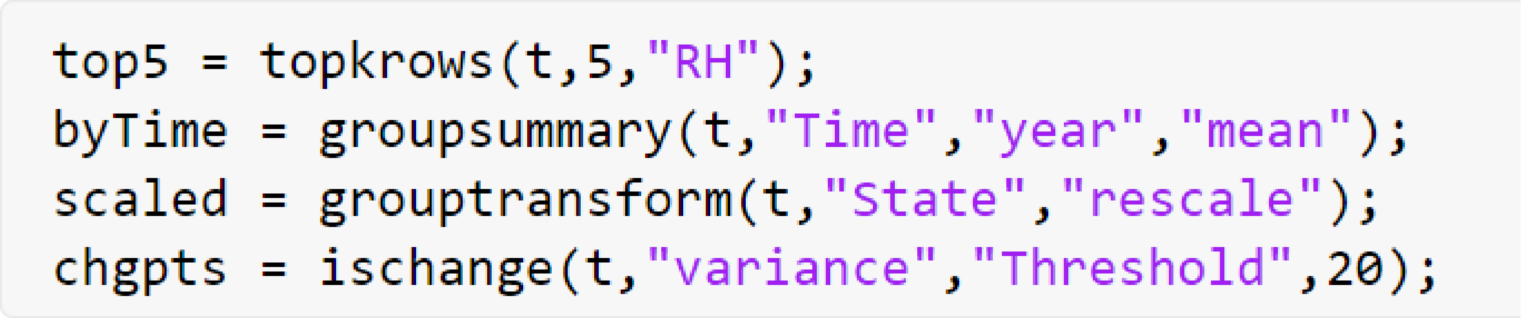


Preprocess

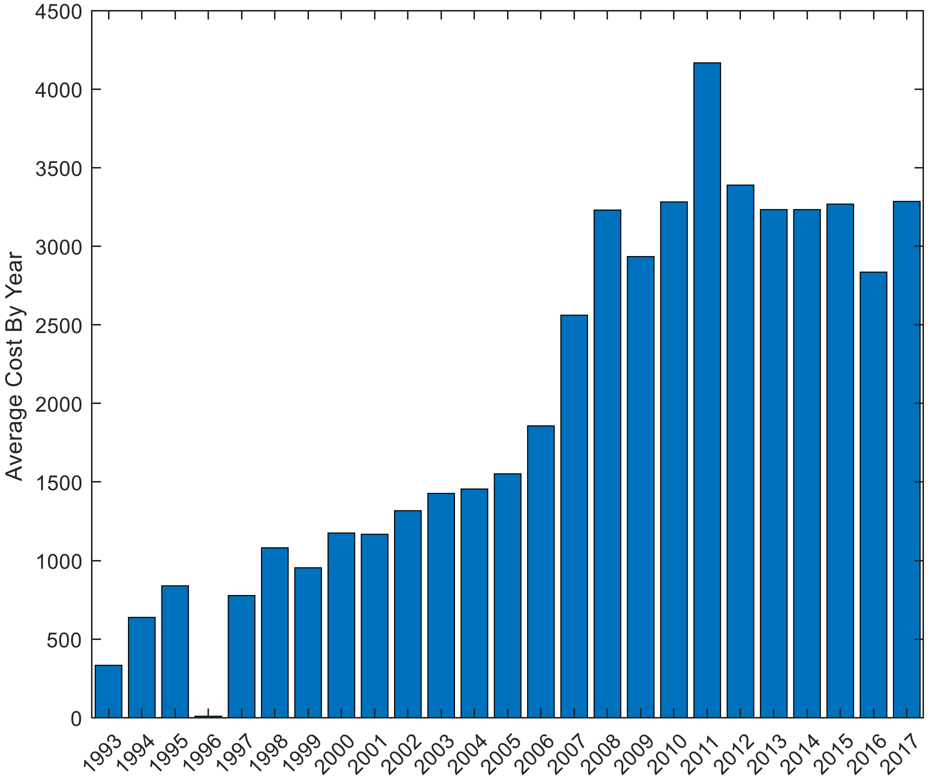
```
t = synchronize(t1,t2,t3);
t = fillmissing(t,"linear");
t = rmoutliers(t);
t = smoothdata(t,"movmedian");
t = normalize(t);
```

New functions for data analysis

- Explore range
- Grouped calculations
- Detect local minima and maxima
- Detect abrupt changes in data with `ischange`

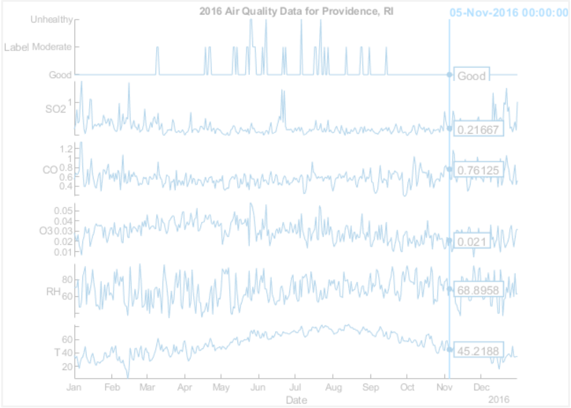


```
top5 = topkrows(t,5,"RH");
byTime = groupsummary(t,"Time","year","mean");
scaled = grouptransform(t,"State","rescale");
chgpts = ischange(t,"variance","Threshold",20);
```

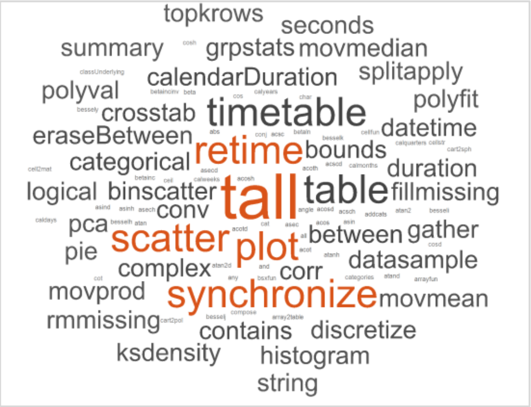


Data Analysis & Visualization

Access



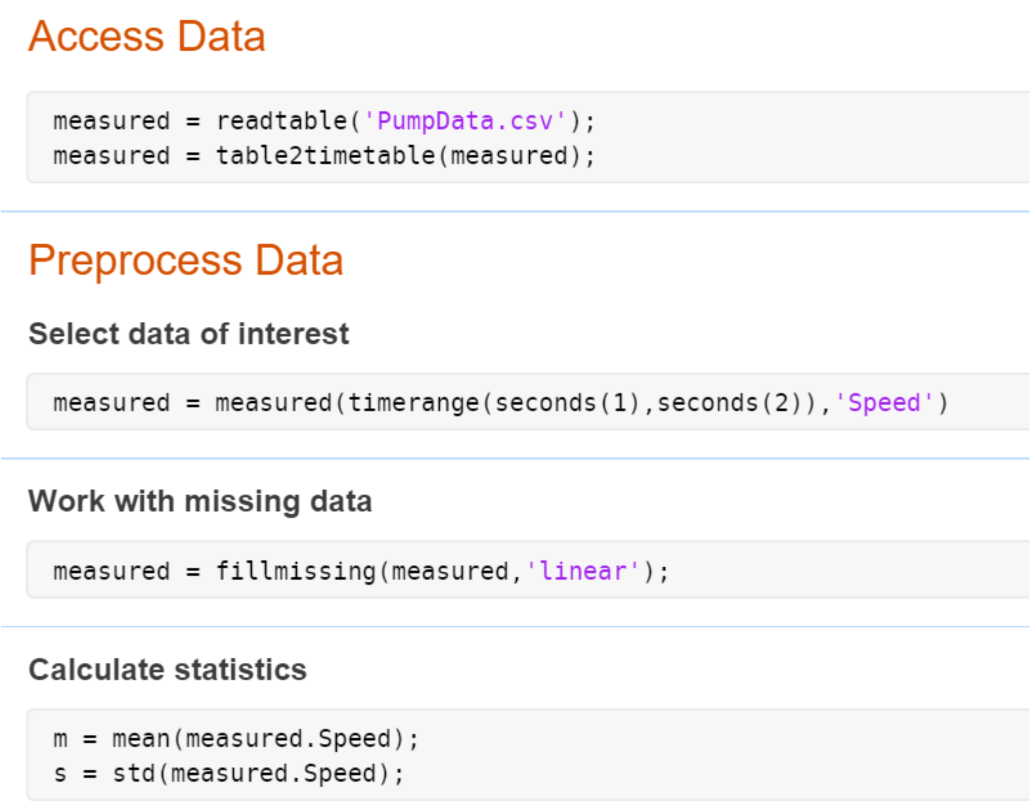
Analysis & Visualization



Big Data

Big Data Without Big Changes

One file



Access Data

```
measured = readtable('PumpData.csv');
measured = table2timetable(measured);
```

Preprocess Data

Select data of interest

```
measured = measured(timerange(seconds(1),seconds(2)),'Speed')
```

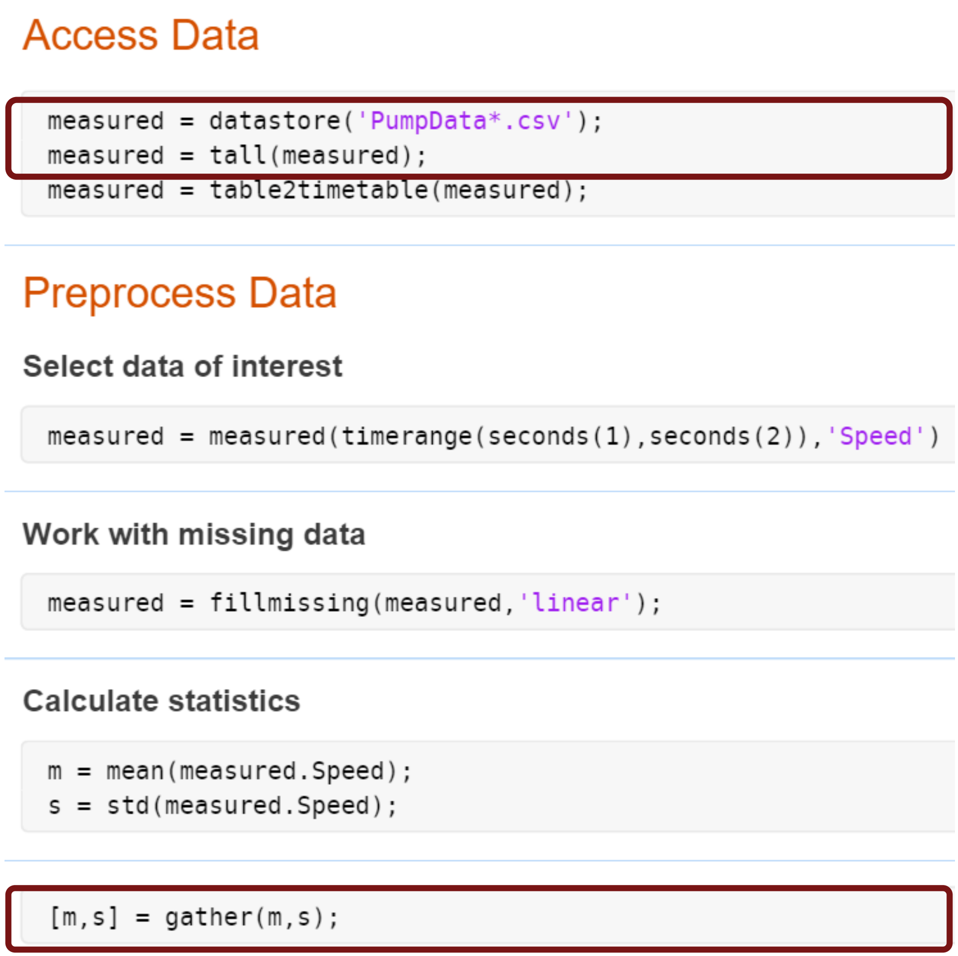
Work with missing data

```
measured = fillmissing(measured,'linear');
```

Calculate statistics

```
m = mean(measured.Speed);
s = std(measured.Speed);
```

One hundred files



Access Data

```
measured = datastore('PumpData*.csv');
measured = tall(measured);
measured = table2timetable(measured);
```

Preprocess Data

Select data of interest

```
measured = measured(timerange(seconds(1),seconds(2)),'Speed')
```

Work with missing data

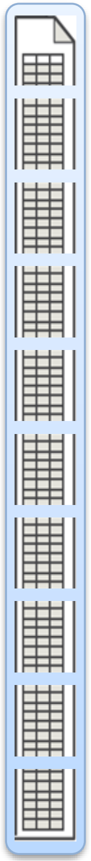
```
measured = fillmissing(measured,'linear');
```

Calculate statistics

```
m = mean(measured.Speed);
s = std(measured.Speed);
```

```
[m,s] = gather(m,s);
```

`tall` Arrays R2016b



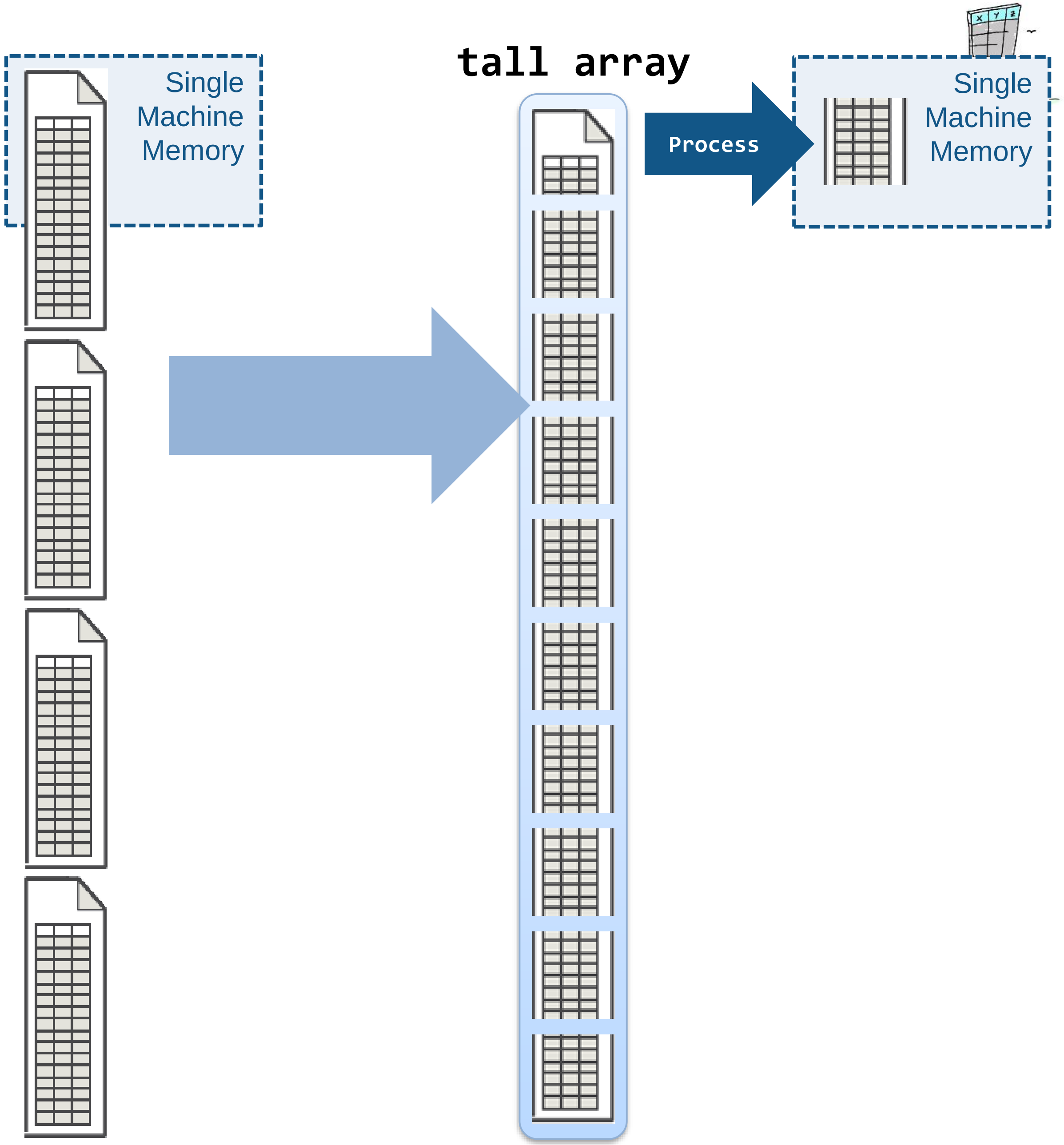
- New data type designed for data that doesn't fit into memory
- Lots of observations (hence "tall")
- Looks like a normal MATLAB array
  - Supports numeric types, tables, datetimes, strings, etc…
  - Supports several hundred functions for basic math, stats, indexing, etc.
  - **Statistics and Machine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

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

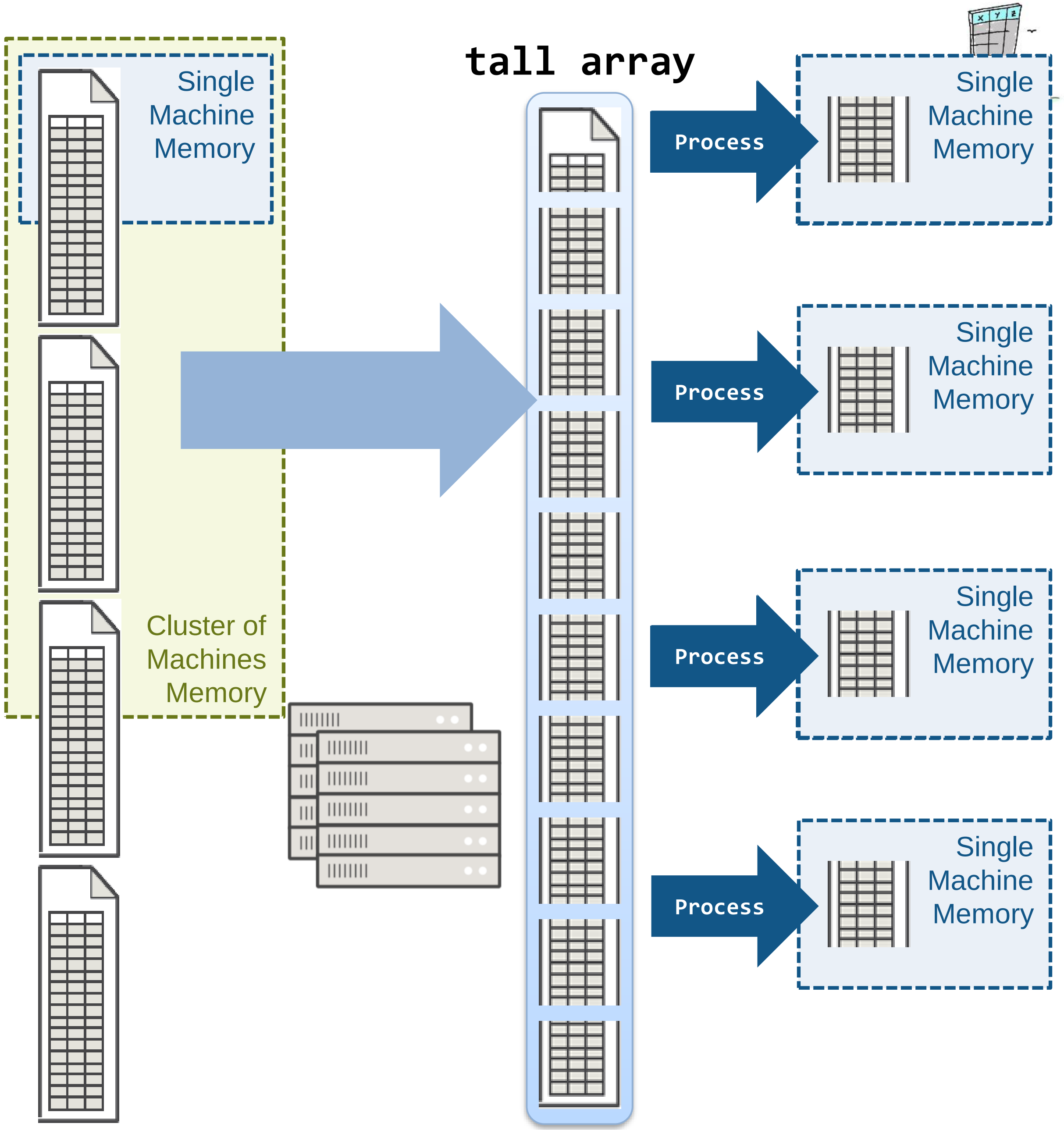
- Processing code for tall arrays is the same as ordinary arrays



`tall` Arrays R2016b

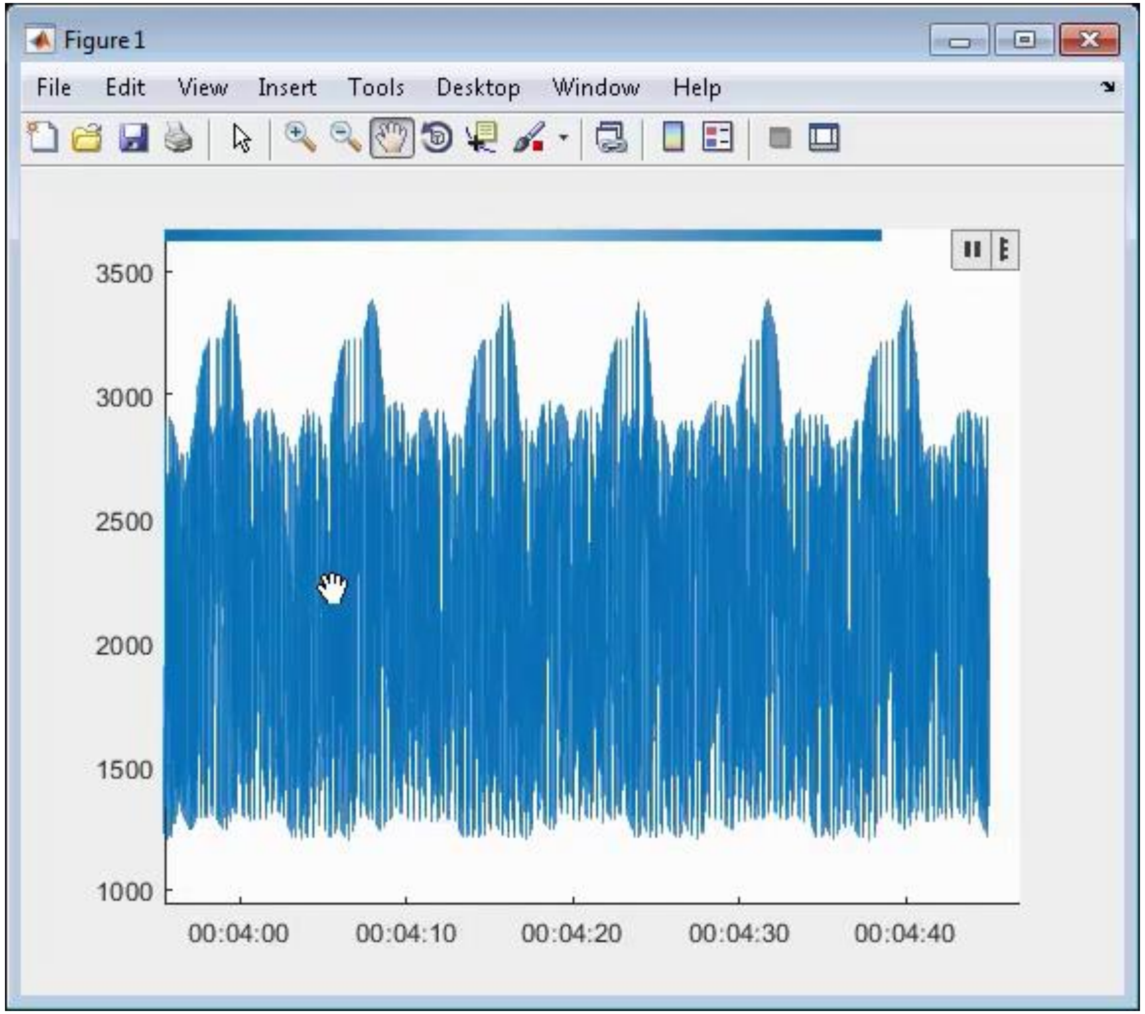
- With Parallel Computing Toolbox, process several “chunks” at once

- Can scale up to clusters with MATLAB Parallel Server



Visualizing Big Data Using `tall` Arrays

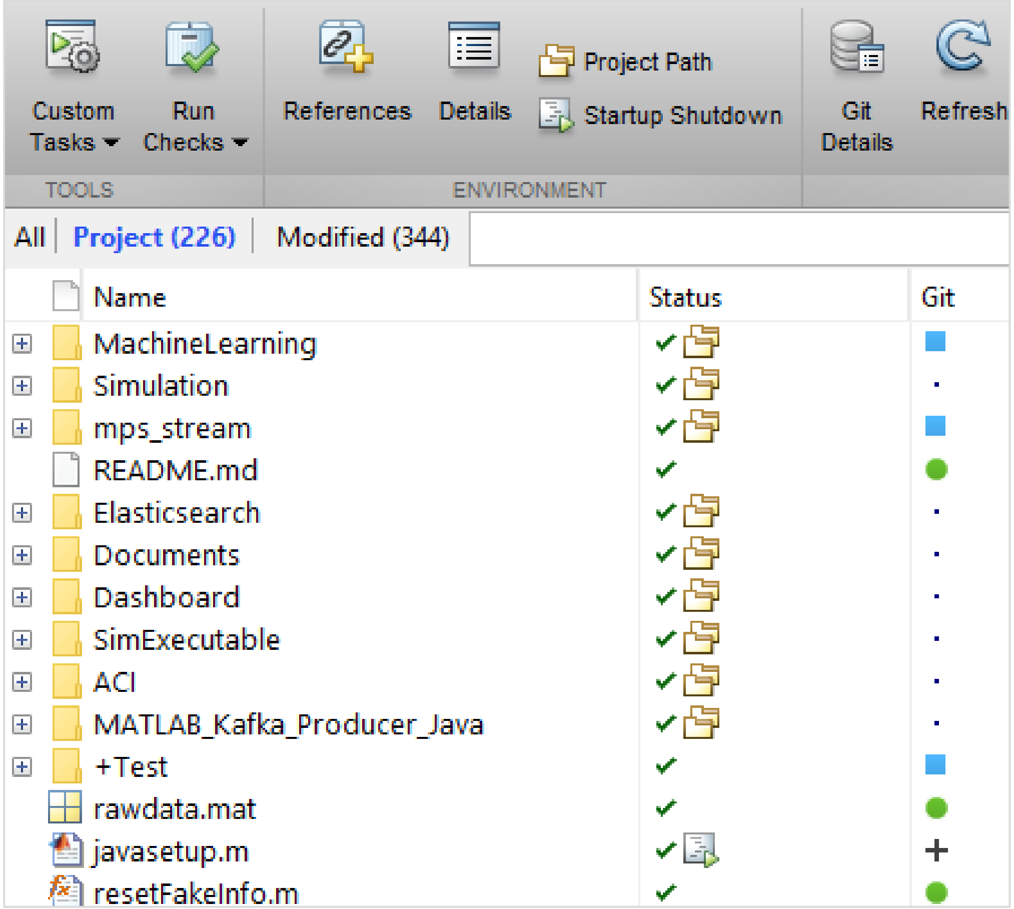
- Support for:
  - `histogram`
  - `histogram2`
  - `ksdensity`
  - `plot`
  - `scatter`
  - `binscatter`
  - `wordcloud`
  - `heatmap`



- Support will continue to grow!

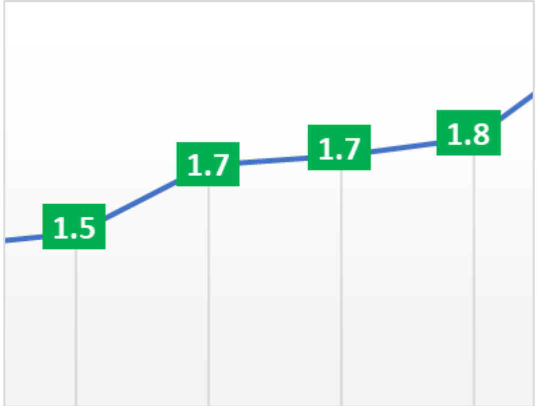
Agenda

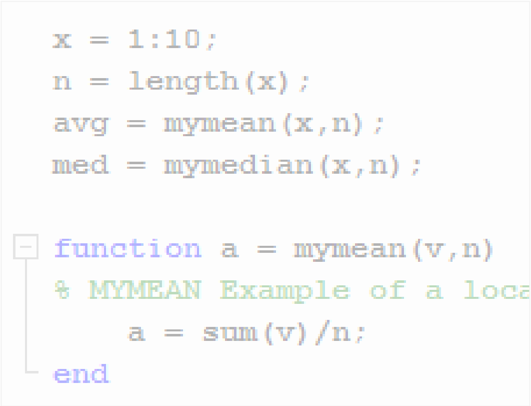
- Desktop & Live Editor
- Data Analysis & Visualization
- Language & Programming
- App Building & Sharing
- Hardware Support
- Toolbox Updates



Name	Status	Git
MachineLearning	✓	🟦
Simulation	✓	·
mps_stream	✓	🟦
README.md	✓	●
Elasticsearch	✓	·
Documents	✓	·
Dashboard	✓	·
SimExecutable	✓	·
ACI	✓	·
MATLAB_Kafka_Producer_Java	✓	·
+Test	✓	🟦
rawdata.mat	✓	●
javasetup.m	✓	+
resetFakeInfo.m	✓	●

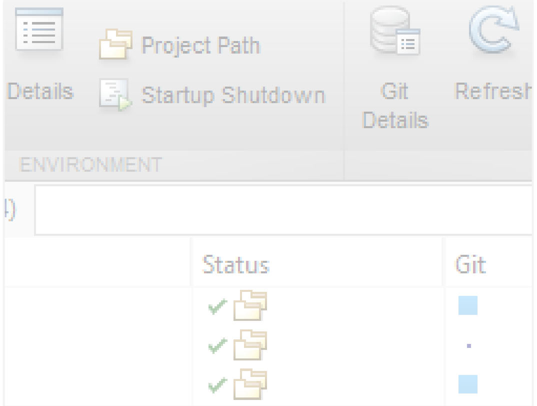
Language & Programming





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

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



Language Execution

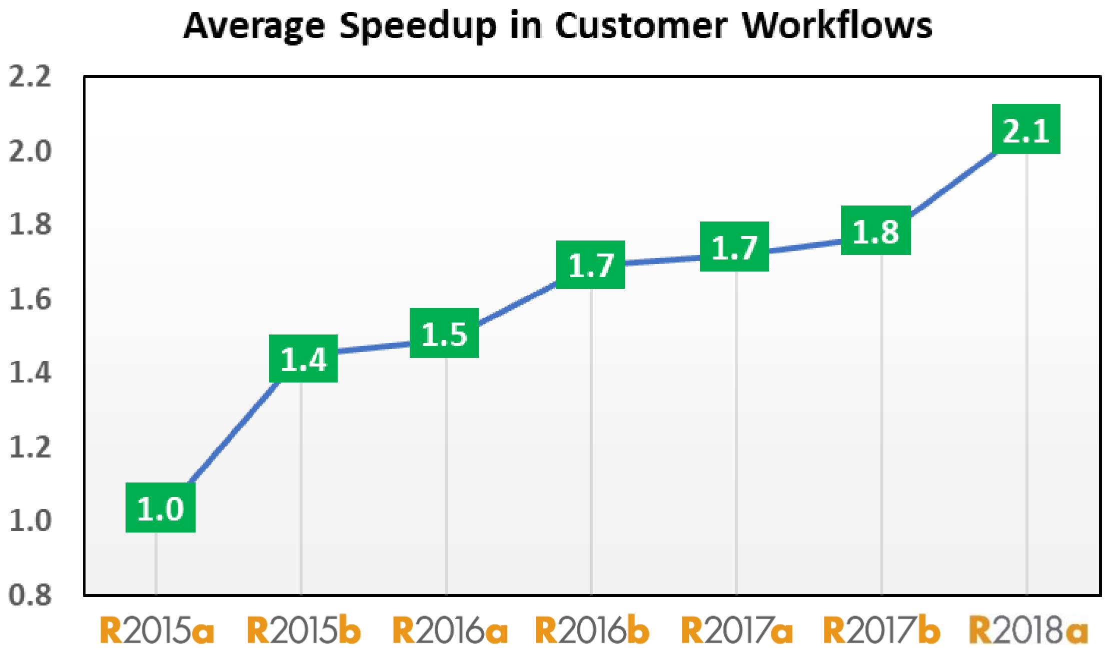
Programming

Collaboration and Maintenance

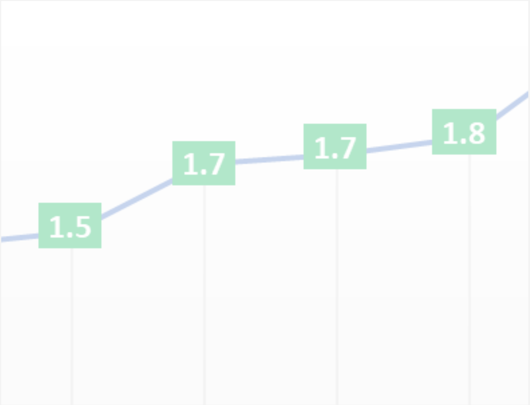
Run MATLAB code faster with redesigned execution engine.

R2015b

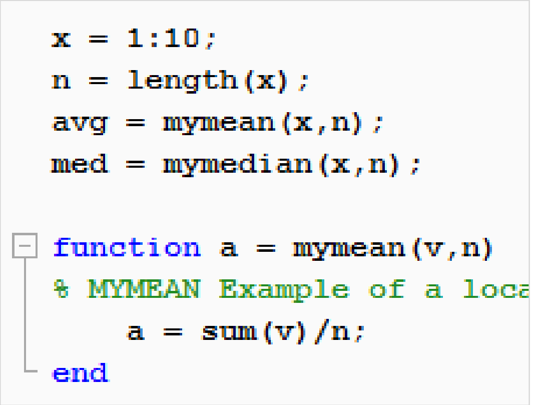
- All MATLAB code is now JIT compiled
- Incremental improvements each release
  - Execute loops with scalar math faster
  - Construct objects and set properties faster
  - Improved script and try/catch performance
  - Render plots with large numbers of markers faster using less memory
  - Increased speed of MATLAB startup



Language & Programming



Language Execution



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

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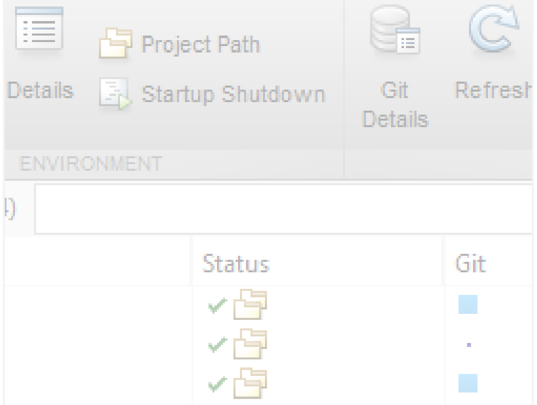
% MYMEAN Example of a loca
    a = sum(v)/n;
end
```

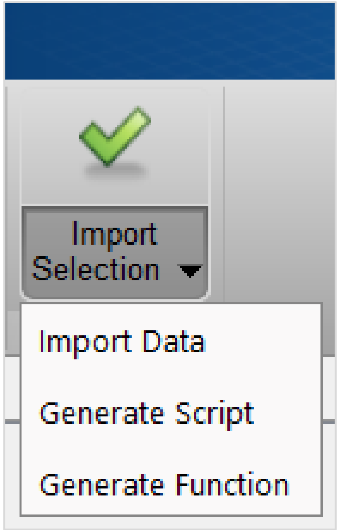
Programming

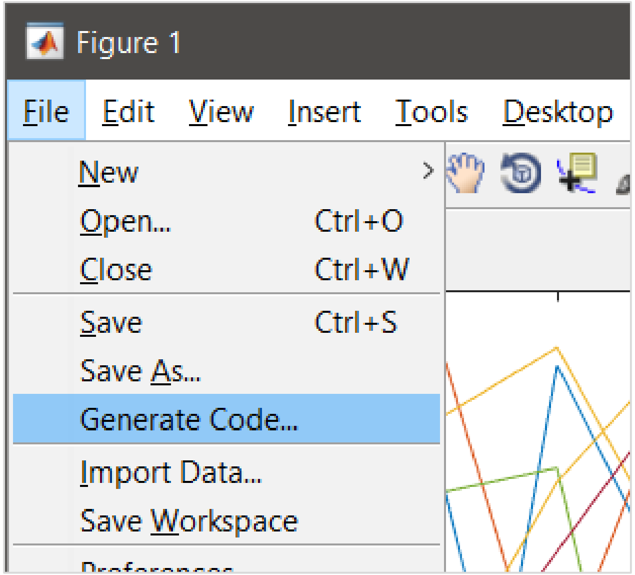


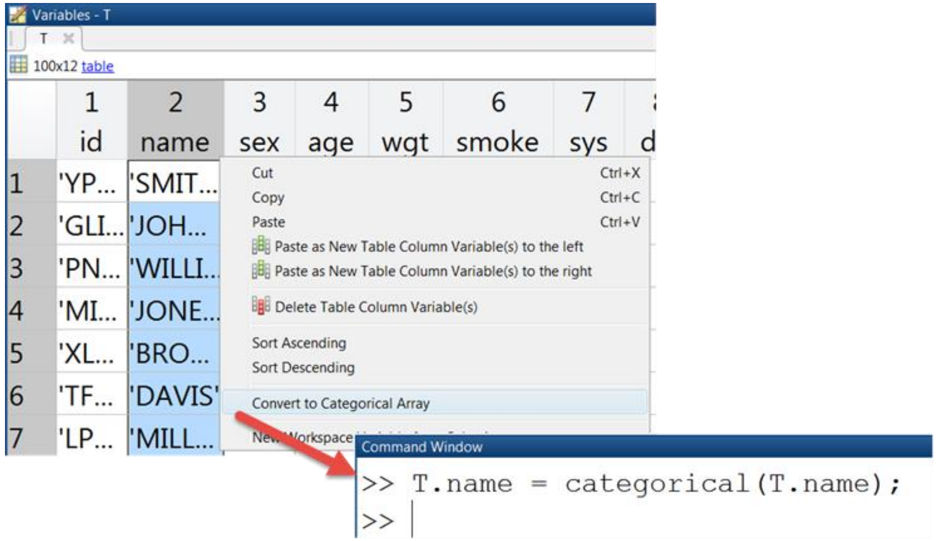
Collaboration and Maintenance

Automatically Generate MATLAB Code

- 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





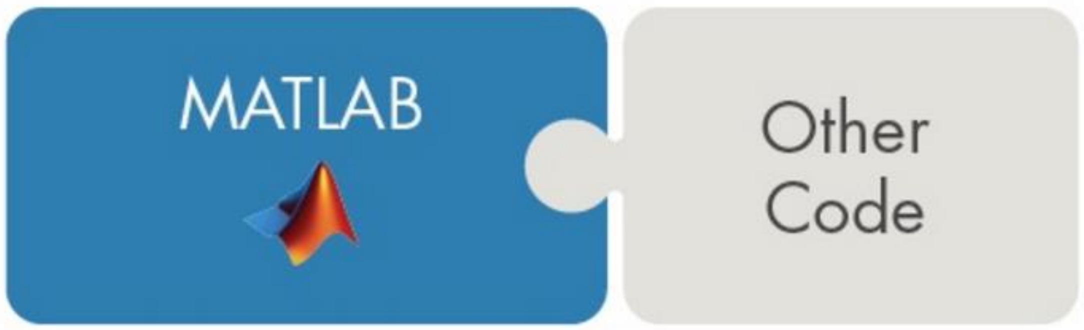

Variables - T
T
100x12 table
Cut Ctrl+X
Copy Ctrl+C
Paste Ctrl+V
Paste as New Table Column Variable(s) to the left
Paste as New Table Column Variable(s) to the right
Delete Table Column Variable(s)
Sort Ascending
Sort Descending
Convert to Categorical Array
New Workspace
Command Window

	1 id	2 name	3 sex	4 age	5 wgt	6 smoke	7 sys	d
1	'YP...	'SMIT...						
2	'GLI...	'JOH...						
3	'PN...	'WILLI...						
4	'MI...	'JONE...						
5	'XL...	'BRO...						
6	'TF...	'DAVIS'						
7	'LP...	'MILL...						

```
>> T.name = categorical(T.name);
>>
```

Using MATLAB with Other Languages

Calling Libraries Written in Another Language From MATLAB



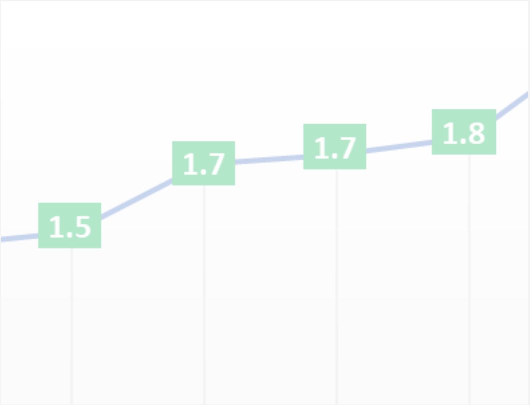
- Java
- Python
- C
- C++ → Call C++ libraries directly from MATLAB R2019a
- Fortran
- COM components and ActiveX® controls
- RESTful, HTTP, and WSDL web services

Calling MATLAB from Another Language

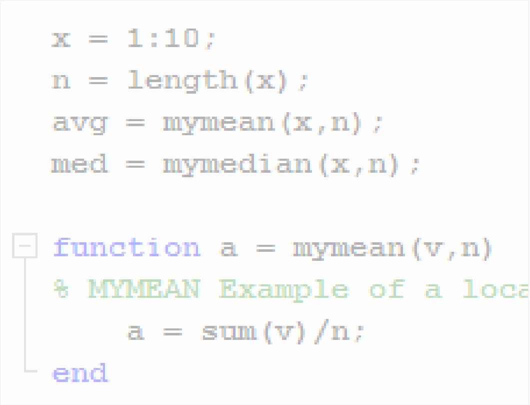
Your Coding Environment
MATLAB

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

Language & Programming



Language Execution



```
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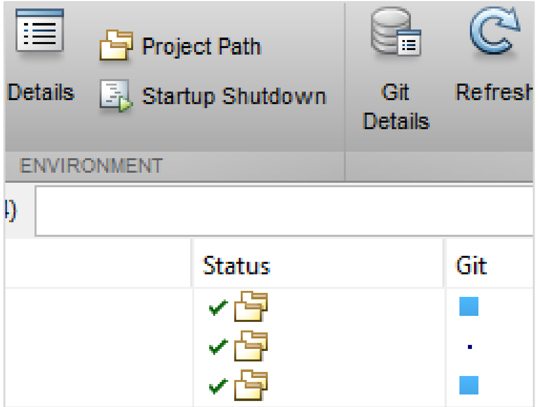
avg = mymean(x,n);
med = mymedian(x,n);

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

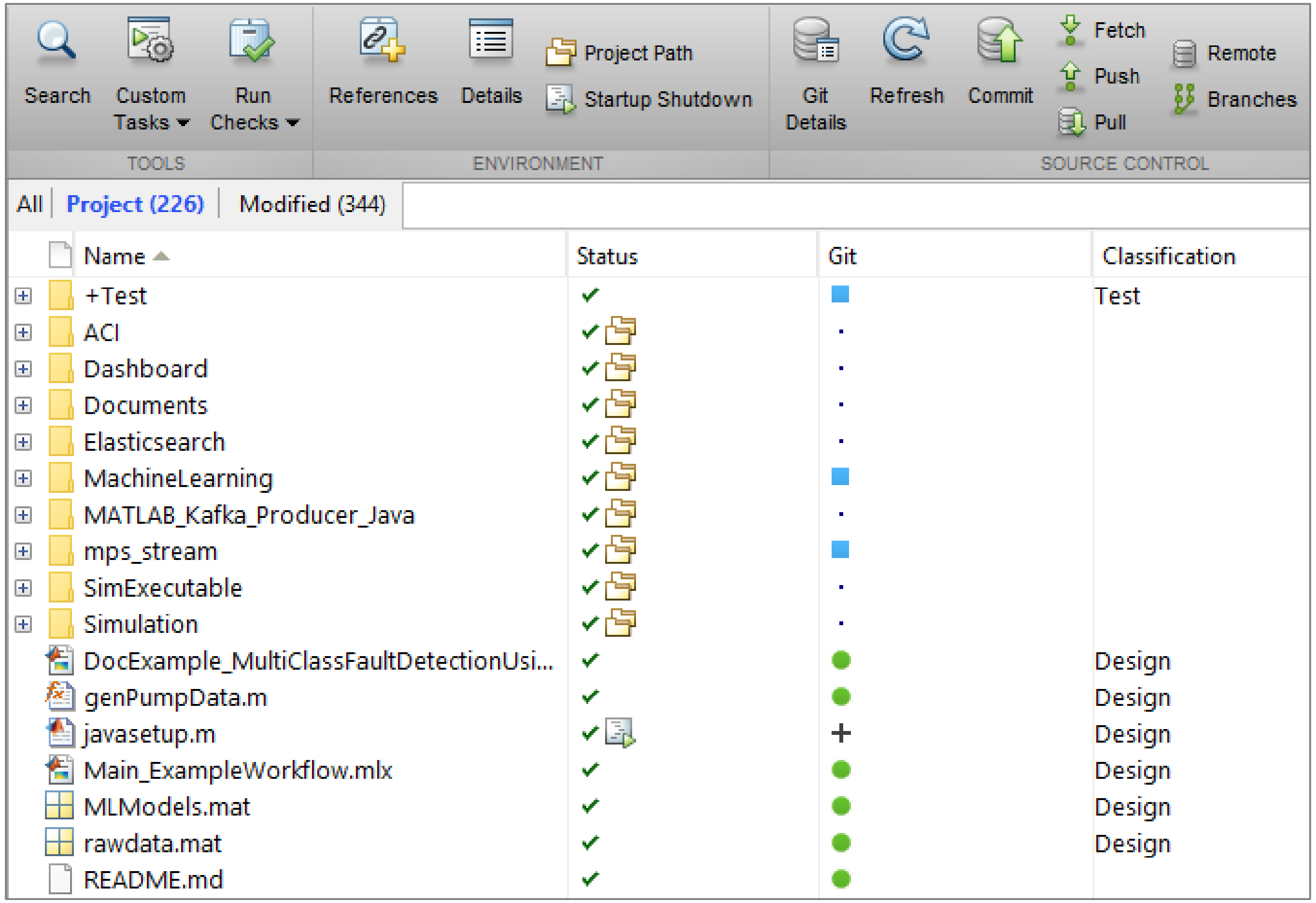
Programming



Collaboration and Maintenance

Organize, manage, and share your code with MATLAB projects R2019a

- Configure your environment
- Analyze dependencies
- Track and control changes
- Package and share projects

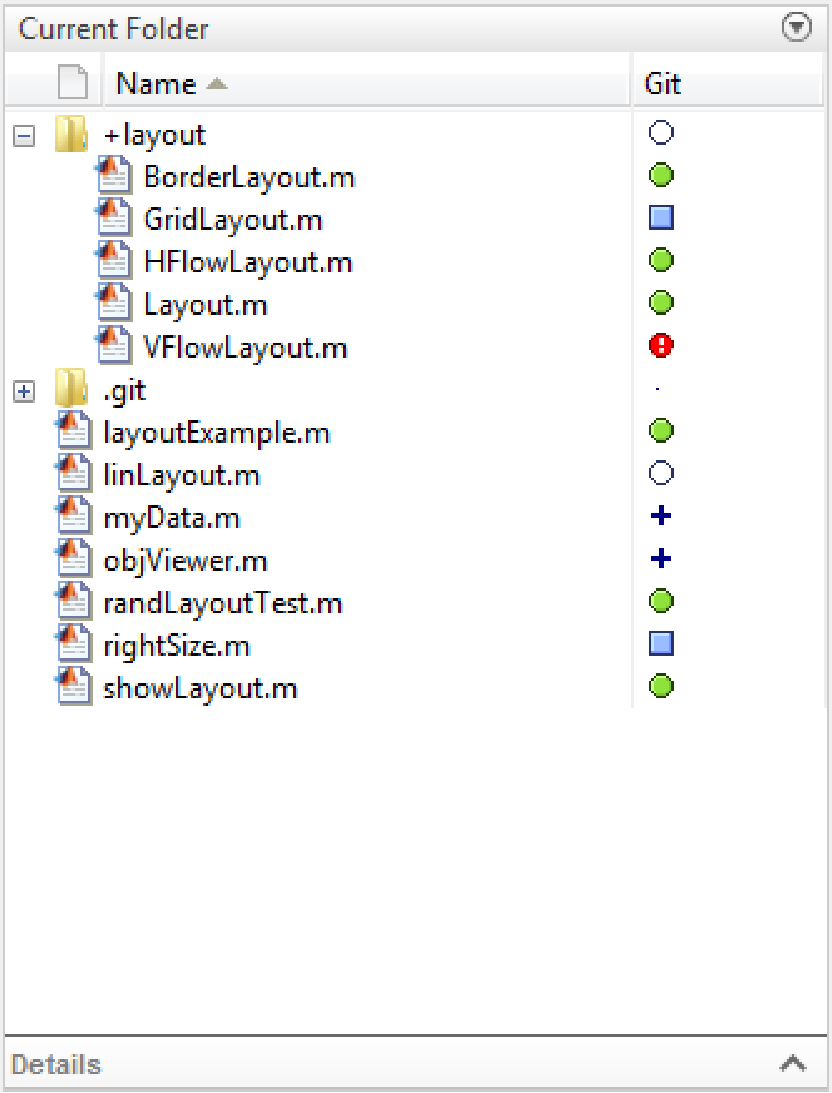


Name	Status	Git	Classification
+Test	✓	■	Test
ACI	✓	·	
Dashboard	✓	·	
Documents	✓	·	
Elasticsearch	✓	·	
MachineLearning	✓	■	
MATLAB_Kafka_Producer_Java	✓	·	
mps_stream	✓	■	
SimExecutable	✓	·	
Simulation	✓	·	
DocExample_MultiClassFaultDetectionUsi...	✓	●	Design
genPumpData.m	✓	●	Design
javasetup.m	✓	+	Design
Main_ExampleWorkflow.mlx	✓	●	Design
MLModels.mat	✓	●	Design
rawdata.mat	✓	●	Design
README.md	✓	●	

Source Control Integration

R2014b

- 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



Current Folder

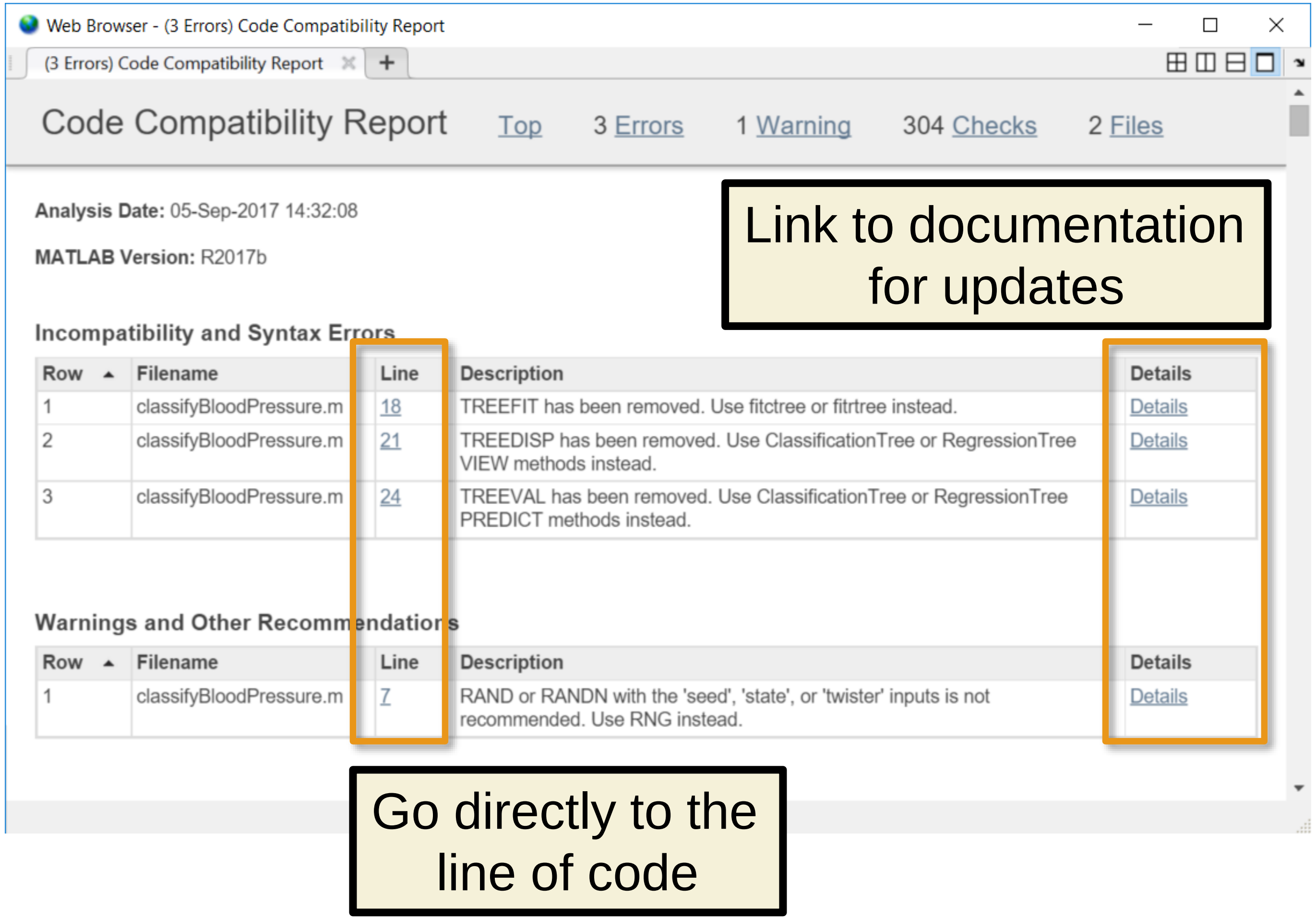
Name	Git
+layout	○
BorderLayout.m	●
GridLayout.m	■
HFlowLayout.m	●
Layout.m	●
VFlowLayout.m	!
.git	·
layoutExample.m	●
linLayout.m	○
myData.m	+
objViewer.m	+
randLayoutTest.m	●
rightSize.m	■
showLayout.m	●

Details

Code Compatibility Report

R2017b

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



Web Browser - (3 Errors) Code Compatibility Report
(3 Errors) Code Compatibility Report

Code Compatibility Report Top 3 Errors 1 Warning 304 Checks 2 Files

Analysis Date: 05-Sep-2017 14:32:08

MATLAB Version: R2017b

Incompatibility and Syntax Errors

Row	Filename	Line	Description	Details
1	classifyBloodPressure.m	18	TREEFIT has been removed. Use fitctree or fitrtree instead.	Details
2	classifyBloodPressure.m	21	TREEDISP has been removed. Use ClassificationTree or RegressionTree VIEW methods instead.	Details
3	classifyBloodPressure.m	24	TREEVAL has been removed. Use ClassificationTree or RegressionTree PREDICT methods instead.	Details

Warnings and Other Recommendations

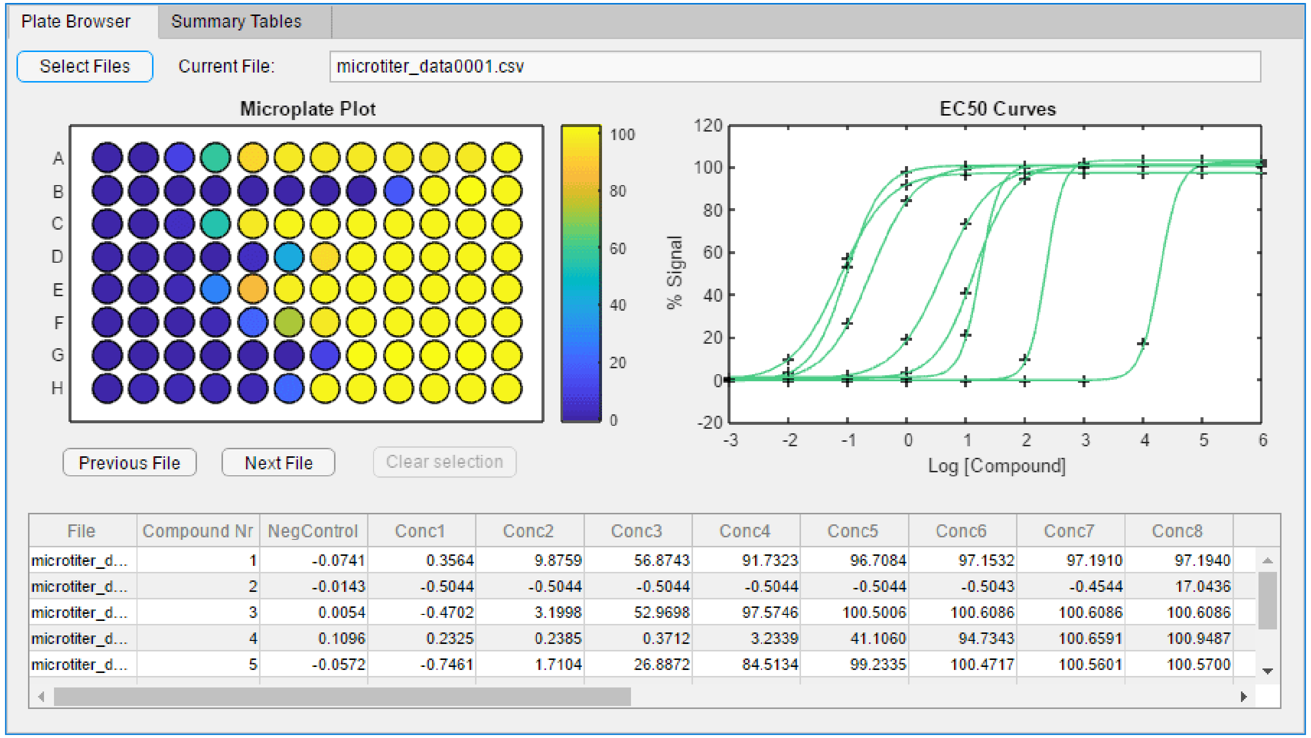
Row	Filename	Line	Description	Details
1	classifyBloodPressure.m	7	RAND or RANDN with the 'seed', 'state', or 'twister' inputs is not recommended. Use RNG instead.	Details

Link to documentation for updates

Go directly to the line of code

Agenda

- Desktop & Live Editor
- Data Analysis & Visualization
- Language & Programming
- App Building & Sharing
- Hardware Support
- Toolbox Updates

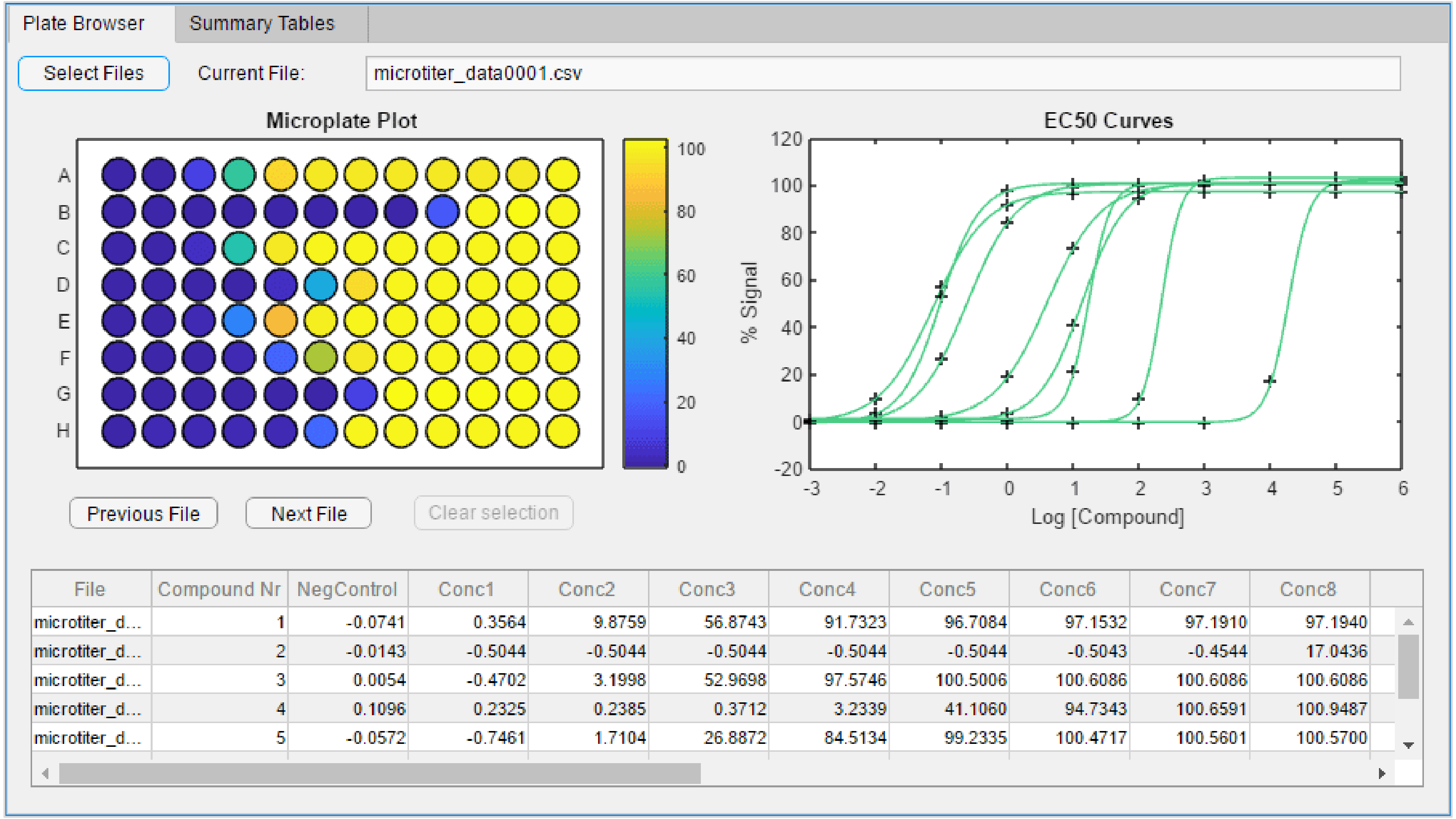


Current File: microtiter_data0001.csv

File	Compound Nr	NegControl	Conc1	Conc2	Conc3	Conc4	Conc5	Conc6	Conc7	Conc8
microtiter_d...	1	-0.0741	0.3564	9.8759	56.8743	91.7323	96.7084	97.1532	97.1910	97.1940
microtiter_d...	2	-0.0143	-0.5044	-0.5044	-0.5044	-0.5044	-0.5044	-0.5043	-0.4544	17.0436
microtiter_d...	3	0.0054	-0.4702	3.1998	52.9698	97.5746	100.5006	100.6086	100.6086	100.6086
microtiter_d...	4	0.1096	0.2325	0.2385	0.3712	3.2339	41.1060	94.7343	100.6591	100.9487
microtiter_d...	5	-0.0572	-0.7461	1.7104	26.8872	84.5134	99.2335	100.4717	100.5601	100.5700

App Designer includes an extensive library of components*

- Standard components
- Gauges, lamps, knobs, and switches
- Container components (tabs, panels)

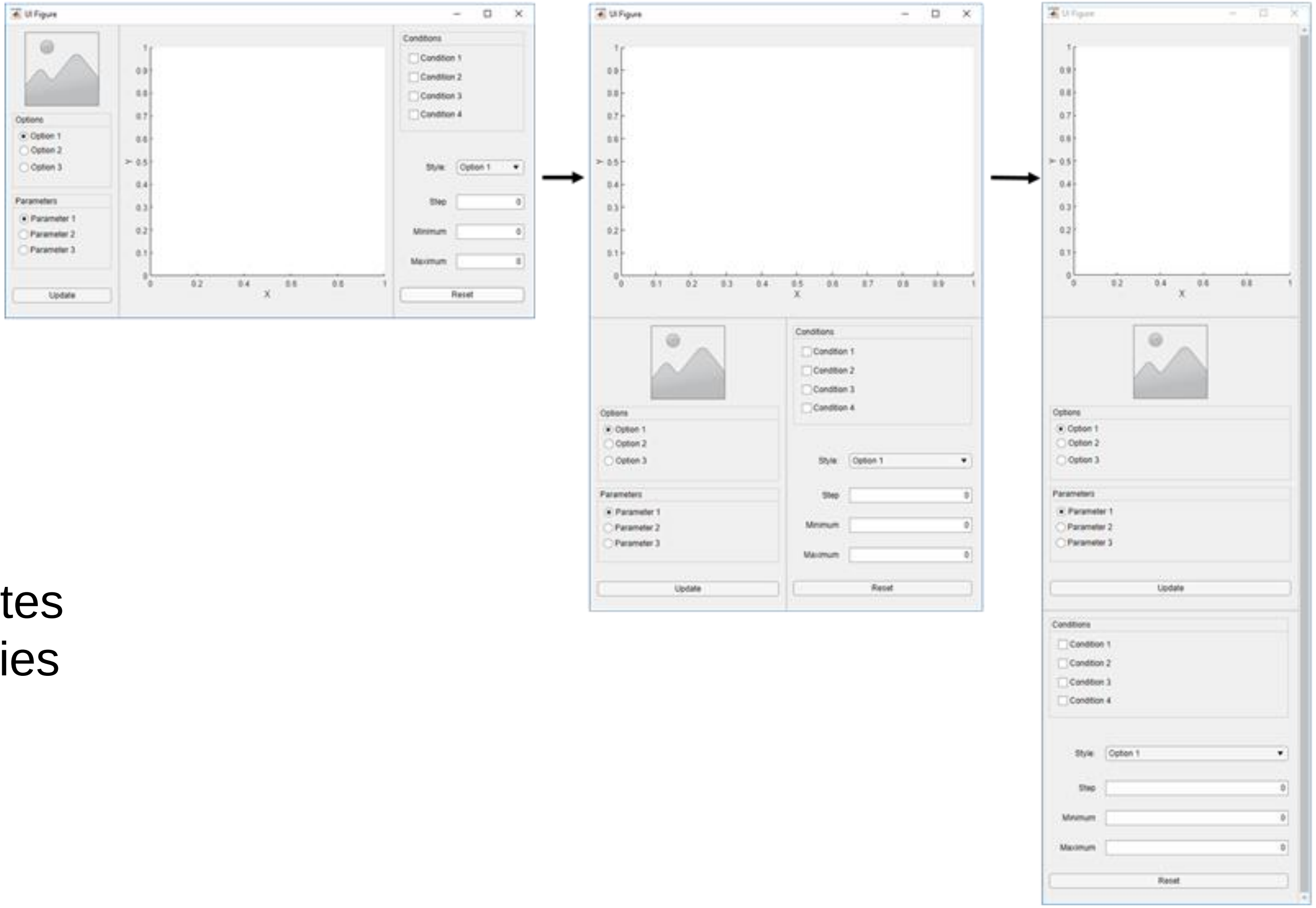


File	Compound Nr	NegControl	Conc1	Conc2	Conc3	Conc4	Conc5	Conc6	Conc7	Conc8
microtiter_d...	1	-0.0741	0.3564	9.8759	56.8743	91.7323	96.7084	97.1532	97.1910	97.1940
microtiter_d...	2	-0.0143	-0.5044	-0.5044	-0.5044	-0.5044	-0.5044	-0.5043	-0.4544	17.0436
microtiter_d...	3	0.0054	-0.4702	3.1998	52.9698	97.5746	100.5006	100.6086	100.6086	100.6086
microtiter_d...	4	0.1096	0.2325	0.2385	0.3712	3.2339	41.1060	94.7343	100.6591	100.9487
microtiter_d...	5	-0.0572	-0.7461	1.7104	26.8872	84.5134	99.2335	100.4717	100.5601	100.5700

* View component gallery at https://www.mathworks.com/products/matlab/app-designer/component-gallery.html

Interactively lay out your app in the App Designer design canvas

- Drag and drop components
- Use alignment hints to get a precise layout
- Create apps that automatically adjust size, location, and visibility of app content
- App Designer automatically generates the object-oriented code that specifies the app’s layout and design

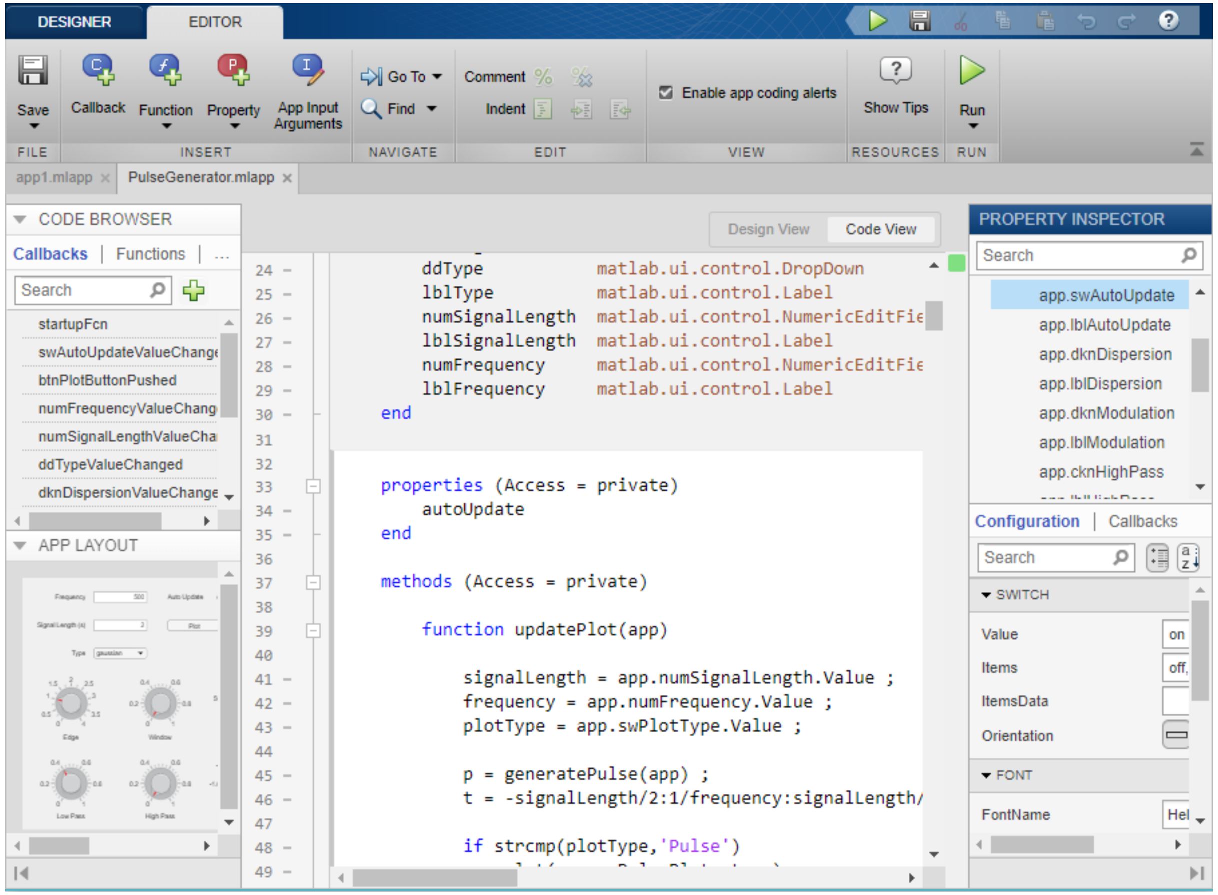


Use the integrated editor to define app behavior

- Control behavior with callbacks, and custom mouse and keyboard interactions

- Code Analyzer automatically checks for coding problems

- Property and method management



```
        ddType              matlab.ui.control.DropDown
        lblType             matlab.ui.control.Label
        numSignalLength     matlab.ui.control.NumericEditFie
        lblSignalLength     matlab.ui.control.Label
        numFrequency        matlab.ui.control.NumericEditFie
        lblFrequency        matlab.ui.control.Label
    end


    properties (Access = private)
        autoUpdate
    end

    methods (Access = private)

        function updatePlot(app)

            signalLength = app.numSignalLength.Value ;
            frequency = app.numFrequency.Value ;
            plotType = app.swPlotType.Value ;

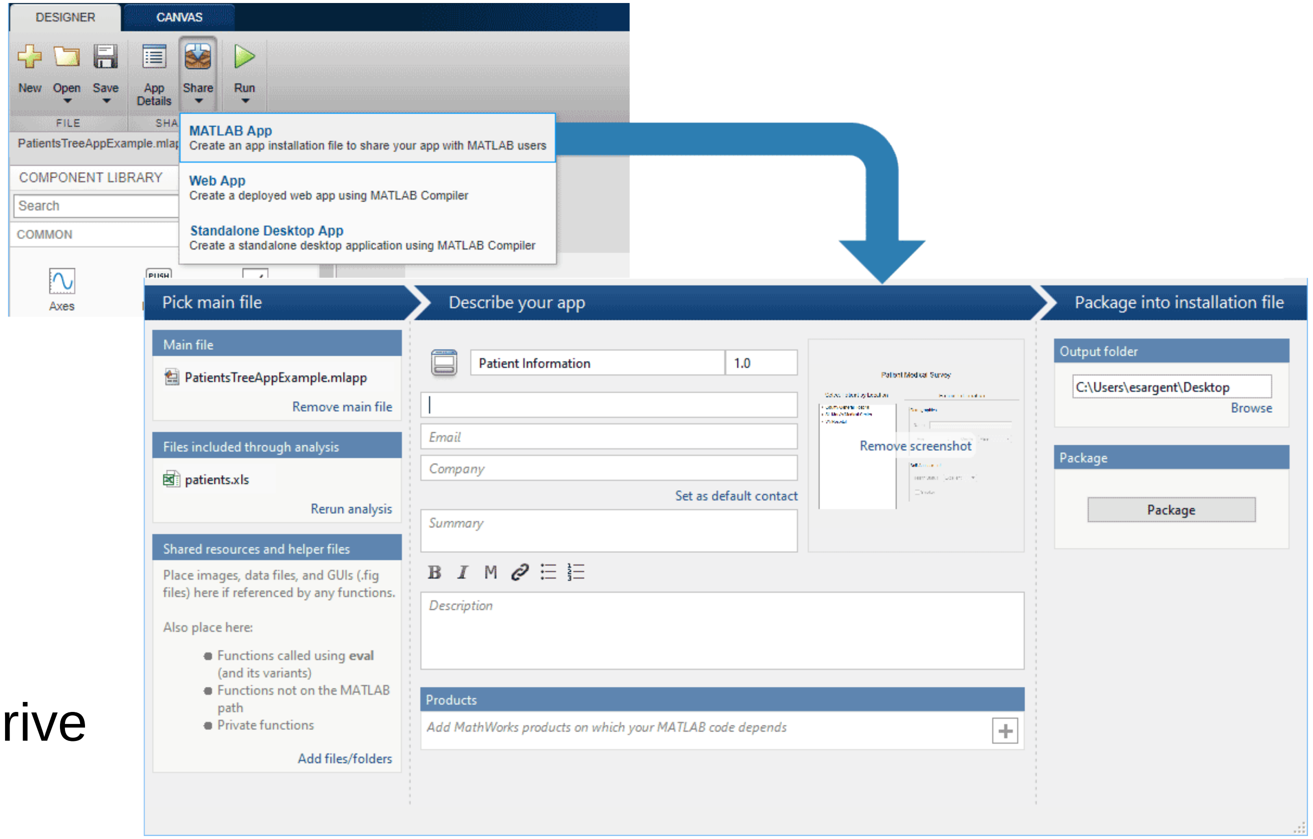
            p = generatePulse(app) ;
            t = -signalLength/2:1/frequency:signalLength/

            if strcmp(plotType,'Pulse')
```

Share Apps with Other MATLAB Users

- Directly as MATLAB files
  - `.mlapp` file
  - Manually provide other supporting files *(data, other code files)*
- As a packaged app
  - `.mlappinstall` file
  - Installed apps appear in the Apps tab in the MATLAB toolstrip
- Through MATLAB Online and MATLAB Drive
  - Others can both run and collaborate on the design of the app

R2019a



MATLAB App
Create an app installation file to share your app with MATLAB users

Web App
Create a deployed web app using MATLAB Compiler

Standalone Desktop App
Create a standalone desktop application using MATLAB Compiler

Pick main file
Describe your app
Package into installation file
Main file
PatientsTreeAppExample.mlapp
Remove main file
Files included through analysis
patients.xls
Rerun analysis
Shared resources and helper files

Place images, data files, and GUIs (.fig files) here if referenced by any functions.

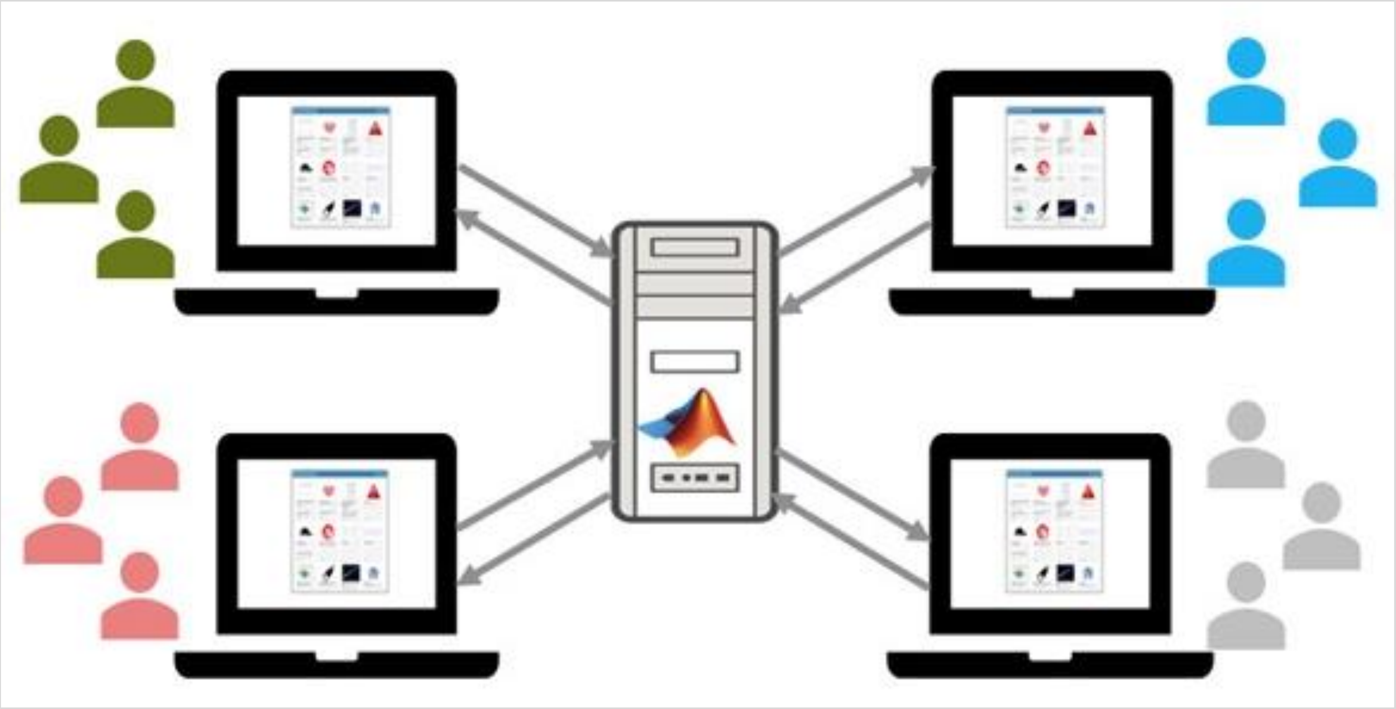
Also place here:

- Functions called using **eval** (and its variants)
- Functions not on the MATLAB path
- Private functions

Create Standalone Desktop and Web Apps

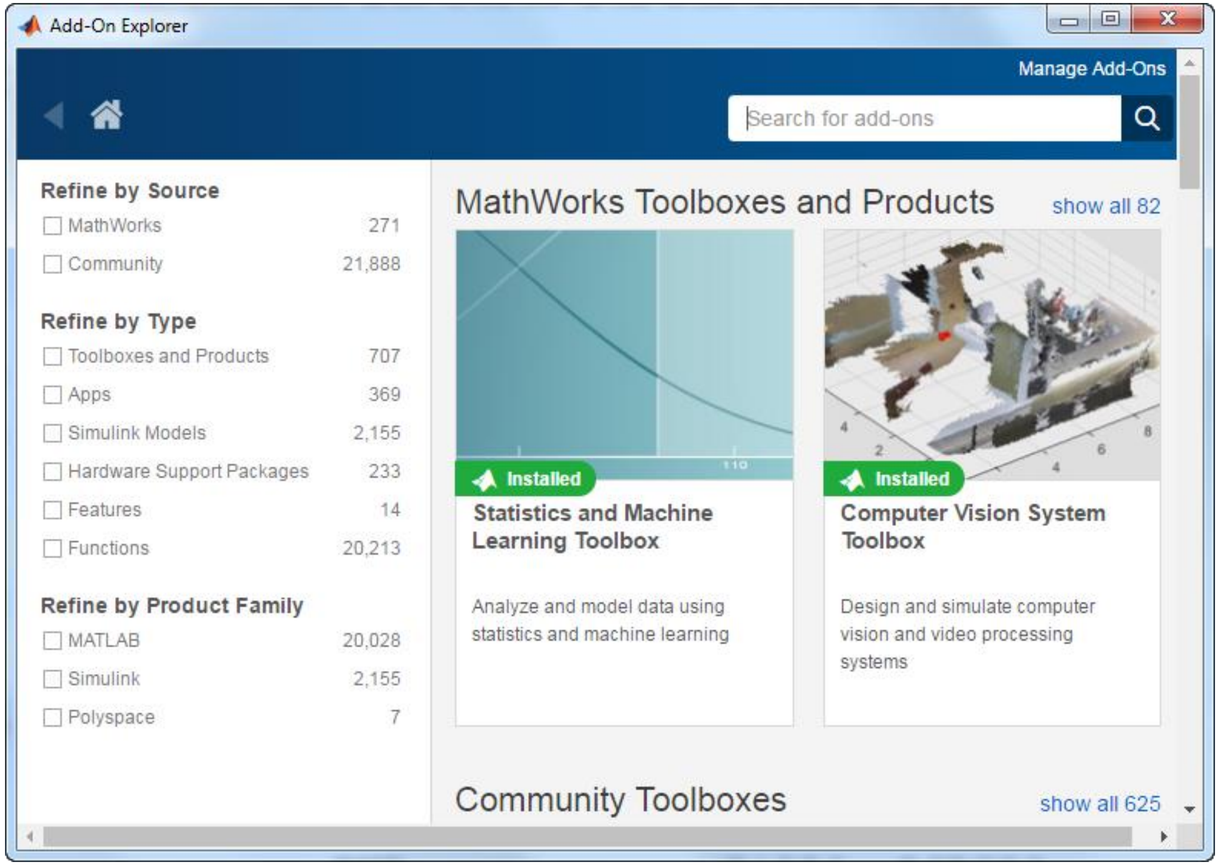
- Create standalone applications

- Package apps as web apps
  - Share via a unique URL
  - Access directly from a browser



Add-Ons Extend the Capabilities of MATLAB

- Create and share custom toolboxes
  - Package as a single installer file
  - Can include code, data, apps, examples, documentation
- **Add-On Explorer**
  - Find and install add-ons
  - Includes MathWorks + community content
- **Add-On Manager**
  - View and manage installed add-ons



Refine by Source

□ MathWorks	271
□ Community	21,888

Refine by Type

□ Toolboxes and Products	707
□ Apps	369
□ Simulink Models	2,155
□ Hardware Support Packages	233
□ Features	14
□ Functions	20,213

Refine by Product Family

□ MATLAB	20,028
□ Simulink	2,155
□ Polyspace	7

MathWorks Toolboxes and Products — show all 82

Installed — Statistics and Machine Learning Toolbox

Analyze and model data using statistics and machine learning

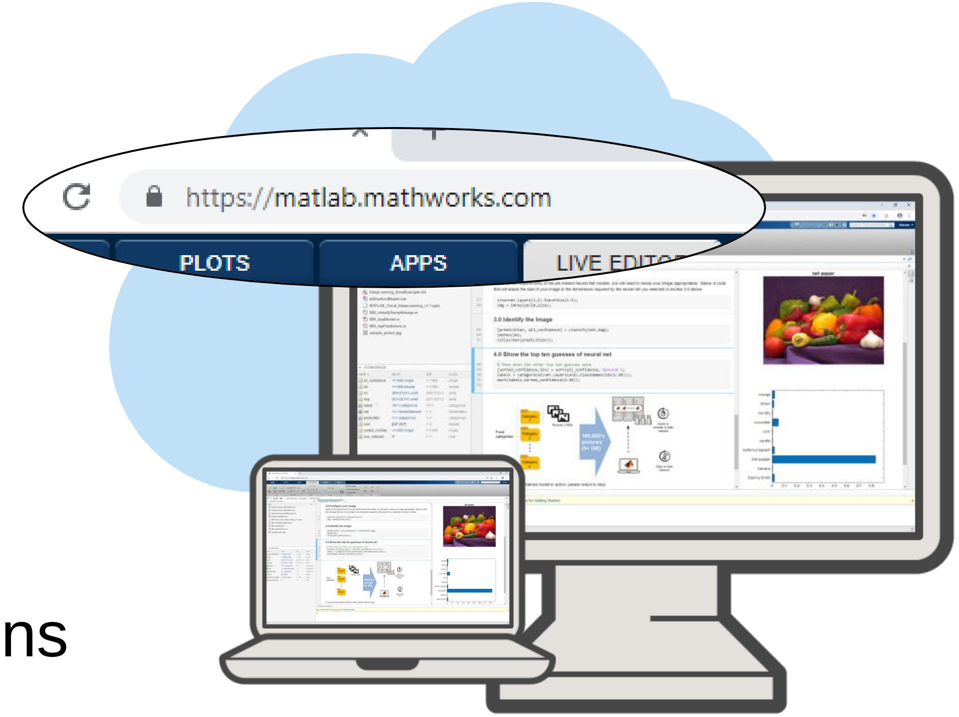
Installed — Computer Vision System Toolbox

Design and simulate computer vision and video processing systems

Community Toolboxes — show all 625

Access MATLAB through your browser with MATLAB Online

- Use the latest version of MATLAB
- No downloads, installations, configurations or maintenance required
- Share your work with a unique URL
- Collaborate with others by setting permissions
- All named academic, commercial and home user accounts are eligible



New in R2019a

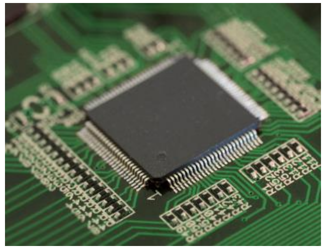
- App Designer in MATLAB Online
- Single Sign-On with MathWorks.com

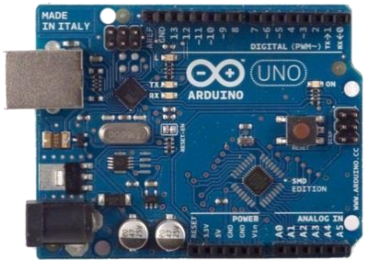
Agenda

- Desktop & Live Editor
- Data Analysis & Visualization
- Language & Programming
- App Building & Sharing
- Hardware Support
- Toolbox Updates

Data & RF Embedded Imaging Specialty

Hardware: Breadth and Depth





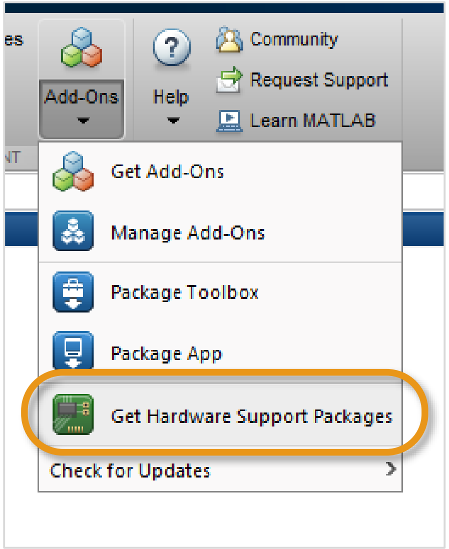
- Serial
- I2C
- SPI
- Bluetooth
- IVI
- VISA
- VXIplug&play
- MODBUS
- GigE Vision
- USB3 Vision
- DCAM
- Camera Link
- CAN
- J1939
- OPC standards

and more…

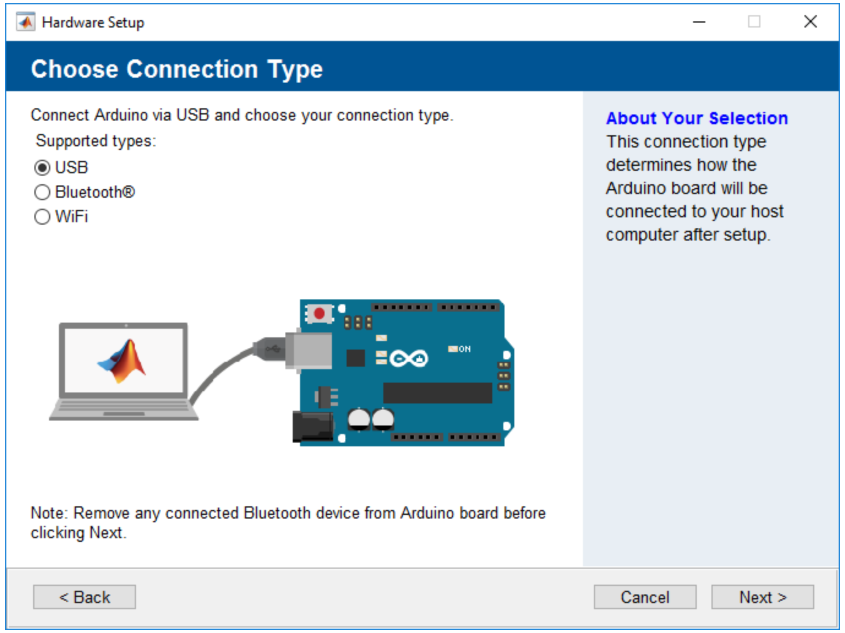
Data & RF **Embedded** **Imaging** **Specialty** **Standards**

Hardware: Getting Up and Running Fast

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



- Guided setup of Arduino connection



Choose Connection Type

Connect Arduino via USB and choose your connection type.

Supported types:

● USB

○ Bluetooth®

○ WiFi

Note: Remove any connected Bluetooth device from Arduino board before clicking Next.

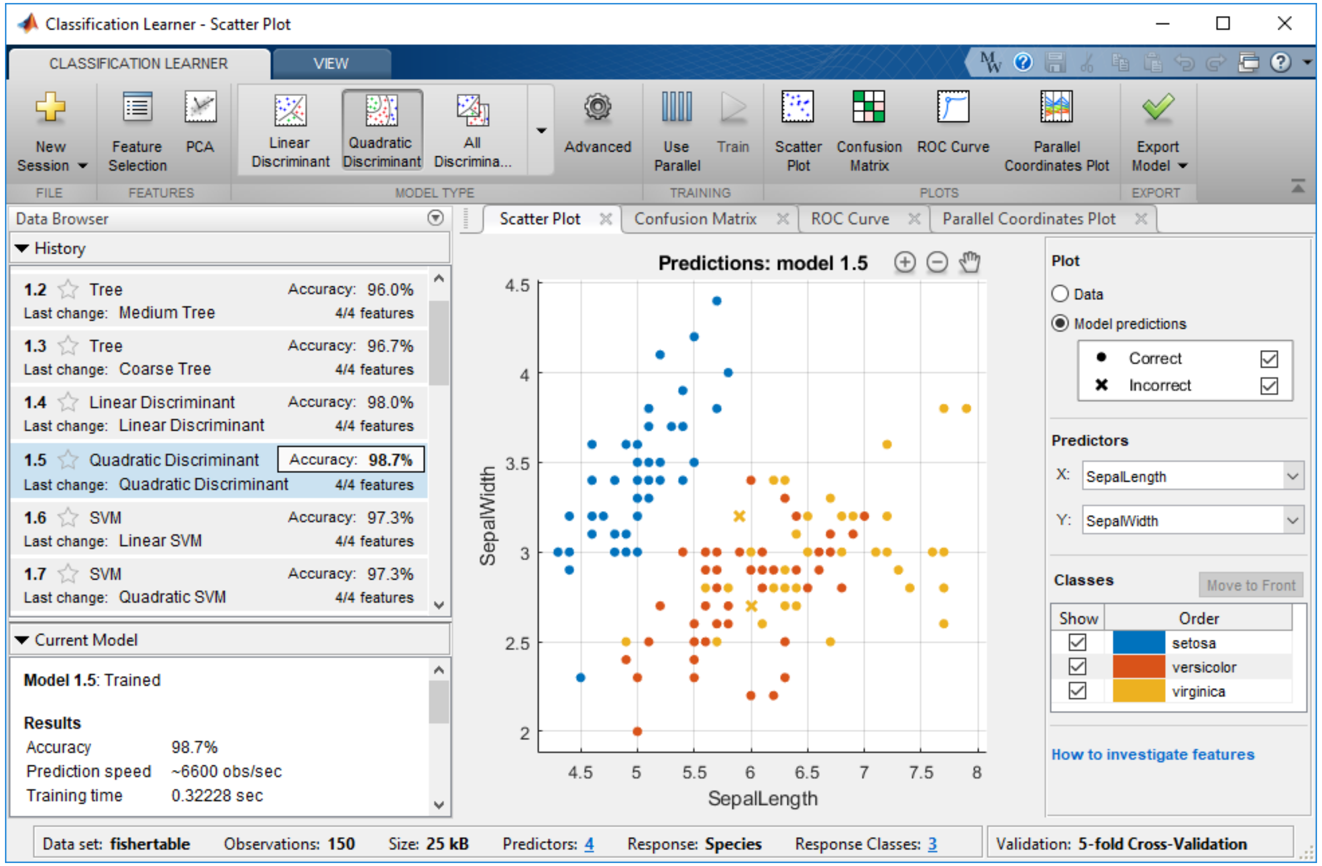
About Your Selection

This connection type determines how the Arduino board will be connected to your host computer after setup.

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

Agenda

- Desktop & Live Editor
- Data Analysis & Visualization
- Language & Programming
- App Building & Sharing
- Hardware Support
- Toolbox Updates



History

1.2 ☆ Tree	Accuracy: 96.0%	
Last change: Medium Tree	4/4 features	
1.3 ☆ Tree	Accuracy: 96.7%	
Last change: Coarse Tree	4/4 features	
1.4 ☆ Linear Discriminant	Accuracy: 98.0%	
Last change: Linear Discriminant	4/4 features	
1.5 ☆ Quadratic Discriminant	Accuracy: 98.7%	
Last change: Quadratic Discriminant	4/4 features	
1.6 ☆ SVM	Accuracy: 97.3%	
Last change: Linear SVM	4/4 features	
1.7 ☆ SVM	Accuracy: 97.3%	
Last change: Quadratic SVM	4/4 features	

Current Model

Model 1.5: Trained

Results

Accuracy 98.7%
Prediction speed ~6600 obs/sec
Training time 0.32228 sec

○ Data
● Model predictions
● Correct ☑
✖ Incorrect ☑

Predictors
X: SepalLength
Y: SepalWidth

Show	Order
☑	setosa
☑	versicolor
☑	virginica

Data set: **fishertable** Observations: **150** Size: **25 kB** Predictors: 4 Response: **Species** Response Classes: 3 Validation: **5-fold Cross-Validation**

Machine Learning

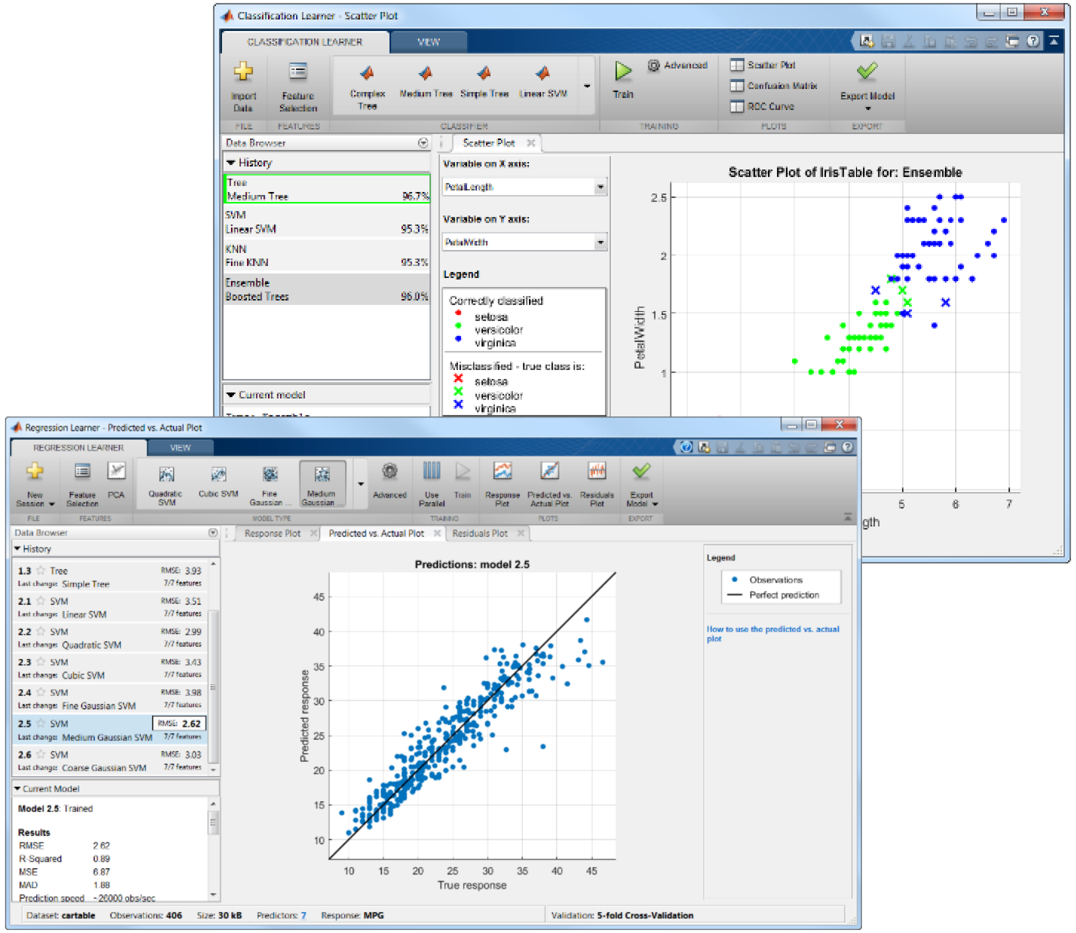
> ***"I would have never attempted machine learning if this app was not available."***

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
  - Regression Learner app

- Apply algorithms to out-of-memory data using tall arrays

- Generate C code for predictive models *(requires MATLAB Coder)*



Classification Learner - Scatter Plot

History

Tree
Medium Tree 96.7%

SVM
Linear SVM 95.3%

KNN
Fine KNN 95.3%

Ensemble
Boosted Trees 96.0%

Variable on X axis: PetalLength

Variable on Y axis: PetalWidth

Regression Learner - Predicted vs. Actual Plot

History

1.3 Tree RMSE: 3.93
Last change: Simple Tree 7/7 features

2.1 SVM RMSE: 3.51
Last change: Linear SVM 7/7 features

2.2 SVM RMSE: 2.99
Last change: Quadratic SVM 7/7 features

2.3 SVM RMSE: 3.43
Last change: Cubic SVM 7/7 features

2.4 SVM RMSE: 3.98
Last change: Fine Gaussian SVM 7/7 features

2.5 SVM RMSE: 2.62
Last change: Medium Gaussian SVM 7/7 features

2.6 SVM RMSE: 3.03
Last change: Coarse Gaussian SVM 7/7 features

Current Model

Model 2.5: Trained

Results

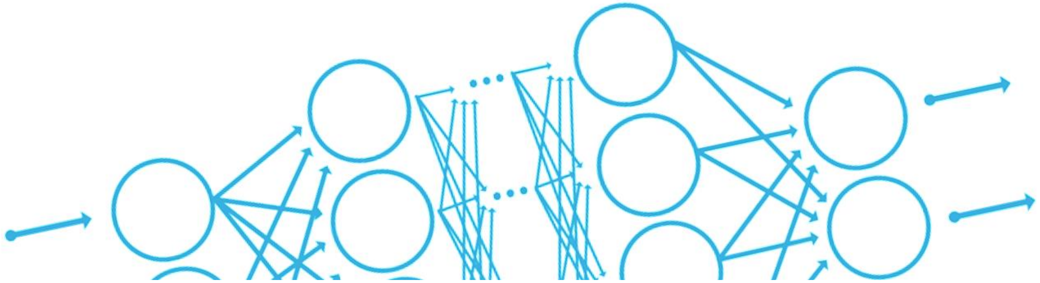
RMSE	2.62
R-Squared	0.89
MSE	6.87
MAD	1.88
Prediction speed	~26000 obs/sec

Dataset: **cartable** Observations: **406** Size: **30 kB** Predictors: **7** Response: **MPG** Validation: **5-fold Cross-Validation**

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
- Automatically generate high-performance CUDA code for embedded deployment *(requires GPU Coder)*
- Performance improvements for training and prediction on CPUs and GPUs



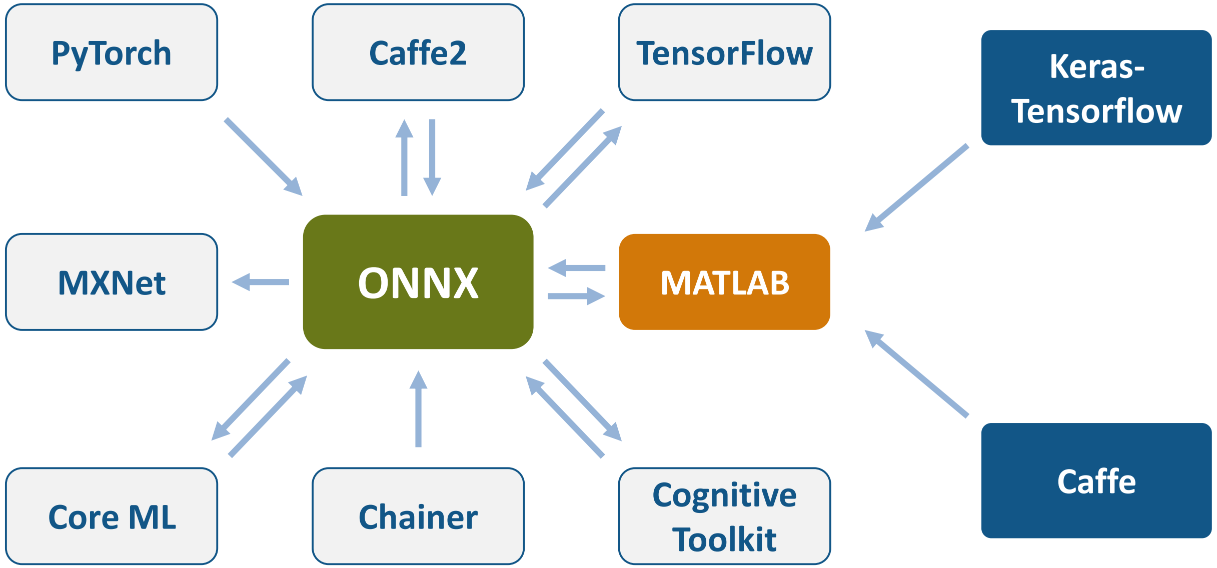
Interoperability with Deep Learning Frameworks

- Import and export models using the Open Neural Network Exchange (ONNX) format

- Model importers
  - Caffe
  - TensorFlow-Keras

- Generate CUDA code for models imported from ONNX *(using GPU Coder)*

- Access pretrained models with a single line of code



PyTorch

Caffe2

TensorFlow

Keras-Tensorflow

MXNet

ONNX

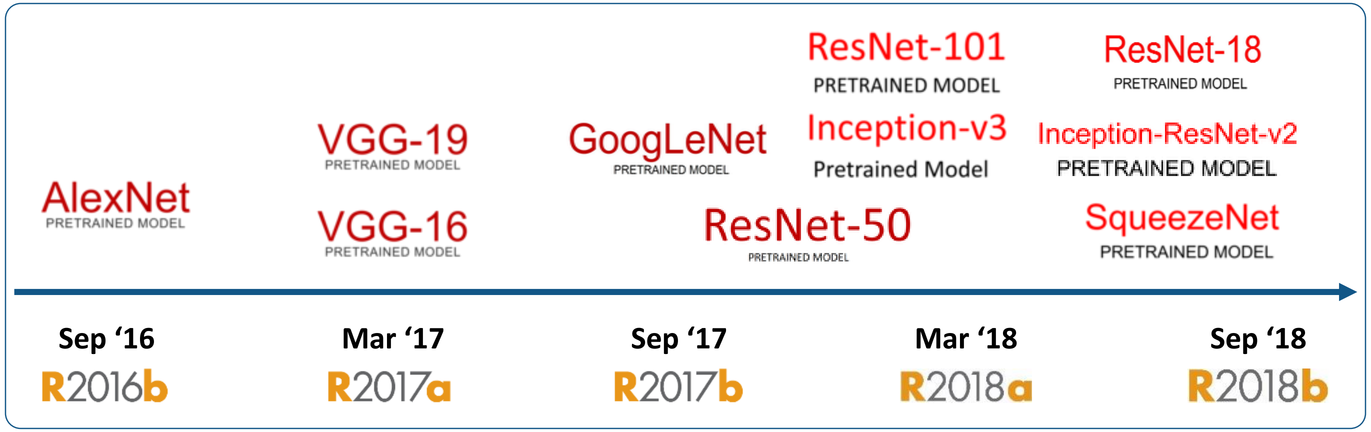
MATLAB

Core ML

Chainer

Cognitive Toolkit

Caffe



ResNet-101 PRETRAINED MODEL

ResNet-18 PRETRAINED MODEL

VGG-19 PRETRAINED MODEL

GoogLeNet PRETRAINED MODEL

Inception-v3 Pretrained Model

Inception-ResNet-v2 PRETRAINED MODEL

AlexNet PRETRAINED MODEL

VGG-16 PRETRAINED MODEL

ResNet-50 PRETRAINED MODEL

SqueezeNet PRETRAINED MODEL

Sep '16 R2016b

Mar '17 R2017a

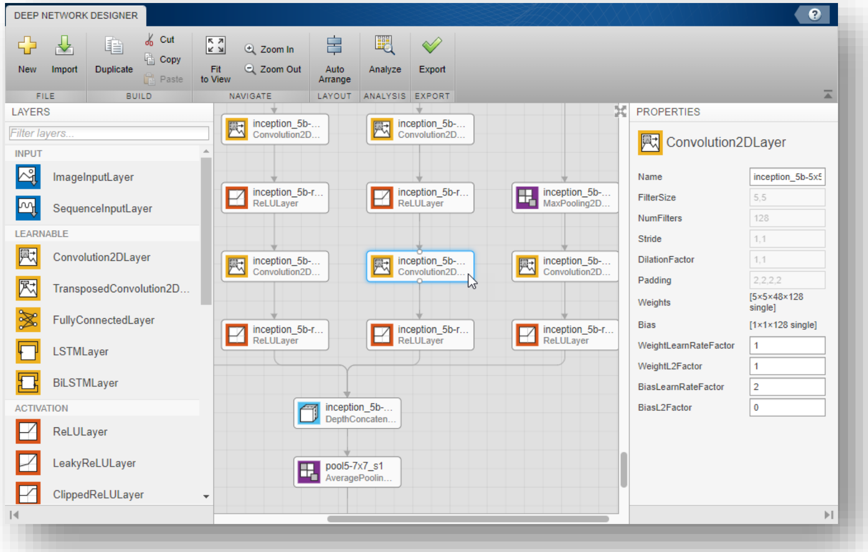
Sep '17 R2017b

Mar '18 R2018a

Sep '18 R2018b

Designing and Building Deep Learning Models

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



Convolution2DLayer

Name: inception_5b-5x5

FilterSize: 5,5

NumFilters: 128

Stride: 1,1

DilationFactor: 1,1

Padding: 2,2,2,2

Weights: [5×5×48×128 single]

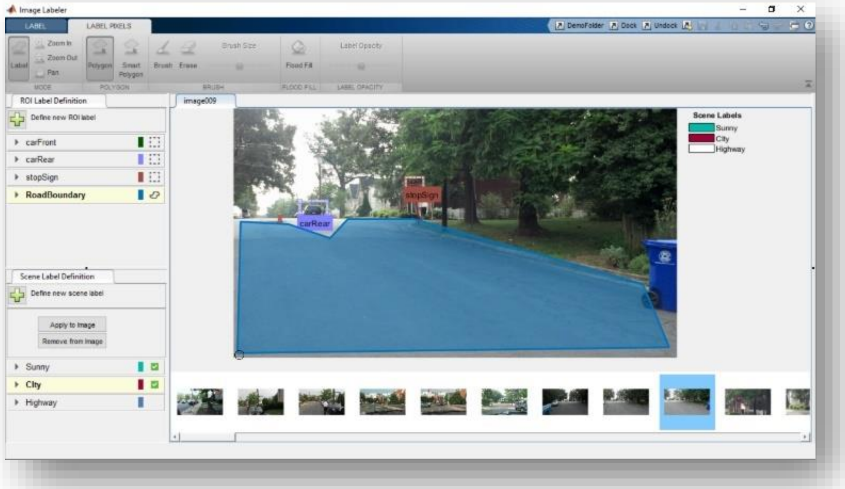
Bias: [1×1×128 single]

WeightLearnRateFactor: 1

WeightL2Factor: 1

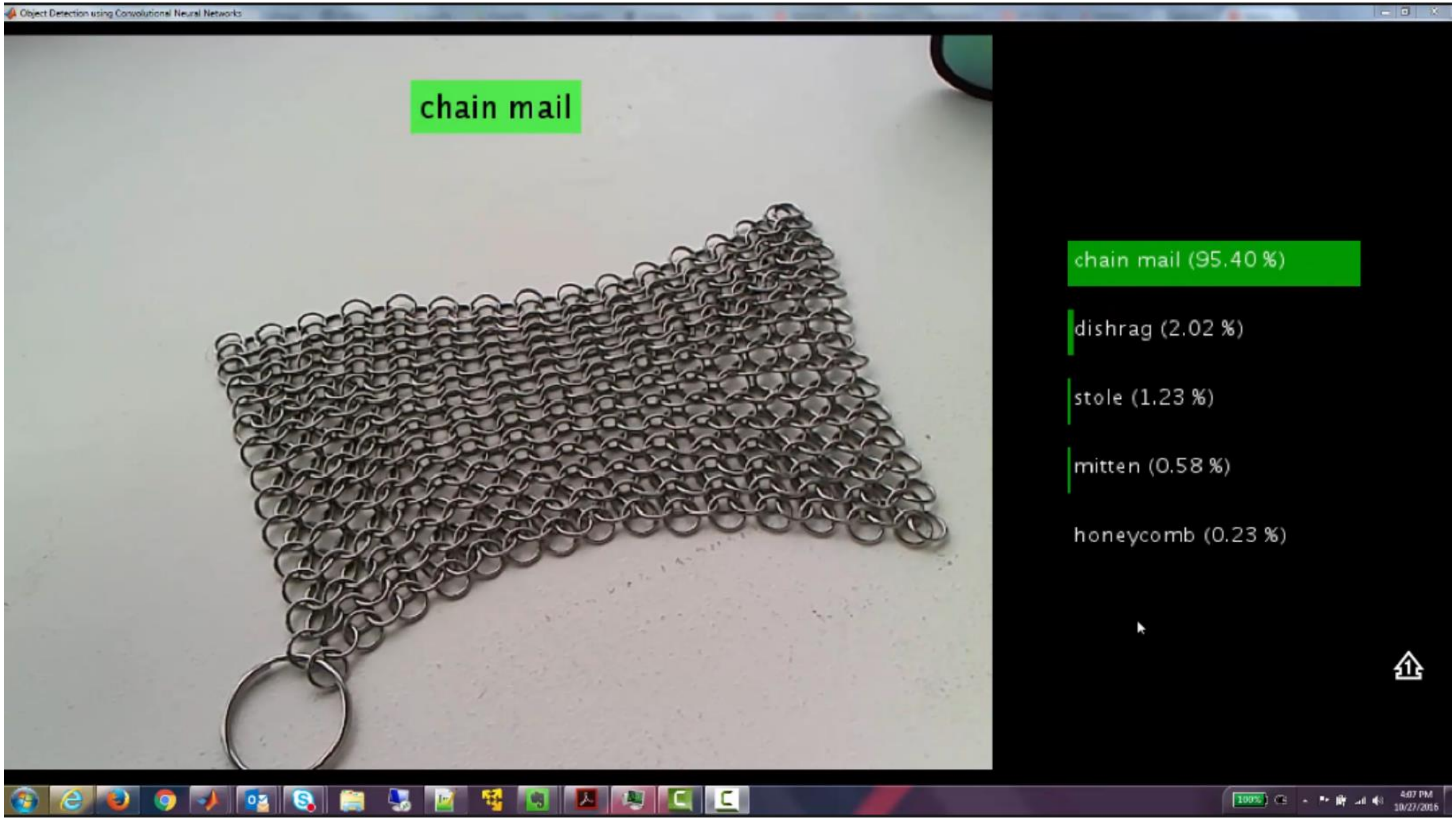
BiasLearnRateFactor: 2

BiasL2Factor: 0



Deep Learning Toolbox
Computer Vision System Toolbox
Audio System Toolbox

Example 1: Object recognition using deep learning



Object Detection using Convolutional Neural Networks

chain mail (95.40 %)

dishrag (2.02 %)

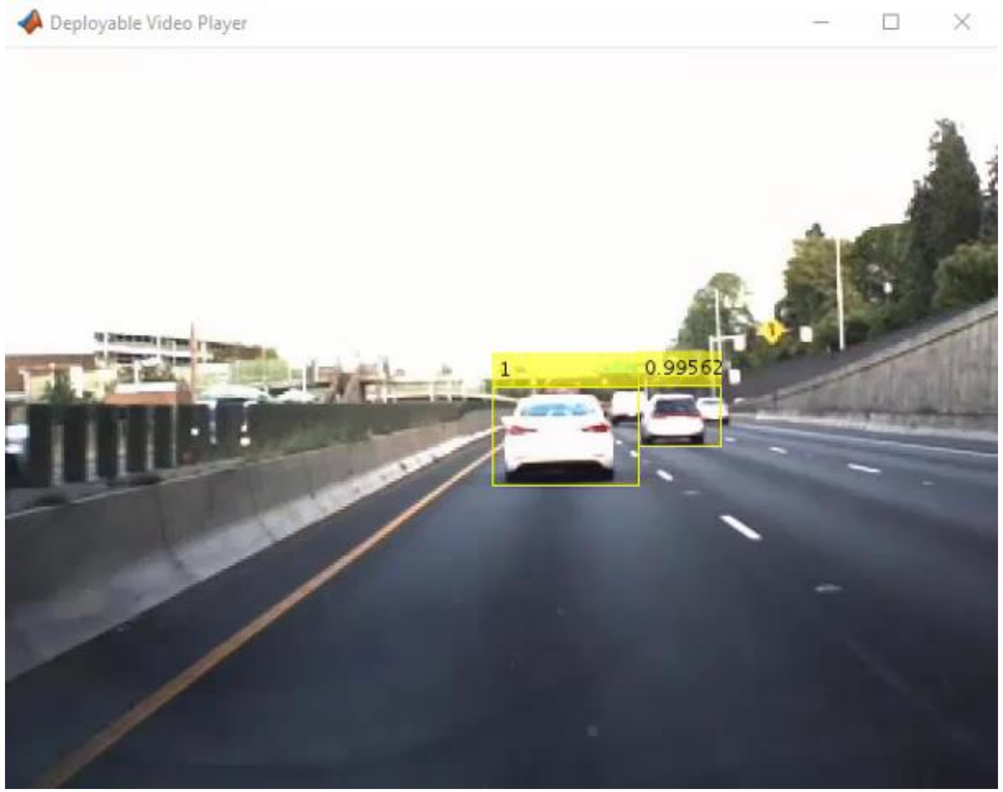
stole (1.23 %)

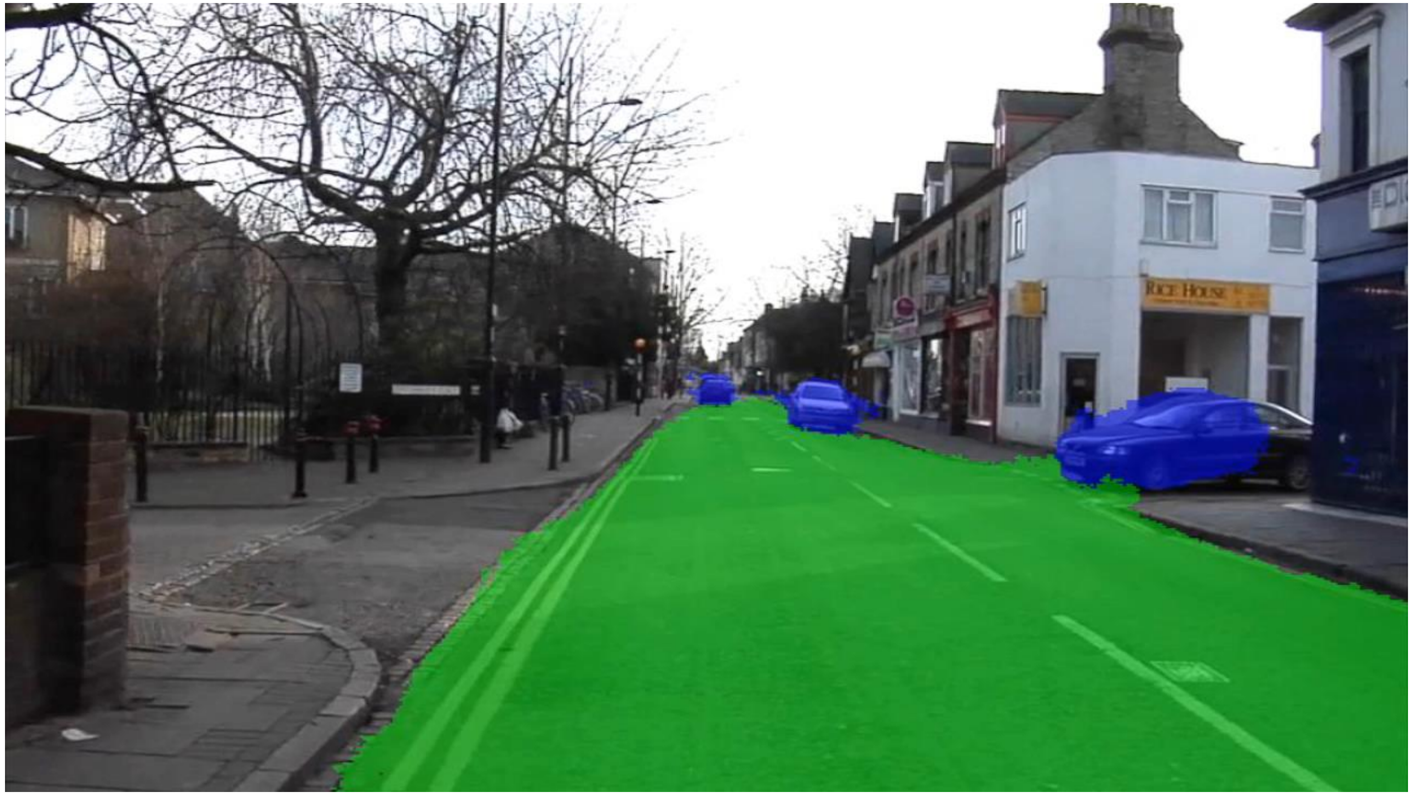
mitten (0.58 %)

honeycomb (0.23 %)

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

Example 2: Detection and localization using deep learning

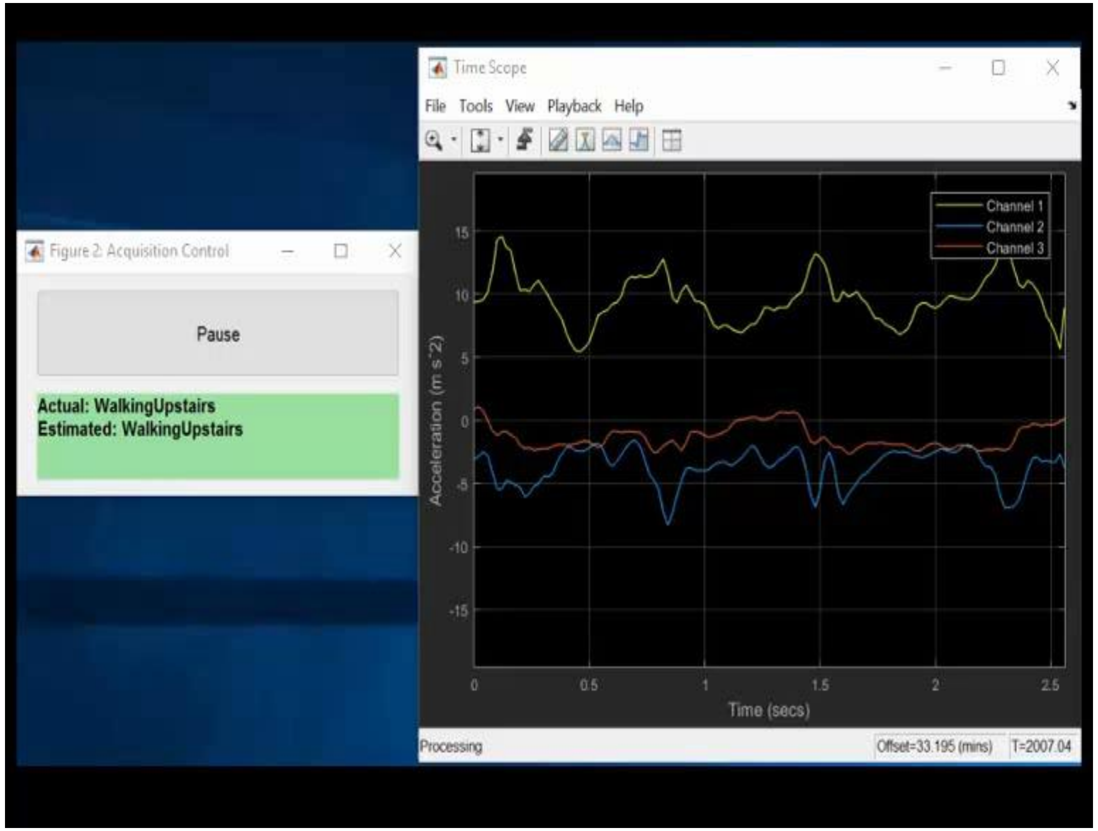




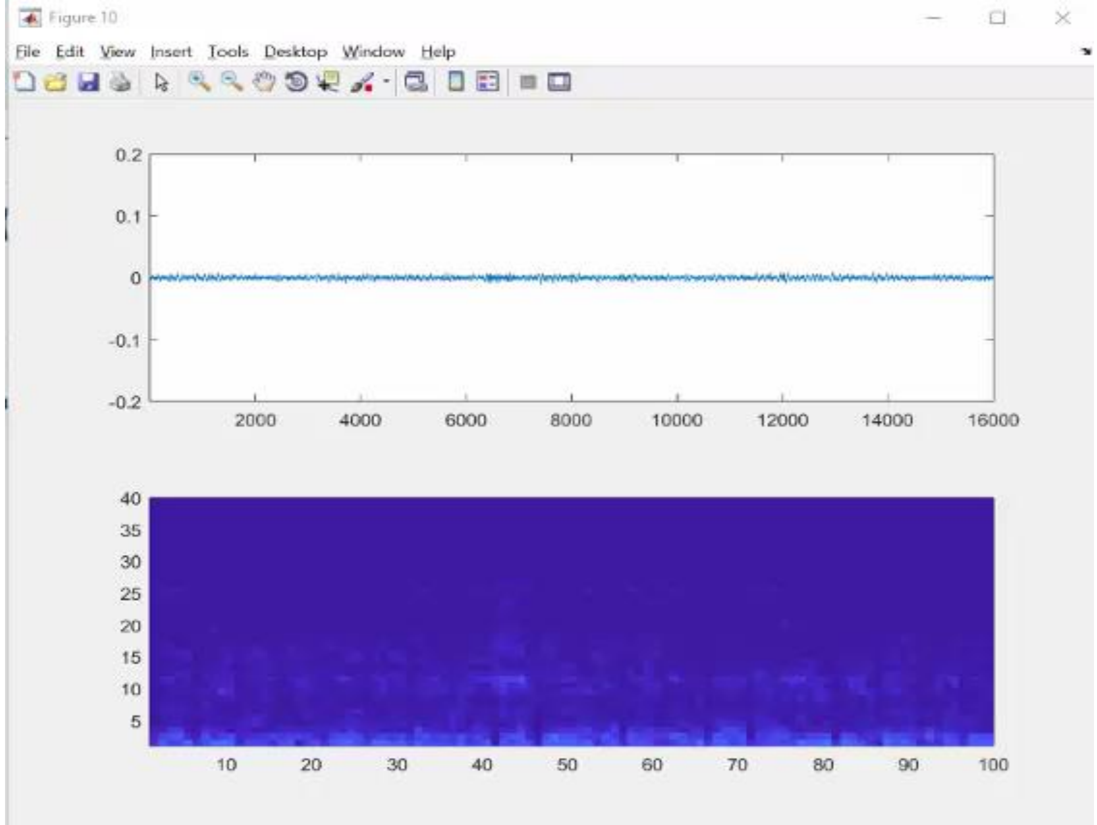
Regions with Convolutional Neural Network Features (R-CNN)

Semantic Segmentation using SegNet

Example 3: Analyzing signal data using deep learning



Actual: WalkingUpstairs
Estimated: WalkingUpstairs

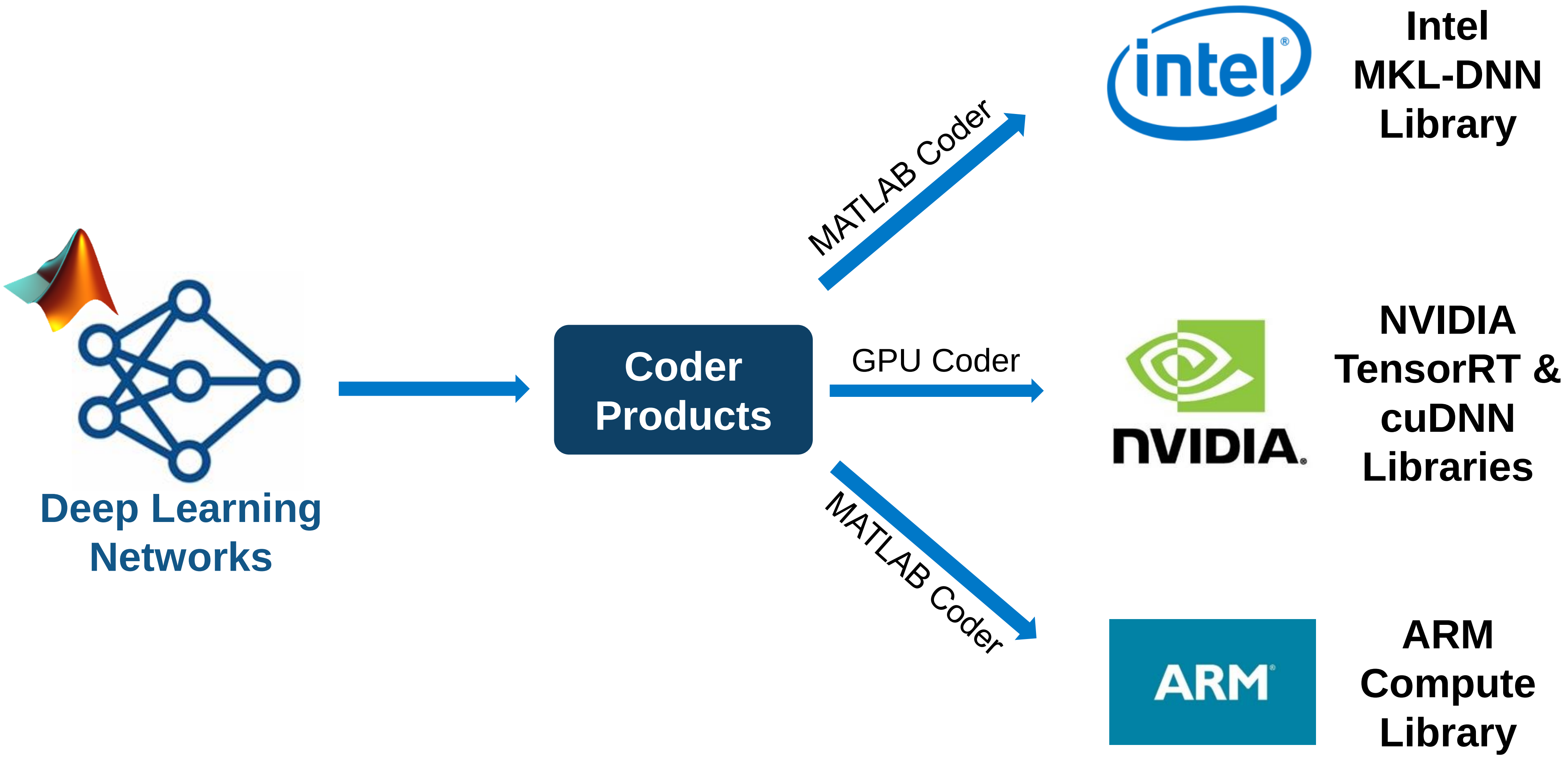


Signal Classification using LSTMs

Speech Recognition using CNNs

Deploying Deep Learning Models for Inference

R2017b+



Deep Learning Networks

Coder Products

MATLAB Coder

GPU Coder

MATLAB Coder

Intel MKL-DNN Library

NVIDIA TensorRT & cuDNN Libraries

ARM Compute Library

GPU Coder

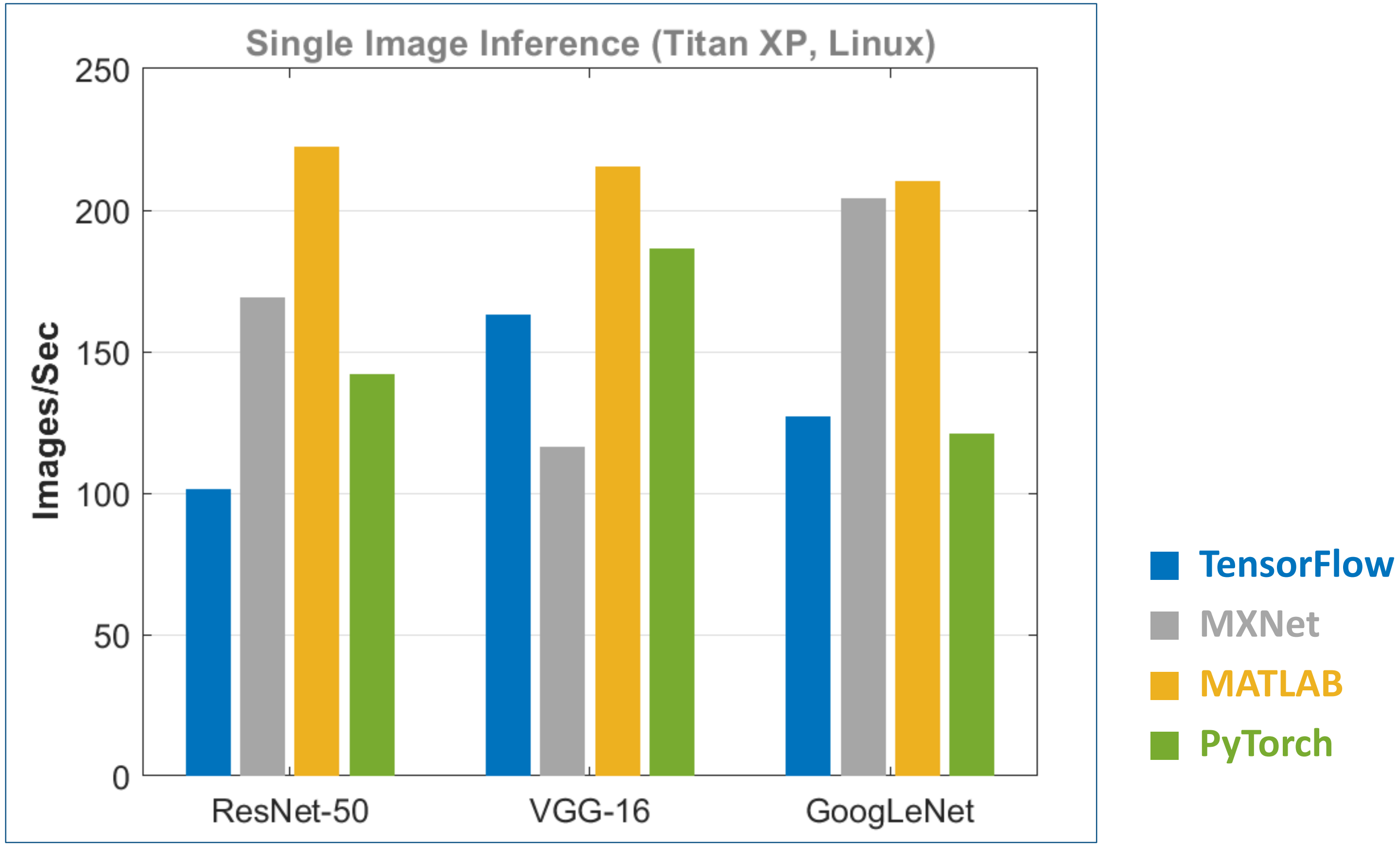
Automatically generate CUDA code from MATLAB

- 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

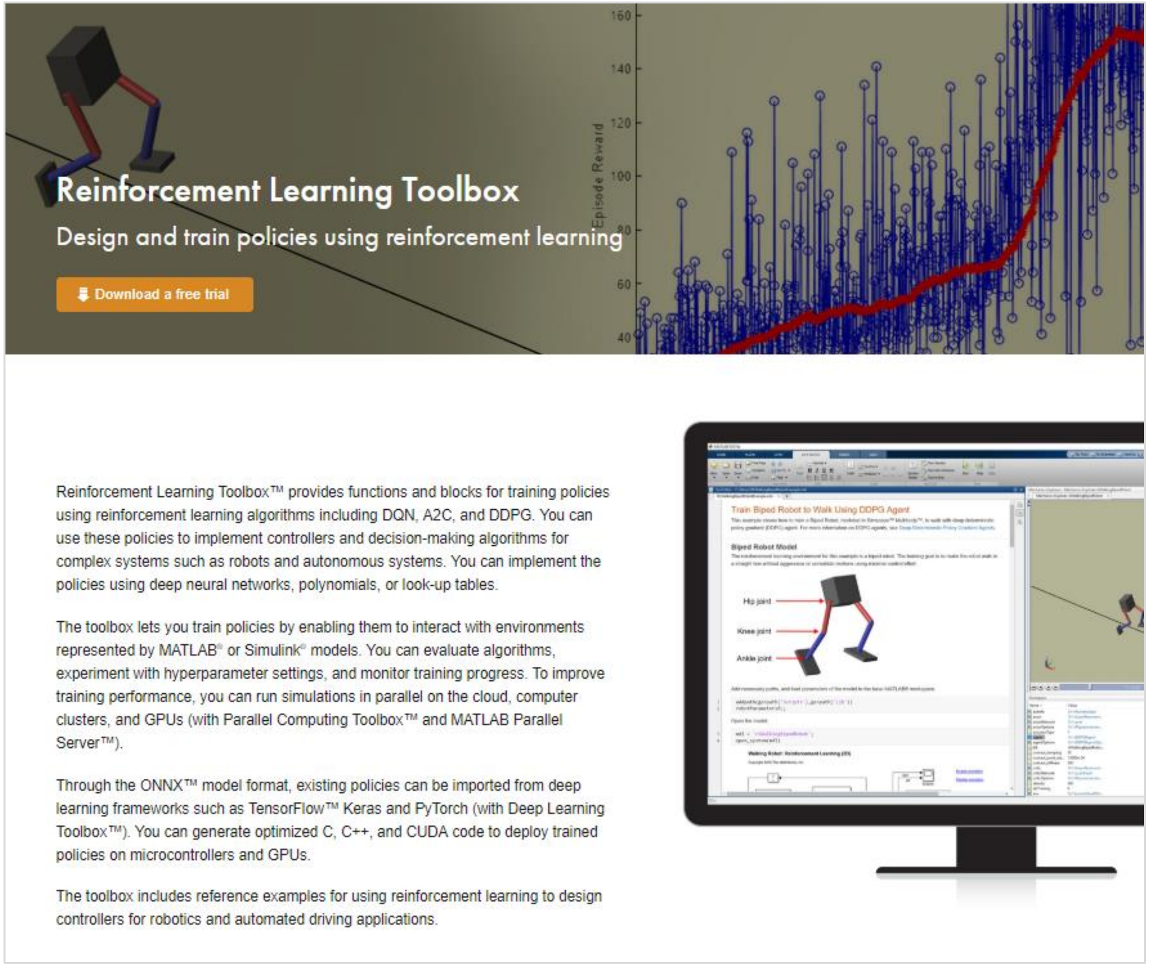
R2018b



New Product: Reinforcement Learning Toolbox

R2019a

- Built-in and custom algorithms for reinforcement learning
- Environment modeling in MATLAB and Simulink
- Deep Learning Toolbox support for designing policies
- Training acceleration through GPUs and cloud resources
- Deployment to embedded devices and production systems
- Reference examples for getting started



Reinforcement Learning Toolbox

Design and train policies using reinforcement learning

Reinforcement Learning Toolbox™ provides functions and blocks for training policies using reinforcement learning algorithms including DQN, A2C, and DDPG. You can use these policies to implement controllers and decision-making algorithms for complex systems such as robots and autonomous systems. You can implement the policies using deep neural networks, polynomials, or look-up tables.

The toolbox lets you train policies by enabling them to interact with environments represented by MATLAB® or Simulink® models. You can evaluate algorithms, experiment with hyperparameter settings, and monitor training progress. To improve training performance, you can run simulations in parallel on the cloud, computer clusters, and GPUs (with Parallel Computing Toolbox™ and MATLAB Parallel Server™).

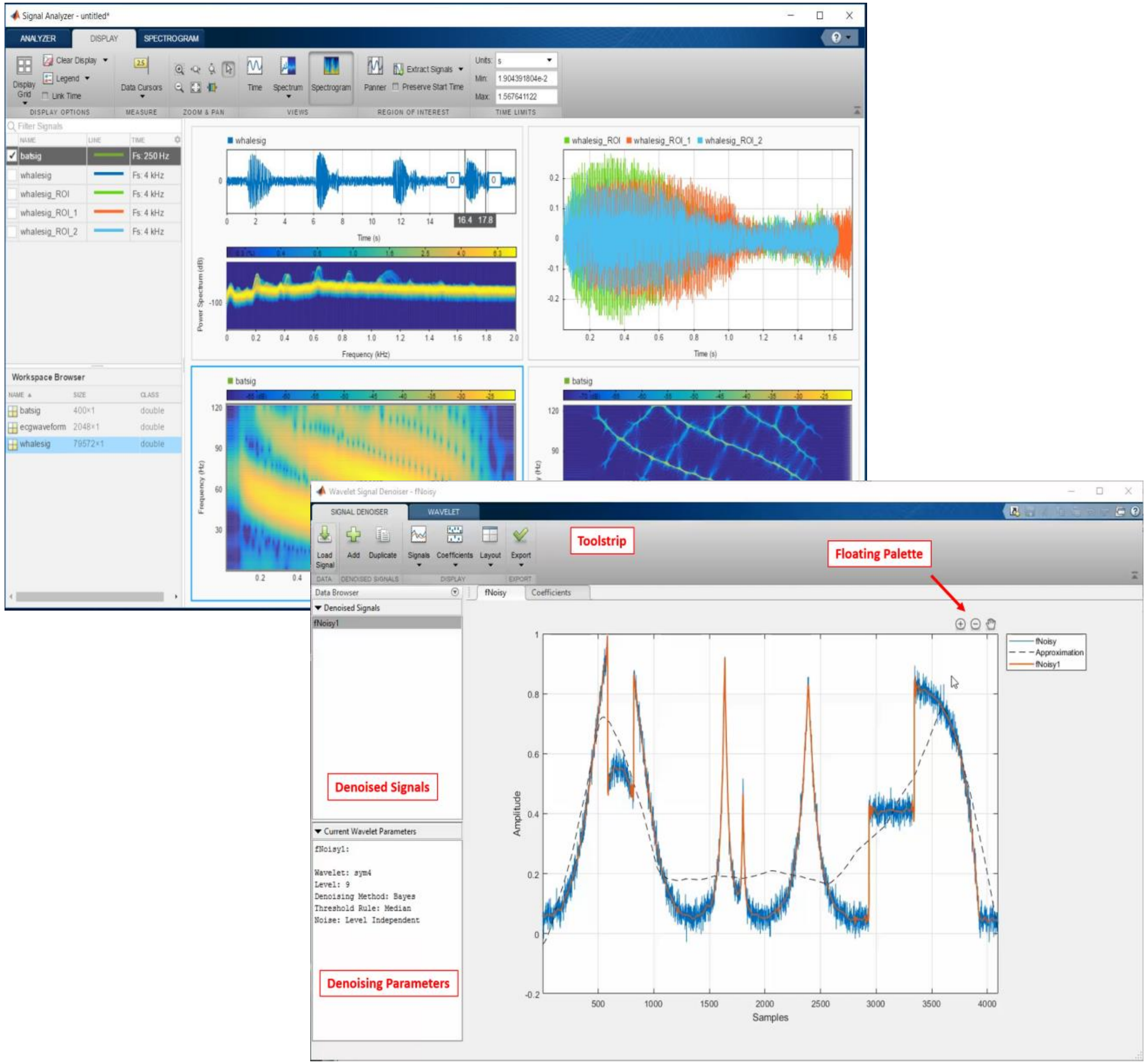
Through the ONNX™ model format, existing policies can be imported from deep learning frameworks such as TensorFlow™ Keras and PyTorch (with Deep Learning Toolbox™). You can generate optimized C, C++, and CUDA code to deploy trained policies on microcontrollers and GPUs.

The toolbox includes reference examples for using reinforcement learning to design controllers for robotics and automated driving applications.

Signal Processing

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

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



Name	Line	Time
batsig		Fs: 250 Hz
whalesig		Fs: 4 kHz
whalesig_ROI		Fs: 4 kHz
whalesig_ROI_1		Fs: 4 kHz
whalesig_ROI_2		Fs: 4 kHz

Name	Size	Class
batsig	400×1	double
ecgwaveform	2048×1	double
whalesig	79572×1	double

```
fNoisy1:

Wavelet: sym4
Level: 9
Denoising Method: Bayes
Threshold Rule: Median
Noise: Level Independent
```

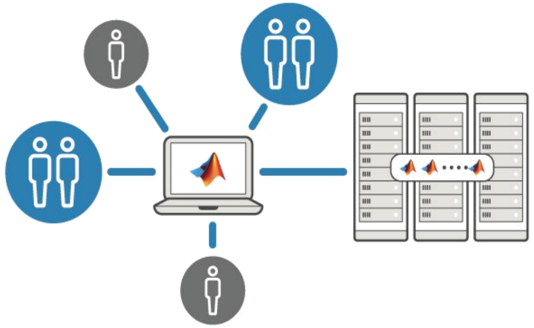
Signal Processing Toolbox
Wavelet Toolbox

MATLAB Parallel Server for Campus-Wide License

R2019a

Included in Max-Planck campus-wide license

- **One license, unlimited scaling for the entire campus**
  - HPC centers and central clusters can enable entire clusters New
  - Researchers and departments can set up their own MATLAB clusters



- **Simplify license administration by consolidating**
  - For HPC, a single network activation can accommodate multiple clusters of any size
  - Researchers self-serve with online licensing once you add them as Licensed End Users

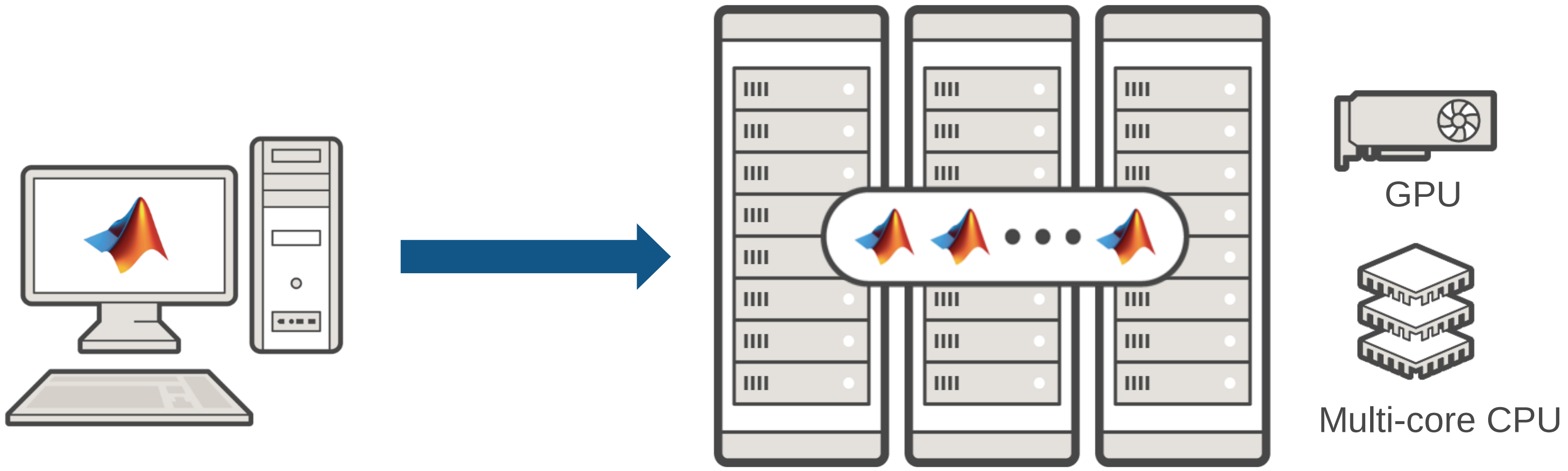
To use new model with any release

1) get updated license file <u>and</u> update network license manager

OR 2) use online licensing

Parallel Computing with MATLAB: Scaling parallel computing to clouds and clusters

- Prototype code on end-user desktop
- Integrate code with computing resources and infrastructure
- Access and monitor jobs directly from MATLAB



GPU

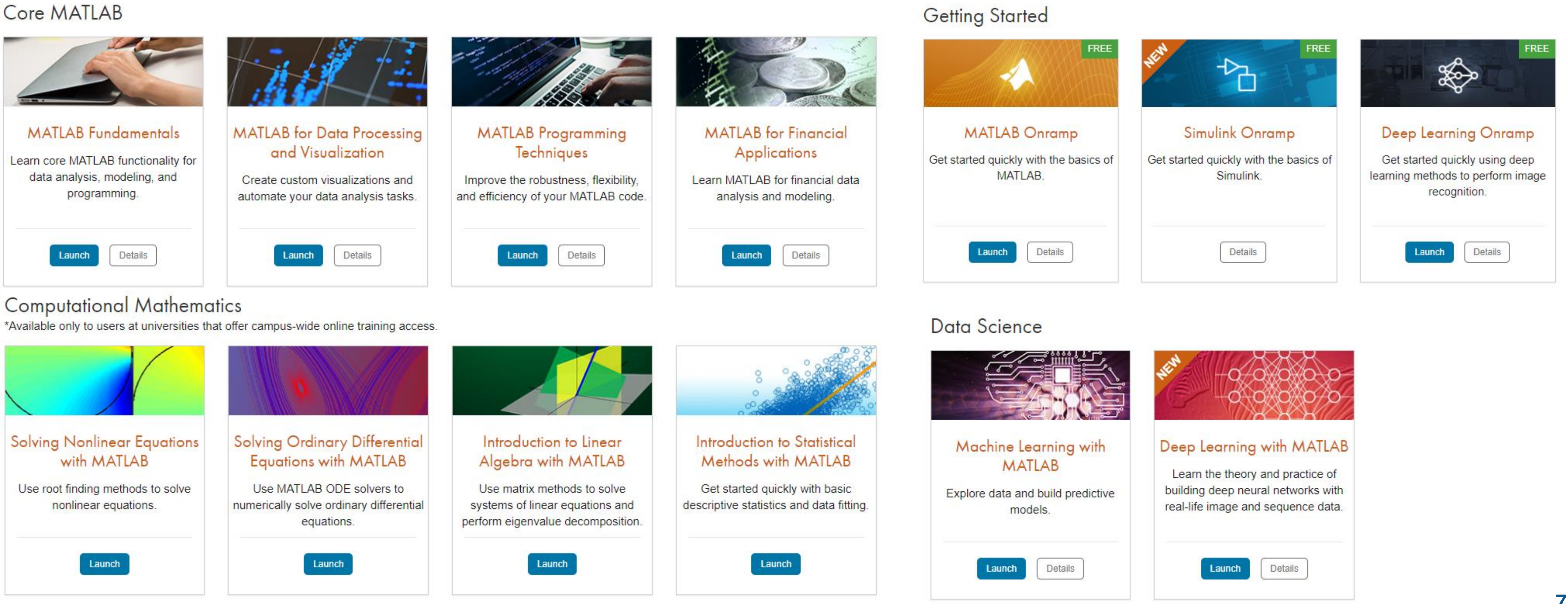
Multi-core CPU

MATLAB
Parallel Computing Toolbox

MATLAB Parallel Server

Resources

- Online trainings



Core MATLAB

MATLAB Fundamentals
Learn core MATLAB functionality for data analysis, modeling, and programming.
Launch Details

MATLAB for Data Processing and Visualization
Create custom visualizations and automate your data analysis tasks.
Launch Details

MATLAB Programming Techniques
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Resources

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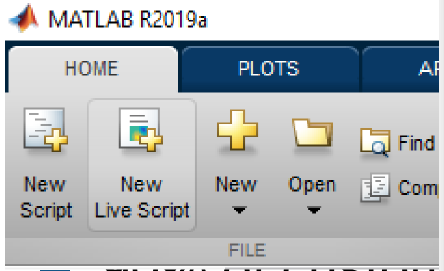
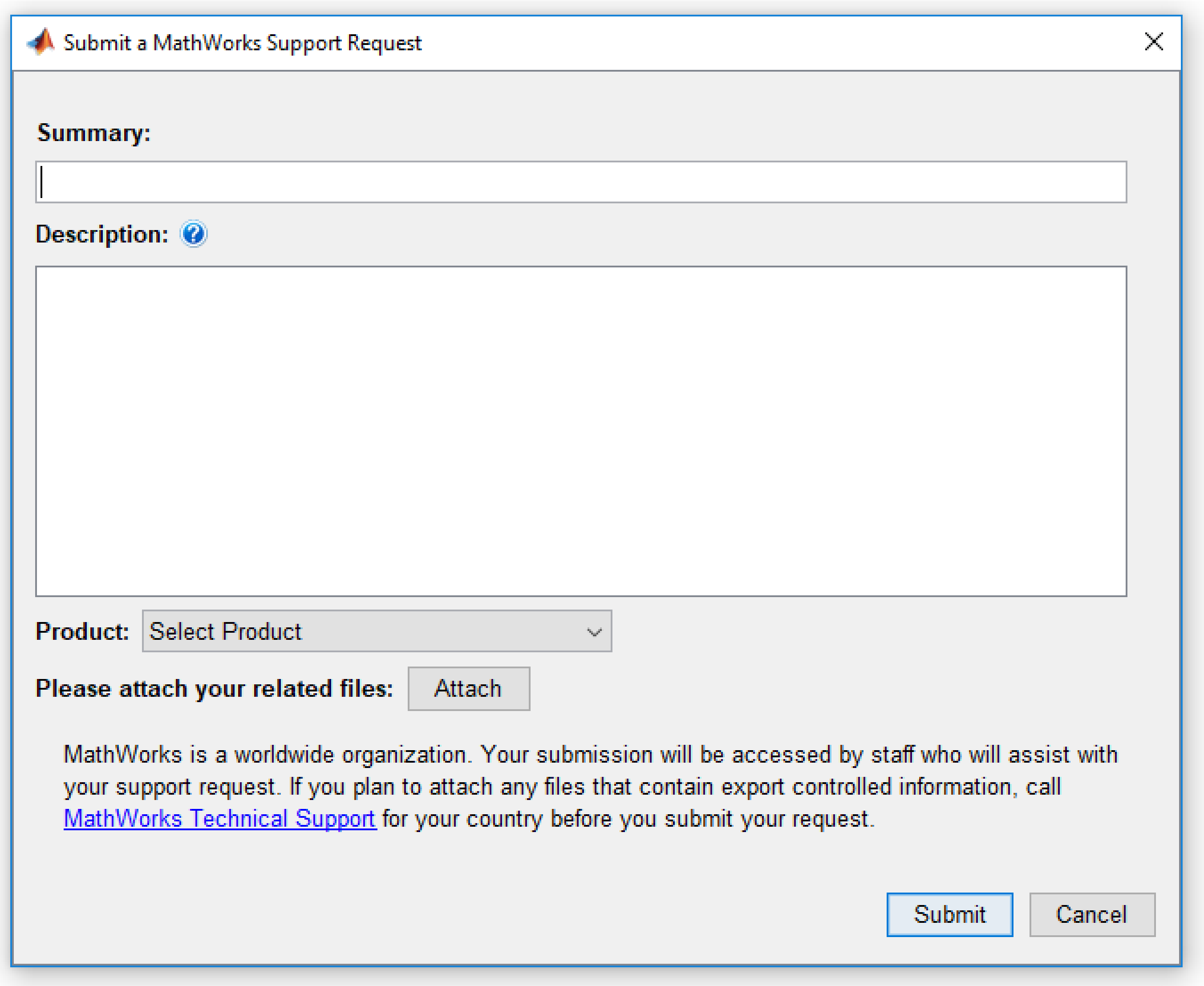
- Tech support
  - 95% of calls a
  - 90% of custom





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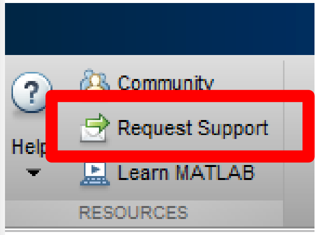

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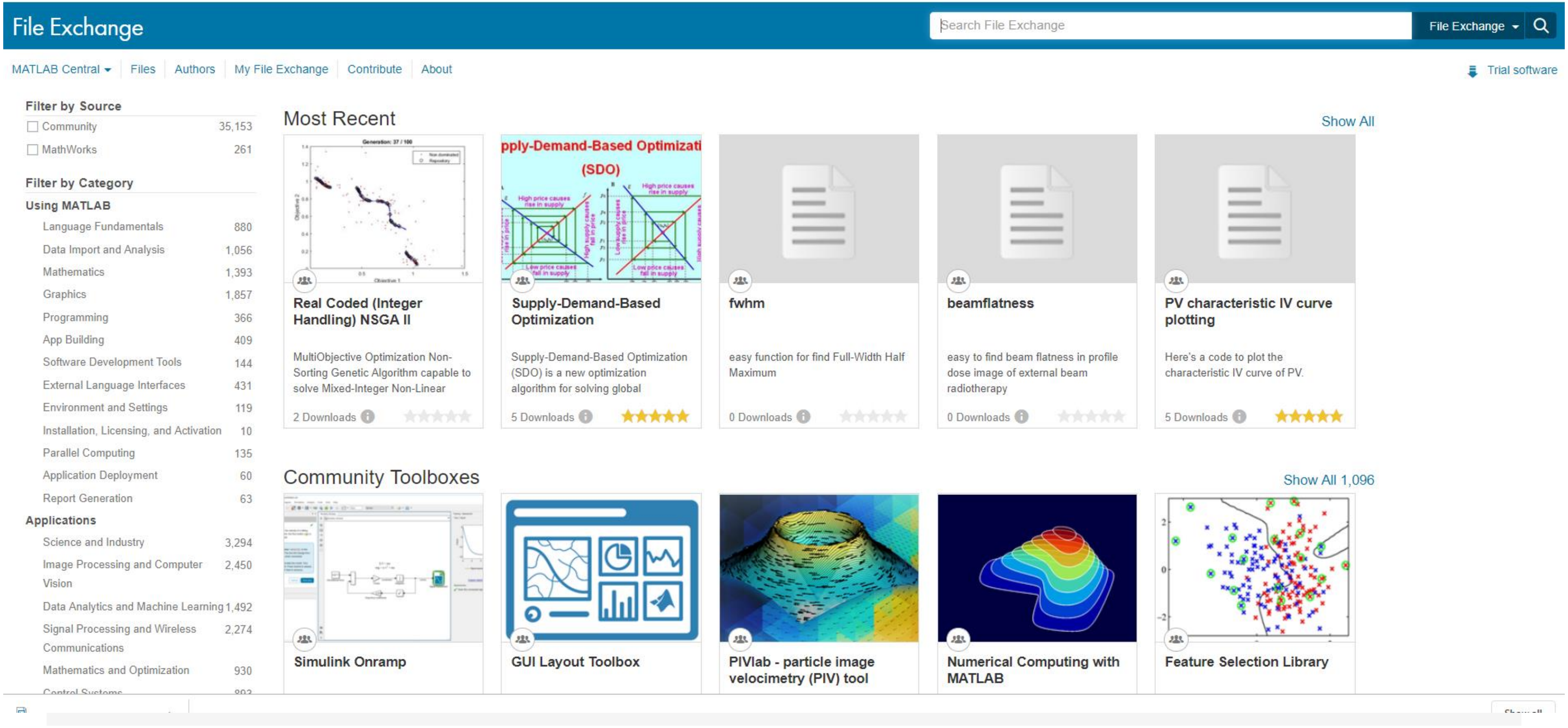

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