What’s New in MATLAB 2015

Joe Hicklin
Talks showing off new features

- What’s New in Simulink in Releases 2015a and 2015b
  - 11:15–11:45

- Machine Learning for Predictive Modelling
  - 14:30 – 15:15

- Development and Testing of Robotic Applications Using MATLAB and Simulink
  - 16:15 – 17:00
A quick look at some new features
New Axis Location: origin

\[ x = -10:0.01:10; \]
\[ \text{plot}(x, \text{sinc}(x)) \]
**New Axis Location: origin**

```matlab
x = -10:0.01:10;
plot(x, sinc(x))
set(gca, 'xaxislocation', 'origin')
```
New Axis Location: origin

x = -10:0.01:10;
plot(x, sinc(x))

set( gca, 'xaxislocation', 'origin' )
set( gca, 'yaxislocation', 'origin' )
Bivariate Histograms

\[ x = \text{randn}(100000, 1); \]

\[ \text{histogram}(x) \]
Bivariate Histograms

\[ x = \text{randn}(100000, 1); \]
\[ y = x .* \text{randn}(100000, 1); \]
\[ \text{histogram2}(x, y) \]
Array Size Limit

Have you done this?

% I need an array with a million elements
Array Size Limit

Have you done this?

% I need an array with a million elements
V = rand(1000000);
Array Size Limit

Have you done this?

```matlab
% I need an array with a million elements
V = rand(1000000);
```

What happens now?
Array Size Limit

Have you done this?

```matlab
% I need an array with a million elements
V = rand(1000000);
```

What happens now?

```
Error using rand
Requested 1000000x1000000 (7450.6GB) array exceeds maximum array size preference.
```
Array Size Limit

Error using rand
Requested 1000000x1000000 (7450.6GB) array exceeds maximum array size preference.
What is the average departure delay for each airline?

```matlab
>> T(1:15, :)
ans =

    DepTime  ArrTime  UniqueCarrier  FlightNum  ArrDelay  DepDelay  Origin  Dest
    ______   ______  _____________  ________  ________  ________  _____  _____
     '1434'   '1522'   'AS'         67         7         14     'SEA'   'KTN'
     '1545'   '1628'   'AS'         67         -7        -5     'KIN'   'SIT'
     '1500'   '1600'   'AS'         67         25        20     'SEA'   'KTN'
     '1114'   '1342'   'TW'         469        -2        -1     'SJU'   'MIA'
     '1725'   '2104'   'ER'         240        -2         0     'SJU'   'PHL'
     '700'    '1101'   'AR'         662        24         0     'SJU'   'JFK'
     '1735'   '2131'   'AR'         688        13         0     'SJU'   'JFK'
     '1829'   '2000'   'ER'         942        0         0     'SJU'   'MIA'
     '1301'   '1925'   'AR'         606       -61         1     'DFW'   'SJU'
     '1326'   '1947'   'AR'         919        1         7     'ORD'   'SJU'
     '945'    '1249'   'AS'         60         64        65     'KTN'   'SEA'
     '700'    '1752'   'AS'         60         2         0     'JNU'   'KIN'
     '825'    '1100'   'AS'         60       -10         0     'KTN'   'SEA'
     '740'    '1034'   'AS'         60        14         0     'KTN'   'SPA'
     '1002'   '1025'   'US'         295        -9        -3     'DCA'   'IND'
```
Working with “Grouped Data”

```matlab
[groups, airline] = findgroups( T.UniqueCarrier );
```

<table>
<thead>
<tr>
<th>groups(1:10)</th>
<th>airline</th>
</tr>
</thead>
<tbody>
<tr>
<td>ans =</td>
<td>ans =</td>
</tr>
<tr>
<td>4</td>
<td>'AS'</td>
</tr>
<tr>
<td>4</td>
<td>'AS'</td>
</tr>
<tr>
<td>4</td>
<td>'AS'</td>
</tr>
<tr>
<td>23</td>
<td>'AA'</td>
</tr>
<tr>
<td>9</td>
<td>'AA'</td>
</tr>
<tr>
<td>2</td>
<td>'AA'</td>
</tr>
<tr>
<td>2</td>
<td>'AA'</td>
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<td>2</td>
<td>'AA'</td>
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<td>2</td>
<td>'AA'</td>
</tr>
<tr>
<td>2</td>
<td>'AA'</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T.UniqueCarrier(1:10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ans =</td>
</tr>
<tr>
<td>'AS'</td>
</tr>
<tr>
<td>'AS'</td>
</tr>
<tr>
<td>'AS'</td>
</tr>
<tr>
<td>'TK'</td>
</tr>
<tr>
<td>'EA'</td>
</tr>
<tr>
<td>'AA'</td>
</tr>
<tr>
<td>'AA'</td>
</tr>
<tr>
<td>'AA'</td>
</tr>
<tr>
<td>'AA'</td>
</tr>
<tr>
<td>'AA'</td>
</tr>
</tbody>
</table>
Working with “Grouped Data”

\[
\text{meanDelay} = \text{splitapply}( @\text{mean}, \text{T.DepDelay}, \text{groups} ) ;
\]

\[
\begin{array}{c}
\text{meanDelay} = \\
8.4664 \\
7.8672 \\
0.7273 \\
7.8045 \\
10.9007 \\
7.6073 \\
9.9095 \\
7.2765 \\
9.7174 \\
12.3190 \\
8.8806 \\
10.0412 \\
-1.1978 \\
7.6559 \\
2.6522 \\
9.2473 \\
5.7511 \\
9.3809 \\
7.1375 \\
5.6855 \\
9.3467 \\
7.0602 \\
7.7787 \\
3.9444 \\
9.2057 \\
7.6384 \\
8.9213 \\
8.3746 \\
13.5595 \\
\end{array}
\]

\[
\begin{array}{c}
\text{T.DepDelay(1:10)} \\
14 \\
-5 \\
20 \\
-1 \\
0 \\
0 \\
0 \\
1 \\
7 \\
\end{array}
\]

\[
\begin{array}{c}
\text{groups(1:10)} \\
1 \\
4 \\
4 \\
23 \\
9 \\
2 \\
2 \\
9 \\
2 \\
2 \\
\end{array}
\]
Working with “Grouped Data”

[groups, airline] = findgroups(T.UniqueCarrier);
meanDelay = splitapply(@mean, T.DepDelay, groups);
table(airline, meanDelay)
We support many types of hardware
And now there are two more

We have added support for two popular new systems:

Raspberry Pi 2
- 900 MHz
- Quad core
- 1 GB ram
We have added support for two popular new systems:

BeagleBone Black
  1 GHz
  512 MB ram
  4GB flash rom
  3D Graphics
Python Integration

- MATLAB integrates with several programming languages:
  - C/C++
  - Java
  - FORTRAN
  - COM
  - .NET
  - Python
Call Python from MATLAB

MATLAB Interface to Python

```matlab
>> s = py.string.Template(...
    'Patient Name: $who')
>> substitute(s,pyargs('who','Smith'))

Patient Name: Smith
```
Call MATLAB from Python

**MATLAB Engine API**

```python
>>> import matlab.engine
>>> eng = matlab.engine.start_matlab()
>>> eng.sqrt(9.0)
3.0
```
Deploy MATLAB Components for Python

- MATLAB Compiler SDK
  - Creates deployable MATLAB components for integration with applications written in Python
Graphs in MATLAB

A directed graph with four nodes and three edges.
Graphs in MATLAB

A Graph object
Create
Manipulate
Analyze

A GraphPlot object
View
Let’s make a simple Graph

sourceNodes = [ 1 1 1 2 2 3 3 4 5 5 6 7 ];
targetNodes = [ 2 4 8 3 7 4 6 5 6 8 7 8 ];
G = graph( sourceNodes , targetNodes )

G =
    graph with properties:
      Edges: [12x1 table]
      Nodes: [8x0 table]
Plot a Graph

\[ P = \text{plot}(G); \]

\[
\text{sourceNodes} = [1 1 1 2 2 3 3 4 5 5 6 7]; \\
\text{targetNodes} = [2 4 8 3 7 4 6 5 6 8 7 8];
\]
Plot a Graph

```
layout(P,'circle')
```
Are these drawings of the same graph?
Plot a Graph

```matlab
layout(P, 'layered')
```
Plot a Graph

```
layout( P, 'force' );
```
Graphs in MATLAB

load('MinnesotaRoads');
plot(G);
Graphs in MATLAB

G.Nodes(1:7,:)

ans =

<table>
<thead>
<tr>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>-97.207</td>
<td>49.001</td>
</tr>
<tr>
<td>-96.801</td>
<td>49</td>
</tr>
<tr>
<td>-95.957</td>
<td>49</td>
</tr>
<tr>
<td>-95.931</td>
<td>49</td>
</tr>
<tr>
<td>-95.766</td>
<td>49</td>
</tr>
<tr>
<td>-95.378</td>
<td>48.999</td>
</tr>
<tr>
<td>-97.2</td>
<td>48.972</td>
</tr>
</tbody>
</table>
Graphs in MATLAB

```matlab
P = plot(G, 'XData', G.Nodes.Longitude, 'YData', G.Nodes.Latitude);
```
Useful Graph Algorithms

- **shortestpath**: Shortest path between two single nodes
- **shortestpathtree**: Shortest path tree from node
- **distances**: Shortest path distances of all node pairs
- **bfsearch**: Breadth-first graph search
- **dfsearch**: Depth-first graph search
- **maxflow**: Maximum flow in graph
- **conncomp**: Connected graph components
- **minspanintree**: Minimum spanning tree of graph
- **toposort**: Topological order of directed acyclic graph
- **isdag**: Determine if graph is acyclic
- **transclosure**: Transitive closure
- **transreduction**: Transitive reduction
Graphs in MATLAB

```matlab
P.labelnode(cityIDs, cityNames);
```
Graphs in MATLAB

```matlab
P.labelnode(cityIDs, cityNames);
```
Graphs in MATLAB

```
T = shortestpath(G,Minneapolis,Moorhead);
P.highlight(T,'EdgeColor','r');
```
Graphs in MATLAB

T = shortestpath(G,Minneapolis,Moorhead);
P.highlight(T,'EdgeColor','r');
Graphs in MATLAB

```matlab
P.NodeCData = distances(G, Minneapolis);
title('Distance from Minneapolis (miles)');
colorbar
```
Graphs in MATLAB

```matlab
P.NodeCData = distances(G, Minneapolis);
title('Distance from Minneapolis (miles)');
colorbar
```
Minnesota gets a lot of snow.

You plow the snow
Your equipment is in Minneapolis
You don’t have to plow every road
Drivers must be able to get from every town to every other town

What is the least you must plow?

```
tree = minspantree(G,'root',minneapolis);
highlight(P,tree, 'LineWidth', 3);
```
Minnesota gets a lot of snow.

You plow the snow
Your equipment is in Minneapolis
You don’t have to plow every road
Drivers must be able to get from every town to every other town

What is the least you must plow?

```matlab
tree = minspantree(G,'root',minneapolis);
highlight(P,tree, 'LineWidth', 3);
```
Add-On Explorer

The File Exchange on MATLAB Central

About 20,000 submissions

An underused resource

Awareness

Complexity
Add-On Explorer
Add-On Explorer
Add-On Explorer
Add-On Explorer

MATLAB EXPO 2015
UNITED KINGDOM

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Add-On Explorer
Add-On Explorer
Add-On Explorer

MATLAB EXPO 2015
UNITED KINGDOM
Add-On Manager

Command Window

>> demoDrawTubularMesh
Add-On Explorer
Add-On Manager

```matlab
>> demoDrawTubularMesh
```
Add-On Manager
Add-On Manager

- Aerospace Blockset version 3.16
- Aerospace Toolbox version 2.10
- Antenna Toolbox version 1.1
- Bioinformatics Toolbox version 4.5.2
- Communications System Toolbox version 6.1
- Computer Vision System Toolbox version 7.0

Sort By: Installed Date

Installed on 21 September 2015

Learn More ▼ Uninstall
Add-On Explorer

I searched for “Vibration”
133 results

“Spectral”
512 results

“Machine Learning”
125 results
## Add-On Explorer

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>133</td>
</tr>
<tr>
<td>Spectral</td>
<td>512</td>
</tr>
<tr>
<td>Machine Learning</td>
<td>125</td>
</tr>
<tr>
<td>Support Vector</td>
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<tr>
<td>Classify</td>
<td>411</td>
</tr>
<tr>
<td>Detect</td>
<td>1342</td>
</tr>
<tr>
<td>Control</td>
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</tr>
<tr>
<td>Control Phase</td>
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<td>Love</td>
<td>26</td>
</tr>
<tr>
<td>Beauty</td>
<td>26</td>
</tr>
<tr>
<td>Truth</td>
<td>84</td>
</tr>
<tr>
<td>Beer</td>
<td>10</td>
</tr>
<tr>
<td>Monkey</td>
<td>3</td>
</tr>
<tr>
<td>Yogurt</td>
<td>0</td>
</tr>
</tbody>
</table>

Don’t start doing this when you have a deadline!
MATLAB Execution Engine

MATLAB

Language
R2015b
“LXE”

Math

Graphics
R2014b
MATLAB Execution Engine

Old system had two different execution mechanisms – a JIT and an Interpreter. New system has a single execution mechanism.

Old JIT was designed for FORTRAN-like constructs within MATLAB. New JIT is designed for the entire MATLAB language.

Old system had a monolithic architecture that was difficult to extend. New system has a Modular, Thread-safe, and Platform re-targetable architecture.
MATLAB Execution Engine
Performance Improvement Highlights

- Econometrics Toolbox: American Basket Demo executes **60% faster**
- Image processing with active contours executes **32% faster**
- SVM classification for Machine Learning executes **12% faster**
- Examples used in “Speeding up MATLAB” webinar execute **30% faster**
- k-NN classification for Machine Learning executes **37% faster**
- Machine Learning classification executes **25% faster**
- Image Processing executes **15% faster**
- Performance in Object-Oriented MATLAB Code on File Exchange executes **10-40% faster**
- Wireless Application demo executes **50% faster**
Application Level Benchmarks

99% on par or faster with LXE
64% more than 10% faster

![Graph showing performance ratios between R2015a and R2015b]
Core and Toolbox UPS tests

Tests slower with the LXE (10%)

Tests faster with the LXE (55%)

90% on par or faster with LXE
55% more than 10% faster
39% more than 25% faster

Lower-level tests show more variability
MATLAB Execution Engine

Summary

R2015b runs MATLAB programs faster than previous releases.

We will continue to increase performance.

We will add new features more easily and more quickly.
What’s New in MATLAB 2015