What's New in MATLAB 2015

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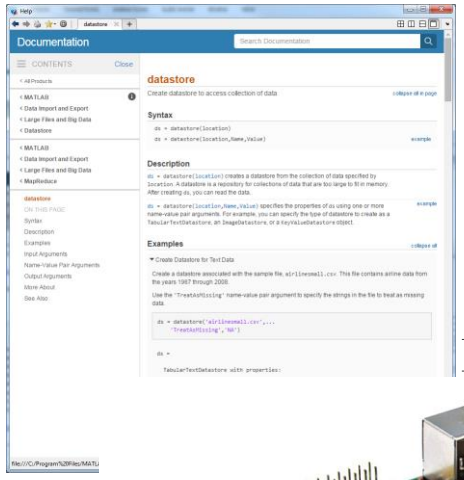
MATLAB EXPO 2015
UNITED KINGDOM

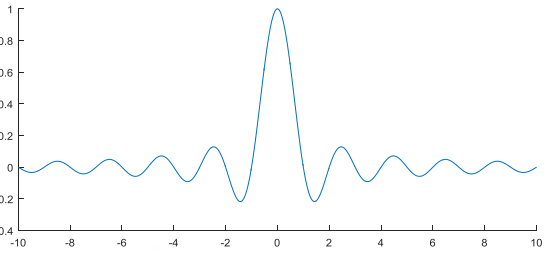
Talks showing off new features

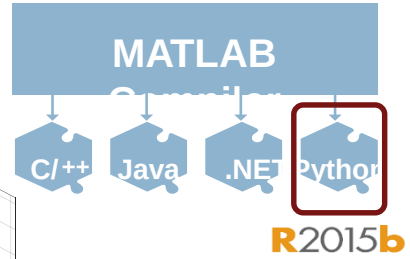
- What's New in Simulink in Releases 2015a and 2015b
  - **11:15–11:45**
- Machine Learning for Predictive Modelling
  - **14:30 – 15:15**
- Development and Testing of Robotic Applications Using MATLAB and Simulink
  - **16:15 – 17:00**

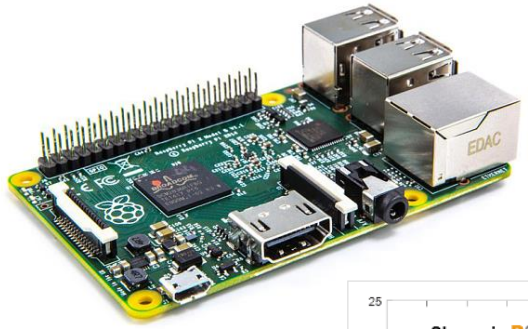
A quick look at some new features

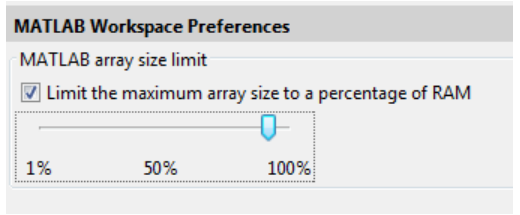
```
>> T(1:15,:)

ans =

    DepTime    ArrTime    UniqueCarrier    FlightNum    ArrDelay    DepDelay    Origin    Dest
    _______    _______    _____________    _________    ________    ________    ______    ____

    '1434'     '1522'     'AS'                67           7          14        'SEA'     'KTN'
    '1545'     '1628'     'AS'                67          -7          -5        'KTN'     'SIT'
    '1500'     '1600'     'AS'                67          25          20        'SEA'     'KTN'
    '1114'     '1342'     'TW'               469           2          -1        'SJU'     'MIA'
    '1725'     '2104'     'EA'               940          -2           0        'SJU'     'PHL'
    '700'      '1101'     'AA'               662          24           0        'SJU'     'JFK'
    '1735'     '2131'     'AA'               688          13           0        'SJU'     'JFK'
    '1829'     '2000'     'EA'               942           0           0        'SJU'     'MIA'
    '1301'     '1925'     'AA'               606          -6           1        'DFW'     'SJU'
    '1326'     '1947'     'AA'               919           1           7        'ORD'     'SJU'
    '945'      '1249'     'AS'                60          84          65        'KTN'     'SEA'
    '700'      '752'      'AS'                60           2           0        'JNU'     'KTN'
    '825'      '1100'     'AS'                60         -10           0        'KTN'     'SEA'
    '740'      '1034'     'AS'                60          14           0        'KTN'     'SEA'
    '1002'     '1025'     'US'               295          -9          -3        'DCA'     'IND'
```

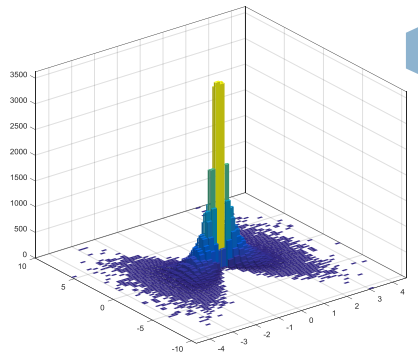


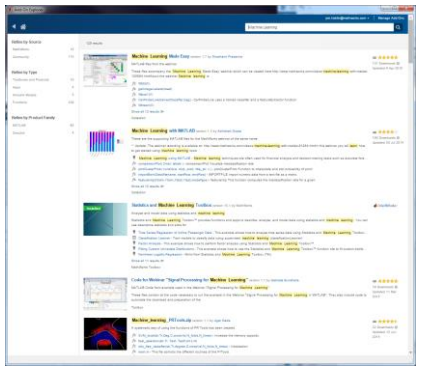


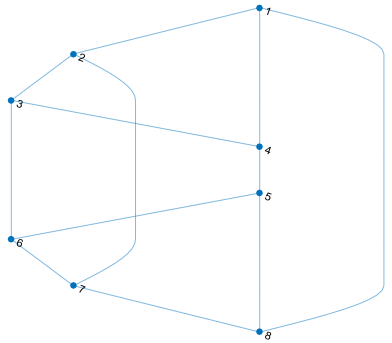


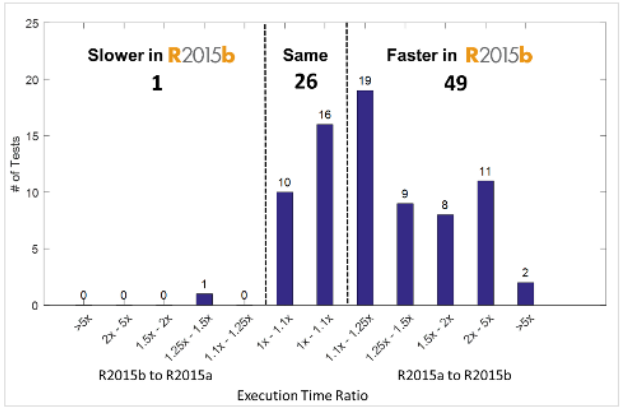






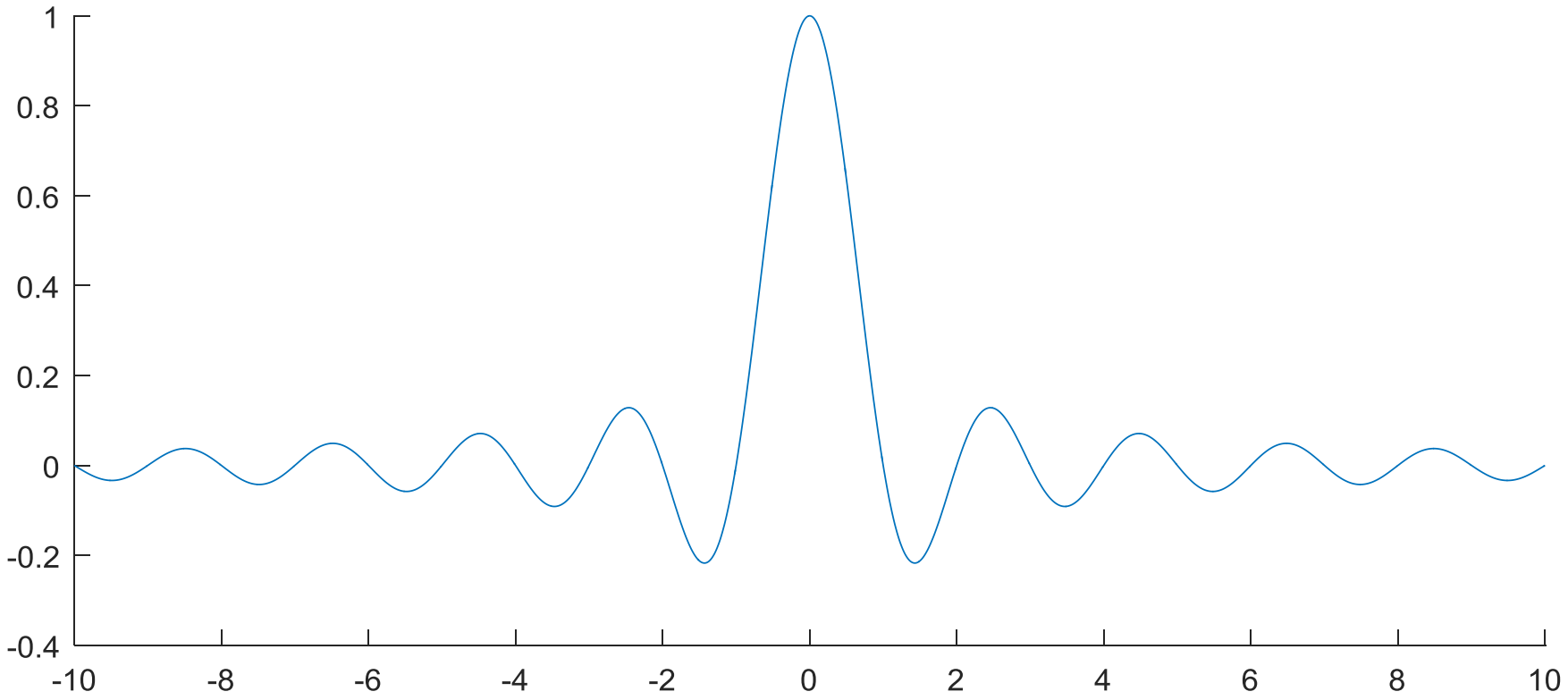






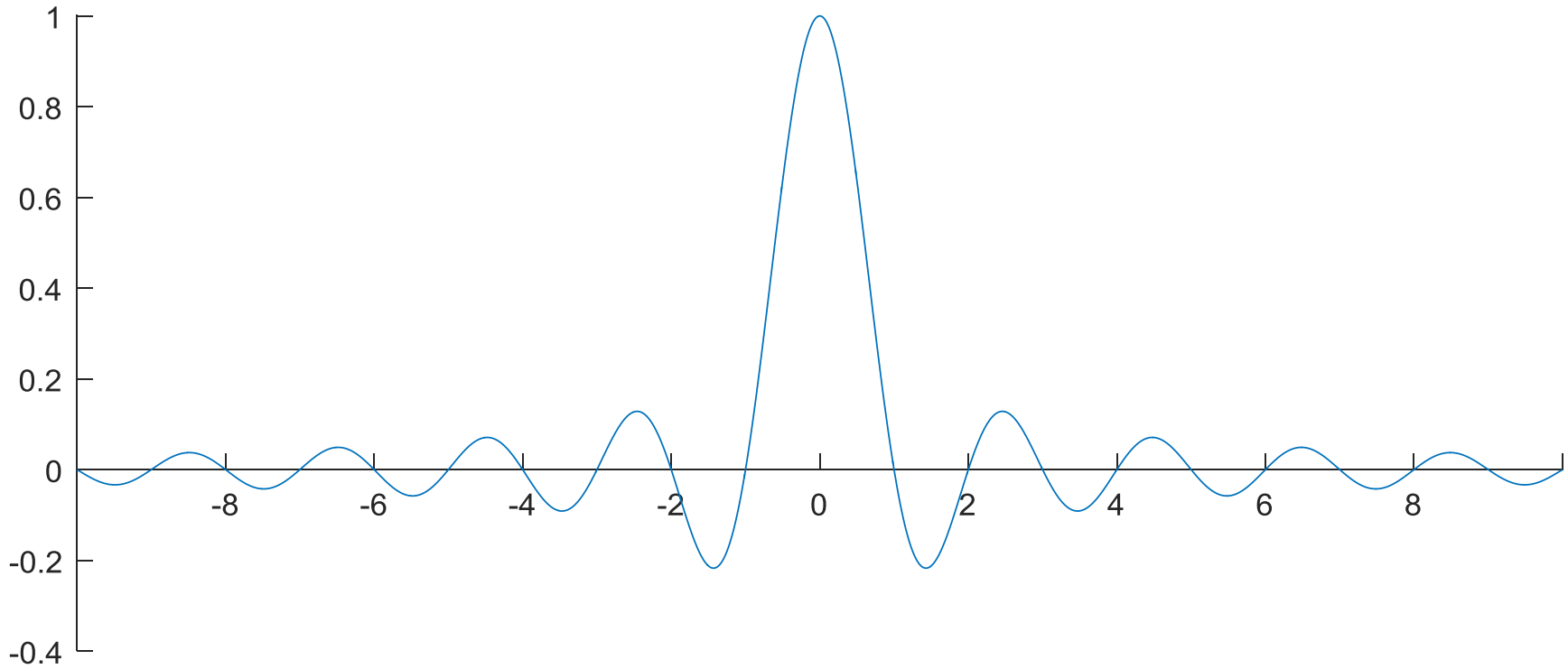
New Axis Location: origin

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



New Axis Location: origin

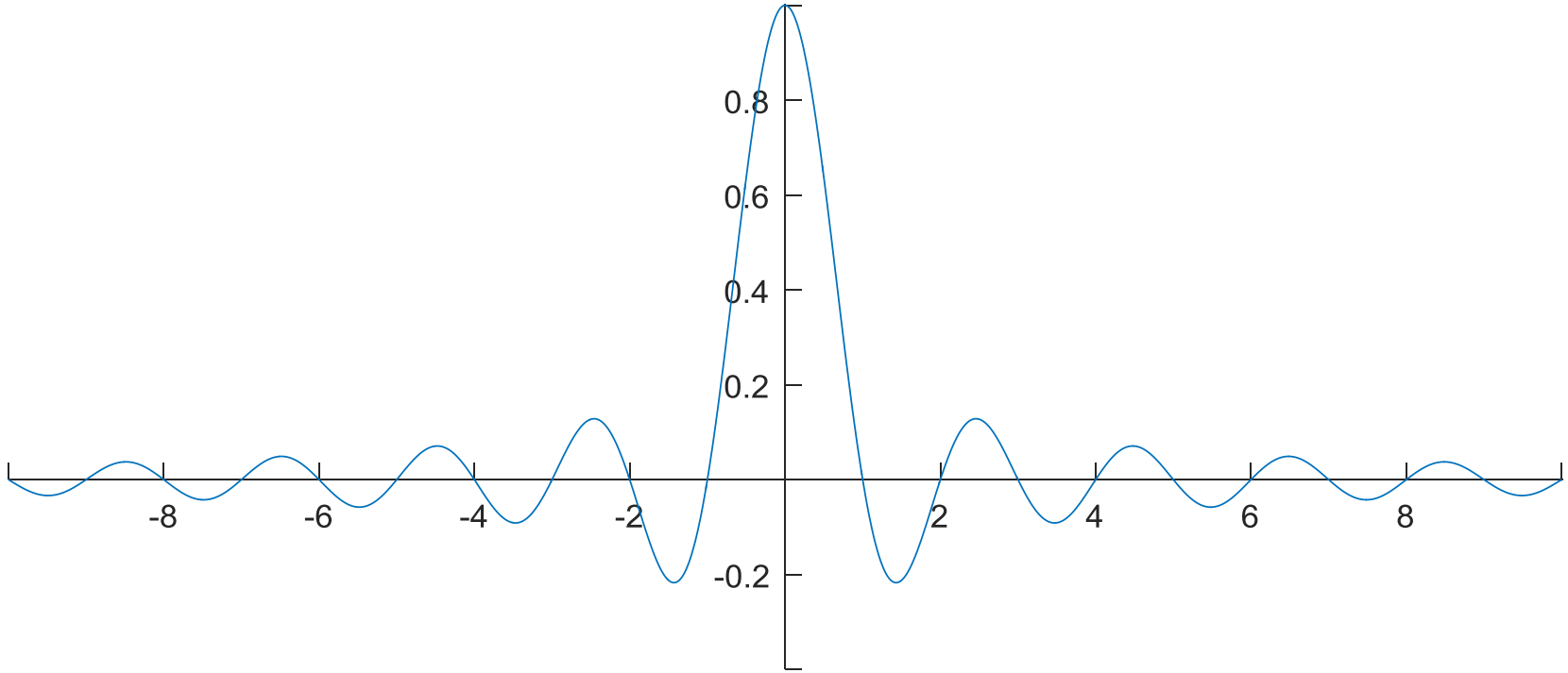
```
x = -10:0.01:10;
plot(x, sinc(x))
```




```
set (gca, 'xaxislocation', 'origin' )
```

New Axis Location: origin

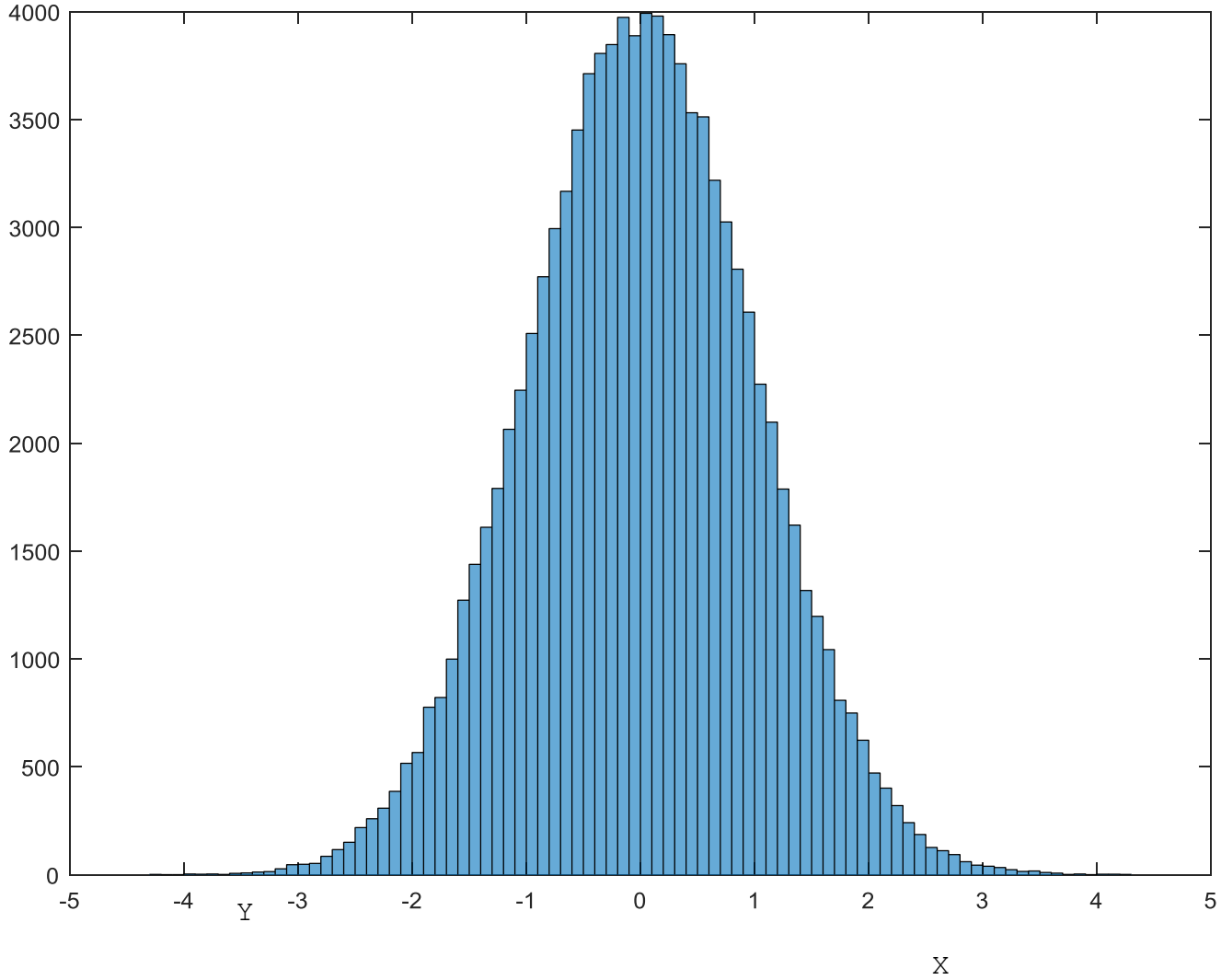
```
x = -10:0.01:10;
plot(x, sinc(x))
```




```
set( gca, 'xaxislocation', 'origin' )
set( gca, 'yaxislocation', 'origin' )
```

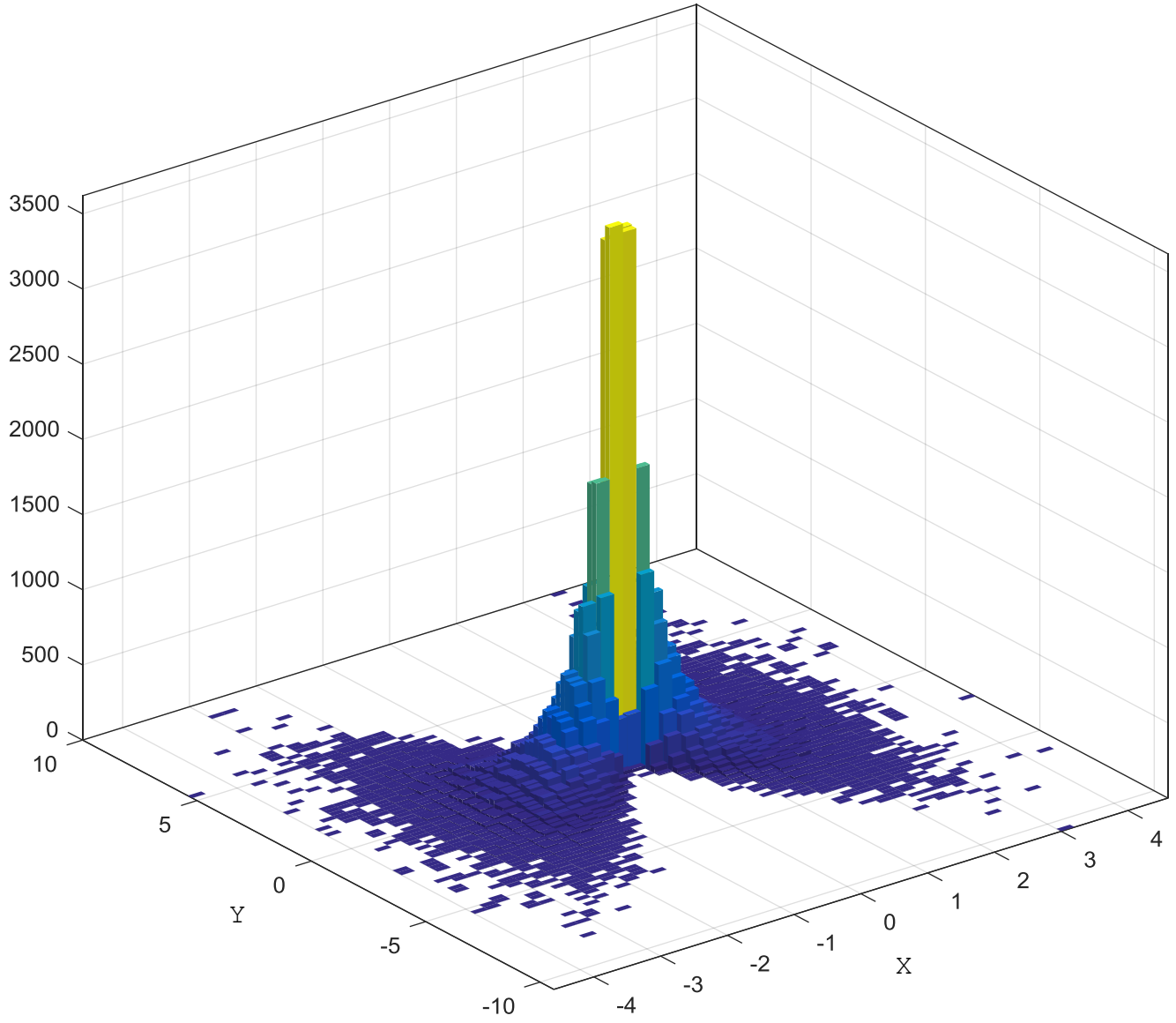
Bivariate Histograms

```
x = randn(100000, 1);

histogram(x)
```



Bivariate Histograms

```
x =      randn(100000, 1);
y = x .* randn(100000, 1);

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?

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

What happens now?

Array Size Limit

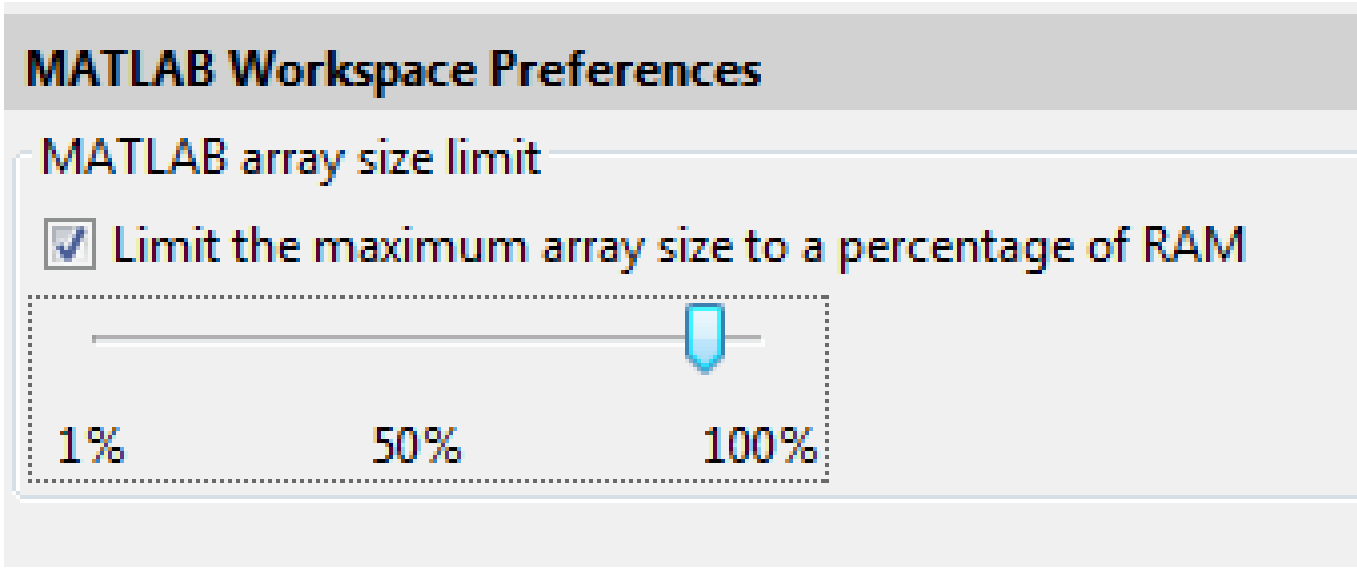
Have you done this?

```
% 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.
```

Working with “Grouped Data”

What is the average departure delay for each airline?

```
>> 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	'KTN'	'SIT'
'1500'	'1600'	'AS'	67	25	20	'SEA'	'KTN'
'1114'	'1342'	'TW'	469	2	-1	'SJU'	'MIA'
'1725'	'2104'	'EA'	940	-2	0	'SJU'	'PHL'
'700'	'1101'	'AA'	662	24	0	'SJU'	'JFK'
'1735'	'2131'	'AA'	688	13	0	'SJU'	'JFK'
'1829'	'2000'	'EA'	942	0	0	'SJU'	'MIA'
'1301'	'1925'	'AA'	606	-6	1	'DFW'	'SJU'
'1326'	'1947'	'AA'	919	1	7	'ORD'	'SJU'
'945'	'1249'	'AS'	60	84	65	'KTN'	'SEA'
'700'	'752'	'AS'	60	2	0	'JNU'	'KTN'
'825'	'1100'	'AS'	60	-10	0	'KTN'	'SEA'
'740'	'1034'	'AS'	60	14	0	'KTN'	'SEA'
'1002'	'1025'	'US'	295	-9	-3	'DCA'	'IND'

Working with “Grouped Data”

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

```
>> groups(1:10)

ans =

     4
     4
     4
    23
     9
     2
     2
     9
     2
     2
```

```
airline =

    '9E'
    'AA'
    'AQ'
    'AS'
    'B6'
    'CO'
    'DH'
    'DL'
    'EA'
    'EV'
    'F9'
    'FL'
    'HA'
    'HP'
    'ML'
    'MQ'
    'NW'
    'OH'
    'OO'
    'PA'
    'PI'
    'PS'
    'TW'
    'TZ'
    'UA'
    'US'
    'WN'
    'XE'
    'YV'
```

```
>> T.UniqueCarrier(1:10)

ans =

    'AS'
    'AS'
    'AS'
    'TW'
    'EA'
    'AA'
    'AA'
    'EA'
    'AA'
    'AA'
```

Working with “Grouped Data”

```
meanDelay = splitapply( @mean, T.DepDelay, groups );
```

```
meanDelay =

    8.4664
    7.8672
    0.7273
    7.8045
   10.9007
    7.6073
    9.9009
    7.2765
    9.7174
   12.3190
    8.8806
   10.0412
   -1.1978
    7.6959
    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
```

```
>> T.DepDelay(1:10)

ans =

    14
    -5
    20
    -1
     0
     0
     0
     0
     1
     7
```

```
>> groups(1:10)

ans =

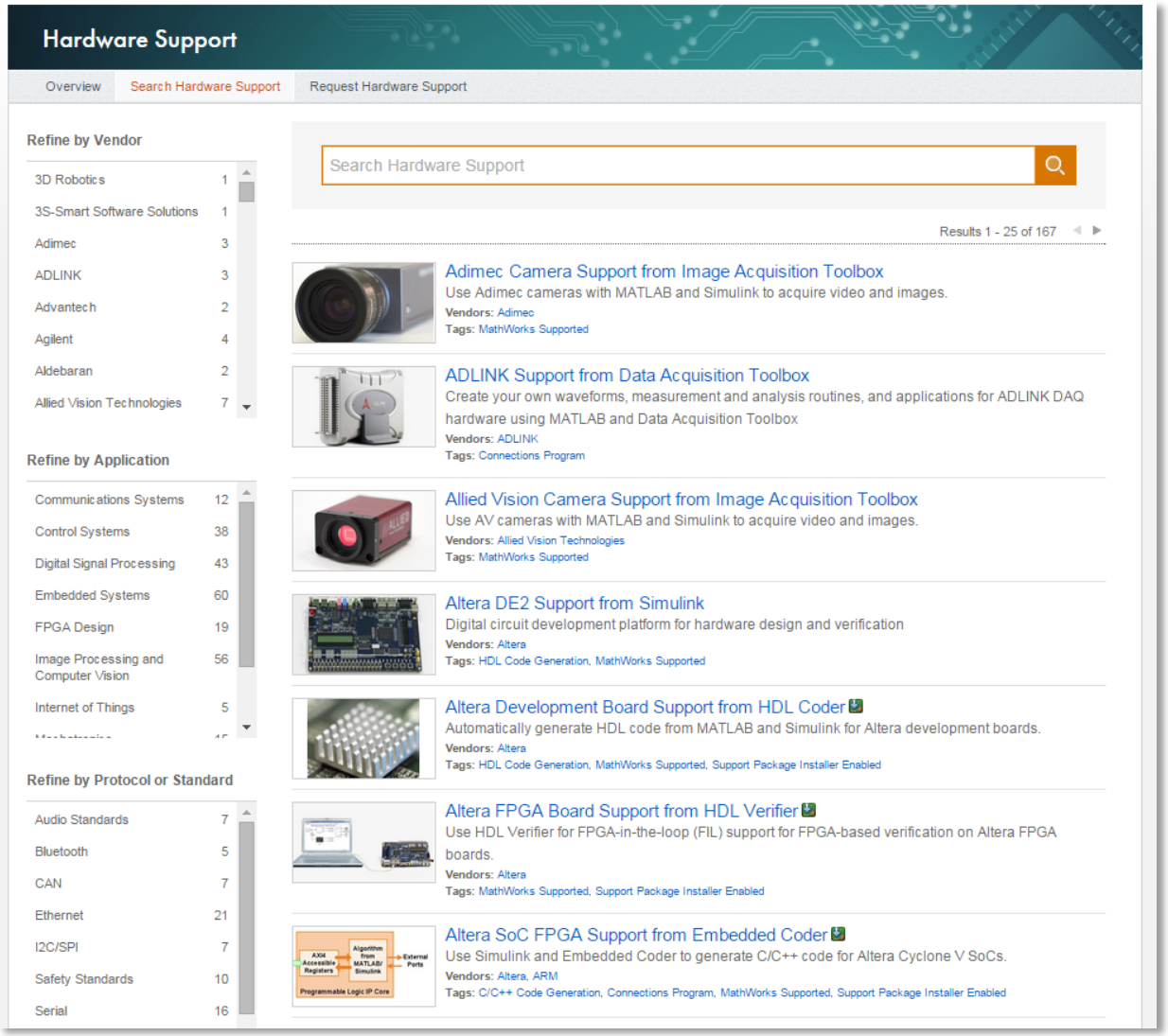
     4
     4
     4
    23
     9
     2
     2
     9
     2
     2
```

Working with “Grouped Data”

```
[groups, airline] = findgroups(T.UniqueCarrier);
meanDelay = splitapply( @mean, T.DepDelay, groups);
table(airline, meanDelay)
```

airline	meanDelay
'9E'	8.4664
'AA'	7.8672
'AQ'	0.72727
'AS'	7.8045
'B6'	10.901
'CO'	7.6073
'DH'	9.9009
'DL'	7.2765
'EA'	9.7174
'EV'	12.319
'F9'	8.8806
'FL'	10.041
'HA'	-1.1978
'HP'	7.6959
'ML'	2.6522
'MQ'	9.2473
'NW'	5.7511
'OH'	9.3809
'OO'	7.1375
'PA'	5.6855
'PI'	9.3467
'PS'	7.0602
'TW'	7.7787
'TZ'	3.9444
'UA'	9.2057
'US'	7.6384
'WN'	8.9213
'XE'	8.3746
'YV'	13.559

We support many types of hardware

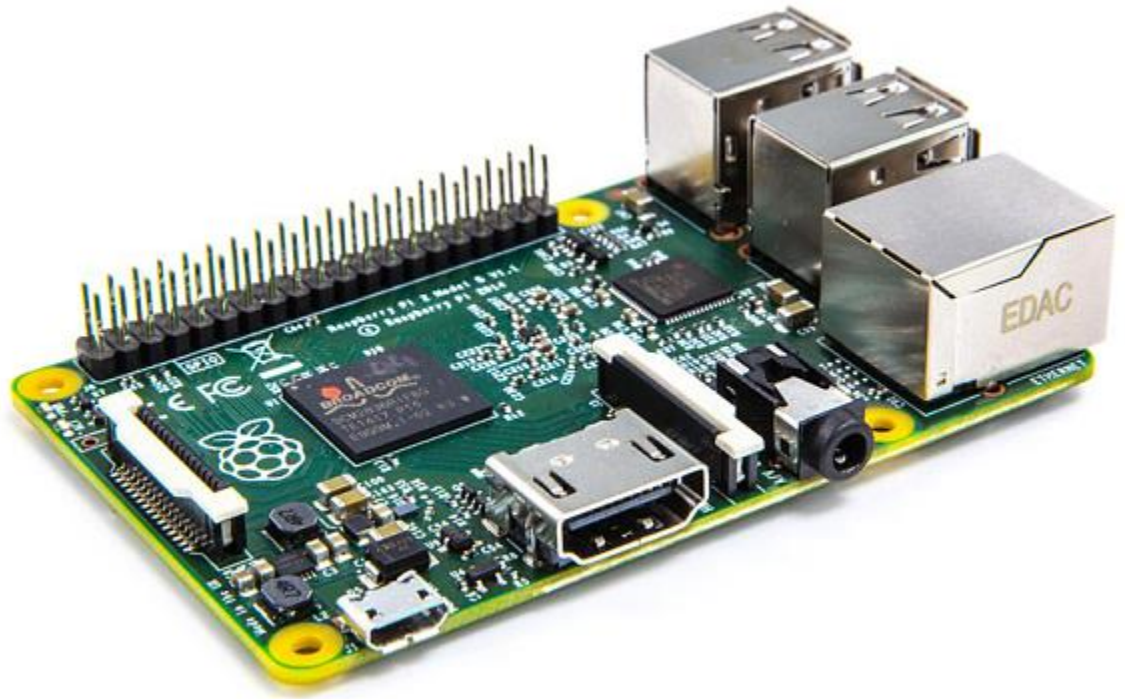


And now there are two more

We have added support for two popular new systems:

Raspberry Pi 2

- 900 MHz
- Quad core
- 1 GB ram

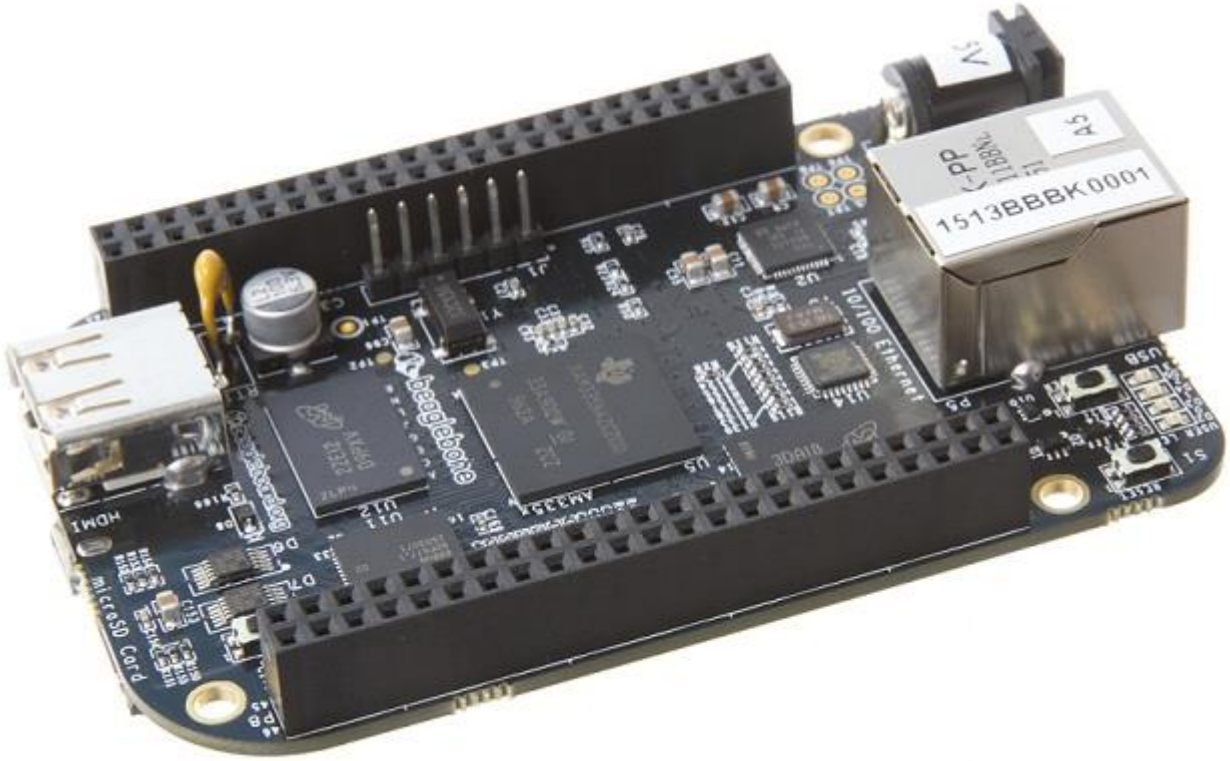


And now there are two more

We have added support for two popular new systems:

BeagleBone Black

- 1 GHz
- 512 MB ram
- 4GB flash rom
- 3D Graphics

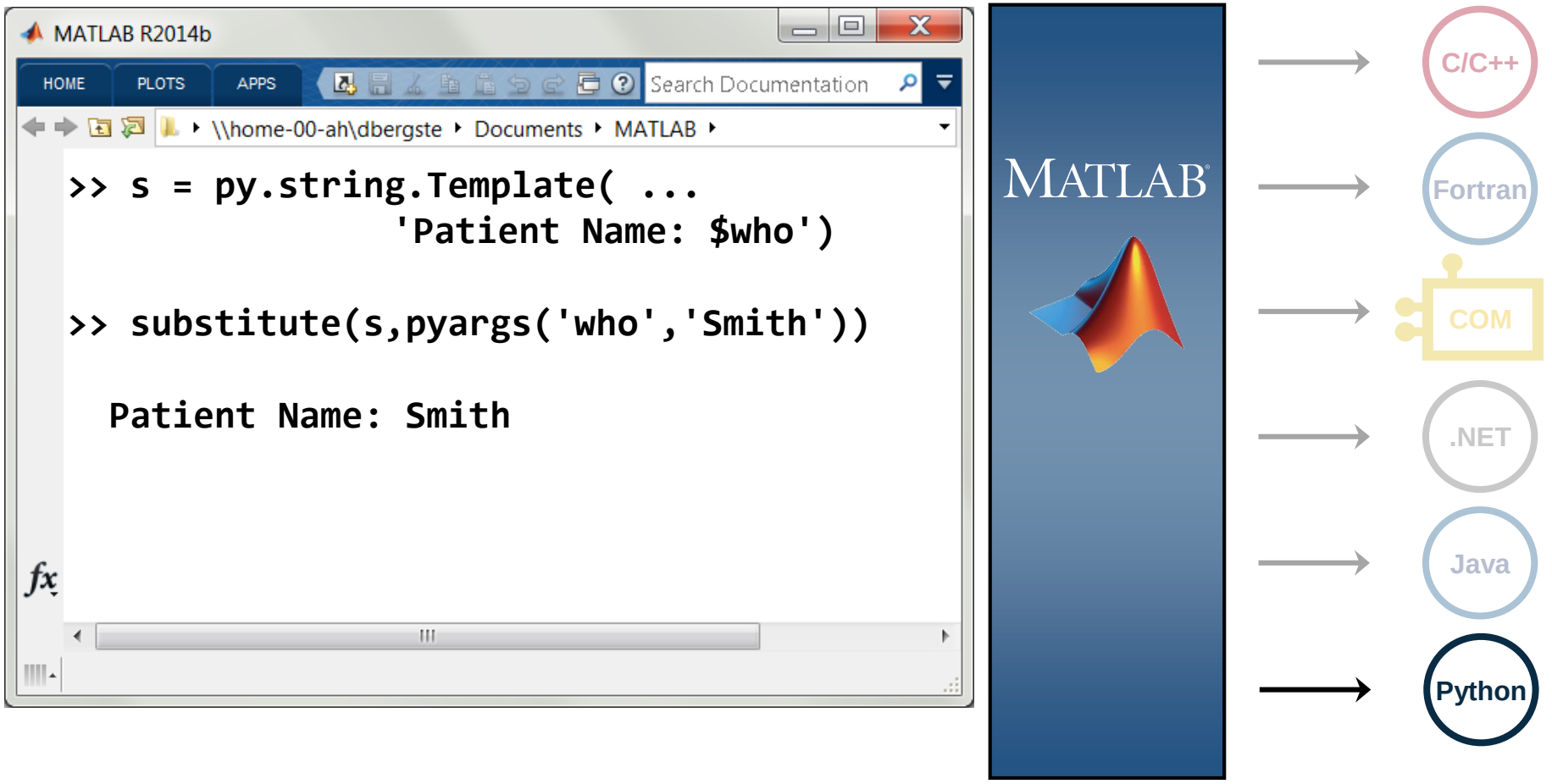


Python Integration

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

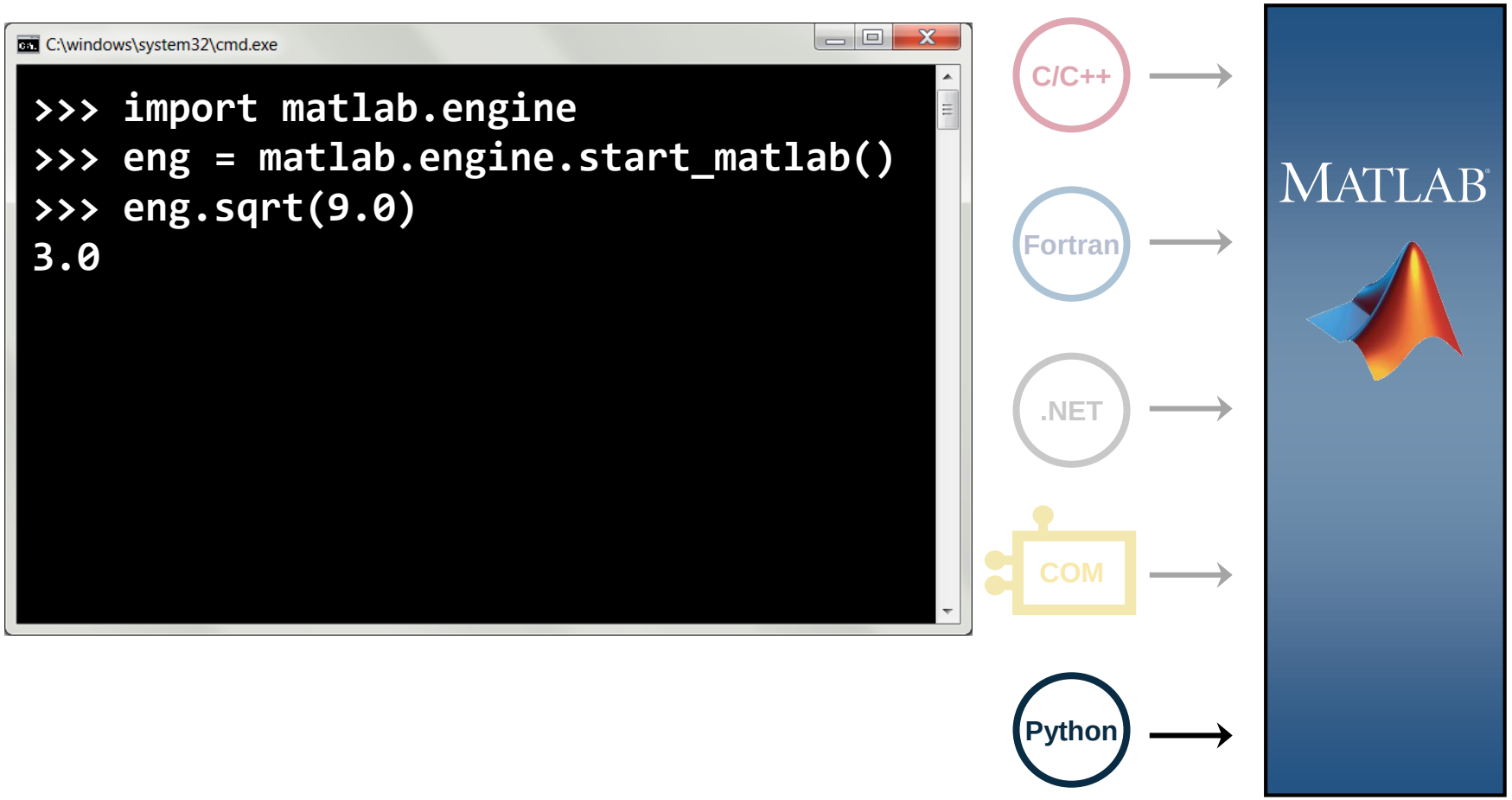
Call Python from MATLAB

MATLAB Interface to Python



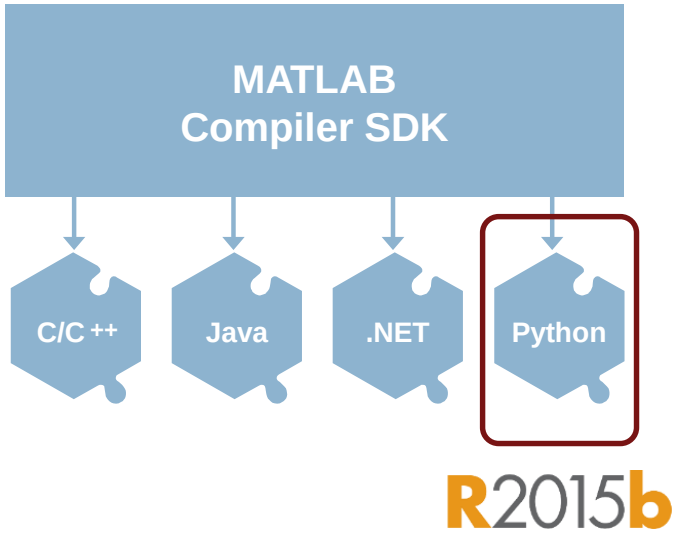
Call MATLAB from Python

MATLAB Engine API



Deploy MATLAB Components for Python

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

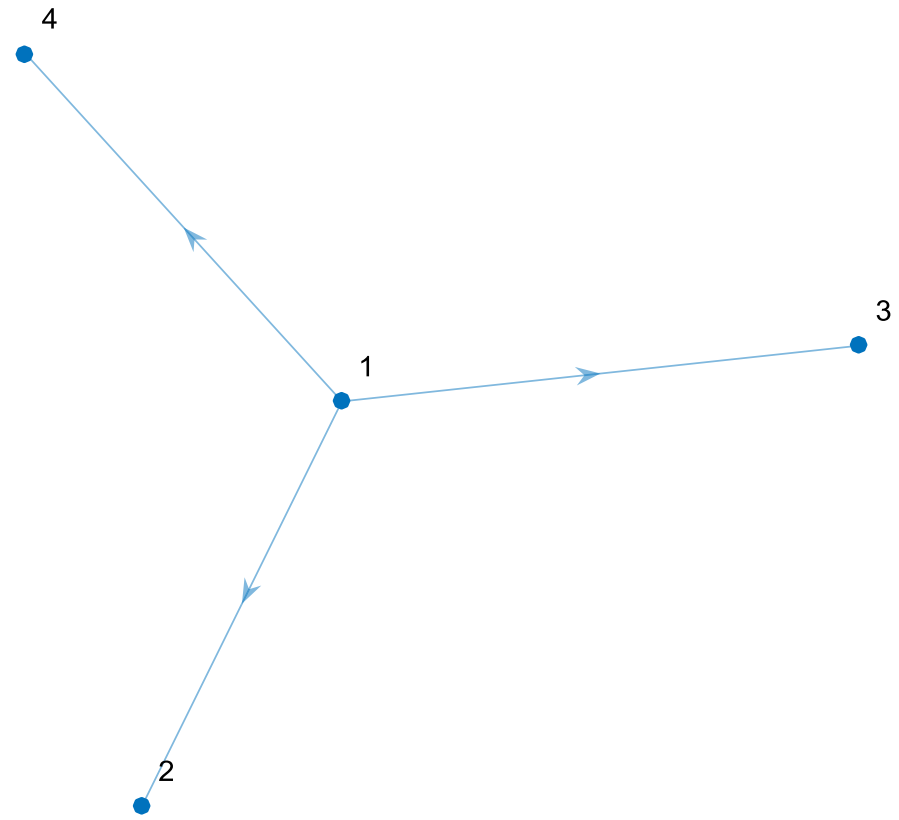


Graphs in MATLAB

A directed graph

with four nodes

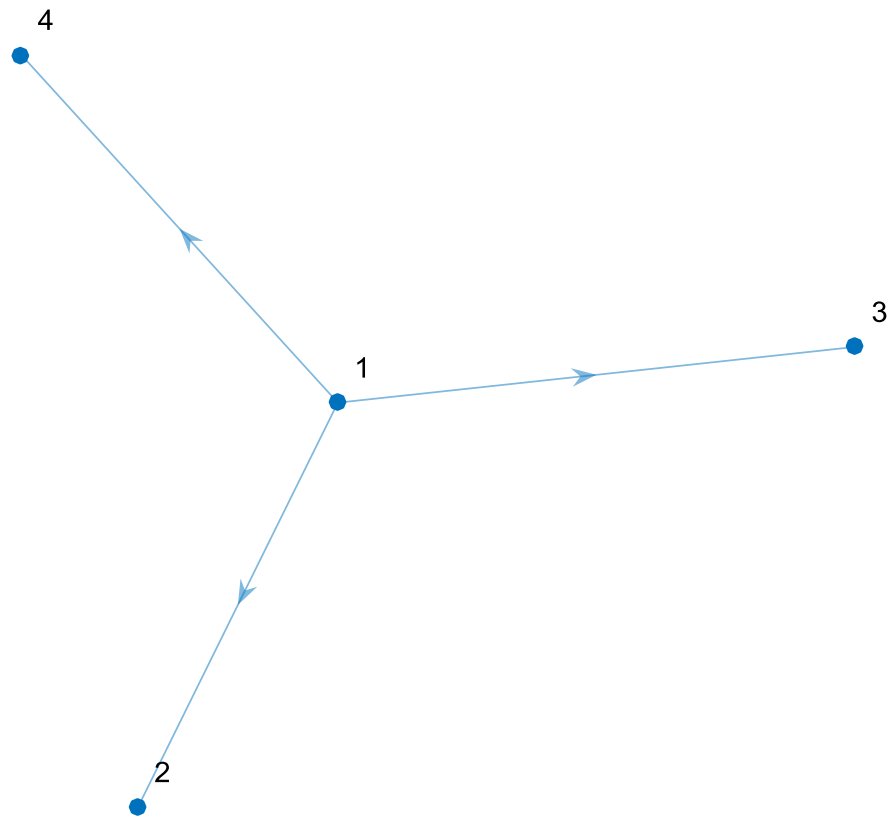
and three edges.



Graphs in MATLAB

A Graph object
- Create
- Manipulate
- Analyze

A GraphPlot object
- View



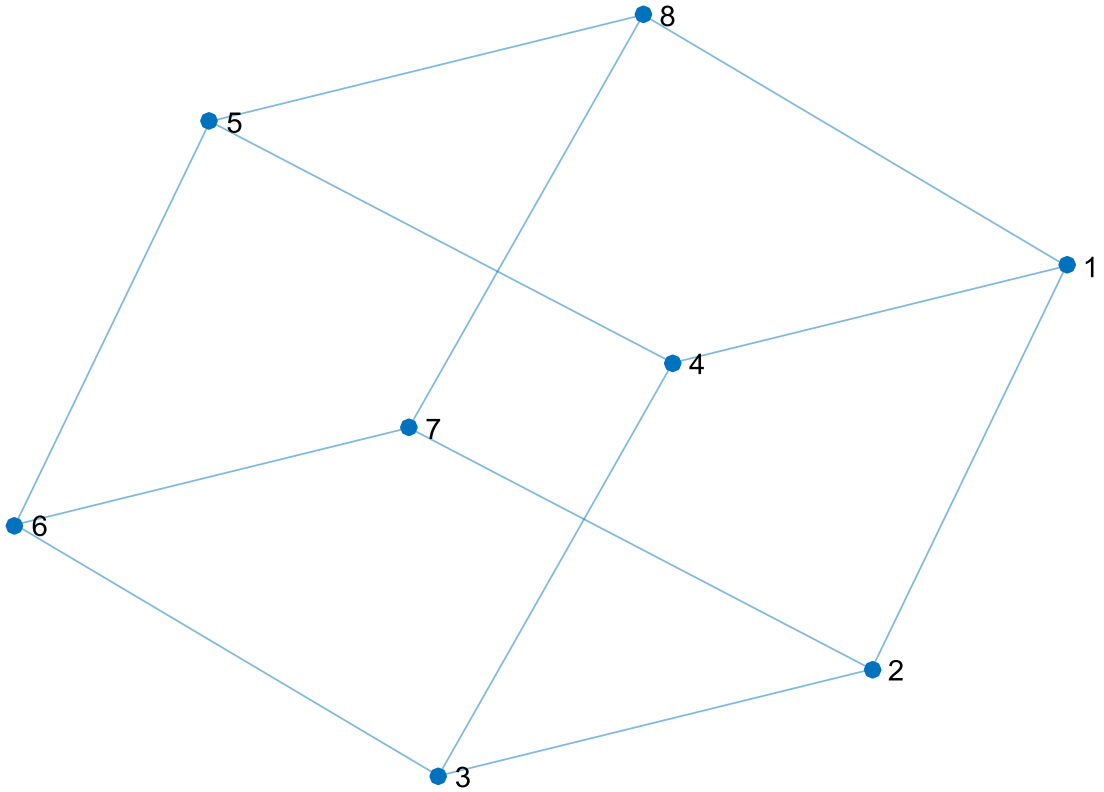
Let's make a simple Graph

```
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

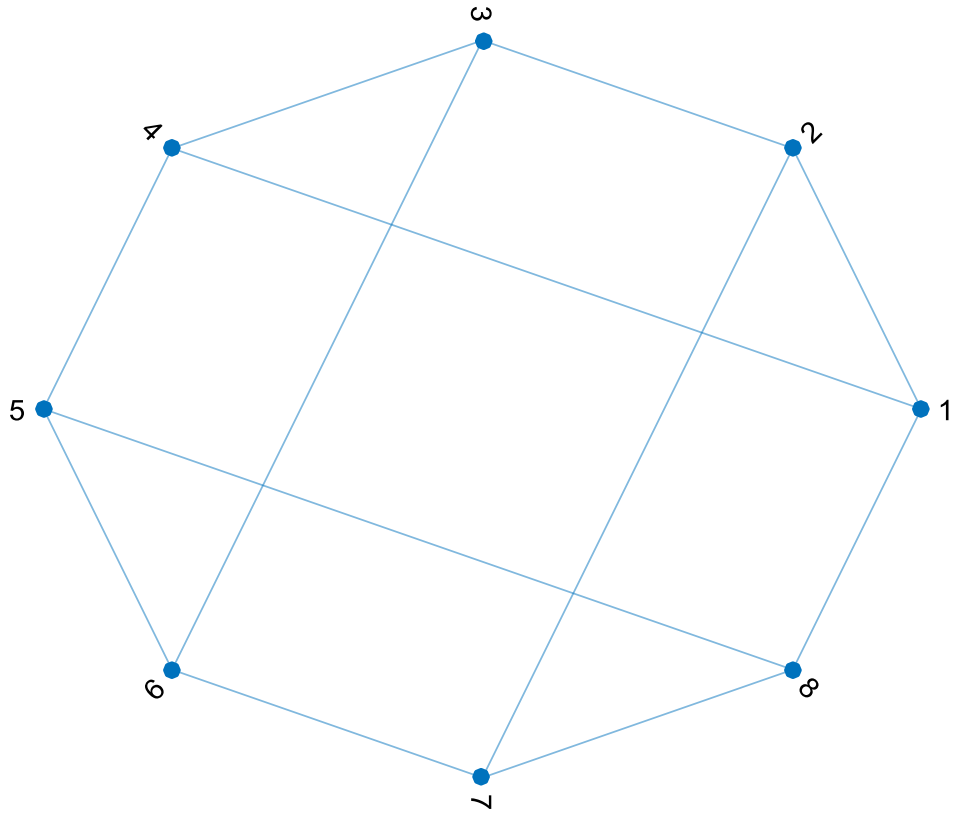
```
P = plot(G);
```



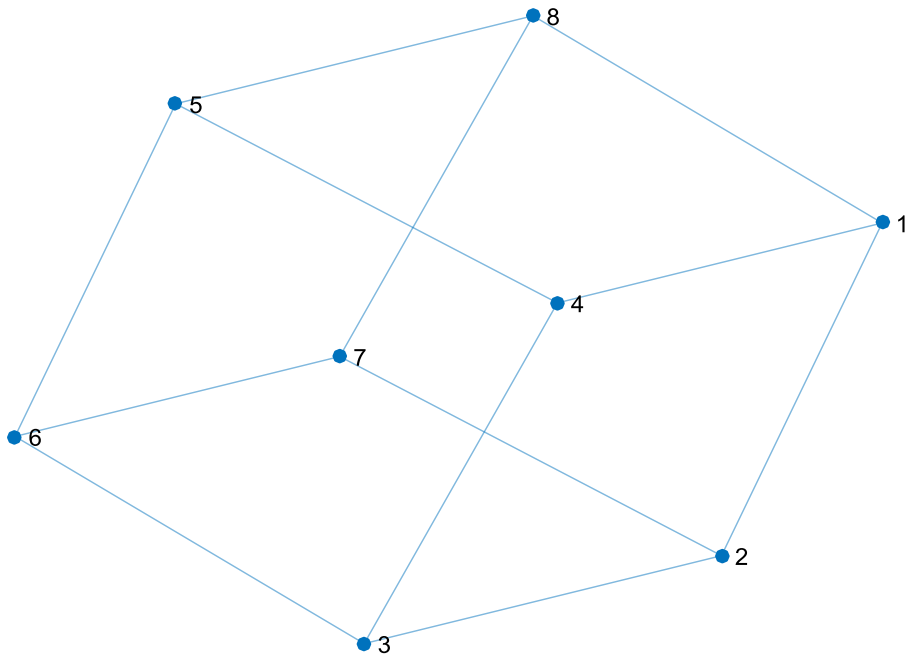

```
sourceNodes = [1 1 1 2 2 3 3 4 5 5 6 7];
targetNodes = [2 4 8 3 7 4 6 5 6 8 7 8];
```

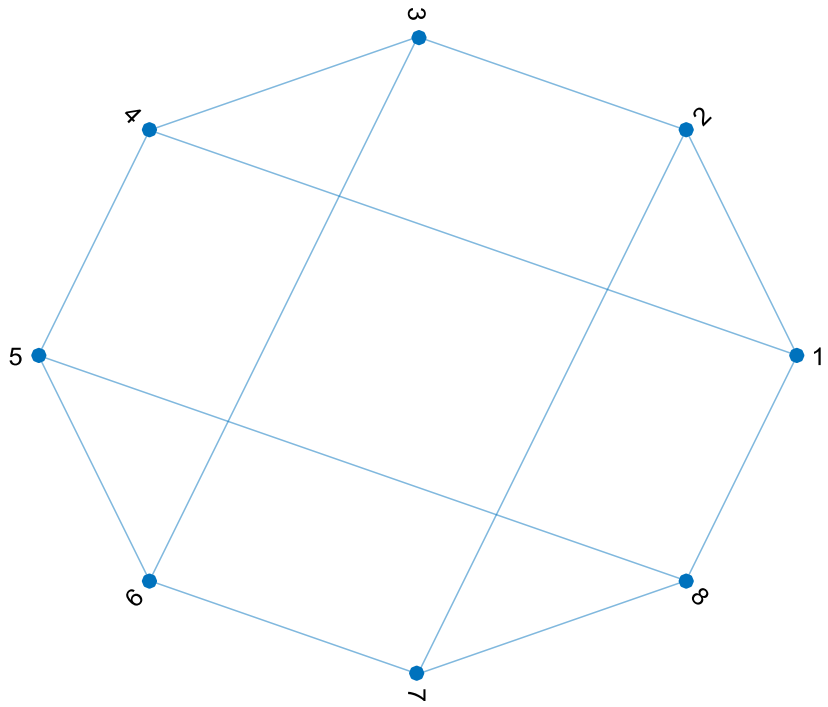
Plot a Graph

```
layout( P,'circle' )
```



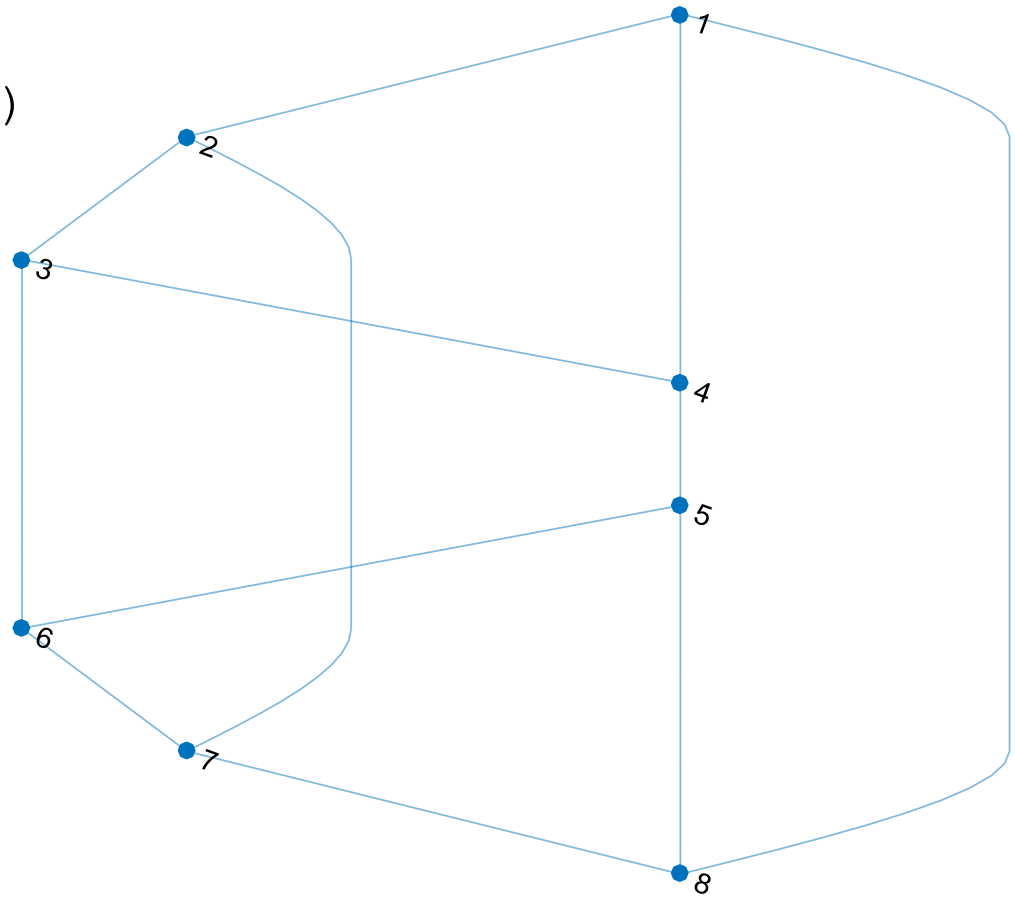
Are these drawings of the same graph?





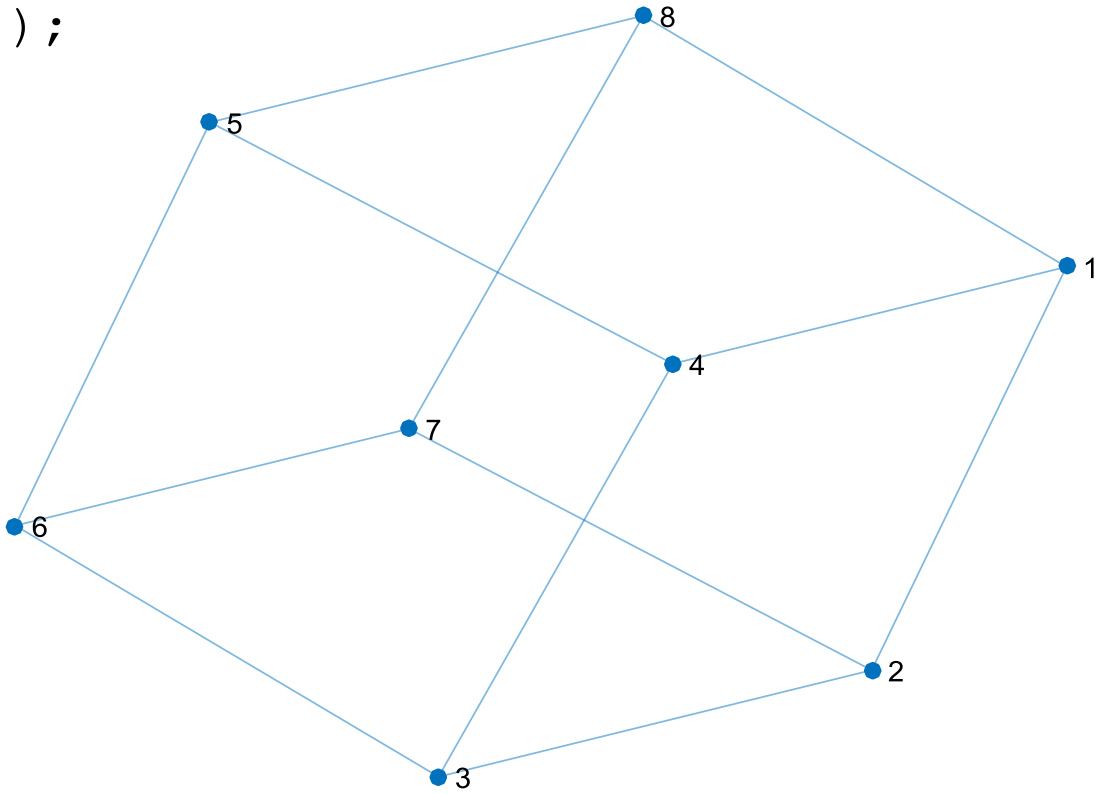
Plot a Graph

```
layout(P, 'layered' )
```



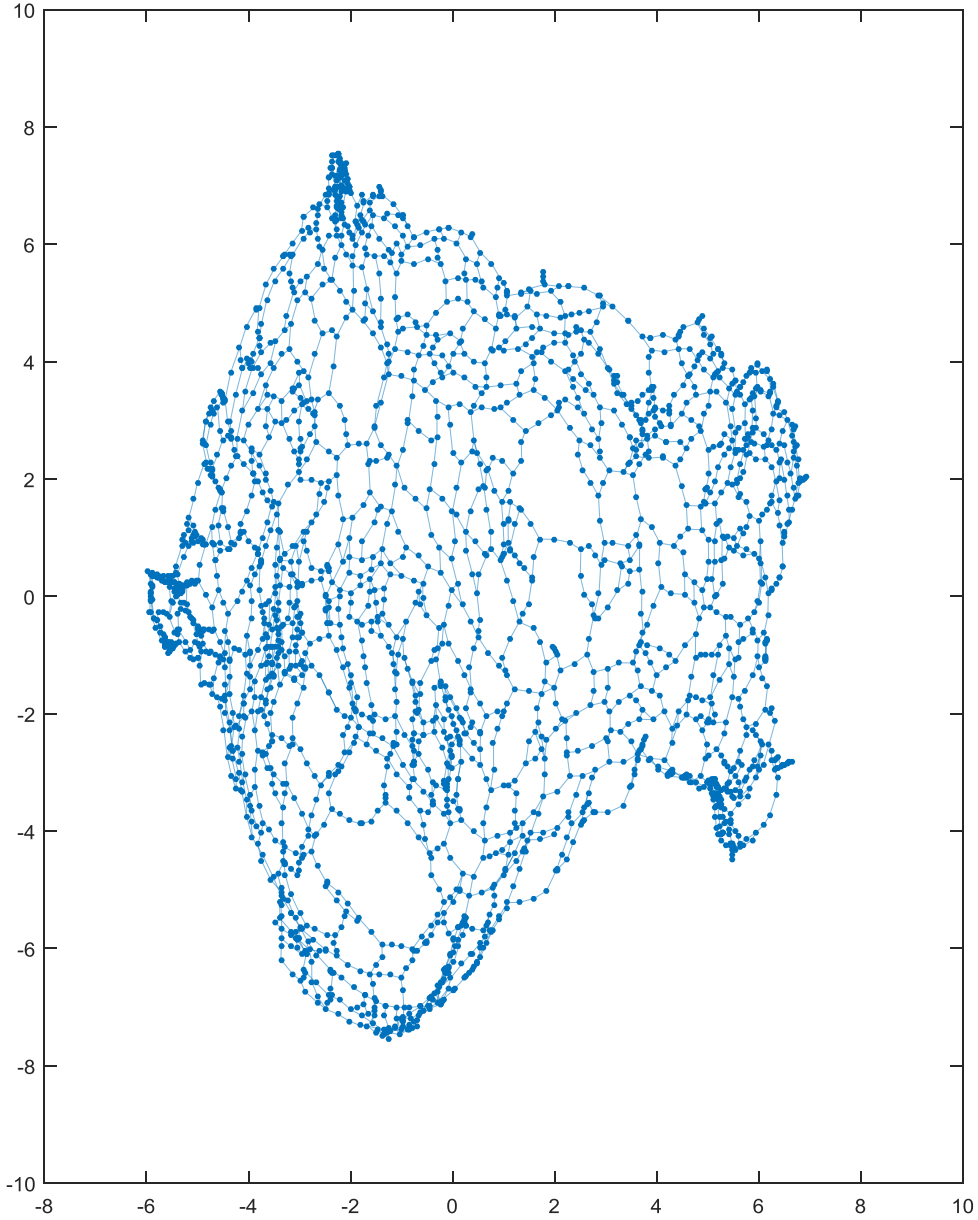
Plot a Graph

```
layout( P, 'force' );
```



Graphs in MATLAB

```
load('MinnesotaRoads');
plot(G);
```

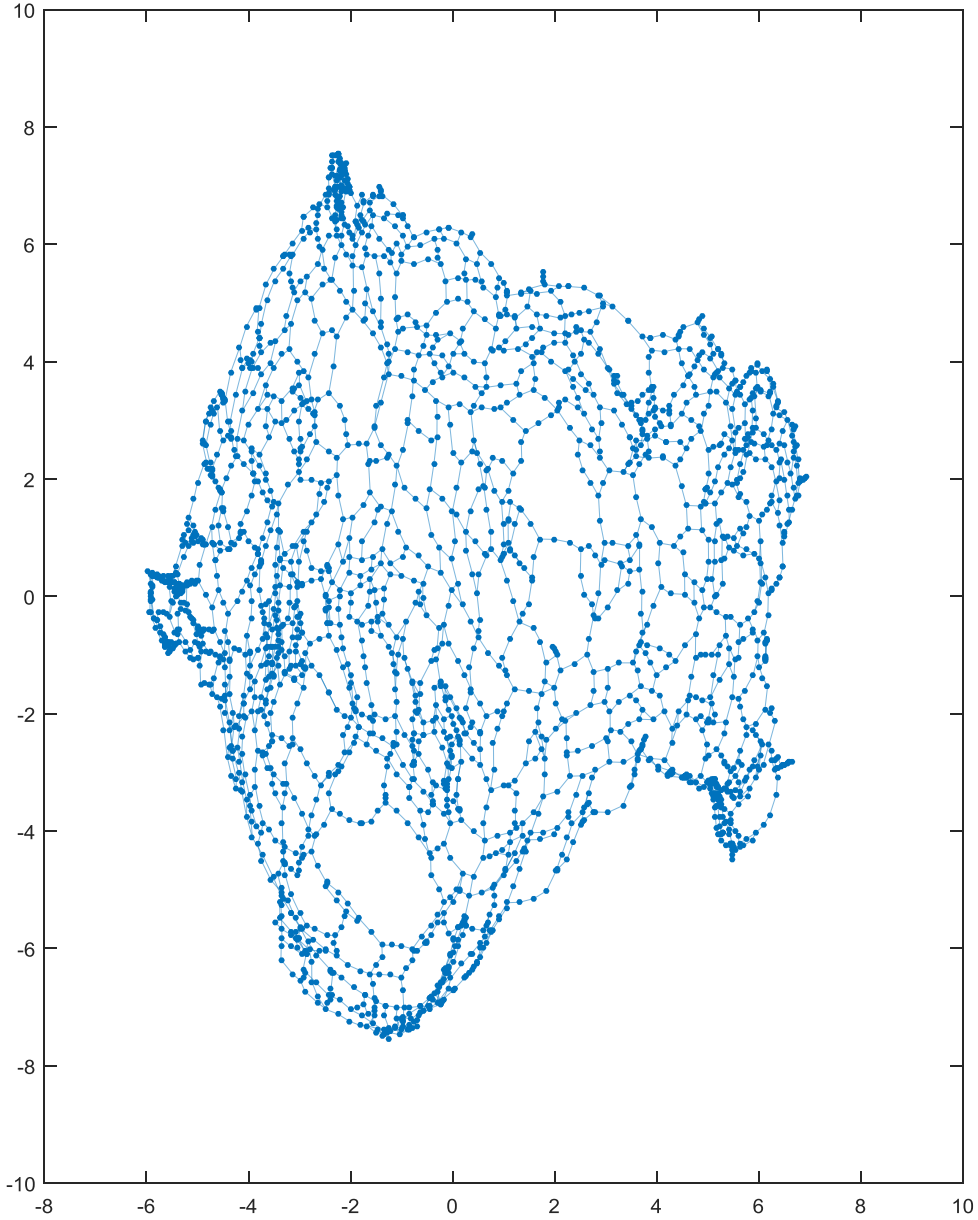


Graphs in MATLAB

```
G.Nodes( 1:7,: )

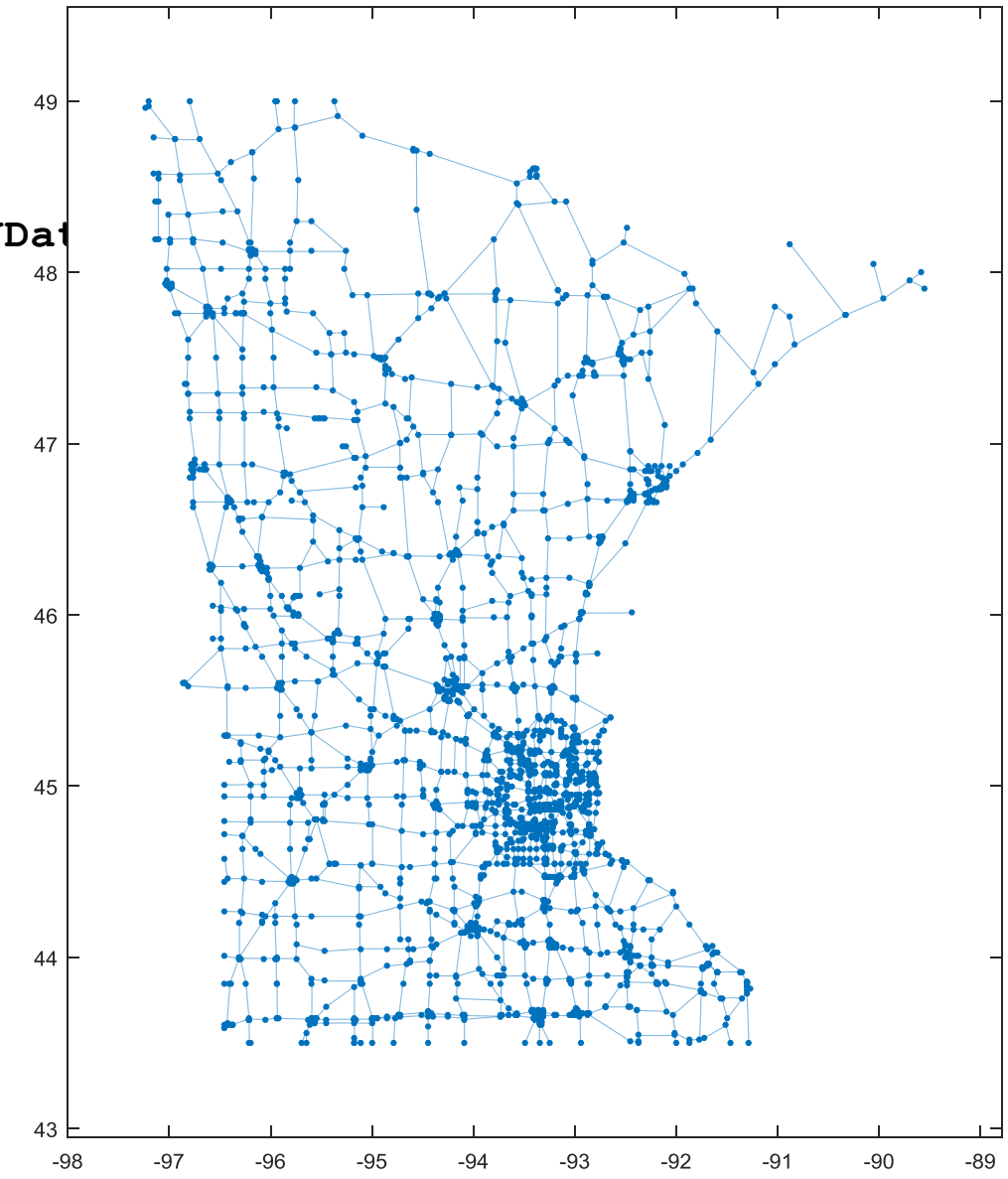
ans =

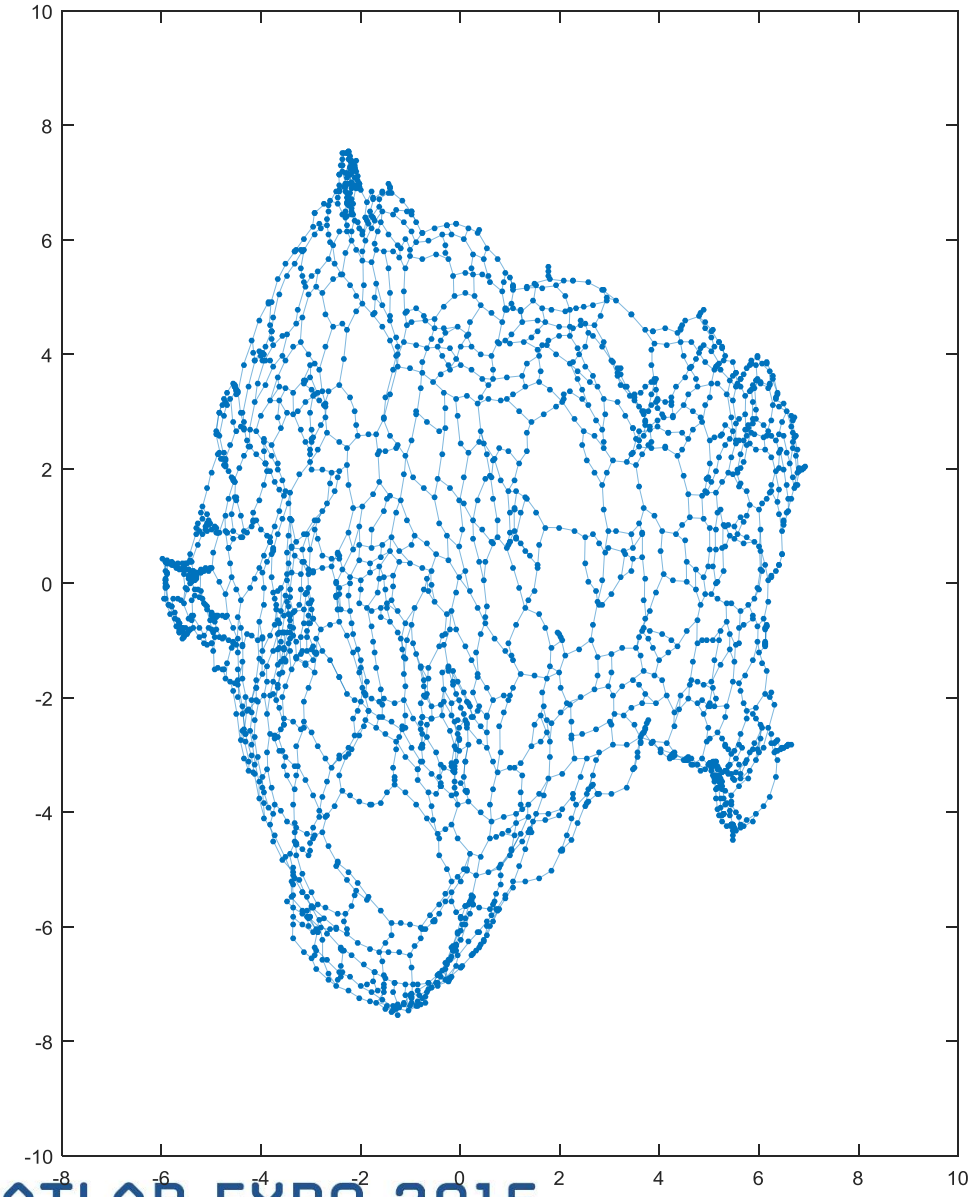
    Longitude    Latitude
    _________    ________
    -97.207      49.001
    -96.801           49
    -95.957           49
    -95.931           49
    -95.766           49
    -95.378      48.999
      -97.2      48.972
```

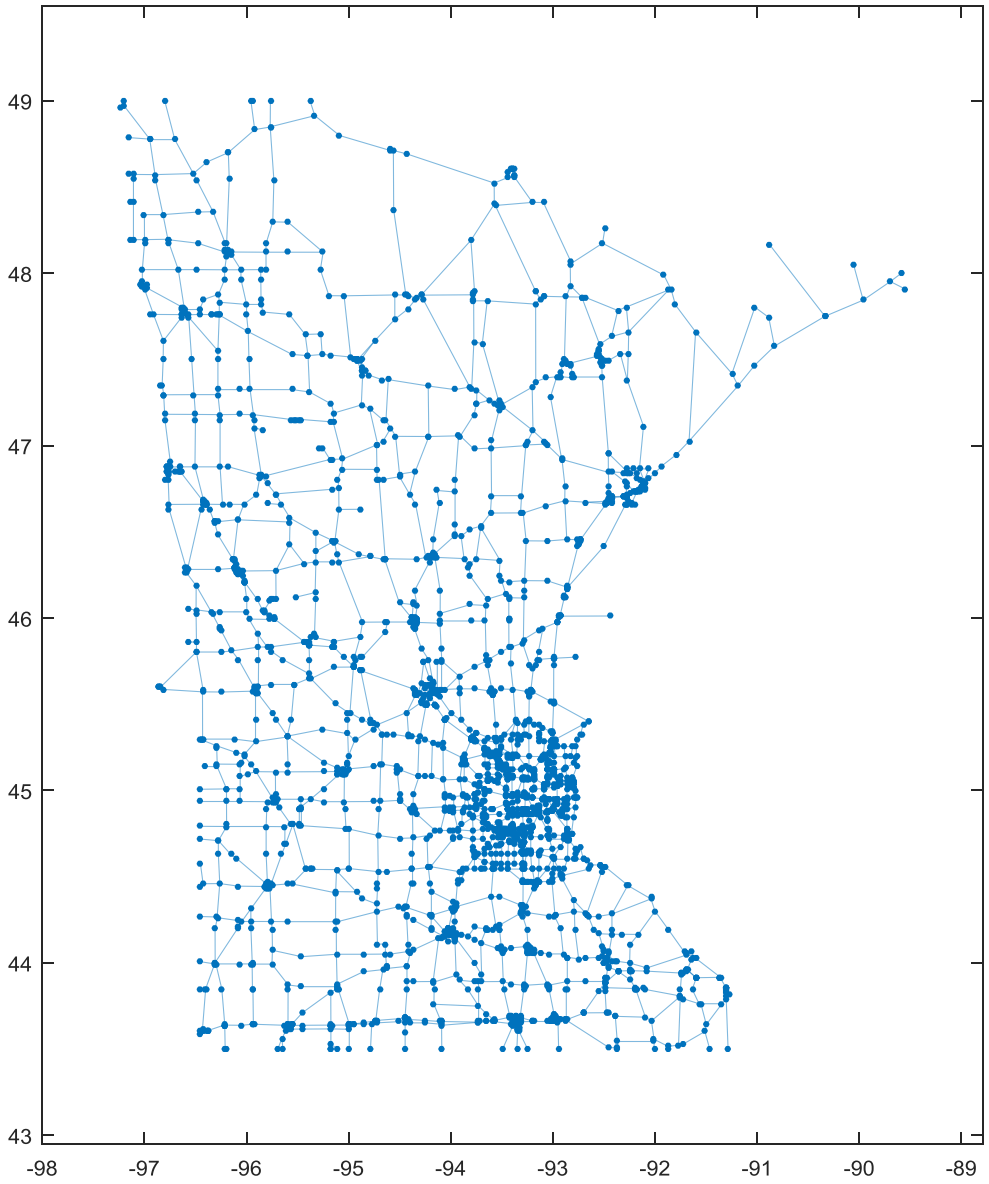


Graphs in MATLAB

```
P = plot(G, 'XData', G.Nodes.Longitude, 'YDat
```




10
8
6
4
2
0
-2
-4
-6
-8
-10
-8
-6
-4
-2
0
2
4
6
8
10

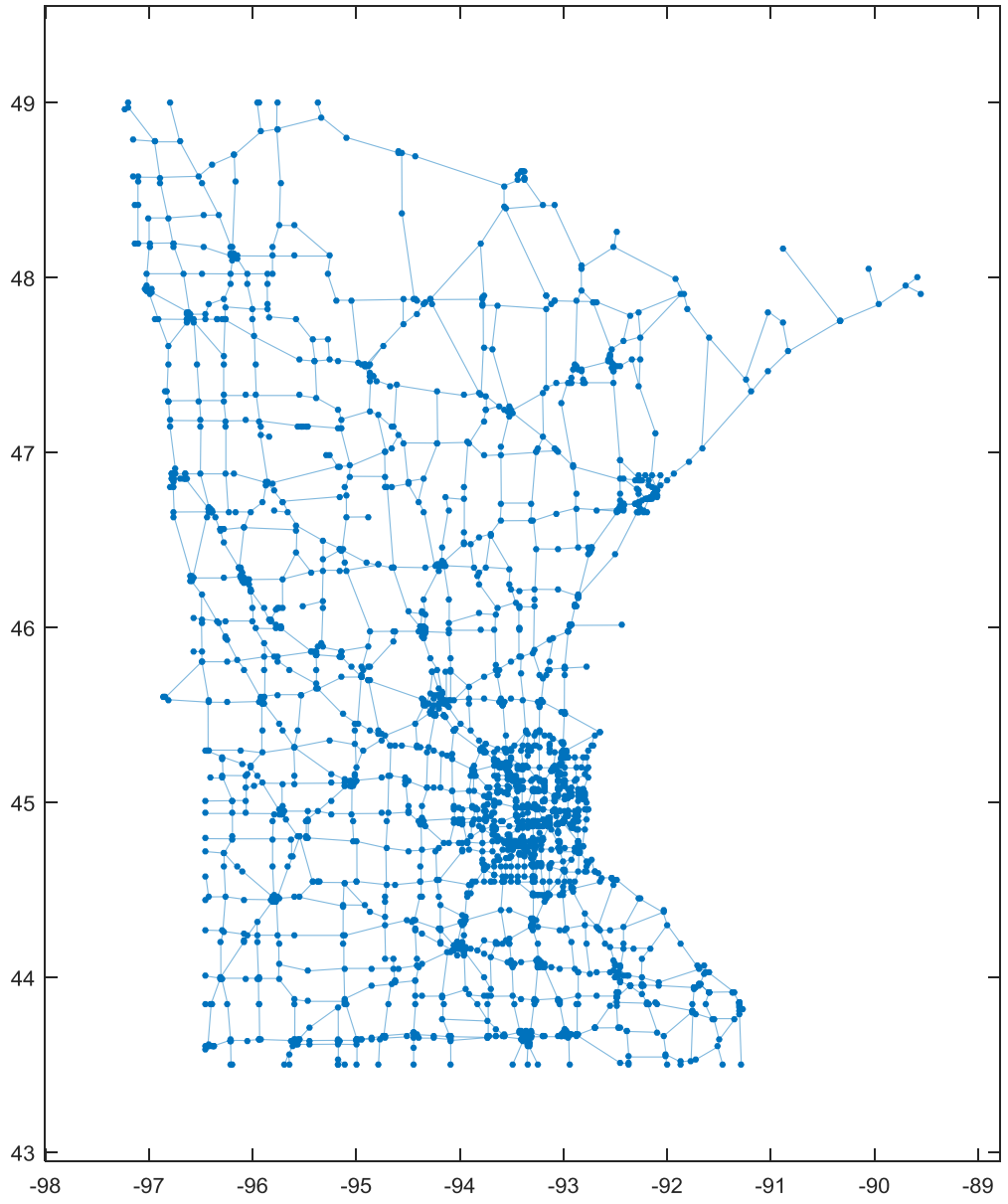

49
48
47
46
45
44
43
-98
-97
-96
-95
-94
-93
-92
-91
-90
-89

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
minspantree	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

```
P.labelnode(cityIDs, cityNames);
```



Graphs in MATLAB

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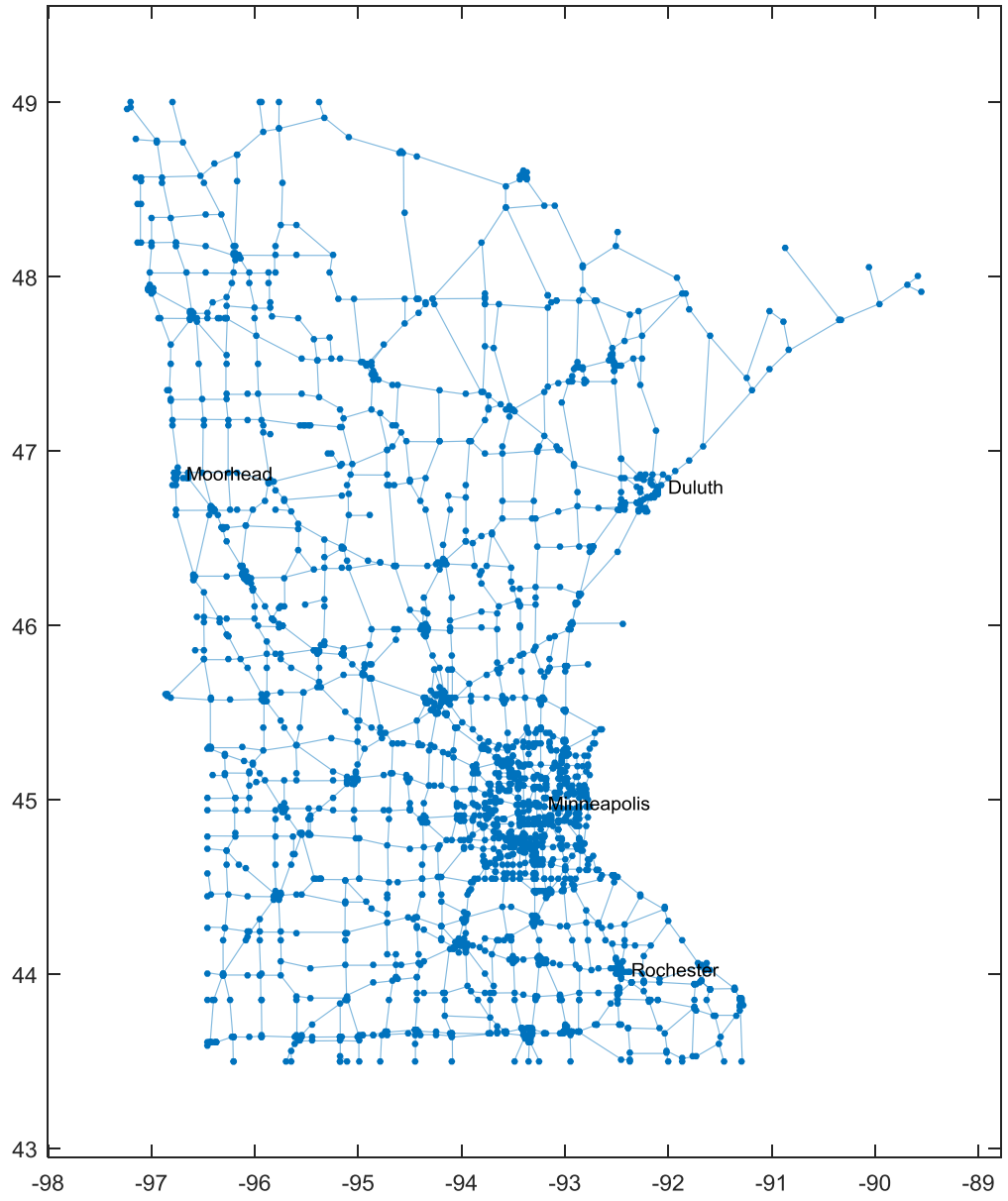

Graphs in MATLAB

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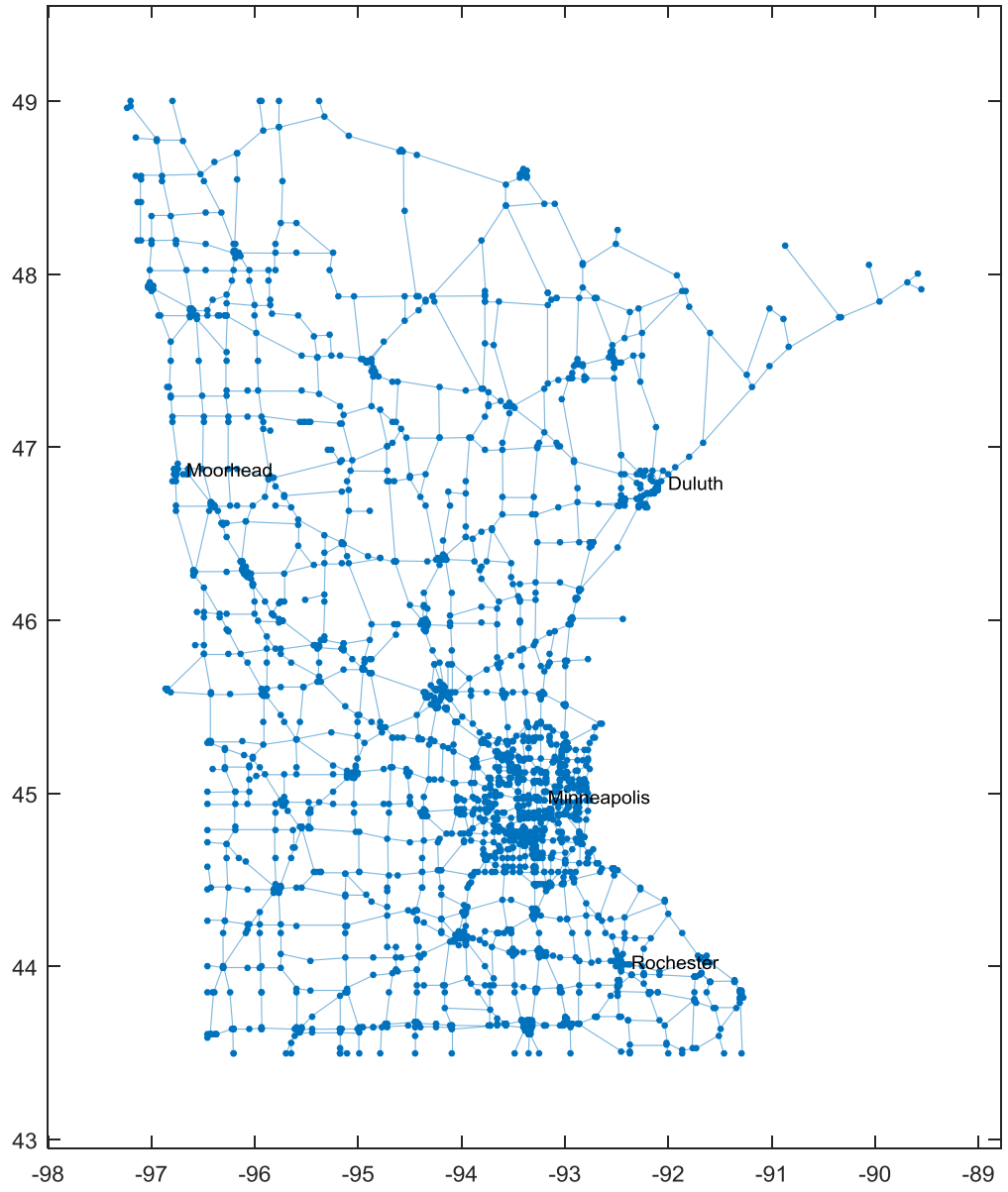

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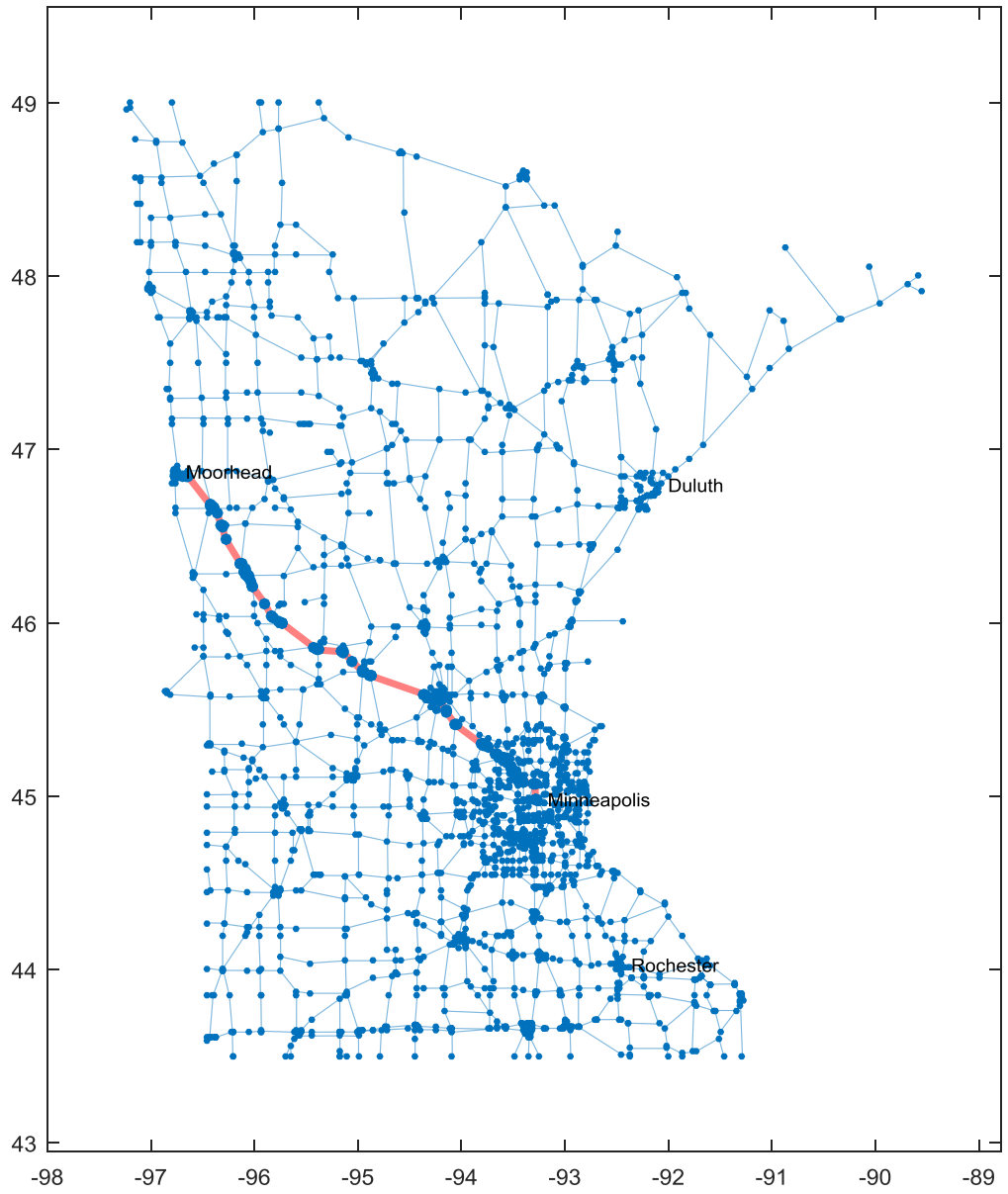
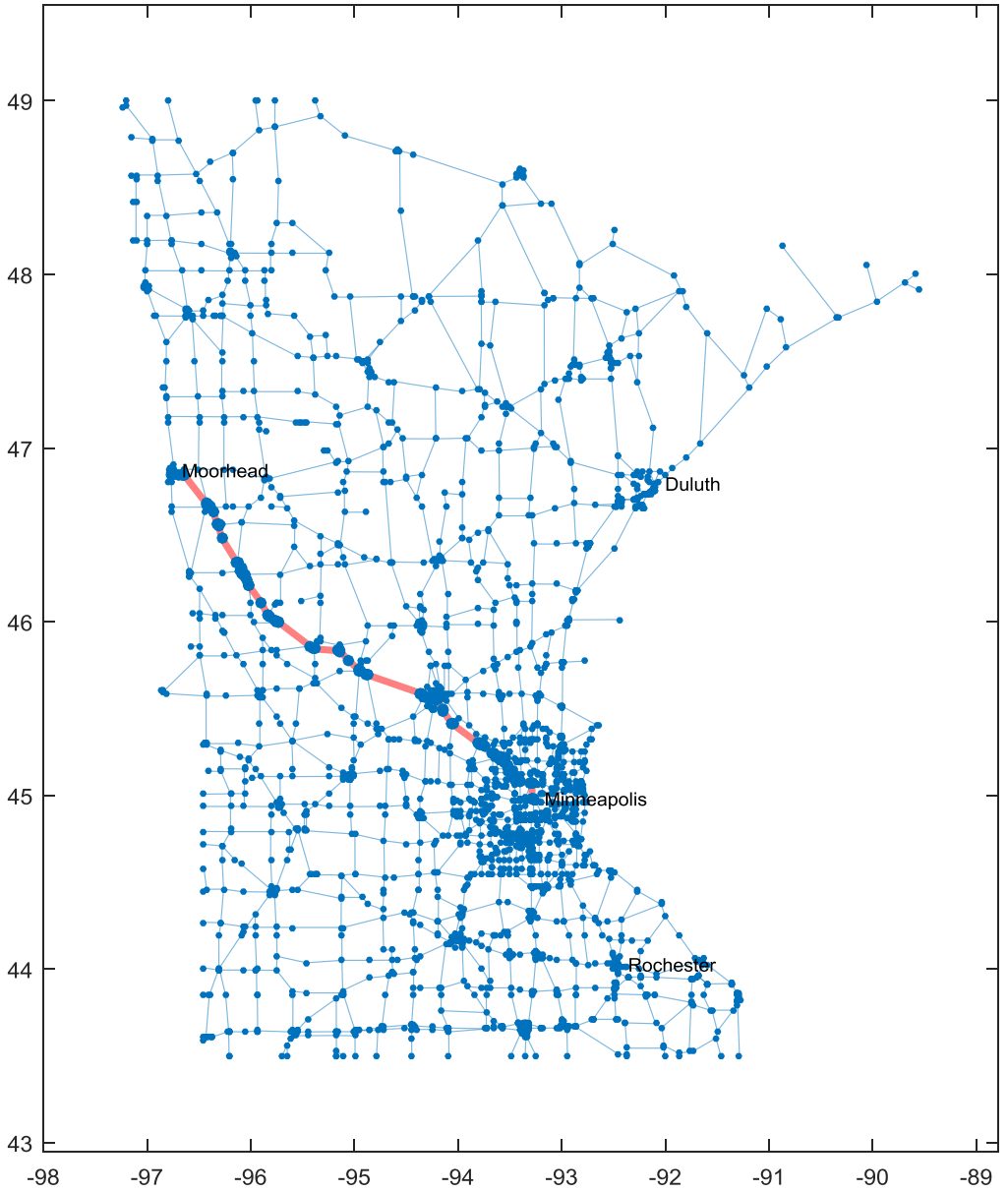


Graphs in MATLAB

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



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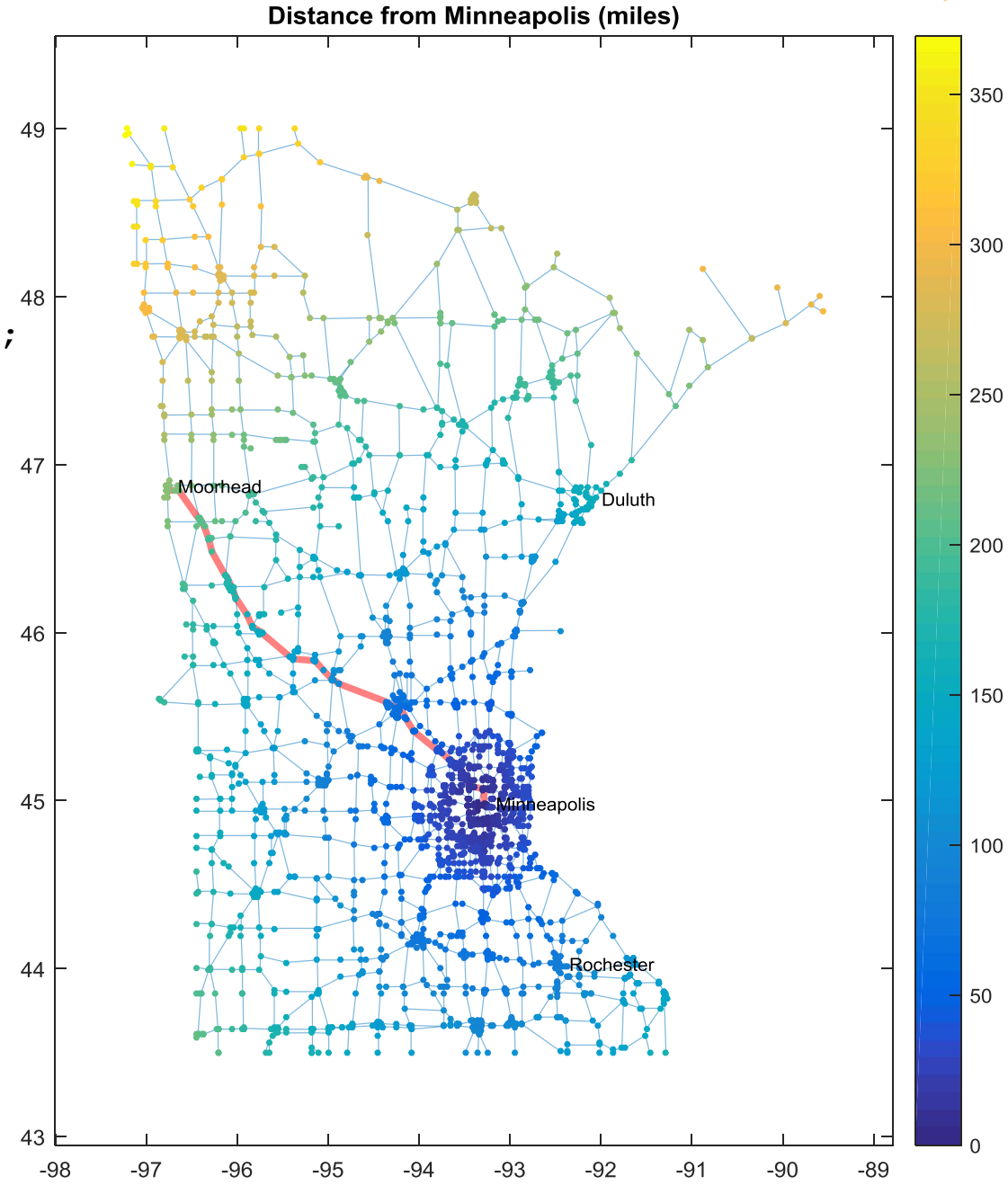


Minnesota gets a lot of snow.

You plow the snow

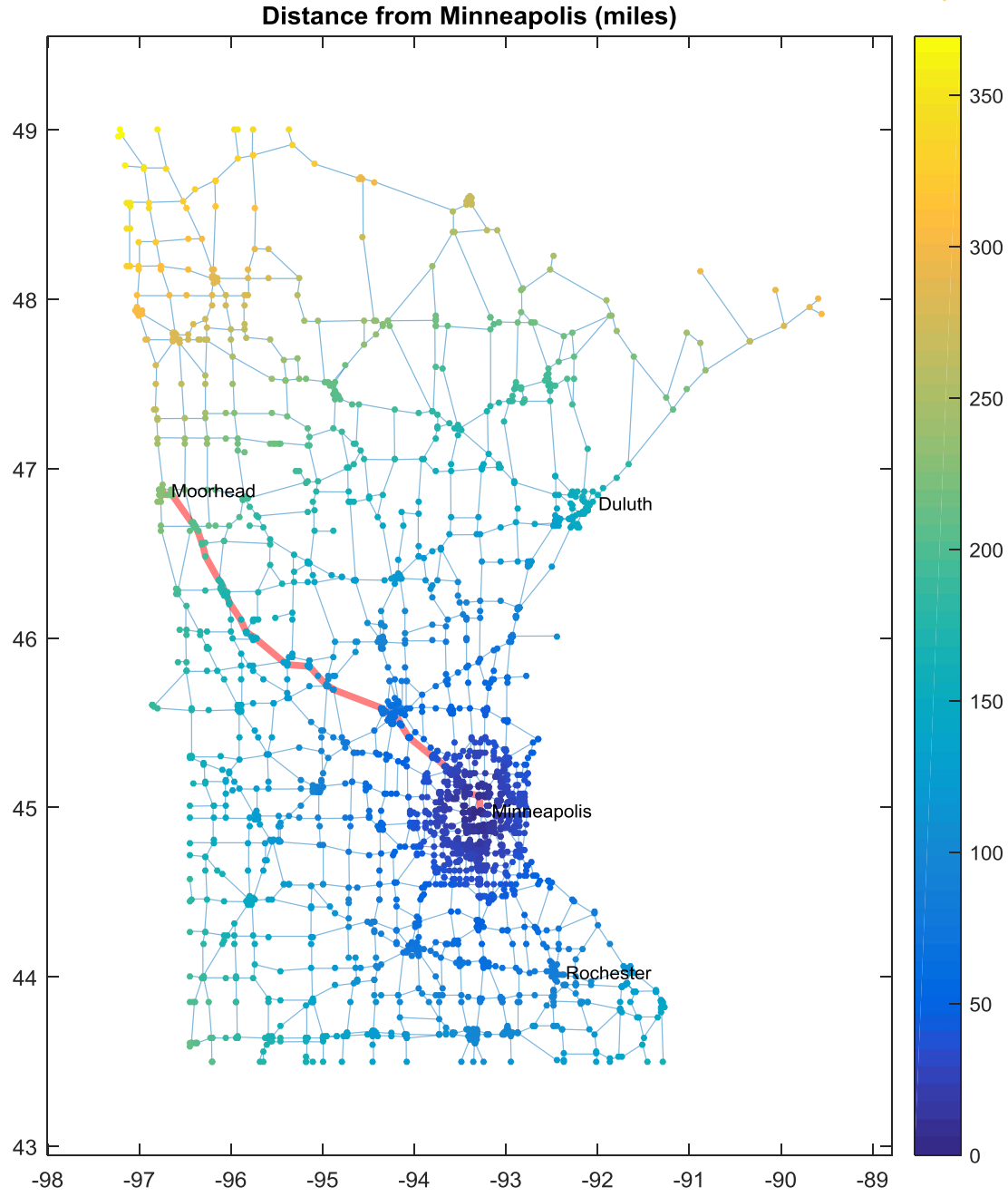
Your equipment is in Minneapolis

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);
```



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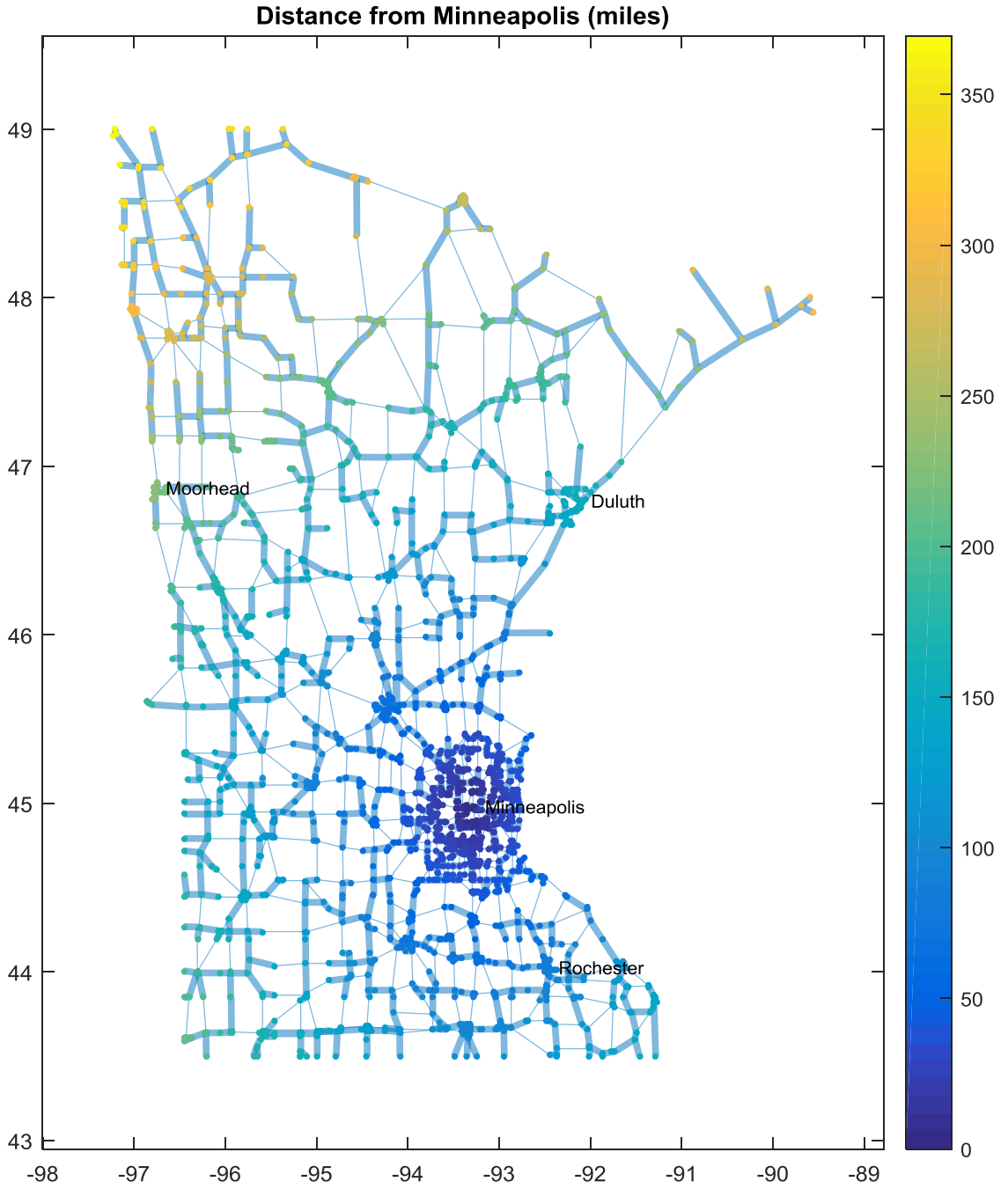


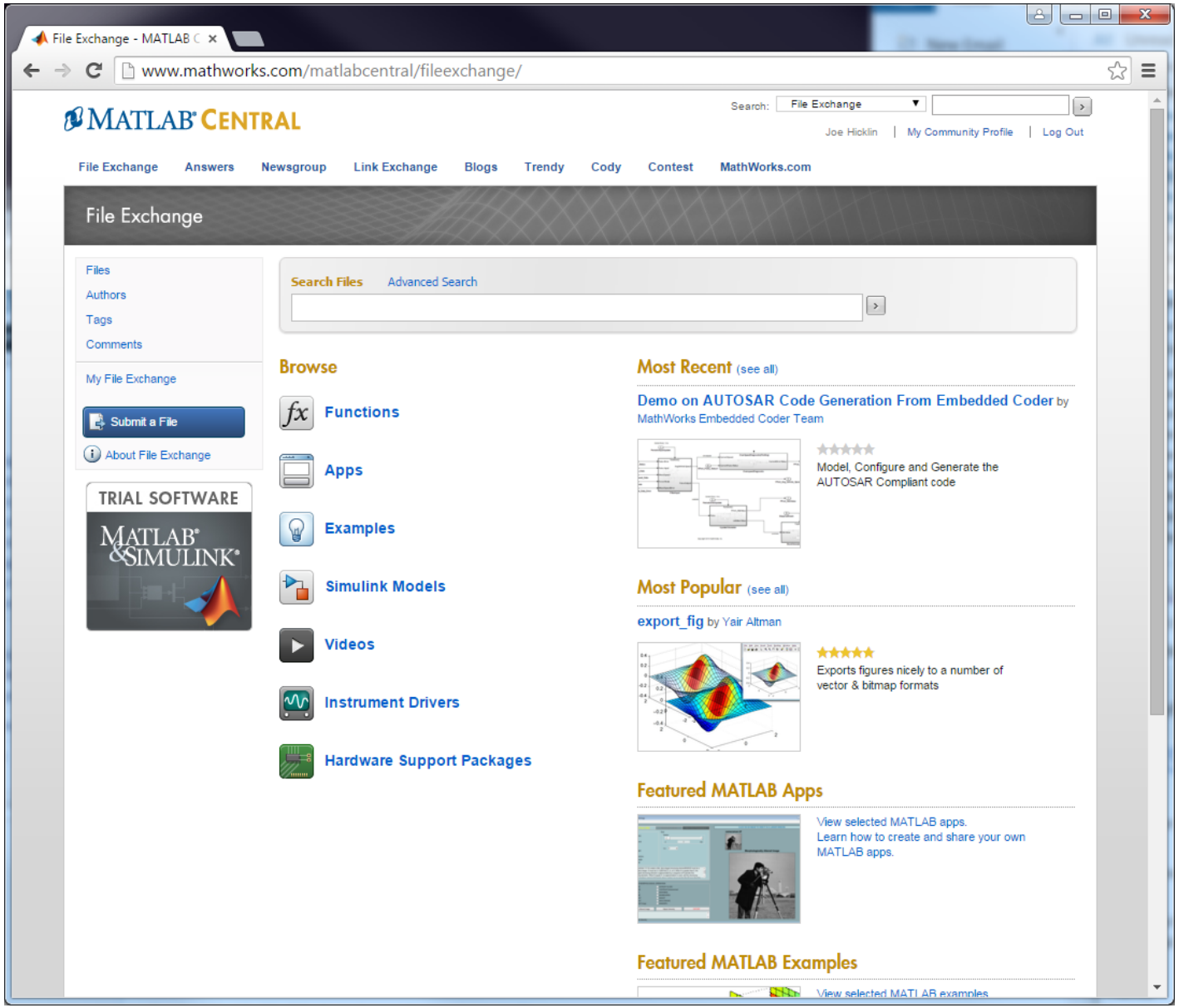
Add-On Explorer

The File Exchange on MATLAB Central

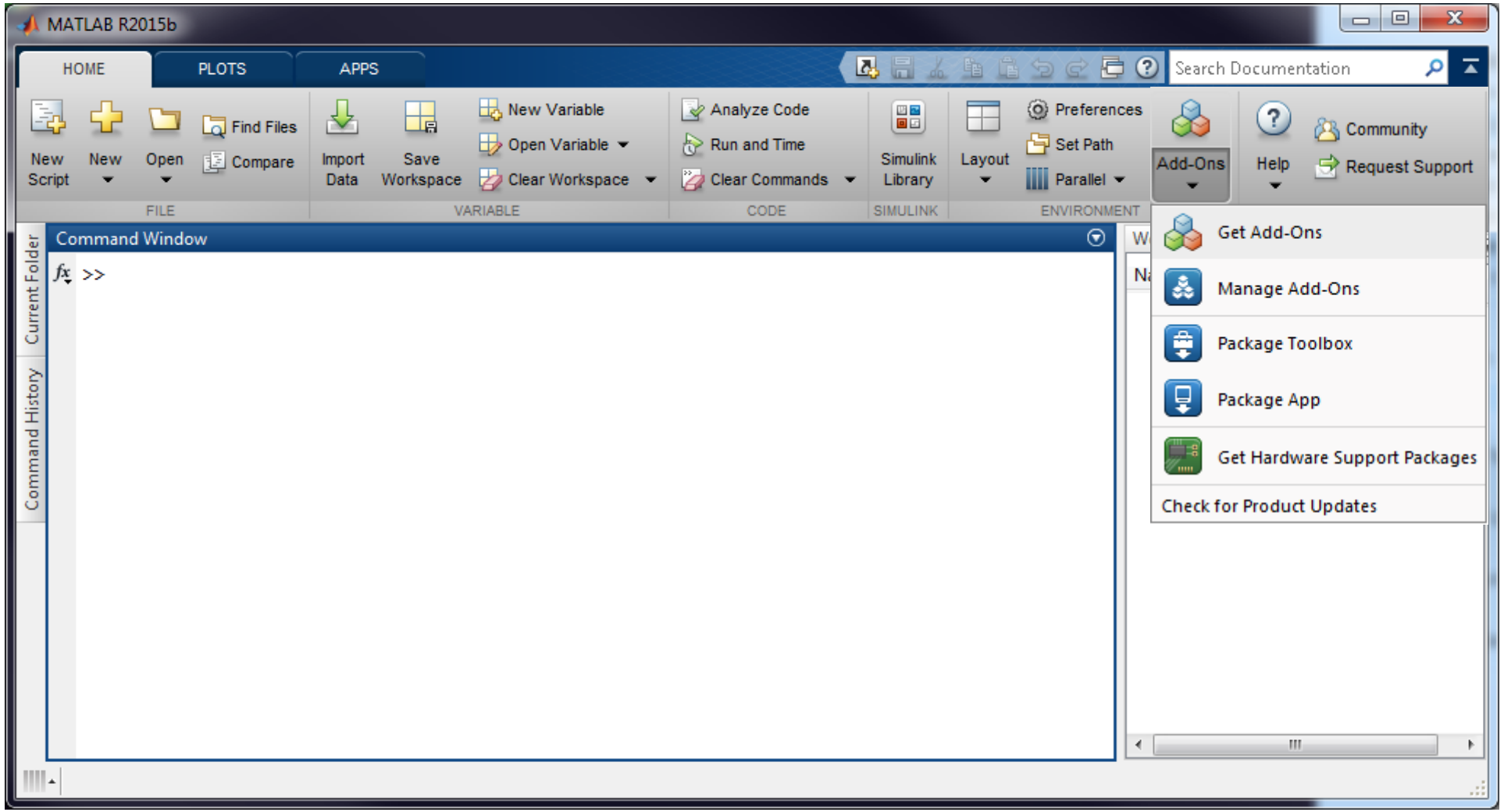
About 20,000 submissions

An underused resource

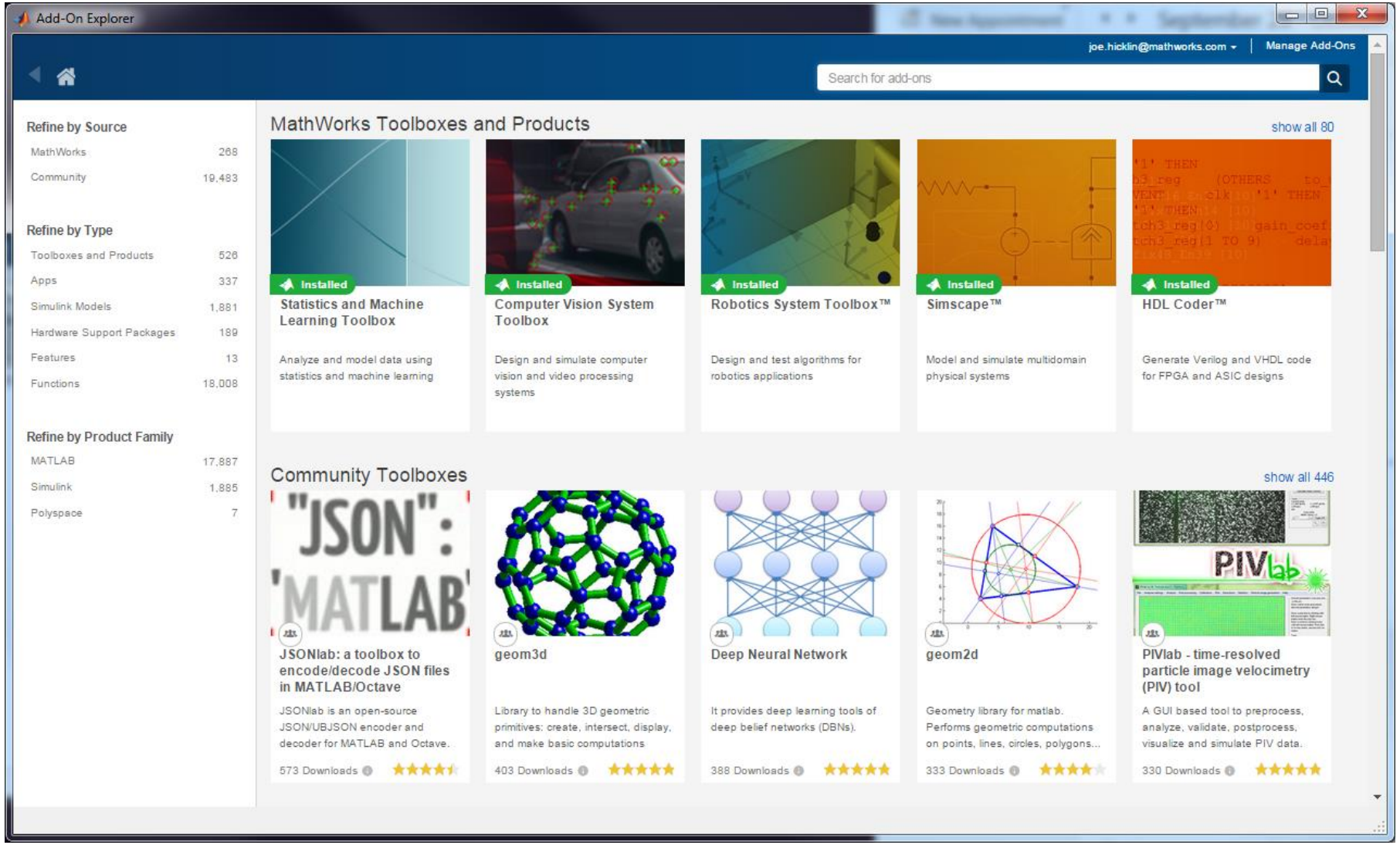
- Awareness
- Complexity



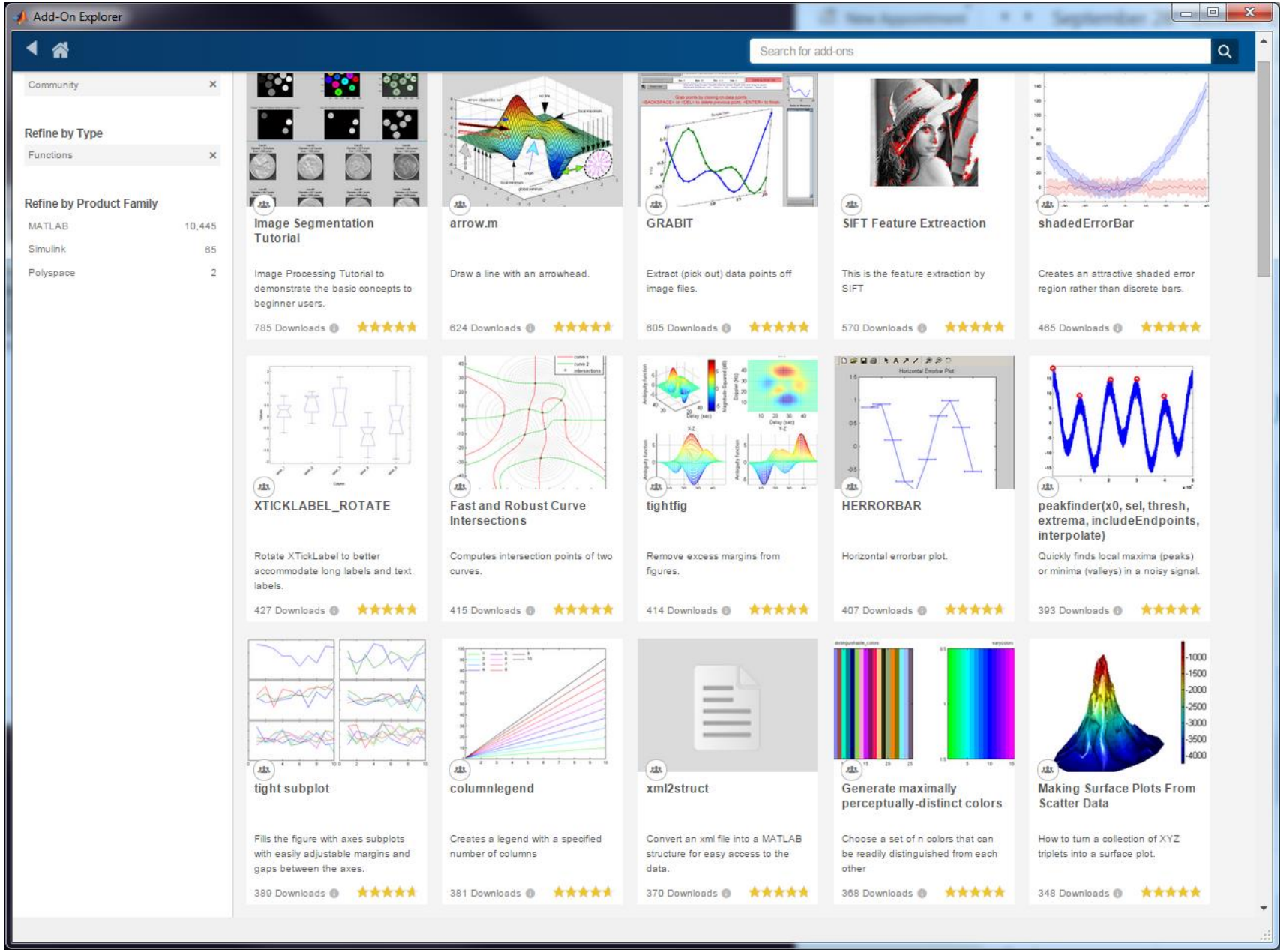
Add-On Explorer



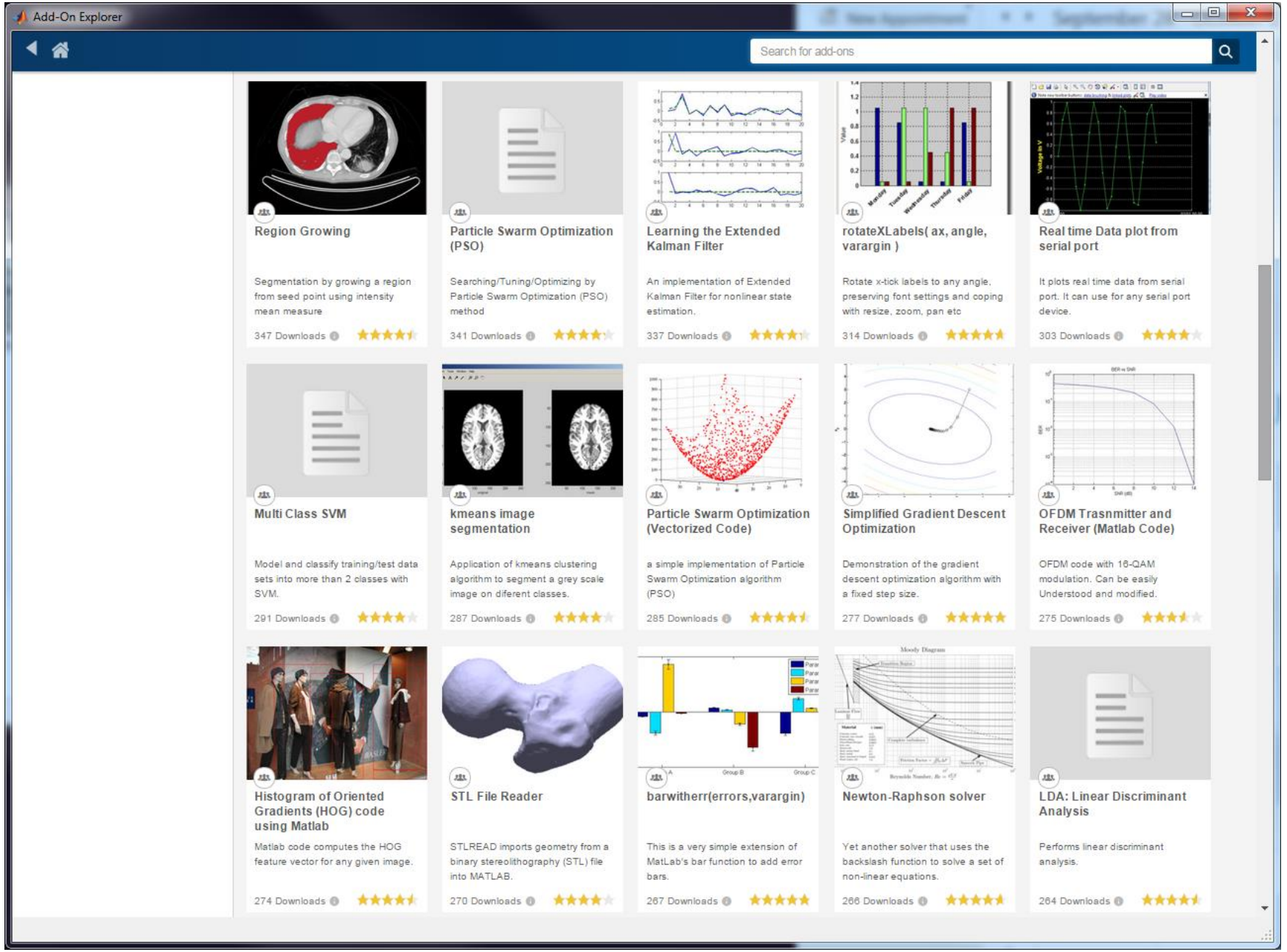
Add-On Explorer



Add-On Explorer



Add-On Explorer



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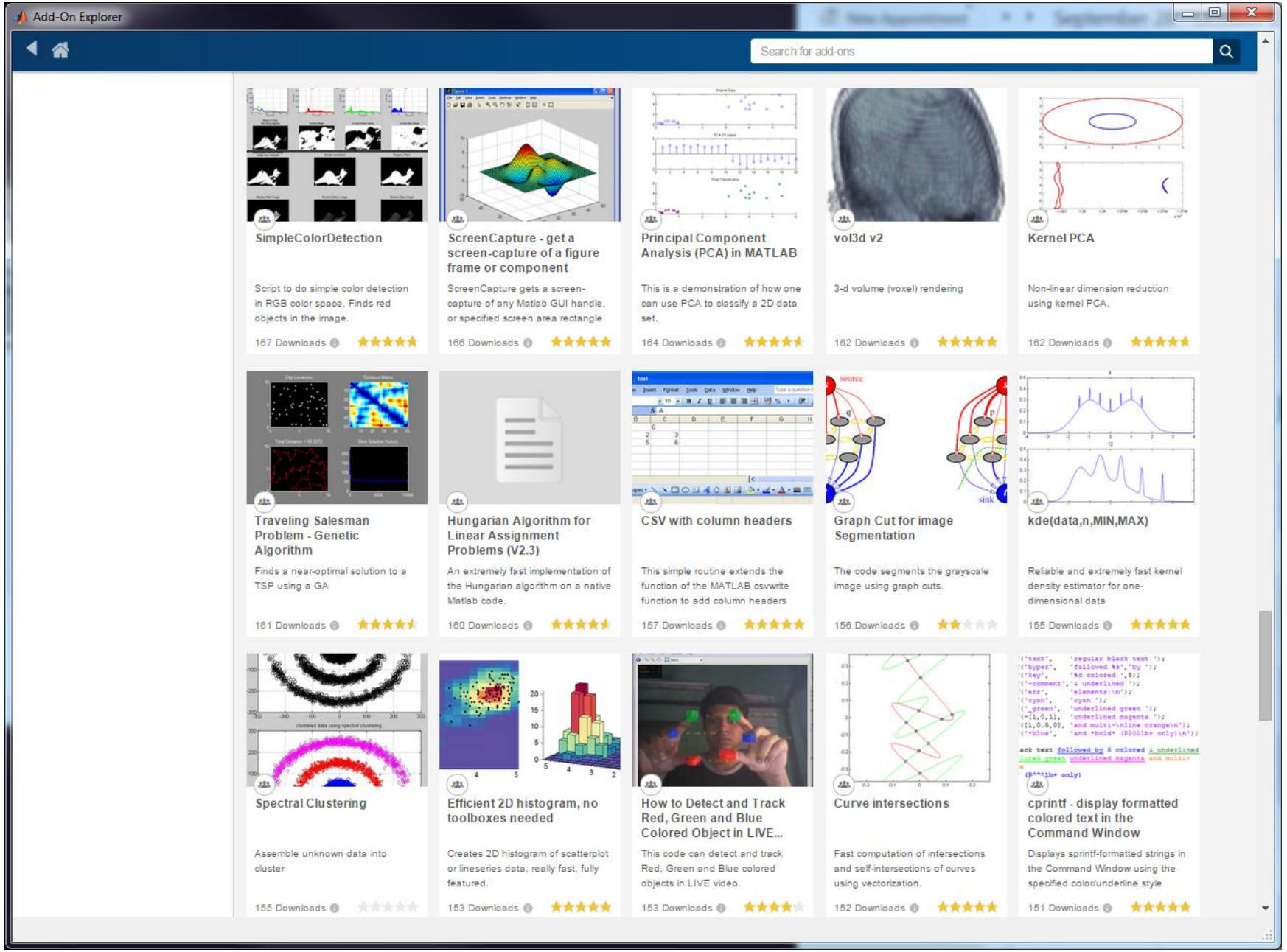
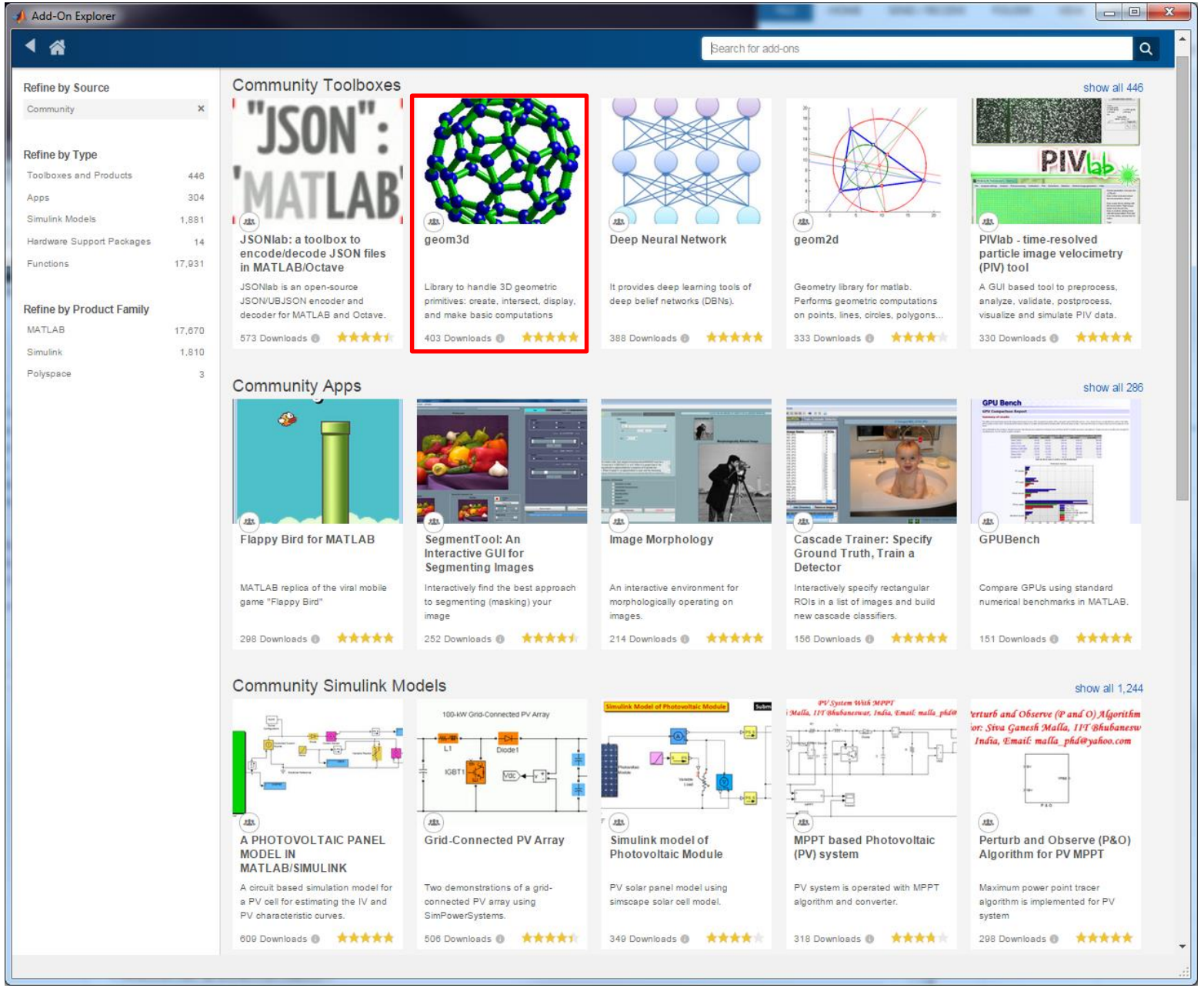
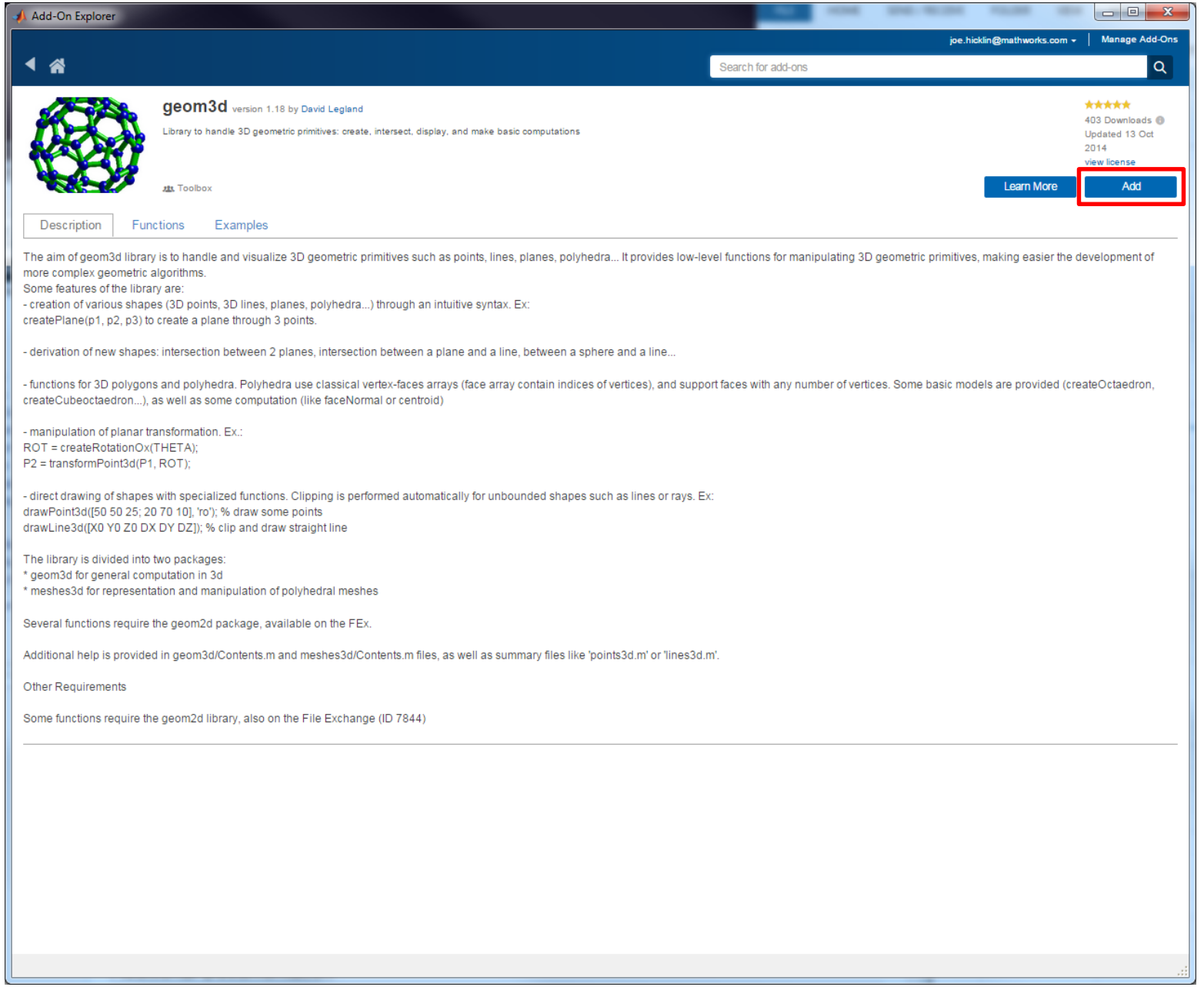


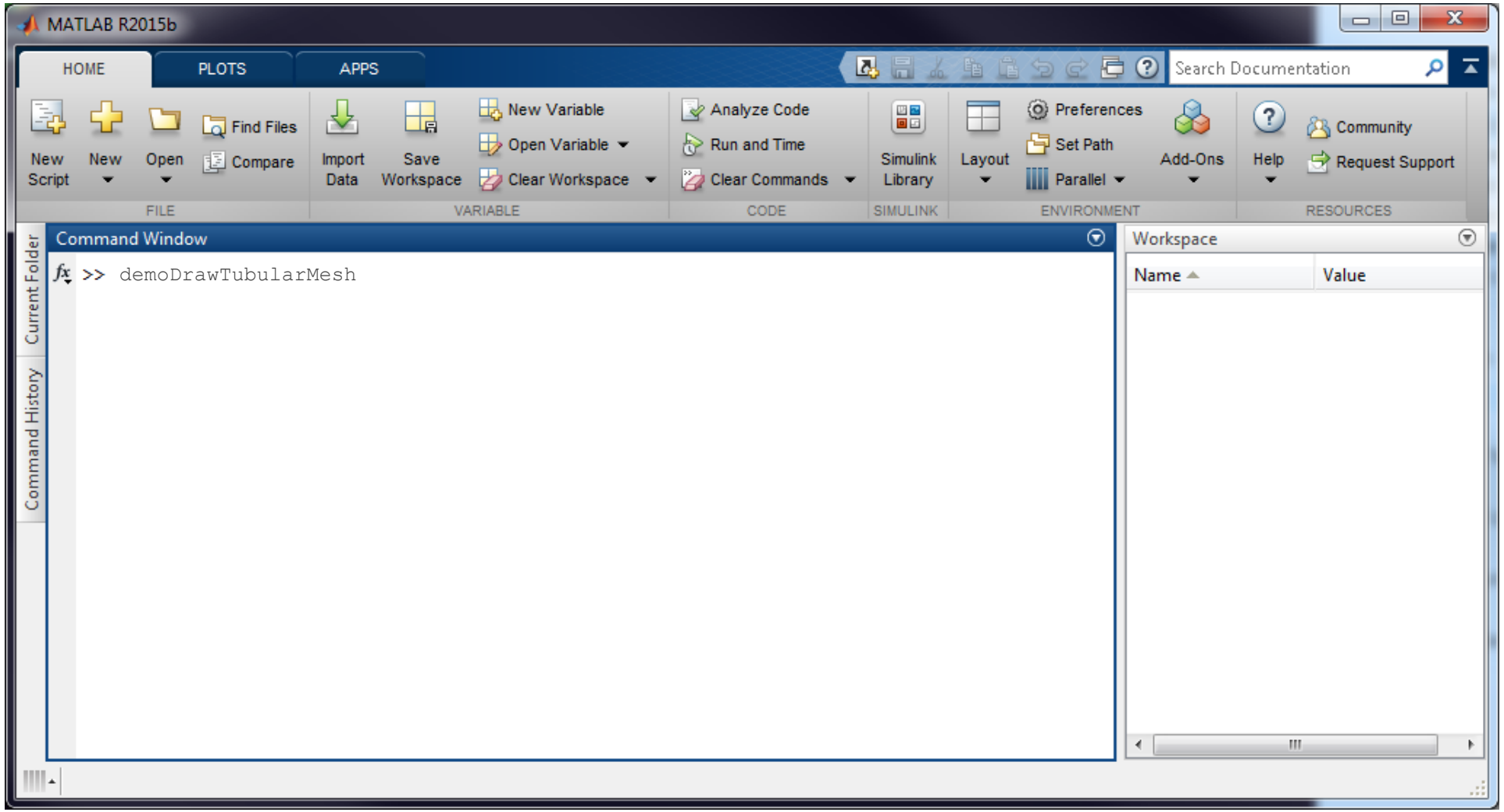
Add-On Explorer



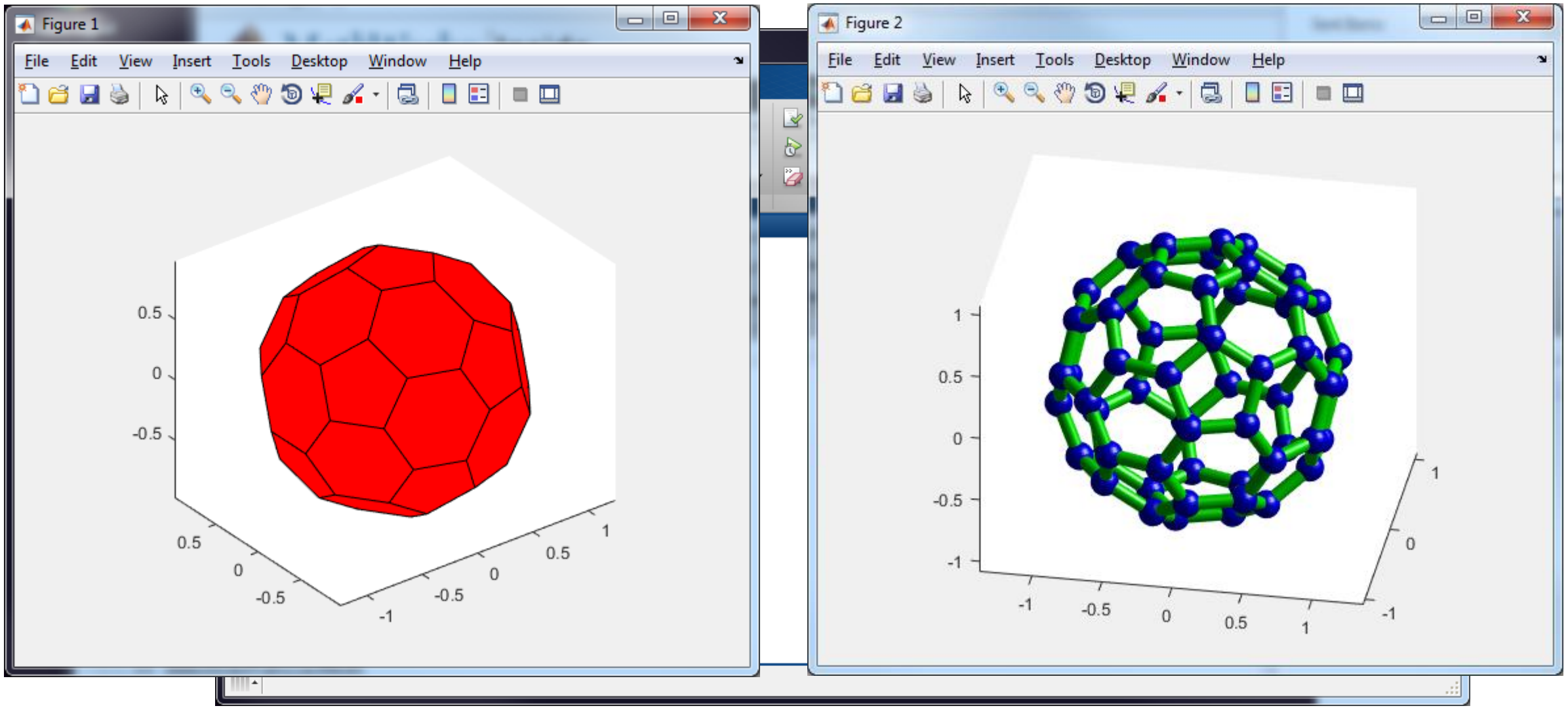
Add-On Explorer



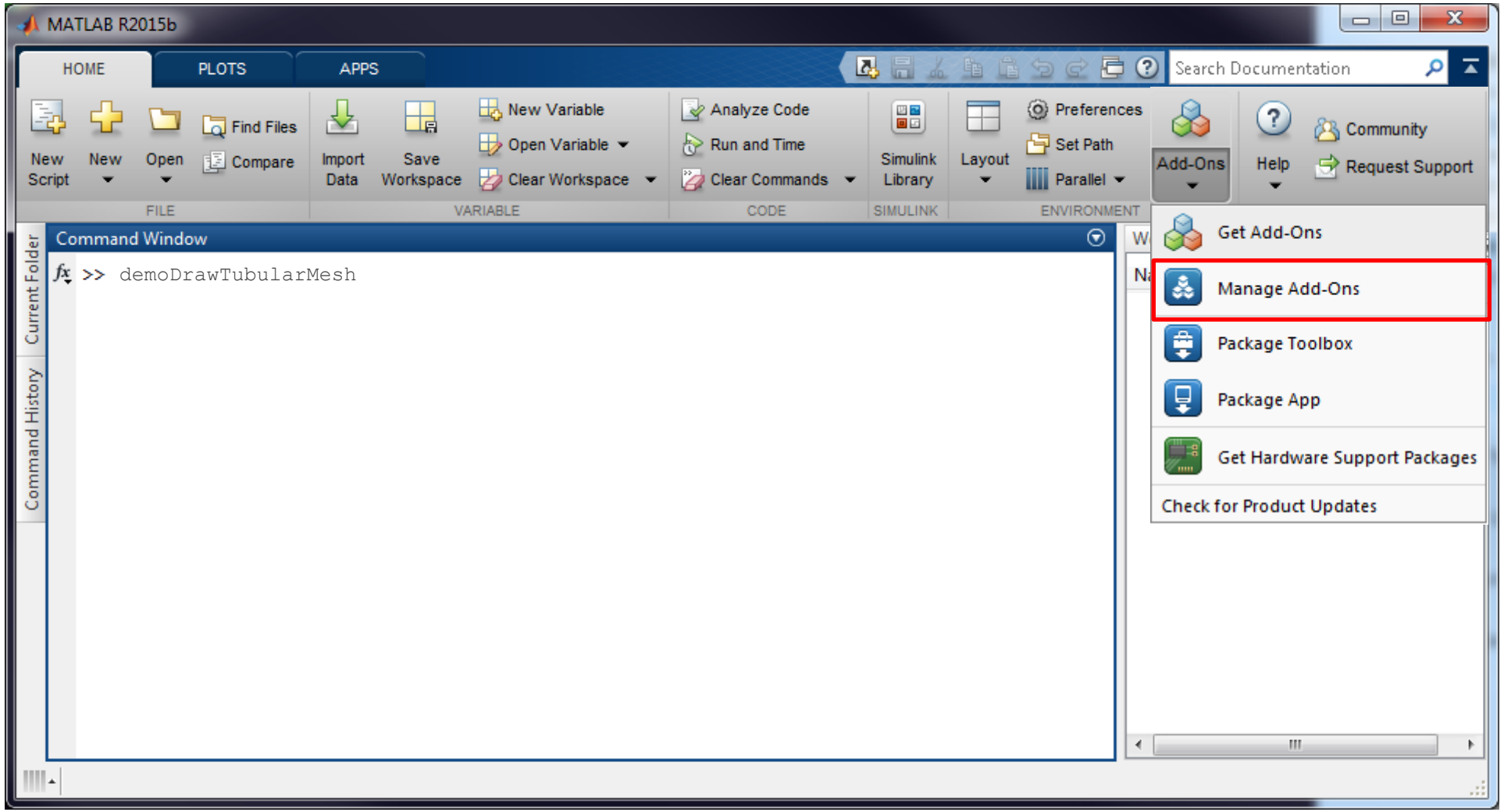
Add-On Manager



Add-On Explorer



Add-On Manager



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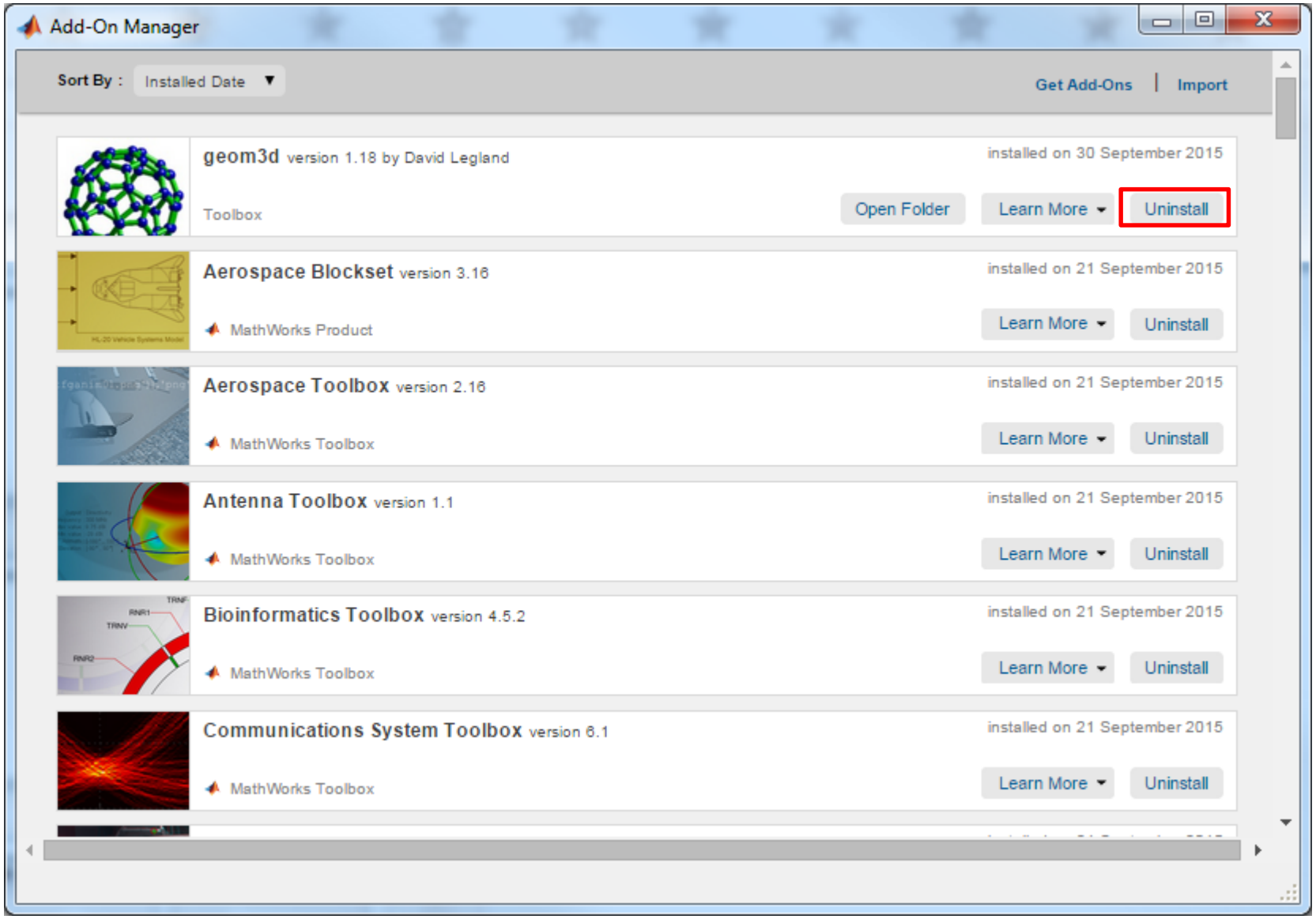
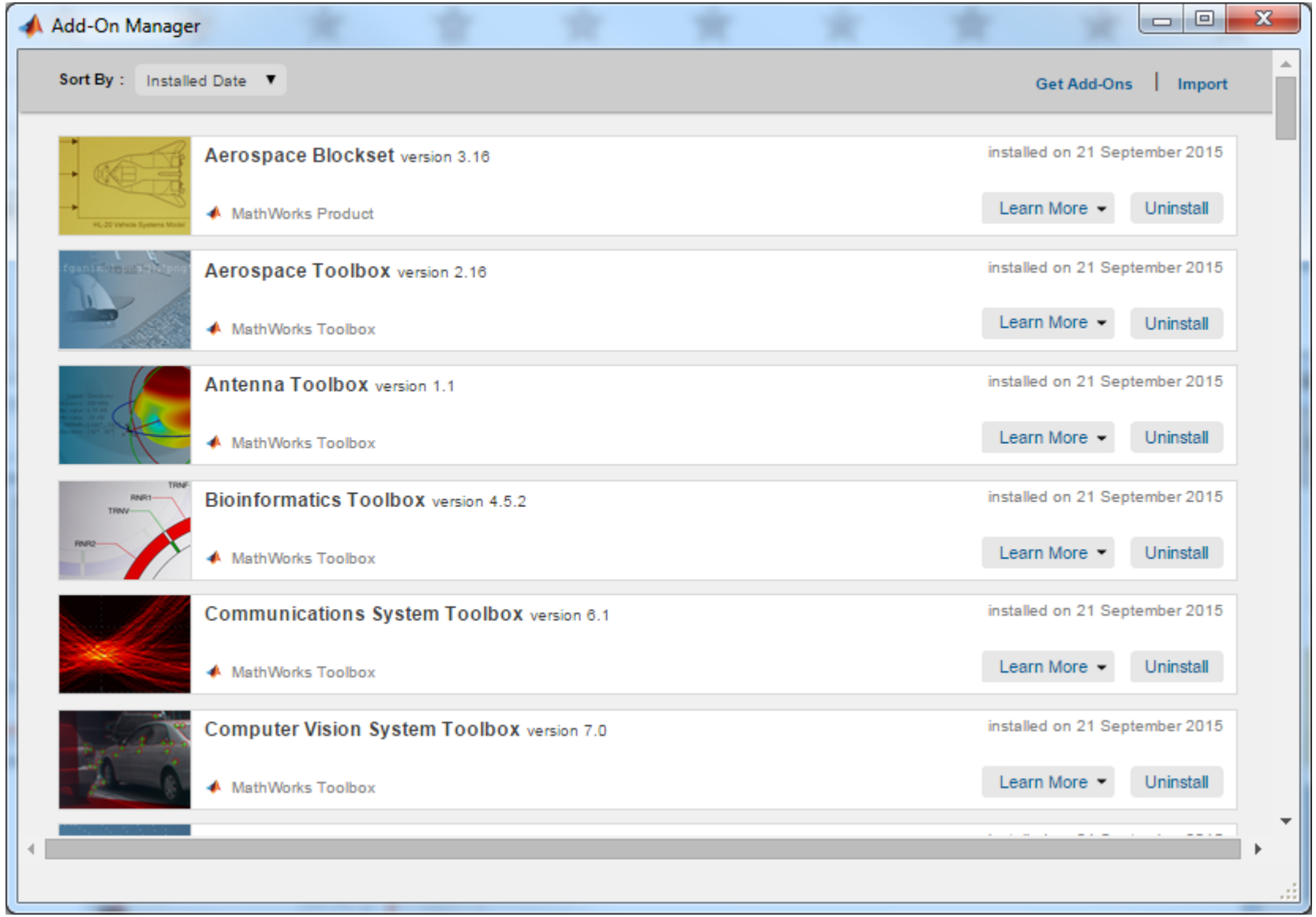


Add-On Manager



Add-On Explorer

I searched for “Vibration”

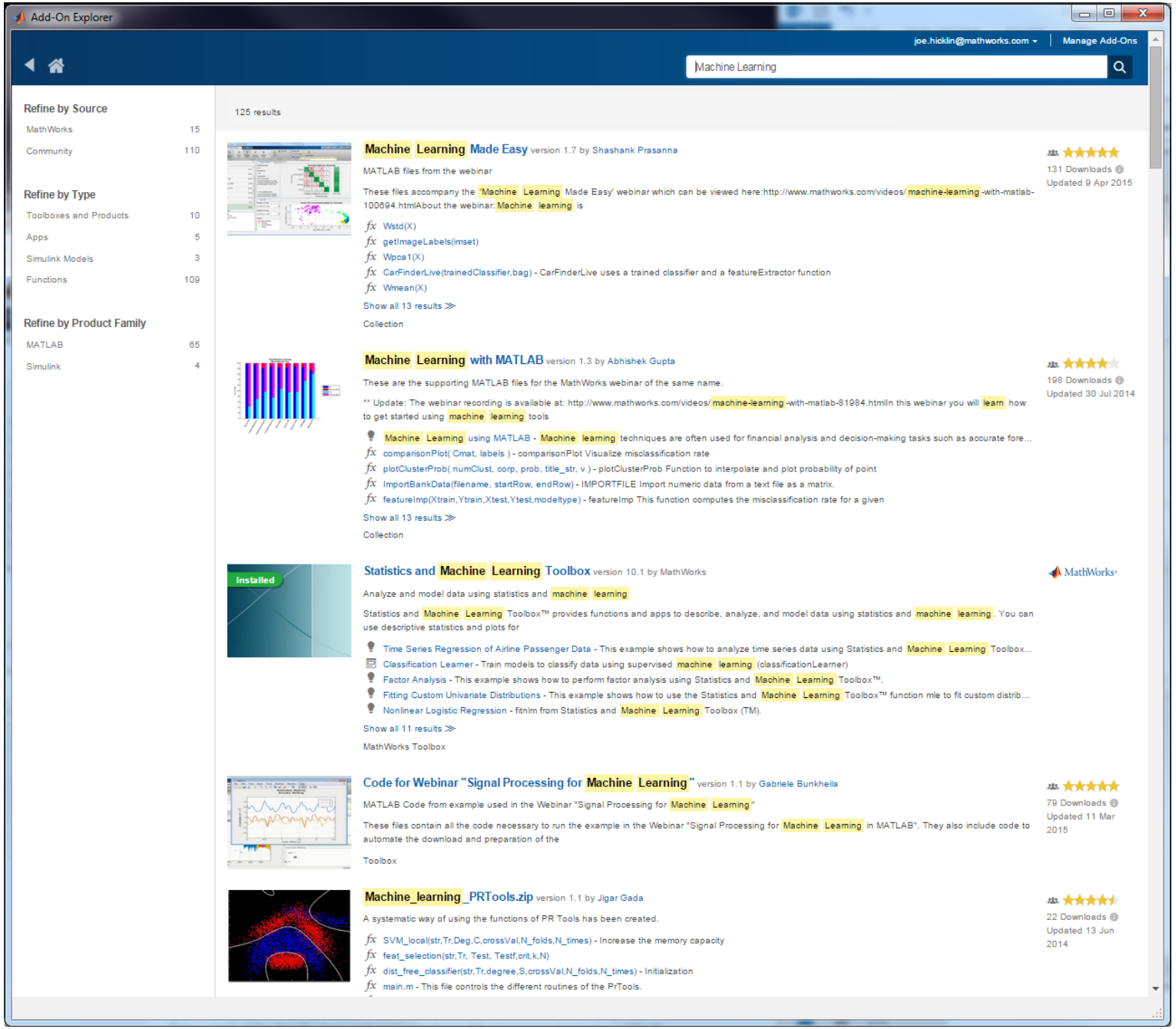
133 results

“Spectral”

512 results

“Machine Learning”

125 results

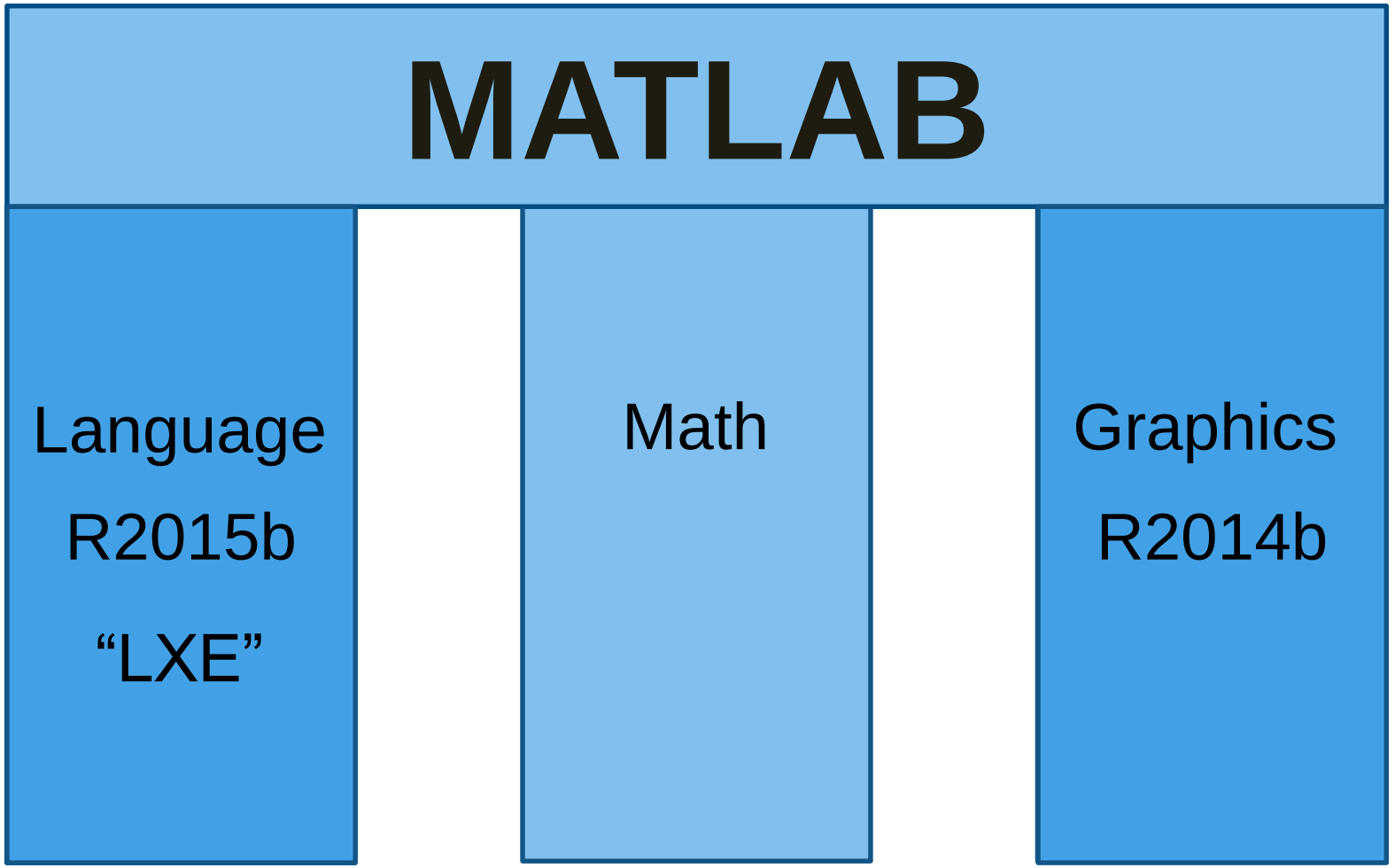


Add-On Explorer

Vibration	133
Spectral	512
Machine Learning	125
Support Vector	226
Classify	411
Detect	1342
Control	3919
Control Phase	191
Love	26
Beauty	26
Truth	84
Beer	10
Monkey	3
Yogurt	0

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

MATLAB Execution Engine



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**

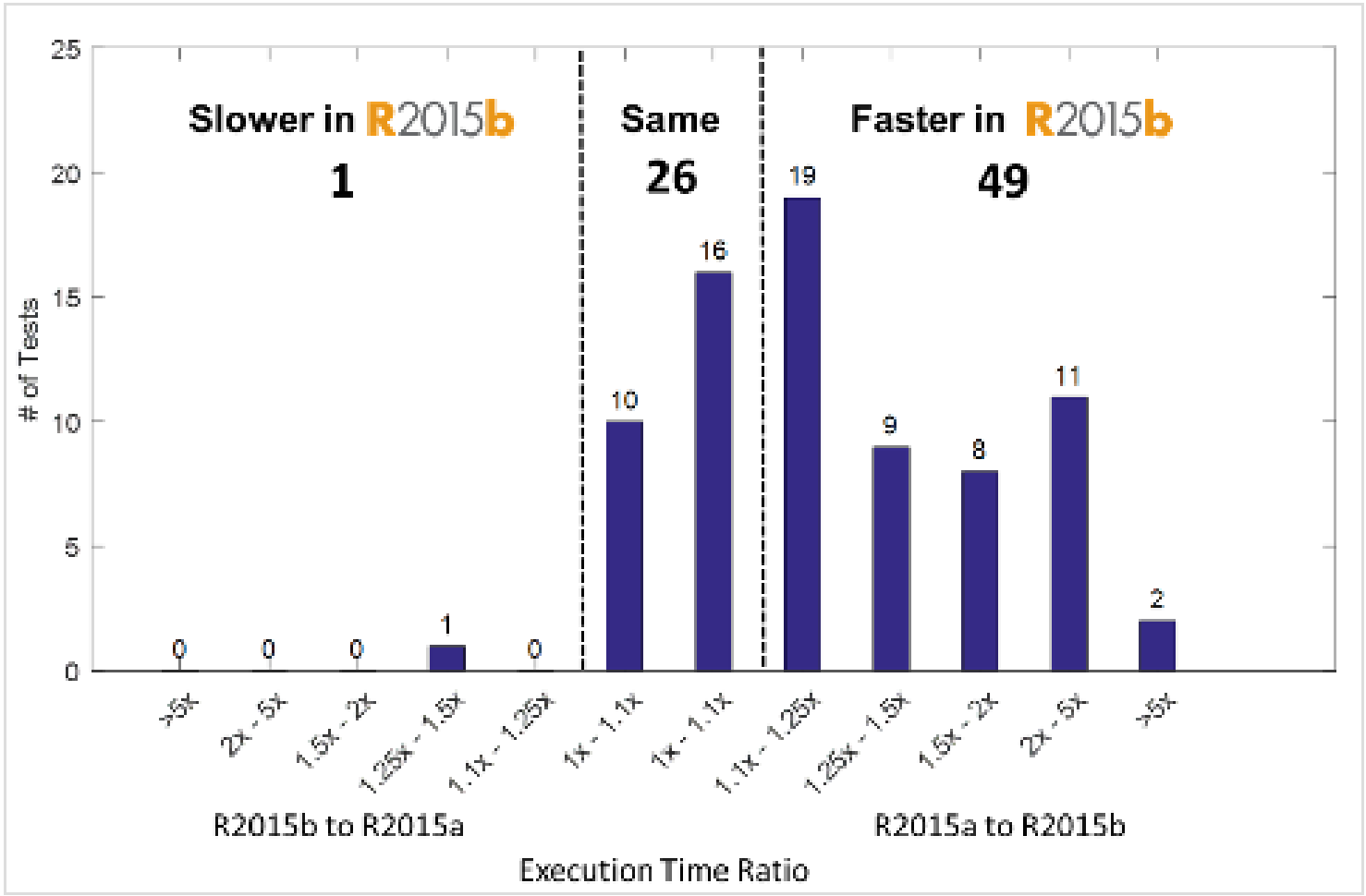
Image Processing executes **15% faster**

Performance in Object-Oriented MATLAB Code on File Exchange executes **10-40% faster**

Wireless Application demo executes **50% faster**

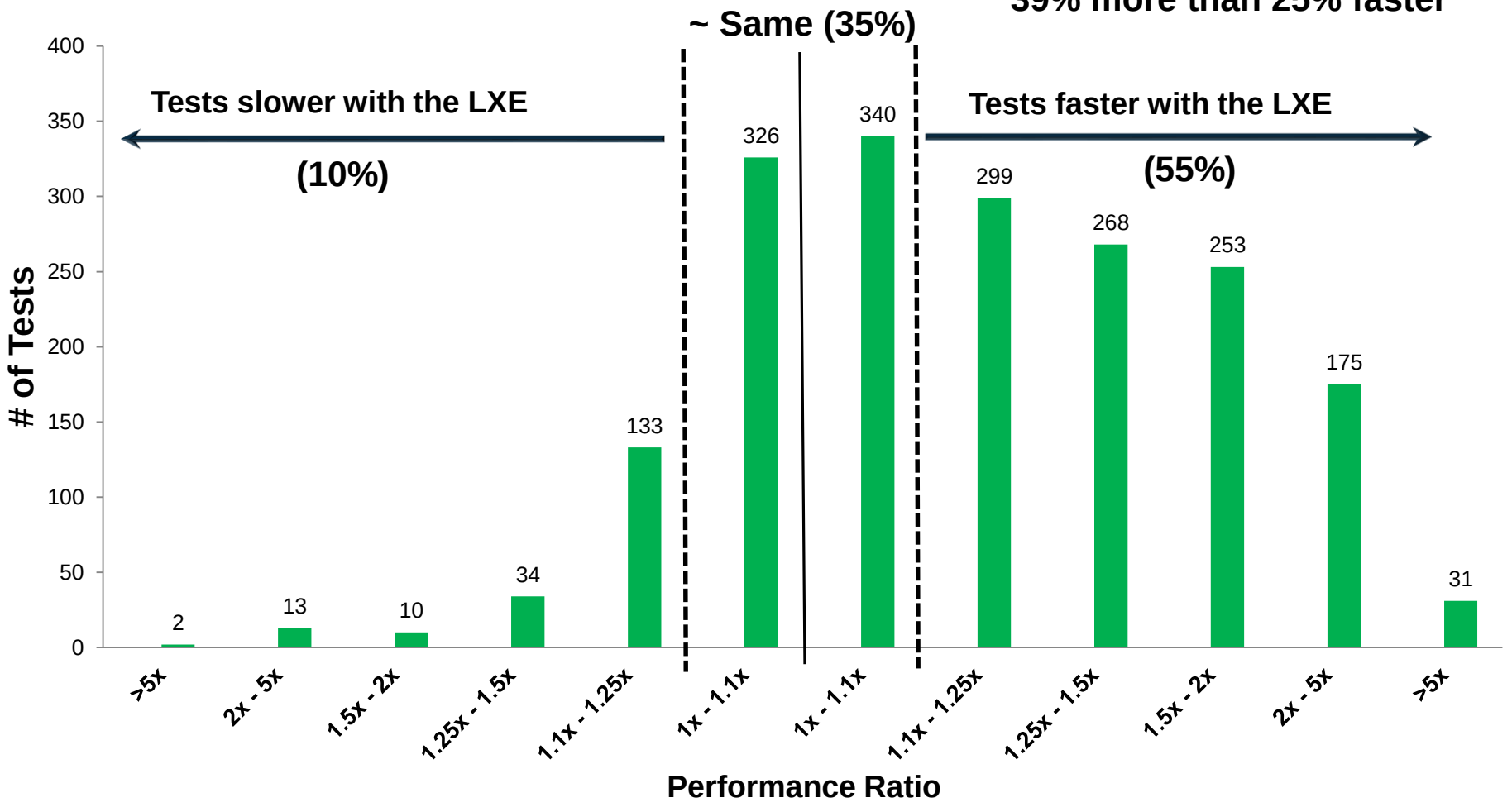
Application Level Benchmarks

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



Core and Toolbox UPS tests

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

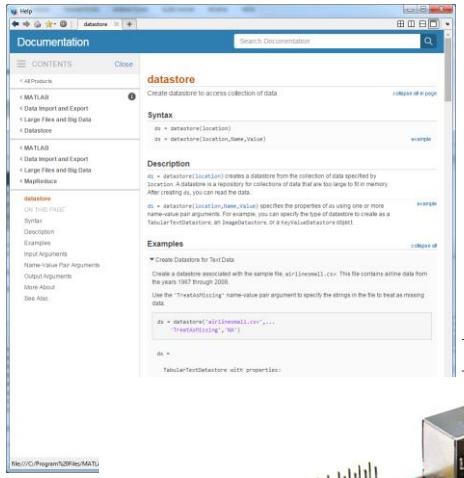
R2015b runs MATLAB programs faster than previous releases.

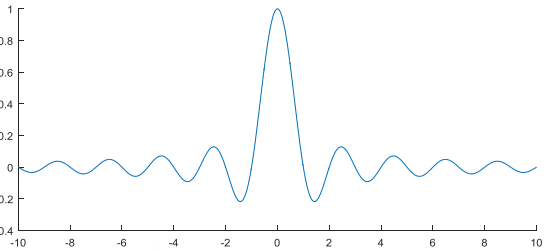
We will to continue to increase performance.

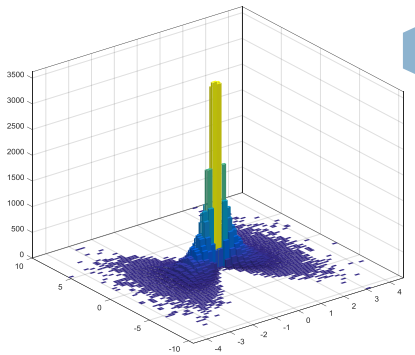
We will add new features more easily and more quickly.

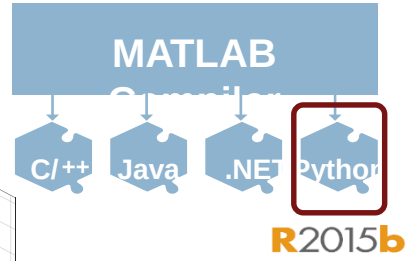
What's New in MATLAB 2015

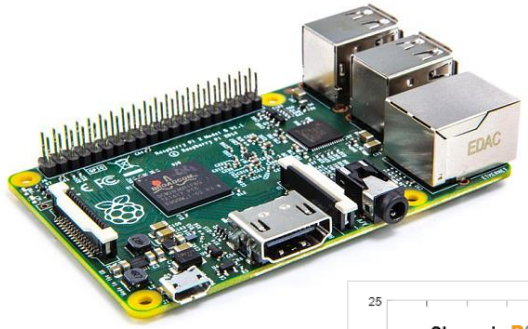
```
>> T(1:15,:)

ans =

    DepTime    ArrTime    UniqueCarrier    FlightNum    ArrDelay    DepDelay    Origin    Dest
    _______    _______    _____________    _________    ________    ________    ______    ____

    '1434'     '1522'     'AS'                67           7          14        'SEA'     'KTN'
    '1545'     '1628'     'AS'                67          -7          -5        'KTN'     'SIT'
    '1500'     '1600'     'AS'                67          25          20        'SEA'     'KTN'
    '1114'     '1342'     'TW'               469           2          -1        'SJU'     'MIA'
    '1725'     '2104'     'EA'               940          -2           0        'SJU'     'PHL'
    '700'      '1101'     'AA'               662          24           0        'SJU'     'JFK'
    '1735'     '2131'     'AA'               688          13           0        'SJU'     'JFK'
    '1829'     '2000'     'EA'               942           0           0        'SJU'     'MIA'
    '1301'     '1925'     'AA'               606          -6           1        'DFW'     'SJU'
    '1326'     '1947'     'AA'               919           1           7        'ORD'     'SJU'
    '945'      '1249'     'AS'                60          84          65        'KTN'     'SEA'
    '700'      '752'      'AS'                60           2           0        'JNU'     'KTN'
    '825'      '1100'     'AS'                60         -10           0        'KTN'     'SEA'
    '740'      '1034'     'AS'                60          14           0        'KTN'     'SEA'
    '1002'     '1025'     'US'               295          -9          -3        'DCA'     'IND'
```

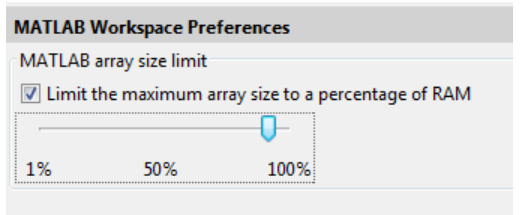


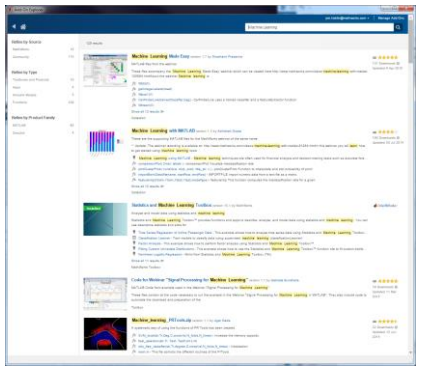


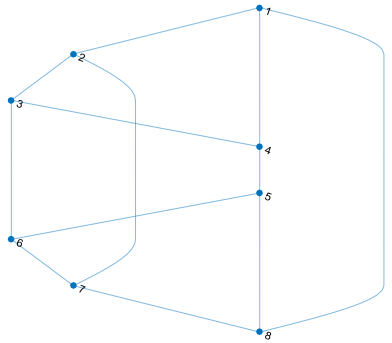


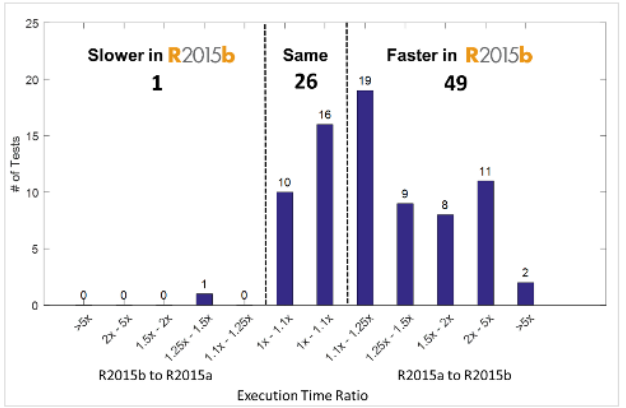












MATLAB EXPO 2015
UNITED KINGDOM