CNBC Matlab Mini-Course

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Day 2: More Stuff

Scientific Functions

Trig:	sin, cos, tan, asin, acos, atan sinh, cosh, tanh, asinh, acosh, ...
Rounding:	floor, ceil, round, fix
Modular:	rem, mod
Exponential:	exp, log, log2, log10, sqrt
Primes:	factor, primes
Polynomials:	roots, polyfit, polyval

Matrix Functions

Determinant:	det
Inverse:	inv, pinv
Eigenvalues:	eig, svd
Fourrier:	fft

And many, many more...

Inf and NaN

3/0 returns Inf

0/0 returns NaN

3+Inf

Inf/Inf

-Inf, -NaN

Complex Numbers

sqrt(-16)

3.5i

2 - 3.5i

(2+3i) * (4+5i)

Predicates

```
isreal(3)
isprime(1 : 13)
isnumeric([2 3 5])
isempty([ ])
isinf(Inf)
isnan(NaN)
islogical(1 == 1)
ischar('a')
isequal('foo', 'aardvark')
```

What percentage of the first 1000 integers is prime?

```
mean(isprime(1:1000))
```

Return Values

Functions can return multiple values:

```
A = rand(5, 3);

s = size(A)

[rows, cols] = size(A)
```

Optional Return Values

Functions can choose whether to return values, depending on if the user is asking for values.

```
plot([1 2 3], [3 1 2])
```
no return value

```
h = plot([1 2 3], [3 1 2])
set(h, 'LineStyle', '--')
set(h, 'LineWidth', 8)
```
single return value

Variable Number of Arguments

Some functions accept a variable number of arguments:

peaks

peaks(10)

Variable In and Out

```
hist(randn(2000,1))

hist(randn(2000,1), 50)

counts = hist(randn(2000,1), 5)

[counts, centers] = hist(randn(2000,1), 5)
```

nargin and **nargout**

Inside a function, **nargin** is the number of input arguments supplied with the call.

nargout is the number of output arguments requested with the call.

Testing nargin/nargout

```
function [x,y,z] = nargtest(p,q,r,s,t)
  if nargout >= 1
    x = 50;
    if nargout >= 2
      y = 'foo';
      if nargout >= 3
        z = 3:7;
      end
    end
  end
  whos     % show the local workspace
end
```

Try:

```
  a = nargtest(5,6,7)
  [a, b] = nargtest(3)
  [a, ~, c] = nargtest(9,8)
```

Name Spaces

- **Base workspace:** variables created outside of any function exist in the base workspace.

- **Local workspaces:** each function executes in a separate local workspace holding the arguments, return variables, and any local variables created by the function.

  Functions cannot access variables of the base workspace.

Name Spaces (cont.)

- **Global workspace:** variables declared global by a function are accessed in the global workspace.

  It's a good idea to also declare the variable global in the base workspace.

Global Variables

```
global pts
pts = 0 : pi/20 : 2*pi ;
```

```
function h = circ(x,y)
    % draws a circle centered on (x,y)
  global pts
  hh = plot(x+cos(pts), y+sin(pts));
  if nargout > 0
    h = hh;   % return h only if requested
  end
end
```

Scripts Called By Functions

- Scripts do not have their own workspaces.
- A script called from the keyboard executes in the base workspace.
- A script called from within a function executes in the function's local workspace.

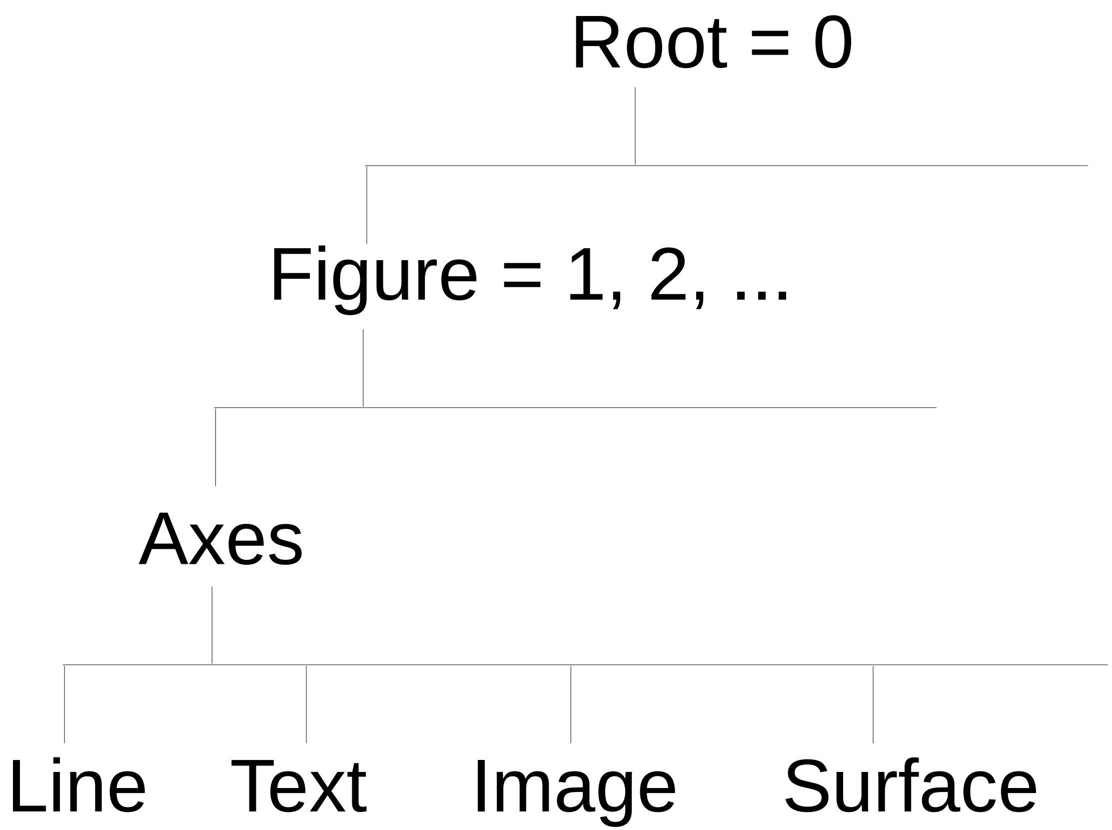
Resetting Variables

clear x	removes variable x and undoes any global declaration

You can also click on a variable in the workspace pane and hit the Delete key, or right-click on the variable and choose from the menu.

clear all	clears everything
clear global	clears global declarations
whos global	shows all global variables

Handle Graphics



Taking Apart A Figure

```
clf, plot(rand(5, 3))

ax = get(gcf, 'Children')
get(ax)

lines = get(gca, 'Children')
get(lines(1))
```

Multiple Axes: Subplot

```
clf

subplot(2,2,1),  plot(rand(5, 5))
subplot(2,2,2),  bar3(rand(5, 3))
subplot(2,2,3),  a=rand(15, 1);  pie(a, a > 0.7)
subplot(2,2,4),  polar(cos(0:150))

set(gca, 'Position', [0.32  0.1  0.4  0.4])
```

Row-major order

Exploring Graphics Objects

set(gca,'Units')

set(gca)

propedit(gca) *click on “More Properties”*

Matlab online documentation:
Help pulldown menu or '?' icon:
> Documentation
> MATLAB
> Graphics
> Graphics Objects

3D Graphics

peaks

rotate3d on

or put mouse in figure area and
click on the 3D rotation arrow in the toolbar

set(gca, 'CameraViewAngleMode', 'manual')

or right-click in the figure,
select Rotate Options, then
select Fixed Aspect Ratio Axes

Plotting Surfaces

```
[x, y, z] = peaks;

surf(x, y, z, z)

surf(x, y, z, x)

surf(x, y, z, rand(length(x)))
```

Plotting in 3D

Don't type all this in! Download this file:

www.cs.cmu.edu/~dst/Tutorials/Matlab/helix.m

or *cd /afs/andrew/usr/dst/matlab*

```
function helix
  pts = 0 : pi/20 : 4*pi;
  x1 = cos(pts);  y1 = sin(pts);
  x2 = cos(pts+pi);  y2 = sin(pts+pi);
  z = pts/(2*pi);

  clf, whitebg(gcf, [0 0 0]), hold on
  plot3(x1, y1, z, 'y')
  plot3(x2, y2, z, 'w')
  axis([ -3 3  -3 3  0 2])
  view(95, 9)
end
```

Helix (cont.)

```
colors = 'rgbm';

for i = 4 : 4 : length(pts)-4
  plot3([x1(i) x2(i)], [y1(i) y2(i)], z([i i]), ...
         colors(ceil(rand(1)*length(colors))), 'LineWidth', 3)
end

axis off
set(gcf, 'Color', 'k')
set(gca, 'CameraViewAngleMode', 'manual')

az = -180 ;

while true
  view(az, 9), pause(0.05)
  az = az + 5 ;
end
```

Color Maps

```
clf reset, peaks, colorbar

m = colormap;
whos m

colormap(spring)
brighten(0.5)

colormap(jet)

colormap(parula)

colormap(bone)

colormap(hot)

colormapeditor
```

Northern parula

2D Data

```
[x, y] = meshgrid(-2 : 0.05 : 2) ;
z = sin(x) .* cos(y);
contour(z, 20)
imagesc(z)
colormap(hot)
imagesc(x(:), y(:), z)
surf(z), colormap(jet)
surfc(z)
```

Surface Objects

```
sphere

[x,y,z] = sphere(20);
x(1 : 5 : 21*21) = NaN;
surf(x, y, z)
alpha(0.7)
```

Use the rotate tool to rotate the sphere; set Fixed Aspect Ratio Axes first.

```
surf(x, y, z, rand(size(x)))
shading interp, grid off, axis off
set(gcf, 'Color', 'w')
```

Data From Files

Create a file temps.txt:

Use the “New Script” button.

Enter this data:

```
38    50
42    53
33    57
45    56
44    46
41    40
```

Save the file as temps.txt

load temps.txt

plot(temps)

Importing Data From Files

- You can import data from Excel (and many other file formats) using the Import Data button.

  Select the file you want to import; the wizard will guide you through the rest.

- There are also built-in functions specifically for dealing with Excel files:

  doc xlsread
  doc xlswrite

Curve Fitting for Extrapolation

```
x = randn(1, 2000);
y = sin(x) + 0.2 * randn(1, 2000) ;
clf, hold on, plot(x, y, '.')
```

```
c = polyfit(x, y, 3)
```

Example polynomial representation:

c = [5 -1 4 3]

$5x^3 – x^2 + 4x + 3$

```
pts = min(x) : range(x)/100 : max(x);
```

```
plot(pts, polyval(c, pts), 'r', 'LineWidth', 3)
```

Saving Variables

```
clear all
a = 'aardvark'
[x, y, z] = sphere(5);
save stuff.mat
clear all
whos -file stuff.mat
load stuff.mat

save junk.dat x y -ascii
type junk.dat
```

General Operating System Stuff

pwd

cd

dir

ls *.m

delete stuff.mat

!ps -a

Debugging

Poor man's debugger:

Remove semicolons from assignments.
Add 'quoted strings' in appropriate places.
Add a call to **keyboard**. (Use **return** to return from keyboard input mode.)

```
function y = buggy(vec)
  p = vec > 5
  'got this far'
  keyboard
  z = p * vec
  y = sin(z) ;
end
```

Try: buggy([4 6])
Type 'return' to exit keboard mode and continue.

The Matlab Debugger

dbtype helix

dbstop helix 5

helix

dbstep

dbstep 7

whos

Look at the Stack pulldown menu in the toolbar.

dbstep 30

dbquit

dbclear helix

doc debug

Formatted Output

```
for i = 1 : 10
  fprintf('The square root of %2d is %f \n', ...
            i, sqrt(i))
end
```

```
doc fprintf
```

```
title(sprintf('f(x) over range %g to %g', ...
       -3.5, 5.125))
```