Matlab 3: More Graph, Animation, and GUI

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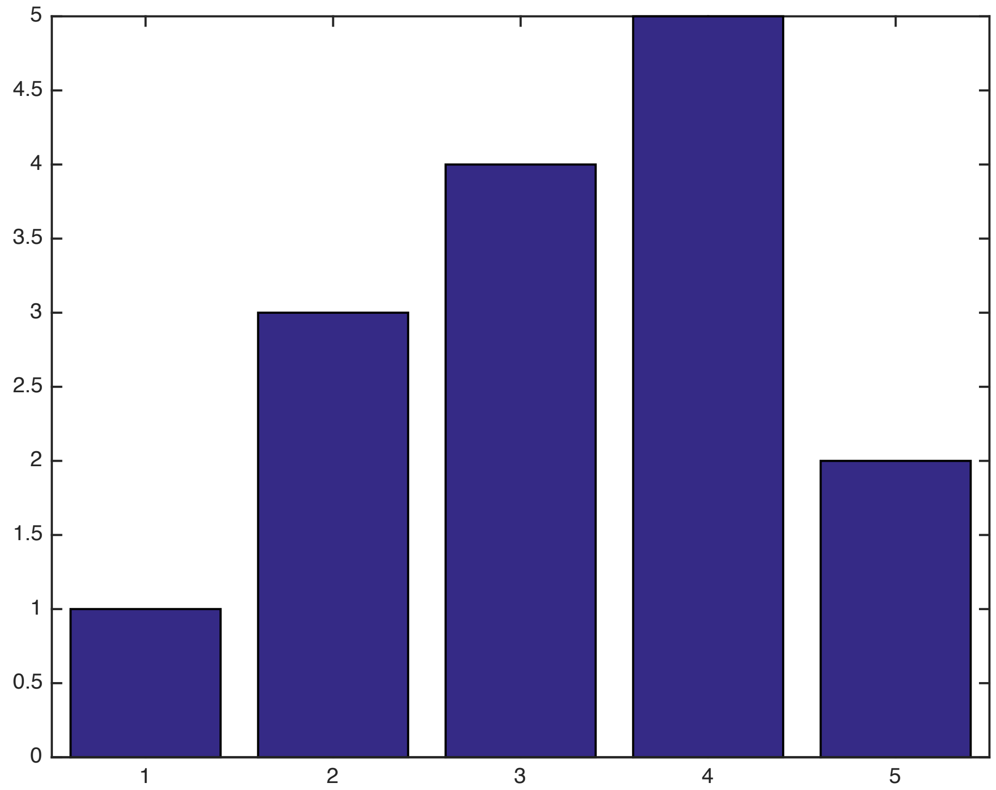
Slides are based on the materials from Prof. Roger Jang

Bar Chart

- Fewer and discrete samples

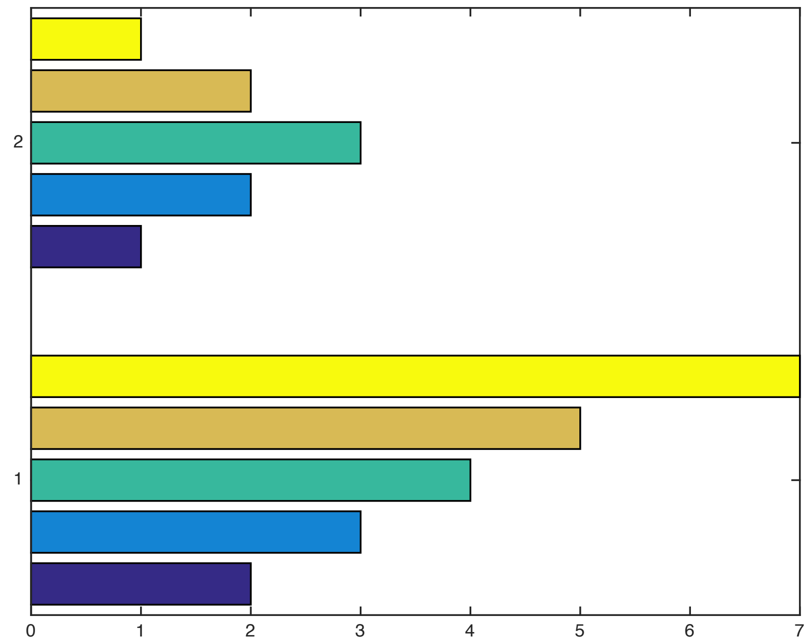
```
x = [1 3 4 5 2];
bar(x);
```



Bar Chart (cont.)

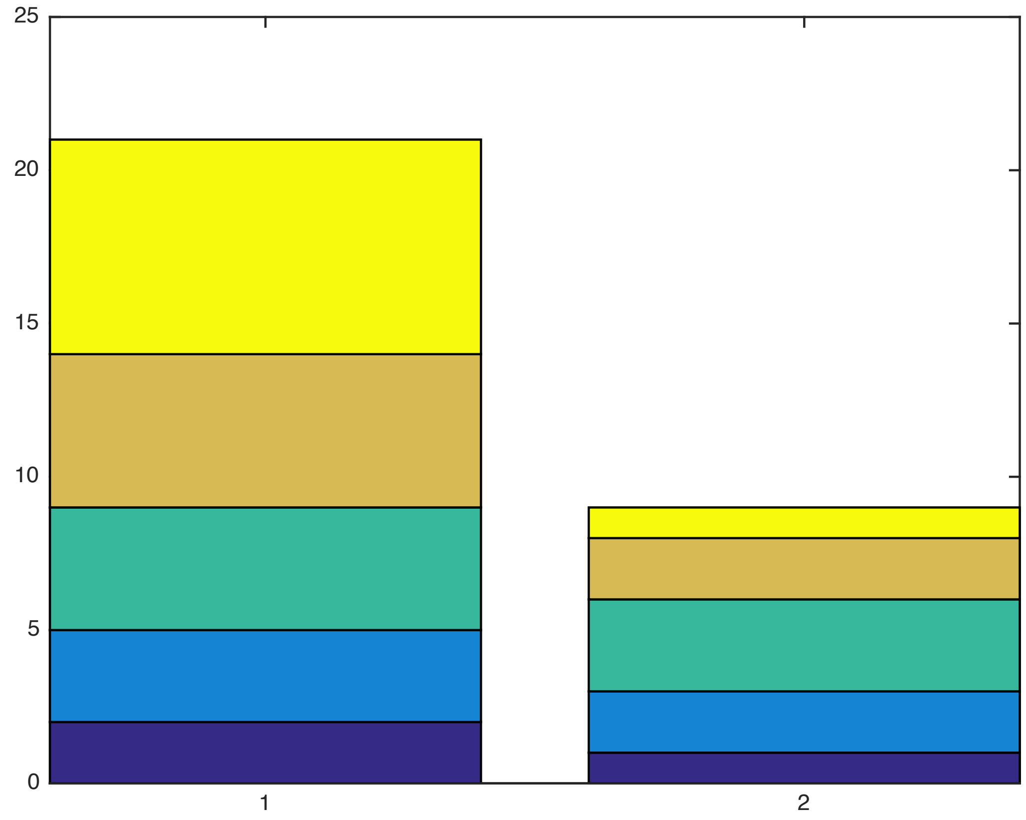
- For 2-D matrices, data in the same row are group together
- barh plots bar charts horizontally

```
x = [2 3 4 5 7;
     1 2 3 2 1];
barh(x);
```



Stacked Bar Chart

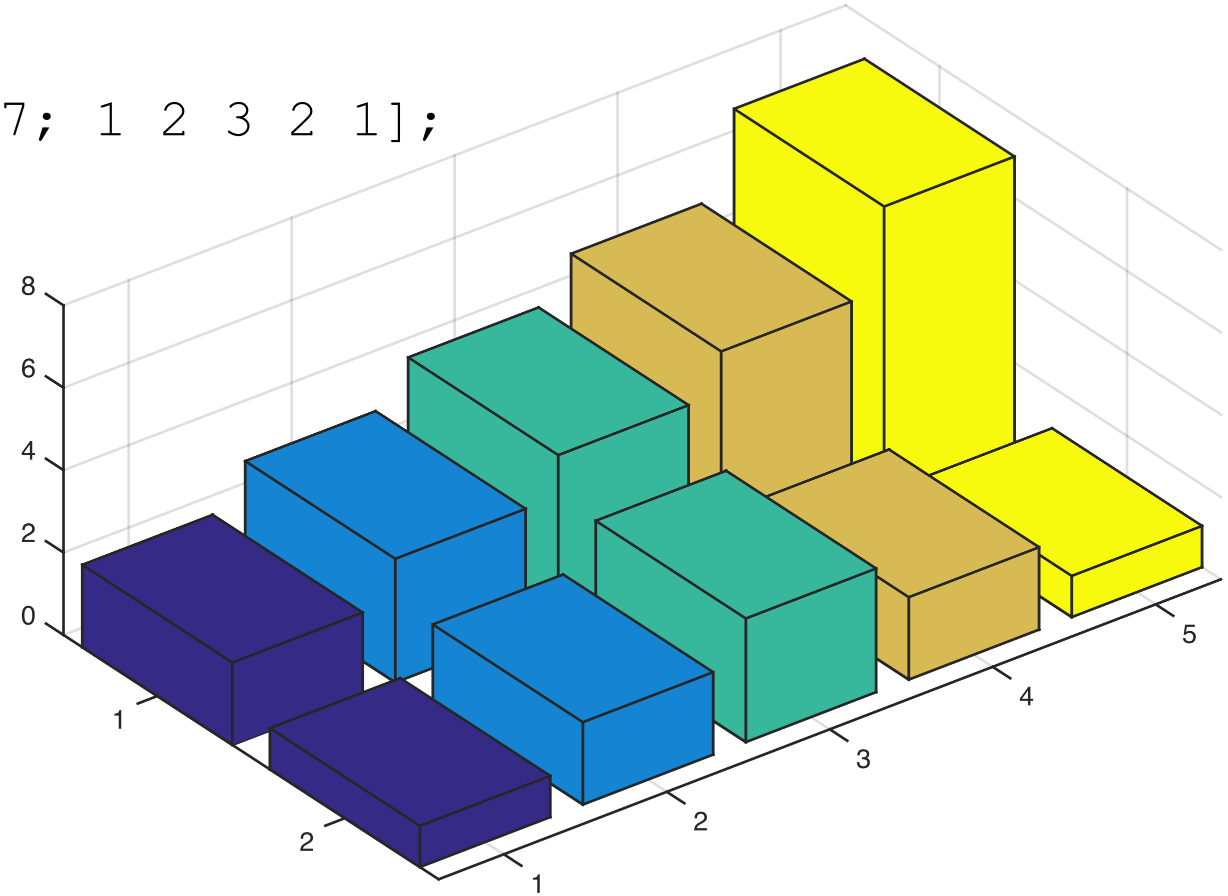
```
x = [2 3 4 5 7; 1 2 3 2 1];
bar(x,'stack')
```



3D Bar Chart

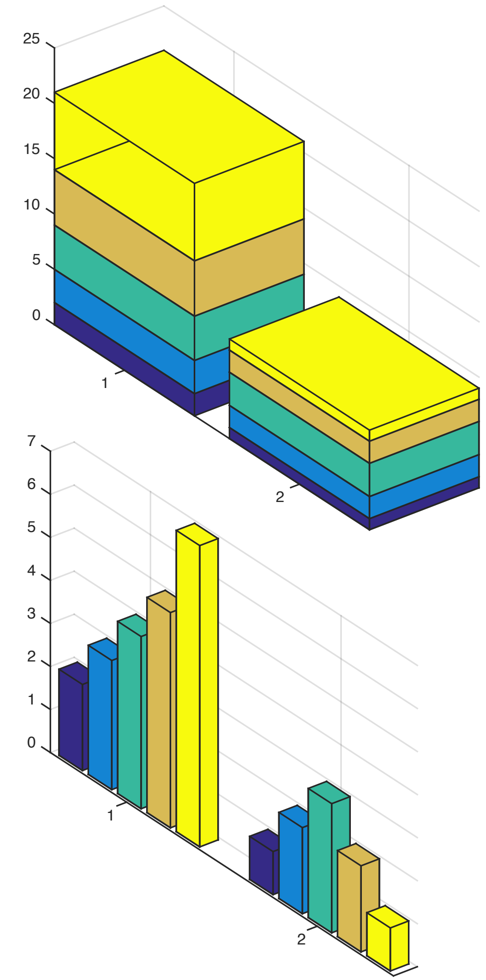
- bar3 allows us to create 3D bar charts

```
x = [2 3 4 5 7; 1 2 3 2 1];
bar3(x)
```



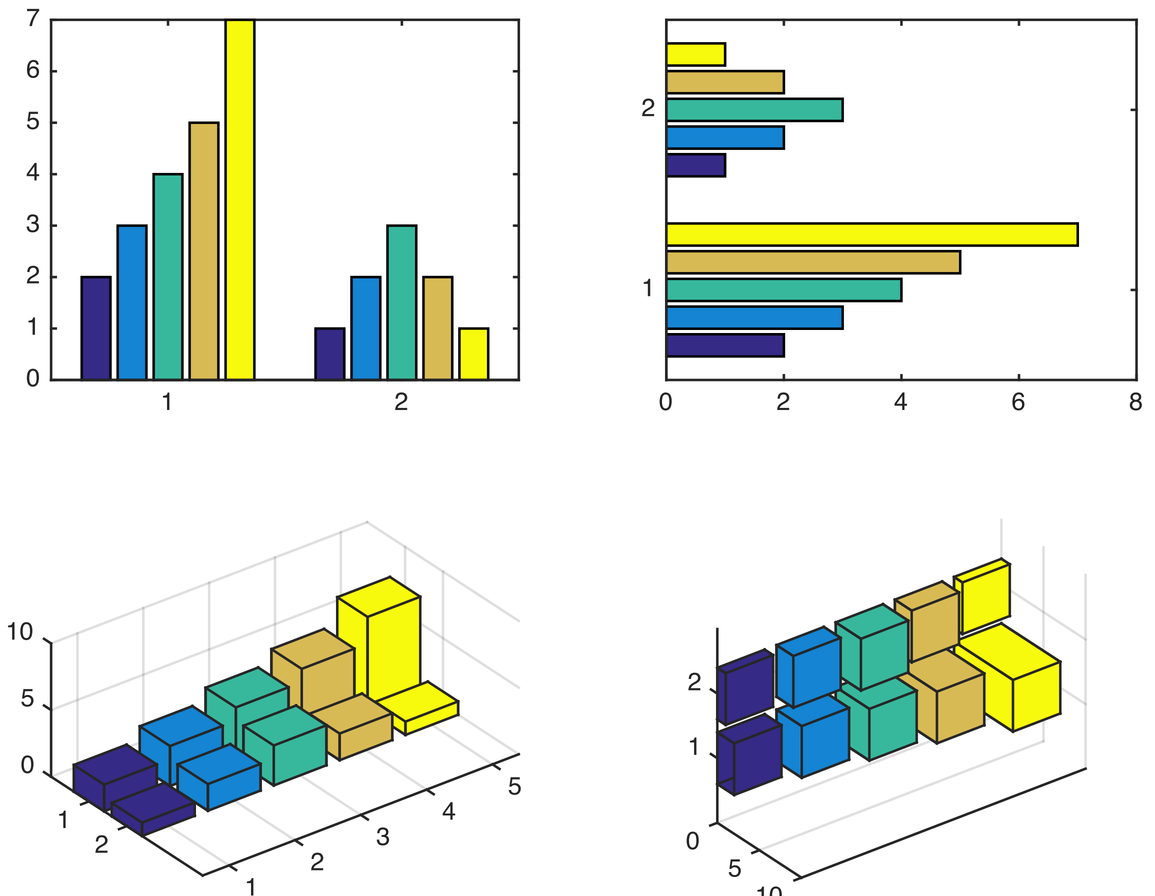
Stack versus Group

```
x = [2 3 4 5 7; 1 2 3 2 1];
bar3(x, 'stack')
figure
bar3(x, 'group')
```



Summary of Bar and Bar3

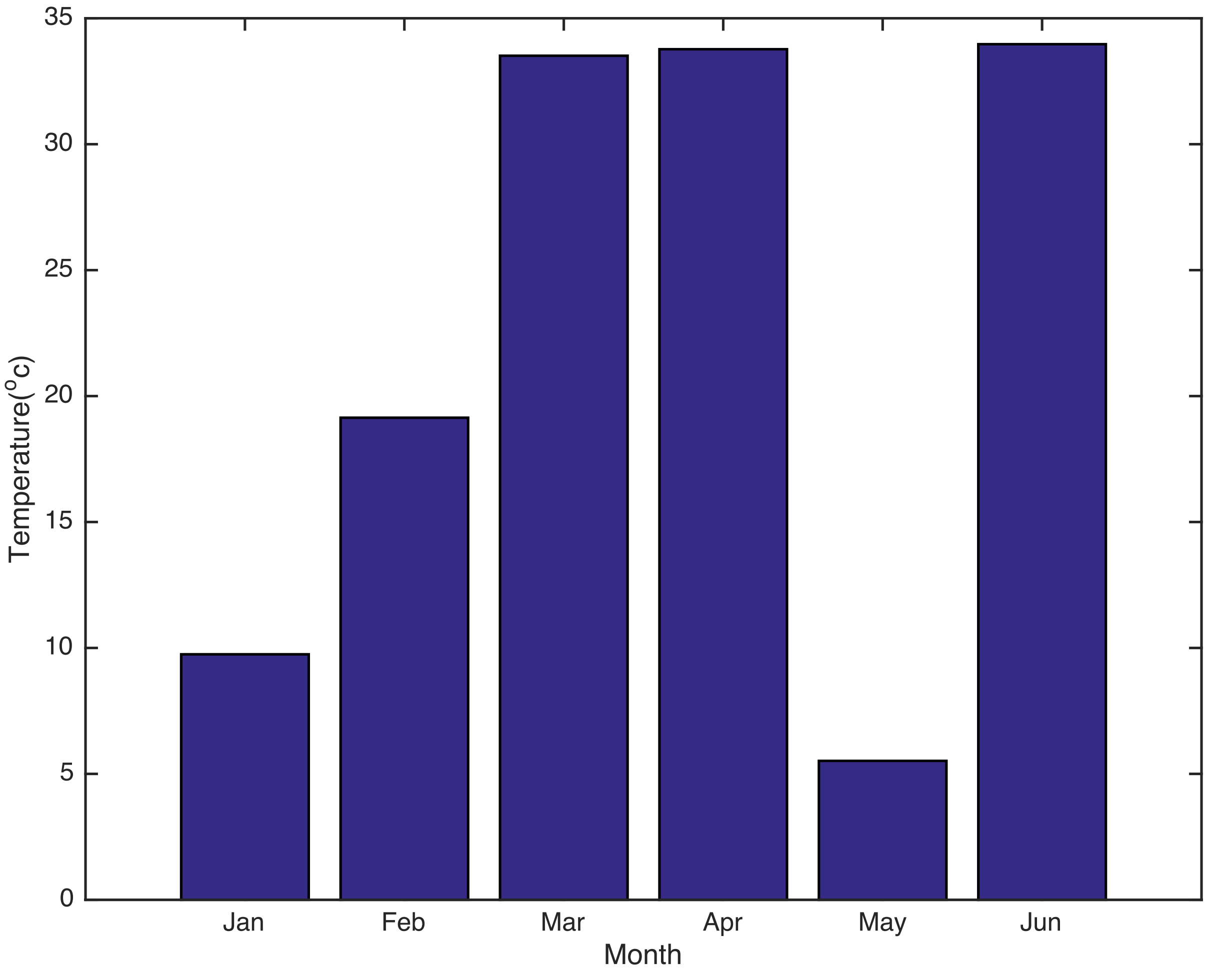
- Exercise: recreate this figure



A Comprehensive Example

```
x = 1:6;
y = 35*rand(1, 6);
bar(x, y);
xlabel('Month');
ylabel('Temperature(^{o}c)');
set(gca, 'xticklabel', {'Jan','Feb','Mar', 'Apr', 'May', 'Jun'});
```

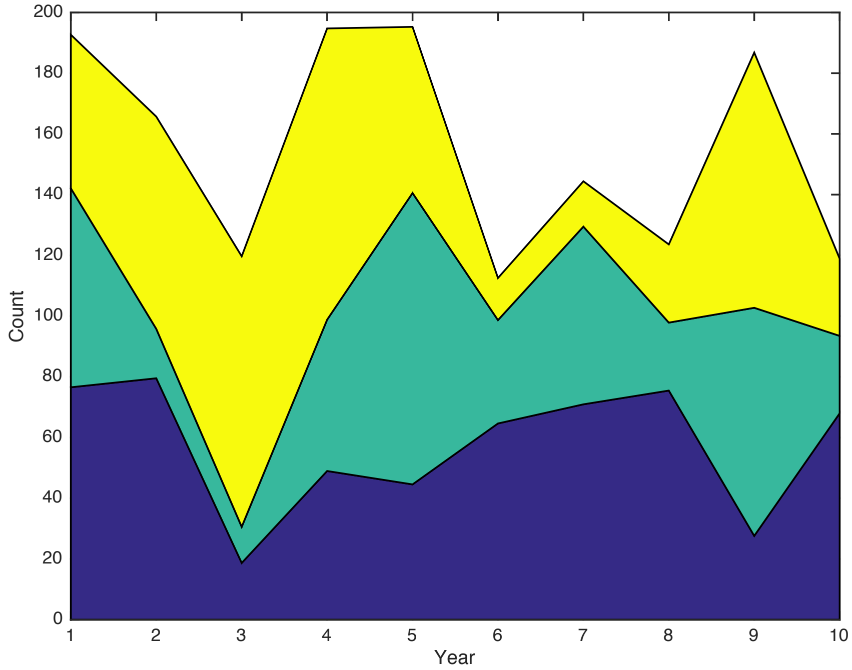
A Comprehensive Example (cont.)



Area Graph

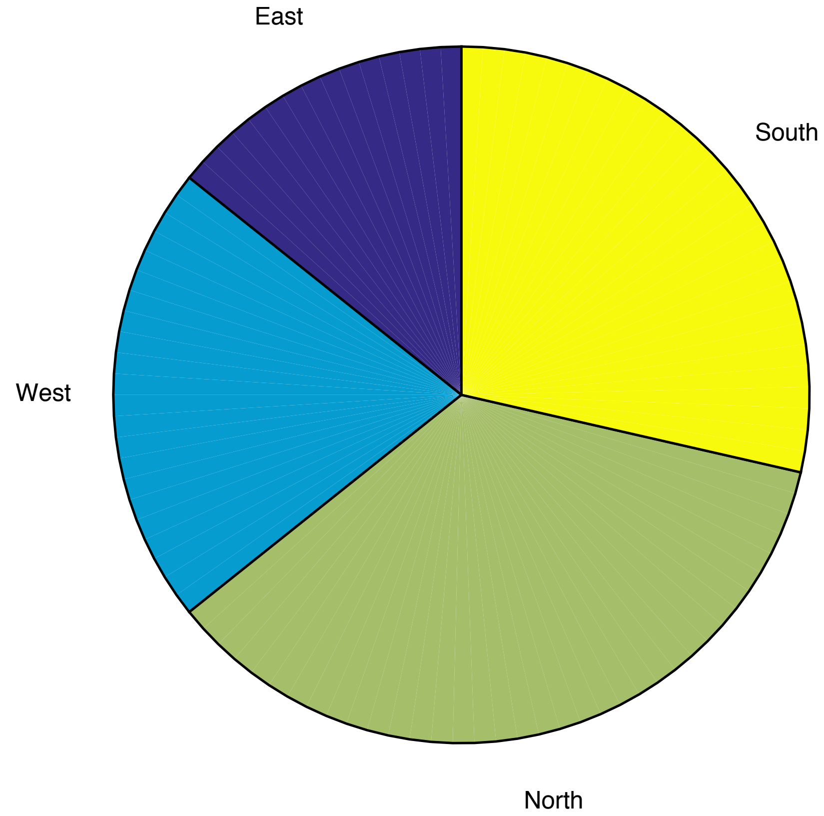
- Similar to stacked bar charts
- E.g., total head counts of undergraduates, graduates, and employees

```
y = rand(10,3)*100;
x = 1:10;
area(x, y);
xlabel('Year');
ylabel('Count')
```



Pie Chart

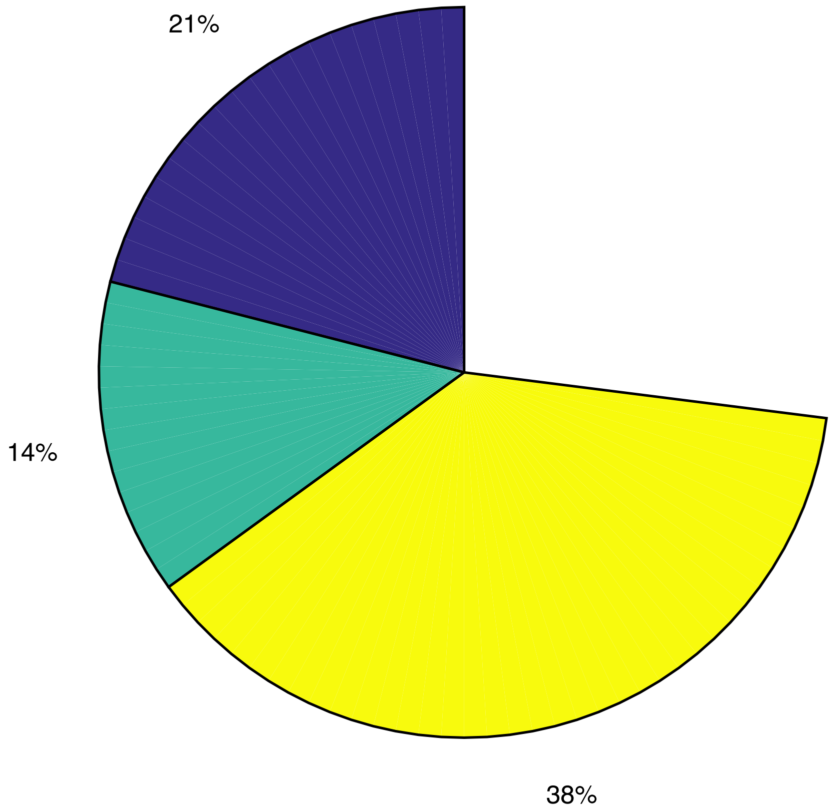
```
x = [2 3 5 4];
label={'East', 'West', 'North', 'South'};
pie(x, label);
```



Partial Pie Chart

- If the sum of the vector is less than 1, we get a partial pie chart

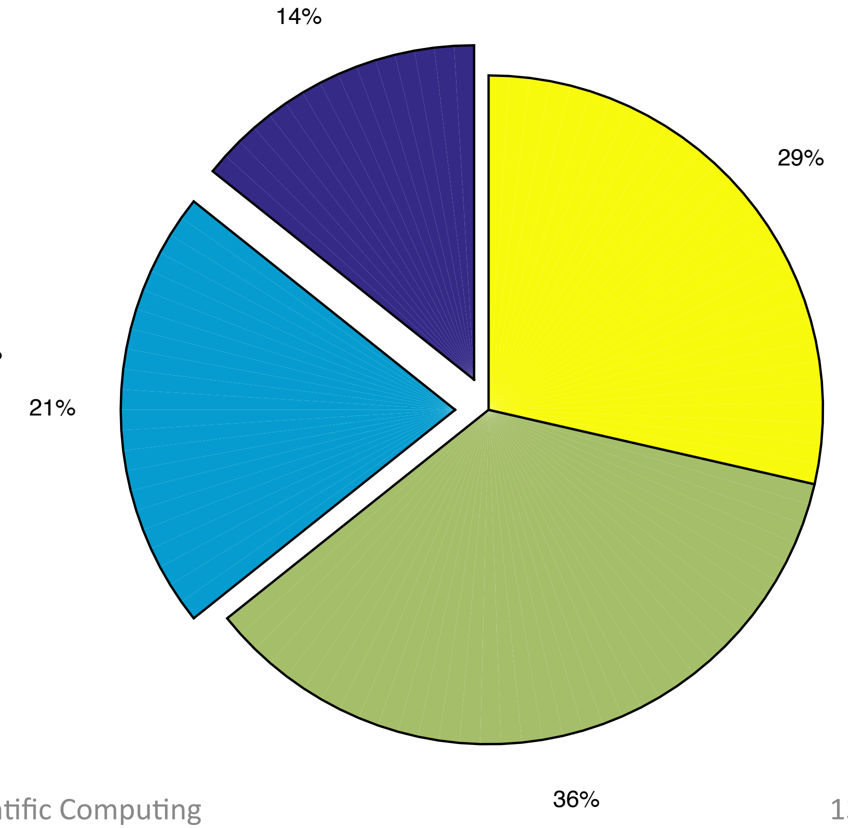
```
x = [0.21, 0.14, 0.38];
pie(x);
```



Explode Pie Chart

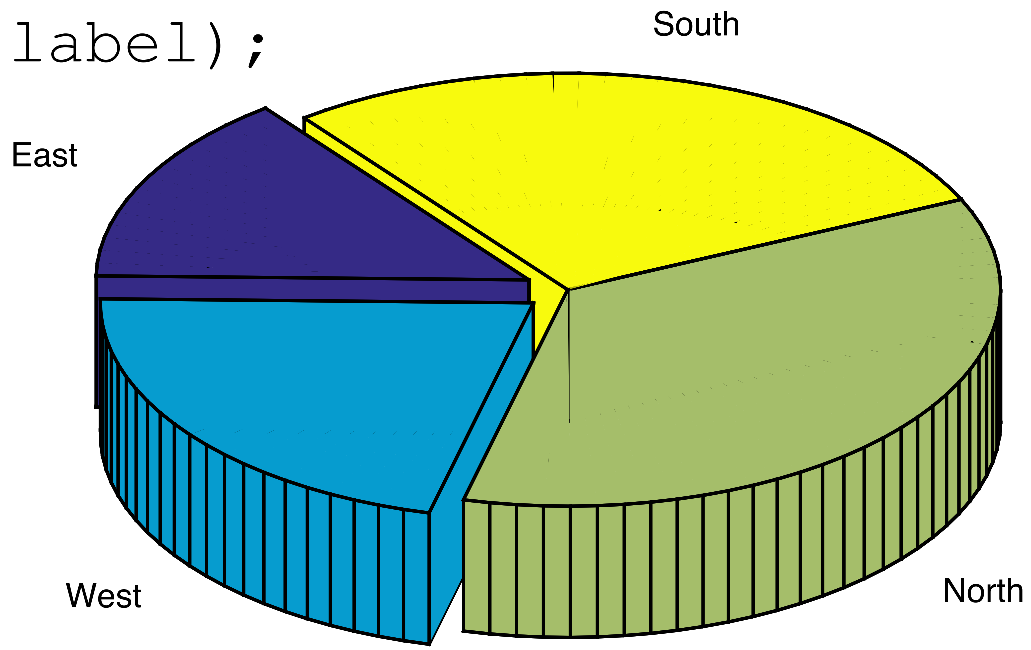
- Use a binary (zero versus nonzero) vector to indicate if a piece should be separated from the rest

```
x = [2 3 5 4];
explode = [1 0.5 0 0];
pie(x, explode);
```



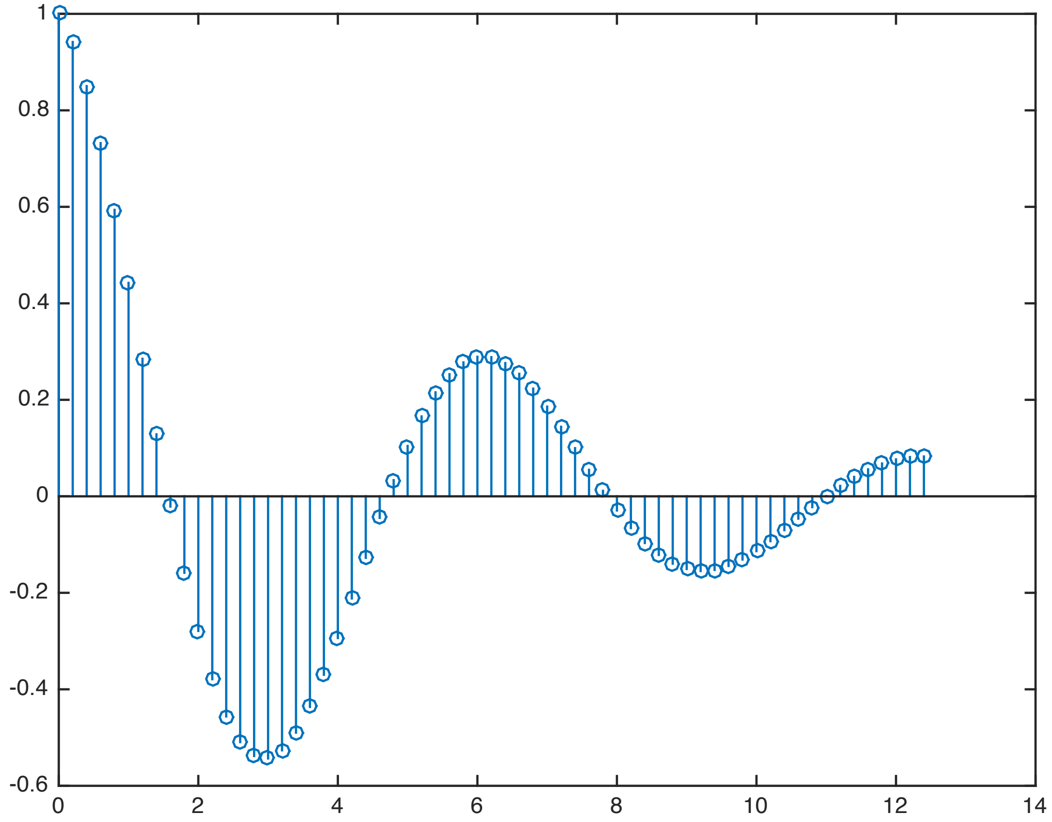
3D Pie Chart

```
x = [2 3 5 4];
explode = [1 0.5 0 0];
label={'East', 'West', 'North', 'South'};
pie3(x, explode, label);
```



Stem Plot

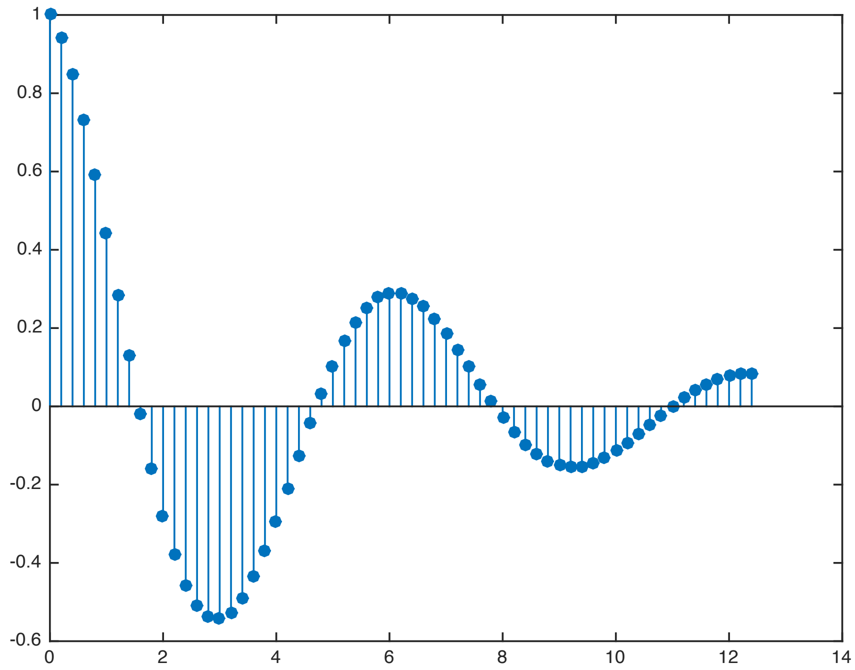
```
t = 0:0.2:4*pi;
y = cos(t).*exp(-t/5);
stem(t, y)
```



Stem Plot (cont.)

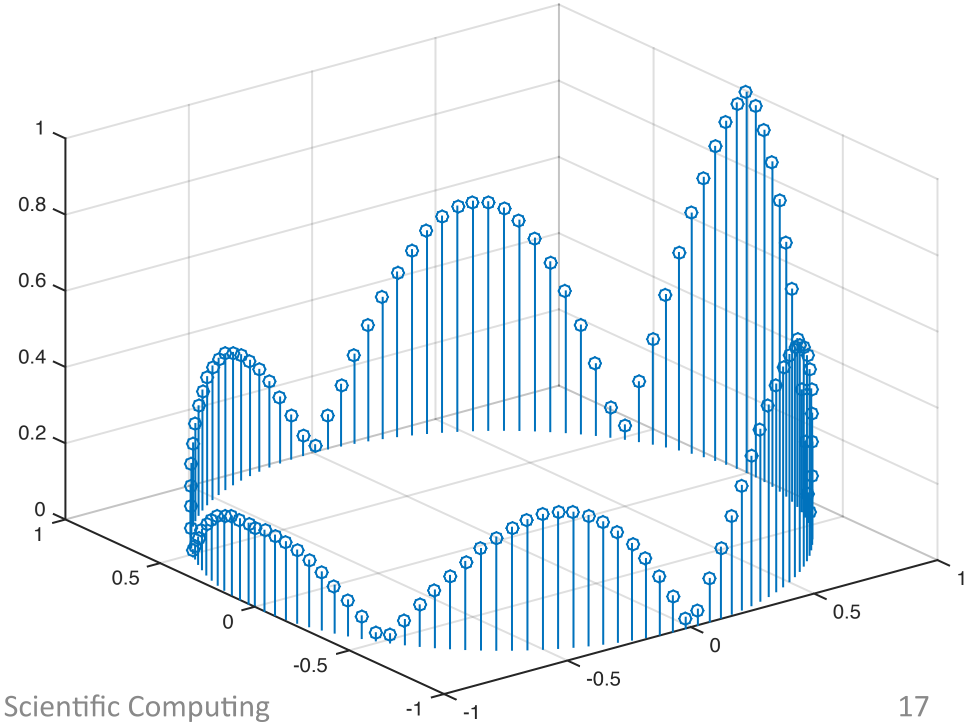
- Suitable for presenting digital signals
- Solid circle can be done by adding ‘fill’

```
t = 0:0.2:4*pi;
y = cos(t).*exp(-t/5);
stem(t, y, 'fill')
```



3D Stem Plot

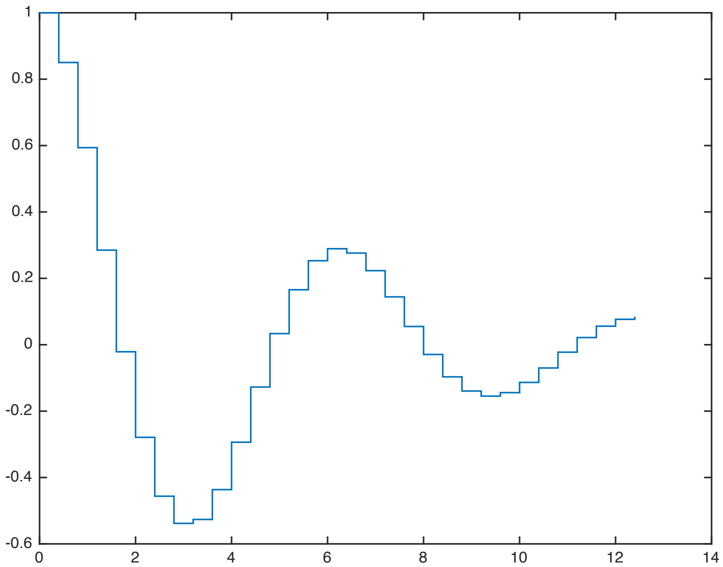
```
theta = -pi:0.05:pi;
x = cos(theta);
y = sin(theta);
z = abs(cos(3*theta)).*exp(-abs(theta/2));
stem3(x, y, z);
```



Stairstep Plots

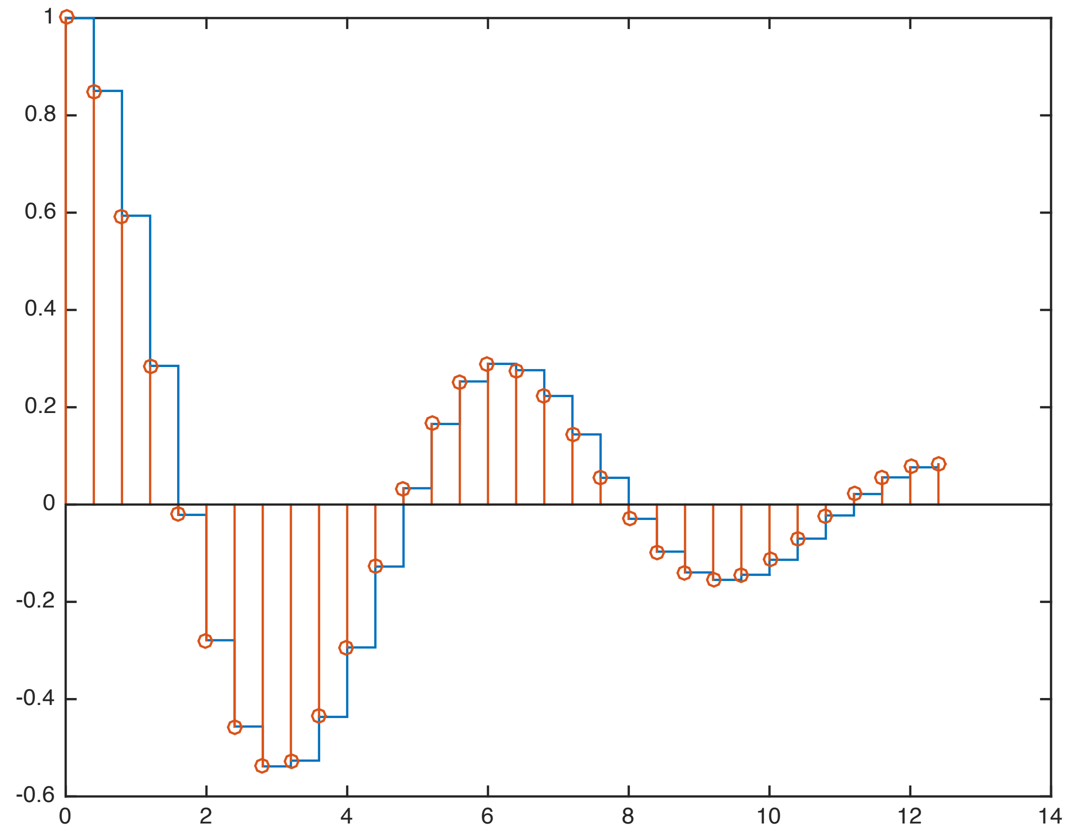
- Similar to stem, but add a horizontal segment from each sample to the sample on its right
  - Known as Zero-Order Hold (ZOH): convert discrete signals into continuous ones

```
t = 0:0.4:4*pi;
y = cos(t).*exp(-t/5);
stairs(t, y);
```



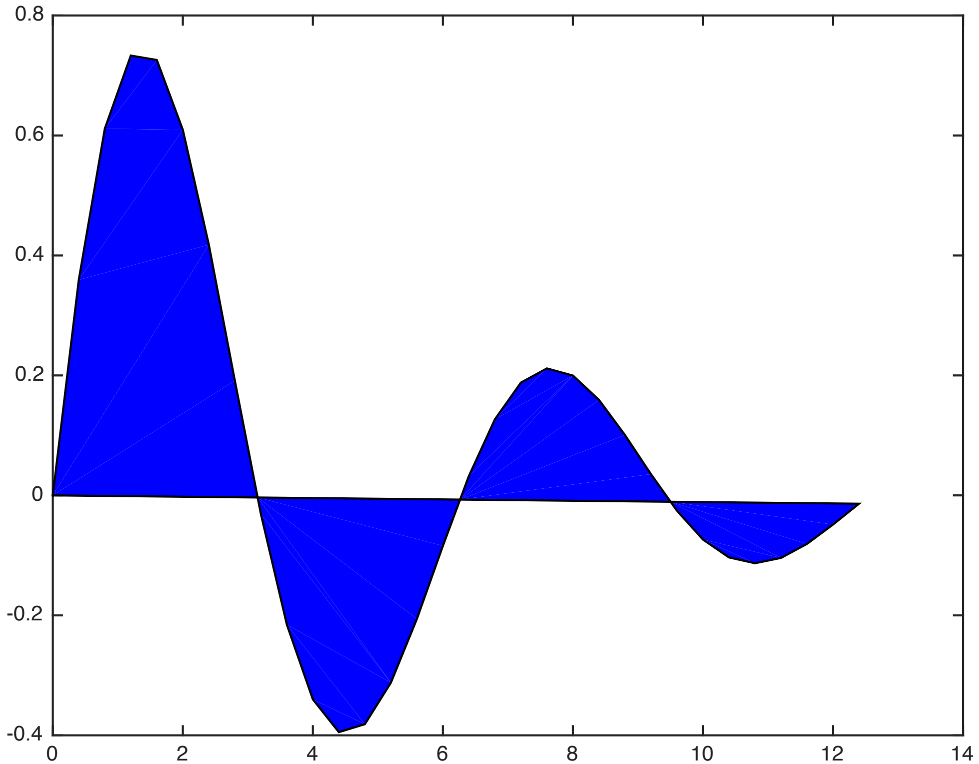
Stem + Stairstep

```
t = 0:0.4:4*pi;
y = cos(t).*exp(-t/5);
stairs(t, y);
hold on
stem(t, y);
hold off
```



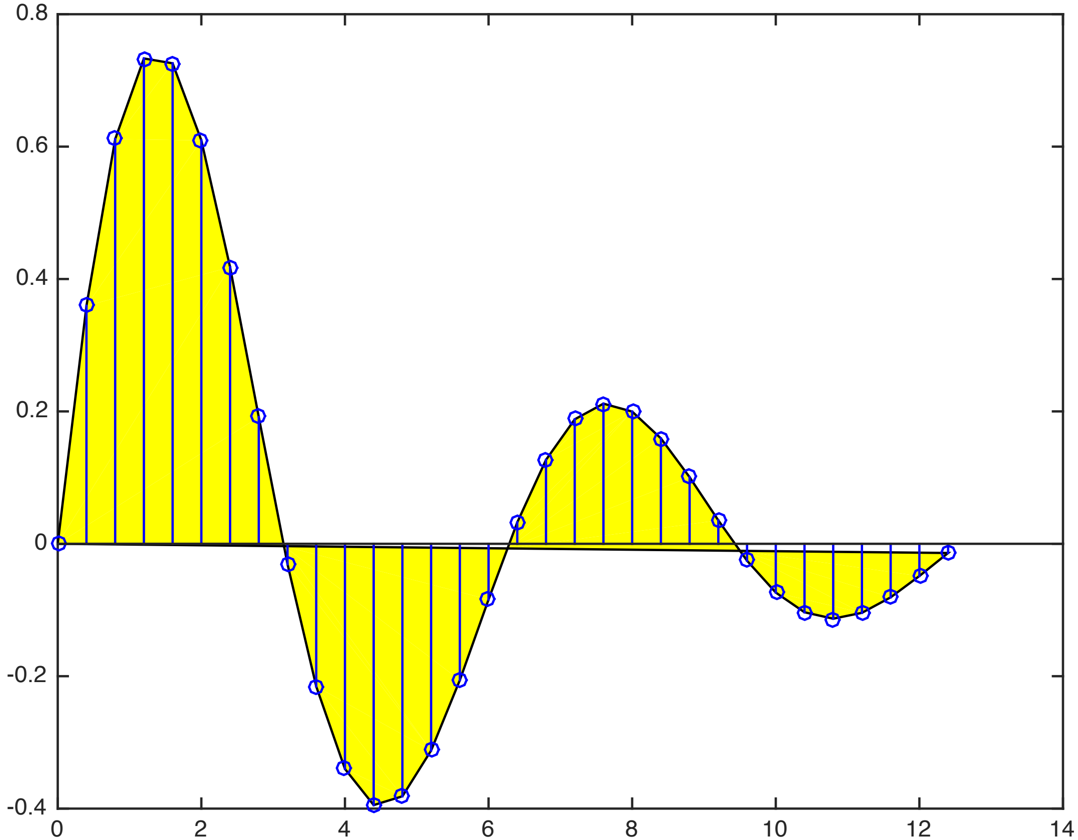
Fill Plot

```
t = 0:0.4:4*pi;
y = sin(t).*exp(-t/5);
fill(t, y, 'b')
```



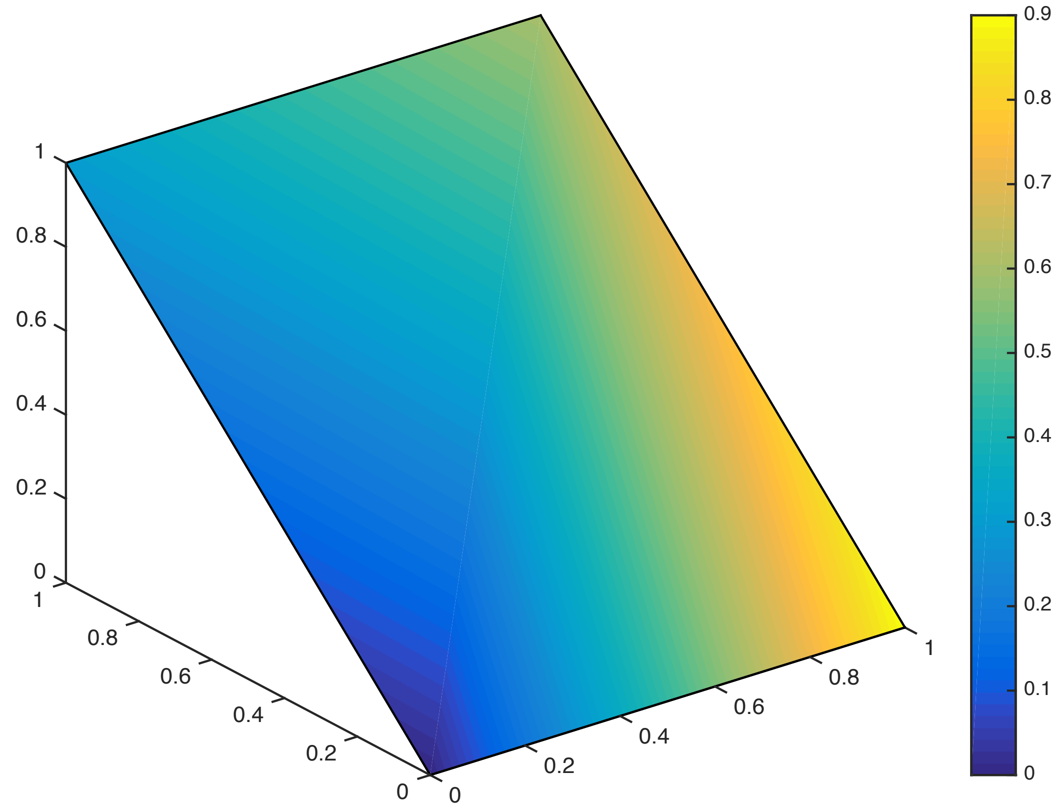
Stem + Fill

```
t = 0:0.4:4*pi;
y = sin(t).*exp(-t/5);
fill(t, y, 'y');
hold on
stem(t, y, 'b');
```



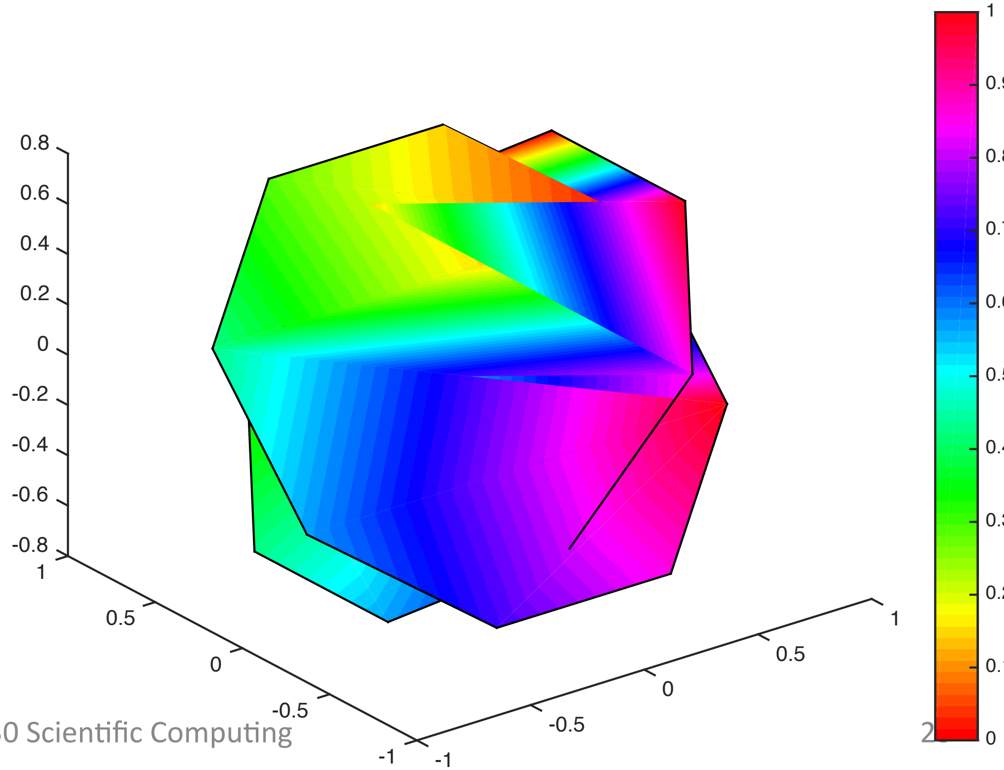
Fill3 Plot

```
X = [0 0 1 1];
Y = [0 1 1 0];
Z = [0 1 1 0];
C = [0 0.3 0.6 0.9];
fill3(X, Y, Z, C);
colorbar;
```



Fill3 Plot

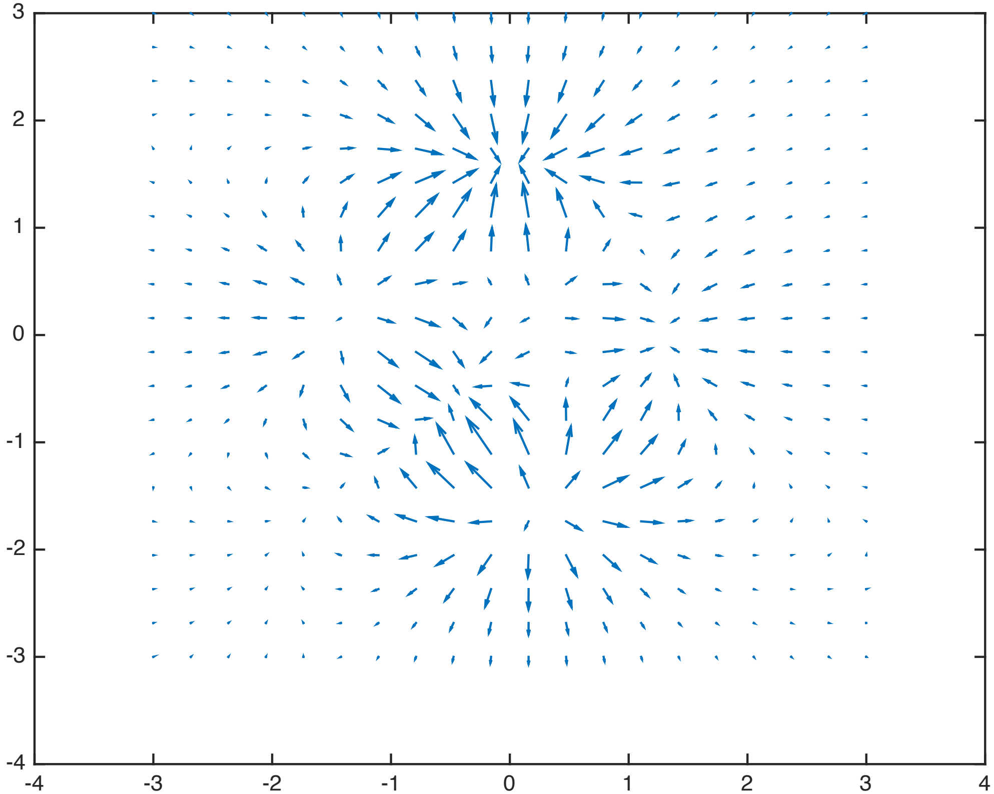
```
t = (1/16:1/8:1)*2*pi;
x = cos(t);
y = sin(t);
c = linspace(0, 1, length(t));
fill3(x, y/sqrt(2), y/sqrt(2), c, x/sqrt(2), y, x/sqrt(2), c);
colorbar;
```



Quiver Plots

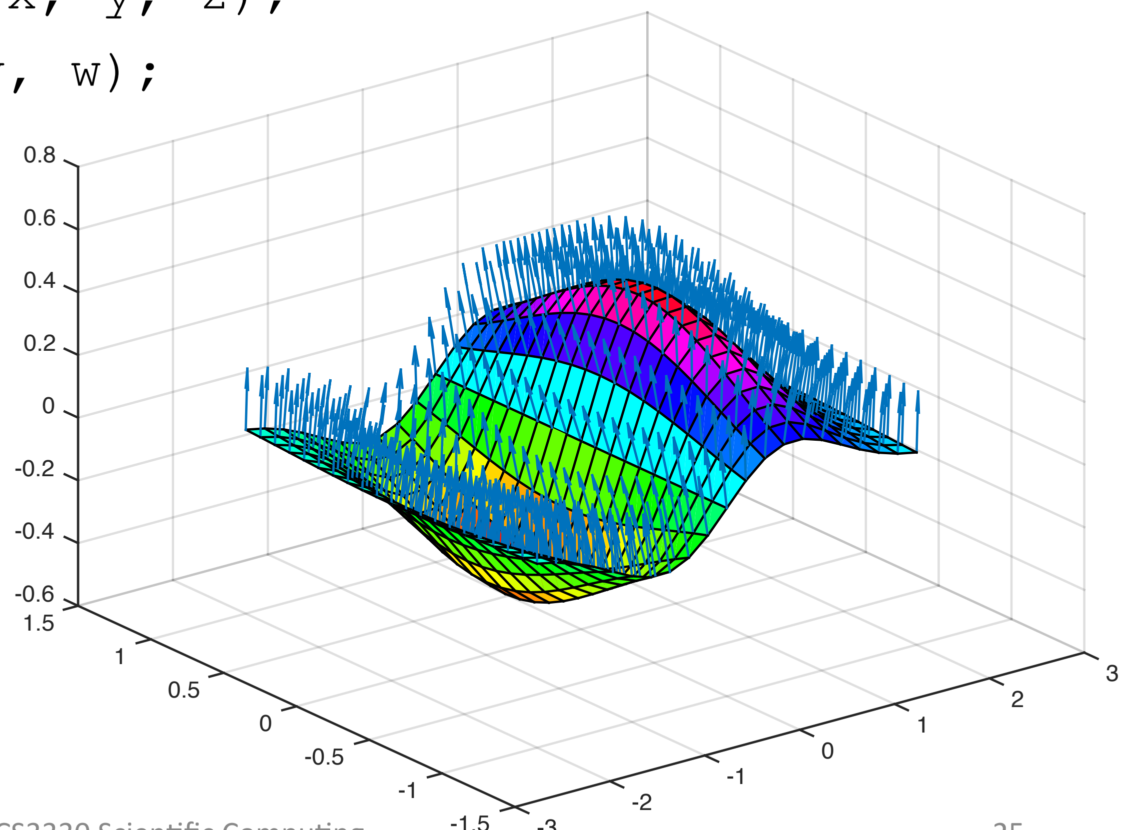
- Suitable for vector fields, such as wind vectors, electric field

```
[x, y, z] = peaks(20);
[u, v] = gradient(z);
quiver(x,y,u,v);
```



Quiver3 Plot

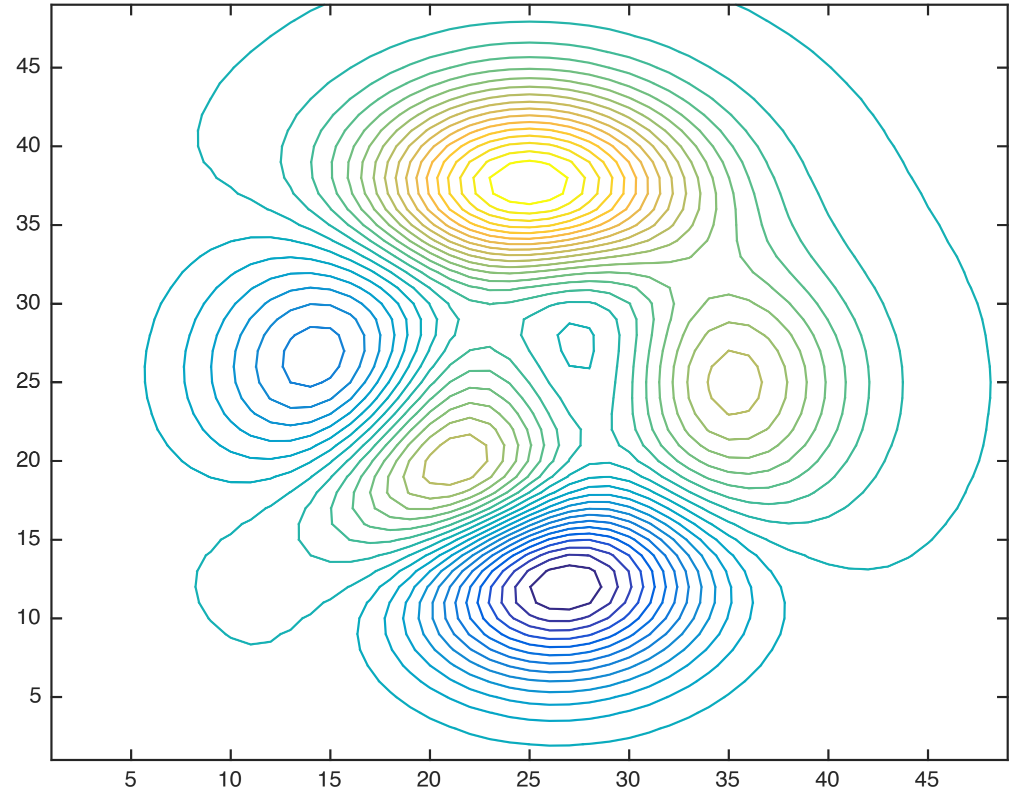
```
[x, y] = meshgrid(-2:0.2:2, -1:0.1:1);
z = x.*exp(-x.^2-y.^2);
[u, v, w] = surfnorm(x, y, z);
quiver3(x, y, z, u, v, w);
hold on;
surf(x, y, z)
```



Contour Plot

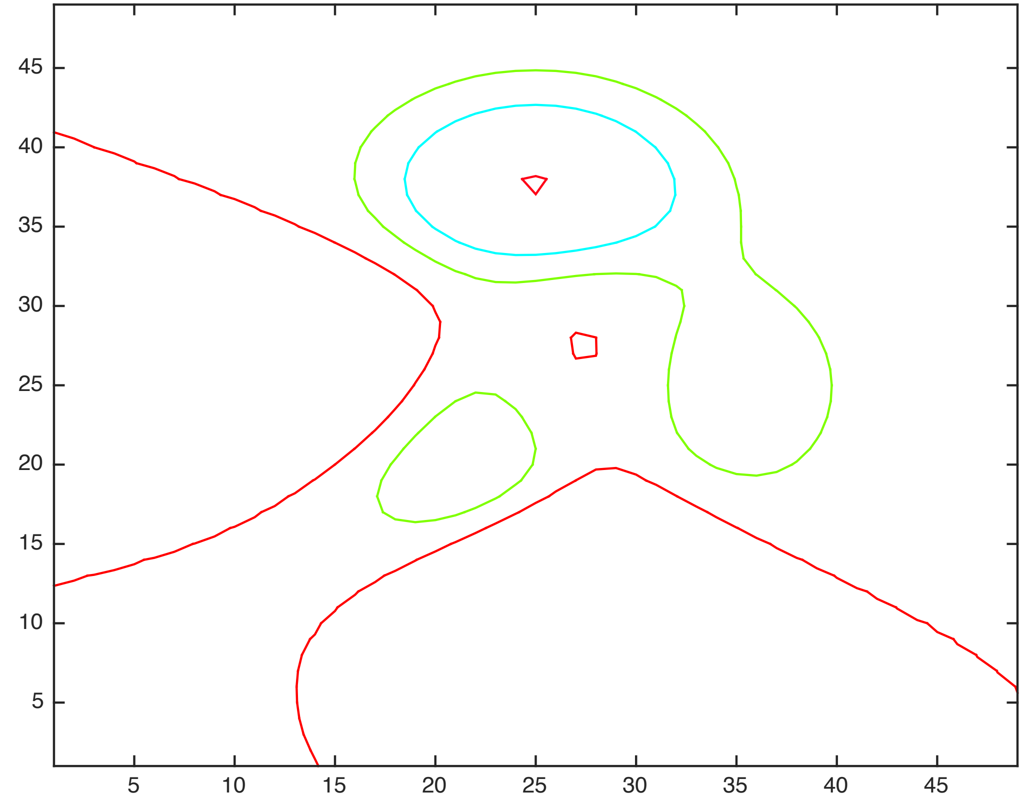
- X and y are column and row indices, and z is the value in the matrix

```
z = peaks;
contour(z, 30);
```



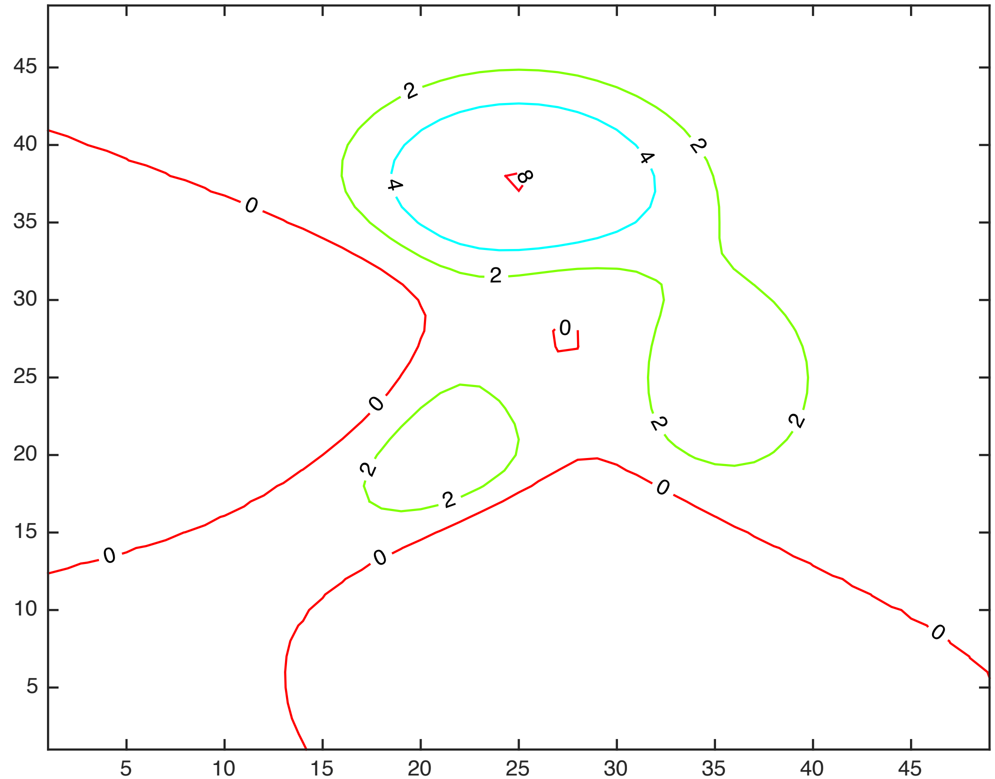
Specify the Levels

```
z = peaks;
contour(z, [0, 2, 4, 8]);
```



Label the Levels

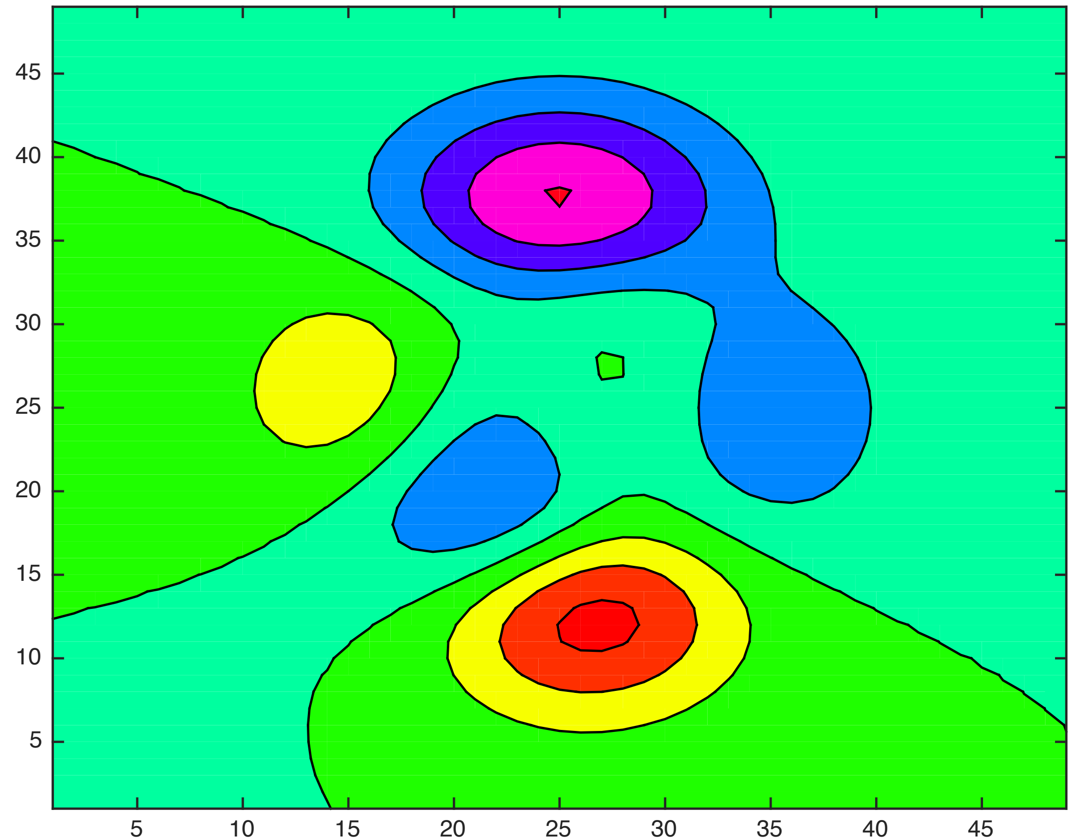
```
z = peaks;
[c,handle] = contour(z, [0, 2, 4, 8]);
clabel(c, handle);
```



Contourf Plot

- Fill in colors among levels

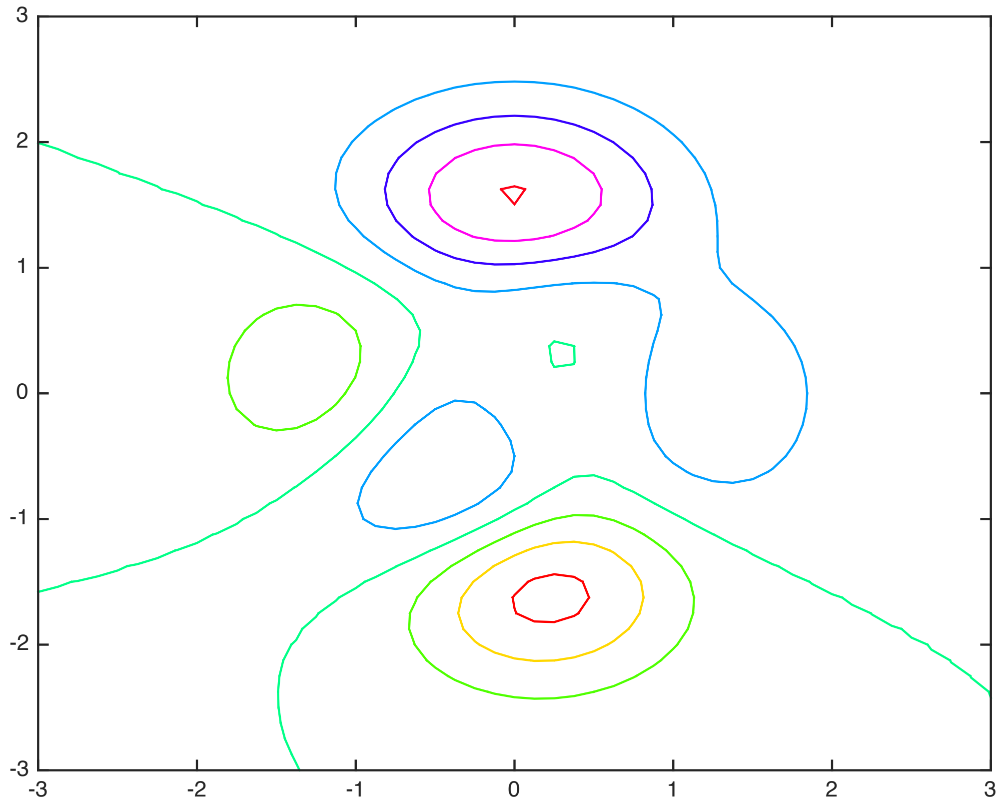
```
z = peaks;
contourf(z);
```



Alternative Way to Plot Contour

- Precisely specify z values

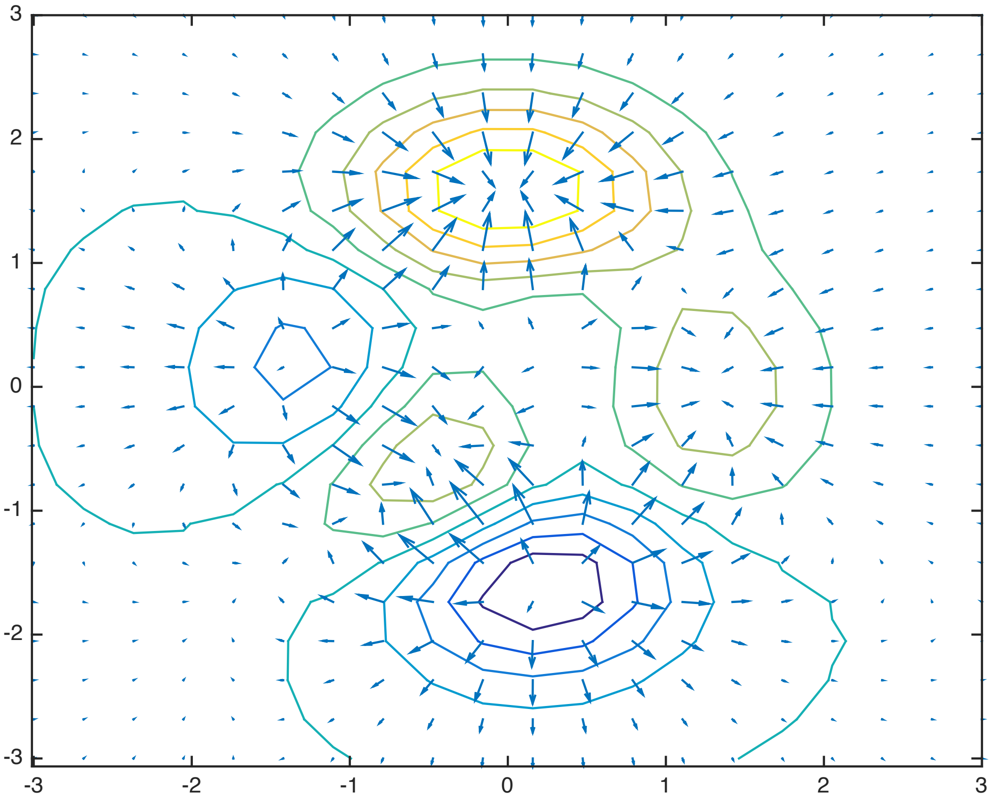
```
[x,y,z] = peaks;
contour(x, y, z);
```



Contour + Quiver

- Contour and gradient vectors are always orthogonal

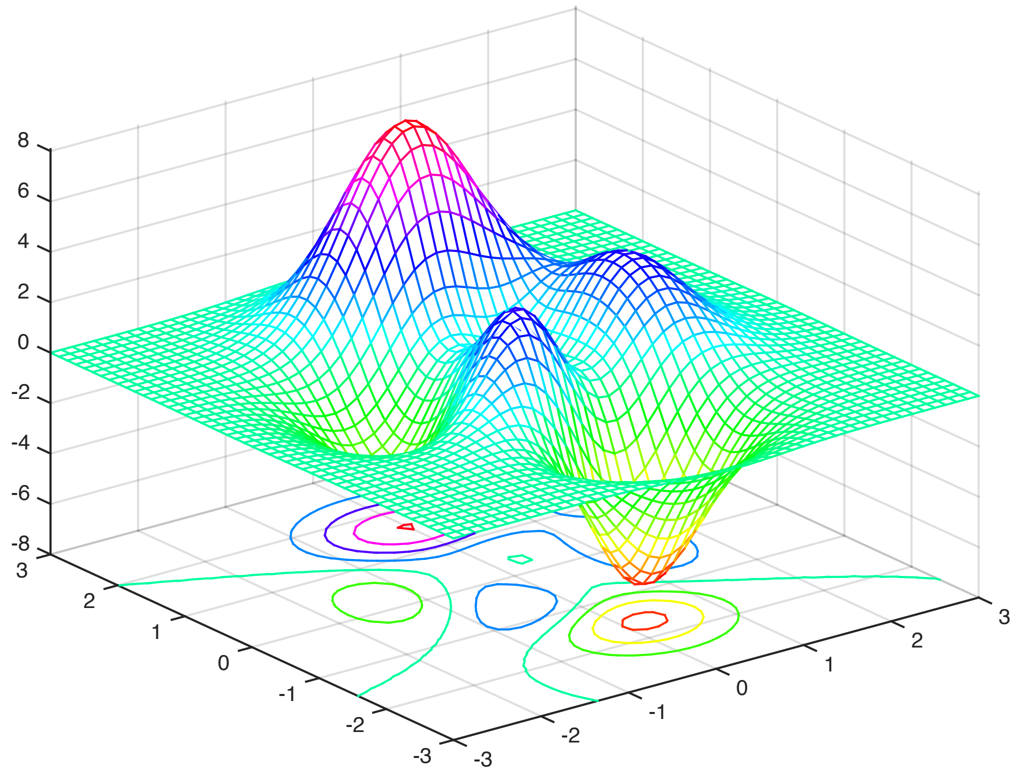
```
[x, y, z] = peaks(20);
[u, v] = gradient(z);
contour(x, y, z, 10);
hold on;
quiver(x,y,u,v);
```



Recap: Surfc and Meshc

- 3D plot with contour

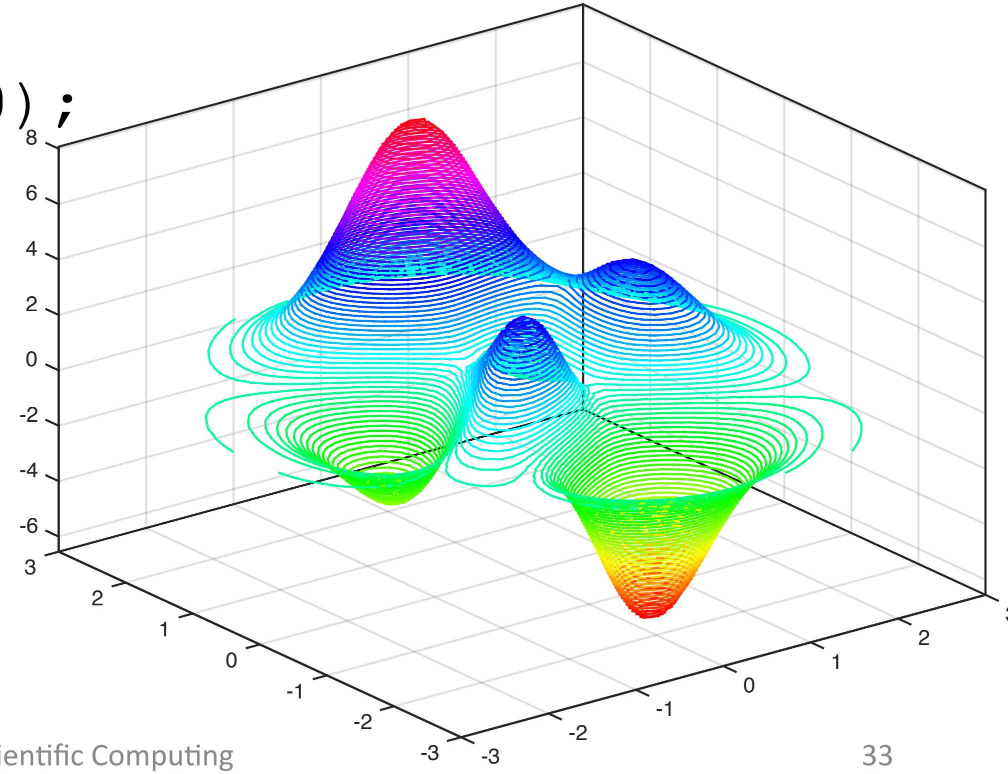
```
[x, y, z] = peaks;
meshc(x, y, z);
```



3D Contour

- What about contour in 3D?

```
[x, y, z] = peaks;
contour3(x, y, z, 100);
```



Contour in Polar Coordinates

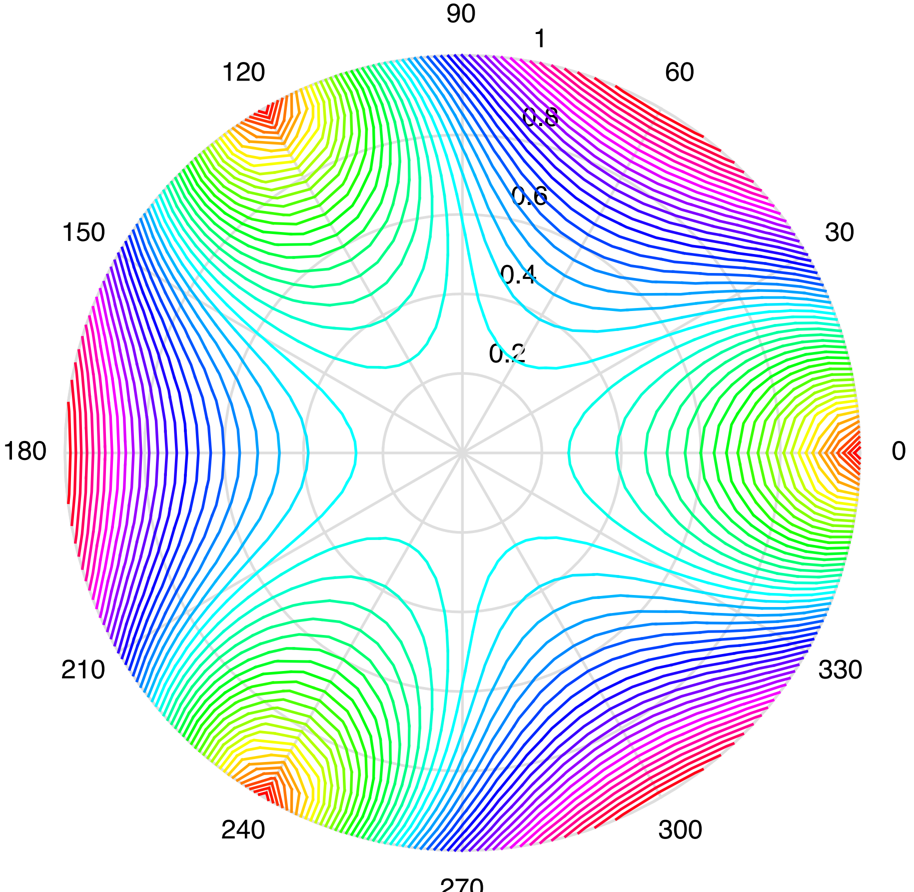
- Have to code it! For example:


```
t = linspace(0, 2*pi, 61);
r = 0:0.05:1;
[tt, rr] = meshgrid(t, r);
[xx, yy] = pol2cart(tt, rr);
zz = xx + sqrt(-1)*yy;
ff = abs(zz.^3-1);
contour(xx, yy, ff, 50);
```

But Where are the Polar Axes

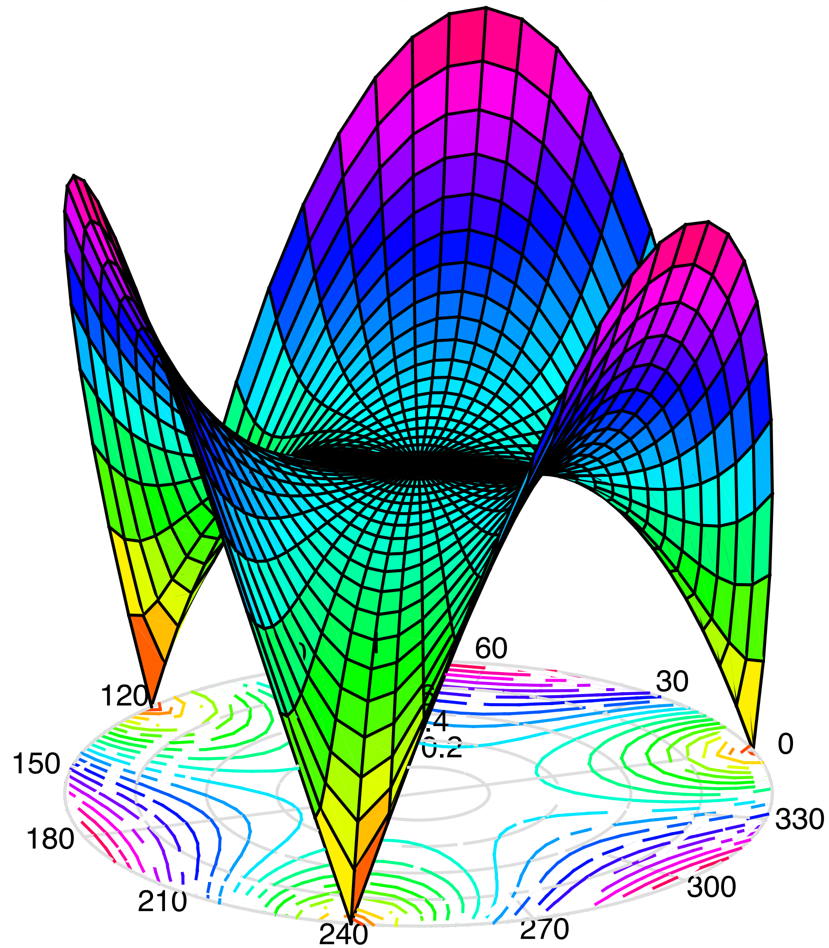
- Need to create them using polar command

```
h = polar([0 0], [0 1]);
delete(h);
hold on
contour(xx, yy, ff, 50);
hold off
```



Putting Everything Together

```
t = linspace(0, 2*pi, 61);
r = 0:0.05:1;
[tt, rr] = meshgrid(t, r);
[xx, yy] = pol2cart(tt, rr);
zz = xx + sqrt(-1)*yy;
ff = abs(zz.^3-1);
h = polar([0 2*pi], [0 1]);
delete(h);
hold on
contour(xx, yy, ff, 20);
surf(xx, yy, ff);
view(-19, 22);
```



Summary: More Plot Commands

- bar, barh, bar3, bar3h
- area
- pie, pie3
- stem, stem3
- stairs
- fill, fill3
- quiver, quiver3
- contour, contourf, contour3

Animations in Matlab

- There are two ways to generate animations (i.e., a sequence of frames essentially)
  - *Movie*: we pre-render multiple frames in memory beforehand, and then display them one after another ← non-realtime, memory hungry
  - *Object*: using graphic handle to manipulate objects ← realtime, but may not work for complicated animation due to computation power

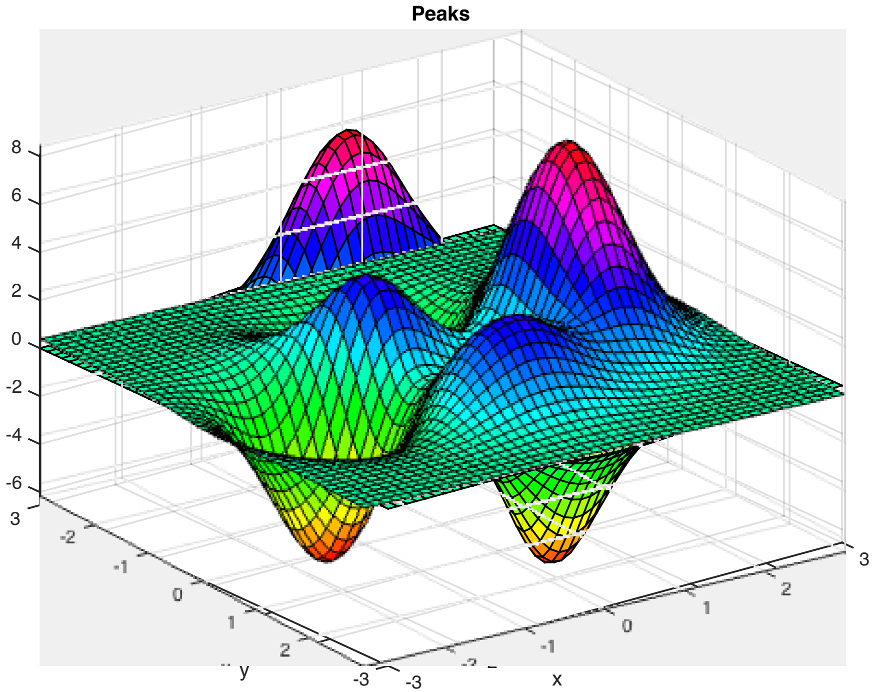
Generate Animation Using Movie

- Pre-rendered animation generation is done in two steps
- First, we plot figures, and use getframe(...) to capture the resulting figure into a struct ← the whole movie is a 1-D vector of structs
- Then, we use movie(...) to play the vector ← the repeat times and speed can be adjusted

Changing the Viewing Angles

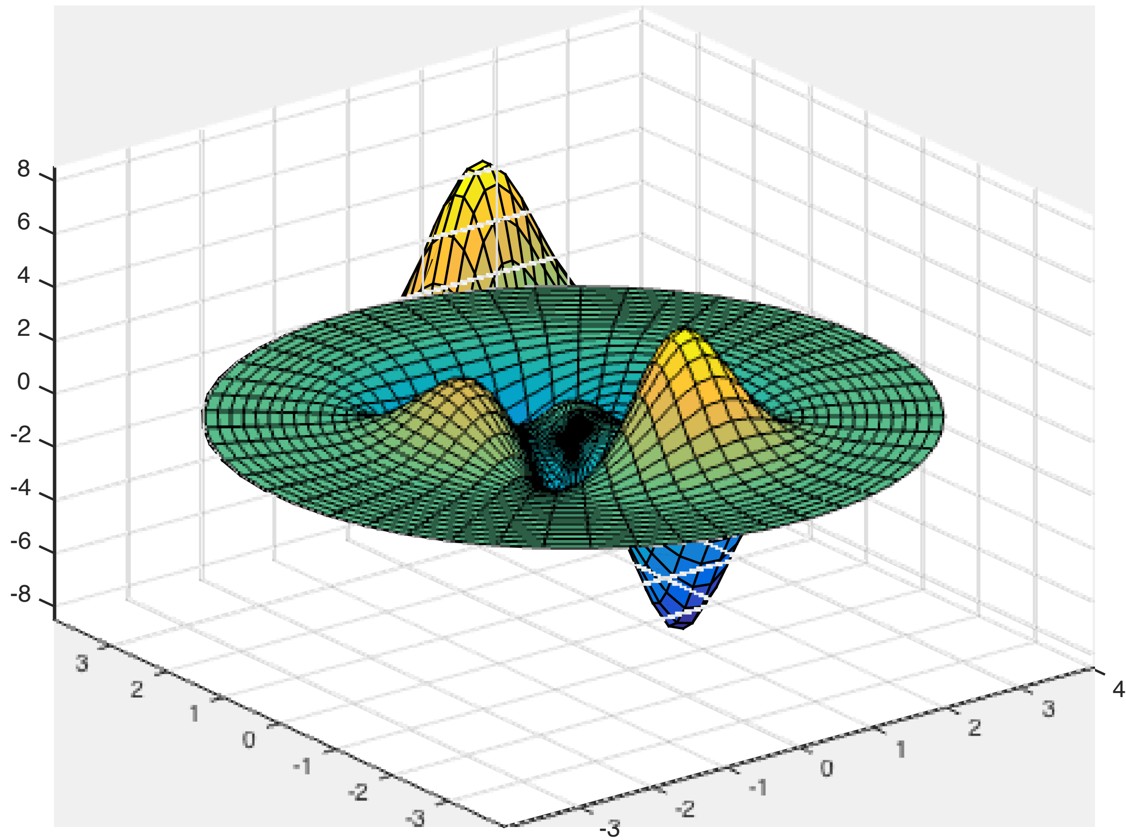
- Try it, and guess what do 3 and 1 do in the movie(...) command

```
n = 50;
colormap hsv;
peaks;
for i = 1:n
    view([-37.5+i*360/n, 30]);
   M(i) = getframe;
end
movie(M, 3, 1);
```



Scaling Z Values

```
clear
r=linspace(0, 4, 30);
t=linspace(0, 2*pi, 50);
[rr, tt]=meshgrid(r, t);
xx=rr.*cos(tt);
yy=rr.*sin(tt);
zz=peaks(xx,yy);
n = 30;
scale = cos(linspace(0, 2*pi, n));
for i = 1:n
        surf(xx, yy, zz*scale(i));
        axis([-inf inf -inf inf -8.5 8.5]);
        M(i) = getframe;
end
movie(M, 5);
```



Load and Display Images

- First save the image: http://s1.dmcdn.net/LVJQN.jpg
- Read the image into matrix X

```
>> X=imread('LVJQN.jpg'); display(size(X));
ans =    1080         1920            3
```

- What type of images it is? RGB…
- Display it using imshow(X) or image(X)

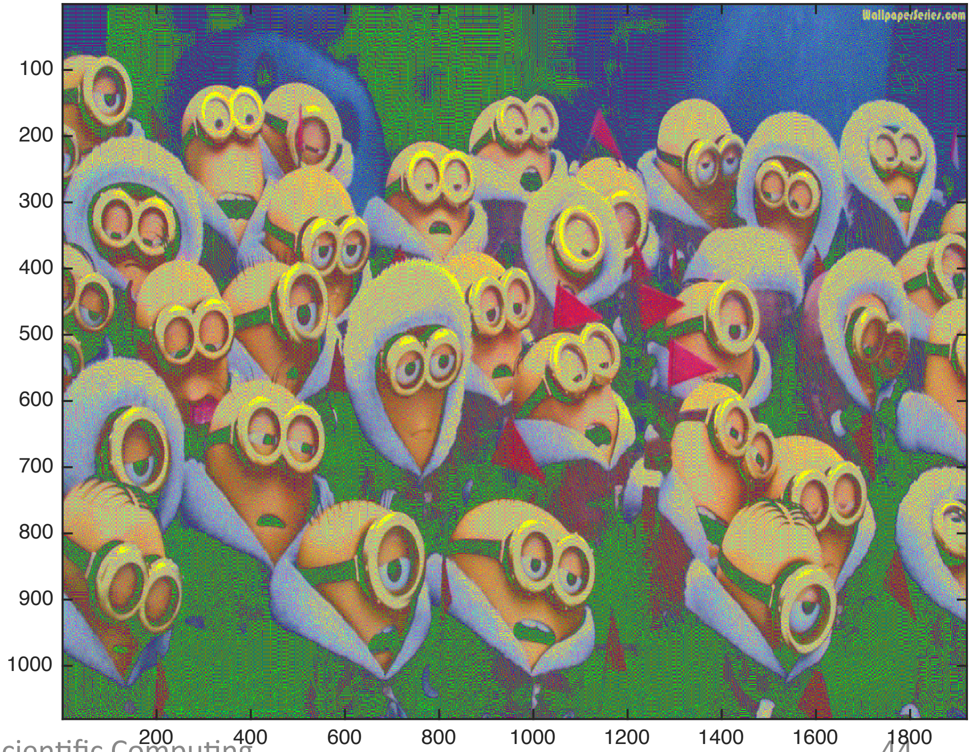
Load and Display Images (cont.)

Convert RGB into Indexed Images

- Try this:

```
colormap hsv;
I = rgb2ind(X, colormap);
image(I);
```

- Doesn't look good, Why?
- Have to find the best colormap!



Quantize the RGB Images

- Quantization is a process to convert continuous values into discrete ones (finite choices)

```
[I,map] = rgb2ind(X,64);
figure;
image(I);
colormap(map);
```

Changing Coloarmap

- Between positive and negative films

```
clear M
image(I);
colormap(map);
n = 30;
for i = 1:n
  colormap(((i-1)*(1-map)+(n-i)*map)/n);
  M(i) = getframe;
end
movie(M, -5);
```

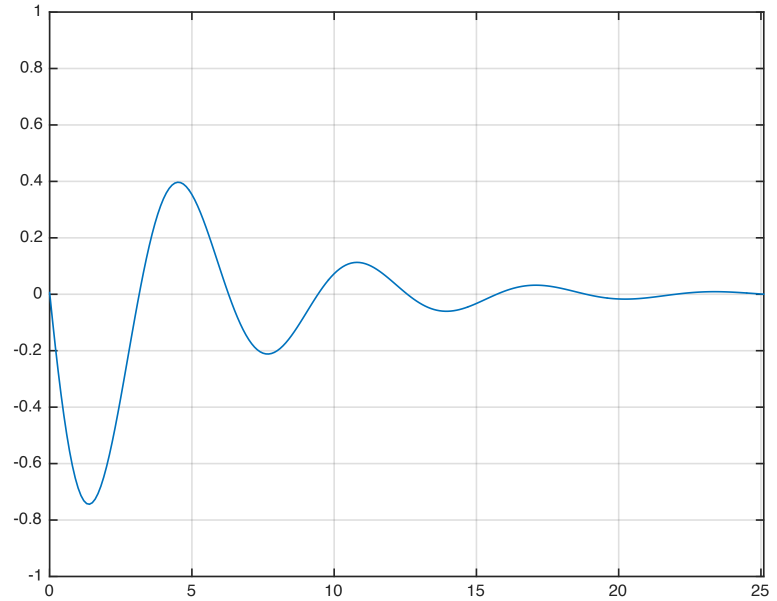
Generate Animation Using Object

- Real-time rendering using object
- Curve is an object, with the following attributes
  - xdata: x values of samples
  - ydata: y values of samples
- Use curve's handle to adjust the value
- Use drawnow command to update the curve

Decaying Sin Wave

- Function: $y = \sin(x-k)e^{-\frac{x}{5}}$

```
x = 0:0.1:8*pi;
h = plot(x, sin(x).*exp(-x/5));
axis([-inf inf -1 1]);
grid on
for i = 1:50000
   y = sin(x-i/50).*exp(-x/5);
   set(h, 'ydata', y);
   drawnow
end
```

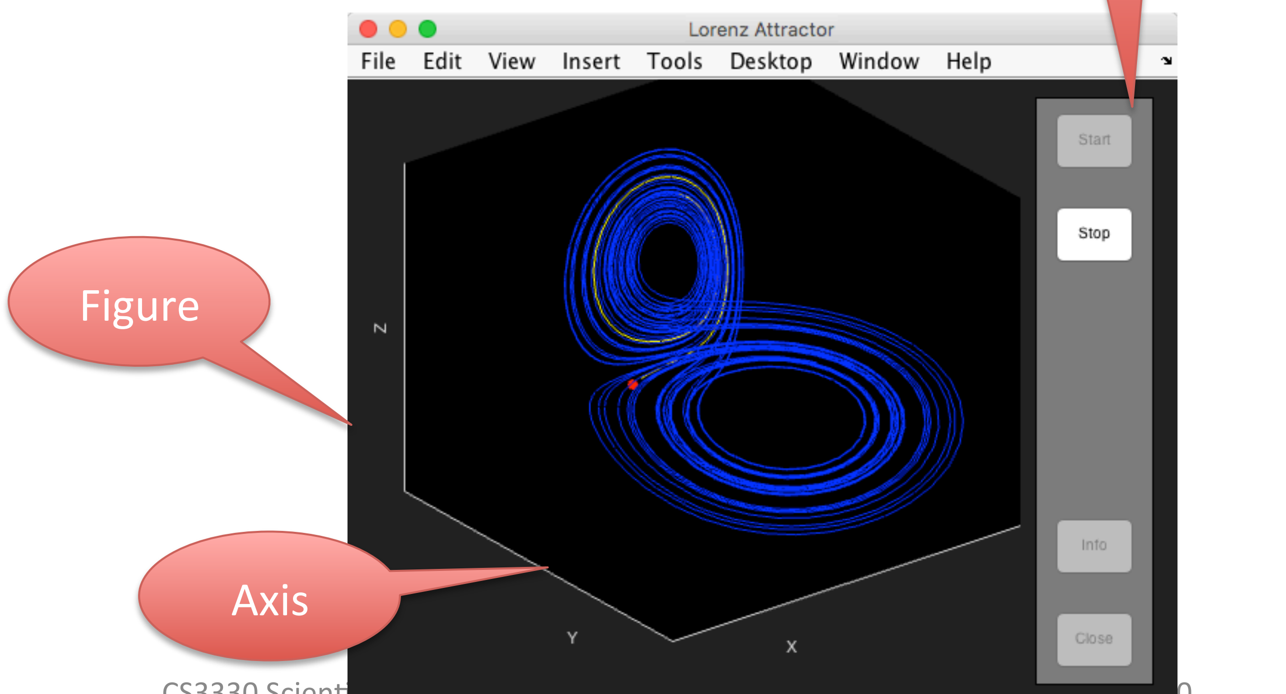


Some Animation Demos in Matlab

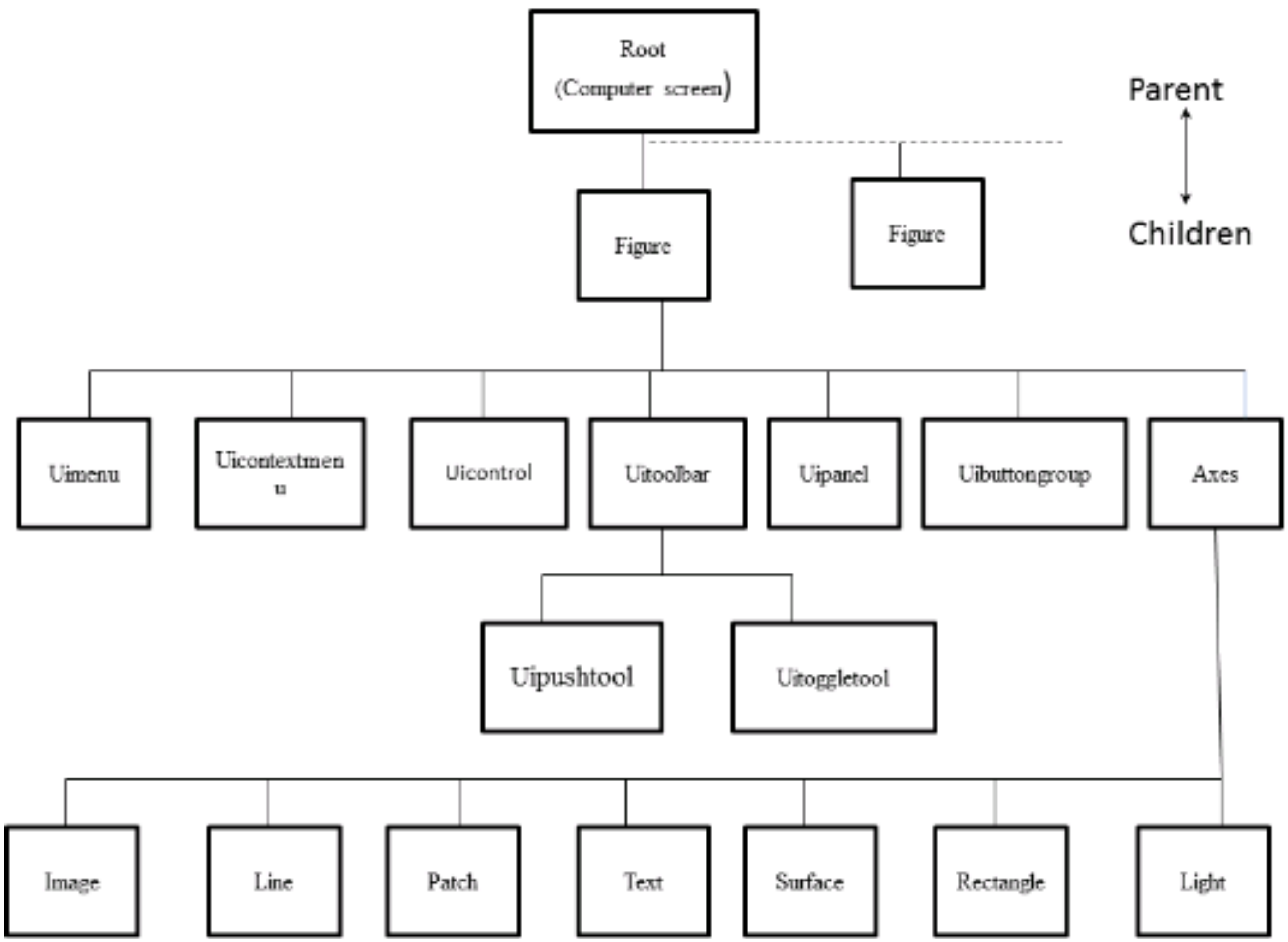
- lorenz: Animated Lorenz chaotic attractor
- truss: bending bridge animation
- travel: solving the traveling salesman problem using a randomized algorithm
- fitdemo: nonlinear curve fitting demo

Handle Graphics

- Each graphic component is an object
- Each object has a handle
- Handles can be used to access the object’ s attributes



Hierarchy of Graphics Components



Two Ways of Access Attributes

- Using GUI
  - View → Property Editor → More Properties
  - Command: propedit
- Using commands
  - set: set the value of an attribute
  - get: get the current value of an attribute
  - findobj: finding the right handle

Recap: Set Attributes

```
t = 0:0.1:4*pi;
y = exp(-t/5).*sin(t);
h = plot(t, y);
set(h, 'Linewidth', 3);
set(h, 'Marker', 'o');
set(h, 'MarkerSize', 20);
```

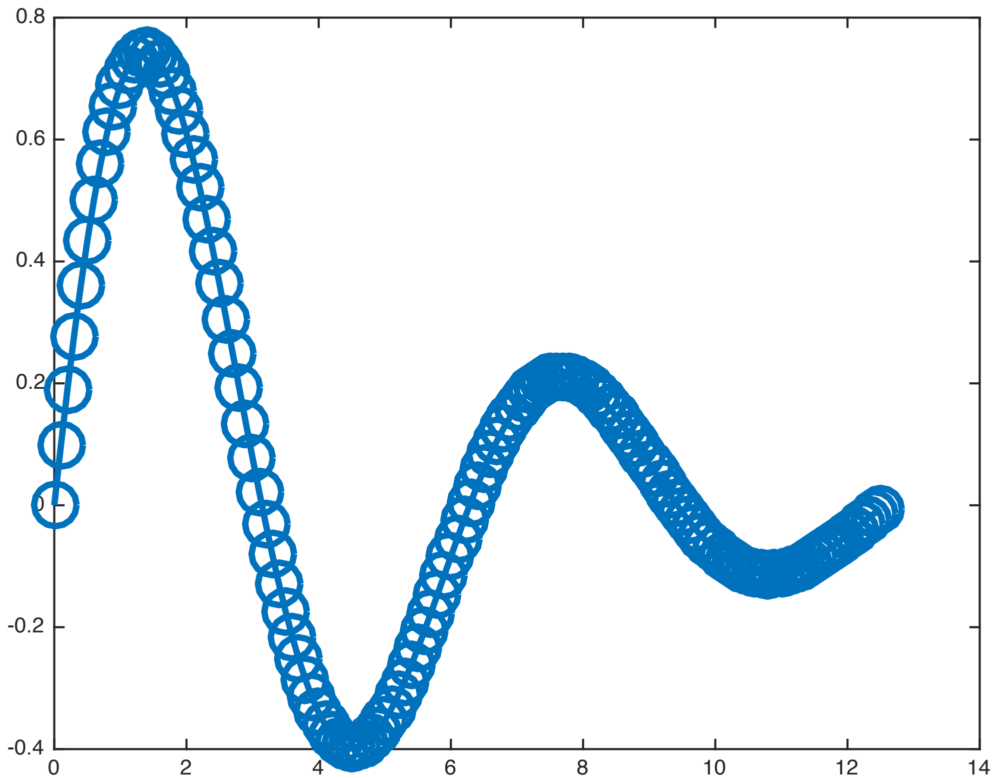


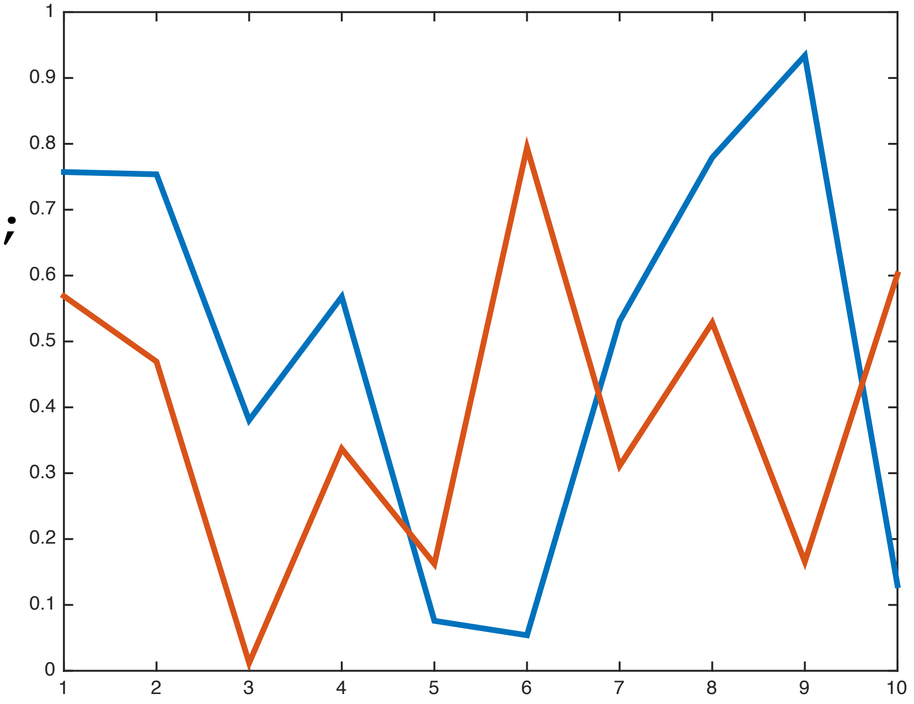
Figure Out All Attributes

```
>> set(h)
   AlignVertexCenters: {'on'  'off'}
           BusyAction: {'queue'  'cancel'}
        ButtonDownFcn: {}
             Children: {}
             Clipping: {'on'  'off'}
                Color: {1x0 cell}
            CreateFcn: {}
            DeleteFcn: {}
          DisplayName: {}
.......
```

How to Use Findobj

- E.g., h=findobj(gcf, 'type', 'line') ← find all the lines in the focused figure

```
plot(rand(10,2));
h=findobj('type', 'line') ;
set(h, 'LineWidth', 3);
```

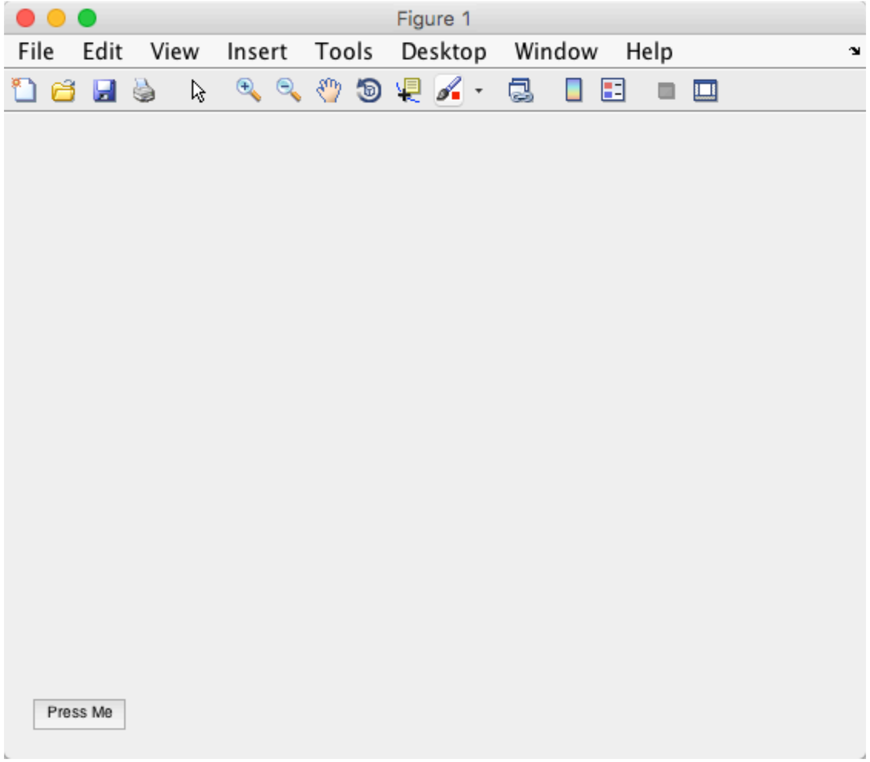


GUI Design

- Similar to what we saw in earlier demos
  - Uicontrol
  - Mouse Events
- Uicontrol creates various UI components
  - Push button, sliding bar, radio button, frame, check box, edit box, list menu, popup menu

Uicontrol Example

```
h = uicontrol;
set(h, 'String', 'Press Me');
cmd = 'fprintf(''Button Pressed!\n''); ';
set(h, 'Callback',cmd);
```

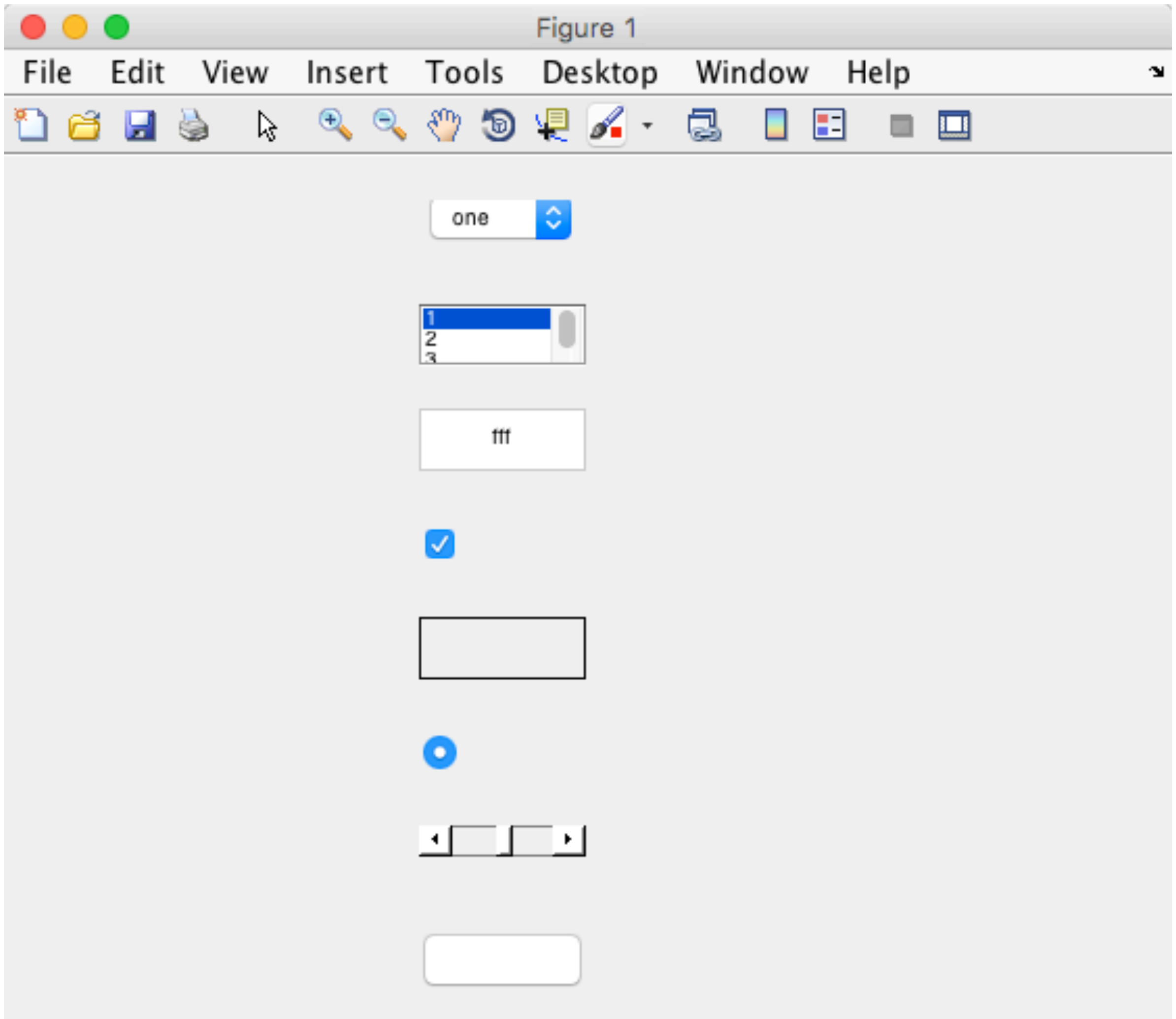


Other Uicontrol Components

- Exercise: Try this in your own Matlab

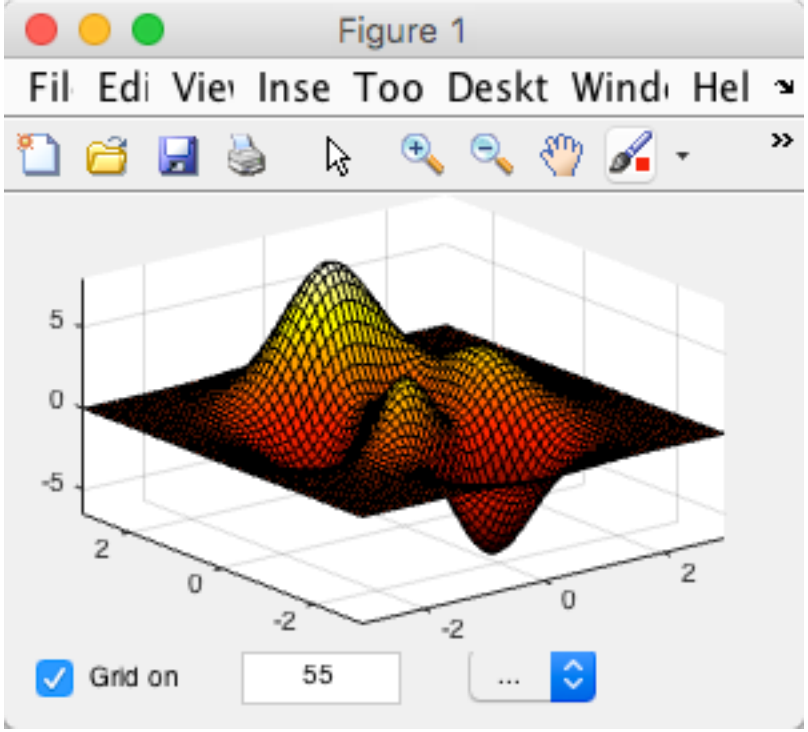
```
uicontrol('style', 'push', 'position', [200  20 80 30]);
uicontrol('style', 'slide', 'position', [200 70 80 30]);
uicontrol('style', 'radio', 'position', [200 120 80 30]);
uicontrol('style', 'frame', 'position', [200 170 80 30]);
uicontrol('style', 'check', 'position', [200 220 80 30]);
uicontrol('style', 'edit', 'position', [200 270 80 30]);
uicontrol('style', 'list', 'position', [200 320 80 30],
'string', '1|2|3|4');
uicontrol('style', 'popup', 'position', [200 370 80 30],
'string', 'one|two|three');
```

Other Uicontrol Components (cont.)



A Complete Example: ui02.m

- Download, execute, and read the code from: http://nmsl.cs.nthu.edu.tw/images/courses/CS3330_2016/ui02.m



Mouse Events

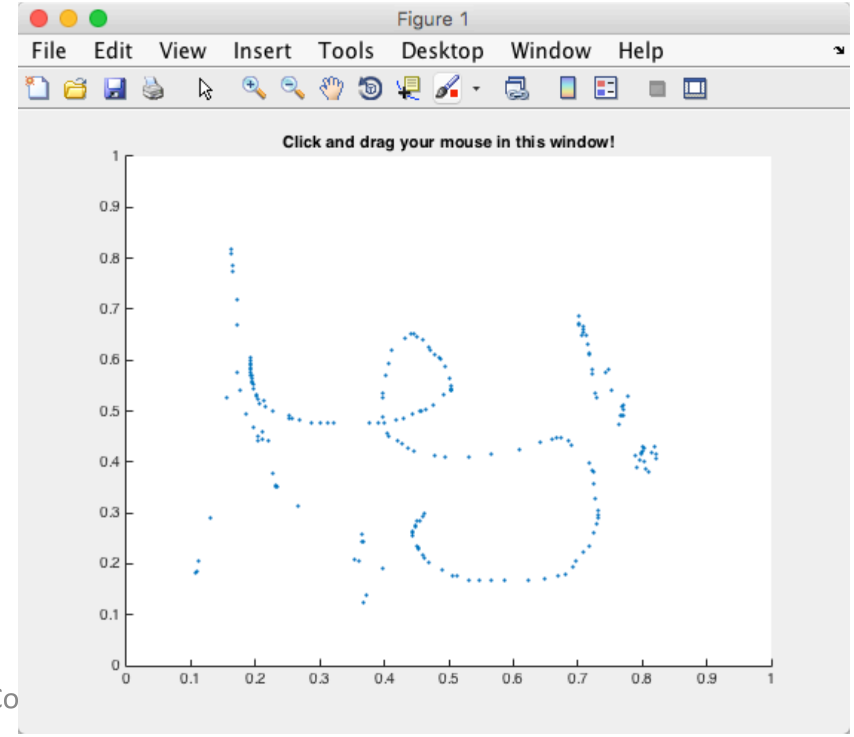
- Main mouse events for callback functions
  - WindowButtonDownFcn: invoked when the button is pressed
  - WindowButtonUpFcn: invoked when the button is released
  - WindowButtonMotionFcn: invoked when the mouse is moving (with and without the button is pressed)

Design of A Drawing Canvas

- High-level idea is
  - When mouse button is pressed: install callback functions for button release and mouse move
  - When mouse button is release: uninstall the two callback functions

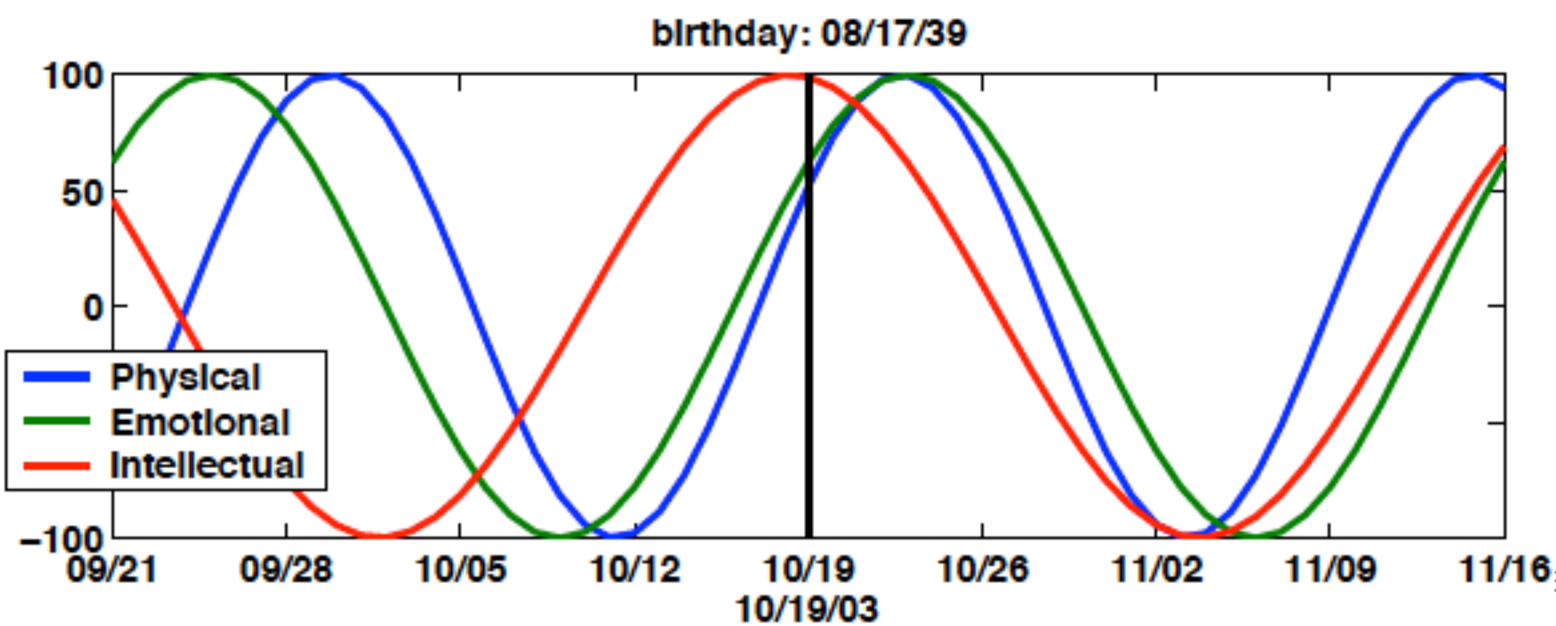
A Complete Example: mouse01.m

- Download, execute, and read the code from: http://nmsl.cs.nthu.edu.tw/images/courses/CS3330_2016/mouse01.m



Matlab #3 Homework (M3)

1. (3%) Biorhythms were very popular in the 1960s. You can still find many Web sites today that offer to prepare personalized biorhythms, or that sell software to compute them. Biorhythms are based on the notion that three sinusoidal cycles influence our lives. The physical cycle has a period of 23 days, the emotional cycle has a period of 28 days, and the intellectual cycle has a period of 33 days. For any individual, the cycles are initialized at birth.



Matlab #3 Homework (M3) cont.

The date and graphics functions in Matlab make the computation and display of biorhythms particularly convenient. The following code segment is part of a program that plots a biorhythm for an eight-week period centered on the current date.

```
t0 = datenum(<yourbirthday>);
t1 = fix(now);
t = (t1-28):1:(t1+28);
y = 100*[sin(2*pi*(t-t0)/23)
sin(2*pi*(t-t0)/28)
sin(2*pi*(t-t0)/33)];
plot(t,y)
```

Matlab #3 Homework (M3) cont.

Answer the following three questions:

1. Complete this program, using your own birthday, and the line , datetick , title , datestr , and legend functions. Your program should produce something like previous figure.
2. All three cycles started at zero when you were born. How long does it take until all three simultaneously return to that initial condition? How old were you, or will you be, on that date? Plot your biorhythm near that date.
3. Is it possible for all three cycles to reach their maximum or minimum at exactly the same time? If yes, when?