Department of Electrical Engineering, Technion – IIT
Signal and Image Processing Laboratory

Advanced MATLAB®

Graphics and GUI

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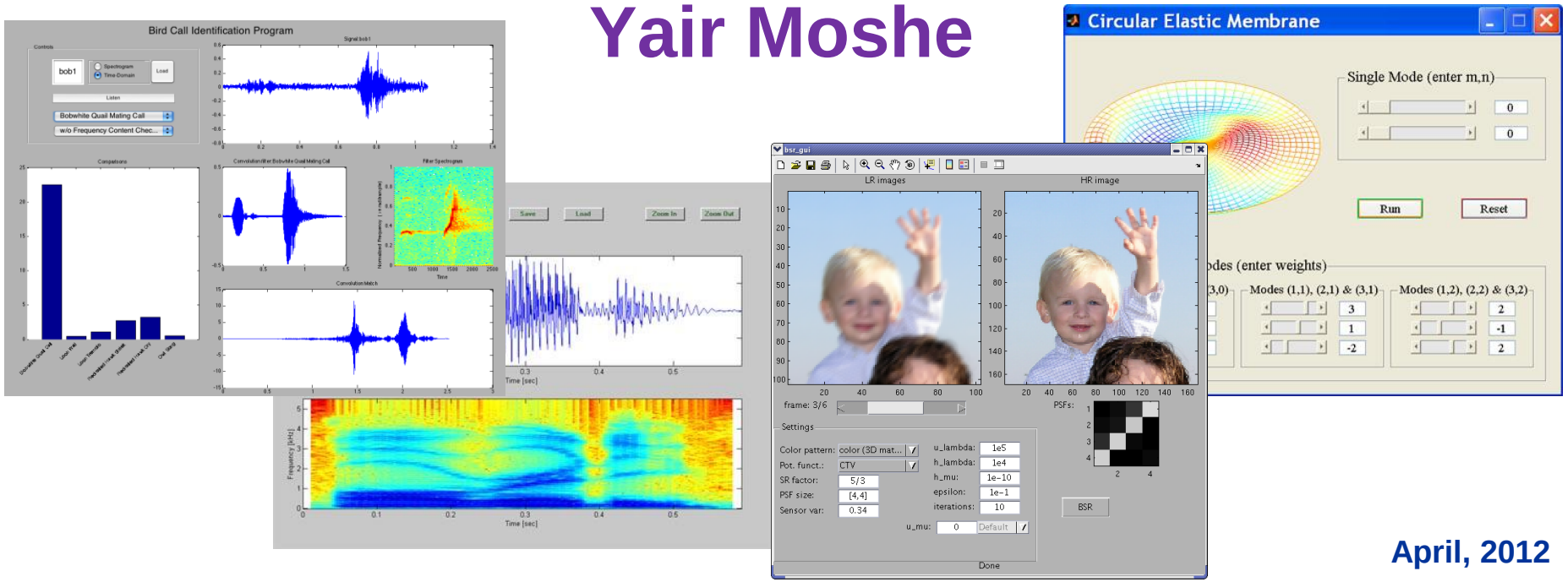


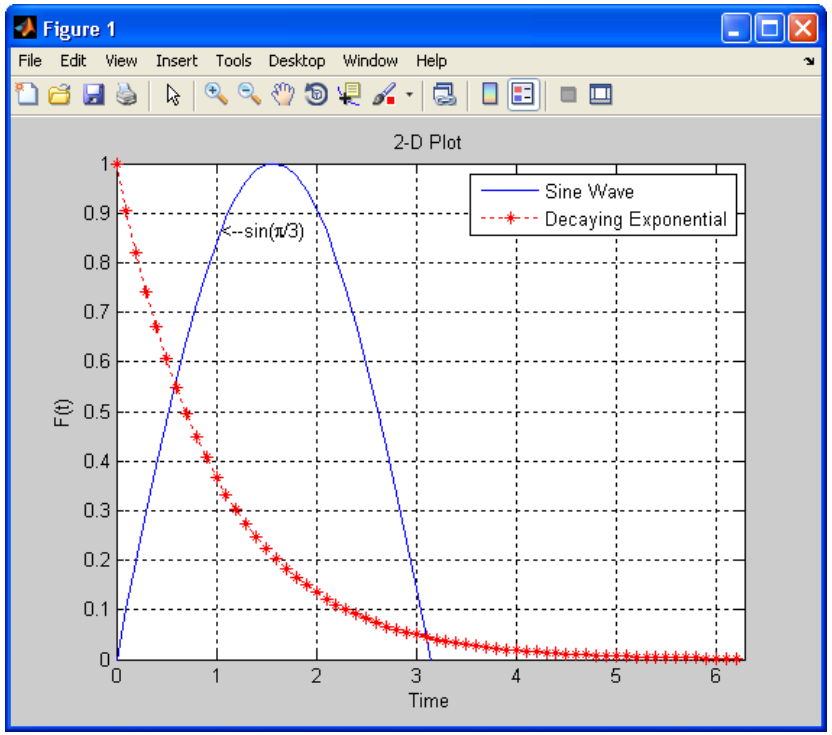
April, 2012

Outline

- **Graphics**
- **Animation**
- **Image and Video**
- **Handle Graphics Objects**
- **Creating GUI using GUIDE**

2-D Plotting

```
x=0:.1:2*pi;
y=sin(x);
plot(x,y)
grid on
hold on
plot(x, exp(-x), 'r:*')
hold off
axis([0 2*pi 0 1])
title('2-D Plot')
xlabel('Time')
ylabel('F(t)')
text(pi/3, sin(pi/3), '<--sin(\pi/3) ')
legend('Sine Wave',
       'Decaying Exponential')
```



Line Specification

Specifier	Line Color	Specifier	Marker
r	**red**	**.**	**point**
g	**green**	**o**	**circle**
b	**blue**	**x**	**cross**
c	**cyan**	**+**	**plus**
m	**magenta**	*****	**asterix**
y	**yellow**	**s**	**square**
k	**black**	**d**	**diamond**
w	**white**	**v**	**triangle down**
Specifier	Line Style	**^**	**triangle up**
-	**solid**	**<**	**triangle left**
--	**dashed**	**>**	**triangle right**
:	**dotted**	**p**	**pentagram**
:.	**dash-dot**	**h**	**hexagram**

The Figure Window

The figure window contains useful actions in its menu and toolbars:

- **Zooming in and out**
- **Panning**
- **Rotating 3-D axes (and other camera actions)**
- **Copying & pasting**
- **Plot Edit Mode**
- **Plot tools (interactive plotting)**
  - Figure Palette
  - Plot Browser
  - Property Inspector
- **Data Cursor Mode**
- **Data brushing and linking**

The Figure Window

- **Generate M-Code to reproduce the figure**
- **Saving & exporting**
  - Figures can be saved in a binary .fig file format
  - Figures can be exported to many standard graphics file formats etc., EPS (recommended),TIFF, JPEG, GIF, PNG, BMP, EMF
- **Printing**

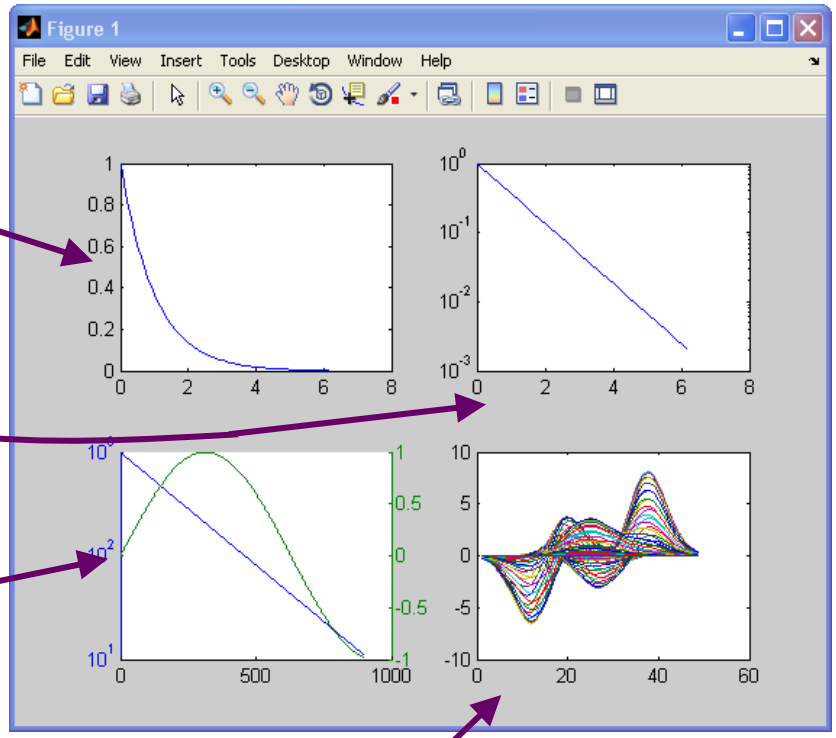
Subplots & Scales for Axes

```
subplot(2,2,1)
x=0:.1:2*pi;
plot(x, exp(-x))

subplot(2,2,2)
semilogy(x, exp(-x))

subplot(2,2,3)
t = 0:900;
z1 = 1000*exp(-0.005*t);
z2 = sin(0.005*t);
plotyy(t,z1,t,z2,'semilogy','plot');

subplot(2,2,4)
plot(peaks)
```



Data Brushing and Linking

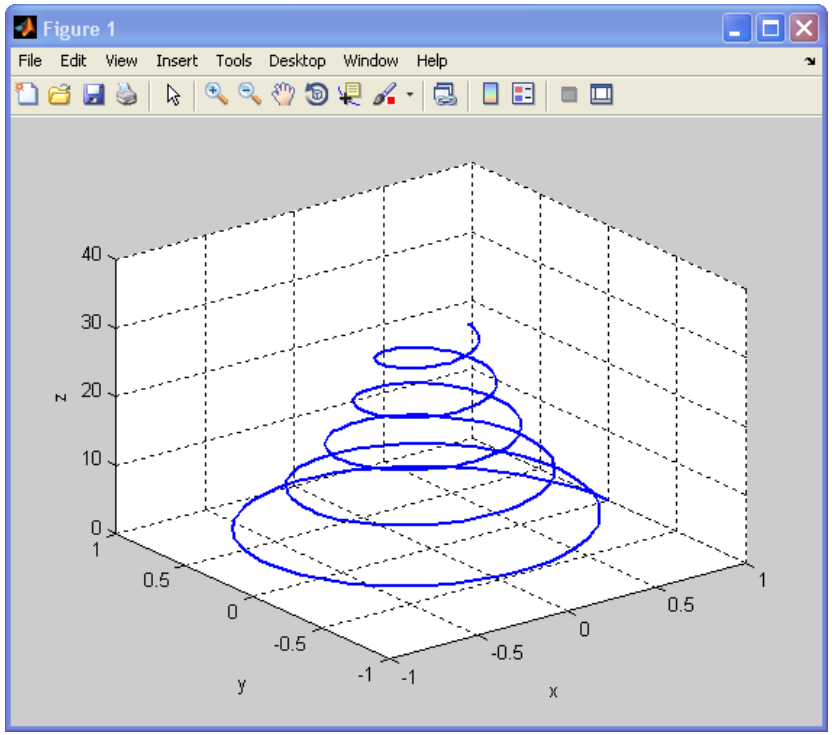
- **Data Brushing**
  - Manually select observations on an interactive data display
  - Can select, remove, and replace individual data values
- **Data Linking**
  - Linked plots visibly respond to changes in the current workspace variables they display and vice versa
- **Each one of these tools is useful by itself but when used together they are very powerful**

Data Statistics & Curve Fitting

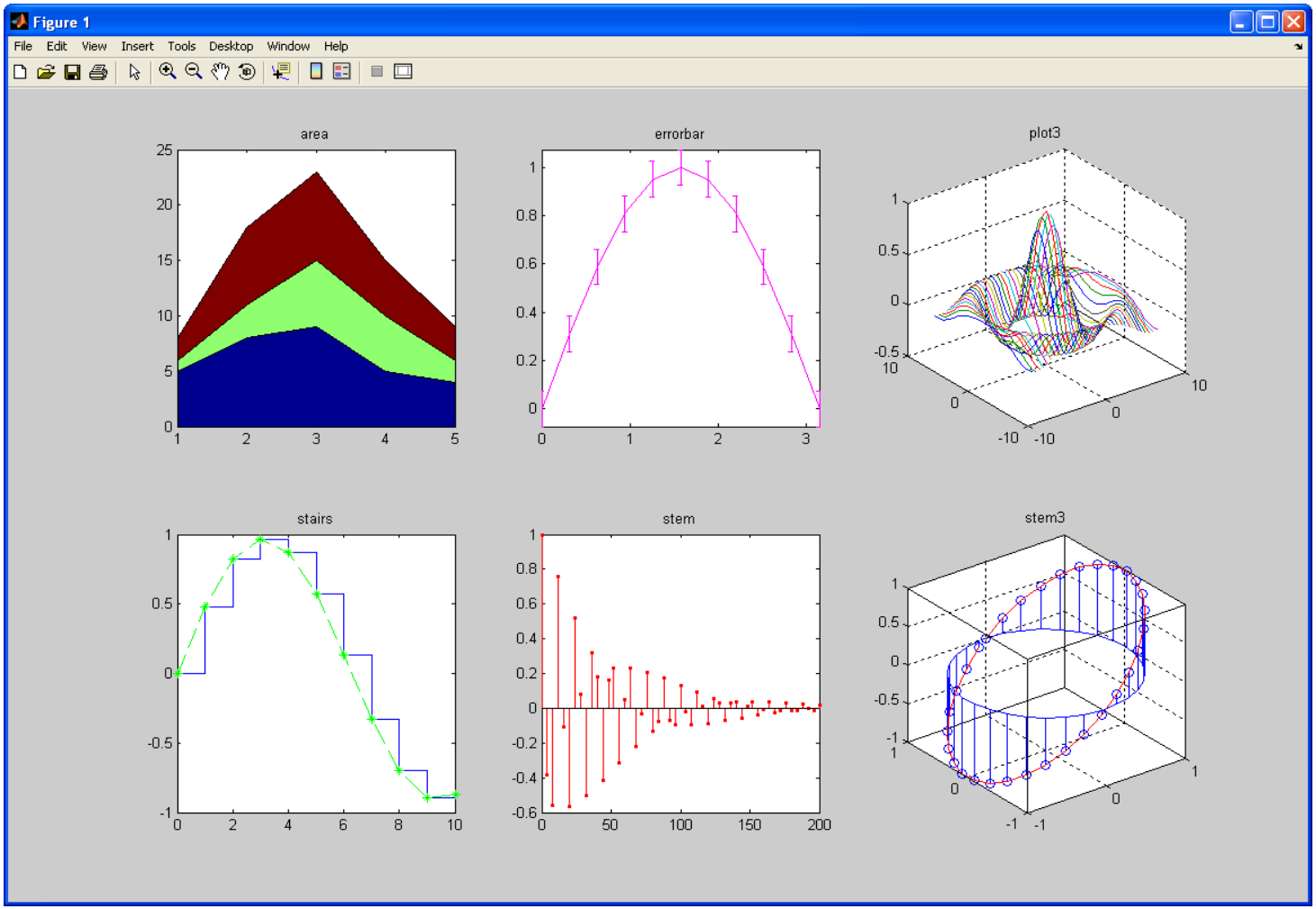
- **Data Statistics Tool**
  - Calculates basic statistics about the central tendency and variability of data plotted in a graph
  - Plots any of the statistics the a graph
- **Basic Fitting Interface**
  - Fits data using a spline interpolant, a shape-preserving interpolant, or a polynomial up to degree 10
  - Plots multiple fits simultaneously for a given data set
  - Examines the numerical results of a fit
  - Annotates the plot with the numerical fit results and the norm of residuals

3-D Plotting

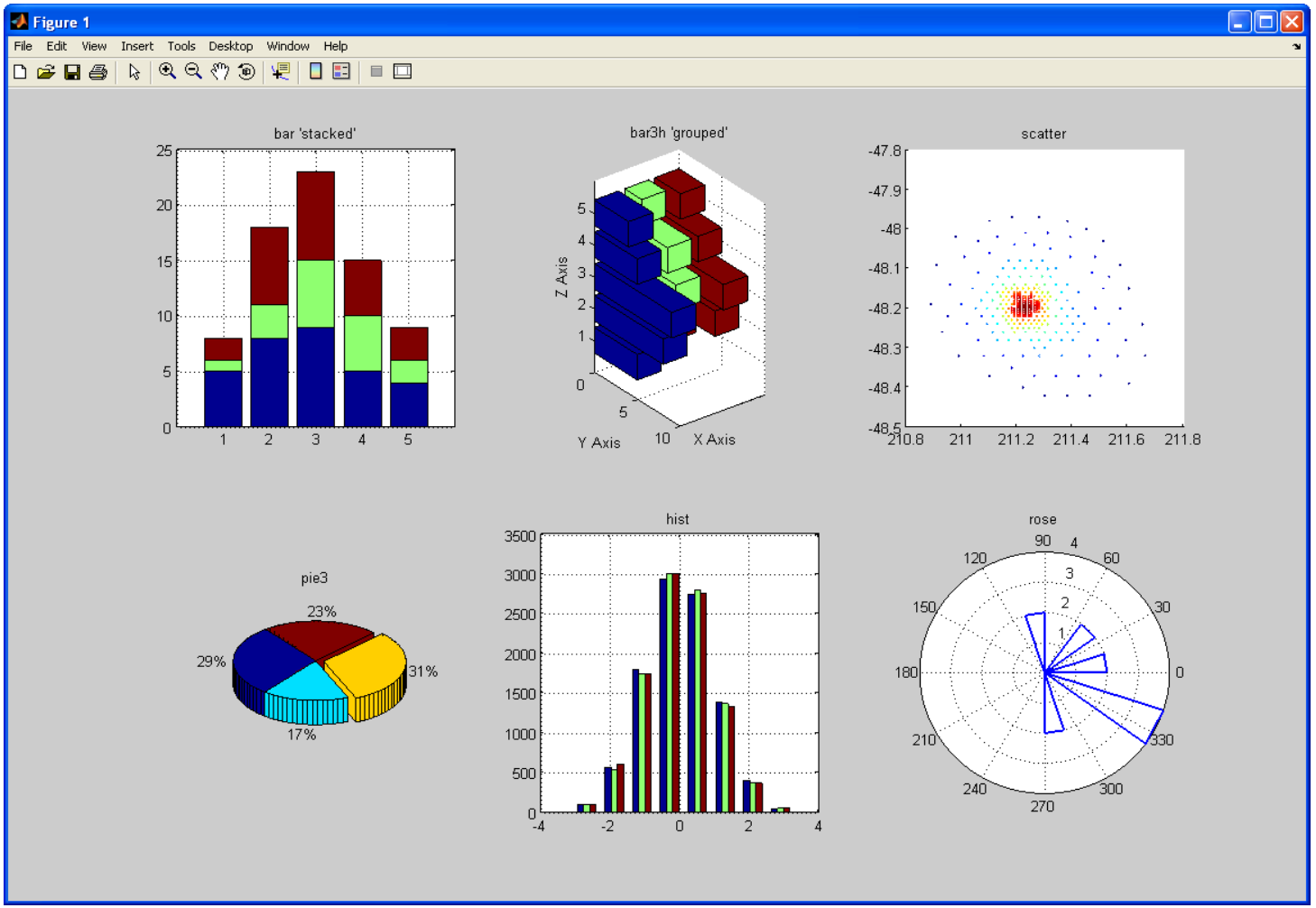
```
z = 0:0.1:10*pi;
x = exp(-z/20).*cos(z);
y = exp(-z/20).*sin(z);
plot3(x,y,z,'LineWidth',2)
grid on
xlabel('x')
ylabel('y')
zlabel('z')
```



Specialized Plotting Routines



3-D Meshes and Surfaces



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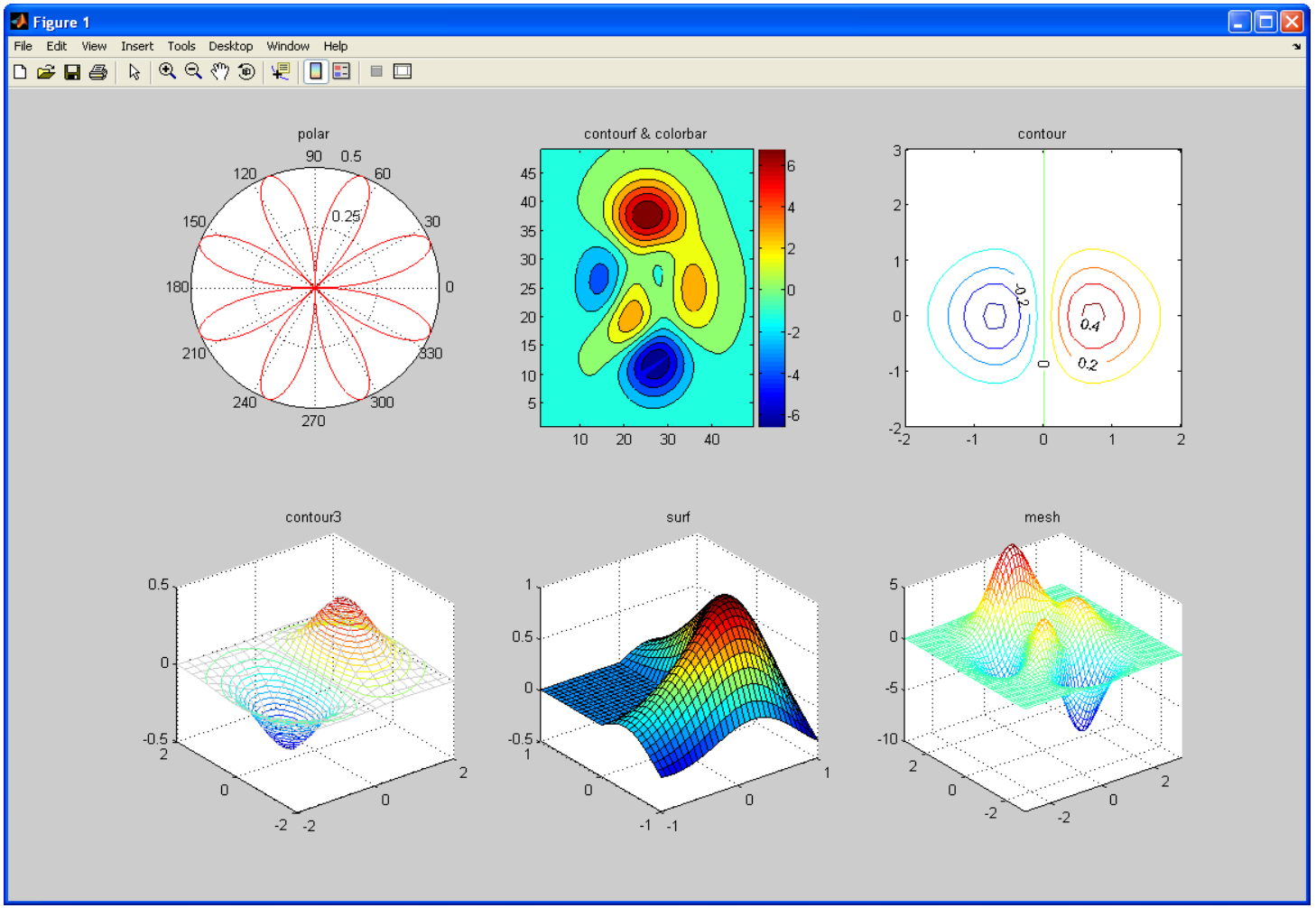
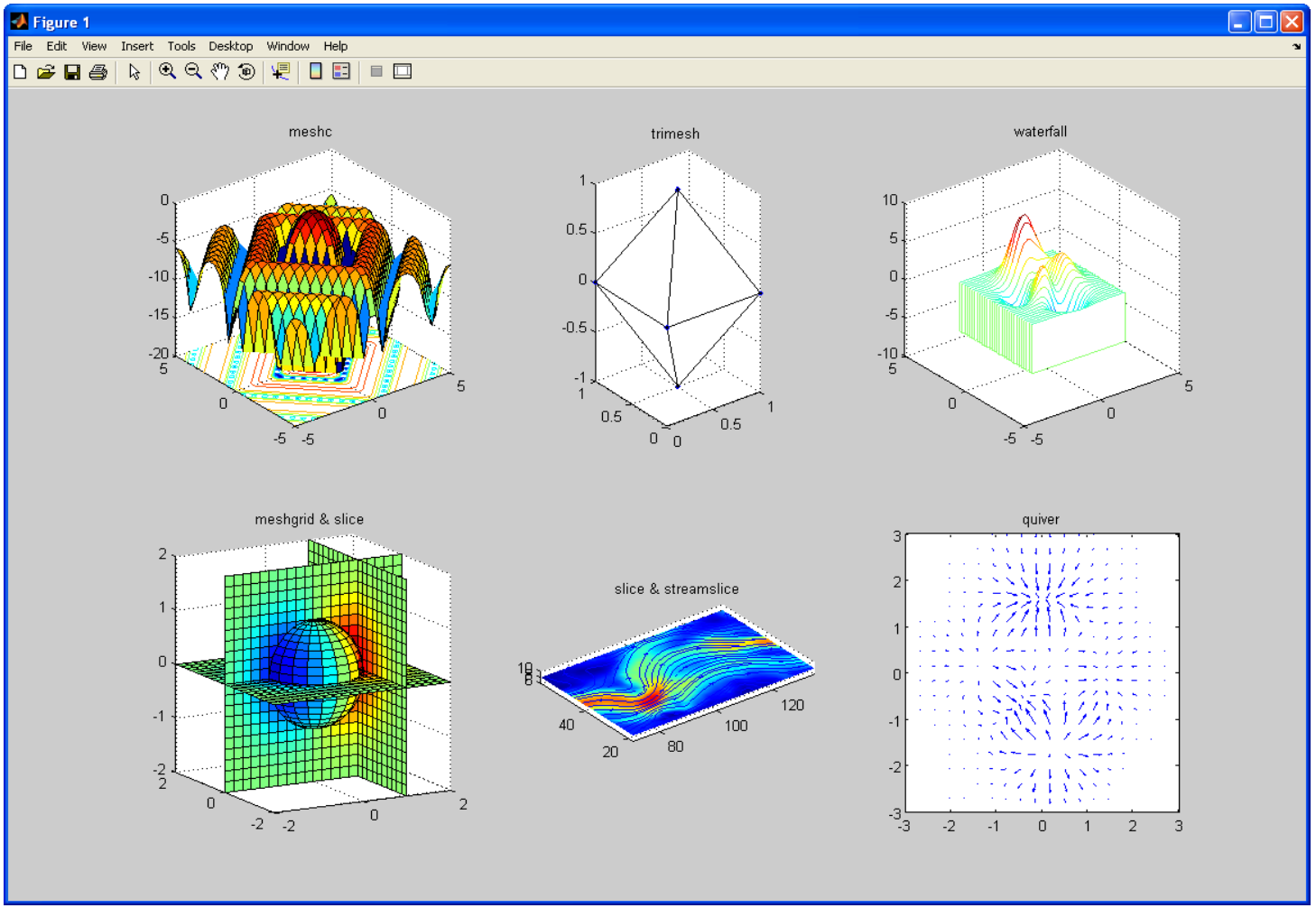


3-D Meshes and Surfaces



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Animation

MATLAB provides two ways of generating moving, animated graphics:

1. **On the fly - Continually erase and then redraw the objects on the screen, making incremental changes with each redraw**
2. **Frame by frame capture and playback - Save a number of different pictures and then play them back as a movie**

On the Fly Animation, 1st example

```
% initialize surface object
x = -pi:0.1:pi;
xsize = size(x,2);

f = zeros(xsize);
for y = 1:xsize
    f(:,y) = cos(y/xsize*pi) + sin(x);
end

% draw surface first time
hSurface = surface(f, 'LineStyle', 'none');
view(3);    % set the default 3D view
```

On the Fly Animation, 1st example

```
% function drawing loop
for j=0:0.01:10

    % update surface function
    for y = 1:xsize
        f(:,y) = cos(y/xsize*pi+j) + sin(x+j);
    end

    % update surface ZData
    set(hSurface, 'ZData', f);

    drawnow;
end
```

On the Fly Animation, 2nd example

```
t = 0:pi/20:2*pi;
y = exp(sin(t));
h = plot(t,y,'YDataSource','y');
for k = 1:.1:10
    y = exp(sin(t.*k));
    refreshdata(h,'caller')       % Evaluate y in the function workspace
    drawnow; pause(.1)
end
```

Frame by Frame Animation

Example of frame by frame movie creation and playing:

```
[x,y] = meshgrid([-10:0.5:10]);
for j = 1:15
    z = besselj(0, (j-1)*0.2 + sqrt(x.^2 +y.^2));
    surf(x,y,z)
    axis([-10 10 -10 10 -.5 1])
    M(j) = getframe;
end

frame_order = [1:15 14:-1:1];
number_repeats = 5;
movie(M, [number_repeats frame_order]);
```

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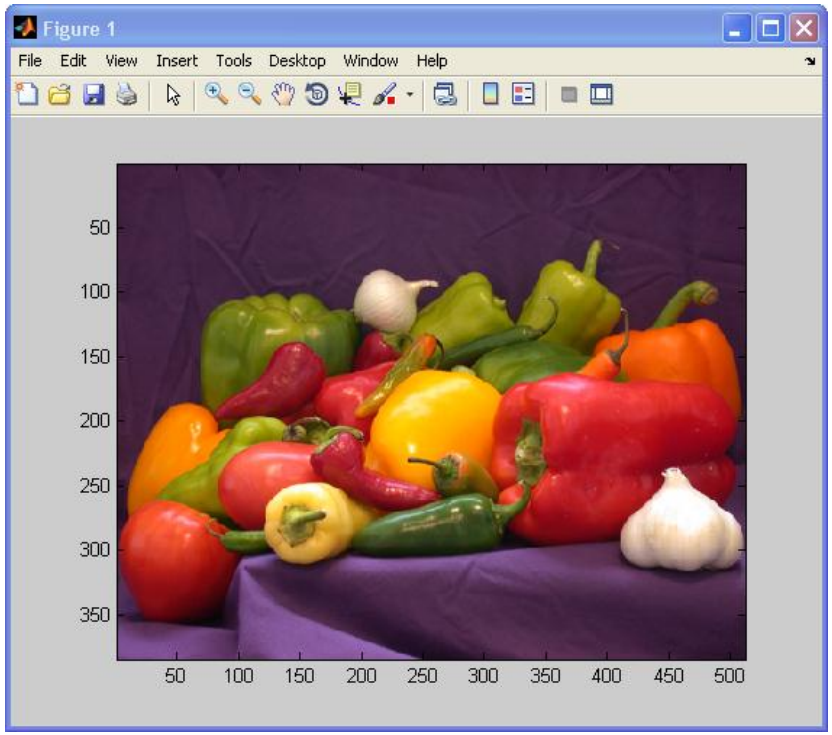
Images

```
[x,map]=...
   imread('peppers.png');
image(x)
colormap(map)
```



- **Image I/O**
  - imread, imwrite, iminfo
- **Image display**
  - image – Display
  - imagesc – Scale and display

Images

- **Image display**
  - imshow – Display
  - subimage – Display multiple images in a single figure even if they have different colormaps
- **Image exploration**
  - imtool – Provides tools for pixel information, pixel region, distance, image information, adjust contrast, crop image, and display range

Video

- **Media Player** (from Simulink)
  - mplay - View video from MATLAB workspace, multimedia file, or Simulink model
- **AVI**
  - aviread, avifile, addframe, close, aviinfo – Allows frame-by-frame manipulation of AVI files, old an not recommended

Video

Since version R2010b, improved in more recent versions

- **Video reader & writer**
  - VideoReader, VideoWriter - Read and write video data from a file
  - Replaces counterpart AVI functions
  - VideoReader replaces mmreader
  - VideoWriter supports 'Motion JPEG AVI‘, ‘Motion JPEG 2000’, 'Uncompressed AVI‘, ‘MPEG-4’ (H.264)

Video I/O example

```
% Open input and output files
inFile = VideoReader('xylophone.mpg');
outFile = VideoWriter('out.avi', 'Motion JPEG AVI');
open(outFile);

% Read one frame at a time
for k = 1 : inFile.NumberOfFrames
    curFrame = read(inFile, k);
    outFrame = curFrame * 2;
    writeVideo(outFile, outFrame);        % Write to output file

    % Show input and output
    …
end

close (outFile);
```

Computer Vision System Toolbox

Example of reading and playing a video:

```
hvfr = vision.VideoFileReader('viplanedeparture.avi');
hp = vision.VideoPlayer;

while ~isDone(hvfr)
    videoFrame = step(hvfr);
    step(hp, videoFrame);
end

release(hp);
release(hvfr);
```

Since version R2010a

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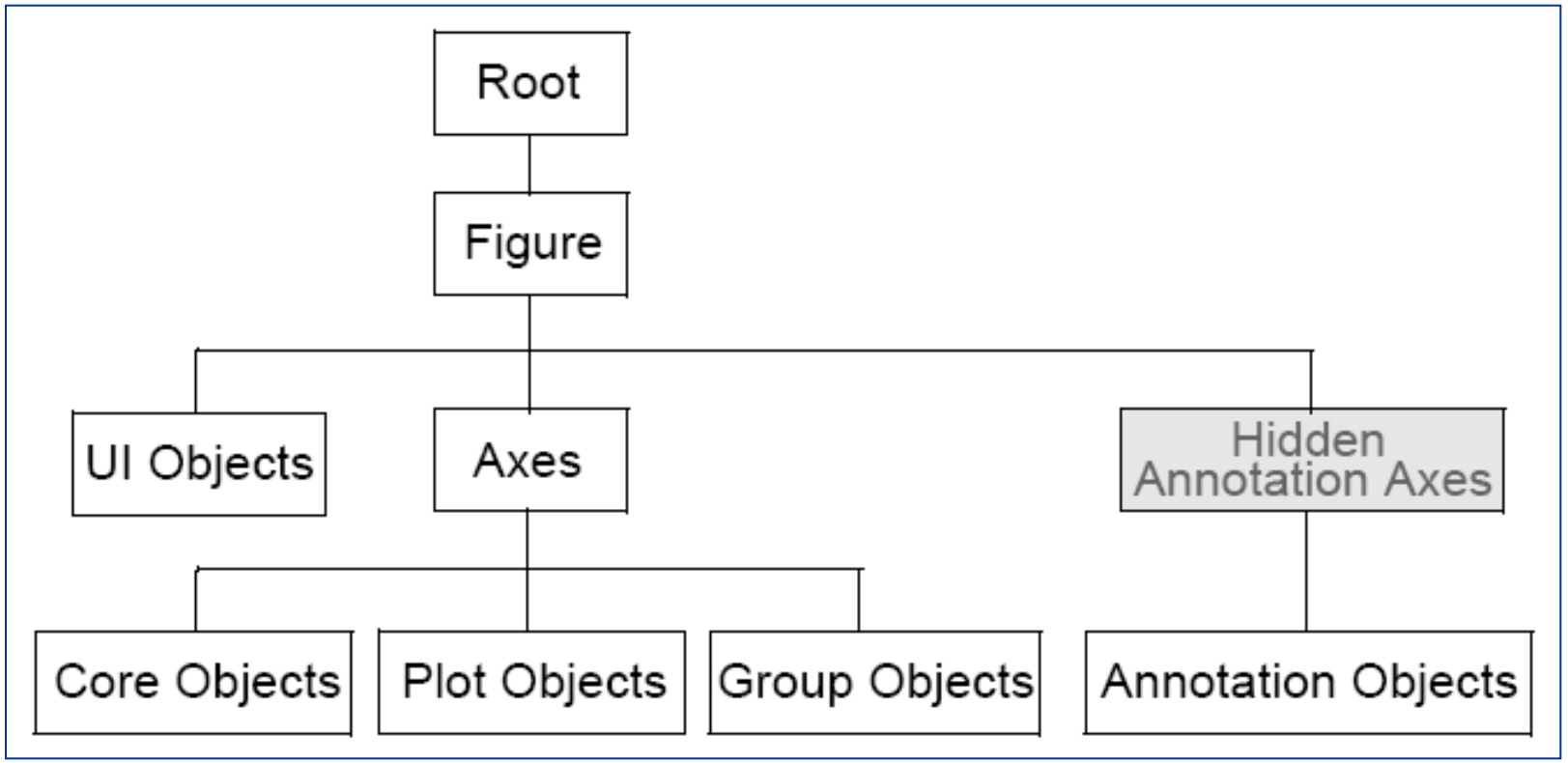
Handle Graphics Objects

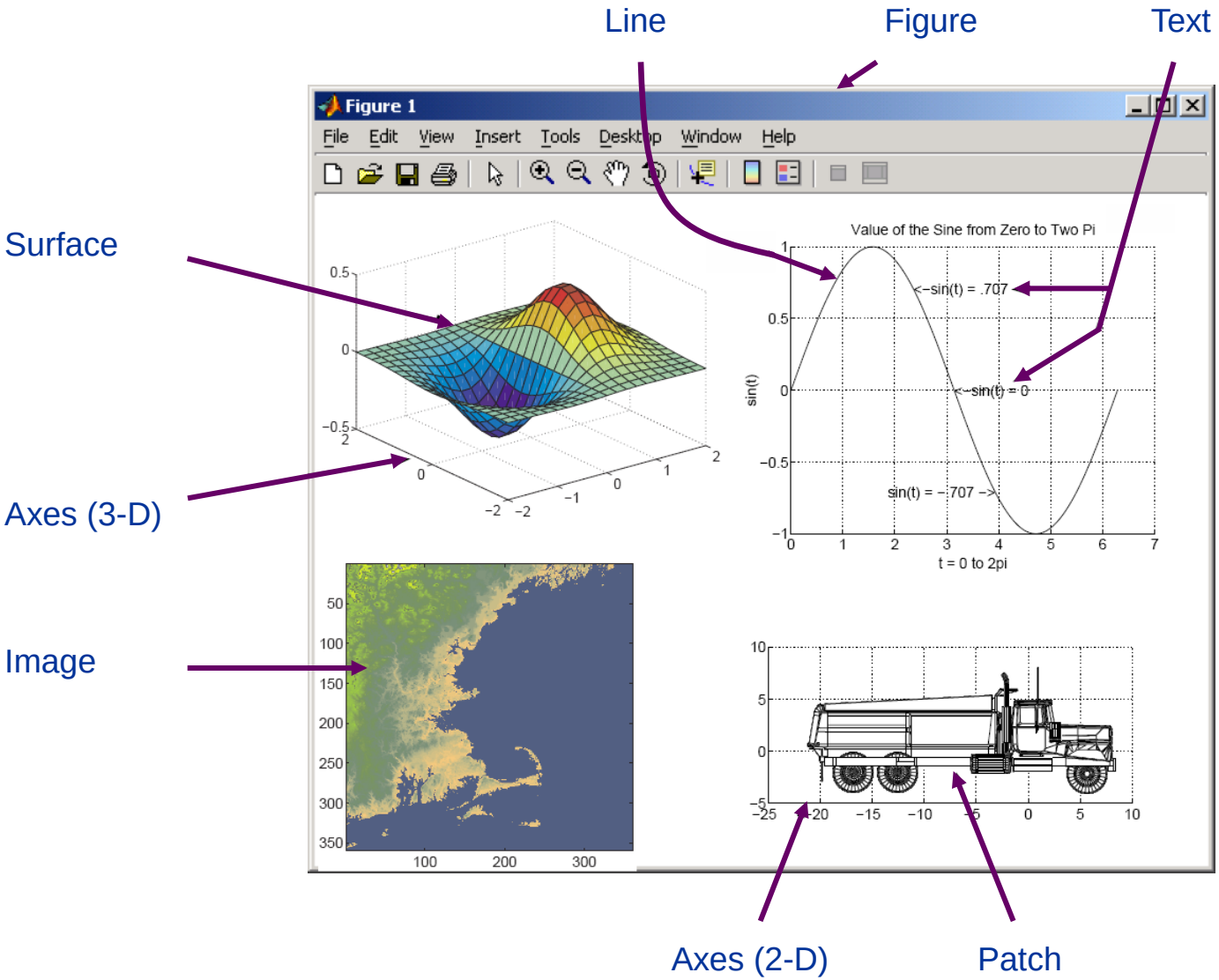
- **Handle Graphics is an object-oriented structure for creating, manipulating and displaying graphics**
- **Graphics objects are the basic drawing elements used in MATLAB**
- **Every graphics object has:**
  - A unique identifier, called a handle
  - A set of characteristics, called properties

Graphics Objects Hierarchy

Objects are organized into a hierarchy:



Core Graphics Objects



Composite Graphics Objects

- **Composite Objects are core objects that have been grouped together to provide a more convenient interface**
- **Plot objects**
  - areaseries, barseries, contourgroup, errorbarseries, lineseries, quivergroup, scattergroup, stairseries, stemseries, surfaceplot
- **Group objects**
  - hggroup – Enables to control visibility or selectability of a group of objects
  - hgtransform – Enables to transform (etc., rotate, translate, scale) a group of objects
- **Annotation objects**
  - Created in a hidden axes that extends the full size of the figure
  - Enables to specify the locations anywhere in the figure using normalized coordinates

Obtaining an Object's Handle

- **Upon creation, for example:**
  - h = plot(x_data, y_data, …)
- **Using utility functions:**
  - 0 - root object handle (the screen)
  - gcf – returns the handle of the current figure
  - gca - returns the handle of the current axis in the current figure
  - gco - returns the handle of the current object in the current figure
  - gcbo - returns the handle of the object whose callback is currently executing
  - gcbf - returns the handle of the figure that contains the object whose callback is currently executing
  - findobj(handles,'PropertyName',PropertyValue) – return objects with specific properties

Setting and Getting Properties

- **Return a list of all object properties and their current values:**
  - get(handle)
- **Return current value of an object property:**
  - get(handle, ‘PropertyName’)
  - Example: get(gcf, 'Color')
- **Return a list of all user-settable object properties and their current values:**
  - set(handle)
- **Return a list of all possible values for an object property:**
  - set(handle,’PropertyName’)
  - Example: set(gca, 'XDir')
- **Set an object property to a new value:**
  - set(handle, ‘PropertyName’, ‘NewPropertyValue’)
  - Example: set(gca, 'XDir', 'Reverse')
- **All the above can also be done (but not at runtime) using the Property Editor**

Example – Specifying Figure Position

```
space = 5;
top_space = 80;
scn_size = get(0,'ScreenSize');

pos1  = [space, 2/3*scn_size(4) + space,...
          scn_size(3)/2 - 2*space, scn_size(4)/3 - (top_space + space)];
pos2 = [pos1(1) + scn_size(3)/2, pos1(2),...
         pos1(3), pos1(4)];

h1 = figure(1);
peaks;
h2 = figure(2);
membrane;

set(h1, 'Position', pos1)
set(h2, 'Position', pos2)
```

Example – Background Image

```
% Create background axes and move them to the background
hback = axes('units','normalized','position',[0 0 1 1]);
uistack(hback,'bottom');

% Load background image and display it
[back map]=imread('sipl.gif');
image(back)
colormap(map)

% Turn the handlevisibility off so that we don't inadvertently plot into
% the axes again. Also, make the axes invisible
set(hback,'handlevisibility','off','visible','off')

% Now we can use the figure as required
axes('position',[0.1,0.1,0.85,0.35])
plot(rand(10))
```

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What is GUIDE?

- **GUIDE is MATLAB's Graphical User Interface (GUI) Development Environment**
- **GUIDE stores GUIs in two files:**
  - .fig file - Contains a complete description of the GUI figure layout and the GUI components
    - Changes to this file are made in the Layout Editor
  - .m file - Contains the code that controls the GUI
    - Initialization code and callbacks
    - You can program the behavior of the GUI in this file using the M-file Editor

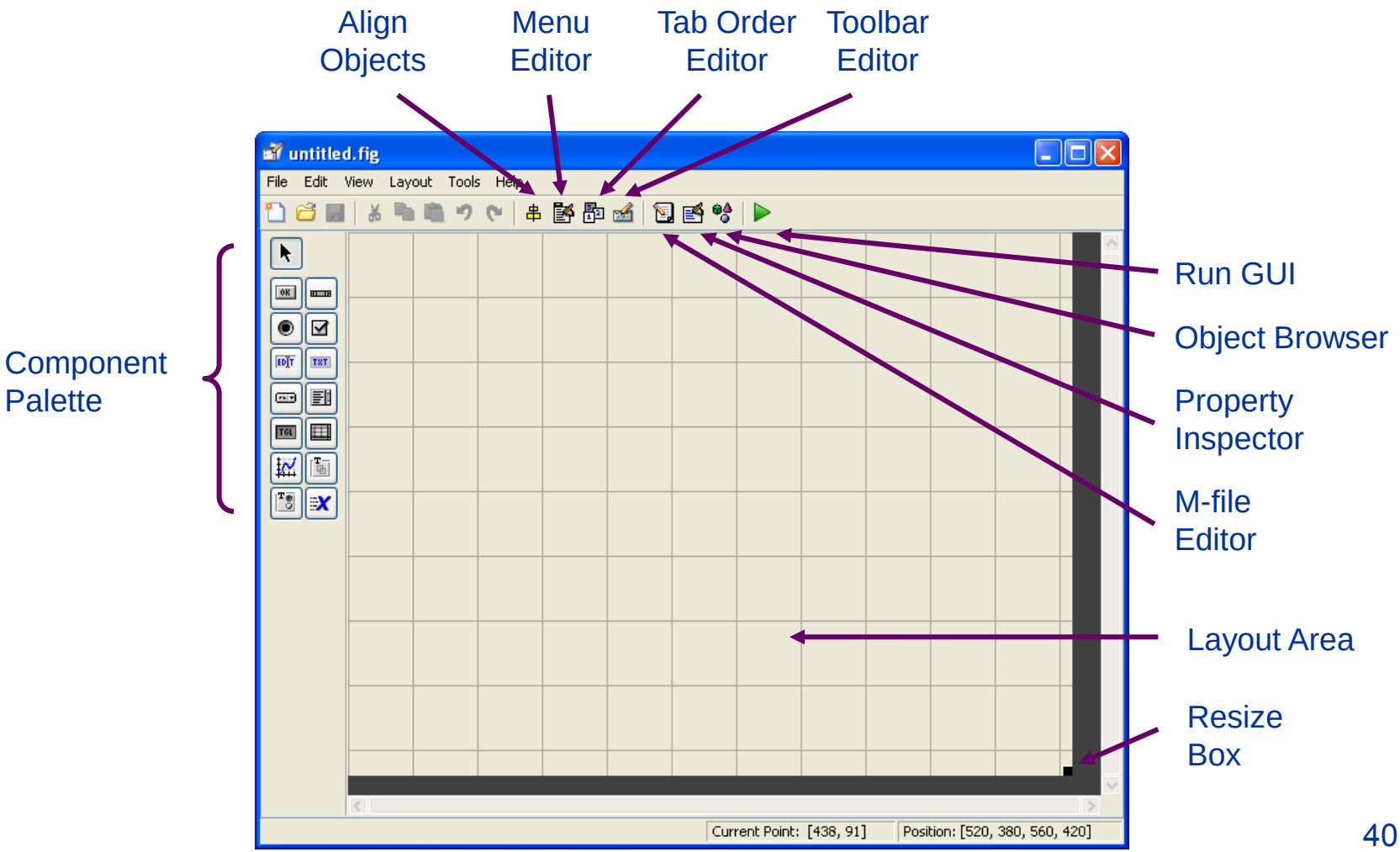
Creating a GUI

Typical stages of creating a GUI are:

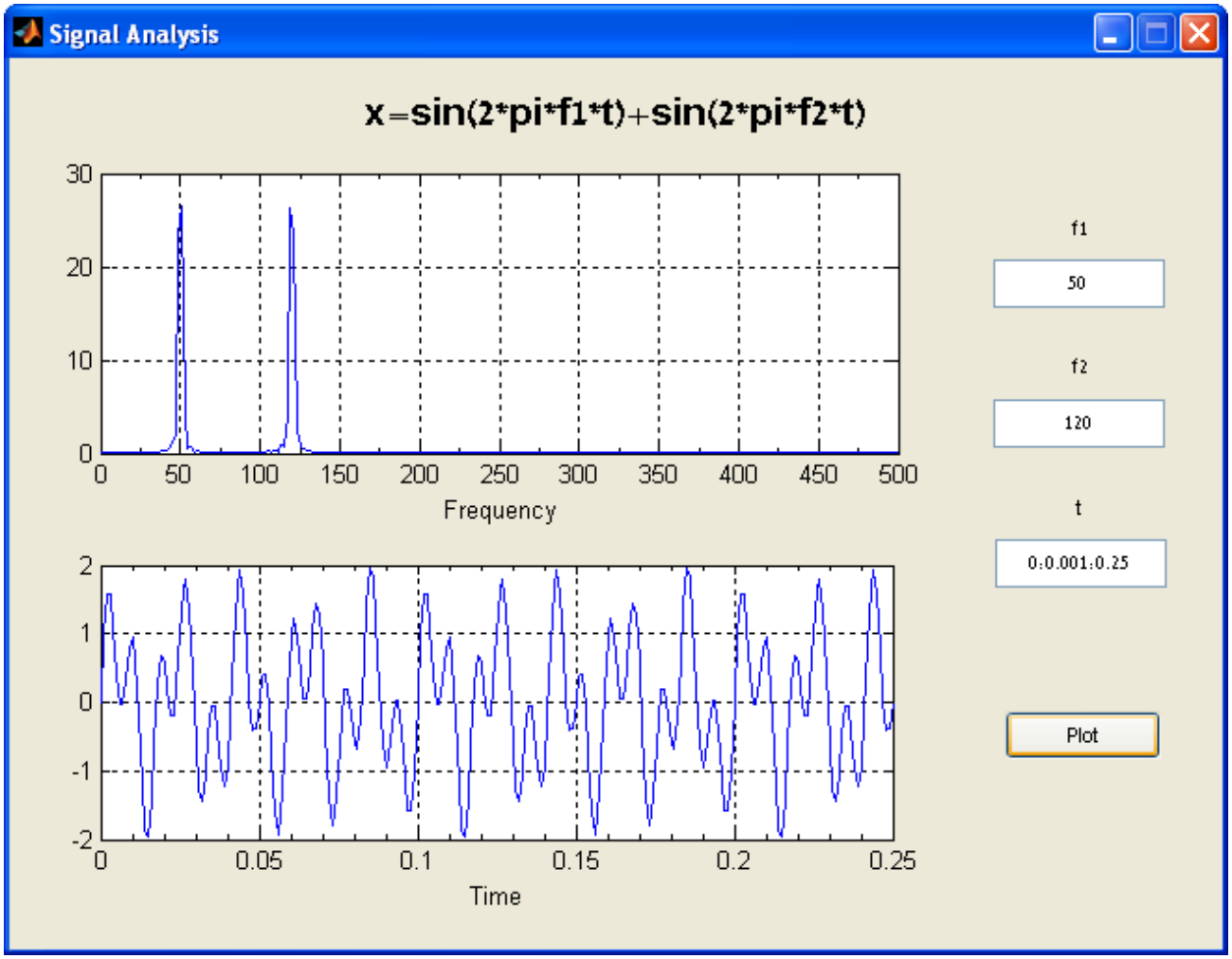
1. **Designing the GUI**
2. **Laying out the GUI**
   - Using the Layout Editor
3. **Programming the GUI**
   - Writing callbacks in the M-file Editor
4. **Saving and Running the GUI**

It is also possible to create a GUI programmatically

The Layout Editor



Hands-On GUIDE Example



Callbacks

- **A callback is a function that executes when a specific event occurs on a graphics object**
  - Also called event handler in some programming languages
- **A property of a graphics object**
  - All objects: ButtonDownFnc, CreateFnc, DeleteFnc
  - User interface controls: Callback, KeyPressFcn,
  - Figure: CloseRequestFcn, KeyPressFcn, KeyReleaseFcn, ResizeFcn, WindowButtonDownFcn, WindowButtonMotionFcn, WindowButtonUpFcn, WindowKeyPressFcn, WindowKeyReleaseFcn, WindowScrollWheelFcn
  - …
- **Stored in the GUI's M-file**

Writing Callbacks

A callback is usually made of the following stages:

1. **Getting the handle of the object initiating the action (the object provides event / information / values)**
2. **Getting the handles of the objects being affected (the object whose properties are to be changed)**
3. **Getting necessary information / values**
4. **Doing some calculations and processing**
5. **Setting relevant object properties to effect action**
6. **Save any changes that have been made to the handles structure by using**

   guidata(hObject, handles)

   – hObject is the handle to the component object that executes the callback

Writing Callbacks

Callback from example:

```
% --- Executes on button press in plot_button.
function plot_button_Callback(hObject, eventdata, handles)
% hObject    handle to plot_button (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get user input from GUI
f1 = str2double(get(handles.f1_input,'String'));
f2 = str2double(get(handles.f2_input,'String'));
t = eval(get(handles.t_input,'String'));

% Calculate data
…

% Create frequency plot
axes(handles.frequency_axes) % Select the proper axes
plot(f,m(1:257))
xlabel('Frequency');
set(handles.frequency_axes,'XMinorTick','on')
grid on
…
```

Managing Data

- **Most GUIs generate or use data specific to the application**
- **GUI components often need to communicate data to one another**
- **Several basic mechanism serve this need:**
  - UserData property
  - Application data (getappdata, setappdata, isappdata, rmappdata)
  - Using the handles structure (guidata)
  - Nested functions
- **It is also possible to make several different GUIs work together**
  - Communicate by setting each other's properties or by returning outputs

Image Processing Modular Tools

- **Many of the interactive tools of the Image Processing Toolbox are modular and can be combined into your custom GUI**
  - For image processing applications
  - imcontrast, imcolormaptool, imcrop, imdisplayrange, imdistline, imageinfo, immagbox, imoverview, impixelinfo, impixelregion, impixelregionpanel, imsave, imscrollpane

More Information

- **MATLAB user manuals – Graphics, 3-D Visualization, Creating Graphical User Interfaces, Image Processing Toolbox, Image Acquisition Toolbox, Video and Image Processing Blockset, …**
- **Marchand P., Holland T. O., Graphics and GUIs with MATLAB, 3ed, 2003, CRC Press**
- **Smith T. S., MATLAB Advanced GUI Development, 2006, Dog Ear Publishing**

Documents from Mathworks can be found at:

http://www.mathworks.com/help/index.html

Most of this info can also be found in MATLAB Help

Thank You

Any questions?