11 Graphical User Interface Design in MATLAB

Introduction

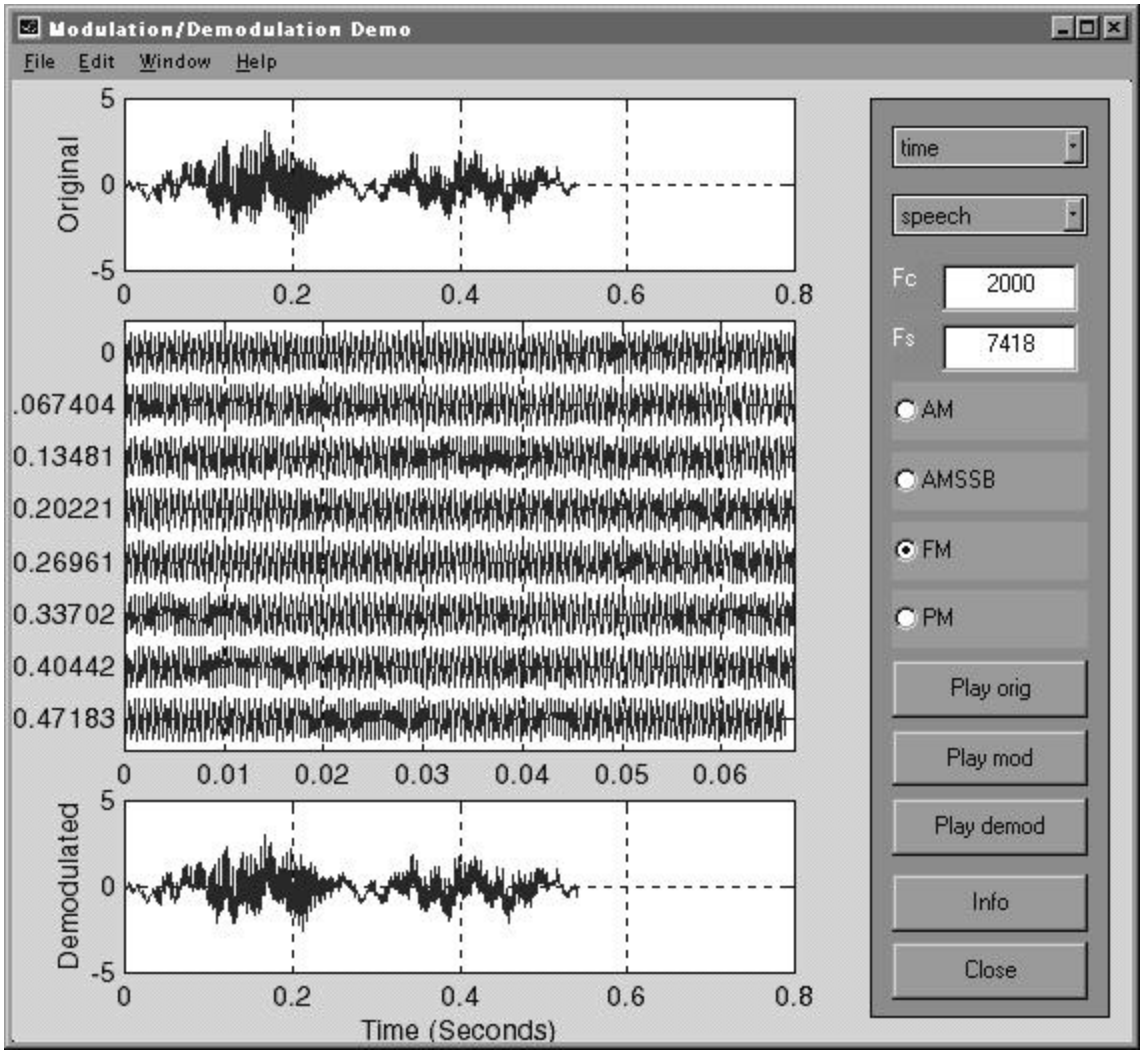
MATLAB is well known for its numerical problem solving power. Traditionally programs written by engineers have very simple interfaces, and often only the author is the one who uses the program once it is completed. There are occasions where a more polished user interface, specifically a graphical user interface (GUI) is desired:

- You wish to have a nontechnical, yet computer literate, person use your programs to perform some ongoing data analysis task, etc.
- You wish to share your tool (program(s)) with other members of your work group, but want the interface to be friendly
- You are writing a utility function for your own use and would like it to be easy to use
- You wish to build an interactive demonstration to best show off a concept or idea to others, e.g., others students etc.
- You or your company is a third-party developer of tools for the MATLAB user community

- Others?

Starting with version 4, The MathWorks, creators of MATLAB, introduced a set of *event driven* components that can be used to create GUIs in MATLAB.

Example: The GUI application `moddemo` from the signal processing toolbox.



- The MathWorks itself has incorporated many GUI based demo programs into the current release of MATLAB
- `moddemo` demonstrates basic modulation theory (ECE4620)

Overview of GUI Design and the Supplied Development Tools

- Since MATLAB is a cross-platform software package (primary platforms include Win95/NT, Unix, and Macintosh) the GUI components are derived from those in common to all the supported platforms
- In MATLAB 4 GUI design required hand coding of GUI components; some add-on tools such as *GUIMaker*[1] were available later
- With MATLAB 5 a multipart GUI building tool named *Guide*, which stands for Graphical User Interface Development Environment, was introduced (Guide is also included in the student edition)
- A MATLAB figure window is the area where GUI components are placed
- The basic GUI components/objects available in MATLAB 5 are all variations on `uicontrol( ..... )`
  - Push buttons
  - Radio buttons
  - Checkboxes
  - UI editable text
  - UI static text

1. Included in the book by Patrick Marchand, *Graphics and GUIs with MATLAB*, CRC Press Inc., 1996. ISBN 0-8493-9487-2.

  - Sliders (scroll bars)
  - Frames
  - Listboxes
  - Pop-up menus

- Plot screens are created using `axis`
- Custom figure window menus are created using `uimenu`
- The complete listing of user interface functions and tools, as given by MATLAB help, is:

```
» help uitools
  Graphical user interface tools.

  GUI functions.
    uicontrol  - Create user interface control.
    uimenu     - Create user interface menu.
    ginput     - Graphical input from mouse.
    dragrect   - Drag XOR rectangles with mouse.
    rbbox      - Rubberband box.
    selectmoveresize   - Interactively select, move,
                         resize, or copy objects.
    waitforbuttonpress - Wait for key/buttonpress over
                         figure.
    waitfor    - Block execution and wait for event.
    uiwait     - Block execution and wait for resume.
    uiresume   - Resume execution of blocked M-file.

  GUI design tools.
    guide       - Design GUI.
    align       - Align uicontrols and axes.
    cbedit      - Edit callback.
    menuedit    - Edit menu.
```

```
   propedit    - Edit property.
```

Dialog boxes.

```
   dialog     - Create dialog figure.
   axlimdlg   - Axes limits dialog box.
   errordlg   - Error dialog box.
   helpdlg    - Help dialog box.
   inputdlg   - Input dialog box.
   listdlg    - List selection dialog box.
   menu       - Generate menu of choices for user input.
   msgbox     - Message box.
   questdlg   - Question dialog box.
   warndlg    - Warning dialog box.
   uigetfile  - Standard open file dialog box.
   uiputfile  - Standard save file dialog box.
   uisetcolor - Color selection dialog box.
   uisetfont  - Font selection dialog box.
   pagedlg    - Page position dialog box.
   printdlg   - Print dialog box.
   waitbar    - Display wait bar.
```

Menu utilities.

```
   makemenu   - Create menu structure.
   menubar    - Computer dependent default setting for
                MenuBar property.
   umtoggle   - Toggle "checked" status of uimenu
                object.
   winmenu    - Create submenu for "Window" menu item.
```

Toolbar button group utilities.

```
   btngroup   - Create toolbar button group.
   btnstate   - Query state of toolbar button group.
   btnpress   - Button press manager for toolbar button
                group.
```

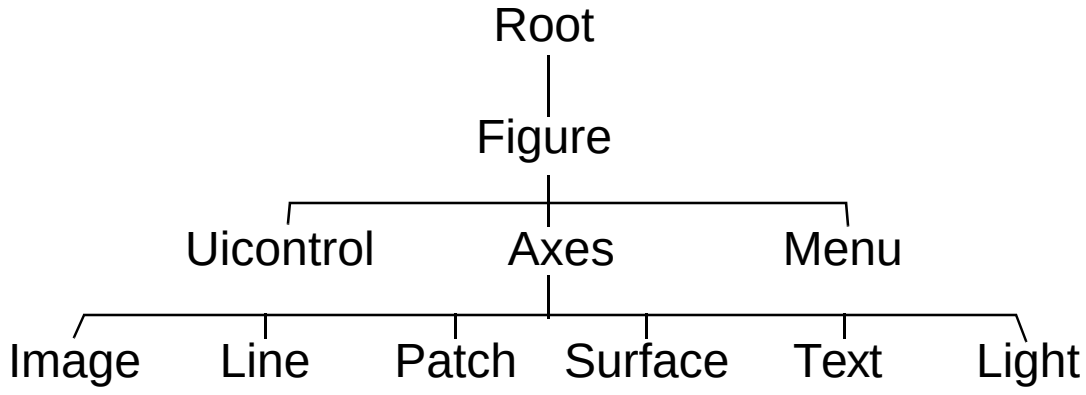
```
  btndown    - Depress button in toolbar button group.
  btnup      - Raise button in toolbar button group.

User-defined figure/axes property utilities.
  clruprop   - Clear user-defined property.
  getuprop   - Get value of user-defined property.
  setuprop   - Set user-defined property.

Miscellaneous utilities.
  allchild   - Get all object children.
  hidegui    - Hide/unhide GUI.
  edtext     - Interactive editing of axes text
               objects.
  getstatus  - Get status text string in figure.
  setstatus  - Set status text string in figure.
  popupstr   - Get popup menu selection string.
  remapfig   - Transform figure objects' positions.
  setptr     - Set figure pointer.
  getptr     - Get figure pointer.
  overobj    - Get handle of object the pointer is
               over.
```

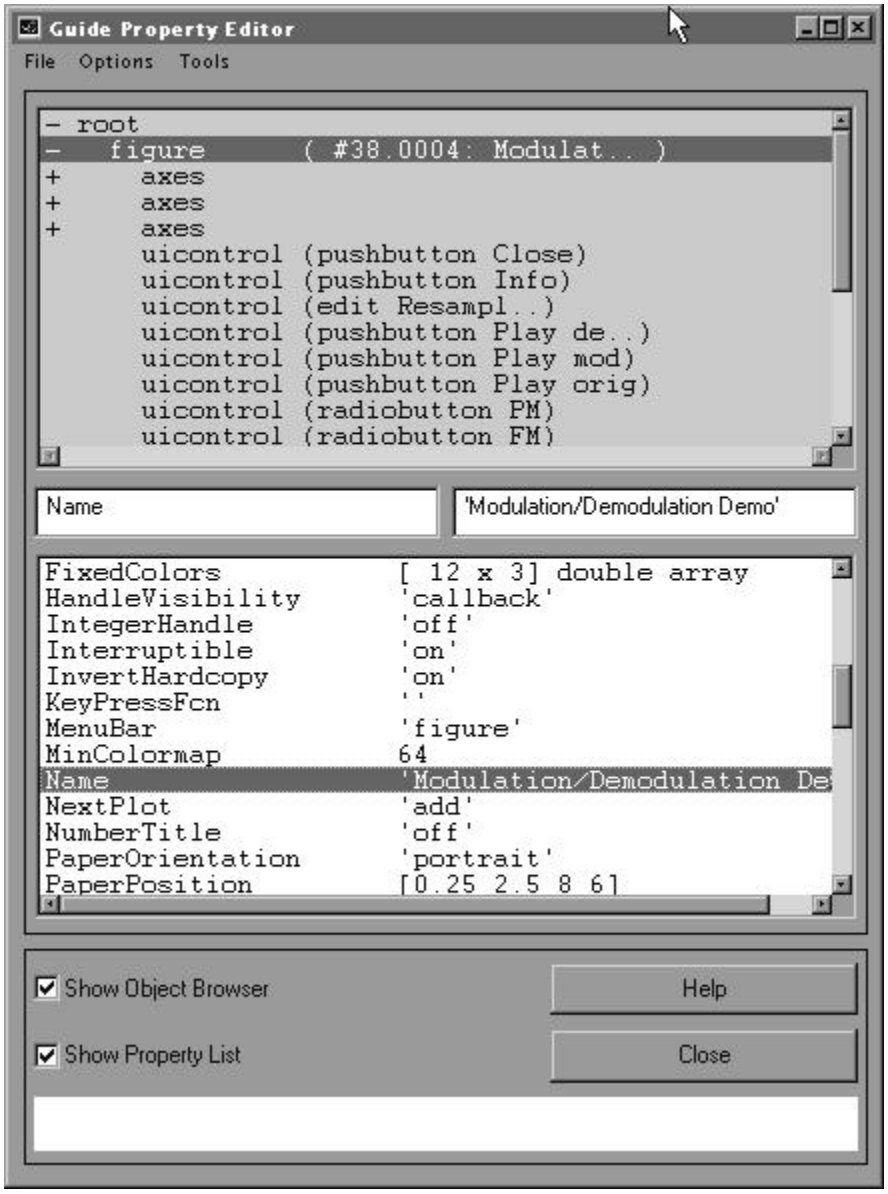
Handle Graphics

- Everything that appears in a figure window is part of the *Handle Graphics* object hierarchy



- All of the Handle Graphics objects have properties

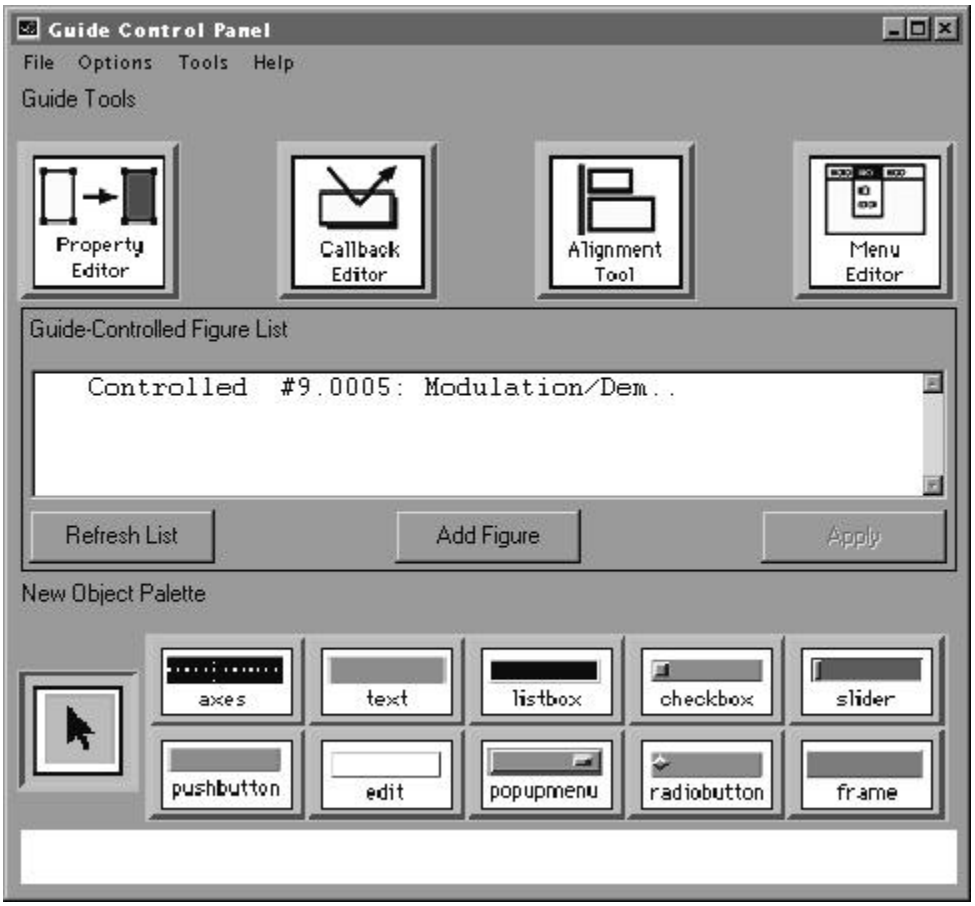
```
» moddemo; propedit; % This is one of Guide's tools
```



Guide

- At this point MATLAB GUI design is starting to look rather complicated
- It is true that there are many details to manage in a GUI application

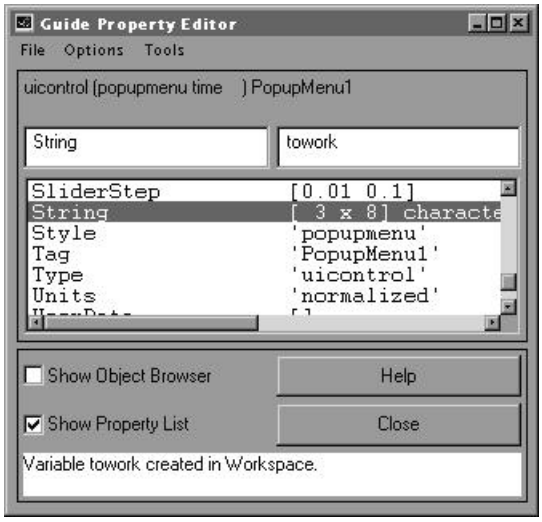
- To make managing these details easier MATLAB 5 comes equipped with Guide, which is composed of the *Guide Control Panel* and four supporting tools:
  - Guide Property Editor (screen shot given above under Handle Graphics)
  - Guide Callback Editor
  - Guide Alignment Tool
  - Guide Menu Editor
- Guide Control Panel

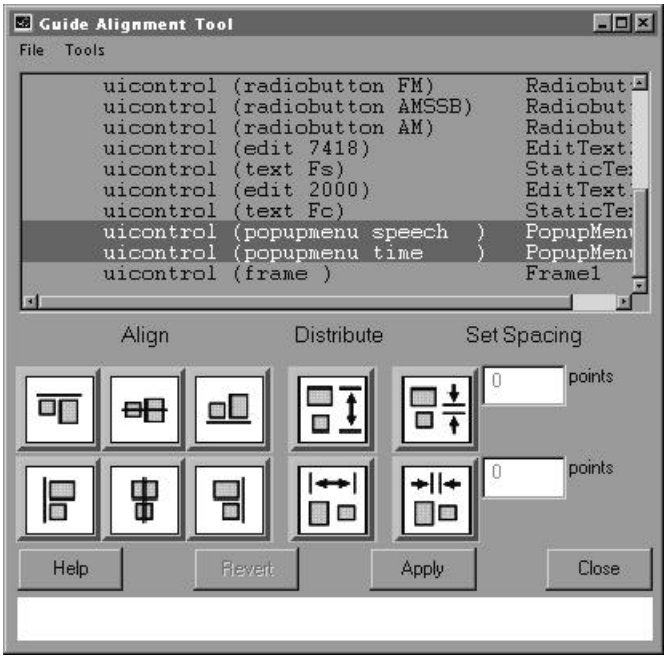


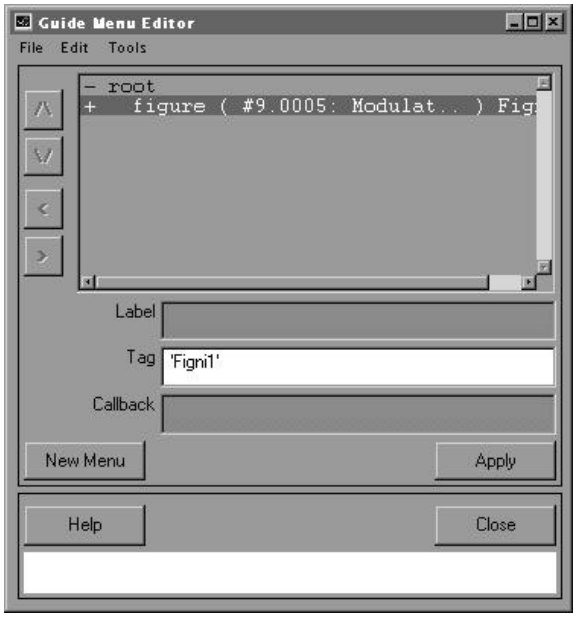
Click these buttons to bring up the other tools.

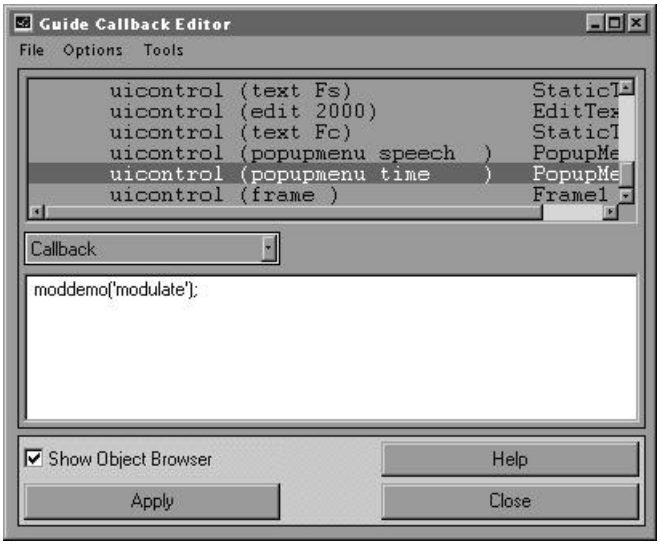
Click these buttons and then draw GUI object on a clean figure window

- The four supporting tools









- How do we use all of these tools?
  - In one session this is simply not possible

Building a Simple GUI Application

- To demonstrate simple GUI building, we will construct a MATLAB application that plots the Fourier series of a squarewave, that is plots

$$x(t) = \sum_{\substack{n=1 \\ n = \text{odd}}}^{N} \frac{1}{n} \sin[2\pi n f_o t] \qquad (11.1)$$

  for $f_o = 1$ Hz and $0 \le t \le 1$

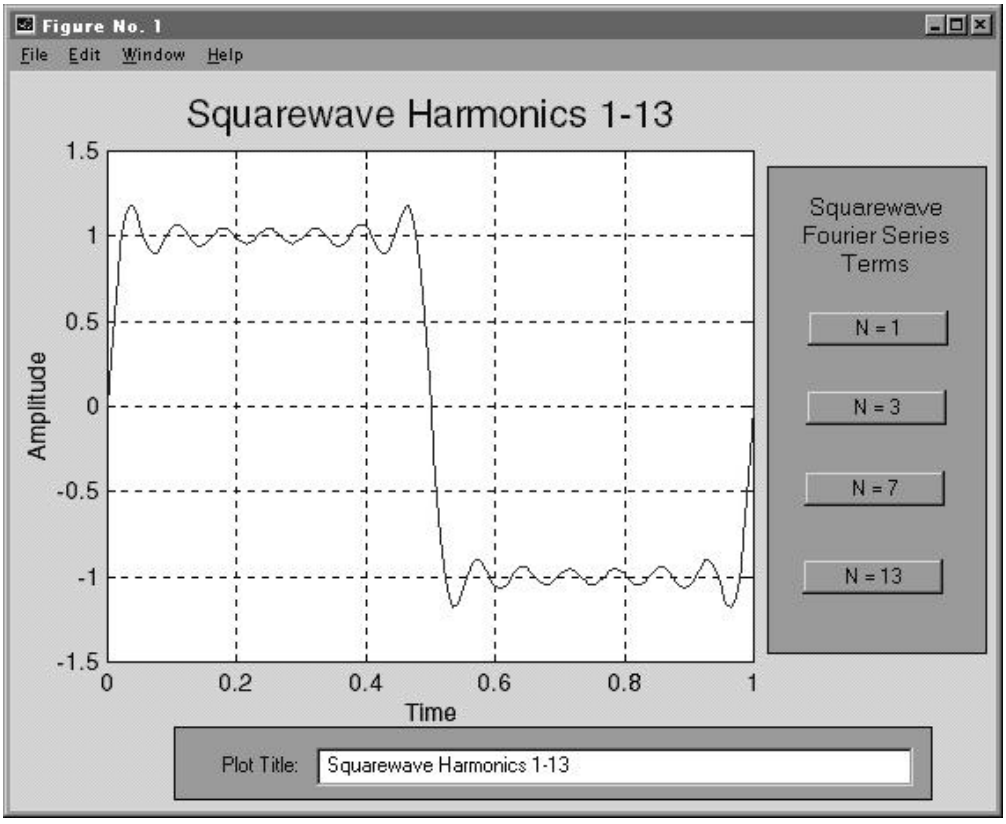
- Using *push buttons* we will allow the user to choose either $N = 1, 3, 7,$ or 13
- Using *UI editable* text we will allow the user to specify a custom title for the plot
- To response to events created by the application the function `gui_demo1_cb.m` is written (what the MathWorks calls a *switchyard callbacks* function)

```
function gui_demo1_cb(action)
%        gui_demo1_cb(action)
%
% This function handles all of the callbacks
% from the GUI figure window created with the
% files: gui_demo1.m and gui_demo1.mat
% Mark Wickert 12/11/97
%
switch action %Choose an action
case 'push_n1'
   t = 0:1/200:1;
   x = sin(2*pi*t)*4/pi;
```

```
   plot(t,x);
   grid;
   ylabel('Amplitude')
   xlabel('Time')
   case 'push_n3'
   t = 0:1/200:1;
   x = sin(2*pi*t)+1/3*sin(3*2*pi*t);
   x = x*4/pi;
   plot(t,x);
   grid;
   ylabel('Amplitude')
   xlabel('Time')
case 'push_n7'
   t = 0:1/200:1;
   x = sin(2*pi*t)+1/3*sin(3*2*pi*t)+ ...
         1/5*sin(5*2*pi*t)+1/7*sin(7*2*pi*t);
   x = x*4/pi;
   plot(t,x);
   grid;
   ylabel('Amplitude')
   xlabel('Time')
case 'push_n13'
   t = 0:1/200:1;
   x = sin(2*pi*t)+1/3*sin(3*2*pi*t)+ ...
         1/5*sin(5*2*pi*t)+1/7*sin(7*2*pi*t)+ ...
         1/9*sin(9*2*pi*t)+1/11*sin(11*2*pi*t)+ ...
         1/13*sin(13*2*pi*t);
   x = x*4/pi;
   plot(t,x);
   grid;
   ylabel('Amplitude')
   xlabel('Time')
```

```
case 'make_title'
   my_title = get(gcbo,'String');
   title(my_title,'fontsize',16);
end
```

- The GUI figure window is created using Guide and the various UI objects are fine tuned and connected to the callback handling function `gui_demo1_cb.m` using the supporting tools
- The result of creating the GUI in Guide is two files:
  - `gui_demo1.m` which contains all of the detailed interface set-up code, and
  - `gui_demo1.mat` which contains additional GUI set-up code
- The completed application is shown below



- The details of how to create and *wire-up* the interface will be discussed in class