MATLAB®

The Language of Technical Computing

- Computation
- Visualization
- Programming

Creating Graphical User Interfaces

Version 7

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1

Getting Started with GUIDE

What Is GUIDE?

GUIDE, the MATLAB® Graphical User Interface development environment, provides a set of tools for creating graphical user interfaces (GUIs). These tools greatly simplify the process of designing and building GUIs. You can use the GUIDE tools to

- Lay out the GUI

  Using the GUIDE Layout Editor, you can lay out a GUI easily by clicking and dragging GUI components — such as panels, buttons, text fields, sliders, menus, and so on — into the layout area.

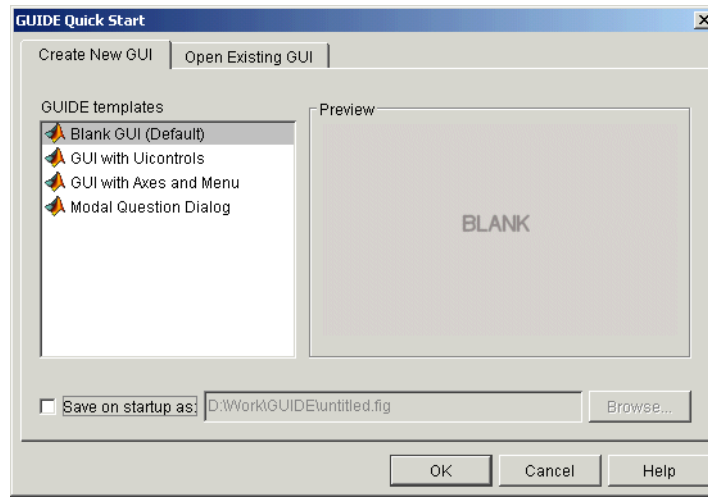
- Program the GUI

  GUIDE automatically generates an M-file that controls how the GUI operates. The M-file initializes the GUI and contains a framework for all the GUI callbacks — the commands that are executed when a user clicks a GUI component. Using the M-file editor, you can add code to the callbacks to perform the functions you want them to.

The following sections provide an overview of creating GUIs with GUIDE.

Starting GUIDE

To start GUIDE, enter `guide` at the MATLAB prompt. This displays the **GUIDE Quick Start** dialog, as shown in the following figure.



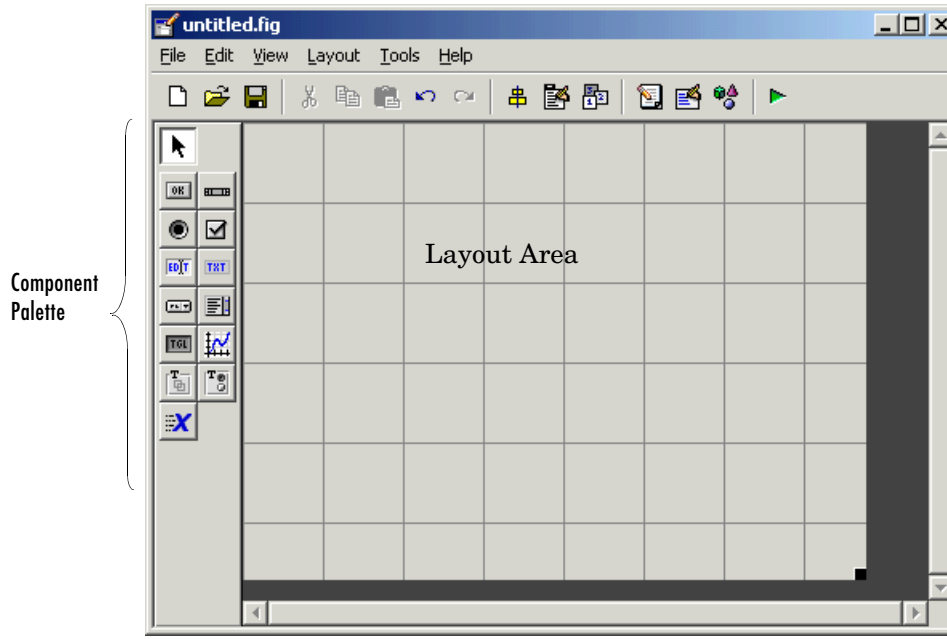
From the Quick Start dialog, you can

- Create a new GUI from one of the GUIDE templates — prebuilt GUIs that you can modify for your own purposes.
- Open an existing GUI.

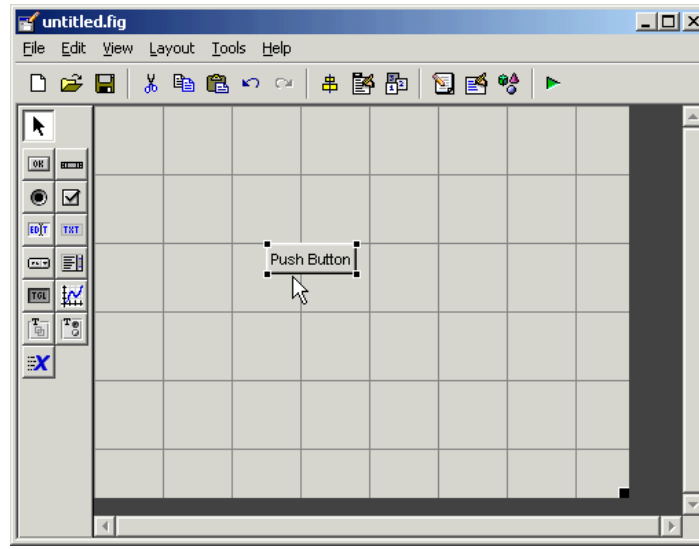
Once you have selected one of these options, clicking **OK** opens the GUI in the Layout Editor.

The Layout Editor

When you open a GUI in GUIDE, it is displayed in the Layout Editor, which is the control panel for all of the GUIDE tools. The following figure shows the Layout Editor with a blank GUI template.



You can lay out your GUI by dragging components, such as push buttons, pop-up menus, or axes, from the component palette, at the left side of the Layout Editor, into the layout area. For example, if you drag a push button into the layout area, it appears as in the following figure.

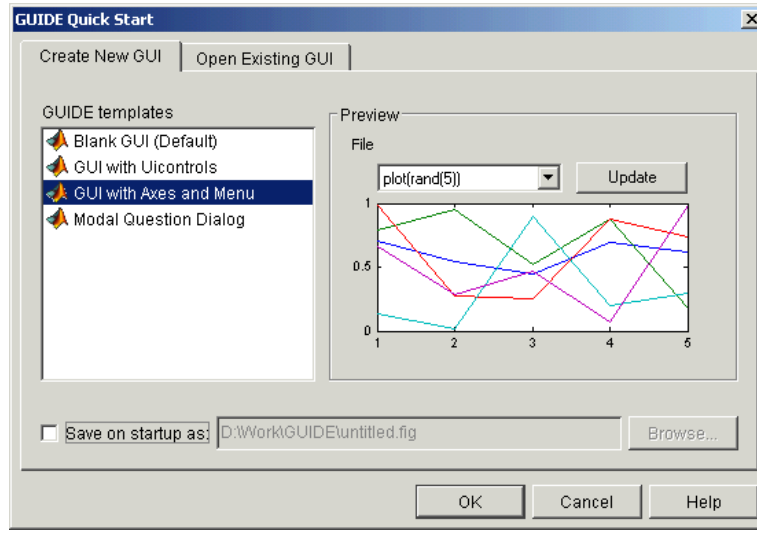


You can also use the Layout Editor to set basic properties of the GUI components.

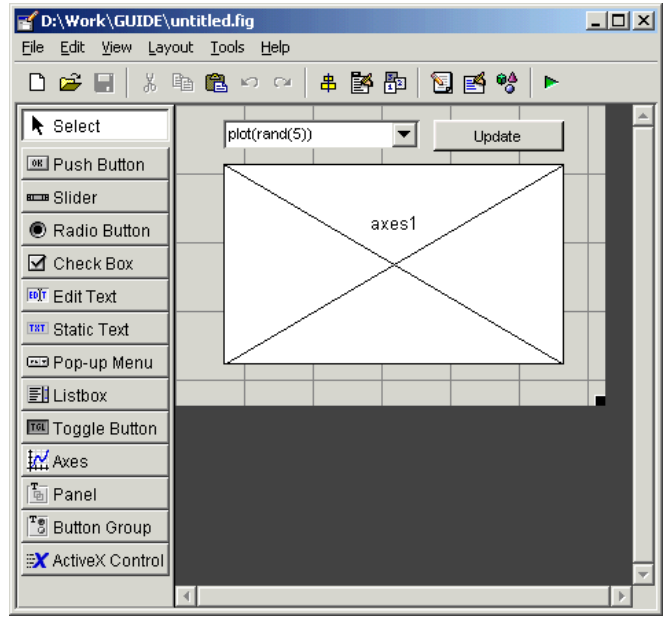
To learn more about the Layout Editor, see “Using the Layout Editor” on page 3-9. See “Laying Out the GUI” on page 2-3 for a detailed example of laying out a GUI.

GUIDE Templates

The GUIDE Quick Start dialog provides templates for several basic types of GUIs. The advantage of using templates is that often you can modify a template more quickly and easily than by starting from a blank GUI. When you select a template in the Templates pane, a preview of it appears in the right-hand pane. For example, when you select the **GUI with Axes and Menu**, the Quick Start dialog appears as in the following figure.



Clicking **OK** opens the template in the Layout Editor, as shown in the following figure.



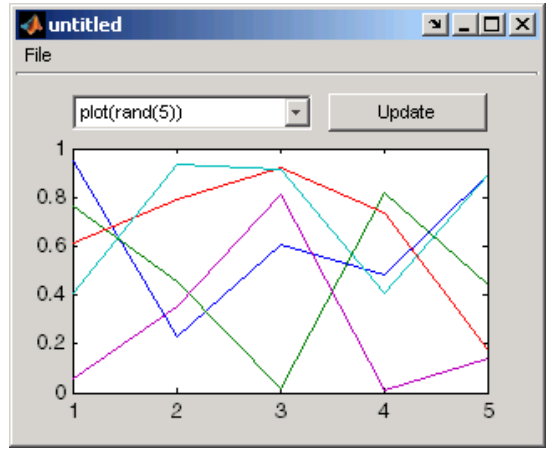
To display the names of the GUI components in the component palette, select **Preferences** from the **File** menu, check the box next to **Show names in component palette**, and click **OK**.

Note that the Layout Editor does not display the functioning GUI. The next section describes how to run the actual GUI from the Layout Editor.

To learn more about templates, see “Using GUIDE Templates” on page 3-2.

Running a GUI

To run a GUI, select **Run** from the **Tools** menu, or click the run button on the toolbar. This displays the functioning GUI outside the Layout Editor. For example, when you run the GUI with Axes and Menu template, it appears as shown in the following figure.



This GUI displays various MATLAB plots. Select a plot from the pop-up menu and click **Update**.

Note If you are running the GUI for the first time and have not yet saved it, GUIDE first asks you if you want to save the figure and M-files that define the GUI. If you click **Yes**, GUIDE displays a **Save As** dialog box. After you have saved the files, GUIDE runs the GUI and opens an M-file for the GUI in the default text editor. See “GUI FIG-Files and M-Files” on page 1-9 for information about these files.

GUI FIG-Files and M-Files

GUIDE stores a GUI in two files, which are generated the first time you save or run the GUI:

- A FIG-file, with extension `.fig`, which contains a complete description of the GUI layout and the components of the GUI: push buttons, menus, axes, and so on.
- An M-file, with extension .m, which contains the code that controls the GUI, including the callbacks for its components.

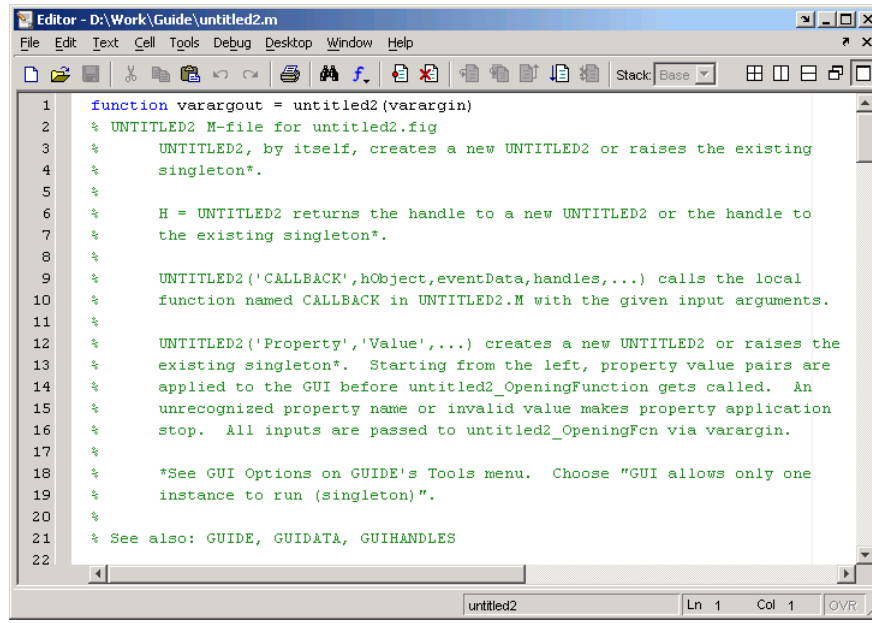
These two files correspond to the tasks of laying out and programming the GUI. When you lay out of the GUI in the Layout Editor, your work is stored in the FIG-file. When you program the GUI, your work is stored in the M-file.

Programming the GUI M-file

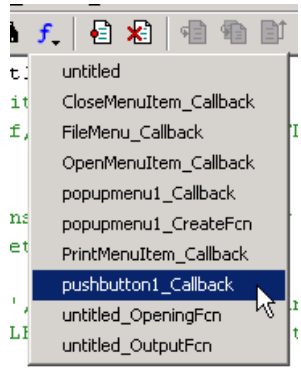
After laying out your GUI, you can program the GUI M-file using the M-file editor. GUIDE automatically generates this file from your layout the first time you save or run the GUI. The GUI M-file

- Initializes the GUI
- Contains code to perform tasks before the GUI appears on the screen, such as creating data or graphics
- Contains the callback functions that are executed each time a user clicks a GUI component

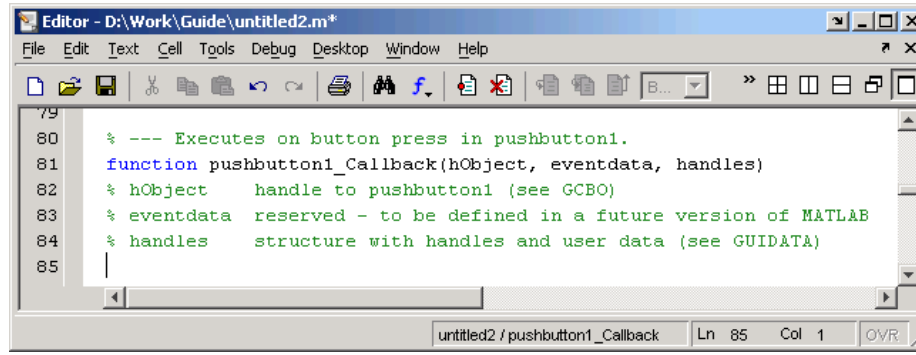
Initially, each callback contains just a function definition line. You then use the M-file editor to add code that makes the component function the way you want it to. To open the M-file, click the M-file Editor icon  on the Layout Editor toolbar. The following figure shows the M-file for the GUI with Axes and Menu template.



You can view the callback for any of the GUI components by clicking the function icon on the toolbar. This displays a list of all the callbacks, as shown in the following figure.



Clicking a callback on the list displays the section of the M-file containing the callback, where you can edit it. This example shows the callback template for `pushbutton1_Callback`.



To learn more about programming the M-file, see Chapter 4, “Programming GUIs.”

Editing Version 5 GUIs with Version 7 GUIDE

In MATLAB Version 5, GUIDE saved GUI layouts as MAT-file/M-file pairs. Since MATLAB Version 6, GUIDE saves GUI layouts as FIG-files. GUIDE also generates an M-file to program the GUI callbacks. However, this M-file does not contain layout code as did M-files created in Version 5.

Use the following procedure to edit a Version 5 GUI with Version 7 GUIDE:

1. Display the Version 5 GUI.
2. Obtain the handle of the GUI figure. If the figure's handle is hidden (i.e., the figure's `HandleVisibility` property is set to `off`), set the root `ShowHiddenHandles` property to `on`:

   ```
   set(0,'ShowHiddenHandles','on')
   ```

   Then get the handle from the root's `Children` property:

   ```
   hObject = get(0,'Children');
   ```

   This statement returns the handles of all figures that exist when you issue the command. For simplicity, ensure that the GUI is the only figure displayed.
3. Pass the handle as an argument to the `guide` command:

   ```
   guide(hObject)
   ```

Saving the GUI in Version 7 GUIDE

When you save the edited GUI with Version 7 GUIDE, MATLAB creates a FIG-file that contains all the layout information. The original MAT-file/M-file combination is no longer used. To display the revised GUI, run the M-file generated by GUIDE.

Updating Callbacks

Ensure that the `Callback` properties of the uicontrols in your GUI are set to the desired callback string or callback M-file name when you save the FIG-file. If your Version 5 GUI used an M-file that contained a combination of layout code and callback routines, then you should restructure the M-file to contain only the commands needed to initialize the GUI and the callback functions. The

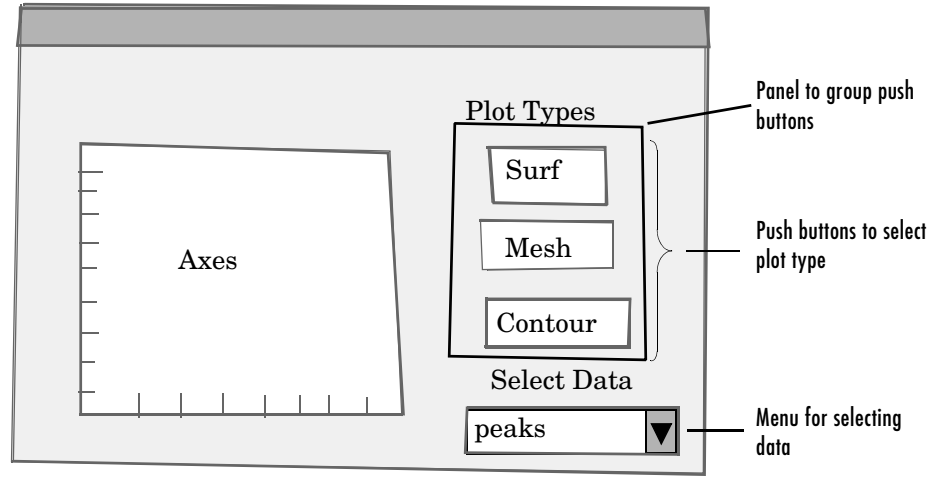
M-file generated by Version 7 GUIDE can provide a model of how to restructure your code.

2

Creating a GUI

Designing the GUI

The GUI used in this example contains an axes that displays either a surface, mesh, or contour plot of data selected from the pop-up menu. The following picture shows a sketch that you might use as a starting point for the design.



A panel contains three push buttons that enable you to select the type of plot you want. The pop-up menu contains three strings — `peaks`, `membrane`, and `sinc`, which correspond to MATLAB functions. You can select the data to plot from this menu.

Laying Out the GUI

This section illustrates how to lay out GUI components (i.e., a panel, axes, and user interface controls, such as push buttons, pop-up menus, static text, etc.) in the GUI. We recommend that you create the GUI for yourself, as this is the best way to learn how to use GUIDE.

The section explains how to

View Layout and Code for the Example

If you are reading this in the MATLAB Help browser, you can click the following links to display the GUIDE Layout Editor and the MATLAB Editor with a completed version of this example. This enables you to see the values of all component properties and to understand how the components are assembled to create the GUI. You can also see a complete listing of the code that is discussed in the following sections.

Note The following links execute MATLAB commands and are designed to work within the MATLAB Help browser.

- Layout Editor with completed GUI layout
- MATLAB Editor with completed M-file. The M-file contains the code that controls the GUI.

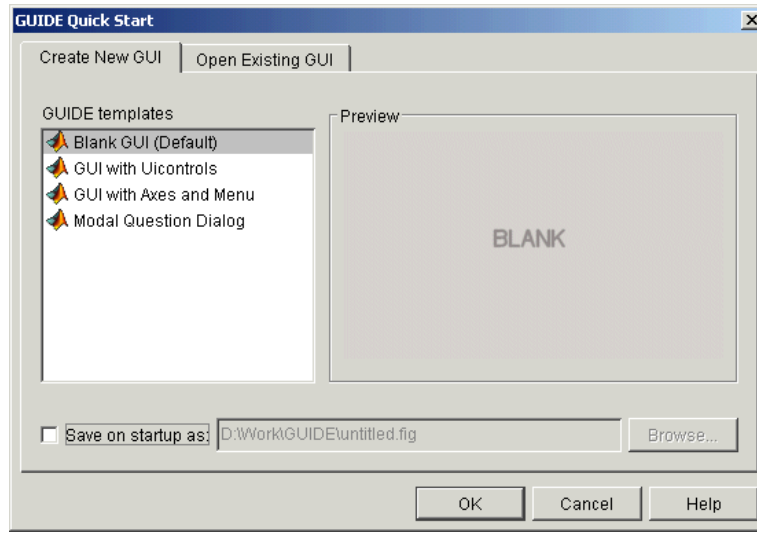
An Animated Demo of Creating a GUI

The following link displays an animated version of this example.

Show GUIDE demonstration

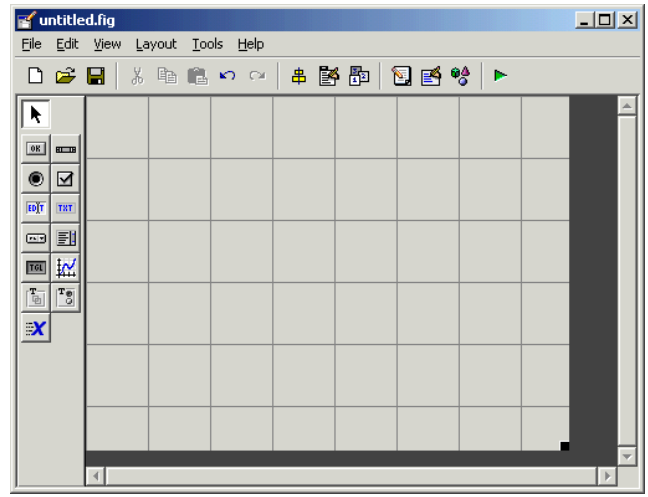
Open a New GUI in the Layout Editor

Open GUIDE by typing `guide` at the MATLAB prompt. This displays the **Guide Quick Start** dialog shown in the following figure.

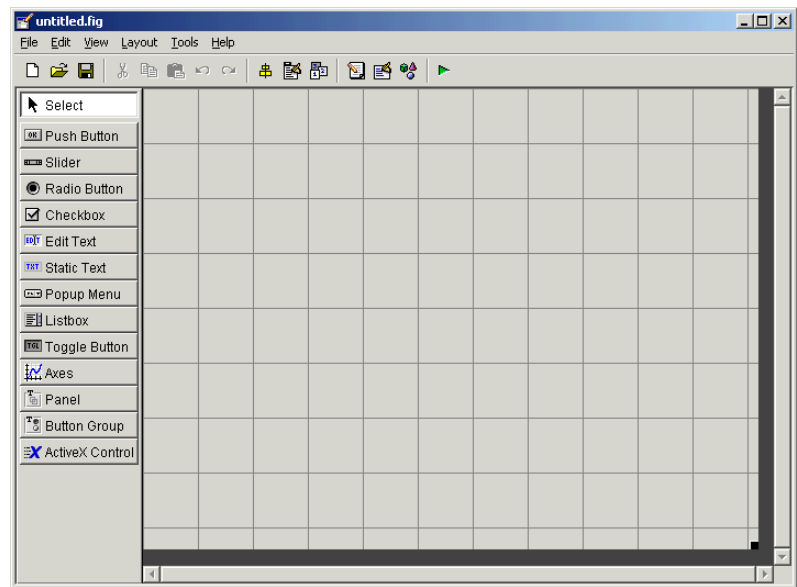


If GUIDE is already open, you can display a similar dialog, by selecting **New** from the **File** menu. This dialog has no **Open Existing GUI** tab.

In the Quick Start dialog, select the **Blank GUI (default)** template. Click **OK** to display the blank GUI in the Layout Editor, as shown in the following figure.

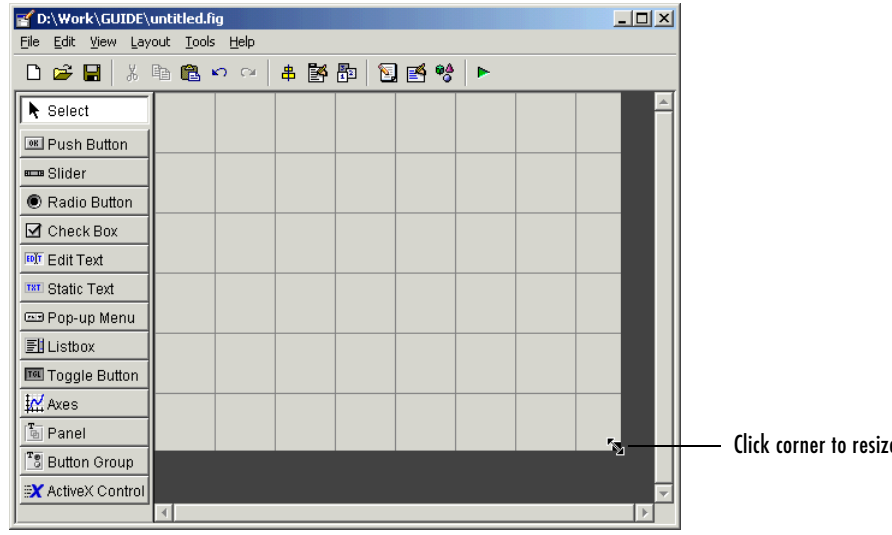


To display the names of the GUI components in the component palette, select **Preferences** from the **File** menu, check the box next to **Show names in component palette**, and click **OK**. The Layout Editor then appears as shown in the following figure.



Set the GUI Figure Size

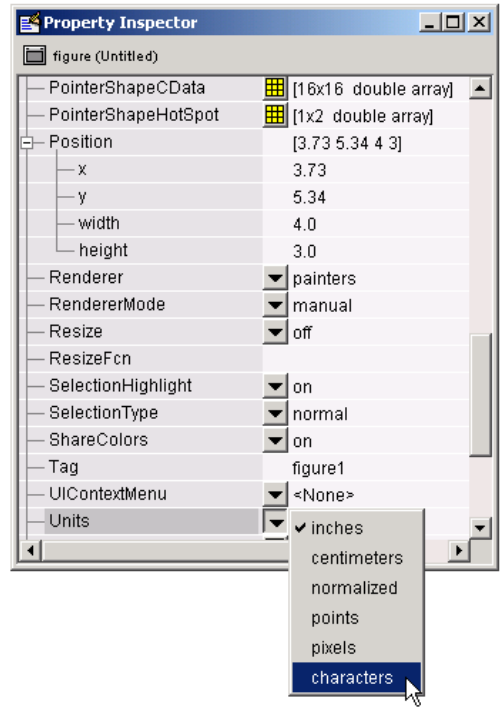
Specify the size of the GUI by resizing the grid area in the Layout Editor. Click on the lower-right corner and resize the grid until it is about 4-by-3 inches.



If you want to set the position or size of the GUI to an exact value, do the following:

1. Select **Property Inspector** from the **View** menu.
2. Select the button next to `Units` and then select `inches` from the pop-up menu
3. Click the **+** sign next to `Position`**.**
4. Type the `x` and `y` coordinates of the point where you want the lower left corner of the GUI to appear, and its width and height, as shown in the following figure.
5. Reset the `Units` property to `characters`.

Note Setting the `Units` property to `characters` gives the GUI a more consistent appearance across platforms.



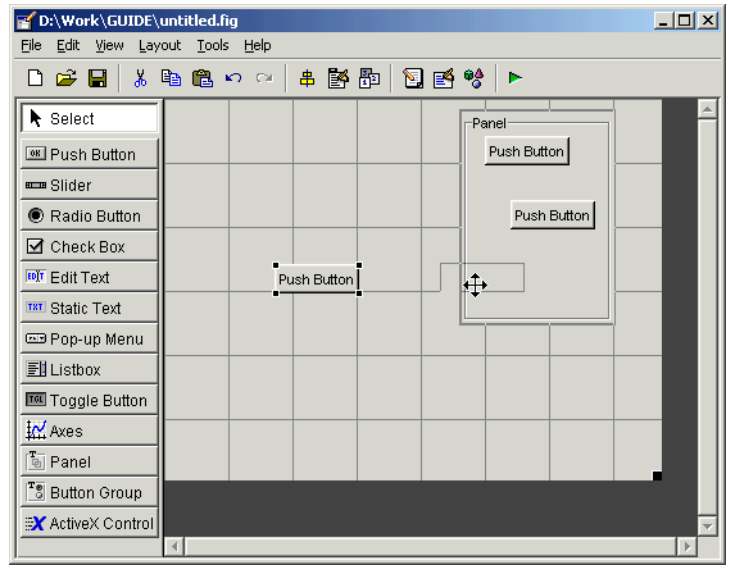
Add the Components

1 Add the panel and push buttons to the GUI. Select the following components from the component palette and drag them into the layout area:

- A panel
- Three push buttons

Select the panel and move it to where it appears in the original sketch. Resize the panel to approximately 1-by-1.5 inches by selecting it with the mouse, and then clicking and dragging the lower-left corner. Now, move the three

push buttons into the panel. As you move each push button into the panel, GUIDE highlights the panel to indicate that the panel is the potential parent of the push button. The following figure shows the highlight.



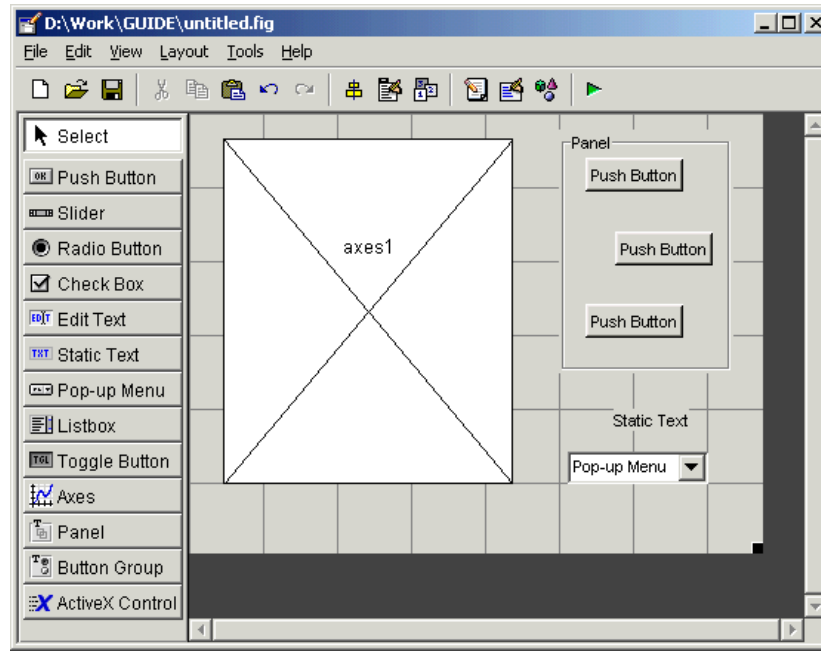
Note Panels, button groups, and figures can all be parents of component objects and display this highlight when you move a component into them.

---

2 Add the remaining components to the GUI.

- A static text
- A pop-up menu
- An axes

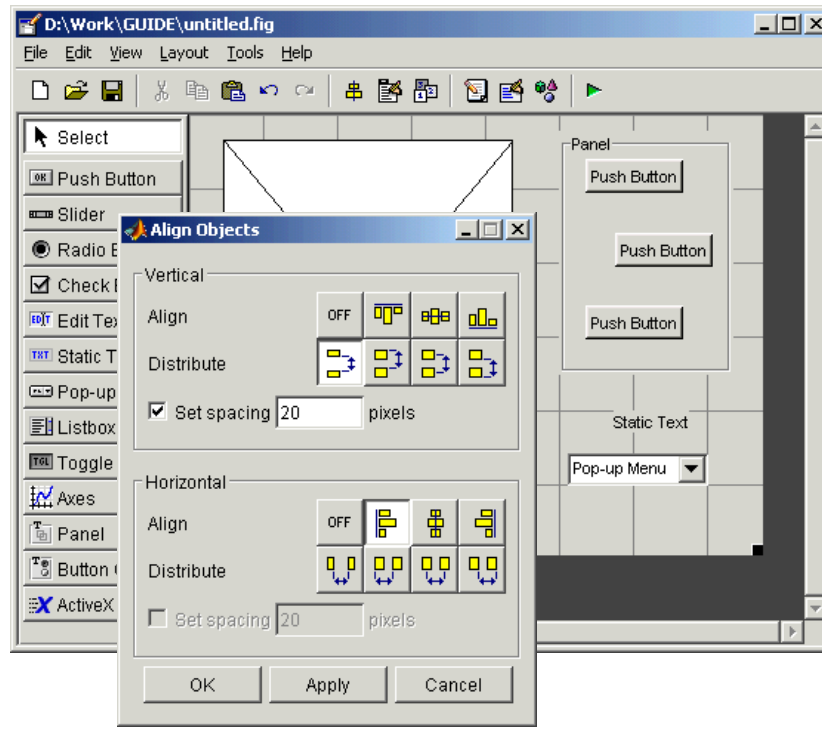
Arrange the components as shown in the following figure. Resize the axes component to approximately 2-by-2.



Align the Components

You can use the Alignment Tool to align components with respect to one another if they have the same parent. For example, to align the three push buttons:

1. Select all three push buttons by pressing **Ctrl** and clicking them.
2. Select **Align Objects** from the **Tools** menu to display the Alignment Tool.
3. Make the following settings in the Alignment Tool, as shown in the following figure:
   - 20 pixels spacing between push buttons in the vertical direction.
   - Left-aligned in the horizontal direction.
4. Click **OK**.



Now align the tops of the axes and the panel. Note that when the panel moves, its contents move with it.

To learn more about the Layout Editor, see “Using the Layout Editor” on page 3-9

Setting Properties for GUI Components

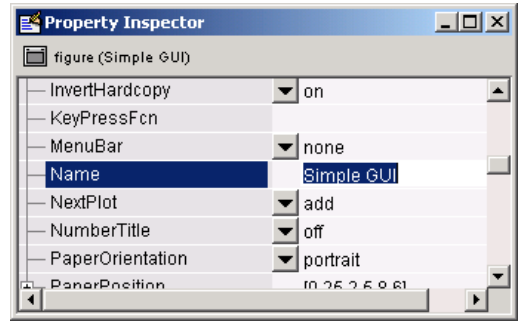
To set the properties of each GUI component, select the **Property Inspector** from the **View** menu to display the **Property Inspector** dialog box. When you select a component in the Layout Editor, the Property Inspector displays that component's properties. If no component is selected, the Property Inspector displays the properties of the GUI figure.

This section tells you how to set these properties:

Name Property

The value of a figure's `Name` property is the title that displays at the top of the GUI.

The first time you save or run the GUI, GUIDE sets the value of `Name` to the name of the FIG-file. Once the GUI is saved, you can set the value of `Name` to the string you want to use as its title. In the field next to `Name`, type `Simple GUI`, as shown in the following figure.

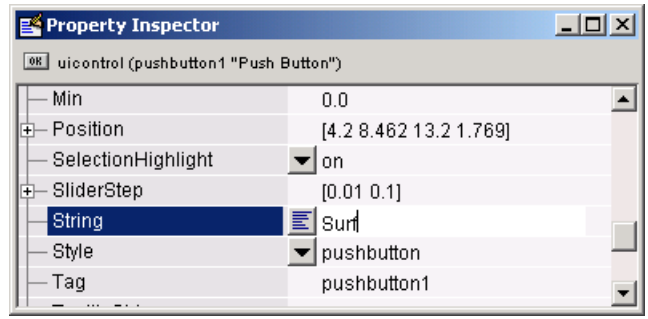


Title Property

A panel's `Title` property controls the title that appears at the top or bottom of the panel. Select the panel in the Layout Editor and then scroll down in the Property Inspector until you come to `Title`. In the field to the right of `Title`, change `Panel` to `Plot Types`. Use the `TitlePosition` property to control the position of the title.

String Property for Push Buttons and Static Text

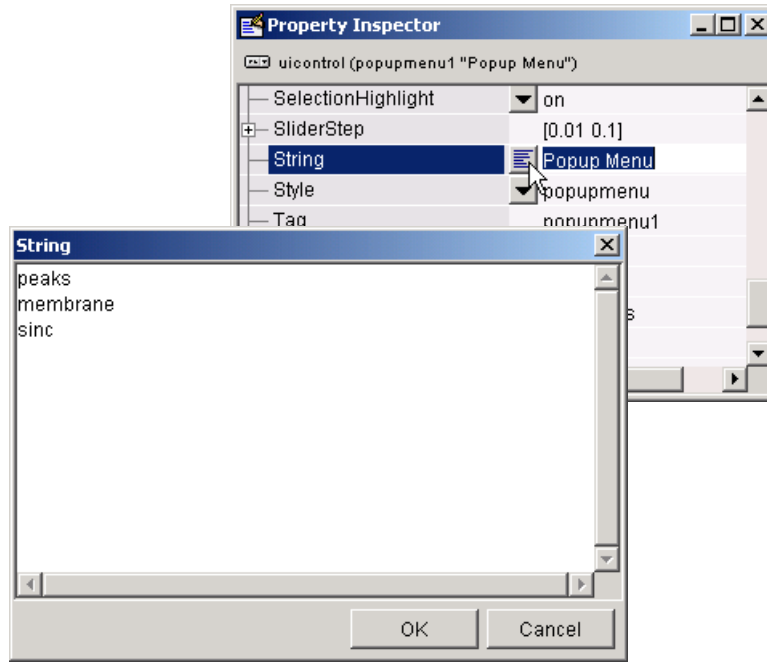
You can set the label in some user interface controls, such as push buttons, by using the `String` property. For example, to set the label of the top push button, select the push button in the Layout Editor and then, in the Property Inspector, scroll down until you come to `String`. In the field to the right of `String`, change `Push Button` to `Surf`, as shown in the following figure.



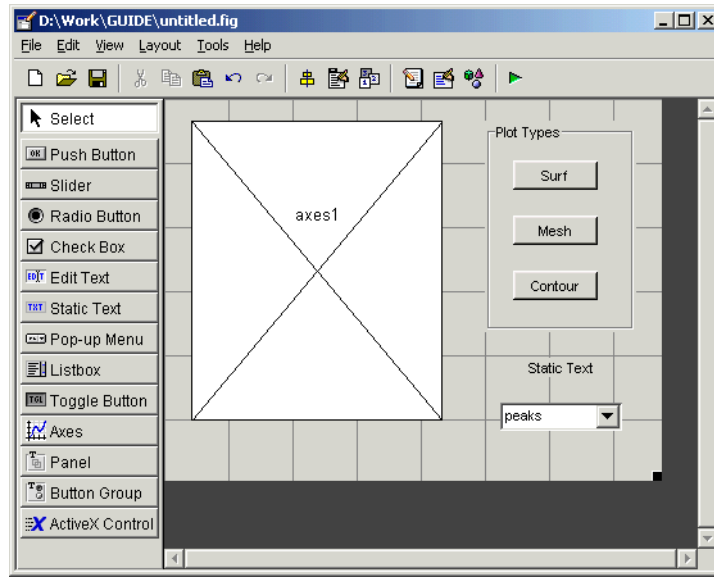
You can view the change by clicking the Layout Editor. Similarly, change the `String` property of the middle push button to `Mesh`, the bottom push button to `Contour`, and the `Static Text` to `Select Data`.

String Property for Pop-up Menus

A pop-up menu's `String` property controls the list of menu items. To set the pop-up menu items, select the pop-up menu in the Layout Editor. In the Property Inspector, click the icon next to `String`. This opens the `String` property edit box. Delete `Pop-up Menu` in the `String` property edit box, and type `peaks`, `membrane`, and `sinc` on three separate lines, as shown in the following figure.



When you click on the Layout Editor, the current layout of the GUI appears as in the following figure.



Callback Properties

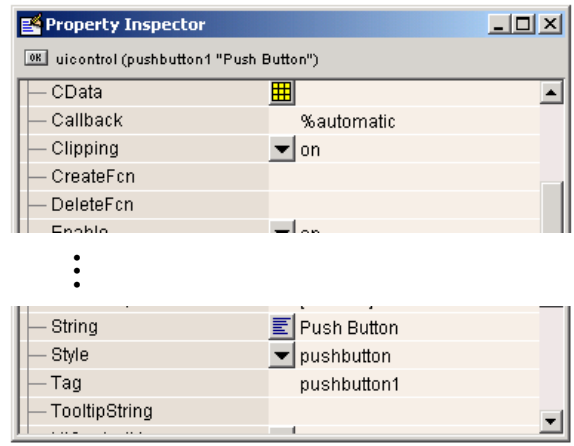
Components use *callbacks* to do their work. A callback is a function that executes when a user performs a specific action such as clicking a push button, selecting a menu item, or pressing a keyboard key, or when a component is created or deleted. Each component and menu item has properties that specify its callbacks. When you create a GUI, you must program the callbacks you need to control operation of the GUI.

A component can have many callback properties, but the most common one is the `Callback` property. The code you provide for the `Callback` property performs the primary work of the component. It executes, for example, when a user presses a push button, moves a slider, or selects a menu item. "Programming the GUI" on page 2-17 shows you how to program the `Callback` property for the push buttons and pop-up menu in this example.

The Tag Property

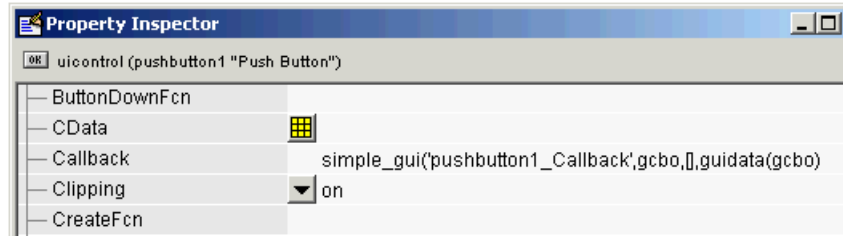
The `Tag` property provides a string as a unique identifier for each component. GUIDE uses this identifier to construct unique callback names for the different components in the GUI.

When you first add a component to a layout, GUIDE sets the value of `Tag` to a default string such as `pushbutton1`. If the component has a `Callback` property, GUIDE also sets the value of `Callback` to the string `%automatic`. The following figure shows an example.

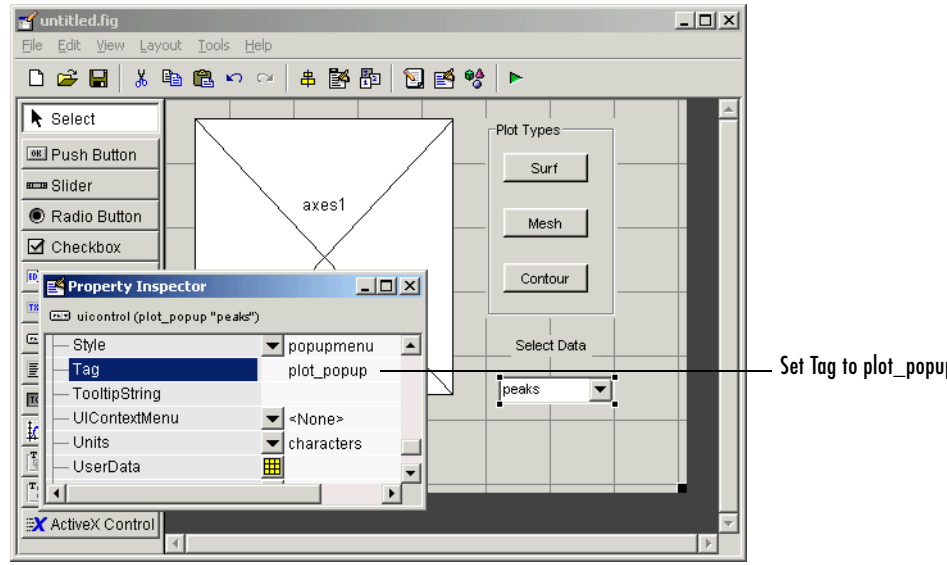


When you save or run the GUI, GUIDE generates an M-file that includes stubs for the `Callback` functions for each component that has one. GUIDE creates a unique function name for each `Callback` function in the M-file by prefixing the value of the `Tag` property to the string `_Callback`, for example, `pushbutton1_Callback`. GUIDE also changes the value of the `Callback` property to a string that is a calling sequence for the callback. For example, if the name of the GUI M-file is `simple_gui`, the new value of the `Callback` property becomes

```
untitled('pushbutton1_Callback',gcbo,[],guidata(gcbo))
```



You can redefine the value of `Tag` to be more descriptive, but the value of each `Tag` property must be unique for a given GUI. In this example, change the `Tag` property of the pop-up menu to `plot_pop-up` before you save or run the GUI for the first time. The following figure shows the new `Tag` value.



When you save or run the GUI, GUIDE sets the name of the callback subfunction in the pop-up menu `Callback` property to `plot_pop-up_Callback`. If you later change the `Tag`, GUIDE updates the `Callback` property to match the new `Tag` — see “Changing a Tag” on page 3-53.

Similarly, change the push button tags to `surf_pushbutton`, `mesh_pushbutton`, and `contour_pushbutton`.

To learn more, see “Setting Component Properties — The Property Inspector” on page 3-40.

Programming the GUI

After laying out the GUI and setting component properties, the next step is to program it. This section explains how to do that. The section covers

Creating the GUI M-File

When you first save or run the GUI, GUIDE generates a function M-file that contains the most commonly used callbacks for each component. It also contains some initialization code, an opening function callback, and an output function callback. Each callback is a subfunction that initially consists of a framework that contains just a function definition. You must add code to the callbacks to make them work.

You can save a GUI by selecting **Save** or **Save as** from the File menu, or by clicking the Save icon on the toolbar. You can run the GUI by selecting **Run** from the Tools menu or by clicking the Run icon on the toolbar.

After GUIDE generates the M-file, it opens the **Save GUI as** dialog. Type a name in the **File name** field. GUIDE assigns the same name to FIG-file and the M-file. When you click **Save**, GUIDE saves the M-file and opens it in the M-file Editor. If you are building the GUI in this example, use the filename `simple_gui`.

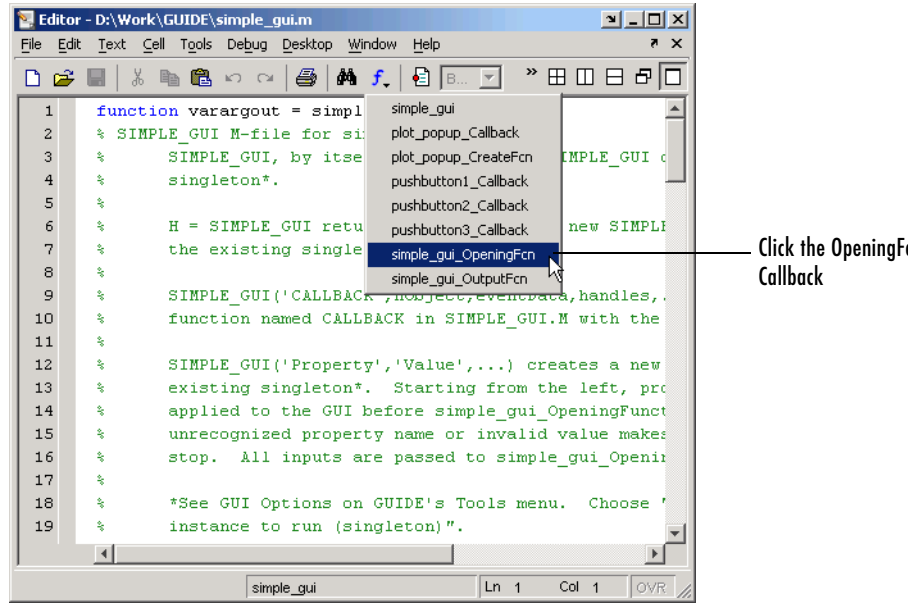
For more information, see "Understanding the GUI M-File" on page 4-2.

Opening the GUI M-File

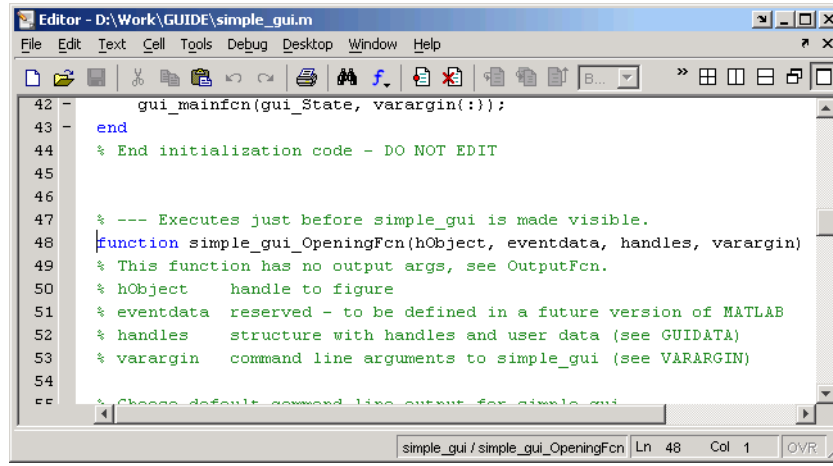
In this section you add code to the callbacks for the three push buttons and the pop-up menu.

Once GUIDE has created the M-file, you can open it in the MATLAB editor by clicking the M-file Editor icon on the toolbar. In the editor, you can move the

cursor to a specific callback by clicking the function icon on the toolbar, then selecting the callback you want in the pop-up menu that displays.



For example, clicking `simple_gui_OpeningFcn` moves the cursor to the opening function. The next topic explains how you can add code to the opening function to create data for the GUI or perform other tasks.



Sharing Data Between Callbacks

This topic describes the process for sharing data between callbacks in a GUI. Subsequent topics, “Adding Code to the Opening Function” on page 2-20 and “Adding Code to the Callbacks” on page 2-22, contain examples.

You can share data between callbacks by storing the data in the MATLAB `handles` structure. All components in a GUI share the same `handles` structure. It is passed as an input argument to all callbacks generated by GUIDE.

For example, to store data contained in vector `X` in the `handles` structure, you

1. Choose a name for the field of the `handles` structure where you want to store the data, for example, `handles.my_data`

2. Add the field to the `handles` structure and set it equal to `X` with the following statement:

   ```
   handles.my_data = X;
   ```

3. Save the `handles` structure with the `guidata` function:

   ```
   guidata(hObject,handles)
   ```

Here, `hObject` is the handle to the component object that executes the callback. The component’s object handle is passed as the input argument, `hObject`, to each of its callbacks that is generated by GUIDE.

Note To save any changes that you make to the `handles` structure, you must use the command `guidata(hObject,handles)`. It is not sufficient to just set the value of a `handles` field.

To retrieve `X` in another callback, use the command

```
X = handles.my_data;
```

You can access the data in the `handles` structure in any callback because `hObject` and `handles` are input arguments for all the callbacks generated by GUIDE.

For more detailed information on the `handles` structure, see "Managing GUI Data with the Handles Structure" on page 4-26.

Adding Code to the Opening Function

The Opening Function

The opening function is the first callback in every GUI M-file. You can use it to perform tasks that need to be done before the user has access to the GUI, for example, to create data or to read data from an external source.The code in the opening function is executed just before the GUI is made visible to the user, but after all the components have been created.

In this example, you add code that creates three data sets in the opening function, using the MATLAB functions `peaks`, `membrane`, and `sinc`.

Note that GUIDE names the opening function with the name of the M-file prefixed to `_OpeningFcn`. In this example, the M-file is named `simple_gui.m`, so that the opening function is named `simple_gui_OpeningFcn`.

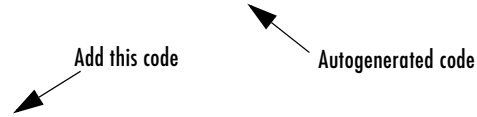
For more information about the opening function see "Opening Function" on page 4-4.

Adding the Code

To create data for the GUI to plot, add the following code to the opening function immediately after the comments following the function declaration.

```
% --- Executes just before simple_gui is made visible.
function simple_gui_OpeningFcn(hObject, eventdata, handles, varargin)
```

```
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to untitled (see VARARGIN)
```




```
% Create the data to plot
handles.peaks=peaks(35);
handles.membrane=membrane;
[x,y] = meshgrid(-8:.5:8);
r = sqrt(x.^2+y.^2) + eps;
sinc = sin(r)./r;
handles.sinc = sinc;
handles.current_data = handles.peaks;
surf(handles.current_data)
```

The first six executable lines create the data using the MATLAB functions `peaks`, `membrane` and `sinc` to generate the data.

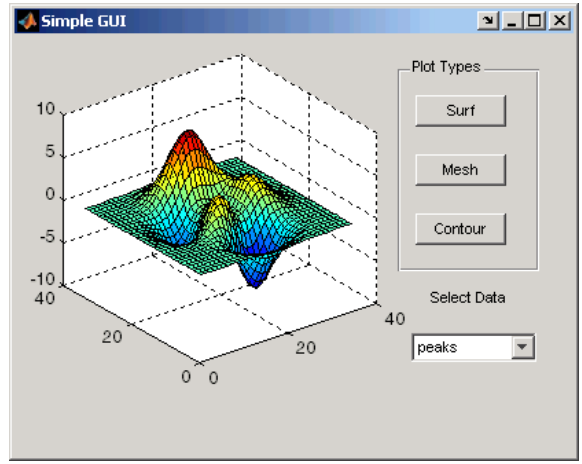
The next line, `handles.current_data = handles.peaks`, sets the `current_data` field of the handles structure equal to the data for peaks. In the example GUI, the pop-up menu displays `peaks` as the initial selection. The value of `handles.current_data` changes each time a user selects a different plot from the pop-up menu — see “Pop-up Menu Callback” on page 2-24.

The last line displays the surf plot for peaks, which appears when the GUI is first opened.

GUIDE automatically generates two more lines of code in the opening function, which follow the code that you add:

- `handles.output = hObject` saves the handle to the GUI for later access by the output function. While this command is not necessary in this example, it is useful if you want to return the GUI handle to the command line. For more information about the output function see “Output Function” on page 4-5.
- `guidata(hObject,handles)` saves the `handles` structure.

The following figure shows how the GUI now looks when it first displays.



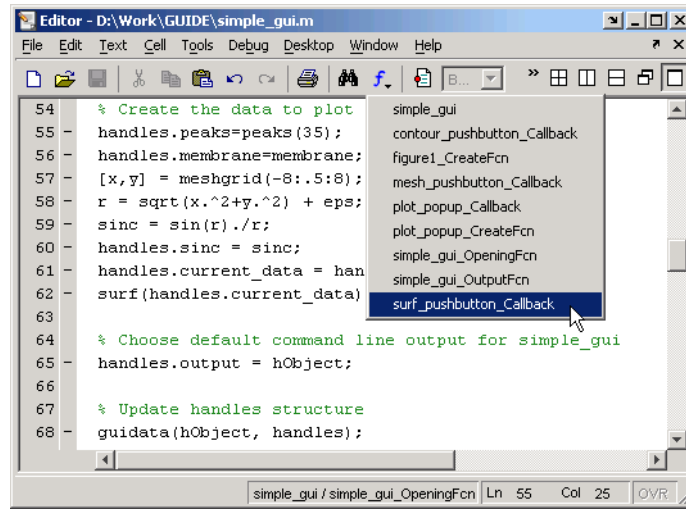
Adding Code to the Callbacks

When the GUI is completed and running, and a user clicks a user interface control, such as a push button, MATLAB executes the callback specified by the component's `Callback` property. In the example, the name of the **Surf** push button callback is `surf_pushbutton_Callback`. For information about the naming of callbacks see "The Tag Property" on page 2-14.

This section describes how to add the code for the callbacks.

Push Button Callbacks

Each of the push buttons creates a different type of plot using the data specified by the current selection in the pop-up menu. Their callbacks get data from the `handles` structure and then plot it. To add code to the surf push button callback, click `surf_pushbutton_Callback` in the callback pop-up menu.



Add the code after the comments following the function definition, as shown below:

Surf push button callback:

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

Add this code

Autogenerated code

```
% Display surf plot of the currently selected data
surf(handles.current_data);
```

You can add similar code to the **Mesh** and **Contour** push button callbacks after the autogenerated code.

Add this code to the **Mesh** push button callback:

```
% Display mesh plot of the currently selected data
mesh(handles.current_data);
```

Add this code to the **Contour** push button callback:

```
% Display contour plot of the currently selected data
contour(handles.current_data);
```

Pop-up Menu Callback

The pop-up menu enables users to select the data to plot. Every time a user selects one of the three plots, the pop-up menu callback reads the pop-up menu `Value` property to determine what item is currently displayed and sets `handles.current_data` accordingly. Add the following code to the `plot_popup_Callback` after the comments following the function definition.

```
% --- Executes on selection change in data_popup.
function plot_popup_Callback(hObject, eventdata, handles)
% hObject    handle to surf_pushbutton (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
```

Autogenerated code

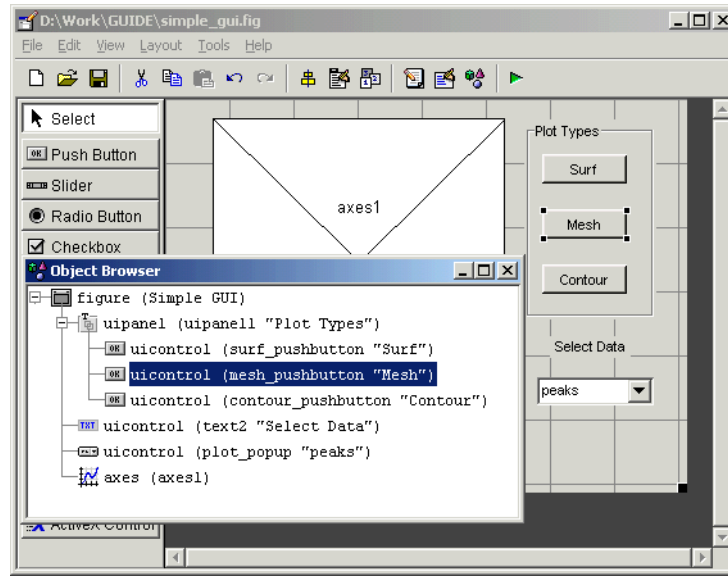
Add this code

```
val = get(hObject,'Value');
str = get(hObject, 'String');
switch str{val};
case 'peaks' % User selects peaks
   handles.current_data = handles.peaks;
case 'membrane' % User selects membrane
   handles.current_data = handles.membrane;
case 'sinc' % User selects sinc
   handles.current_data = handles.sinc;
end
guidata(hObject,handles)
```

Using the Object Browser to Identify Callbacks

In this example, it is easy to keep track of the GUI component that corresponds to each callback. But in a more complicated GUI, keeping track of callbacks can be more difficult. To identify the component corresponding to a callback, select **Object Browser** from the **View** menu in the Layout Editor or by clicking the Object Browser icon on the toolbar. This displays the Object Browser as shown in the following figure. The Object Browser lists the `tag` and `string`

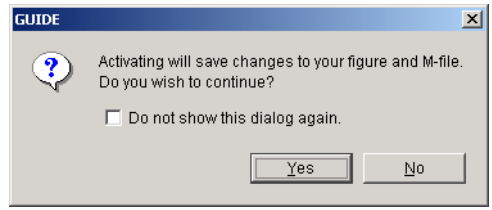
properties of each component of the GUI. Selecting the name of a component in the list also selects the component in the Layout Editor. For example, in the following figure, the `uicontrol (mesh_pushbutton Mesh )` is selected in the Object Browser. The tag `mesh_pushbutton` corresponds to the callback `mesh_pushbutton_Callback`. Note that the corresponding component, the mesh push button, is also selected in the Layout Editor.



To learn more about programming GUIs in GUIDE, see Chapter 4, “Programming GUIs.”

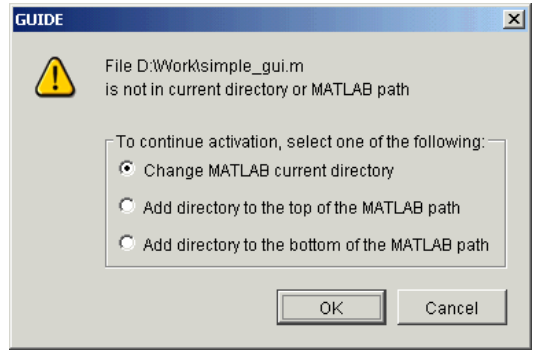
Saving and Running a GUI

After writing the callbacks, you can run the GUI by selecting **Run** from the **Tools** menu or clicking the **Run** button on the GUIDE toolbar. If you have not saved the GUI recently, GUIDE displays the following dialog box.

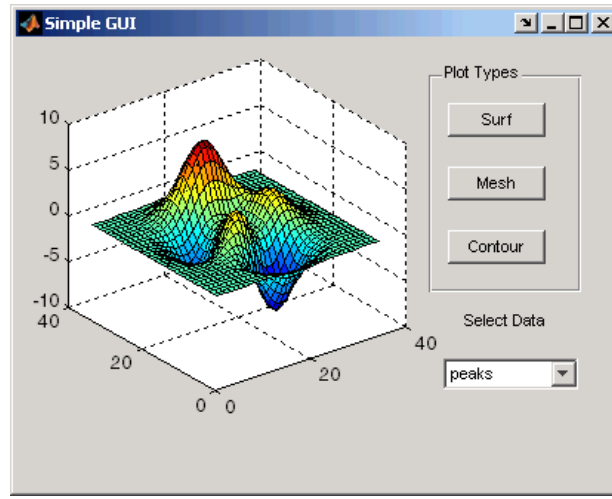


If this happens, click **Yes** and then save the GUI files to a writable directory.

If the directory where you save the GUI is not on the MATLAB path, GUIDE opens the following dialog, giving you the option of changing the current working directory to the directory containing the GUI files, or adding that directory to the MATLAB path.

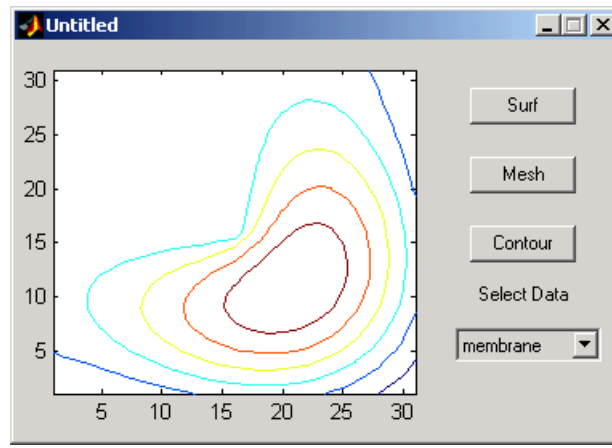


Click **OK** to change the current working directory. GUIDE then opens the GUI as shown in the following figure.



Note The name of the FIG-file saved by the Layout Editor and the generated M-file must match. See "Renaming GUI Files" if you want to rename files after first activating the GUI.

Next, select **membrane** in the pop-up menu and click the **Contour** push button. The GUI should look like the following figure.



Try experimenting with this GUI by adding another data set in the opening function, and a push button that displays a plot of the data set. Make sure to add the name of the new data set to the pop-up menu as well.

For more examples of creating GUIs with GUIDE, see the following sections:

- “GUI Applications” on page 5-1
- “Using GUIDE Templates” on page 3-2

3

Laying Out GUIs and Setting Properties

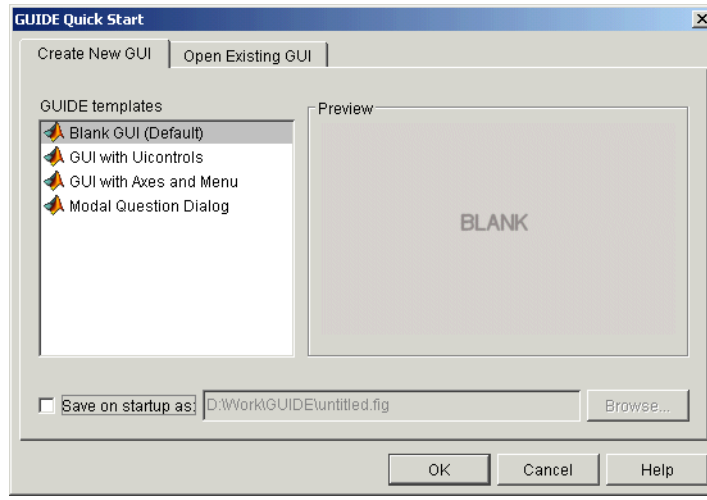
Using GUIDE Templates

GUIDE provides several templates, which are simple examples that you can modify to create your own GUIs. The templates are fully functional GUIs: their callbacks are already programmed. You can view the code for these callbacks to see how they work, and then modify the callbacks for your own purposes.

You can access the templates in two ways:

- Start GUIDE by entering `guide` at the MATLAB prompt.
- If GUIDE is already open, select **New** from the **File** menu in the Layout Editor.

Starting GUIDE displays the **GUIDE Quick Start** dialog as shown in the following figure.



The **Quick Start** dialog gives you two options:

- Select the **Open Existing GUI** tab and open a GUI that you have already created.
- Select the **Create New GUI** tab and open one of the templates.

The preceding figure shows the **Quick Start** dialog with the **Create New GUI** tab selected. Selecting a template in the left pane displays a preview in the

right pane. Clicking **OK** opens the GUI template in the Layout Editor. If you select **Save on startup as** and type in name in the field to the right, GUIDE saves the GUI before opening it in the Layout Editor. If you choose not to save the GUI at this point, GUIDE prompts you to save it the first time you run the GUI.

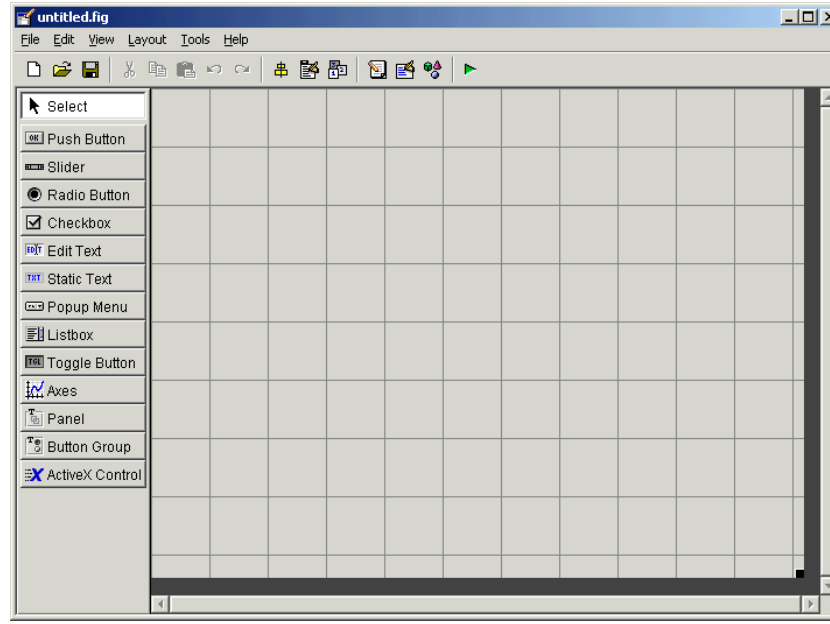
GUIDE provides four templates, which are described in the following sections:

- "Blank GUI" on page 3-3
- "GUI with Uicontrols" on page 3-4
- "GUI with Axes and Menu" on page 3-5
- "Modal Question Dialog" on page 3-6

To view the M-file for any of these templates, open the template in the Layout Editor and click the M-file Editor icon on the toolbar.

Blank GUI

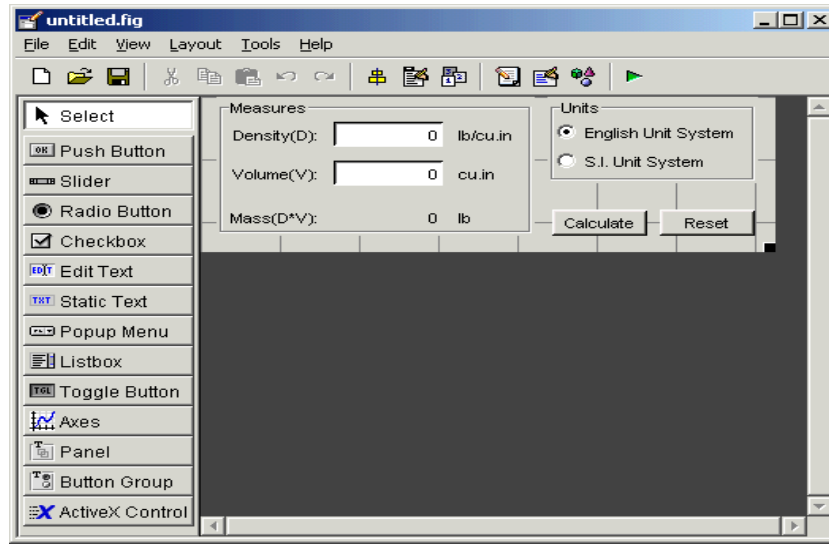
The blank GUI template displayed in the Layout Editor is shown in the following figure.



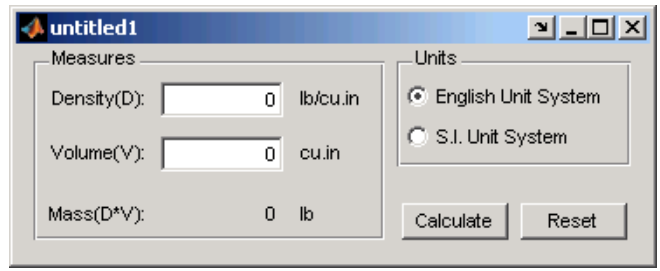
Select the blank GUI if the other templates are not suitable starting points for the GUI you are creating, or if you prefer to start with an empty GUI.

GUI with Uicontrols

The following figure shows the GUI with Uicontrols template displayed in the Layout Editor.



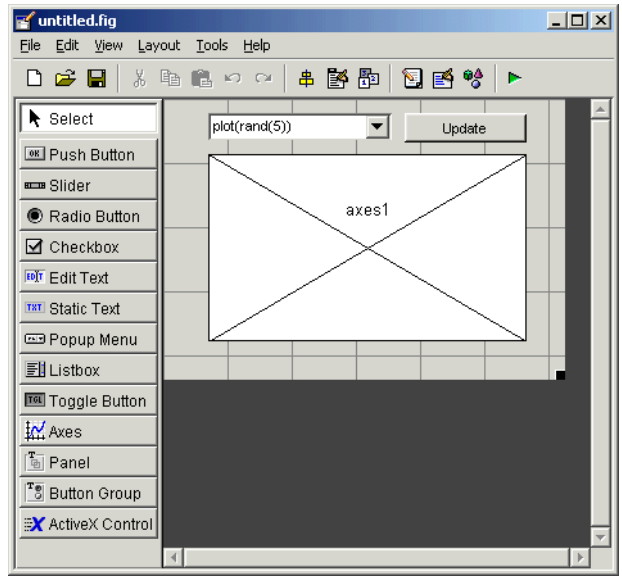
When you run the GUI by clicking the Run icon , the GUI appears as shown in the following figure.



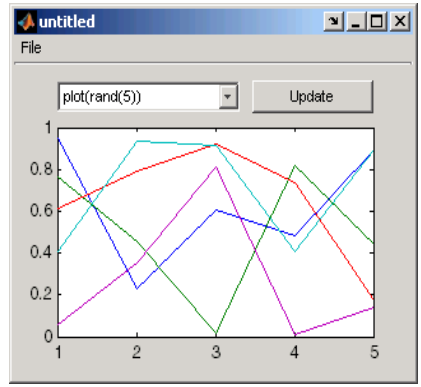
When a user enters values for the density and volume of an object, and clicks the **Calculate** button, the GUI calculates the mass of the object and displays the result next to `Mass(D*V)`.

GUI with Axes and Menu

The GUI with axes and menu template is shown in the following figure.



When you run the GUI by clicking the Run icon on the toolbar, the GUI displays a plot of five random numbers generated by the MATLAB `rand(5)` command, as shown in the following figure.



You can select other plots in the pop-up menu. Clicking the **Update** button displays the currently selected plot on the axes.

The GUI also has a **File** menu with three items:

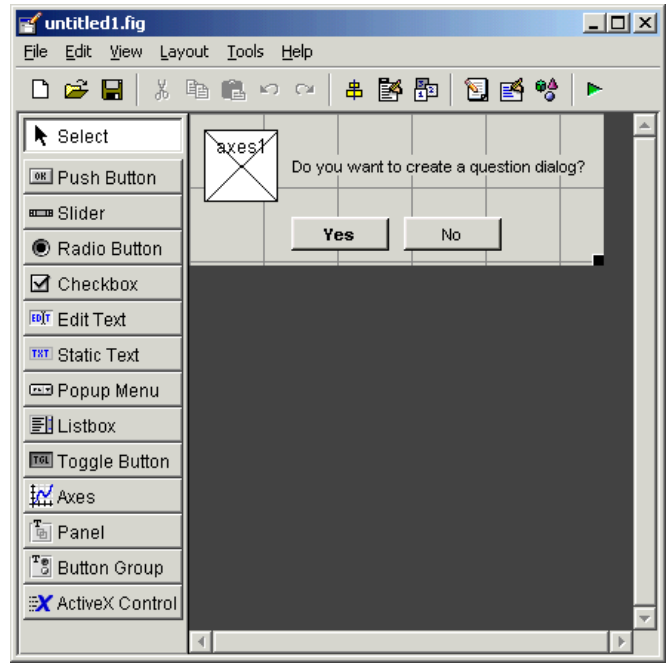
- Selecting **Open** displays a dialog from which you can open files on your computer.
- Selecting **Print** executes the `printdlg` command, which opens the **Print** dialog:

  ```
  printdlg(handles.figure1)
  ```

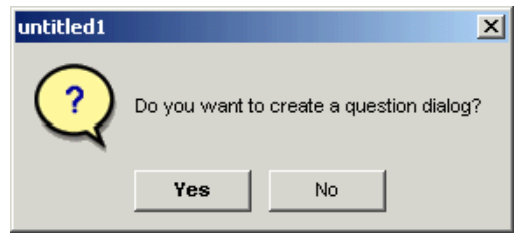
  Note that `handles.figure1` contains the current plot. Clicking **Yes** in the **Print** dialog prints the plot.
- Selecting **Close** closes the GUI.

Modal Question Dialog

The modal question dialog template displayed in the Layout Editor is shown in the following figure.



Running the GUI displays the dialog shown in the following figure:



The GUI returns the text string `Yes` or `No`, depending on which button you press. The GUI is *blocking*, which means that the current M-file stops executing until the GUI restores execution. You can make a GUI blocking by adding the following command to the opening function:

```
uiwait(handles.figure1);
```

To restore access to other MATLAB windows once a button is clicked, add the following command to callbacks for both the **Yes** and **No** push buttons:

```
uiresume(handles.figure1);
```

The GUI is also *modal,* which means that the user cannot interact with other MATLAB windows until clicking one of the buttons. See “Using Modal Figure Windows” on page 4-38 for more information on making a GUI modal.

Select this template if you want your GUI to return a string or to be modal.

See “Example: Using the Modal Dialog to Confirm an Operation” on page 4-40 for an example of using this template with another GUI.

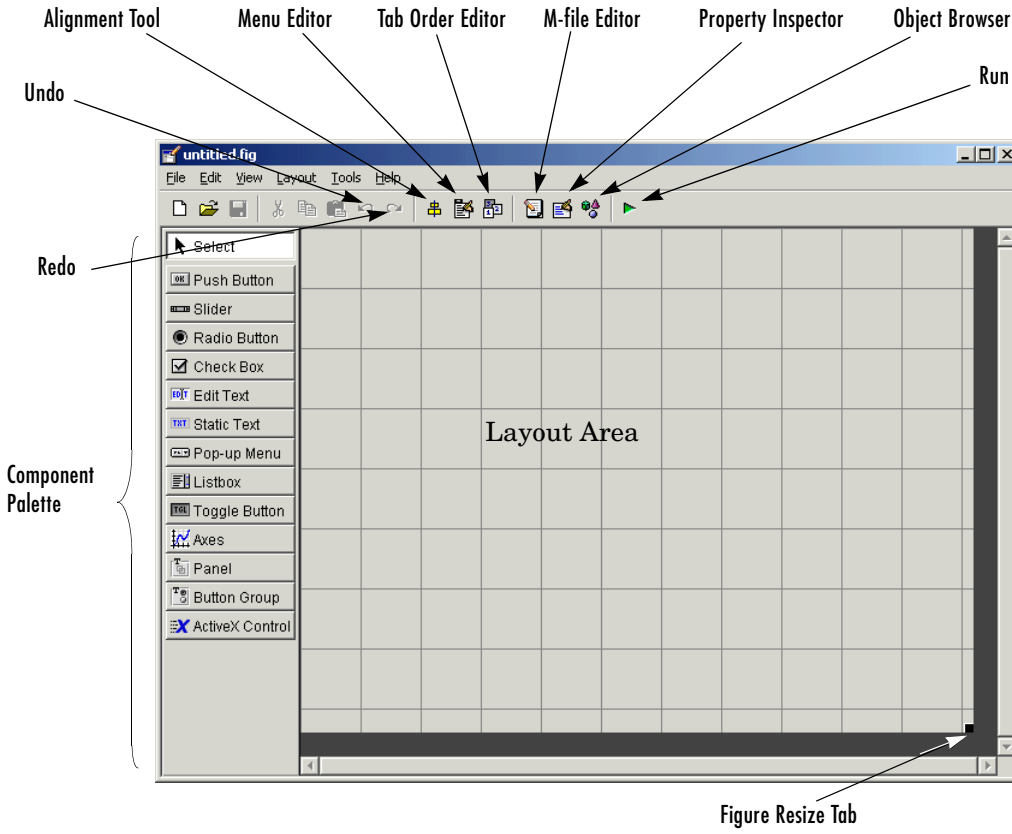
Using the Layout Editor

The Layout Editor enables you to select GUI components from the *component palette*, at the left side of Layout Editor, and arrange them in the layout area, to the right. When you click the **Run** icon , the functioning GUI appears outside the Layout Editor.

This section covers the following topics:

Starting the Layout Editor

To start the Layout Editor, first open the GUIDE Quick Start dialog by entering `guide` at the MATLAB prompt. Click **OK** in the dialog to open a blank GUI template in the Layout Editor, as shown in the following picture.



If you want to load an existing GUI for editing, type

```
guide filename.fig
```

or use **Open** from the **File** menu on the Layout Editor.

Selecting Components from the Component Palette

The component palette at the left of the Layout Editor contains the components that you can add to your GUI. This section describes these components.

After selecting the components for your GUI and placing them in the layout area, you need to set their properties and program their callbacks. The following sections describe how to do this:

- "Setting Component Properties — The Property Inspector" on page 3-40
- "Programming Callbacks for GUI Components" on page 4-8

Push Button

Push buttons generate an action when clicked. For example, an **OK** button might close a dialog box and apply settings. When you click a push button, it appears depressed; when you release the mouse, the button appears raised and its callback executes.

Toggle Button

Toggle buttons generate an action and indicate whether they are turned on or off. When you click a toggle button, it appears depressed, showing that it is on. When you release the mouse button, the toggle button's callback executes. However, unlike a push button, the toggle button remains depressed until you click the toggle button a second time. When you do so, the button returns to the raised state, showing that it is off, and again executes its callback.

Radio Button

Radio buttons are similar to check boxes, but are typically mutually exclusive within a group of related radio buttons. That is, you can select only one button at any given time. To activate a radio button, click the mouse button on the object. The display indicates the state of the button.

Check Box

Check boxes generate an action when checked and indicate their state as checked or not checked. Check boxes are useful when providing the user with a number of independent choices that set a mode, for example, displaying a toolbar or generating callback function prototypes.

Edit Text

Edit text controls are fields that enable users to enter or modify text strings. Use edit text when you want text as input. The `String` property contains the text entered by the user. The callback executes when you press **Enter** for a

single-line edit text, **Ctl+Enter** for a multi-line edit text, or the focus moves away.

Static Text

Static text controls display lines of text. Static text is typically used to label other controls, provide directions to the user, or indicate values associated with a slider. Users cannot change static text interactively and there is no way to invoke the callback routine associated with it.

Slider

Sliders accept numeric input within a specific range by enabling the user to move a sliding bar, which is called a slider or thumb. Users move the slider by pressing the mouse button and dragging the slider, by clicking in the trough, or by clicking an arrow. The location of the slider indicates a percentage of the specified range.

List Box

List boxes display a list of items and enable users to select one or more items.

Pop-Up Menu

Pop-up menus open to display a list of choices when users click the arrow.

Axes

Axes enable your GUI to display graphics (e.g., graphs and images). Like all graphics objects, axes have properties that you can set to control many aspects of its behavior and appearance. See “Axes Properties” in the MATLAB Graphics documentation for more information on axes objects.

Panel

Panels group GUI components. Panels can make a user interface easier to understand by visually grouping related controls. A panel can have a title and various borders.

Panel children can be panels and button groups as well as axes and user interface controls. The position of each component within a panel is interpreted relative to the panel. If you move the panel, its children move with it and maintain their positions on the panel.

Button Group

Button groups are like panels but can be used to manage exclusive selection behavior for radio buttons and toggle buttons.

For radio buttons and toggle buttons that are managed by a button group, you must include the code to control them in the button group's `SelectionChangeFcn` callback function, not in the individual uicontrol `Callback` functions. A button group overwrites the `Callback` properties of radio buttons and toggle buttons that it manages.

ActiveX Component

ActiveX components enable you to display ActiveX controls in your GUI. See "Adding an ActiveX Control to a GUI" on page 4-17 for an example.

Note Only figures can have child ActiveX components. Panels and button groups cannot.

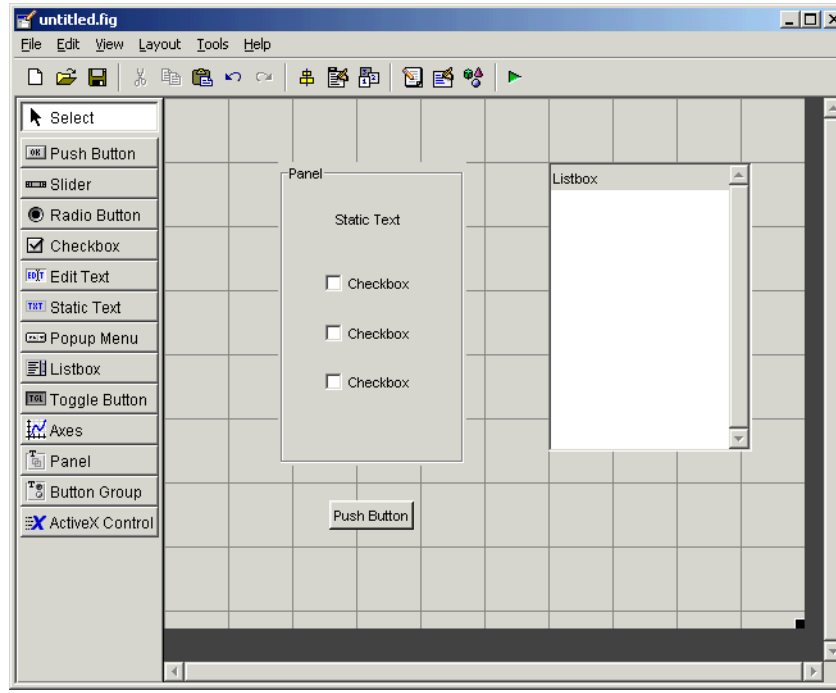
ActiveX components are available only on the Microsoft Windows platform.

Adding Components to the Layout Area

You can place a component in the layout area in one of these ways:

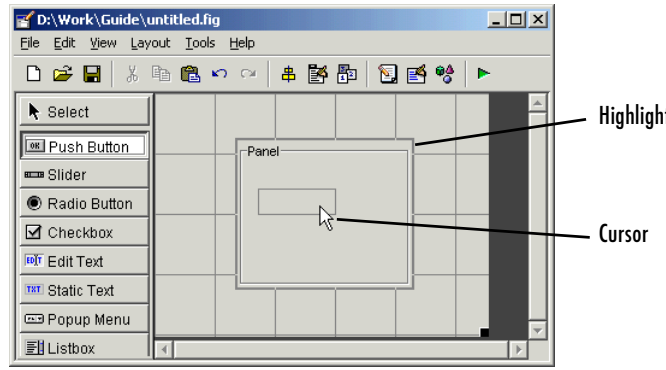
- Drag the component from the component palette into the layout area and drop it.
- Select the component in the component palette. The cursor changes to a cross.
  - Place the cursor in the layout area where you want the upper-left corner of the component to be and click.
  - Place the cursor in the layout area where you want the upper-left corner of the component to be, then set the size of the control by clicking and dragging the cursor to the lower-left corner before releasing the mouse button.

This is an example of a GUI in the Layout Editor. Note that components in the Layout Editor are not active. "Running the GUI" on page 3-19describes how to generate a functioning GUI.

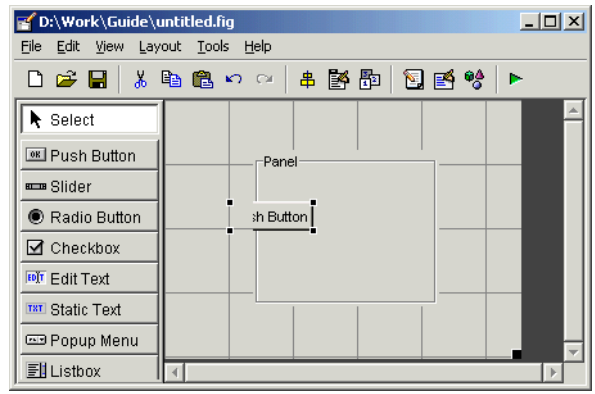


Adding a Component to a Panel or Button Group

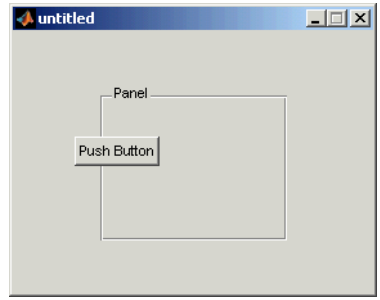
To add a component to a panel or button group, select the component in the component palette then move the cursor over the desired panel or button group. The position of the cursor determines the component's parent. Notice that GUIDE highlights the potential parent as shown in the following figure. The highlight indicates that if you drop the component or click the cursor, the component will be a child of the highlighted panel or button group.



If the component is not entirely contained in the panel or button group, it appears to be clipped in the layout editor.



When you run the GUI, the entire component is displayed and straddles the panel or button group border. The component is nevertheless a child of the panel and behaves accordingly.



You can use the Object Browser to determine the child objects of a panel or button group. “Viewing the Object Hierarchy — The Object Browser” on page 3-56 tells you how.

Adding an ActiveX Control

When you drag an ActiveX component from the component palette into the layout area, GUIDE opens a dialog that lists all the registered ActiveX controls on your system. When you select an ActiveX control and click **Create**, the control appears as a small box in the Layout Editor.

Note The available ActiveX controls vary on different systems. An ActiveX control can be the child of a figure only. It cannot be the child of a panel or button group.

Working with Components in the Layout Area

This topic provides basic information about selecting, moving, copying, and deleting components in the layout area.

Other topics that may be of interest are

- “Aligning Components in the Layout Editor” on page 3-34
- “Front-to-Back Positioning” on page 3-38
- “Setting the Tab Order — The Tab Order Editor” on page 3-69

Selecting Components

You can select components in the layout area in the following ways.

- Click a single component to select it.
- Press **Ctrl+A** to select all child objects of the figure. This does not select components that are child objects of panels or button groups.
- Click and drag the cursor to create a rectangle that encloses the components you want to select. If the rectangle encloses a panel or button group, only the panel or button group is selected, not its children. If the rectangle encloses part of a panel or button group, only the components within the rectangle that are child objects of the panel or button group are selected.
- Select multiple components using the **Shift** and **Ctrl** keys.

Note You can select multiple components only if they have the same parent. Use the Object Browser to determine the child objects of a figure, panel, or button group. "Viewing the Object Hierarchy — The Object Browser" on page 3-56 tells you how.

Moving Components

Select one or more components that you want to move, then do one of the following:

- Drag the selected components to the desired position and drop them. You can move components from the figure into a panel or button group. You can move components from a panel or button group into the figure or into another panel or button group.

  The position of the cursor when you drop the components determines the parent of all the selected components. Look for the highlight as described in "Adding a Component to a Panel or Button Group" on page 3-14.

  In some cases, one or more of the selected components may lie outside its parent's boundary. Such a component is not visible in the Layout Editor but can be selected by dragging a rectangle that encloses it. It is visible, however, in the active GUI.

- Press and hold the arrow keys until the components have moved to the desired position. Note that the components remain children of the figure,

panel, or button group from which you move them, even if they move outside its boundaries.

Copying, Cutting, and Clearing Components

Use standard menu and pop-up menu commands, toolbar icons, keyboard keys, and shortcut keys to copy, cut, and clear components.

Copying. Copying places a copy of the selected components on the clipboard. A copy of a panel or button group includes its children.

Cutting. Cutting places a copy of the selected components on the clipboard and deletes them from the layout area. If you cut a panel or button group, you also cut all its children.

Clearing. Clearing deletes the selected components from the layout area. It does not place a copy of the components on the clipboard.

Pasting and Duplicating Components

Pasting. Use standard menu and pop-up menu commands, toolbar icons, and short-cut keys to paste components. GUIDE pastes the contents of the clipboard to the upper-left corner (location [0,0]) of the

- Figure, if no components are selected
- Parent of a selected component, if the component is not a panel or button group
- Panel or button group, if only one panel or button group is selected
- Parent of two or more selected components, even if one is a panel or button group

Consecutive pastes place each copy to the lower right of the last one.

Duplicating. Select one or more components that you want to duplicate, then do one of the following:

- Copy and paste the selected components as described above.
- Select **Duplicate** from the **Edit** menu or the pop-up menu. **Duplicate** places the copy to the lower right of the original.

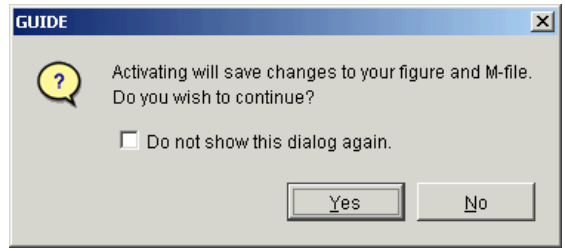
- Right-click and drag the component to the desired location. The position of the cursor when you drop the components determines the parent of all the selected components. Look for the highlight as described in “Adding a Component to a Panel or Button Group” on page 3-14.

Running the GUI

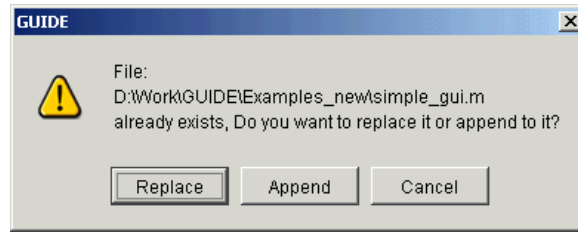
To run the GUI you design in the Layout Editor, select **Run** in the **Tools** menu or click the **Run** icon on the toolbar.

When you run a GUI, the following occurs:

- GUIDE first prompts you to save both the M-file and FIG-file with the dialog shown in the following figure.



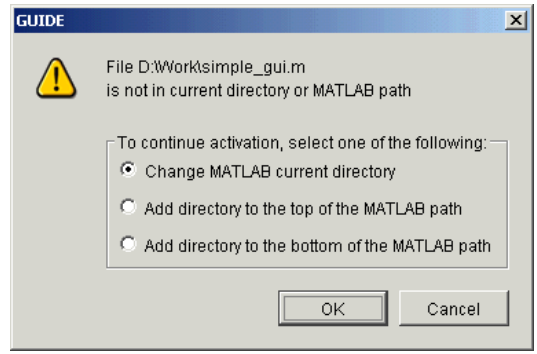
- If you click **Yes** and you have not saved the GUI previously, GUIDE opens a **Save As** dialog box so you can select a name for both the FIG-file and the M-file GUIDE generates.
- When you click **Save** in the **Save As** dialog box, GUIDE saves the FIG-file with the same name as the M-file, but with a `.fig` extension.
- If an M-file with the same name exists, GUIDE prompts you to replace or append to the existing code in the M-file.



Replace — writes over the existing file.

Append — inserts new callbacks for components added since the last save and make changes to the code based on change made from the Application Options dialog.

- If the directory in which you saved the GUI is not on the MATLAB path, GUIDE opens a dialog box with three options, as shown in the following figure.



Change MATLAB current directory — changes the MATLAB current directory to the directory where you saved the GUI.

Add directory to the top of the MATLAB path — adds the directory where you saved the GUI to the top of the MATLAB path.

Add directory to the bottom of the MATLAB path — adds the directory where you saved the GUI to the bottom of the MATLAB path.

- MATLAB executes the M-file to display the GUI. The options specified in the Application Options dialog are functional in the GUI.

Note GUIDE automatically saves both the M-file and the FIG-file when you run the GUI.

Saving the Layout

Once you have created the GUI layout, you can save it as a FIG-file (a binary file that saves the contents of a figure) using the **Save** or **Save As** item from the **File** menu. GUIDE generates the M-file automatically when you save or run the figure.

Renaming GUI Files

Use **Save As** from the Layout Editor **File** menu to rename the GUI FIG-file. GUIDE renames the FIG-file and the GUI M-file and also resets the callback properties to properly execute the callbacks.

Exporting a GUI to a Single M-File

You can export a GUI from GUIDE to a single M-file that does not require a FIG-file. This enables you to

- View the layout code for the GUI
- Run the GUI in MATLAB 6.1

Note If the GUI contains a panel or a button group, you will not be able to run it in MATLAB versions earlier than 7.0.

To export your GUI, do the following steps:

1. Save the GUI in GUIDE, if you have not already done so.
2. Select **Export** from the **File** menu. If you changed the GUI since you last saved it, this opens a dialog informing you that exporting will save changes to your figure and M-file, and asking if you want to continue.
3. Click **OK** in the confirmation dialog.

4 Save the exported M-file in the **Save As** dialog. By default, GUIDE gives the exported M-file the name of the GUI M-file with `_export` appended.

Note If you save a large data set in the GUI figure or in a uicontrol, GUIDE might also export a MAT-file containing the data in addition to exporting an M-file. For example, the data could be saved in a figure or uicontrol `UserData` property, or in a figure `Colormap` property. The name of the MAT-file is the same as the exported M-file except for the extension `.mat`.

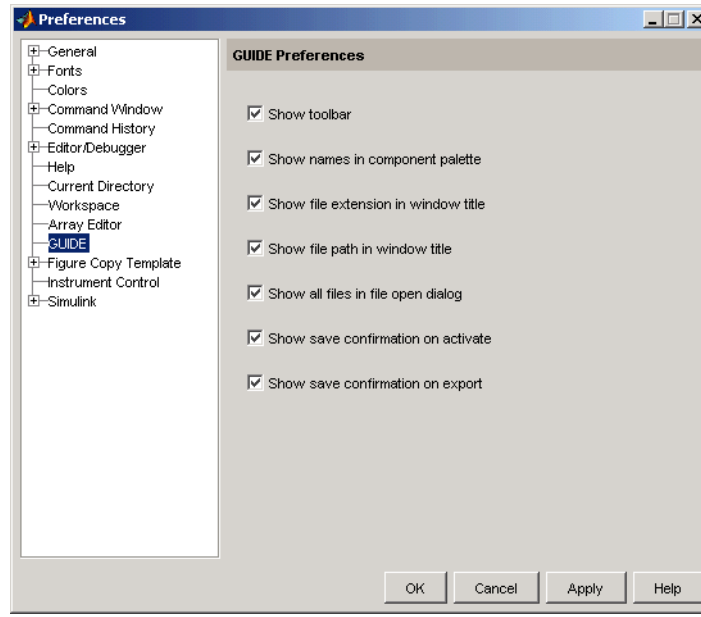
Displaying the GUI

You can display the GUI figure using the `openfig`, `open`, or `hgload` command. These commands load FIG-files into the MATLAB workspace. Note that the displayed GUI is not active.

Generally, however, you launch your GUI by executing the M-file that GUIDE generates. This M-file contains the commands to load the GUI and provides a framework for the component callbacks. See "Configuring the GUI M-File" on page 3-25 for more information.

Layout Editor Preferences

You can set preferences for the Layout Editor by selecting **Preferences** from the **File** menu.



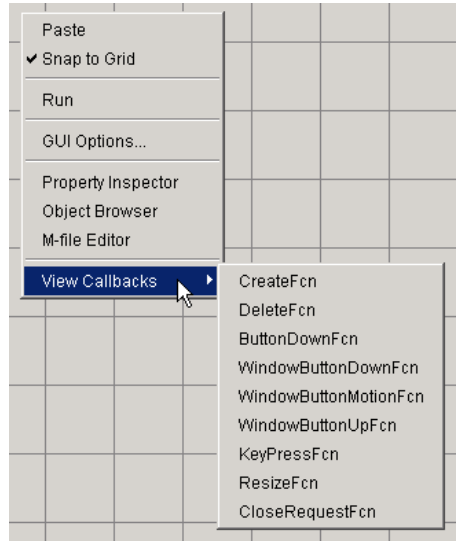
Layout Editor Context Menus

When working in the Layout Editor, you can select an object with the left mouse button and then click the right button to display a context menu.

Like the **View** menu in the Layout Editor, these context menus enable you to add a callback subfunction to your GUI M-file for any of the object properties that define callback routines. See “Callback Properties” on page 3-51 for more information.

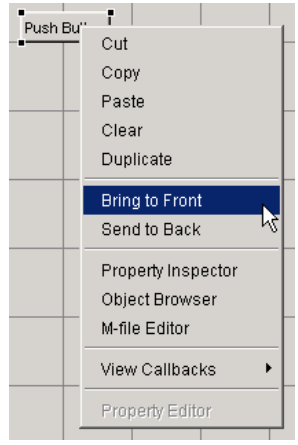
Figure Context Menus

The following picture shows the context menu associated with a figure object. Note that all properties that define callback routines for figures are listed in the submenu.



Component Context Menus

The following picture shows the context menu associated with user interface control components, as well as with axes, panels, and button groups. The callback properties listed in the **View Callbacks** submenu differ for different components.

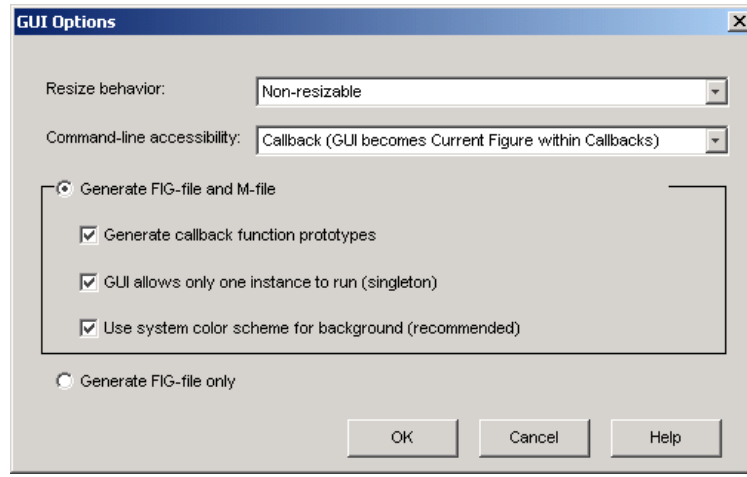


Selecting GUI Options

After opening a new GUI template in the Layout Editor, but before saving the GUI, you can configure the GUI using the **GUI Options** dialog. Access the dialog by selecting **GUI Options** from the Layout Editor **Tools** menu.

Configuring the GUI M-File

The **GUI Options** dialog enables you to select whether you want GUIDE to generate only a FIG-file for your layout or both a FIG-file and an M-file. You can also select a number of different behaviors for your GUI.



The following sections describe the options in this dialog:

Resize Behavior

You can control whether users can resize the figure window containing your GUI and how MATLAB handles resizing. GUIDE provides three options:

- **Non-resizable** — Users cannot change the window size (default).
- **Proportional** — MATLAB automatically rescales the components in the GUI in proportion to the new figure window size.
- **Other (Use ResizeFcn)** — Program the GUI to behave in a certain way when users resize the figure window.

The first two approaches simply set properties appropriately and require no other action. **Other (Use ResizeFcn)** requires you to write a callback routine that recalculates sizes and positions of the components based on the new figure size. The following sections discuss each approach.

Making Your GUI Nonresizable

Certain types of GUIs are typically nonresizable. Warning and simple question dialog boxes, particularly modal windows, are usually not resizable. After a simple interaction, users dismiss these GUIs so changing their size is not necessary.

Property Settings. GUIDE sets the following properties to create nonresizable GUIs:

- `Units` properties of the figure, axes, user interface controls, panels, and button groups are set to `characters` (the Layout Editor default) so the GUI displays at the correct size on different computers.
- `Resize` figure property is set to `off`.
- `ResizeFcn` figure property is left unset.

Allowing Proportional GUI Resizing

Use this approach if you want to allow users to resize the GUI and are satisfied with a behavior that simply scales each component's size and relative position in proportion to the new figure size. Note that the font size of component labels does not resize and, if the size is reduced enough, these labels may become unreadable. This approach works well with simple GUI tools and dialog boxes that apply settings without closing.

Property Settings. GUIDE sets the following properties to create proportional resizing GUIs:

- `Units` properties of the axes, user interface controls, panels, and button groups are set to `normalized` so that these components resize and reposition as the figure window changes size.
- `Units` property of the figure is set to `characters` so the GUI displays at the correct size at run-time, based on any changes in font size.
- `Resize` figure property set to `on` (the default).
- `ResizeFcn` figure property is left unset.

User-Specified Resize Operation

You can create GUIs that accommodate resizing, while at the same time maintain the appearance and usability of your original design by programming the figure `ResizeFcn` callback routine. This callback routine allows you to recalculate the size and position of each component based on the new figure size.

This approach to handling figure resizing is used most typically in GUI-based applications that require user interaction on an ongoing basis. Such an application might contain axes for displaying data and various components whose position and size are critical to the successful use of the interface.

Property Settings. GUIDE sets the following properties to implement this style of GUI:

- `Units` properties of the figure, axes, user interface controls, panels, and button groups are set to `characters` so the GUI displays at the correct size at run-time.
- `Resize` figure property is set to `on` (the default).
- `ResizeFcn` figure property requires a callback routine to handle resizing.

See “The Address Book Resize Function” on page 5-43 for an example of a user-written resize function.

Command-Line Accessibility

You can restrict access to the GUI figure handle from the command line with the **Command-line accessibility** options. This prevents users from inadvertently changing the appearance of the GUI by entering commands,

such as `plot`, that alter the current figure. With the default option, which is **Callback (GUI becomes Current Figure within Callbacks)**, the GUI can become the MATLAB current figure, by the command `gcf`, only while a callback is executing.

There may be occasions when you want the GUI figure handle to be accessible from the command line. For example, you might want the GUI to display plots created at the command line. In this case, you should select **On (GUI may become Current Figure from Command Line)**.

Access Options

There are four options for **Command-line accessibility**:

- **Callback (GUI becomes Current Figure within Callbacks)**
- **Off (GUI never becomes Current Figure)**
- **On (GUI may become Current Figure from Command Line)**
- **Other (Use settings from Property Inspector)**

The following table summarizes how the four **Command-line accessibility** options configure `HandleVisibility` and `IntegerHandle` in the Property Inspector (see Figure Properties That Control Access):

Option	Handle Visibility	Integer Handle
Callback	`Callback`	`off`
Off	`off`	`off`
On	`on`	`on`
Other	user specifies	user specifies

Figure Properties That Control Access

There are two figure properties that control command-line accessibility of the figure:

- `HandleVisibility` — Determines whether the figure's handle is visible to commands that attempt to access the current figure.
- `IntegerHandle` — Determines if a figure's handle is an integer or a floating-point value.

HandleVisibility — Callback. Setting `HandleVisibility` to `callback` causes handles to be visible from within callback routines or functions invoked by callback routines, but not from within functions invoked from the command line. This provides a means to protect GUIs from command-line users, while allowing callback routines to have complete access to object handles. You should use this option if your GUI contains axes.

HandleVisibility — Off. Setting the `HandleVisibility` property to `off` removes the handle of the figure from the list of root object children so it will not become the current figure (which is the target for graphics output). The handle remains valid, however, so a command that specifies the handle explicitly still works (such as `close(1)`). However, you cannot use commands that operate only on the current figure or axes. These commands include `xlabel`, `ylabel`, `zlabel`, `title`, `gca`, `gcf`, and `findobj`.

HandleVisibility — On. Handles are always visible when `HandleVisibility` is `on`.

IntegerHandle. Setting the `IntegerHandle` property to `off` causes MATLAB to assign nonreusable real-number handles (e.g., 67.0001221...) instead of integers. This greatly reduces the likelihood of someone accidently performing an operation on the figure.

Using findobj

When you set the **Command-line accessibility** to `off`, the handle of the GUI figure is hidden. This means you cannot use `findobj` to locate the handles of the uicontrols in the GUI. As an alternative, the GUI M-file creates an object `handle` structure that contains the `handles` of each uicontrol in the GUI and passes this structure to subfunctions.

Generate FIG-File and M-File

Select **Generate FIG-file and M-file** in the **GUI Options** dialog if you want GUIDE to create both the FIG-file and the GUI M-file (this is the default). Once you have selected this option, you can select any of the following items in the frame to configure the M-file:

- Generate callback function prototypes
- Application allows only one instance to run (singleton)
- Use system color scheme for background

Generate Callback Function Prototypes

When you select **Generate callback function prototypes** in the **GUI Options** dialog, GUIDE adds the most commonly used subfunctions to the GUI M-file for any component you add to the GUI. You must then write the code for the callback in this subfunction.

GUIDE also adds a subfunction whenever you edit a callback routine from the Layout Editor's right-click context menu and when you add menus to the GUI using the Menu Editor.

Naming Callback Subfunctions

When you add a component to your GUI layout, GUIDE assigns a value to its `Tag` property, which is then used to generate the name of the callback.

For example, the first push button you add to the layout is tagged `pushbutton1`. When generating the M-file, GUIDE adds a callback subfunction called `pushbutton1_Callback`. If you define a `ButtonDownFcn` for the same push button, GUIDE names its subfunction `pushbutton1_ButtonDownFcn`.

Callback Function Syntax

The callback function syntax is of the form

```
function objectTag_Callback(hObject, eventdata, handles)
```

The arguments are listed in the following table.

Argument	Description
`hObject`	The handle of the object whose callback is executing.
`eventdata`	Empty — reserved for future use.
`handles`	A structure containing the handles of all components in the GUI whose fieldnames are defined by the object's `Tag` property. Can also be used to pass data to other callback functions or the command line.

For example, if you create a layout having a push button whose `Tag` property is set to `pushbutton1`, then GUIDE generates the following subfunction header in the GUI M-file.

```
function pushbutton1_Callback(hObject, eventdata, handles)
```

Assigning a Callback Property String

When you first add a component to your GUI layout, its `Callback` property is set to the string `%automatic`. This string signals GUIDE to replace it with one that calls the appropriate callback subfunction in the GUI M-file when you save or run the GUI. For example, GUIDE sets the `Callback` property for `pushbutton1` uicontrol to

```
my_gui('pushbutton1_Callback',gcbo,[],guidata(gcbo))
```

where

- `my_gui` is the name of the GUI M-file.
- `pushbutton1` is the value of the component's `Tag` property.
- `pushbutton1_Callback` is the name of the callback routine subfunction defined in `my_gui`.
- `gcbo` is a command that returns the handle of the callback object (i.e., `pushbutton1`).
- `[]` is a place holder for the currently unused `eventdata` argument.
- `guidata(gcbo)` returns the `handles` structure.

See "Callback Function Syntax" on page 3-30 for more information on callback function arguments and "Changing Tag and Callback Properties" on page 3-53 for more information on how to change the names used by GUIDE.

Adding Callbacks to the M-file

If you want GUIDE to include other callbacks in the GUI M-file and provide names for them, you can do one of the following:

- In the Property Inspector, set the value of the callback property, e.g., `KeyPressFcn`, to the string `%automatic`. GUIDE adds the callback to the M-file the next time you save the GUI.
- In the **View** menu, select **View Callbacks**. Then select the desired callback, e.g., **KeyPressFcn**. GUIDE adds the callback to the M-file, opens the M-file if it is not already open, and scrolls to the first line of the new callback.

GUI Allows Only One Instance to Run (Singleton)

This option allows you to select between two behaviors for the GUI figure:

- Allow MATLAB to display only one instance of the GUI at a time.
- Allow MATLAB to display multiple instances of the GUI.

If you allow only one instance, MATLAB reuses the existing GUI figure whenever the command to run the GUI is issued. If a GUI already exists, MATLAB brings it to the foreground rather than creating a new figure.

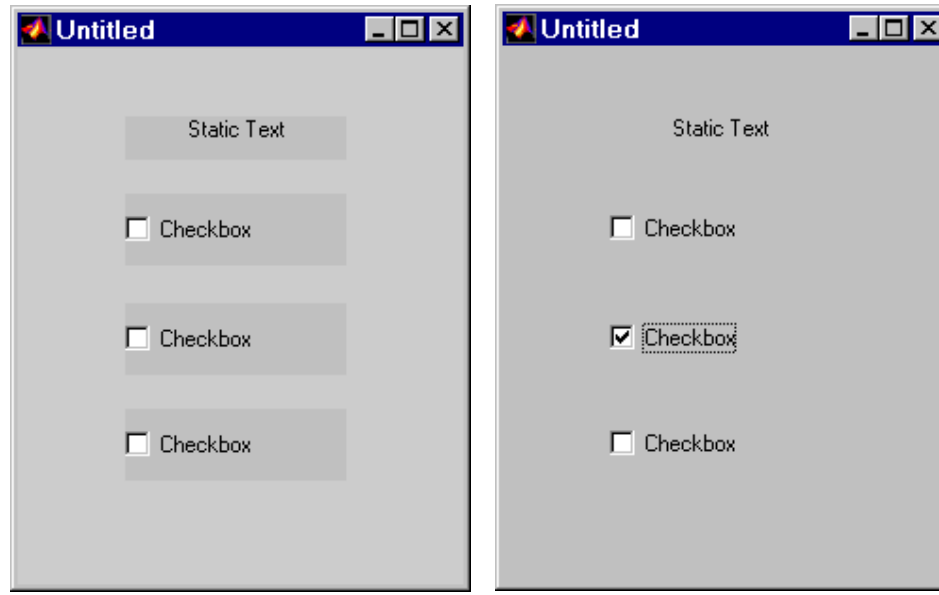
If you clear this option, MATLAB creates a new GUI figure whenever you issue the command to run the GUI.

Using the System Background Colors

The color used for GUI components varies on different computer systems. This option enables you to make the figure background color the same as the default uicontrol background color, which is system dependent.

If you select **Use system color scheme for background** (the default), GUIDE changes the figure background color to match the color of the GUI components.

The following figures illustrate the results with and without system color matching.



Without system color matching

With system color matching

Generate FIG-File Only

Select **Generate FIG-file only** in the **GUI Options** dialog if you do not want GUIDE to generate the M-file. When you save the GUI from the Layout Editor, GUIDE creates a FIG-file, which you can redisplay using the `open` command.

When you select this option, you must set the `Callback` property of each component in your GUI to a string that MATLAB can evaluate and perform the desired action. This string can be an expression or the name of an M-file.

Select this option if you want to use a completely different programming style than that provided by the GUI M-file.

Aligning Components in the Layout Editor

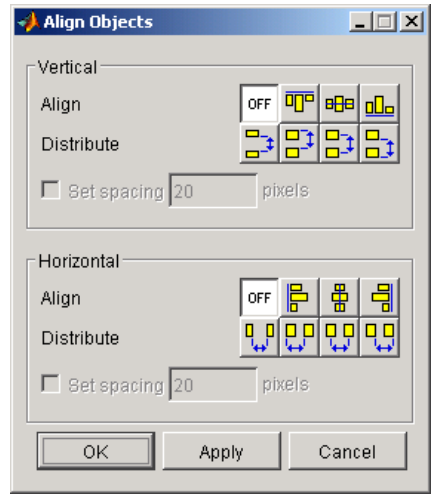
You can select and drag any component or group of components that has the same parent within the layout area. In addition, the Layout Editor provides a number of features that facilitate more precise alignment of objects with respect to one another:

- Alignment Tool — align and distribute groups of components.
- Grid and Rulers — align components on a grid with optional snap to grid.
- Guide Lines — vertical and horizontal snap-to guides at arbitrary locations.
- Bring to Front, Send to Back, Bring Forward, Send Backward — control the front to back arrangement of components.

Aligning Groups of Components — The Alignment Tool

The Alignment Tool enables you to position objects with respect to each other and to adjust the spacing between selected objects. The specified alignment operations apply to all components that are selected when you press the **Apply** button.

Note To select multiple components, they must be contained in the same figure, panel, or button group.



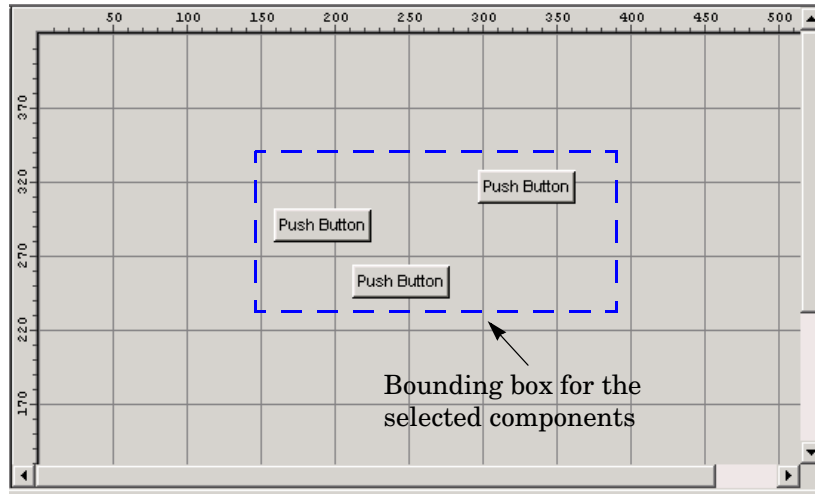
The alignment tool provides two types of alignment operations:

- **Align** — align all selected components to a single reference line.
- **Distribute** — space all selected components uniformly with respect to each other.

Both types of alignment can be applied in the vertical and horizontal directions. Note that, in many cases, it is better to apply alignments independently to the vertical or to the horizontal using two separate steps.

Align Options

There are both vertical and horizontal align options. Each option aligns selected components to a reference line, which is determined by the bounding box that encloses the selected objects. For example, the following picture of the layout area shows the bounding box (indicated by the dashed line) formed by three selected push buttons.



All of the align options (vertical top, center, bottom and horizontal left, center, right) place the selected components with respect to corresponding edge (or center) of this bounding box.

Distribute Options

Distributing components adds equal space between all components in the selected group. The distribute options operate in two different modes:

- Equally space selected components within the bounding box (default)
- Space selected components to a specified value in pixels (check **Set spacing** and specify a pixel value)

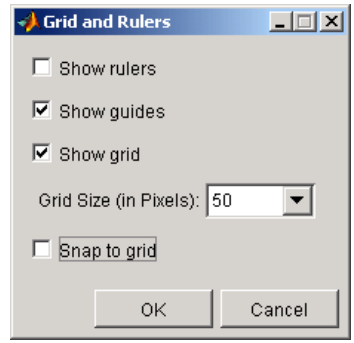
Both modes enable you to specify how the spacing is measured, as indicated by the button labels on the alignment tool. These options include spacing measured with respect to the following edges:

- Vertical — inner, top, center, and bottom
- Horizontal — inner, left, center, and right

Grids and Rulers

The layout area displays a grid and rulers to facilitate component layout. Grid lines are spaced at 50-pixel intervals by default and you can select from a

number of other values ranging from 10 to 200 pixels. You can optionally enable *snap-to-grid*, which causes any object that is moved or resized to within 9 pixels of a grid line to jump to that line. Snap-to-grid works with or without a visible grid.



Use the Grid and Rulers dialog (accessed by selecting **Grid and Rulers** from the **Tools** menu) to:

- Control visibility of rulers, grid, and guide lines
- Set the grid spacing
- Enable or disable snap-to-grid

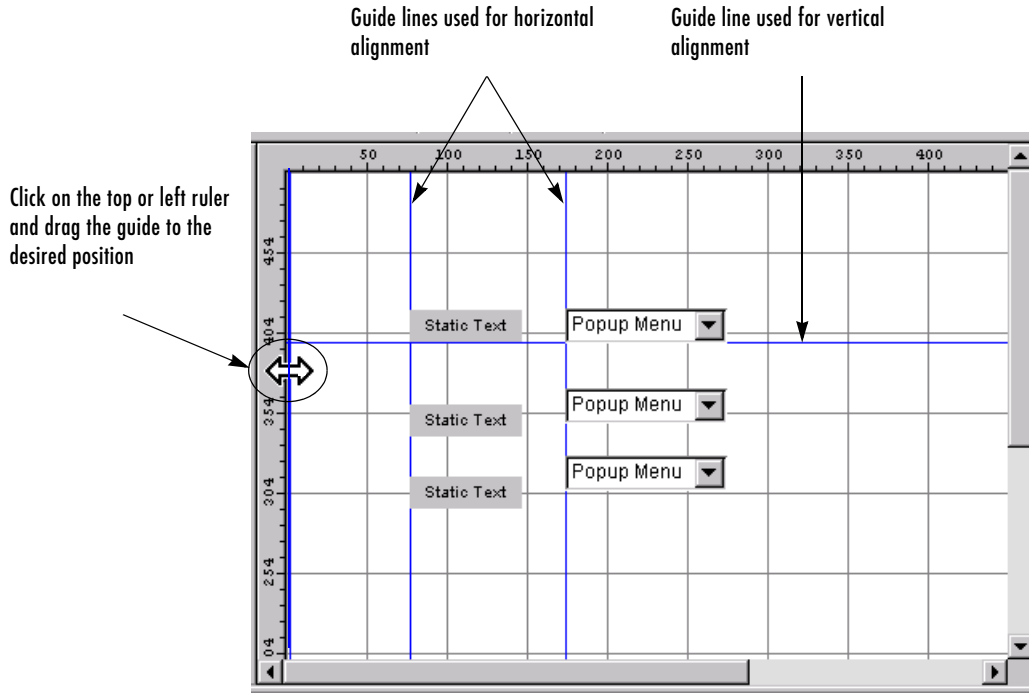
Aligning Components to Guide Lines

The Layout Editor has both vertical and horizontal snap-to guide lines. Components snap to the line when you move or resize them to within nine pixels of the line.

Guide lines are useful when you want to establish a reference for component alignment at an arbitrary location in the Layout Editor.

Creating Guide Lines

To create a guide line, click on the top or left ruler and drag the line into the layout area.



Front-to-Back Positioning

MATLAB figures maintain separate stacks that control the front-to-back positioning for different kinds of components:

- User interface controls such as buttons, sliders, and pop-up menus
- Panels, button groups, and axes
- ActiveX controls

You can control the front-to-back positioning of components that overlap only if those components are in the same stack. For overlapping components that are in different stacks:

- User interface controls always appear on top of panels, button groups, axes, and ActiveX controls they overlap.
- Panels, button groups, and axes always appear on top of ActiveX controls.

The Layout Editor provides four operations that enable you to control front-to-back positioning:

- Bring to Front — move the selected object(s) in front of nonselected objects (available from the right-click context menu, the **Layout** menu, or the **Ctrl+F** shortcut).
- Send to Back — move the selected object(s) behind nonselected objects (available from the right-click context menu, the **Layout** menu, or the **Ctrl+B** shortcut).
- Bring Forward — move the selected object(s) forward by one level, i.e., in front of the object directly forward of it, but not in front of all objects that overlay it (available from the **Layout** menu).
- Send Backward — move the selected object(s) back by one level, i.e., behind the object directly in back of it, but not behind all objects that are behind it (available from the **Layout** menu).

Setting Component Properties — The Property Inspector

The Property Inspector enables you to set the properties of the components in your layout. It provides a list of all settable properties and displays the current value. Each property in the list is associated with an editing device that is appropriate for the values accepted by the particular property. For example, a color picker to change the `BackgroundColor`, a pop-up menu to set `FontAngle`, and a text field to specify the `Callback` string.

See "Programming Callbacks for GUI Components" on page 4-8 to learn how to use these properties when you program callbacks.

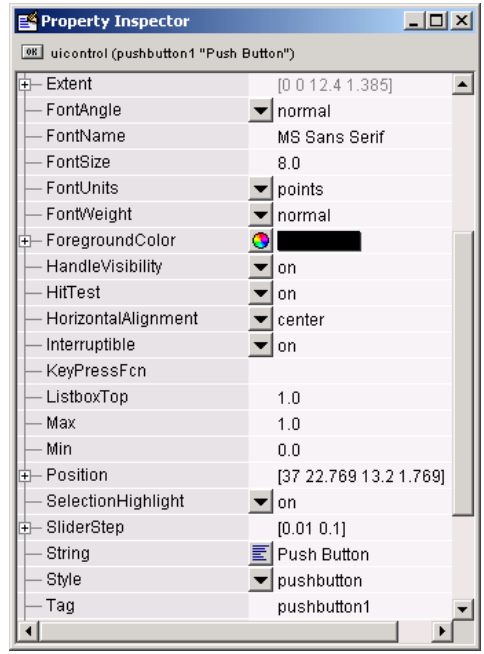
This section covers the following topics:

Displaying the Property Inspector

You can display the Property Inspector by any of the following actions:

- Double-clicking on a component in the Layout Editor
- Selecting **Property Inspector** in the **View** menu
- Right-clicking on a component and selecting **Inspect Properties** from the context menu

This displays the Property Inspector, as shown in the following figure.



To change a property, click in the field to the right of the property name, delete its current value, and type a new value.

What Properties Do I Need to Set?

The properties you need to set depend on the component. The property descriptions will help you decide which properties you need to set. For descriptions of each property, see the property reference pages for each kind of component. They are listed in the following table.

Component	Property Reference Page
User interface controls, including push button, slider, radio button, check box, edit text, static text, list box, and toggle button	Uicontrol Properties
Axes	Axes Properties

Component	Property Reference Page
Panel	Uipanel Properties
Button group	Uibuttongroup Properties
Menu	Uimenu Properties
Context menu (associated with a component using its Uicontextmenu property)	Uicontextmenu Properties

Some Commonly Used Properties

As examples, this section describes four important and commonly used properties of user interface control components: `Tag`, `Callback`, `String`, and `Value`.

Tag

`The Tag` property is an identifier for the component. GUIDE assigns a value to the `Tag` property of every component you insert in your layout (e.g., `pushbutton1`) and then uses this string to name the callback associated with the `Callback` property (e.g., `pushbutton1_Callback`). You should change the `Tag` property to a more descriptive name, so that you can more easily identify the component's callback in the M-file. For example, if you add a push button that closes the GUI, you might set its tag to `close_button`.

GUIDE uses the `Tag` property to

- Construct the name of the generated callback (e.g., `close_button_Callback`) when you run or save the GUI
- Set corresponding callback properties to point to the callback.
- Add a field to the `handles` structure containing the handle of the object (e.g., `handles.close_button`)

Note Since GUIDE uses the `Tag` property to name functions and structure fields, the tag you select must be a valid MATLAB variable name. Use `isvarname` to determine if the string you want to use is valid.

Callback

The `Callback` property specifies the callback that is executed in the GUI M-file when a user activates the component.

String

The `String` property contains text for the component. The following are examples:

- For buttons, check boxes, list boxes, edit text, and static text, the `String` text is displayed on or next to the component.
- For an edit text, the `String` property contains a list of strings that is displayed in the text box. When a user edits the text, the `String` property is updated.

Value

The `Value` property contains a numerical value for the component, which must lie in the range specified by the `Max` and `Min` properties. The following are examples:

- For radio buttons and check boxes, `Max` and `Min` are set to `1` and `0`, respectively, by default. The `Value` property is set to `1` when the radio button or check box is selected, and `0` when it is cleared.
- When a user drags a slider, the `Value` is set to a number between `Max` and `Min` corresponding to the location of the slider button.

Setting Properties for Some Specific Components

This section describes how to set properties for some specific components. The section covers the following topics:

Setting Radio Button Properties

Radio buttons have two states — selected and not selected. You can query and set the state of a radio button through its `Value` property:

- `Value = Max`, button is selected (`1` by default)
- `Value = Min`, button is not selected (`0` by default)

To make radio buttons mutually exclusive within a group, the callback for each radio button must set the `Value` property to `0` on all other radio buttons in the group. MATLAB sets the `Value` property to `1` on the radio button clicked by the user.

The following subfunction, when added to the GUI M-file, can be called by each radio button callback. The argument is an array containing the handles of all other radio buttons in the group that must be cleared.

```
function mutual_exclude(off)
set(off,'Value',0)
```

See “Radio Buttons” on page 4-9 for an example of such a function.

Setting Edit Text Box Properties

The values of the `Min` and `Max` properties for an edit text box determine whether users can enter single or multiple lines of text:

- If `Max  Min > 1`, editable text boxes accept multiline input.
- If `Max  Min <= 1`, editable text boxes accept only single-line input.

Setting List Box Properties

List boxes display a list of items and enable users to select one or more items. The `String` property contains the list of strings displayed in the list box. The first item in the list has an index of 1. Enter the list box items using the Property Inspector, one per line.

The values of the `Min` and `Max` properties for a list box determine whether users can select single or multiple lines of text:

- If `Max  Min > 1`, users can select multiple lines.
- If `Max  Min <= 1`, users can select only a single line.

The `Value` property contains the index into the list of strings that corresponds to the selected item. If the user selects multiple items, then `Value` is a vector of indices.

By default, the first item in the list is highlighted when the list box is first displayed. If you do not want any item highlighted, then set the `Value` property to empty, `[]`. This works only when multiple selection is enabled.

The `ListboxTop` property defines which string in the list displays as the top most item when the list box is not large enough to display all list entries. `ListboxTop` is an index into the array of strings defined by the `String` property and must have a value between 1 and the number of strings. Noninteger values are fixed to the next lowest integer.

Selection Type. MATLAB sets `Selection Type` to `normal` on the first click and to `open` on the second click. The callback can query the `Selection Type` property to determine if it was a single- or double-click.

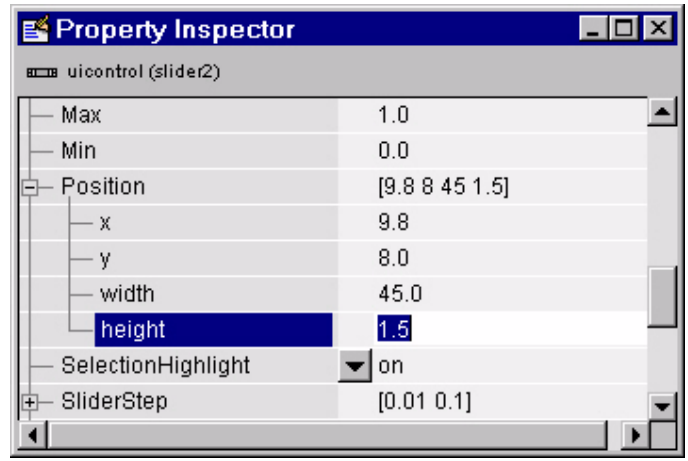
Setting Slider Properties

The following sections describe how to set properties for a slider.

Slider Orientation. You can orient the slider either horizontally or vertically by setting the relative width and height of the `Position` property:

- Horizontal slider — Width is greater than height.
- Vertical slider — Height is greater than width.

For example, these settings create a horizontal slider.



Note If you have set units for your GUI to `characters`, certain combinations of width and height produce a slider with the opposite orientation from the intended. This is because a character is rectangular, i.e., it is higher than it is wide.

Current Value, Range, and Step Size. There are four properties that control the range and step size of the slider:

- `Value` contains the current value of the slider.
- `Max` defines the maximum slider value.
- `Min` defines the minimum slider value.
- `SliderStep` specifies the size of a slider step with respect to the range.

The `Value` property contains the numeric value of the slider. You can set this property to specify an initial condition and query it in the slider's callback to obtain the value set by the user. For example, your callback could contain the statement

```
slider_value = get(handles.slider1,'Value');
```

The `Max` and `Min` properties specify the slider's range (`Max - Min`).

The `SliderStep` property controls the amount the slider `Value` property changes when you click the mouse on the arrow button or on the slider trough. Specify `SliderStep` as a two-element vector. The default, [0.01 0.10], provides a 1 percent change for clicks on an arrow and a 10 percent change for clicks in the trough. The actual step size is a function of the slider step and the slider range.

Designing a Slider. Suppose you want to create a slider with the following behavior:

- Slider range = 5 to 8
- Arrow step size = 0.4
- Trough step size = 1
- Initial value = 6.5

Set the following slider properties using the Property Inspector. `X` denotes the first element of the `SliderStep` vector. `Y` denotes the second element.

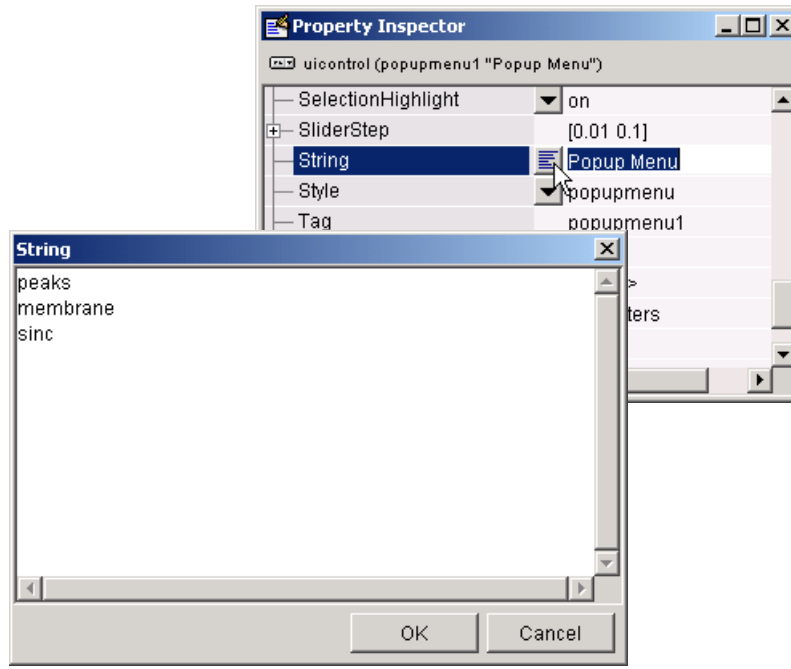
- `SliderStep, X .133`
- `SliderStep, Y .333`
- `Max 8`
- `Min 5`
- `Value 6.5`

`SliderStep` is a percentage of the slider range, which is 3. In this example, `SliderStep` for the arrow step size is `0.4/3 = 0.1333`. `SliderStep` for the trough step size is `1/3 = 0.3333`.

Setting Pop-Up Menu Properties

Pop-up menus open to display a list of choices when users click the arrow.

Adding Items to the Pop-Up Menu. The `String` property contains the list of strings displayed in the pop-up menu. Use the Property Inspector to add items to the pop-up menu by typing one per line in the `String` edit box:



Determining Which Item Is Selected. The `Value` property contains the index of the selected item. For example, if the `String` contains the three items, `peaks`, `membrane`, and `sinc` and the `Value` property has a value of 2, then the item selected is `membrane`.

When not open, a pop-up menu displays the current choice, which is determined by the index contained in the `Value` property. The first item in the list has an index of 1.

Pop-up menus are useful when you want to provide users with a number of mutually exclusive choices, but do not want to take up the amount of space that a series of radio buttons requires.

Enabling or Disabling Controls

You can control whether a control responds to mouse button clicks by setting the `Enable` property. Controls have three states:

- `on` — The control is operational.

- `off` — The control is disabled and its label (set by the `string` property) is grayed out.
- `inactive` — The control is disabled, but its label is not grayed out.

When a control is disabled, clicking on it with the left mouse button does not execute its callback routine. However, the left-click causes two other callback routines to execute:

1. First the figure `WindowButtonDownFcn` callback executes
2. Then the control's `ButtonDownFcn` callback executes

A right mouse button click on a disabled control posts a context menu, if one is defined for that control. See the `Enable` property description for more details.

Setting Panel and Button Group Properties

Panels and button groups group related components. A panel or button group can have a title and a border. You can also specify the background color.

Title. Panel and button group properties enable you to set the title, as well as its font, font size, font angle, font weight, and its position relative to the panel. Suppose you want a panel with the title "Plot Types" and you want the title:

- Displayed in Times font, 12-point, italic, bold
- Positioned at the top right of the panel

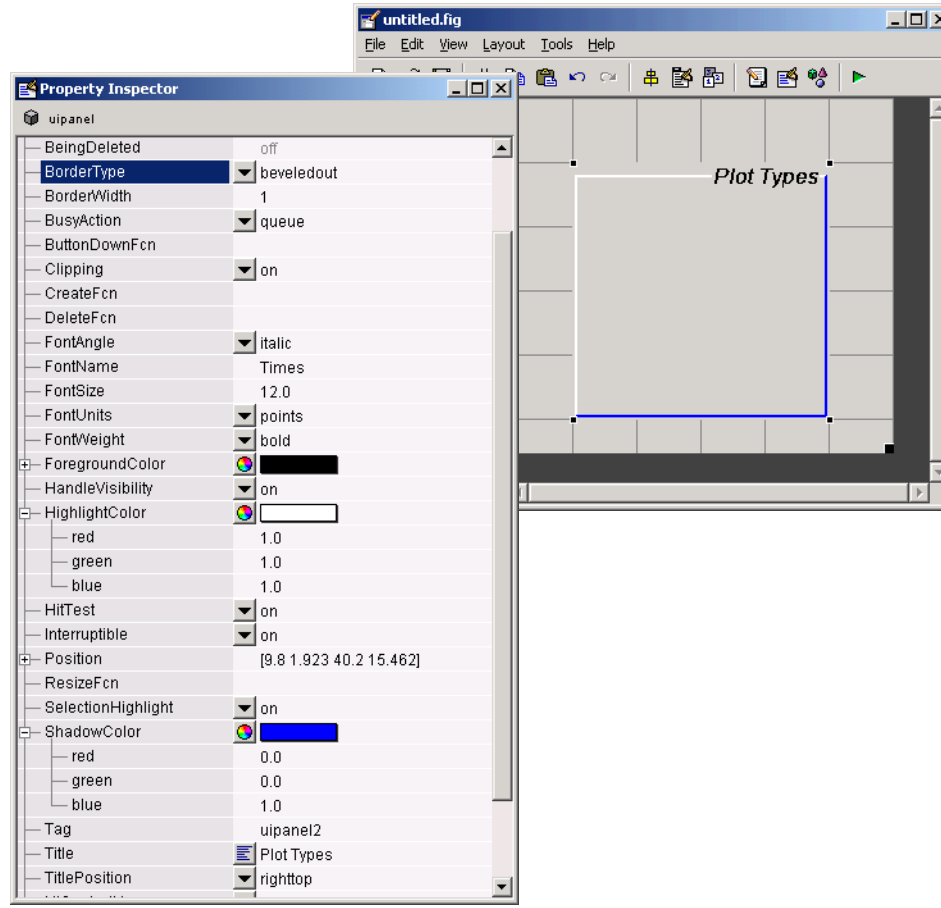
Set the following panel properties:

- `Title Plot Types`
- `FontName Times`
- `FontUnits points`
- `FontSize 12`
- `FontAngle italic`
- `FontWeight bold`
- `TitlePosition righttop`

Border. Suppose, in addition, you want the panel to have a 2-point wide, white and blue, beveled-out border.

Set the following panel properties:

- `BorderType beveledout`
- `BorderWidth 2`
- `HighlightColor` (white)
  - `red 1.0`
  - `green 1.0`
  - `blue 1.0`
- `ShadowColor` (blue)
  - `red 0.0`
  - `green 0.0`
  - `blue 1.0`



Callback Properties

A callback is a function that executes when a user performs a specific action such as clicking a push button or pressing a keyboard key, or when a component is created or deleted. Each component and menu item has properties that specify its callbacks. When you create a GUI, you must program the callbacks you need to control operation of the GUI.

The following table lists the various callback properties and briefly describes the purpose of each callback. See the components' property reference pages to find out which callbacks apply to a specific component.

Callback Property	Description
`ButtonDownFcn`	Executes when the user presses a mouse button while the pointer is on or within five pixels of a component.
`Callback`	Performs the primary work of the component. It executes, for example, when a user clicks a push button or selects a menu item. See "The Tag Property" on page 2-14 for additional information.
`CreateFcn`	Initializes the component when it is created. It executes when the component is created, but before it becomes visible.
`DeleteFcn`	Performs cleanup operations just before the component is destroyed.
`KeyPressFcn`	Executes when the user presses a keyboard key and the callback's component has focus.
`ResizeFcn`	Executes when a user resizes a panel or button group whose **Resize behavior** is set to `Other`.
`SelectionChangeFcn`	Executes when a user selects a different radio button or toggle button in a button group component.

Adding Callbacks to the M-file

If you checked **Generate callback function prototypes** in the GUI Options dialog, GUIDE automatically adds the most commonly used callbacks to the GUI M-file. If you want GUIDE to include other callbacks in the GUI M-file and provide names for them, you can do one of the following:

- In the Property Inspector, set the value of the callback property, e.g., `KeyPressFcn`, to the string `%automatic`. GUIDE adds the callback to the M-file the next time you save the GUI.

- In the **View** menu, select **View Callbacks**. Then select the desired callback, e.g., **KeyPressFcn**. GUIDE adds the callback to the M-file, opens the M-file if it is not already open, and scrolls to the first line of the new callback.

Changing Tag and Callback Properties

This section discusses what you need to keep in mind if you change a component's `tag` or the value of any of its callback properties. This section covers the following topics:

Changing a Tag

Once GUIDE generates the GUI M-file, if you subsequently change a component's `Tag` in the Property Inspector, GUIDE can correctly update the following items according to the new `Tag`, provided that all components have distinct tags:

- The component's callback functions in the M-file
- The value of component's callback properties, which you can view in the Property Inspector
- References in the M-file to the field of the `handles` structure that contains the component's handle

As an example, you might want to assign the same tag to each of a set of radio buttons if you want the same callback to service all of them. In this case, you must also change the name of the callback functions in their callback property values to be the same.

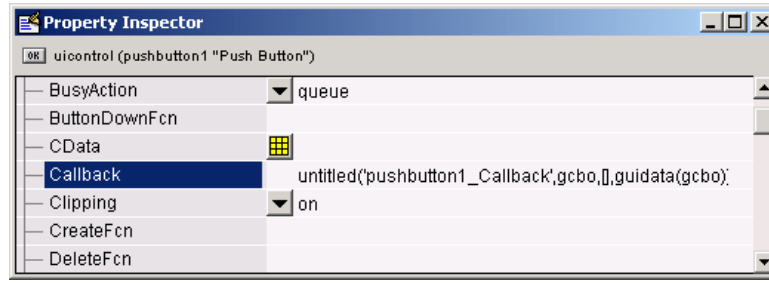
Changing Callback Properties

You can change the value of a callback property using the Property Inspector. The initial value of a callback property for a push button in an untitled GUI is similar to

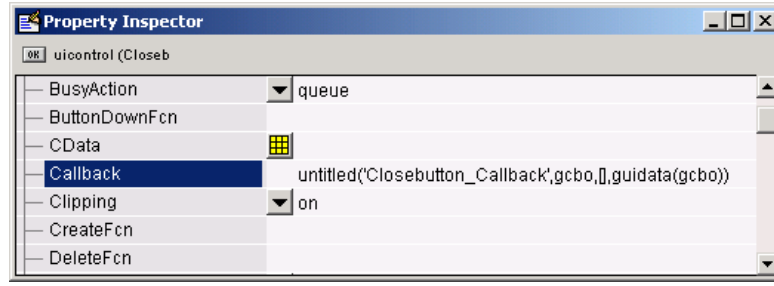
```
untitled('pushbutton1_Callback',gcbo,[],guidata(gcbo))
```

where `pushbutton1_Callback` is the name of the callback function for that push button in the M-file.

Making the Change in the Property Editor. For example, to change the callback name in a push button's callback property, select the push button in the Layout Editor and then select **Property Inspector** in the **View** menu. Scroll down in the Property Inspector until you come to `Callback`, as shown in the following figure.



As shown, the callback property points to `pushbutton1_Callback` in the M-file. If you need to change the callback property to `Closebutton_Callback`, replace the string `pushbutton1_Callback` with `Closebutton_Callback` in the `Callback` field, as shown in the following figure.



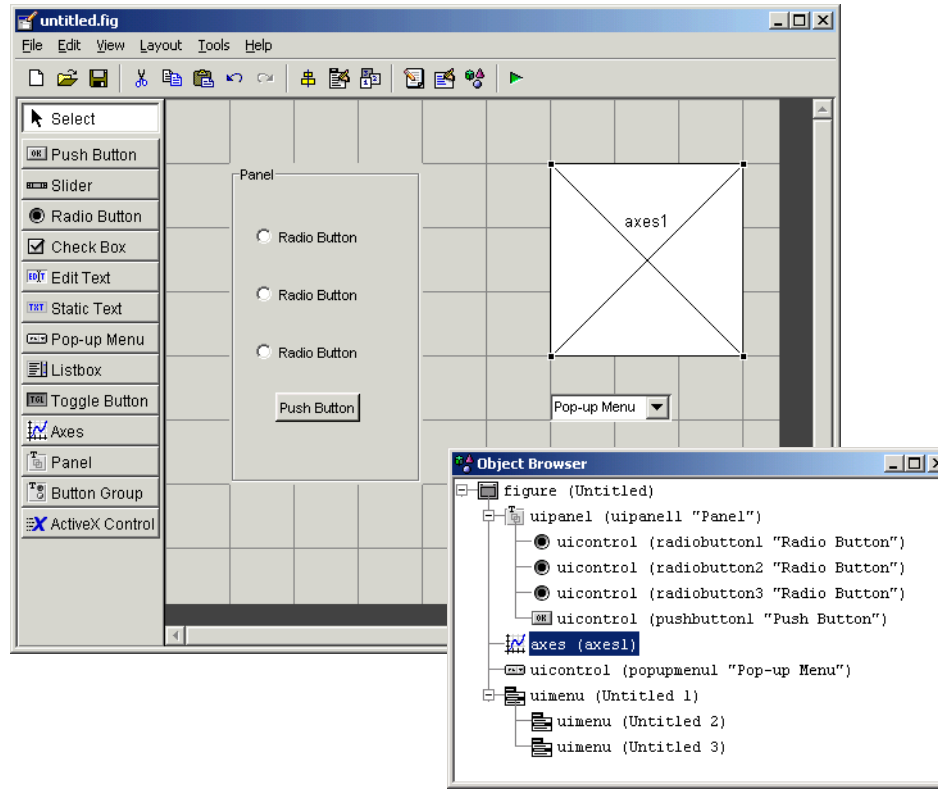
Making Sure Your GUI Still Works. If you change the value of any callback properties manually in the Property Inspector, GUIDE does not update the corresponding callbacks in the M-file, and might not be able to update the callback properties or references to the handles structure. If you change the value of a callback property, you must make sure that

- Callback functions in the M-file are updated.
- Callback function names in the callback properties agree with the names of the appropriate callback functions in the M-file.

- References in the M-file to the field of the `handles` structure that contains the component's handle are updated.

Viewing the Object Hierarchy — The Object Browser

The Object Browser displays a hierarchical list of the objects in the figure. The following illustration shows the figure object and its child objects. It also shows the child objects of the panel and a menu that was created. See “Creating Menus — The Menu Editor” on page 3-57.



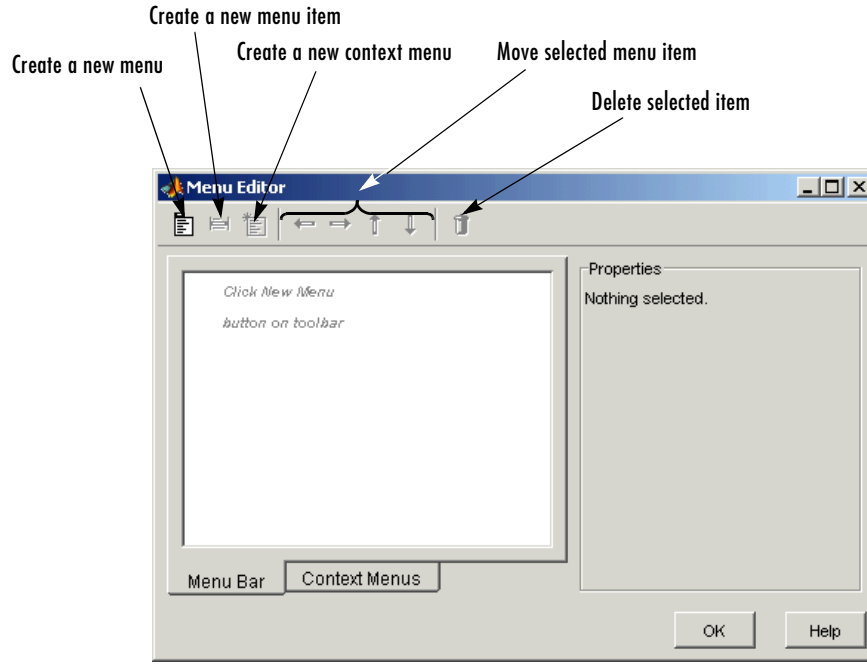
To determine a component’s place in the hierarchy, select it in the Layout Editor. It is automatically selected in the Object Browser. Similarly, if you select an object in the Object Browser, it is automatically selected in the Layout Editor.

Creating Menus — The Menu Editor

MATLAB enables you to create two kinds of menus:

- Menu bar objects — drop-down menus whose titles appear on the figure menu bar.
- Context menu objects — pop up when users right-click on graphics objects. They are also known as shortcut menus.

You can create both types of menus using the Menu Editor. Access the Menu Editor from the **Tools** menu or from the Layout Editor toolbar.



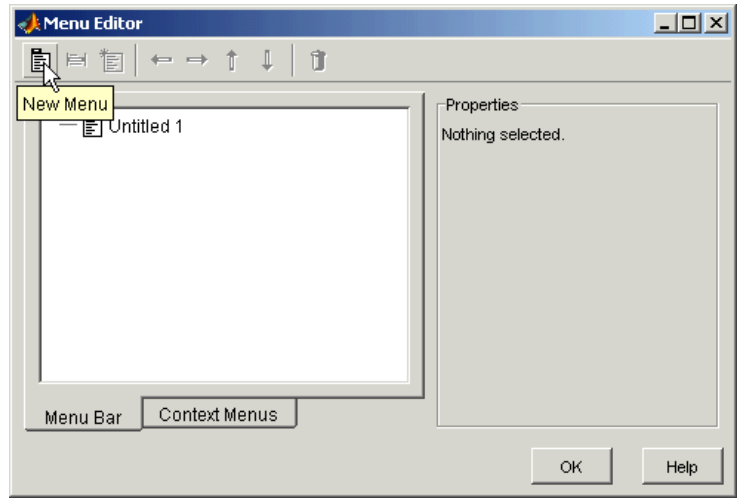
These menus are implemented with `uimenu` and `uicontextmenu` objects. See “Menu Callbacks” on page 3-63 for information about defining callback subfunctions for your menus.

Defining Menus for the Menu Bar

When you create a drop-down menu, MATLAB adds its title to the figure menu bar. You can then create menu items for that menu. Each menu item can have a cascading menu, also known as a submenu, and these items can have cascading menus, and so on.

Creating a Menu

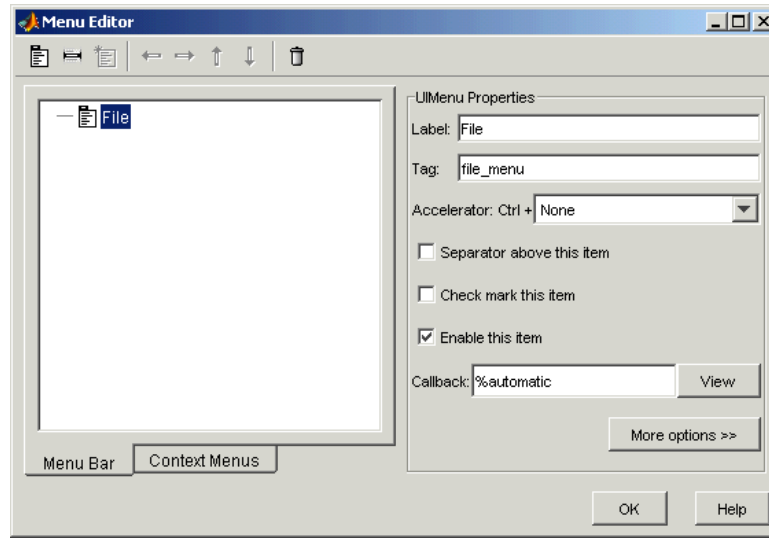
The first step is to click the **New Menu** tool to create a drop-down menu.



Specifying Menu Properties

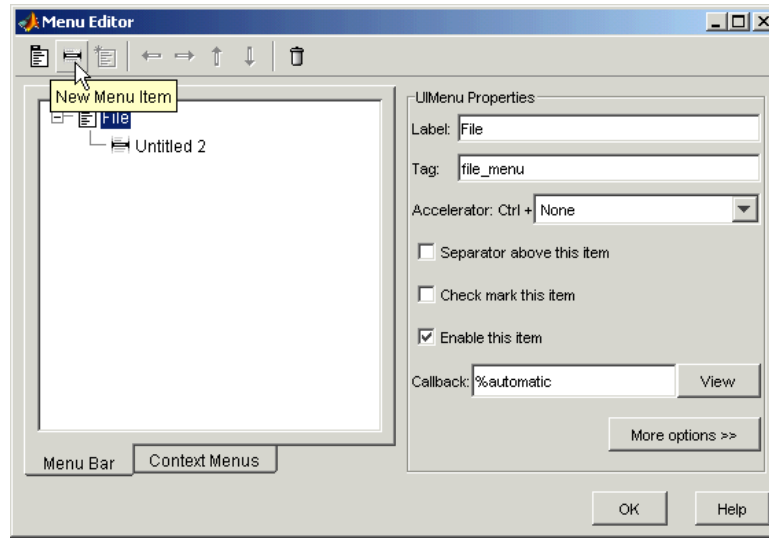
Click on the menu title, Untitled 1 in the picture above, to display fields that allow you to set the `Label`, `Tag`, `Accelerator`, `Separator`, `Checked`, and `Enable` menu properties as well as specify the `Callback` string. GUIDE applies any property changes immediately. Click **More options** to display the Property Inspector where you can edit all the properties for the selected item.

The **View** button displays the callback subfunction in an editor. See “Menu Callbacks” on page 3-63 for more information.



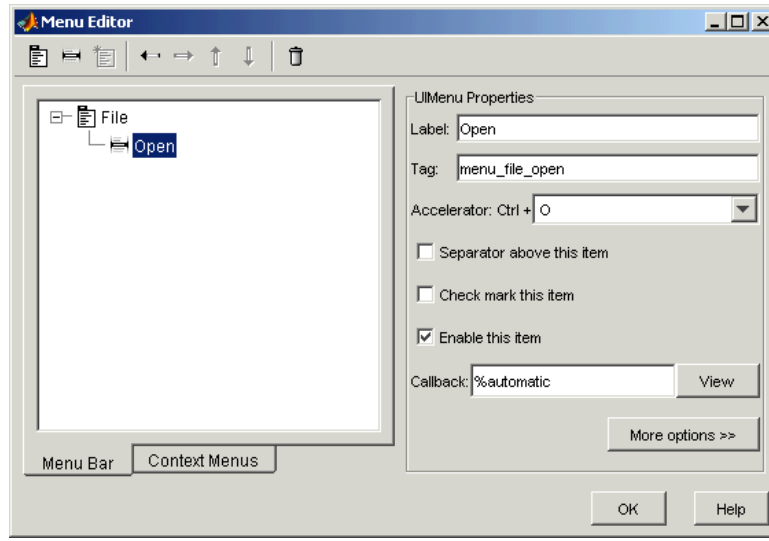
Adding Items to a Menu

Use the **New Menu Item** tool to define the menu items that are displayed in the drop-down menu.



For example, to add an **Open** menu item under `File`, select `File` then click the **New Menu Item** tool.

Fill in the **Label** and **Tag** fields for the new menu item.

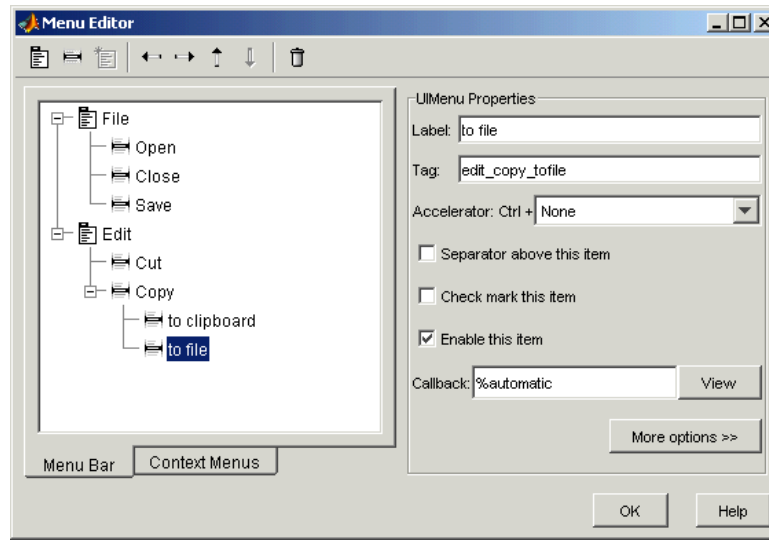


You can also

- Choose a keyboard accelerator for the menu item with the **Accelerator** pop-up menu.
- Select the **Separator above this item** check box to display a separator above the menu item.
- Select the **Check mark this item** check box to display a check next to the menu item when the menu is first opened. A check indicates the current state of the menu item. See the example in “Adding Items to the Context Menu” on page 3-66.
- Select the **Enable this item** check box so that the user can select this item when the menu is first opened. If you deselect this option, the menu item appears dimmed when the menu is first opened, and the user cannot select it.
- Click the **More options** button to open the Property Inspector where you can change all uimenu properties.

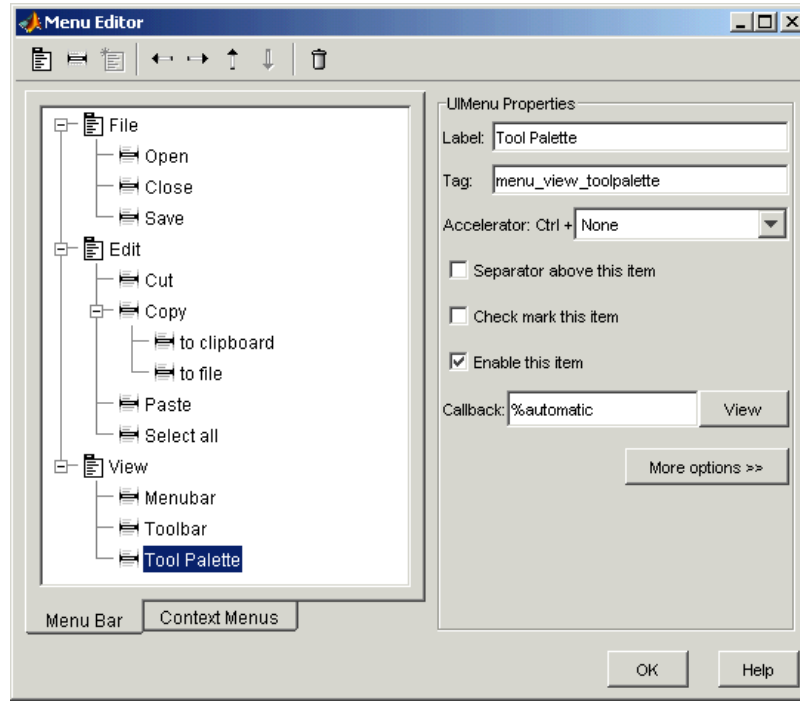
To create additional drop-down menus, use the **New Menu** tool in the same way you did to create the `File` menu. For example, the following picture also shows an `Edit` drop-down menu.

To create a cascading menu, select the menu item that will be the title for the cascading menu, then click the **New Menu Item** tool. In the example below, select `Copy` then click the **New Menu Item** tool.

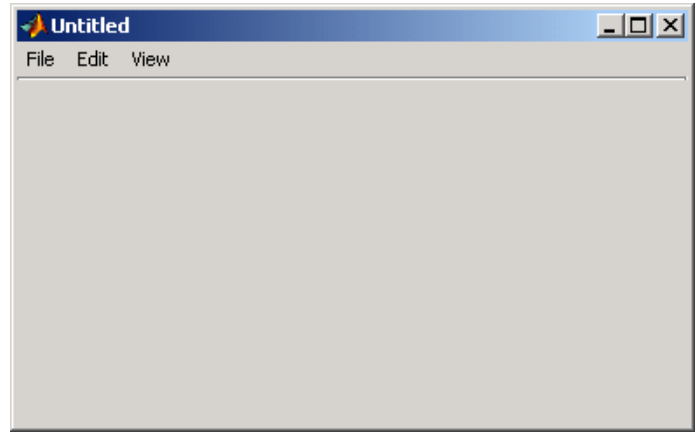


Laying Out Three Menus

The following Menu Editor illustration shows three menus defined for the figure menu bar.



When you run the GUI, the menu titles appear in the menu bar.



Menu Callbacks

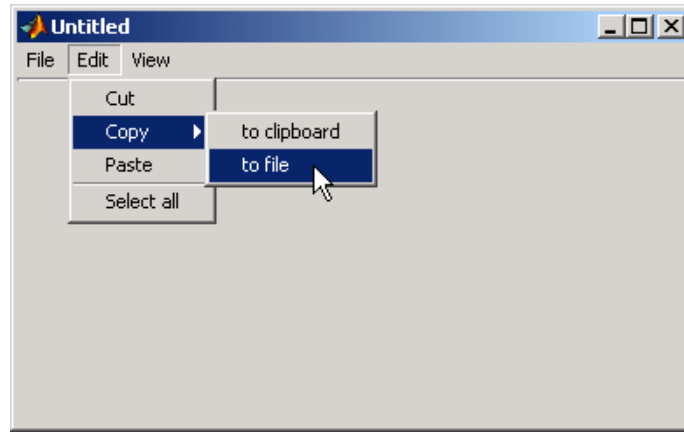
By default, the **Callback** text field in the Menu Editor is set to the string `%automatic`. This causes GUIDE to add the empty callback subfunction to the GUI M-file when you save or run the GUI. If you change this string before saving the GUI, GUIDE does not add a subfunction for that menu item.

Note that if you click the **View** button before saving the GUI, GUIDE asks you to save the GUI. It then runs the GUI, adds the appropriate callback subfunctions to the M-file, and opens the M-file for editing.

Functions Generated in the GUI M-file

The Menu Editor generates an empty callback subfunction for every menu item. Because clicking on a menu title automatically displays the menu below it, you may not need to program callbacks at the title level. However, the callback associated with a menu title can be a good place to enable or disable menu items below it.

Consider the example from the previous section, as illustrated in the following picture.



When a user selects the **to file** item under the **Edit** menu **Copy** item, only the **to file** callback is required to perform the action.

Suppose, however, that only certain objects can be copied to a file. You can use the **Copy** item callback to enable or disable the **to file** item, depending on the type of object selected.

Syntax of the Callback Subfunction

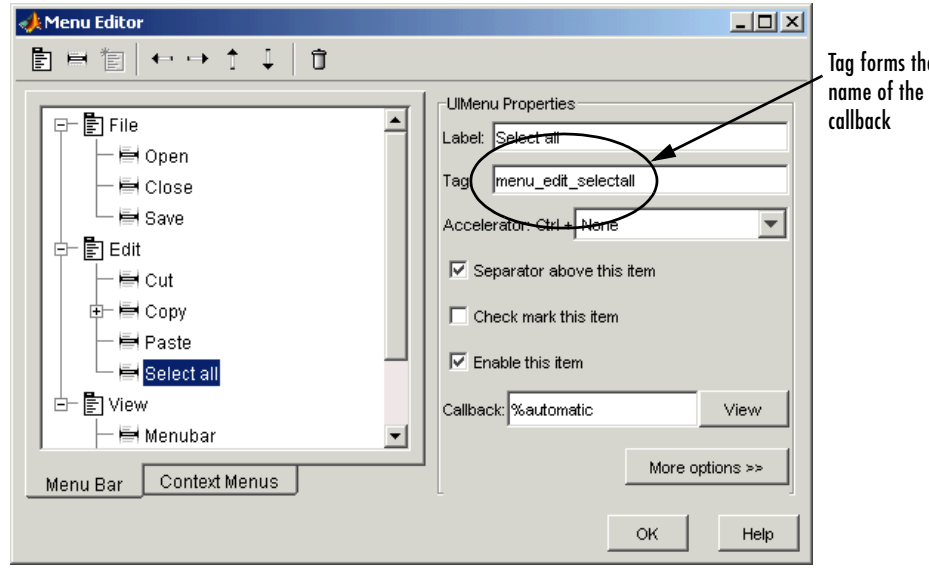
The GUI M-file contains all callbacks for the GUI, including the menu callbacks. All generated callbacks use the same syntax.

For example, the **Select all** menu item from the previous example has following callback string:

```
MyGui('menu_edit_selectall_Callback',gcbo,[],guidata(gcbo))
```

where:

- `MyGui` — is the name of the GUI M-file that launches the figure containing the menus.
- `menu_edit_selectall_Callback` — is the name of the subfunction callback for the **Select All** menu item (derived from the `Tag` specified in the Menu Editor).
- `gcbo` — is the handle of the **Select All** uimenu item.
- `[]` — is an empty matrix used as a place holder for future use.
- `guidata(gcbo)` — gets the `handles` structure from the figure's application data.



This is the automatically generated callback subfunction that you see if you click the **View** button after saving the GUI, or if you edit the GUI M-file.

```
function menu_edit_selectall_Callback(hObject, eventdata,...
         handles)
% hObject    handle to menu_edit_selectall (see GCBO)
% eventdata  reserved - to be defined in a future version of
% MATLAB
% handles    structure with handles and user data (see GUIDATA)
```

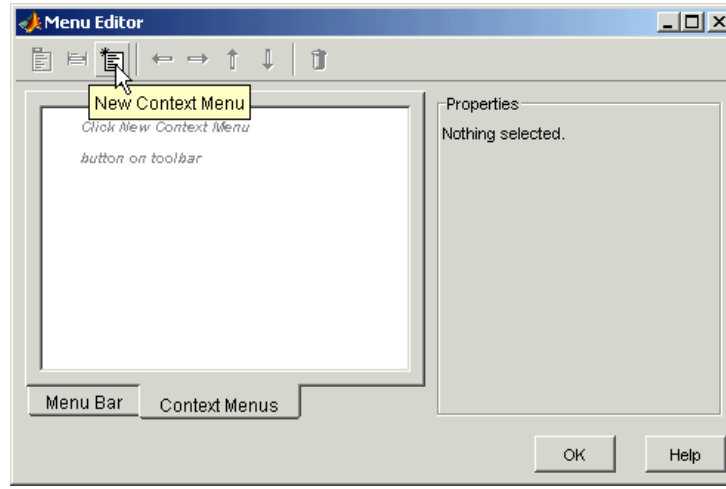
Defining Context Menus

A context menu is displayed when a user right-clicks on the object for which the menu is defined. The Menu Editor enables you to define context menus and associate them with objects in the layout.

See “Defining Menus for the Menu Bar” on page 3-58 for information about defining menus in general.

Creating the Parent Menu

All items in a context menu are children of a menu that is not displayed on the figure menu bar. To define the parent menu, select **New Context Menu** from the Menu Editor’s toolbar.

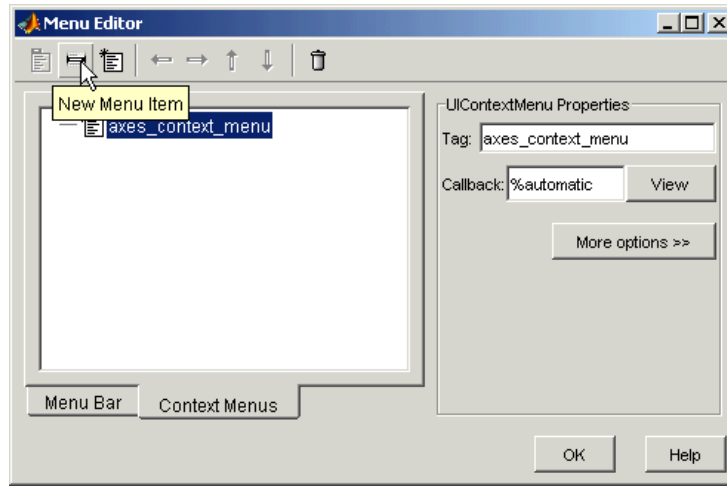


Note You must select the Menu Editor's **Context Menus** tab before you begin to define a context menu.

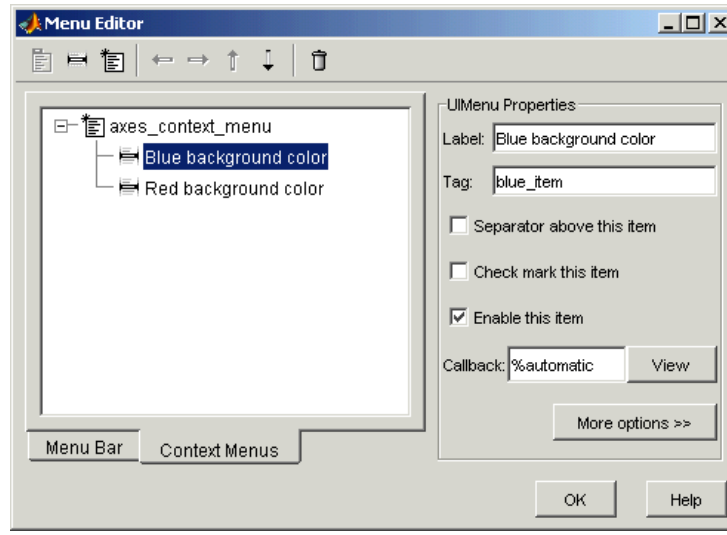
Select the menu and specify the `Tag` to identify the context menu (`axes_context_menu` in this example).

Adding Items to the Context Menu

Create the items that will appear in the context menu using **New Menu Item** on the Menu Editor's toolbar.



When you select the menu item, the Menu Editor displays fields for you to enter the `Label` and `Tag` properties of the menu item.



You can also

- Select the **Separator above this item** check box to display a separator above the menu item when the menu is first opened.
- Select the **Check mark this item** check box to display a check next to the menu item when the menu is first opened.

  A check is particularly useful to indicate the current state of the menu item. For example, suppose you have a menu item called **Show axes** that toggles the visibility of an axes between visible and invisible each time the user selects the menu item. If you want a check to appear next to the menu item when the axes are visible, add the following code to the callback for the **Show axes** menu item:

```
if strcmp(get(gcbo, 'Checked'),'on')
    set(gcbo, 'Checked', 'off');
else
    set(gcbo, 'Checked', 'on');
```

```
end
```

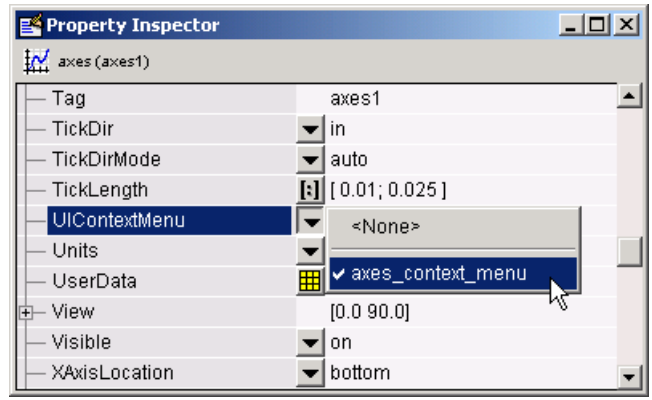
This changes the value of the `Checked` property of the menu item from `on` to `off` or vice versa each time a user selects the menu item.

If you set the axes to be visible when a user first opens the GUI, make sure to select the **Check mark this item** check box in the Menu Editor, so that a check will appear next to the **Show axes** menu item initially.

- Select the **Enable this item** check box so that the user can select this item when the menu is first opened. If you deselect this option, the menu item appears dimmed when the menu is first opened, and the user cannot select it.
- Click the **More options** button to open the Property Inspector where you can change all uimenu properties.

Associating the Context Menu with an Object

In the Layout Editor, select the object for which you are defining the context menu. Use the Property Inspector to set this object's `UIContextMenu` property to the desired context menu.



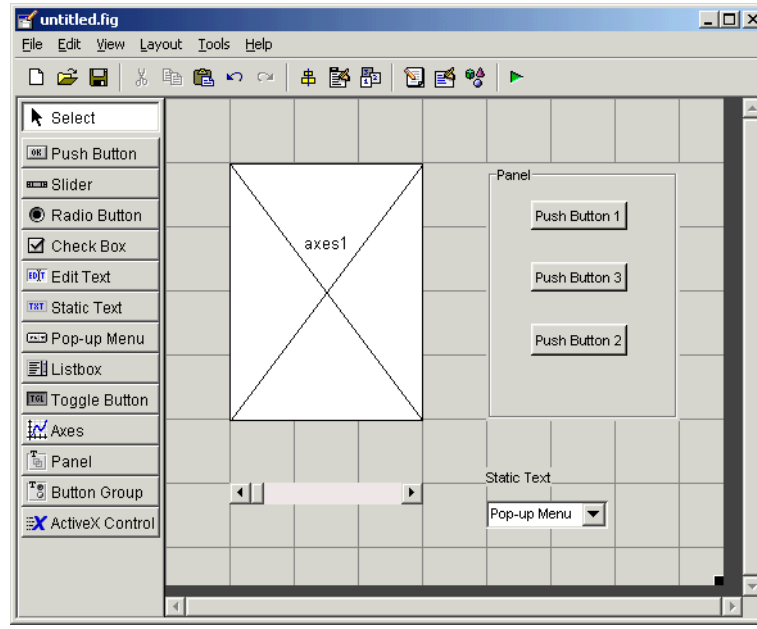
In the GUI M-file, complete the callback subfunction for each item in the context menu. Each callback executes when a user selects the associated context menu item. See "Menu Callbacks" on page 3-63 for information on defining the syntax.

Setting the Tab Order — The Tab Order Editor

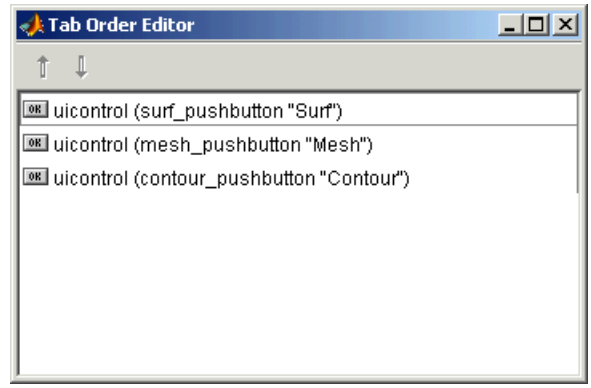
A GUI's tab order is the order in which components of the GUI are selected when a user presses the **Tab** key on the keyboard. When you create a GUI, GUIDE sets the tab order at each level to be the order in which you add components to that level in the Layout Editor. This is often not the best order for the user.

The tab order for each level is determined independently. The figure is the base level, and each panel or button group establishes its own level. If, in tabbing through the components at the figure level, a user tabs to a panel or button group, then subsequent tabs sequence through the components of the panel or button group before returning to the level from which the panel or button group was reached.

The figure in the following GUI contains an axes, a slider, a panel, a static text, and a pop-up menu. Of these, only the slider, the panel, and the pop-up menu at the figure level can be tabbed. The panel contains three push buttons, which can all be tabbed.



To examine and change the tab order of the panel components, click the panel background to select it, then select **Tab Order Editor** in the **Tools** menu of the Layout Editor.



The Tab Order Editor displays the panel's components in their current tab order. To change the tab order, select a component and press the **up** or **down** arrow to move the component up or down in the list. If you set the tab order for the three components in the example to be

1. **Surf** push button
2. **Contour** push button
3. **Mesh** push button

the user first tabs to the **Surf** push button, then to the **Contour** push button and then to the **Mesh** push button. Subsequent tabs sequence through the remaining components at the figure level.

4

Programming GUIs

Understanding the GUI M-File

The GUI M-file generated by GUIDE controls the GUI and determines how it responds to a user's action, such as pressing a push button or selecting a menu item. The M-file contains all the code needed to run the GUI, including the callbacks for the GUI components. While GUIDE generates the framework for this M-file, you must program the callbacks, which are subfunctions of the M-file, to perform the functions you want them to.

This section explains the overall structure of the M-file. The section covers the following topics:

To learn more about programming callbacks, see Subfunctions in the online MATLAB documentation.

Sharing Data with the Handles Structure

When you run a GUI, the M-file creates a `handles` structure that contains all the data for GUI objects, such as controls, menus, and axes. The `handles` structure is passed as an input to each callback. You can use the `handles` structure to

- Share data between callbacks
- Access GUI data

Sharing Data

To store data that is contained in a variable `X`, set a field of the `handles` structure equal to `X` and then save the `handles` structure with the `guidata` function:

```
handles.current_data = X;
guidata(hObject,handles)
```

You can retrieve the data in any other callback with the command

```
X = handles.current_data;
```

For an example of sharing data between callbacks, see “Example: Passing Data Between Callbacks” on page 4-26.

For more information about handles, see “Managing GUI Data with the Handles Structure” on page 4-26.

Accessing GUI Data

You can access any of the data for the GUI components from the `handles` structure. For example, suppose your GUI has a pop-up menu, whose `Tag` is `my_menu`, containing three items, whose `String` properties are `chocolate`, `strawberry`, and `vanilla`. You want another component in the GUI — a push button, for example — to execute a command on the currently selected menu item. In the callback for the push button, you can insert the command

```
all_choices = get(handles.my_menu, 'String')
current_choice = all_choices{get(handles.my_menu, 'Value')};
```

The command sets the value of `current_choice` to `chocolate`, `strawberry`, or `vanilla`, depending on which item is currently selected in the menu.

You can also access the data for the entire GUI from the handles structure. If the figure's `Tag` is `figure1`, then

```
handles.figure1
```

contains the figure's handle. For example, you can make the GUI close itself with the command

```
delete(handles.figure1)
```

For an example of closing a GUI with this command, look at the callback for the **Close** push button for the template described in “GUI with Axes and Menu” on page 3-5.

Functions and Callbacks in the M-File

You can add code to the following parts of the GUI M-file:

- Opening function — executes before the GUI becomes visible to the user.
- Output function — outputs data to the command line, if necessary.

- Callbacks — execute each time the user activates the corresponding component of the GUI.

Common Input Arguments

All functions in the M-file have the following input arguments corresponding to the handles structure:

- `hObject` — the handle to the figure or `Callback` object
- `handles` — structure with handles and user data (see `guidata`)

The `handles` structure is saved at the end of each function with the command

```
guidata(hObject, handles);
```

Additional arguments for the opening and output functions are described in the following sections.

Opening Function

The opening function contains code that is executed just before the GUI is made visible to the user. You can access all the components for the GUI in the opening function, because all objects in the GUI are created before the opening function is called. You can add code to the opening function to perform tasks that need to be done before the user has access to the GUI — for example, creating data, plots or images, or making the GUI blocking with the `uiwait` command.

For a GUI whose file name is `my_gui`, the definition line for the opening function is

```
function my_gui_OpeningFcn(hObject, eventdata, handles, varargin)
```

Besides the arguments `hObject` and `handles` (see "Common Input Arguments" preceding), the opening function has the following input arguments:

- `eventdata` reserved for a future version of MATLAB
- `varargin` command line arguments to untitled (see `varargin`)

All command line arguments are passed to the opening function via `varargin`. If you open the GUI with a property name/property value pair as arguments, the GUI opens with the property set to the specified value. For example,

`my_gui('Position', [71.8 44.9 74.8 19.7])` opens the GUI at the specified position, since `Position` is a valid figure property.

If the input argument is not a valid figure property, you must add code to the opening function to make use of the argument. For an example, look at the opening function for the modal question dialog template. The added code enables you to open the modal dialog with the syntax

```
my_gui('String','Do you want to exit?')
```

which displays the text `'Do you want to exit'` on the GUI. In this case, it is necessary to add code to the opening function because `'String'` is not a valid figure property.

Output Function

The output function returns output arguments to the command line. This is particularly useful if you want to return a variable to another GUI. For an example, see "Example: Using the Modal Dialog to Confirm an Operation" on page 4-40.

GUIDE generates the following lines of code in the output function:

```
% --- Outputs from this function are returned to the command line.
function varargout = my_gui_OutputFcn(hObject, eventdata,
handles)
% Get default command line output from handles structure
varargout{1} = handles.output;
```

If the GUI is not blocking — in other words, if the M-file does not contain the command `uiwait` — the output is simply the handle to the GUI, which is assigned to `handles.output` in the opening function.

To make the GUI return a different output — for example, if you want it to return the result of a user response, such as pressing a push button — do the following:

- Add the command `uiwait;` to the opening function to make the M-file halt execution until a user activates a component in the GUI.
- For each component of the GUI where you expect a user response, make the callback update the value of `handles.output`, and execute `uiresume.`

For example, if the GUI contains a push button whose `String` property is `'Yes'`, add the following code to its callback to make the GUI return `'Yes'` when the user presses the push button:

```
handles.output = 'Yes';
guidata(hObject, handles);
uiresume;
```

See the section "Managing GUI Data with the Handles Structure" on page 4-26 for more information about passing data with the `handles` structure.

When the GUI is called with the command

```
OUT = my_gui
```

and a user presses the **Yes** push button, the GUI returns the output `OUT = 'Yes'` to the command line.

The output `varargout`, which is a cell array, can contain any number of output arguments. By default, GUIDE creates just one output argument, `handles.output`. To create a second output argument, add the command

```
varargout{2} = handles.second_output;
```

to the output function. You can set the value of `handles.second_output` in any callback and then save it with the `guidata` command.

If you want, you can choose more descriptive names than `output` or `second_output` for the fields of the handles structure corresponding to the output arguments.

Callbacks

When a user activates a component of the GUI, the GUI executes the corresponding callback. The name of the callback is determined by the component's `Tag` property and the type of callback. For example, a push button with the `Tag` `print_button` executes the callback

```
function print_button_Callback(hObject, eventdata, handles)
```

Input and Output Arguments

The following examples illustrate various ways to call a GUI named `my_gui` with different arguments. All arguments are passed to the opening function in the GUI M-file.

- Calling `my_gui` with no arguments opens `my_gui`.
- Calling `H = my_gui` opens `my_gui` and returns the handle to `my_gui`.
- Calling `my_gui('Property', Value,...)`, where `'Property'` is a valid figure property, opens `my_gui` using the given property-value pair. You can call the GUI with more than one property-value pair.

  For example, `my_gui('Position', [71.8 44.9 74.8 19.7])` opens the GUI at the specified position, since `Position` is a valid figure property. See the reference page for `figure` for a list of figure properties.
- Calling `my_gui('My_function', hObject, eventdata, handles,...)` calls the subfunction `My_function` in the GUI M-file with the given input arguments.
- Calling `my_gui('Key_word', Value,...)`, where `'Key_word'` is any string that is *not* a valid figure property or the name of a subfunction, creates a new `my_gui`, and passes the pair `'Key_word'`, `Value` to the opening function in the GUI M-file via `varargin`.

  You can use this calling syntax to pass arguments that are not figure properties to the GUI. For example, `my_gui('Temperature', 98.6)` opens the GUI and passes the vector `['Temperature', 98.6]` to the opening function.

See "An Address Book Reader" on page 5-31 for an example that uses this syntax. The example creates a GUI called `address_book`. Calling the GUI with the syntax `address_book('book', my_contacts)` opens the GUI with the MAT-file `my_contacts`, which contains a list of names and addresses you want to display. Note that you can use any string that is not a valid figure property or the name of a callback in place of the string `'book'`. See the reference page for `figure` for a list of figure properties.

Note If you call a GUI with multiple property value pairs, all the pairs that correspond to valid figure properties must precede all the pairs that do not correspond to valid figure properties in the sequence of arguments.

Programming Callbacks for GUI Components

This section explains how to program the callbacks for some specific GUI components. “Callback Properties” on page 3-51 describes the different kinds of callbacks.

See a component’s property reference page to determine which callbacks apply for that component. “Setting Component Properties — The Property Inspector” on page 3-40 provides links to the property reference pages.

This section provides information on the following topics:

Toggle Button Callback

The callback for a toggle button needs to query the toggle button to determine what state it is in. MATLAB sets the `Value` property equal to the `Max` property when the toggle button is depressed (`Max` is 1 by default) and equal to the `Min` property when the toggle button is not depressed (`Min` is 0 by default).

From the GUI M-file

The following code illustrates how to program the callback in the GUI M-file.

```
function togglebutton1_Callback(hObject, eventdata, handles)
button_state = get(hObject,'Value');
if button_state == get(hObject,'Max')
```

```
    % toggle button is pressed
elseif button_state == get(hObject,'Min')
    % toggle button is not pressed
end
```

Note If you have toggle buttons that are managed by a button group component, you must include the code to control them in the button group's `SelectionChangeFcn` callback function, not in the individual toggle button `Callback` functions. A button group overwrites the `Callback` properties of radio buttons and toggle buttons that it manages. See "Button Groups" on page 4-13 for more information.

Adding an Image to a Push Button or Toggle Button

Assign the `CData` property an m-by-n-by-3 array of RGB values that define a truecolor image. For example, the array a defines 16-by-128 truecolor image using random values between 0 and 1 (generated by `rand`).

```
a(:,:,1) = rand(16,128);
a(:,:,2) = rand(16,128);
a(:,:,3) = rand(16,128);
set(hObject,'CData',a)
```

See `ind2rgb` for information on converting an `(X, MAP)` image to an `RGB` image.

Radio Buttons

You can determine the current state of a radio button from within its callback by querying the state of its `Value` property, as illustrated in the following example:

```
if (get(hObject,'Value') == get(hObject,'Max'))
    % then rsdio button is selected-take approriate action
else
    % radio button is not selected-take approriate action
end
```

Note If you have radio buttons that are managed by a button group component, you must include the code to control them in the button group's `SelectionChangeFcn` callback function, not in the individual radio button `Callback` functions. A button group overwrites the `Callback` properties of radio buttons and toggle buttons that it manages. See "Button Groups" on page 4-13 for more information.

Check Boxes

You can determine the current state of a check box from within its callback by querying the state of its `Value` property, as illustrated in the following example:

```
function checkbox1_Callback(hObject, eventdata, handles)
if (get(hObject,'Value') == get(hObject,'Max'))
   % then checkbox is checked-take approriate action
else
   % checkbox is not checked-take approriate action
end
```

Edit Text

To obtain the string a user typed in an edit box, get the `String` property in the callback.

```
function edittext1_Callback(hObject, eventdata, handles)
user_string = get(hObject,'string');
% proceed with callback...
```

For example, setting `Max` to `2`, with the default value of `0` for `Min`, enables users to select multiple lines

Obtaining Numeric Data from an Edit Text Component

MATLAB returns the value of the edit text `String` property as a character string. If you want users to enter numeric values, you must convert the characters to numbers. You can do this using the `str2double` command, which converts strings to doubles. If the user enters nonnumeric characters, `str2double` returns `NaN`.

You can use the following code in the edit text callback. It gets the value of the `String` property and converts it to a double. It then checks whether the converted value is `NaN` (`isnan`), indicating the user entered a nonnumeric character and displays an error dialog (`errordlg`).

```
function edittext1_Callback(hObject, eventdata, handles)
user_entry = str2double(get(hObject,'string'));
if isnan(user_entry)
      errordlg('You must enter a numeric value','Bad Input','modal')
end
% proceed with callback...
```

Triggering Callback Execution

For both UNIX and Windows, clicking on the menu bar of the figure window causes the edit text callback to execute. Clicking on other components or the background of the GUI also executes the callback.

Sliders

You can determine the current value of a slider from within its callback by querying its `Value` property, as illustrated in the following example:

```
function slider1_Callback(hObject, eventdata, handles)
slider_value = get(hObject,'Value');
% proceed with callback...
```

The `Max` and `Min` properties specify the slider's range (`Max - Min`).

List Boxes

Triggering Callback Execution

MATLAB evaluates the list box's callback after the mouse button is released or after certain key press events.

- The arrow keys change the `Value` property and trigger callback execution.
- **Enter** and **Space** do not change the `Value` property but trigger callback execution.

If the user double-clicks, the callback executes after each click. MATLAB sets `Selection Type` to `normal` on the first click and to `open` on the second click. The

callback can query the `Selection Type` property to determine if it was a single- or double-click.

List Box Examples

See the following examples for more information on using list boxes:

- "List Box Directory Reader" on page 5-9 — Shows how to creates a GUI that displays the contents of directories in a list box and enables users to open a variety of file types by double-clicking on the filename.
- "Accessing Workspace Variables from a List Box" on page 5-15 — Shows how to access variables in the MATLAB base workspace from a list box GUI.

Pop-Up Menus

You can program the popup menu callback to work by checking only the index of the item selected (contained in the `Value` property) or you can obtain the actual string contained in the selected item.

This callback checks the index of the selected item and uses a switch statement to take action based on the value. If the contents of the popup menu is fixed, then you can use this approach.

```
function popupmenu1_Callback(hObject, eventdata, handles)
val = get(hObject,'Value');
switch val
case 1
% The user selected the first item
case 2
% The user selected the second item
% proceed with callback...
```

This callback obtains the actual string selected in the pop-up menu. It uses the value to index into the list of strings. This approach may be useful if your program dynamically loads the contents of the pop-up menu based on user action and you need to obtain the selected string. Note that it is necessary to convert the value returned by the `String` property from a cell array to a string.

```
function popupmenu1_Callback(hObject, eventdata, handles)
val = get(hObject,'Value');
string_list = get(hObject,'String');
selected_string = string_list{val}; % convert from cell array
                                    % to string
```

```
% proceed with callback...
```

Panels

Panels group GUI components and can make a user interface easier to understand by visually grouping related controls. Panel children can be panels and button groups as well as axes and user interface controls. The position of each component within a panel is interpreted relative to the panel. If the panel is resized, you may want to reposition its components.

The following callback executes and gets the `Position` property of `uipanel2` whenever the panel is resized. Once you have the size data contained in the `Position` property, you can modify the `Position` properties of the child components to reposition them. Use the `Children` property of `uipanel2` to get the handles of its child components.

```
function uipanel2_ResizeFcn(hObject, eventdata, handles)
% hObject    handle to uipanel1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
pos = get(hObject,'Position');
% proceed with callback...
```

Note This same example also applies to button groups.

Button Groups

Button groups are like panels, but can be used to manage exclusive selection behavior for radio buttons and toggle buttons. The button group's `SelectionChangeFcn` callback is called whenever a selection is made.

For radio buttons and toggle buttons that are managed by a button group, you must include the code to control them in the button group's `SelectionChangeFcn` callback function, not in the individual uicontrol `Callback` functions. A button group overwrites the `Callback` properties of radio buttons and toggle buttons that it manages.

This example of a `SelectionChangeFcn` callback uses the button group's `SelectedObject` property to get the handle of the selected toggle button or

radio button. It then uses the `Tag` property of the selected object to choose the appropriate code to execute.

```
function uibuttongroup1_SelectionChangeFcn(hObject,eventdata,handles)
% hObject    handle to uipanel1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

selection = get(hObject,'SelectedObject');
switch get(selection,'Tag')
    case 'radiobutton1'
        % code piece when radiobutton1 is selected goes here
    case 'radiobutton2'
        % code piece when radiobutton2 is selected goes here
        % ...
end
```

Axes

Axes enable your GUI to display graphics (e.g., graphs and images). Like all graphics objects, axes have properties that you can set to control many aspects of its behavior and appearance. See "Axes Properties" in the MATLAB Graphics documentation for general information on axes objects.

Axes Callbacks

Axes are not uicontrol objects, but can be programmed to execute a callback when users click a mouse button in the axes. Use the axes `ButtonDownFcn` property to define the callback.

Plotting to Axes in GUIs

If your GUI contains axes, you should make sure that the **Command-line accessibility** option in the **GUI Options** dialog is set to **Callback** (the default). This enables you to issue plotting commands from callbacks without explicitly specifying the target axes. See "Command-Line Accessibility" on page 3-27 for more information about how this option works.

Note If your GUI is opened as the result of another GUI's callback, you might need to explicitly specify the target axes. See "GUIs with Multiple Axes" on page 4-16.

Example: Displaying an Image on an Axes

This example shows how to display an image on an axes. The example

- Displays an image file on an axes.
- Resizes the axes to fit the image.
- Resizes the GUI so that its width and height are 100 pixels larger than the image file.

To build the example:

1. Open a blank template in the Layout Editor.
2. Drag an axes into the layout area.
3. Select **M-file editor** from the **View** menu.
4. Add the following code to the opening function:

```
set(hObject, 'Units', 'pixels');
handles.banner = imread([matlabroot filesep 'demos' filesep
'banner.jpg']); % Read the image file banner.jpg
info = imfinfo([matlabroot filesep 'demos' filesep
'banner.jpg']); % Determine the size of the image file
position = get(hObject, 'Position');
set(hObject, 'Position', [position(1:2) info.Width + 100
info.Height + 100]);
axes(handles.axes1);
image(handles.banner)
set(handles.axes1, ...
    'Visible', 'off', ...
    'Units', 'pixels', ...
    'Position', [50 50 info.Width info.Height]);
```

When you run the GUI, it appears as in the following figure.

The preceding code performs the following operations:

- Reads the image file `banner.jpg` using the command `imread`.
- Determines the size of the image file in pixels using the command `imfinfo`.
- Sets the width and height of the GUI to be 100 pixels greater than the corresponding dimensions of the image file, which are stored as `info.Width` and `info.Height`, respectively. The width and height of the GUI are the third and fourth entries of the vector `position`.
- Displays the image in the axes using the command `image(handles.banner)`.
- Makes the following changes to the axes properties:
  - Sets `'Visible'` to `'off'` so that the axes are invisible
  - Sets `'Units'` to `'pixels'` to match the units of the vector position
  - Sets `'Position'` to `[50, 50, info.Width info.Height]` to set the size of the axes equal to that of the image file, and center the image file on the GUI.

GUIs with Multiple Axes

If a GUI has multiple axes, you should explicitly specify which axes you want to target when you issue plotting commands. You can do this using the `axes` command and the `handles` structure. For example,

```
axes(handles.axes1)
```

makes the axes whose `Tag` property is `axes1` the current axes, and therefore the target for plotting commands. You can switch the current axes whenever you want to target a different axes. See “GUI with Multiple Axes” on page 5-2 for an example that uses two axes.

ActiveX Controls

You can insert an ActiveX control into your GUI if you are running MATLAB on Microsoft Windows. When you drag an ActiveX component from the component palette into the layout area, GUIDE displays a dialog in which you can select any registered ActiveX control on your system. When you select an ActiveX control and click **Create**, the control appears as a small box in the Layout Editor. You can then program the control to do what you want it to.

See MATLAB COM Client Support in the online MATLAB documentation to learn more about ActiveX controls.

This section covers the following topics:

Adding an ActiveX Control to a GUI

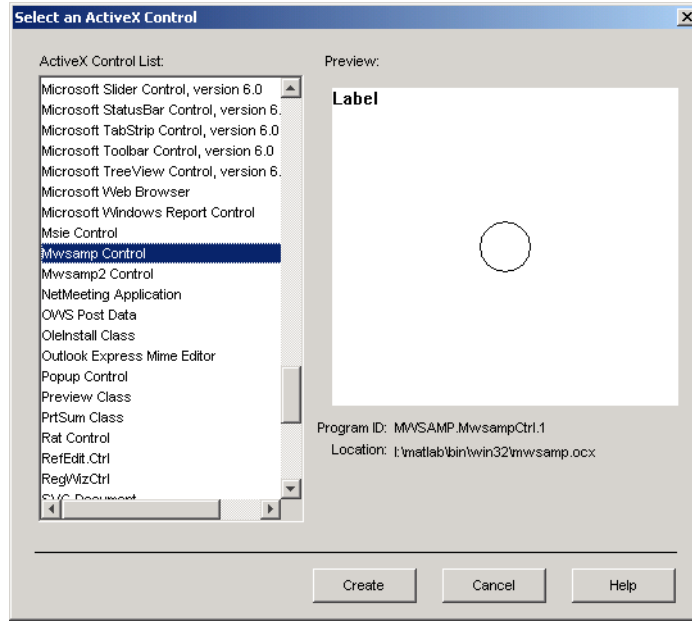
This section shows how to add an ActiveX control to a GUI. The section describes a simple ActiveX control that displays a circle. After adding the ActiveX control, you can program the GUI to change the radius of the circle and display the new value of the radius.

Note If MATLAB is not installed locally on your computer — for example, if you are running MATLAB over a network — you might not find the ActiveX control described in this example. To register the control, see Registering Controls and Servers in the online MATLAB documentation.

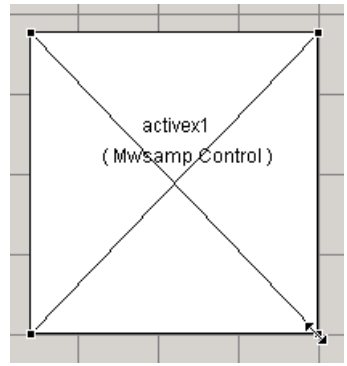
To make the example,

1. Open a new GUI in GUIDE and drag an ActiveX control from the component palette into the Layout Editor.

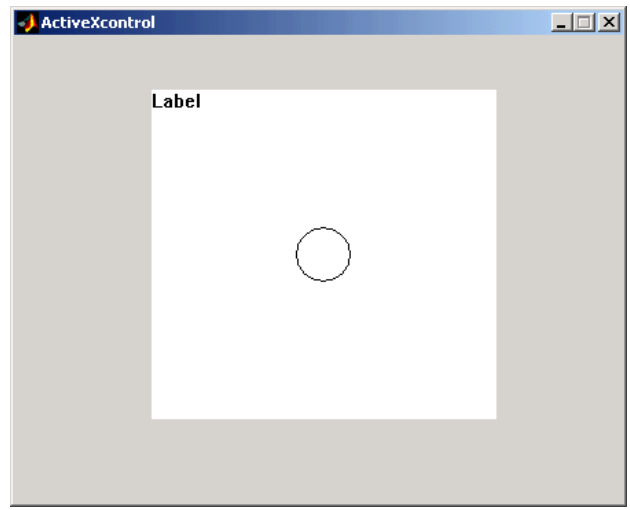
2 Scroll down the **ActiveX Control List** and select **Mwsamp Control.** This displays a preview of the ActiveX control `Mwsamp`, as shown in the following figure.



3 Click **Create** to display the ActiveX control in the Layout Editor, and resize the control to approximately the size of the square shown in the preview pane. You can do this by clicking and dragging a corner of the control, as shown in the following figure.



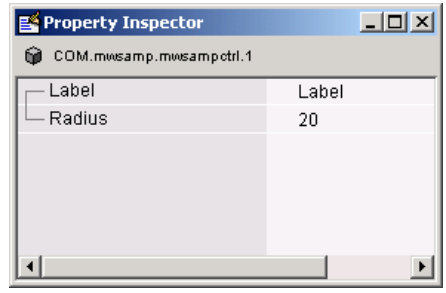
4 Click the **Run** button on the toolbar and save the GUI when prompted. GUIDE displays the GUI shown in the following figure.



Viewing the ActiveX Properties with the Property Inspector

To view the properties of the ActiveX control, right-click the control in the Layout Editor and select **Property Inspector**, or select **Property Inspector**

from the **View** menu. This displays the Property Inspector, as shown in the following figure.



The ActiveX control `mwsamp` has just two properties:

- `Label`, which contains the text that appears at the top of the control
- `Radius`, the default radius of the circle, which is 20

The example in the next section shows how to program the GUI to

- Change the radius when a user clicks the circle
- Change the label to display the new radius

Adding a Callback to an ActiveX Control to Change a Property

To change a property of the control when a user performs an action, you need to add a callback to an ActiveX control. For example, to make `mwsamp` decrease the radius of the circle by 10 percent and display the new value each time a user clicks the ActiveX control, you can add an *event*, or callback, corresponding to the click action. To do so,

1. Right-click the ActiveX control in the Layout Editor to bring up its context menu.

2. In the context menu, place the cursor over **View Callbacks** and select **Click**. This creates a callback called `activex1_Click` and opens the GUI M-file with the first line of the callback highlighted.

3. Add the following commands to the `activex1_Click` callback:

```
hObject.radius = .9*hObject.radius;
hObject.label = ['Radius = ' num2str(hObject.radius)];
```

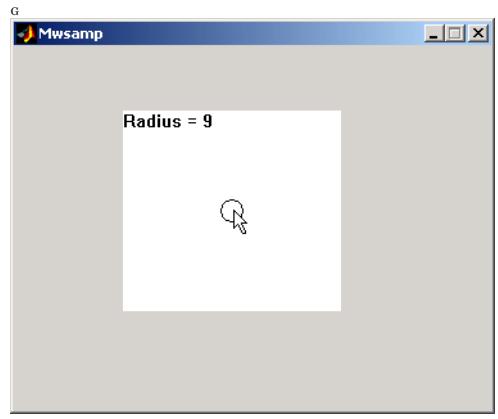
```
refresh(handles.figure1);
```

4 Add the following command to the opening function:

```
handles.activex1.label = ...
['Radius = ' num2str(handles.activex1.radius)];
```

5 Run the GUI.

Now, each time you click the ActiveX control, the radius of the circle is reduced by 10 percent and the new value of the radius is displayed, as shown in the following figure.



GUI After Clicking the Circle Six Times

If you click the GUI enough times, the circle disappears entirely.

Adding a Uicontrol to Change an ActiveX Control Property

You can also add other Uicontrols to the GUI to change the properties of an ActiveX control. For example, you can add a slider that changes the radius of the circle in the Mwsamp GUI. To do so,

1 Drag a slider into the layout area.

2 Right-click the slider and select **M-file Editor**.

3 Add the following command to the `slider1` callback:

```
handles.activex1.radius = ...
get(hObject, 'Value')*handles.default_radius;
handles.activex1.label = ...
['Radius = ' num2str(handles.activex1.radius)];
refresh(handles.figure1);
```

4 Add the following command to the opening function:

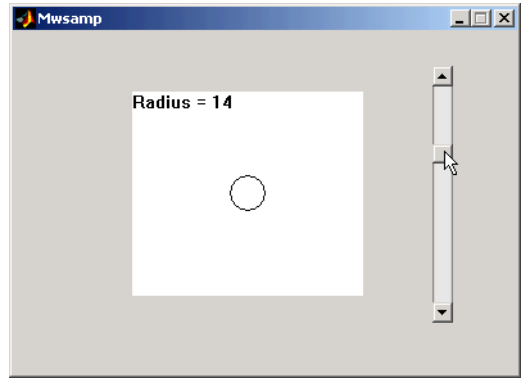
```
handles.default_radius = handles.activex1.radius;
```

5 Add the following command at the end of the code in the `activex1_Click` callback:

```
set(handles.slider1, 'Value', ...
hObject.radius/handles.default_radius);
```

6 Run the GUI.

When you move the slider by clicking and dragging, the radius changes to a new value between 0 and the default radius of 20, as shown in the following figure.



The command

```
handles.activex1.radius = ...
get(hObject, 'Value')*handles.default_radius;
```

does the following:

- Gets the `Value` of the slider, which in this example is a number between 0 and 1, the default values of the slider's `Min` and `Max` properties.
- Sets `handles.activex1.radius` equal to the `Value` times the default radius.

Note that clicking the ActiveX control causes the slider to change position corresponding to the new value of the radius. The command

```
set(handles.slider1, 'Value', ...
hObject.radius/handles.default_radius);
```

in the `activex1_Click` callback resets the slider's `Value` each time the user clicks the ActiveX control.

Viewing the Methods for an ActiveX Control

To view the available methods for the ActiveX control, you first need to obtain the handle to the control. One way to do this is the following:

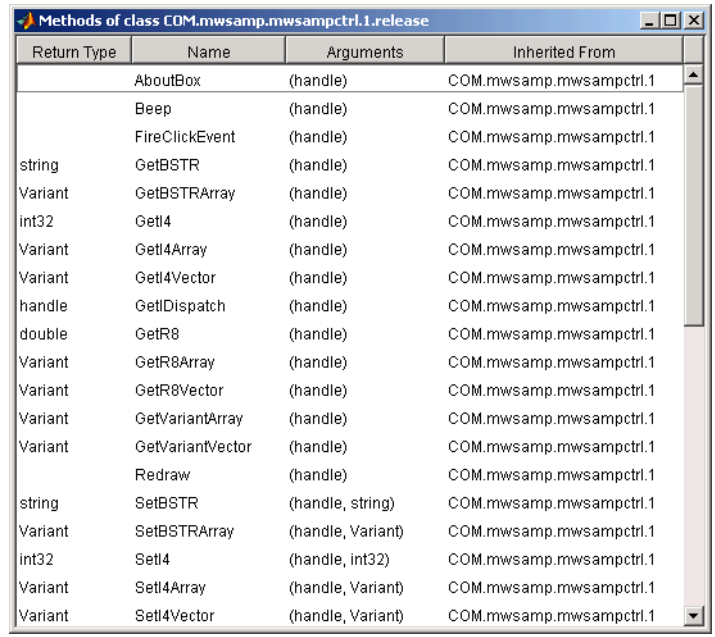
1. In the GUI M-file, add the command `keyboard` on a separate line of the `activex1_Click` callback. The command `keyboard` puts MATLAB in debug mode and pauses at the `activex1_Click` callback when you click the ActiveX control.

2. Run the GUI and click the ActiveX control.

The handle to the control is now set to `hObject`. To view the methods for the control, enter

```
methodsview(hObject)
```

at the MATLAB prompt. This displays the available methods in a new window, as shown in the following figure.



Return Type	Name	Arguments	Inherited From
	AboutBox	(handle)	COM.mwsamp.mwsampctrl.1
	Beep	(handle)	COM.mwsamp.mwsampctrl.1
	FireClickEvent	(handle)	COM.mwsamp.mwsampctrl.1
string	GetBSTR	(handle)	COM.mwsamp.mwsampctrl.1
Variant	GetBSTRArray	(handle)	COM.mwsamp.mwsampctrl.1
int32	GetI4	(handle)	COM.mwsamp.mwsampctrl.1
Variant	GetI4Array	(handle)	COM.mwsamp.mwsampctrl.1
Variant	GetI4Vector	(handle)	COM.mwsamp.mwsampctrl.1
handle	GetIDispatch	(handle)	COM.mwsamp.mwsampctrl.1
double	GetR8	(handle)	COM.mwsamp.mwsampctrl.1
Variant	GetR8Array	(handle)	COM.mwsamp.mwsampctrl.1
Variant	GetR8Vector	(handle)	COM.mwsamp.mwsampctrl.1
Variant	GetVariantArray	(handle)	COM.mwsamp.mwsampctrl.1
Variant	GetVariantVector	(handle)	COM.mwsamp.mwsampctrl.1
	Redraw	(handle)	COM.mwsamp.mwsampctrl.1
string	SetBSTR	(handle, string)	COM.mwsamp.mwsampctrl.1
Variant	SetBSTRArray	(handle, Variant)	COM.mwsamp.mwsampctrl.1
int32	SetI4	(handle, int32)	COM.mwsamp.mwsampctrl.1
Variant	SetI4Array	(handle, Variant)	COM.mwsamp.mwsampctrl.1
Variant	SetI4Vector	(handle, Variant)	COM.mwsamp.mwsampctrl.1

Alternatively, you can enter

```
methods(hObject)
```

which displays the available methods in the Command Window.

For more information about methods for ActiveX controls, see Invoking Methods in the online MATLAB documentation. See the reference pages for `methodsview` and `methods` for more information about these functions.

Figures

Figures are the windows that contain the GUIs you design with the Layout Editor. See the Figure Properties reference page for information on what figure characteristics you can control.

Displaying Plots in a Separate Figure

To prevent a figure from becoming the target of plotting commands issued at the command line or by other GUIs, you can set the `HandleVisibility` and `IntegerHandle` properties to `off`. However, this means the figure is also

hidden from plotting commands issued by your GUI. To issue plotting commands from your GUI,

- Create a figure and axes.
- Save the handle of the figure in the `handles` structure.
- Create an axes, save its handle, and set its `Parent` property to the figure handle.
- Create the plot, save the handles, and set their Parent properties to the handle of the axes.

The following code illustrates these steps:

```
fHandle =
figure('HandleVisibility','off','IntegerHandle','off',...
    'Visible','off');
aHandle = axes('Parent',fHandle);
pHandles = plot(PlotData,'Parent',aHandle);
set(fHandle,'Visible','on')
```

Note that not all plotting commands accept property name/property value specifications as arguments. Consult the reference page for the specific command to see what arguments you can specify.

Managing GUI Data with the Handles Structure

GUIDE provides a mechanism, called the *handles structure*, for storing and retrieving shared data using the same structure that contains the GUI component handles. The `handles` structure, which contains the handles of all the components in the GUI, is passed to each callback in the GUI M-file. Therefore, this structure is useful for saving any shared data. The following example illustrates this technique.

If you are not familiar with MATLAB structures, see Structures for more information.

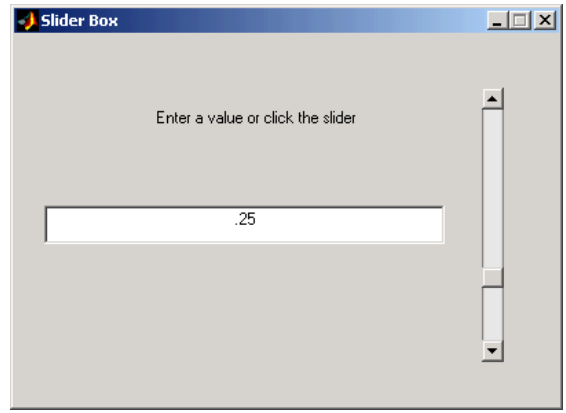
This section covers the following topics:

Example: Passing Data Between Callbacks

This example demonstrates how to use the `handles` structure to pass data between callbacks. The example passes data between a slider and an editable text box in the following way:

- When a user moves the slider, the text box displays the slider's current value.
- When a user types a value into the text box, the slider updates to this value.
- If a user enters a value in the text box that is out of range for the slider — that is, a value that is not between 0 an 1 — the application returns a message indicating how many times he has entered an erroneous value.

The following figure shows the GUI with a static text field above the edit text box.



Defining the Data Fields in the Opening Function

The GUI records the number of times a user enters an erroneous value in the text box and stores this number in a field of the `handles` structure. You can define this field, called `number_errors`, in the opening function as follows:

```
handles.number_errors = 0;
```

Type this command before the following line, which GUIDE automatically inserts into the opening function.

```
guidata(hObject, handles); % Save the updated structure
```

The `guidata` command saves the `handles` structure so that it can be retrieved in the callbacks.

Note To save any changes that you make to the handles structure, you must add the command `guidata(hObject, handles)` following the code that implements the changes.

Setting the Edit Text Value from the Slider Callback

The following command in the slider callback updates the value displayed in the edit text when a user moves the slider and releases the mouse button.

```
set(handles.edit1,'String',...
```

```
    num2str(get(handles.slider1,'Value')));
```

The code combines three commands:

- The `get` command obtains the current value of the slider.
- The `num2str` command converts the value to a string.
- The `set` command resets the `String` property of the edit text to the updated value.

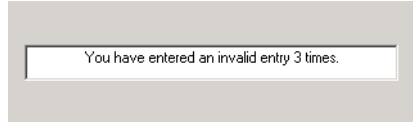
Setting the Slider Value from the Edit Text Callback

The edit text callback sets the slider's value to the number the user types in, after checking to see if it is a single numeric value between 0 and 1. If the value is out of range, then the error count is incremented and the edit text displays a message telling the user how many times they have entered an invalid number.

```
val = str2double(get(handles.edit1,'String'));
% Determine whether val is a number between 0 and 1
if isnumeric(val) & length(val)==1 & ...
   val >= get(handles.slider1,'Min') & ...
   val <= get(handles.slider1,'Max')
   set(handles.slider1,'Value',val);
else
% Increment the error count, and display it
   handles.number_errors = handles.number_errors+1;
   guidata(hObject,handles); % store the changes
   set(handles.edit1,'String',...
   ['You have entered an invalid entry ',...
num2str(handles.number_errors),' times.']);
end
```

If the user types a number between 0 and 1 in the edit box and then clicks outside the edit box, the callback sets `handles.slider1` to the new value and the slider moves to the corresponding position.

If the entry is invalid — for example, `2.5` — the GUI increments the value of `handles.number_errors` and displays a message like the following:



Application Data

Application data provides a way for applications to save and retrieve data stored with the GUI. This technique enables you to create what is essentially a user-defined property for an object. You can use this property to store data.

The GUI M-file uses application data to store the `handles` structure.

When using the GUIDE-generated M-file, it is simpler to use `guidata` than to access application data directly.

Functions for Accessing Application Data

The following functions provide access to application data.

Functions for Accessing Application-Defined Data

Function	Purpose
`setappdata`	Specify application data
`getappdata`	Retrieve named application data
`isappdata`	True if the named application data exists
`rmappdata`	Remove the named application data

Designing for Cross-Platform Compatibility

You can use specific property settings to create a GUI that behaves more consistently when run on different platforms:

- Use the default font (uicontrol `FontName` property).
- Use the default background color (uicontrol `BackgroundColor` property).
- Use figure character units (figure `Units` property).

Using the Default System Font

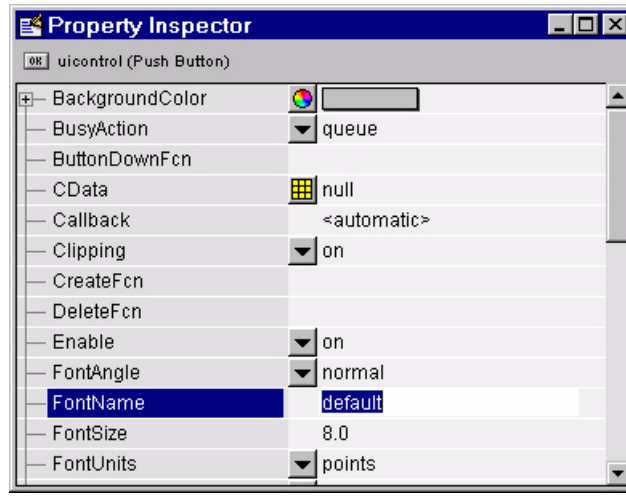
By default, uicontrols use the default font for the platform on which they are running. For example, when displaying your GUI on PCs, uicontrols uses MS San Serif. When your GUI runs on a different platform, it uses that computer's default font. This provides a consistent look with respect to your GUI and other application GUIs.

If you have set the `FontName` property to a named font and want to return to the default value, you can set the property to the string `default`. This ensures that MATLAB uses the system default at runtime.

From within the GUI M-file, use the set command. For example, if there is a push button in your GUI and its handle is stored in the `pushbutton1` field of the `handles` structure, then the statement,

```
set(handles.pushbutton1,'FontName','default')
```

sets the `FontName` property to use the system default. You can also use the Property Inspector to set this property:



Specifying a Fixed-Width Font

If you want to use a fixed-width font for a uicontrol, set its `FontName` property to the string `fixedwidth`. This special identifier ensures that your GUI uses the standard fixed-width font for the target platform.

You can find the name of the fixed-width font that is used on a given platform by querying the root `FixedWidthFontName` property.

```
get(0,'FixedWidthFontName')
```

Using a Specific Font Name

You can specify an actual font name (such as Times or Courier) for the `FontName` property. However, doing so may cause your GUI to look poorly when run on a different computer. If the target computer does not have the specified font, it will substitute another font that may not look good in your GUI or may not be the standard font used for GUIs on that system. Also, different versions of the same named font may have different size requirements for a given set of characters.

Using Standard Background Color

By default, uicontrols use the standard background color for the platform on which it is running (e.g., the standard shade of gray on the PC differs from that

on UNIX). When your GUI is deployed on a different platform, it uses that computer's standard color. This provides a consistent look with respect to your GUI and other application GUIs.

If you change the `BackgroundColor` to another value, MATLAB always uses the specified color.

Cross-Platform Compatible Figure Units

Cross-platform compatible GUIs should look correct on computers having different screen sizes and resolutions. Since the size of a pixel can vary on different computer displays, using the default figure `Units` of `pixels` does not produce a GUI that looks the same on all platforms.

For this reason, GUIDE sets the figure `Units` property to `characters`.

System-Dependent Units

Figure character units are defined by characters from the default system font; one character unit equals the width of the letter x in the system font. The height of one character is the distance between the baselines of two lines of text (note that character units are not square).

GUIDE sets the figure `Units` property to `characters` so that your GUIs automatically adjust the size and relative spacing of components as the GUI displays on different computers. For example, if the size of the text label on a component becomes larger because of different system font metrics, then the component size and the relative spacing between components increases proportionally.

Types of Callbacks

The primary mechanism for implementing a GUI is programming the callbacks of the GUI components used to build the interface.

Callback Properties for All Graphics Objects

All graphics objects have three properties that enable you to define callback routines:

- `ButtonDownFcn` — MATLAB executes this callback when users click the left mouse button and the cursor is over the object or within a five-pixel border around the object. See "Which Callback Executes" for information specific to uicontrols
- `CreateFcn` — MATLAB executes this callback when creating the object.
- `DeleteFcn` — MATLAB executes this callback just before deleting the object.

Callback Properties for Figures

Figures have additional properties that execute callback routines with the appropriate user action. Only the `CloseRequestFcn` has a callback defined by default:

- `CloseRequestFcn` — MATLAB executes the specified callback when a request is made to close the figure (by a `close` command, by the window manager menu, or by quitting MATLAB).
- `KeyPressFcn` — MATLAB executes the specified callback when users press a key and the cursor is within the figure window and no component has focus.
- `ResizeFcn` — MATLAB executes the specified callback routine when users resize the figure window.
- `WindowButtonDownFcn` — MATLAB executes the specified callback when users click the mouse button and the cursor is within the figure, but not over an enabled uicontrol.
- `WindowButtonMotionFcn` — MATLAB executes the specified callback when users move the mouse button within the figure window.
- `WindowButtonUpFcn` — MATLAB executes the specified callback when users release the mouse button, after having pressed the mouse button within the figure.

Callbacks for Specific Components

Some components have additional properties that execute callback routines with the appropriate user action:

- `Callback` — MATLAB executes the specified callback when a user activates a user interface control (`uicontrol`) or menu (`uimenu`) object, for example, when a user presses a push button or selects a menu item.
- `KeyPressFcn` — MATLAB executes the specified callback when a user presses a key and the callback's component has focus.
- `ResizeFcn` — MATLAB executes the specified callback routine when users resize a panel (`uipanel`) or button group (`uibuttongroup`) object.
- `SelectionChangeFcn` — MATLAB executes the specified callback routine when a user selects a different radio button or toggle button in a button group component.

Which Callback Executes

Clicking on an enabled uicontrol prevents any `ButtonDownFcn` and `WindowButtonDownFcn` callbacks from executing. If you click on an inactive uicontrol, figure, or other graphics objects having callbacks defined, MATLAB first executes the `WindownButtonDownFcn` of the figure (if defined) and then the `ButtonDownFcn` of the object targeted by the mouse click.

Adding a Callback

To add a callback subfunction to the GUI M-file, click the right mouse button while the object is selected to display the Layout Editor context menu. Select the desired callback from the context menu and GUIDE adds the subfunction stub to the GUI M-file.

Interrupting Executing Callbacks

By default, MATLAB allows an executing callback to be interrupted by subsequently invoked callbacks. For example, suppose you have created a dialog box that displays a progress indicator while loading data. This dialog could have a “Cancel” button that stops the loading operation. The “Cancel” button’s callback routine would interrupt the currently executing callback routine.

There are cases where you may not want user actions to interrupt an executing callback. For example, a data analysis tool may need to perform lengthy calculations before updating a graph. An impatient user may inadvertently click the mouse on other components and thereby interrupt the calculations while in progress. This could change the MATLAB state before returning to the original callback.

The following sections provide more information on this topic:

- “Controlling Interruptibility”
- “The Event Queue”
- “Event Processing During Callback Execution”

Controlling Interruptibility

All graphics objects have an `Interruptible` property that determines whether their callbacks can be interrupted. The default value is `on`, which means that callbacks can be interrupted. However, MATLAB checks the event queue only when it encounters certain commands — `drawnow`, `figure`, `getframe`, `pause`, and, `waitfor`. Otherwise, the callback continues to completion.

The Event Queue

MATLAB commands that perform calculations or assign values to properties execute as they are encountered in the callback. However, commands or actions that affect the state of the figure window generate events that are placed in a queue. Events are caused by any command that causes the figure to be redrawn or any user action, such as a button click or cursor movement, for which there is a callback routine defined.

MATLAB processes the event queue only when the callback finishes execution or when the callback contains the following commands:

- drawnow
- figure
- getframe
- pause
- waitfor

When MATLAB encounters one of these commands in a callback, it suspends execution and processes the events in the event queue. The way MATLAB handles an event depends on the event type and the setting of the callback object's Interruptible property:

- Events that would cause another callback to execute (e.g., clicking a push button or figure window mouse button actions) can execute the callback only if the current callback object's Interruptible property is on.
- Events that cause the figure window to redraw execute the redraw regardless of the value of the current callback object's Interruptible property.

Note that callbacks defined for an object's DeleteFcn or CreateFcn or a figure's CloseRequestFcn or ResizeFcn interrupt an executing callback regardless of the value of the object's Interruptible property.

What Happens to Events That Are Blocked — BusyAction Property

All objects have a BusyAction property that determines what happens to their events when processed during noninterruptible callback routine execution.

BusyAction has two possible values:

- queue — Keep the event in the event queue and process it after the noninterruptible callback finishes.
- cancel — Discard the event and remove it from the event queue.

Event Processing During Callback Execution

The following sequence describes how MATLAB processes events while a callback executes:

1. If MATLAB encounters a drawnow, figure, getframe, pause, or waitfor command in the callback routine, MATLAB suspends execution and begins processing the event queue.

2. If the event at the top of the queue calls for a figure window redraw, MATLAB performs the redraw and proceeds to the next event in the queue.

3. If the event at the top of the queue would cause a callback to execute, MATLAB determines whether the object whose callback is suspended is interruptible.

4. If the callback is interruptible, MATLAB executes the callback associated with the interrupting event. If that callback contains a `drawnow`, `figure`, `getframe`, `pause`, or `waitfor` command, MATLAB repeats these steps for the remaining events in the queue.

5. If the callback is not interruptible, MATLAB checks the `BusyAction` property of the object that generated the event.

   a. If `BusyAction` is `queue`, MATLAB leaves the event in the event queue.

   b. If `BusyAction` is `cancel`, MATLAB discards the event.

6. When all events have been processed (either left in the queue, discarded, or handled as a redraw), MATLAB resumes execution of the interrupted callback routine.

This process continues until the callback completes execution. When MATLAB returns the prompt to the command window, all events have been processed.

Controlling Figure Window Behavior

When designing a GUI you need to consider how you want the figure window to behave. The appropriate behavior for a particular GUI depends on intended use. Consider the following examples:

- A GUI that implements tools for annotating graphs is usually designed to be available while the user performs other MATLAB tasks. Perhaps this tool operates on only one figure at a time so you need a new instance of this tool for each graph.
- A dialog that requires an answer to a question may need to block MATLAB execution until the user answers the question. However, the user may need to look at other MATLAB windows to obtain information needed to answer the question. The dialog is blocking.
- A dialog that warns users that the specified operation will delete files so you want to force the user to respond to the warning before performing any other action. In this case, the dialog is both blocking and modal.

The following techniques are useful for handling these GUI design issues:

- Allow single or multiple instances of the GUI at any one time.
- Use modal figure windows that allow users to interact only with the GUI.

Using Modal Figure Windows

Modal windows trap all keyboard and mouse events that occur in any visible MATLAB window. This means a modal GUI figure can process the user interactions with any of its components, but does not allow the user to access any other MATLAB window (including the command window). In addition, a modal window remains stacked on top of other MATLAB windows until it is deleted, at which time focus returns to the window that last had focus. See the figure `WindowStyle` property for more details.

Use modal figures when you want to force users to respond to your GUI before allowing them to take other actions in MATLAB.

Making a Figure Modal

Set the figure's `WindowStyle` property to `modal` to make the window modal. You can use the Property Inspector to change this property or add a statement in

the initialization section of the GUI M-file in the opening function with the `set` command.

```
set(hObject,'WindowStyle','modal')
```

Dismissing a Modal Figure

A GUI using a modal figure must take one of the following actions in a callback routine to release control:

- Delete the figure.

  ```
  delete(handles.figure1)
  ```
- Make the figure invisible.

  ```
  set(handles.figure1,'Visible','off')
  ```
- Change the figure's `WindowStyle` property to `normal`.

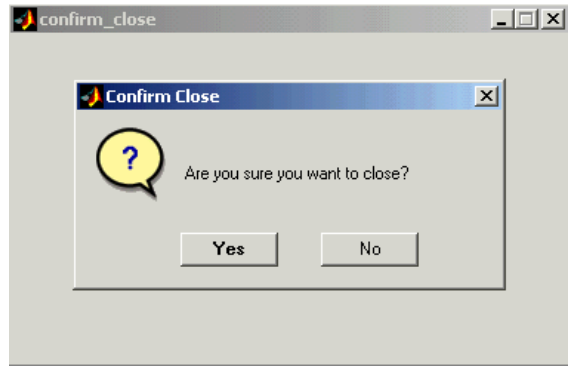
  ```
  set(handles.figure1,'WindowStyle','normal')
  ```

The user can also type **Ctrl+C** in a modal figure to convert it to a normal window.

Example: Using the Modal Dialog to Confirm an Operation

This example illustrates how to use the modal dialog GUI together with another GUI that has a **Close** button. Clicking the **Close** button displays the modal dialog, which asks users to confirm that they really want to proceed with the close operation.

The following figure illustrates the dialog positioned over the GUI application, awaiting the user's response.



The example is presented in the following sections:

View Completed Layouts and Their GUI M-Files

If you are reading this in the MATLAB Help Browser, you can click the following links to display the GUIDE Layout Editor and the MATLAB Editor with a completed version of this example. This enables you to see the values of all component properties and to understand how the components are assembled to create the GUI. You can also see a complete listing of the code that is discussed in the following sections.

Note The following links execute MATLAB commands and are designed to work within the MATLAB Help browser. If you are reading this online or in PDF, you should go to the corresponding section in the MATLAB Help Browser to use the links.

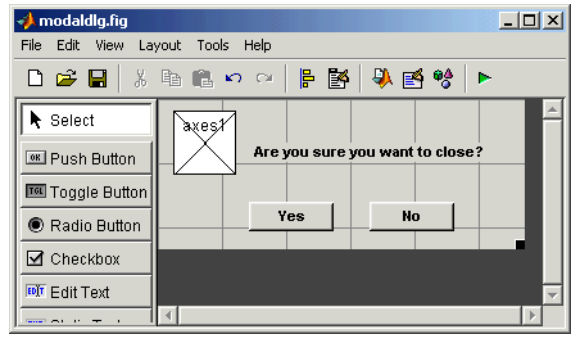
- Click here to display the GUIs in the Layout Editor.
- Click here to display the GUI M-files in the editor.

Setting Up the Close Confirmation Dialog

To set up the dialog, do the following:

1. Select **New** from the **File** menu in the GUIDE Layout Editor.
2. In the **GUIDE Quick Start** dialog, select the **Modal Question Dialog** template and click **OK**.
3. Right-click the static text, `Do you want to create a question dialog?`, in the Layout Editor and select **Property Inspector** from the pop-up menu.
4. Scroll down to `String` in the Property Inspector and change the `String` property to `Are you sure you want to close`?
5. Select **Save** from the **File** menu and type `modaldlg.fig` in the **File name** field.

The GUI should now appear as in the following figure.



Setting Up the GUI with the Close Button

To set up the second GUI with a **Close** button, do the following:

1. Select **New** from the **File** menu in the GUIDE Layout Editor.
2. In the **GUIDE Quick Start** dialog, select **Blank GUI (Default)** and click **OK**. This opens the blank GUI in a new Layout Editor window.
3. Drag a push button from the Component palette of the Layout Editor into the layout area.
4. Right-click the push button and select **Property Inspector** from the pop-up menu.
5. Change the `String` property to `Close`.
6. Change the `Tag` property to `close_pushbutton`.
7. Click the M-file editor icon on the toolbar of the Layout Editor.
8. Click the callback icon on the toolbar of the M-file editor and select `close_pushbutton_Callback` from the menu.

   The following generated code for the close button callback should appear in the M-file editor:

```
% --- Executes on button press in close_pushbutton.
function close_pushbutton_Callback(hObject, eventdata, handles)
% hObject    handle to close_pushbutton (see GCBO)
```

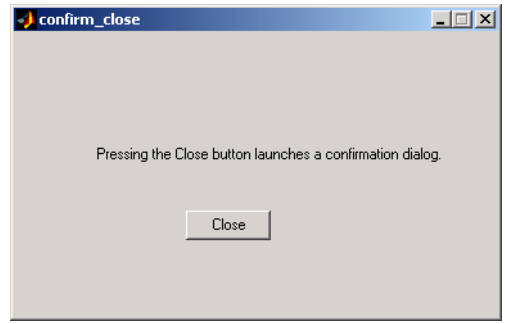
```
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
```

9 After these comments, add the following code:

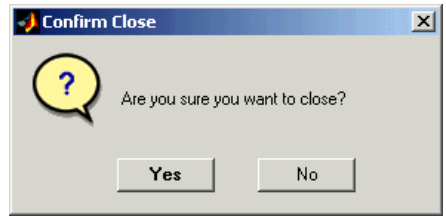
```
% Get the current position of the GUI from the handles structure
% to pass to the modal dialog.
pos_size = get(handles.figure1,'Position');
% Call modaldlg with the argument 'Position'.
user_response = modaldlg('Title','Confirm Close');
switch user_response
case {'No'}
   % take no action
case 'Yes'
   % Prepare to close GUI application window
   %                  .
   %                  .
   %                  .
   delete(handles.figure1)
end
```

Running the GUI with the Close Button

Run the GUI with the **Close** button by clicking the **Run** button on the Layout Editor toolbar. The GUI appears as in the following figure:



When you click the **Close** button on the GUI, the modal dialog appears as shown in the following figure:



Clicking the **Yes** button closes both the close dialog and the GUI that calls it. Clicking the **No** button closes just the dialog.

How the GUI and Dialog Work

This section describes what occurs when you click the **Close** button on the GUI:

1. User clicks the **Close** button. Its callback then
   - Gets the current position of the GUI from the `handles` structure with the command

     ```
     pos_size = get(handles.figure1,'Position')
     ```

   - Calls the modal dialog with the command

     ```
     user_response = modaldlg('Title','Confirm Close');
     ```

     This is an example of calling a GUI with a property value pair. In this case, the figure property is `'Title'`, and its value is the string `'Confirm Close'`. Opening `modaldlg` with this syntax displays the text “Confirm Close” at the top of the dialog. See “Input and Output Arguments” on page 4-7 for more information about the options for calling a GUI.

2. The modal dialog opens with the `'Position'` obtained from the GUI that calls it.

3. The opening function in the modal dialog M-file:
   - Makes the dialog modal.
   - Executes the `uiwait` command, which causes the dialog to wait for the user to click the **Yes** button or the **No** button, or click the close box (`X`) on the window border.

4. When a user clicks one of the two push buttons, the callback for the push button
   - Updates the output field in the `handles` structure
   - Executes `uiresume` to return control to the opening function where `uiwait` is called.
5. The output function is called, which returns the string `Yes` or `No` as an output argument, and deletes the dialog with the command

   ```
   delete(handles.figure1)
   ```
6. When the GUI with the **Close** button regains control, it receives the string `Yes` or `No`. If the answer is `'No'`, it does nothing. If the answer is `'Yes'`, the close button callback closes the GUI with the command

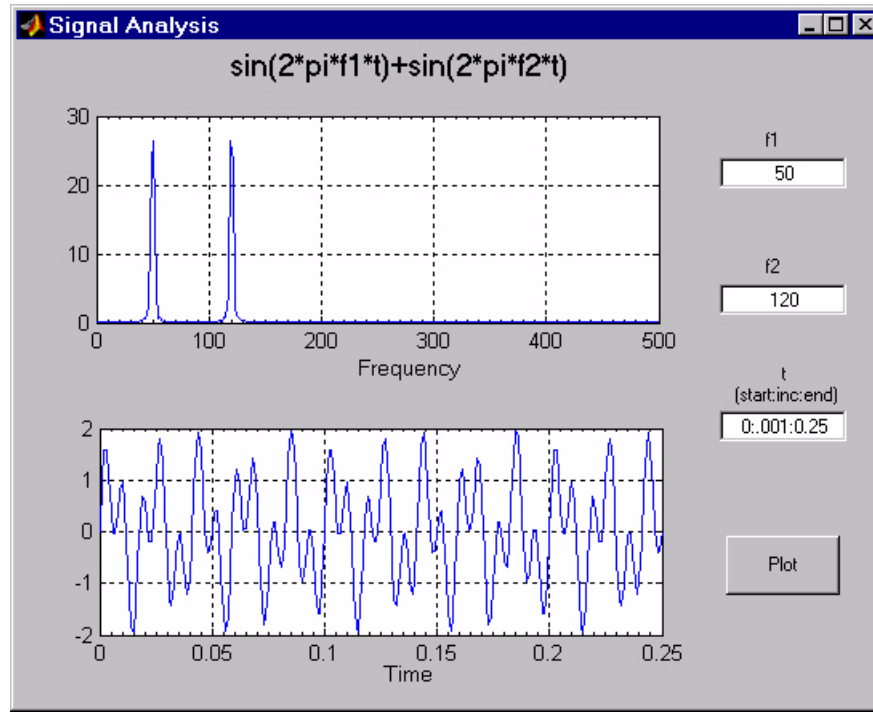
   ```
   delete(handles.figure1)
   ```

5

GUI Applications

GUI with Multiple Axes

This example creates a GUI that contains two axes for plotting data. For simplicity, this example obtains data by evaluating an expression using parameters entered by the user.



Techniques Used in the Example

GUI-building techniques illustrated in this example include

- Controlling which axes is the target for plotting commands.
- Using edit text controls to read numeric input and MATLAB expressions.

View Completed Layout and Its GUI M-File

If you are reading this in the MATLAB Help browser, you can click the following links to display the GUIDE Layout Editor and the MATLAB Editor with a completed version of this example. This enables you to see the values of all component properties and to understand how the components are assembled to create the GUI. You can also see a complete listing of the code that is discussed in the following sections.

Note The following links execute MATLAB commands and are designed to work within the MATLAB Help browser. If you are reading this online or in PDF, you should go to the corresponding section in the MATLAB Help Browser to use the links.

- Click here to display this GUI in the Layout Editor.
- Click here to display the GUI M-file in the MATLAB Editor.

Design of the GUI

This GUI requires three input values:

- Frequency one (`f1`)
- Frequency two (`f1`)
- A time vector (`t`)

When the user clicks the **Plot** button, the GUI puts these values into a MATLAB expression that is the sum of two sine function:

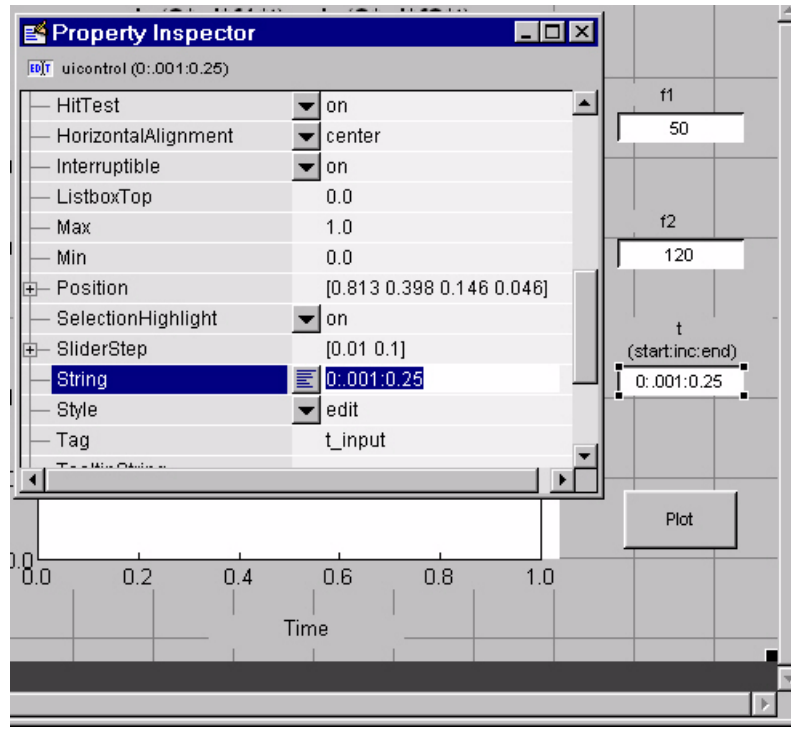
```
x = sin(2*pi*f1*t) + sin(2*pi*f2*t)
```

The GUI then calculates the FFT of `x` and creates two plots — one frequency domain and one time domain.

Specifying Default Values for the Inputs

The GUI uses default values for the three inputs. This enables users to click on the **Plot** button and see a result as soon as the GUI is run. It also helps to indicate what values the user might enter.

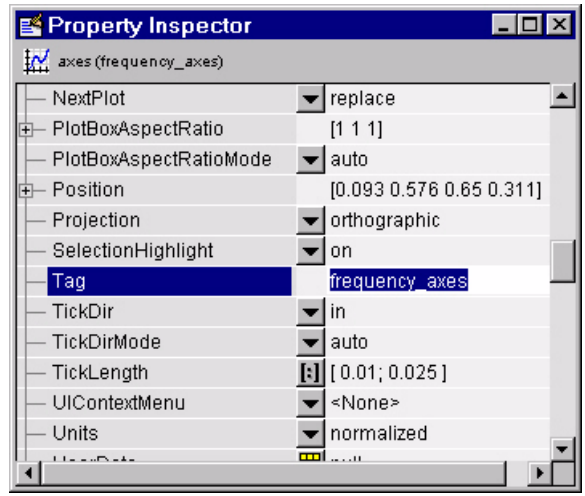
To create the default values, set the `String` property of the edit text. The following figure shows the value set for the time vector.



Identifying the Axes

Since there are two axes in this GUI, you must be able to specify which one you want to target when you issue the plotting commands. To do this, use the `handles` structure, which contains the handles of all components in the GUI.

The field name in the `handles` structure that contains the handle of any given component is derived from the component's `Tag` property. To make code more readable (and to make it easier to remember) this examples sets the `Tag` to descriptive names.



For example, the `Tag` of the axes used to display the FFT is set to `frequency_axes`. Therefore, within a callback, you access its handle with

```
handles.frequency_axes
```

Likewise, the `Tag` of the time axes is set to `time_axes`.

See “Managing GUI Data with the Handles Structure” on page 4-26 for more information on the `handles` structure. See “Plot Push Button Callback” on page 5-6 for the details of how to use the handle to specify the target axes.

GUI Option Settings

There are two GUI option settings that are particularly important for this GUI:

- Resize behavior: **Proportional**
- Command-line accessibility: **Callback**

Proportional Resize Behavior. Selecting **Proportional** as the resize behavior enables users to change the GUI to better view the plots. The components change size in proportion to the GUI figure size. This generally produces good results except when extremes of dimensions are used.

Callback Accessibility of Object Handles. When GUIs include axes, handles should be visible from within callbacks. This enables you to use plotting commands

like you would on the command line. Note that **Callback** is the default setting for command-line accessibility.

See “Selecting GUI Options” on page 3-25 for more information.

Plot Push Button Callback

This GUI uses only the **Plot** button callback; the edit text callbacks are not needed and have been deleted from the GUI M-file. When a user clicks the **Plot** button, the callback performs three basic tasks — it gets user input from the edit text components, calculates data, and creates the two plots.

Getting User Input

The three edit text boxes provide a way for the user to enter values for the two frequencies and the time vector. The first task for the callback is to read these values. This involves:

- Reading the current values in the three edit text boxes using the `handles` structure to access the edit text handles.
- Converting the two frequency values (`f1` and `f2`) from string to doubles using `str2double`.
- Evaluating the time string using `eval` to produce a vector `t`, which the callback used to evaluate the mathematical expression.

The following code shows how the callback obtains the input.

```
% 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'));
```

Calculating Data

Once the input data has been converted to numeric form and assigned to local variables, the next step is to calculate the data needed for the plots. See the `fft` function for an explanation of how this is done.

Targeting Specific Axes

The final task for the callback is to actually generate the plots. This involves

- Making the appropriate axes current using the `axes` command and the handle of the axes. For example,

  ```
  axes(handles.frequency_axes)
  ```

- Issuing the `plot` command.
- Setting any properties that are automatically reset by the `plot` command.

The last step is necessary because many plotting commands (including `plot`) clear the axes before creating the graph. This means you cannot use the Property Inspector to set the `XMinorTick` and grid properties that are used in this example, since they are reset when the callback executes `plot`.

When looking at the following code listing, note how the `handles` structure is used to access the handle of the axes when needed.

Plot Button Code Listing

```
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
x = sin(2*pi*f1*t) + sin(2*pi*f2*t);
y = fft(x,512);
m = y.*conj(y)/512;
f = 1000*(0:256)/512;;

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

% Create time plot
axes(handles.time_axes) % Select the proper axes
```

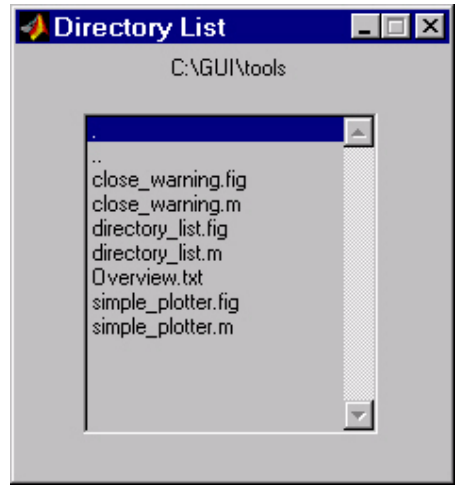
```
plot(t,x)
set(handles.time_axes,'XMinorTick','on')
grid on
```

List Box Directory Reader

This example uses a list box to display the files in a directory. When the user double clicks on a list item, one of the following happens:

- If the item is a file, the GUI opens the file appropriately for the file type.
- If the item is a directory, the GUI reads the contents of that directory into the list box.
- If the item is a single dot (.), the GUI updates the display of the current directory.
- If the item is two dots (..), the GUI changes to the directory up one level and populates the list box with the contents of that directory.

The following figure illustrates the GUI.



View Layout and GUI M-File

If you are reading this in the MATLAB Help browser, you can click the following links to display the GUIDE Layout Editor and the MATLAB Editor with a completed version of this example. This enables you to see the values of all component properties and to understand how the components are assembled to create the GUI. You can also see a complete listing of the code that is discussed in the following sections.

Note The following links execute MATLAB commands and are designed to work within the MATLAB Help browser. If you are reading this online or in PDF, you should go to the corresponding section in the MATLAB Help Browser to use the links.

- Click here to display this GUI in the Layout Editor.
- Click here to display the GUI M-file in the editor.

Implementing the GUI

The following sections describe the implementation:

- "Specifying the Directory to List" — shows how to pass a directory path as input argument when the GUI is run.
- "Loading the List Box" — describes the subfunction that loads the contents of the directory into the list box. This subfunction also saves information about the contents of a directory in the `handles` structure.
- "The List Box Callback" — explains how the list box is programmed to respond to user double clicks on items in the list box.

Specifying the Directory to List

You can specify the directory to list when the GUI is first opened by passing the string `'create'` and a string containing the full path to the directory as arguments. The syntax for doing this is `list_box('create','dir_path')`. If you do not specify a directory (i.e., if you call the GUI M-file with no input arguments), the GUI then uses the MATLAB current directory.

The default behavior of the GUI M-file that GUIDE generates is to run the GUI when there are no input arguments or to call a subfunction when the first input argument is a character string. This example changes this behavior so that you can call the M-file with

- No input arguments — run the GUI using the MATLAB current directory.
- First input argument is `'create'` and second input argument is a string that specifies a valid path to a directory — run the GUI, displaying the specified directory.

- First input argument is not a directory, but is a character string and there is more than one argument — execute the subfunction identified by the argument (execute callback).

The following code listing show the setup section of the GUI M-file, which does one the following:

- Sets the list box directory to the current directory, if no directory is specified.
- Changes the current directory, if a directory is specified.

```
function lbox2_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to untitled (see VARARGIN)

% Choose default command line output for lbox2
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

if nargin == 3,
    initial_dir = pwd;
elseif nargin == 4 & exist(varargin{1},'dir')
    initial_dir = varargin{1};
else
    errordlg('Input argument must be a valid directory','Input
Argument Error!')
    return
end
% Populate the listbox
load_listbox(initial_dir,handles)
```

Loading the List Box

This example creates a subfunction to load items into the list box. This subfunction accepts the path to a directory and the `handles` structure as input arguments. It performs these steps:

- Change to the specified directory so the GUI can navigate up and down the tree as required.
- Use the `dir` command to get a list of files in the specified directory and to determine which name is a directory and which is a file. `dir` returns a structure (`dir_struct`) with two fields, `name` and `isdir`, which contain this information.
- Sort the file and directory names (`sortrows`) and save the sorted names and other information in the `handles` structure so this information can be passed to other functions.

  The `name` structure field is passed to `sortrows` as a cell array, which is transposed to get one file name per row. The `isdir` field and the sorted index values, `sorted_index`, are saved as vectors in the `handles` structure.
- Call `guidata` to save the `handles` structure.
- Set the list box `String` property to display the file and directory names and set the `Value` property to `1`. This is necessary to ensure `Value` never exceeds the number of items in `String`, since MATLAB updates the `Value` property only when a selection occurs and not when the contents of `String` changes.
- Displays the current directory in the text box by setting its `String` property to the output of the `pwd` command.

The `load_listbox` function is called by the opening function of the GUI M-file as well as by the list box callback.

```
function load_listbox(dir_path, handles)
cd (dir_path)
dir_struct = dir(dir_path);
[sorted_names,sorted_index] = sortrows({dir_struct.name}');
handles.file_names = sorted_names;
handles.is_dir = [dir_struct.isdir];
handles.sorted_index = [sorted_index];
guidata(handles.figure1,handles)
set(handles.listbox1,'String',handles.file_names,...
   'Value',1)
set(handles.text1,'String',pwd)
```

The List Box Callback

The list box callback handles only one case: a double-click on an item. Double clicking is the standard way to open a file from a list box. If the selected item

is a file, it is passed to the `open` command; if it is a directory, the GUI changes to that directory and lists its contents.

Defining How to Open File Types

The callback makes use of the fact that the `open` command can handle a number of different file types. However, the callback treats FIG-files differently. Instead of opening the FIG-file, it passes it to the `guide` command for editing.

Determining Which Item the User Selected

Since a single click on an item also invokes the list box callback, it is necessary to query the figure `SelectionType` property to determine when the user has performed a double click. A double-click on an item sets the `SelectionType` property to `open`.

All the items in the list box are referenced by an index from `1` to `n`, where `1` refers to the first item and `n` is the index of the `n`th item. MATLAB saves this index in the list box `Value` property.

The callback uses this index to get the name of the selected item from the list of items contained in the `String` property.

Determining if the Selected Item is a File or Directory

The `load_listbox` function uses the `dir` command to obtain a list of values that indicate whether an item is a file or directory. These values (1 for directory, 0 for file) are saved in the `handles` structure. The list box callback queries these values to determine if current selection is a file or directory and takes the following action:

- If the selection is a directory — change to the directory (`cd`) and call `load_listbox` again to populate the list box with the contents of the new directory.
- If the selection is a file — get the file extension (`fileparts`) to determine if it is a FIG-file, which is opened with `guide`. All other file types are passed to `open`.

The `open` statement is called within a `try/catch` block to capture errors in an error dialog (`errordlg`), instead of returning to the command line.

```
function listbox1_Callback(hObject, eventdata, handles)
if strcmp(get(handles.figure1,'SelectionType'),'open') % If double click
```

```
    index_selected = get(handles.listbox1,'Value');
    file_list = get(handles.listbox1,'String');
    filename = file_list{index_selected}; % Item selected in list box
    if  handles.is_dir(handles.sorted_index(index_selected)) % If directory
        cd (filename)
        load_listbox(pwd,handles) % Load list box with new directory
    else
        [path,name,ext,ver] = fileparts(filename);
        switch ext
        case '.fig'
            guide (filename) % Open FIG-file with guide command
        otherwise
            try
                    open(filename) % Use open for other file types
            catch
                    errordlg(lasterr,'File Type Error','modal')
            end
        end
    end
end
```

Opening Unknown File Types

You can extend the file types that the `open` command recognizes to include any file having a three-character extension. You do this by creating an M-file with the name `openxyz`, where `xyz` is the extension. Note that the list box callback does not take this approach for FIG-files since `openfig.m` is required by the GUI M-file. See `open` for more information.

Accessing Workspace Variables from a List Box

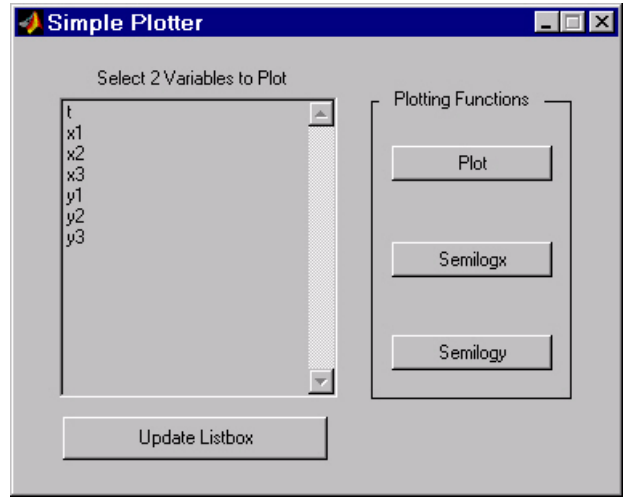
This GUI uses a list box to display workspace variables, which the user can then plot.

Techniques Used in This Example

This example demonstrates how to:

- Populate the list box with the variable names that exist in the base workspace.
- Display the list box with no items initially selected.
- Enable multiple item selection in the list box.
- Update the list items when the user press a button.
- Evaluate the plotting commands in the base workspace.

The following figure illustrates the layout.



Note that the list box callback is not used in this program because the plotting actions are initiated by push buttons. In this situation you must do one of the following:

- Leave the empty list box callback in the GUI M-file.

- Delete the string assigned to the list box `Callback` property.

View Completed Layout and Its GUI M-File

If you are reading this in the MATLAB Help browser, you can click the following links to display the GUIDE Layout Editor and the MATLAB Editor with a completed version of this example. This enables you to see the values of all component properties and to understand how the components are assembled to create the GUI. You can also see a complete listing of the code that is discussed in the following sections.

Note The following links execute MATLAB commands and are designed to work within the MATLAB Help browser. If you are reading this online or in PDF, you should go to the corresponding section in the MATLAB Help Browser to use the links.

- Click here to display this GUI in the Layout Editor.
- Click here to display the GUI M-file in the editor.

Reading Workspace Variables

When the GUI initializes, it needs to query the workspace variables and set the list box `String` property to display these variable names. Adding the following subfunction to the GUI M-file accomplishes this using `evalin` to execute the `who` command in the base workspace. The `who` command returns a cell array of strings, which are used to populate the list box.

```
function update_listbox(handles)
vars = evalin('base','who');
set(handles.listbox1,'String',vars)
```

The function's input argument is the `handles` structure generated by the GUI M-file. This structure contains the handle of the list box, as well as the handles all other components in the GUI.

The callback for the **Update Listbox** push button also calls `update_listbox`.

Reading the Selections from the List Box

This GUI requires the user to select two variables from the workspace and then choose one of three plot commands to create the graph: `plot`, `semilogx`, or `semilogy`.

Enabling Multiple Selection

To enable multiple selection in a list box, you must set the `Min` and `Max` properties so that `Max - Min > 1`. This requires you to change the default `Min` and `Max` values of `0` and `1` to meet these conditions. Use the Property Inspector to set these properties on the list box.

How Users Select Multiple Items

List box multiple selection follows the standard for most systems:

- **Control**-click left mouse button — noncontiguous multi-item selection
- **Shift**-click left mouse button — contiguous multi-item selection

Users must use one of these techniques to select the two variables required to create the plot.

Returning Variable Names for the Plotting Functions

The `get_var_names` subroutine returns the two variable names that are selected when the user clicks on one of the three plotting buttons. The function

- Gets the list of all items in the list box from the `String` property.
- Gets the indices of the selected items from the `Value` property.
- Returns two string variables, if there are two items selected. Otherwise `get_var_names` displays an error dialog explaining that the user must select two variables.

Here is the code for `get_var_names`:

```
function [var1,var2] = get_var_names(handles)
list_entries = get(handles.listbox1,'String');
index_selected = get(handles.listbox1,'Value');
if length(index_selected) ~= 2
   errordlg('You must select two variables',...
            'Incorrect Selection','modal')
else
```

```
    var1 = list_entries{index_selected(1)};
    var2 = list_entries{index_selected(2)};
end
```

Callbacks for the Plotting Buttons

The callbacks for the plotting buttons call `get_var_names` to get the names of the variables to plot and then call `evalin` to execute the plot commands in the base workspace.

For example, here is the callback for the `plot` function:

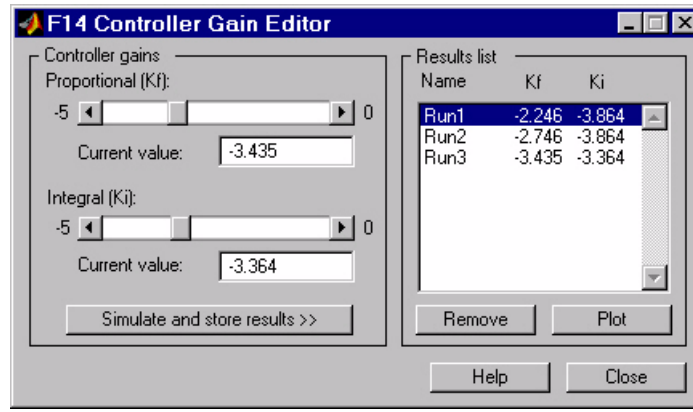
```
function plot_button_Callback(hObject, eventdata, handles)
[x,y] = get_var_names(handles);
evalin('base',['plot(' x ',' y ')'])
```

The command to evaluate is created by concatenating the strings and variables that result in the command:

```
plot(x,y)
```

A GUI to Set Simulink Model Parameters

This example illustrates how to create a GUI that sets the parameters of a Simulink® model. In addition, the GUI can run the simulation and plot the results. The following picture shows the GUI after running three simulations with different values for controller gains.



Techniques Used in This Example

This example illustrates a number of GUI building techniques:

- Opening and setting parameters on a Simulink model from a GUI.
- Implementing sliders that operate in conjunction with text boxes, which display the current value as well as accepting user input.
- Enabling and disabling controls, depending on the state of the GUI.
- Managing a variety of shared data using the `handles` structure.
- Directing graphics output to figures with hidden handles.
- Adding a help button that displays `.html` files in the MATLAB Help browser.

View Completed Layout and Its GUI M-File

If you are reading this in the MATLAB Help browser, you can click the following links to display the GUIDE Layout Editor and the MATLAB Editor with a completed version of this example. This enables you to see the values of

all component properties and to understand how the components are assembled to create the GUI. You can also see a complete listing of the code that is discussed in the following sections.

Note The following links execute MATLAB commands and are designed to work within the MATLAB Help browser. If you are reading this online or in PDF, you should go to the corresponding section in the MATLAB Help Browser to use the links.

- Click here to display this GUI in the Layout Editor.
- Click here to display the GUI M-file in the editor.

How to Use the GUI (Text of GUI Help)

You can use the F14 Controller Gain Editor to analyze how changing the gains used in the Proportional-Integral Controller affect the aircraft's angle of attack and the amount of G force the pilot feels.

Note that the Simulink diagram `f14.mdl` must be open to run this GUI. If you close the F14 Simulink model, the GUI reopens it whenever it requires the model to execute.

Changing the Controller Gains

You can change gains in two blocks:

- The Proportional gain (Kf) in the Gain block
- The Integral gain (Ki) in the Transfer Function block

You can change either of the gains in one of the two ways:

- Move the slider associated with that gain.
- Type a new value into the **Current value** edit field associated with that gain.

The block's values are updated as soon as you enter the new value in the GUI.

Running the Simulation

Once you have set the gain values, you can run the simulation by clicking the **Simulate and store results** button. The simulation time and output vectors are stored in the **Results list**.

Plotting the Results

You can generate a plot of one or more simulation results by selecting the row of results (`Run1`, `Run2`, etc.) in the **Results list** that you want to plot and clicking the **Plot** button. If you select multiple rows, the graph contains a plot of each result.

The graph is displayed in a figure, which is cleared each time you click the **Plot** button. The figure's handle is hidden so that only the GUI can display graphs in this window.

Removing Results

To remove a result from the **Results list**, select the row or rows you want to remove and click the **Remove** button.

Running the GUI

The GUI is nonblocking and nonmodal since it is designed to be used as an analysis tool.

GUI Options Settings

This GUI uses the following GUI option settings:

- Resize behavior: **Non-resizable**
- Command-line accessibility: **Off**
- M-file options selected:
  - Generate callback function prototypes
  - GUI allows only one instance to run

Opening the Simulink Block Diagrams

This example is designed to work with the F14 Simulink model. Since the GUI sets parameters and runs the simulation, the F14 model must be open when the GUI is displayed. When the GUI M-file runs the GUI, it executes the `model_open` subfunction. The purpose of the subfunction is to

- Determine if the model is open (`find_system`).
- Open the block diagram for the model and the subsystem where the parameters are being set, if not open already (`open_system`).
- Change the size of the controller Gain block so it can display the gain value (`set_param`).
- Bring the GUI forward so it is displayed on top of the Simulink diagrams (`figure`).
- Set the block parameters to match the current settings in the GUI.

Here is the code for the `model_open` subfunction.

```
function model_open(handles)
if  isempty(find_system('Name','f14')),
    open_system('f14'); open_system('f14/Controller')
    set_param('f14/Controller/Gain','Position',[275 14 340 56])
    figure(handles.F14ControllerEditor)
    set_param('f14/Controller Gain','Gain',...
        get(handles.KfCurrentValue,'String'))
    set_param('f14/Controller/Proportional plus integral compensator',...
        'Numerator',...
        get(handles.KiCurrentValue,'String'))
end
```

Programming the Slider and Edit Text Components

This GUI employs a useful combination of components in its design. Each slider is coupled to an edit text component so that:

- The edit text displays the current value of the slider.
- The user can enter a value into the edit text box and cause the slider to update to that value.
- Both components update the appropriate model parameters when activated by the user.

Slider Callback

The GUI uses two sliders to specify block gains since these components enable the selection of continuous values within a specified range. When a user changes the slider value, the callback executes the following steps:

- Calls `model_open` to ensure that the Simulink model is open so that simulation parameters can be set.
- Gets the new slider value.
- Sets the value of the **Current value** edit text component to match the slider.
- Sets the appropriate block parameter to the new value (`set_param`).

Here is the callback for the **Proportional (Kf)** slider.

```
function KfValueSlider_Callback(hObject, eventdata, handles)
% Ensure model is open
model_open(handles)
% Get the new value for the Kf Gain from the slider
NewVal = get(hObject, 'Value');
% Set the value of the KfCurrentValue to the new value set by
slider
set(handles.KfCurrentValue,'String',NewVal)
% Set the Gain parameter of the Kf Gain Block to the new value
set_param('f14/Controller/Gain','Gain',num2str(NewVal))
```

Note that, while a slider returns a number and the edit text requires a string, uicontrols automatically convert the values to the correct type.

The callback for the **Integral (Ki)** slider follows a similar approach.

Current Value Edit Text Callback

The edit text box enables users to type in a value for the respective parameter. When the user clicks on another component in the GUI after typing into the text box, the edit text callback executes the following steps:

- Calls `model_open` to ensure that the Simulink model is open so that it can set simulation parameters.
- Converts the string returned by the edit box `String` property to a double (`str2double`).
- Checks whether the value entered by the user is within the range of the slider:

  If the value is out of range, the edit text `String` property is set to the value of the slider (rejecting the number typed in by the user).

  If the value is in range, the slider `Value` property is updated to the new value.

- Sets the appropriate block parameter to the new value (`set_param`).

Here is the callback for the Kf **Current value** text box.

```
function KfCurrentValue_Callback(hObject, eventdata, handles)
% Ensure model is open
model_open(handles)
% Get the new value for the Kf Gain
NewStrVal = get(hObject, 'String');
NewVal = str2double(NewStrVal);
% Check that the entered value falls within the allowable range
if  isempty(NewVal) | (NewVal< -5) | (NewVal>0),
   % Revert to last value, as indicated by KfValueSlider
   OldVal = get(handles.KfValueSlider,'Value');
   set(hObject, 'String',OldVal)
else, % Use new Kf value
   % Set the value of the KfValueSlider to the new value
   set(handles.KfValueSlider,'Value',NewVal)
   % Set the Gain parameter of the Kf Gain Block to the new value
   set_param('f14/Controller/Gain','Gain',NewStrVal)
end
```

The callback for the Ki **Current value** follows a similar approach.

Running the Simulation from the GUI

The GUI **Simulate and store results** button callback runs the model simulation and stores the results in the `handles` structure. Storing data in the `handles` structure simplifies the process of passing data to other subfunction since this structure can be passed as an argument.

When a user clicks on the **Simulate and store results** button, the callback executes the following steps:

- Calls `sim`, which runs the simulation and returns the data that is used for plotting.
- Creates a structure to save the results of the simulation, the current values of the simulation parameters set by the GUI, and the run name and number.
- Stores the structure in the `handles` structure.
- Updates the list box `String` to list the most recent run.

Here is the **Simulate and store results** button callback.

```
function SimulateButton_Callback(hObject, eventdata, handles)
[timeVector,stateVector,outputVector] = sim('f14');
% Retrieve old results data structure
if isfield(handles,'ResultsData') &
~isempty(handles.ResultsData)
   ResultsData = handles.ResultsData;
   % Determine the maximum run number currently used.
   maxNum = ResultsData(length(ResultsData)).RunNumber;
   ResultNum = maxNum+1;
else
   % Set up the results data structure
   ResultsData = struct('RunName',[],'RunNumber',[],...
   'KiValue',[],'KfValue',[],'timeVector',[],...
   'outputVector',[]);
   ResultNum = 1;
end
if isequal(ResultNum,1),
   % Enable the Plot and Remove buttons
   set([handles.RemoveButton,handles.PlotButton],'Enable','on')
end
% Get Ki and Kf values to store with the data and put in the
results list.
Ki = get(handles.KiValueSlider,'Value');
Kf = get(handles.KfValueSlider,'Value');
ResultsData(ResultNum).RunName = ['Run',num2str(ResultNum)];
ResultsData(ResultNum).RunNumber = ResultNum;
ResultsData(ResultNum).KiValue = Ki;
ResultsData(ResultNum).KfValue = Kf;
ResultsData(ResultNum).timeVector = timeVector;
ResultsData(ResultNum).outputVector = outputVector;
% Build the new results list string for the listbox
ResultsStr = get(handles.ResultsList,'String');
if isequal(ResultNum,1)
   ResultsStr = {['Run1',num2str(Kf),' ',num2str(Ki)]};
else
   ResultsStr = [ResultsStr;...
   {['Run',num2str(ResultNum),' ',num2str(Kf),' ', ...
   num2str(Ki)]}];
```

```
end
set(handles.ResultsList,'String',ResultsStr);
% Store the new ResultsData
handles.ResultsData = ResultsData;
guidata(hObject, handles)
```

Removing Results from the List Box

The GUI **Remove** button callback deletes any selected item from the **Results list** list box. It also deletes the corresponding run data from the `handles` structure. When a user clicks on the **Remove** button, the callback executes the following steps:

- Determines which list box items are selected when a user clicks on the **Remove** button and removes these items from the list box `String` property by setting each item to the empty matrix `[]`.
- Removes the deleted data from the `handles` structure.
- Displays the string `<empty>` and disables the **Remove** and **Plot** buttons (using the `Enable` property), if all the items in the list box are removed.
- Save the changes to the `handles` structure (`guidata`).

Here is the **Remove** button callback.

```
function RemoveButton_Callback(hObject, eventdata, handles)
currentVal = get(handles.ResultsList,'Value');
resultsStr = get(handles.ResultsList,'String');
numResults = size(resultsStr,1);
% Remove the data and list entry for the selected value
resultsStr(currentVal) =[];
handles.ResultsData(currentVal)=[];
% If there are no other entries, disable the Remove and Plot button
% and change the list sting to <empty>
if isequal(numResults,length(currentVal)),
   resultsStr = {'<empty>'};
   currentVal = 1;

set([handles.RemoveButton,handles.PlotButton],'Enable','off')
end
% Ensure that list box Value is valid, then reset Value and String
currentVal = min(currentVal,size(resultsStr,1));
```

```
set(handles.ResultsList,'Value',currentVal,'String',resultsStr)
% Store the new ResultsData
guidata(hObject, handles)
```

Plotting the Results Data

The GUI **Plot** button callback creates a plot of the run data and adds a legend. The data to plot is passed to the callback in the `handles` structure, which also contains the gain settings used when the simulation ran. When a user clicks on the **Plot** button, the callback executes the following steps:

- Collects the data for each run selected in the **Results list**, including two variables (time vector and output vector) and a color for each result run to plot.
- Generates a string for the legend from the stored data.
- Creates the figure and axes for plotting and saves the handles for use by the **Close** button callback.
- Plots the data, adds a legend, and makes the figure visible.

Plotting Into the Hidden Figure

The figure that contains the plot is created invisible and then made visible after adding the plot and legend. To prevent this figure from becoming the target for plotting commands issued at the command line or by other GUIs, its `HandleVisibility` and `IntegerHandle` properties are set to `off`. However, this means the figure is also hidden from the `plot` and `legend` commands.

Use the following steps to plot into a hidden figure:

- Save the handle of the figure when you create it.
- Create an axes, set its `Parent` property to the figure handle, and save the axes handle.
- Create the plot (which is one or more line objects), save these line handles, and set their `Parent` properties to the handle of the axes.
- Make the figure visible.

Plot Button Callback Listing

Here is the **Plot** button callback.

```
function PlotButton_Callback(hObject, eventdata, handles)
```

```
currentVal = get(handles.ResultsList,'Value');
% Get data to plot and generate command string with color
% specified
legendStr = cell(length(currentVal),1);
plotColor = {'b','g','r','c','m','y','k'};
for ctVal = 1:length(currentVal);
   PlotData{(ctVal*3)-2} =
handles.ResultsData(currentVal(ctVal)).timeVector;
   PlotData{(ctVal*3)-1} =
handles.ResultsData(currentVal(ctVal)).outputVector;
   numColor = ctVal - 7*( floor((ctVal-1)/7) );
   PlotData{ctVal*3} = plotColor{numColor};
   legendStr{ctVal} =
[handles.ResultsData(currentVal(ctVal)).RunName,...
       '; Kf=', ...

num2str(handles.ResultsData(currentVal(ctVal)).KfValue),...
       ';  Ki=', ...

num2str(handles.ResultsData(currentVal(ctVal)).KiValue)];
end
% If necessary, create the plot figure and store in handles
% structure
if ~isfield(handles,'PlotFigure') |
~ishandle(handles.PlotFigure),
   handles.PlotFigure = figure('Name','F14 Simulation
Output',...
       'Visible','off','NumberTitle','off',...
       'HandleVisibility','off','IntegerHandle','off');
   handles.PlotAxes = axes('Parent',handles.PlotFigure);
   guidata(hObject, handles)
end
% Plot data
pHandles = plot(PlotData{:},'Parent',handles.PlotAxes);
% Add a legend, and bring figure to the front
legend(pHandles(1:2:end),legendStr{:})
% Make the figure visible and bring it forward
figure(handles.PlotFigure)
```

The GUI Help Button

The GUI **Help** button callback displays an HTML file in the MATLAB Help browser. It uses two commands:

- The `which` command returns the full path to the file when it is on the MATLAB path
- The `web` command displays the file in the Help browser.

This is the **Help** button callback.

```
function HelpButton_Callback(hObject, eventdata, handles)
HelpPath = which('f14ex_help.html');
web(HelpPath);
```

You can also display the help document in a Web browser or load an external URL. See the Web documentation for a description of these options.

Closing the GUI

The GUI **Close** button callback closes the plot figure, if one exists and then closes the GUI. The handle of the plot figure and the GUI figure are available from the `handles` structure. The callback executes two steps:

- Checks to see if there is a `PlotFigure` field in the `handles` structure and if it contains a valid figure handle (the user could have closed the figure manually).
- Closes the GUI figure

This is the **Close** button callback.

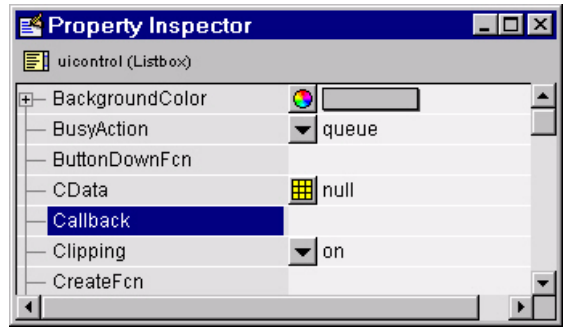
```
function CloseButton_Callback(hObject, eventdata, handles)
% Close the GUI and any plot window that is open
if isfield(handles,'PlotFigure') & ishandle(handles.PlotFigure),
   close(handles.PlotFigure);
end
close(handles.F14ControllerEditor);
```

The List Box Callback and Create Function

This GUI does not use the list box callback since the actions performed on list box items are carried out by push buttons (**Simulate and store results**, **Remove**, and **Plot**). However, GUIDE automatically inserts a callback stub

when you add the list box and automatically sets the `Callback` property to execute this subfunction whenever the callback is triggered (which happens when users select an item in the list box).

In this case, there is no need for the list box callback to execute, so you should delete it from the GUI M-file. It is important to remember to also delete the `Callback` property string so MATLAB does not attempt to execute the callback. You can do this using the property inspector:



See the description of list boxes for more information on how to trigger the list box callback.

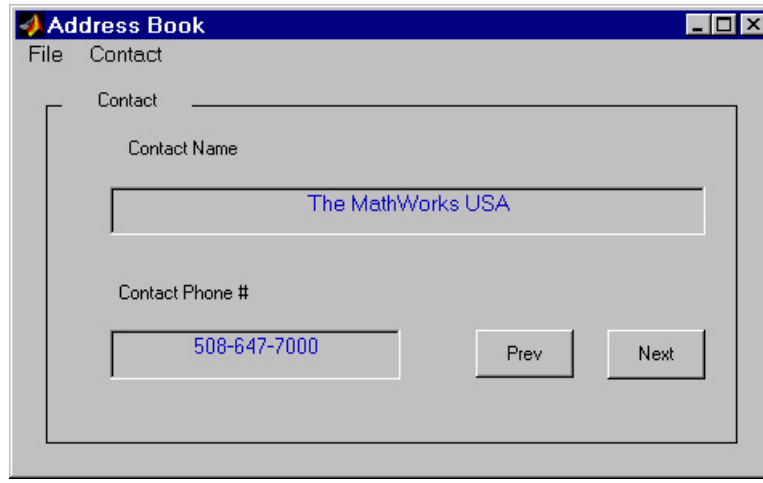
Setting the Background to White

The list box create function enables you to determine the background color of the list box. The following code shows the create function for the list box that is tagged `ResultsList`.

```
function ResultsList_CreateFcn(hObject, eventdata, handles)
% Hint: listbox controls usually have a white background, change
%       'usewhitebg' to 0 to use default.  See ISPC and COMPUTER.
usewhitebg = 1;
if usewhitebg
    set(hObject,'BackgroundColor','white');
else
set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
```

An Address Book Reader

This example shows how to implement a GUI that displays names and phone numbers, which it reads from a MAT-file.



Techniques Used in This Example

This example demonstrates the following GUI programming techniques:

- Uses open and save dialogs to provide a means for users to locate and open the address book MAT-files and to save revised or new address book MAT-files.
- Defines callbacks written for GUI menus.
- Uses the GUI's `handles` structure to save and recall shared data.
- Uses a GUI figure resize function.

Managing Shared Data

One of the key techniques illustrated in this example is how to keep track of information and make it available to the various subfunctions. This information includes

- The name of the current MAT-file

- The names and phone numbers stored in the MAT-file
- An index pointer that indicates the current name and phone number, which must be updated as the user pages through the address book
- The figure position and size
- The handles of all GUI components

The descriptions of the subfunctions that follow illustrate how to save and retrieve information from the `handles` structure. See "Sharing Data with the Handles Structure" on page 4-2 for background information on this structure.

View Completed Layout and Its GUI M-File

If you are reading this in the MATLAB Help browser, you can click the following links to display the GUIDE Layout Editor and the MATLAB Editor with a completed version of this example. This enables you to see the values of all component properties and to understand how the components are assembled to create the GUI. You can also see a complete listing of the code that is discussed in the following sections.

Note The following links execute MATLAB commands and are designed to work within the MATLAB Help browser. If you are reading this online or in PDF, you should go to the corresponding section in the MATLAB Help Browser to use the links.

- Click here to display this GUI in the Layout Editor.
- Click here to display the GUI M-file in the MATLAB Editor.

Running the GUI

The GUI is nonblocking and nonmodal since it is designed to be displayed while you perform other MATLAB tasks.

GUI Option Settings

This GUI uses the following GUI option settings:

- Resize behavior: **User-specified**
- Command-line accessibility: **Off**

- GUI M-file options selected:

  Generate callback function prototypes

  Application allows only one instance to run

Calling the GUI

You can call the GUI M-file with no arguments, in which case the GUI uses the default address book MAT-file, or you can specify an alternate MAT-file from which the GUI reads information. In this example, the user calls the GUI with a pair of arguments, `address_book('book', 'my_list.mat')`. The first argument, `'book'`, is a key word that the M-file looks for in the opening function. If the M-file finds the key word, it knows tho use the second argument as the MAT-file for the address book. Calling the GUI with this syntax is analogous to calling it with a valid property-value pair, such as `('color', 'red')`. However, since `'book'` is not a valid figure property, in this example the opening function in the M-file includes code to recognize the pair `('book', 'my_list.mat')`.

Note that it is not necessary to use the key word `'book'`. You could program the M-file to accept just the MAT-file as an argument, using the syntax `address_book('my_list.mat')`. The advantage of calling the GUI with the pair `('book', 'my_list.mat')` is that you can program the GUI to accept other user arguments, as well as valid figure properties, using the property-value pair syntax. The GUI can then identify which property the user wants to specify from the property name.

The following code shows how to program the opening function to look for the key word `'book'`, and if it finds the key word, to use the MAT-file specified by the second argument as the list of contacts.

```
function address_book_OpeningFcn(hObject, eventdata, handles, varargin)
% Choose default command line output for address_book
handles.output = hObject;
% Update handles structure
guidata(hObject, handles);
% User added code follows
if nargin < 4
    % Load the default address book
    Check_And_Load([],handles);
    % If first element in varargin is 'book' and the second element is a
    % MATLAB file, then load that file
```

```
elseif (length(varargin) == 2 & strcmpi(varargin{1},'book') & (2 ==
exist(varargin{2},'file')))
    Check_And_Load(varargin{2},handles);
else
    errordlg('File Not Found','File Load Error')
    set(handles.Contact_Name,'String','')
    set(handles.Contact_Phone,'String','')
end
```

Loading an Address Book Into the Reader

There are two ways in which an address book (i.e., a MAT-file) is loaded into the GUI:

- When running the GUI, you can specify a MAT-file as an argument. If you do not specify an argument, the GUI loads the default address book (`addrbook.mat`).
- The user can select **Open** under the **File** menu to browse for other MAT-files.

Validating the MAT-file

To be a valid address book, the MAT-file must contain a structure called `Addresses` that has two fields called `Name` and `Phone`. The `Check_And_Load` subfunction validates and loads the data with the following steps:

- Loads (`load`) the specified file or the default if none is specified.
- Determines if the MAT-file is a valid address book.
- Displays the data if it is valid. If it is not valid, displays an error dialog (`errordlg`).
- Returns `1` for valid MAT-files and `0` if invalid (used by the **Open** menu callback)
- Saves the following items in the `handles` structure:
  - The name of the MAT-file
  - The `Addresses` structure
  - An index pointer indicating which name and phone number are currently displayed

Check_And_Load Code Listing

This is the Check_And_Load function.

```
function pass = Check_And_Load(file,handles)
% Initialize the variable "pass" to determine if this is a valid
% file.
pass = 0;
% If called without any file then set file to the default file
% name.
% Otherwise if the file exists then load it.
if isempty(file)
   file = 'addrbook.mat';
   handles.LastFile = file;
   guidata(handles.Address_Book,handles)
end
if exist(file) == 2
   data = load(file);
end
% Validate the MAT-file
% The file is valid if the variable is called "Addresses" and it
% has fields called "Name" and "Phone"
flds = fieldnames(data);
if (length(flds) == 1) & (strcmp(flds{1},'Addresses'))
   fields = fieldnames(data.Addresses);
   if (length(fields) == 2) &(strcmp(fields{1},'Name')) &
(strcmp(fields{2},'Phone'))
       pass = 1;
   end
end
% If the file is valid, display it
if pass
   % Add Addresses to the handles structure
   handles.Addresses = data.Addresses;
   guidata(handles.Address_Book,handles)
   % Display the first entry
   set(handles.Contact_Name,'String',data.Addresses(1).Name)
   set(handles.Contact_Phone,'String',data.Addresses(1).Phone)
   % Set the index pointer to 1 and save handles
   handles.Index = 1;
   guidata(handles.Address_Book,handles)
```

```
else
   errordlg('Not a valid Address Book','Address Book Error')
end
```

The Open Menu Callback

The address book GUI contains a **File** menu that has an **Open** submenu for loading address book MAT-files. When selected, **Open** displays a dialog (`uigetfile`) that enables the user to browser for files. The dialog displays only MAT-files, but users can change the filter to display all files.

The dialog returns both the filename and the path to the file, which is then passed to `fullfile` to ensure the path is properly constructed for any platform. `Check_And_Load` validates and load the new address book.

Open_Callback Code Listing

```
function Open_Callback(hObject, eventdata, handles)
[filename, pathname] = uigetfile( ...
   {'*.mat', 'All MAT-Files (*.mat)'; ...
       '*.*','All Files (*.*)'}, ...
   'Select Address Book');
% If "Cancel" is selected then return
if isequal([filename,pathname],[0,0])
   return
% Otherwise construct the fullfilename and Check and load the file
else
   File = fullfile(pathname,filename);
   % if the MAT-file is not valid, do not save the name
   if Check_And_Load(File,handles)
       handles.LastFIle = File;
       guidata(hObject, handles)
   end
end
```

See the “Creating Menus — The Menu Editor” on page 3-57 section for information on creating the menu.

The Contact Name Callback

The **Contact Name** text box displays the name of the address book entry. If you type in a new name and press enter, the callback performs these steps:

- If the name exists in the current address book, the corresponding phone number is displayed.
- If the name does not exist, a question dialog (`questdlg`) asks you if you want to create a new entry or cancel and return to the name previously displayed.
- If you create a new entry, you must save the MAT-file with the **File** -> **Save** menu.

Storing and Retrieving Data

This callback makes use of the `handles` structure to access the contents of the address book and to maintain an index pointer (`handles.Index`) that enables the callback to determine what name was displayed before it was changed by the user. The index pointer indicates what name is currently displayed. The address book and index pointer fields are added by the `Check_And_Load` function when the GUI is run.

If the user adds a new entry, the callback adds the new name to the address book and updates the index pointer to reflect the new value displayed. The updated address book and index pointer are again saved (`guidata`) in the `handles` structure.

Contact Name Callback

```
function Contact_Name_Callback(hObject, eventdata, handles)
% Get the strings in the Contact Name and Phone text box
Current_Name = get(handles.Contact_Name,'string');
Current_Phone = get(handles.Contact_Phone,'string');
% If empty then return
if isempty(Current_Name)
   return
end
% Get the current list of addresses from the handles structure
Addresses = handles.Addresses;
% Go through the list of contacts
% Determine if the current name matches an existing name
for i = 1:length(Addresses)
   if strcmp(Addresses(i).Name,Current_Name)
       set(handles.Contact_Name,'string',Addresses(i).Name)
       set(handles.Contact_Phone,'string',Addresses(i).Phone)
       handles.Index = i;
       guidata(hObject, handles)
```

```
        return
    end
end
% If it's a new name, ask to create a new entry
Answer=questdlg('Do you want to create a new entry?', ...
    'Create New Entry', ...
    'Yes','Cancel','Yes');
switch Answer
case 'Yes'
    Addresses(end+1).Name = Current_Name; % Grow array by 1
    Addresses(end).Phone = Current_Phone;
    index = length(Addresses);
    handles.Addresses = Addresses;
    handles.Index = index;
    guidata(hObject, handles)
    return
case 'Cancel'
    % Revert back to the original number

set(handles.Contact_Name,'String',Addresses(handles.Index).Name)

set(handles.Contact_Phone,'String',Addresses(handles.Index).Phon
e)
    return
end
```

The Contact Phone Number Callback

The **Contact Phone #** text box displays the phone number of the entry listed in the **Contact Name** text box. If you type in a new number click one of the push buttons, the callback opens a question dialog that asks you if you want to change the existing number or cancel your change.

Like the **Contact Name** text box, this callback uses the index pointer (`handles.Index`) to update the new number in the address book and to revert to the previously displayed number if the user selects **Cancel** from the question dialog. Both the current address book and the index pointer are saved in the `handles` structure so that this data is available to other callbacks.

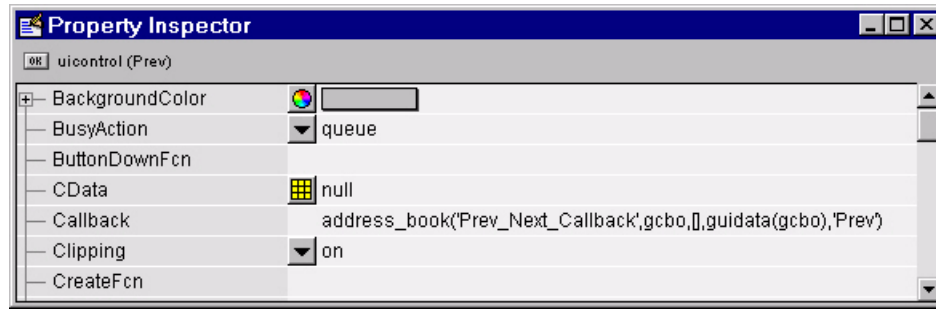
If you create a new entry, you must save the MAT-file with the **File** –> **Save** menu.

Code Listing

```
function Contact_Phone_Callback(hObject, eventdata, handles)
Current_Phone = get(handles.Contact_Phone,'string');
% If either one is empty then return
if isempty(Current_Phone)
    return
end
% Get the current list of addresses from the handles structure
Addresses = handles.Addresses;
Answer=questdlg('Do you want to change the phone number?', ...
    'Change Phone Number', ...
    'Yes','Cancel','Yes');
switch Answer
case 'Yes'
    % If no name match was found create a new contact
    Addresses(handles.Index).Phone = Current_Phone;
    handles.Addresses = Addresses;
    guidata(hObject, handles)
    return
case 'Cancel'
    % Revert back to the original number
    set(handles.Contact_Phone,'String',Addresses(handles.Index).Phone)
    return
end
```

Paging Through the Address Book — Prev/Next

The **Prev** and **Next** buttons page back and forth through the entries in the address book. Both push buttons use the same callback, `Prev_Next_Callback`. You must set the `Callback` property of both push buttons to call this subfunction, as the following illustration of the **Prev** push button `Callback` property setting shows.



Determining Which Button Is Clicked

The callback defines an additional argument, `str`, that indicates which button, **Prev** or **Next**, was clicked. For the **Prev** button `Callback` property (illustrated above), the `Callback` string includes `'Prev'` as the last argument. The **Next** button `Callback` string includes `'Next'` as the last argument. The value of `str` is used in `case` statements to implement each button's functionality (see the code listing below).

Paging Forward or Backward

`Prev_Next_Callback` gets the current index pointer and the addresses from the `handles` structure and, depending on which button the user presses, the index pointer is decremented or incremented and the corresponding address and phone number are displayed. The final step stores the new value for the index pointer in the `handles` structure and saves the updated structure using `guidata`.

Code Listing

```
function Prev_Next_Callback(hObject, eventdata,handles,str)
% Get the index pointer and the addresses
index = handles.Index;
Addresses = handles.Addresses;
% Depending on whether Prev or Next was clicked change the display
switch str
case 'Prev'
    % Decrease the index by one
    i = index - 1;
    % If the index is less then one then set it equal to the index of the
```

```
    % last element in the Addresses array
    if i < 1
        i = length(Addresses);
    end
case 'Next'
    % Increase the index by one
    i = index + 1;
    % If the index is greater than the size of the array then point
    % to the first item in the Addresses array
    if i > length(Addresses)
        i = 1;
    end
end
% Get the appropriate data for the index in selected
Current_Name = Addresses(i).Name;
Current_Phone = Addresses(i).Phone;
set(handles.Contact_Name,'string',Current_Name)
set(handles.Contact_Phone,'string',Current_Phone)
% Update the index pointer to reflect the new index
handles.Index = i;
guidata(hObject, handles)
```

Saving Changes to the Address Book from the Menu

When you make changes to an address book, you need to save the current MAT-file, or save it as a new MAT-file. The **File** submenus **Save** and **Save As** enable you to do this. These menus, created with the Menu Editor, use the same callback, `Save_Callback`.

The callback uses the menu `Tag` property to identify whether **Save** or **Save As** is the callback object (i.e., the object whose handle is passed in as the first argument to the callback function). You specify the menu's `Tag` property with the Menu Editor.

Saving the Addresses Structure

The `handles` structure contains the `Addresses` structure, which you must save (`handles.Addresses`) as well as the name of the currently loaded MAT-file (`handles.LastFile`). When the user makes changes to the name or number, the `Contact_Name_Callback` or the `Contact_Phone_Callback` updates `handles.Addresses`.

Saving the MAT-File

If the user selects **Save**, the `save` command is called to save the current MAT-file with the new names and phone numbers.

If the user selects **Save As**, a dialog is displayed (`uiputfile`) that enables the user to select the name of an existing MAT-file or specify a new file. The dialog returns the selected filename and path. The final steps include

- Using `fullfile` to create a platform-independent pathname.
- Calling `save` to save the new data in the MAT-file.
- Updating the `handles` structure to contain the new MAT-file name.
- Calling `guidata` to save the `handles` structure.

Save_Callback Code Listing

```
function Save_Callback(hObject, eventdata, handles)
% Get the Tag of the menu selected
Tag = get(hObject, 'Tag');
% Get the address array
Addresses = handles.Addresses;
% Based on the item selected, take the appropriate action
switch Tag
case 'Save'
   % Save to the default addrbook file
   File = handles.LastFile;
   save(File,'Addresses')
case 'Save_As'
   % Allow the user to select the file name to save to
   [filename, pathname] = uiputfile( ...
       {'*.mat';'*.*'}, ...
       'Save as');
   % If 'Cancel' was selected then return
   if isequal([filename,pathname],[0,0])
       return
   else
       % Construct the full path and save
       File = fullfile(pathname,filename);
       save(File,'Addresses')
       handles.LastFile = File;
       guidata(hObject, handles)
```

```
    end
end
```

The Create New Menu

The **Create New** menu simply clears the **Contact Name** and **Contact Phone #** text fields to facilitate adding a new name and number. After making the new entries, the user must then save the address book with the **Save** or **Save As** menus. This callback sets the text `String` properties to empty strings:

```
function New_Callback(hObject, eventdata, handles)
set(handles.Contact_Name,'String','')
set(handles.Contact_Phone,'String','')
```

The Address Book Resize Function

The address book defines its own resize function. To use this resize function, you must set the **Application Options** dialog **Resize behavior** to `User-specified`, which in turn sets the figure's `ResizeFcn` property to:

```
address_book('ResizeFcn',gcbo,[],guidata(gcbo))
```

Whenever the user resizes the figure, MATLAB calls the `ResizeFcn` subfunction in the address book M-file (`address_book.m`)

Behavior of the Resize Function

The `resize` function allows users to make the figure wider, to accommodate long names and numbers, but does not allow the figure to be made narrower than its original width. Also, users cannot change the height. These restrictions do not limit the usefulness of the GUI and simplify the `resize` function, which must maintain the proper proportions between the figure size and the components in the GUI.

When the user resizes the figure and releases the mouse, the resize function executes. At that point, the resized figure's dimensions are saved. The following sections describe how the `resize` function handles the various possibilities.

Changing the Width

If the new width is greater than the original width, set the figure to the new width.

The size of the **Contact Name** text box changes in proportion to the new figure width. This is accomplished by:

- Changing the `Units` of the text box to `normalized`.
- Resetting the width of the text box to be 78.9% of the figure's width.
- Returning the `Units` to `characters`.

If the new width is less than the original width, use the original width.

Changing the Height

If the user attempts to change the height, use the original height. However, because the resize function is triggered when the user releases the mouse button after changing the size, the resize function cannot always determine the original position of the GUI on screen. Therefore, the resize function applies a compensation to the vertical position (second element in the figure `Position` vector) as follows:

> vertical position when mouse released + height when mouse released minus the original height

When the figure is resized from the bottom, it stays in the same position. When resized from the top, the figure moves to the location where the mouse button is released.

Ensuring the Resized Figure Is On Screen

The `resize` function calls `movegui` to ensure that the resized figure is on screen regardless of where the user releases the mouse.

When the GUI is first run, it is displayed at the size and location specified by the figure `Position` property. You can set this property with the Property Inspector when you create the GUI.

Code Listing

```
function ResizeFcn(hObject, eventdata, handles)
% Get the figure size and position
Figure_Size = get(hObject, 'Position');
% Set the figure's original size in character units
Original_Size = [ 0 0 94 19.230769230769234];
% If the resized figure is smaller than the
% original figure size then compensate
if (Figure_Size(3)<Original_Size(3)) | (Figure_Size(4) ~= Original_Size(4))
```

```
      if Figure_Size(3) < Original_Size(3)
           % If the width is too small then reset to origianl width
           set(hObject, 'Position',...
    [Figure_Size(1) Figure_Size(2) Original_Size(3) Original_Size(4)])
           Figure_Size = get(hObject, 'Position');
      end
      if Figure_Size(4) ~= Original_Size(4)
           % Do not allow the height to change
           set(hObject, 'Position',...
    [Figure_Size(1), Figure_Size(2)+Figure_Size(4)-Original_Size(4),...
    Figure_Size(3), Original_Size(4)])
      end
end
% Adjust the size of the Contact Name text box
% Set the units of the Contact Name field to 'Normalized'
set(handles.Contact_Name,'units','normalized')
% Get its Position
C_N_pos = get(handles.Contact_Name,'Position');
% Reset it so that it's width remains normalized relative to figure
set(handles.Contact_Name,'Position',...
    [C_N_pos(1) C_N_pos(2)  0.789 C_N_pos(4)])
% Return the units to  Characters
set(handles.Contact_Name,'units','characters')
% Reposition GUI on screen
movegui(hObject, 'onscreen')
```

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