Chapter 6: Graphical User Interfaces

August 22, 2016
Chapter 6 Topics

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Anatomy of a GUI (1)

- An application with a **Graphical User Interface (GUI)** allows a user to interact with the application in multiple ways unlike a command line application.
- A GUI consists of three types of objects: **components**, **events** and **listeners**
  - **Component**: An object that defines a screen element for displaying information or interacting with the user. For example: a button, a label, a text field etc.
  - **Container**: A container is a special type of component that is used to hold and organize other components. For example: a frame, a window, a panel etc.
Anatomy of a GUI (2)

- **Event**: An object that represents an occurrence we are interested in.
  - Button clicked, mouse pressed, mouse moved, keyboard key pressed, timer expired etc.
  - Most GUI components generate an event to indicate a user action related to that component.
  - Applications that respond to events from a GUI are examples of event-driven applications.

- **Listener**: An object that *waits* for an event to occur and responds when it does.

- In a GUI program, we need to establish the relationships between the listener, the event it listens for, and the component that generates the event.
Anatomy of a GUI (3)

To create a Java program that contains a GUI, we must:
- instantiate and set up the necessary components,
- implement listener classes that define what happens when particular events occur, and
- establish the relationship between the listeners and the components that generate the events of interest.

Components, events and related classes are primarily defined in two Java packages:
- `java.awt`: The original Abstract Windowing Toolkit GUI package that contains many important classes.
- `javax.swing`: The Swing package was added later and is more versatile. It builds upon the AWT package.
Containers: Frames and Panels

- Containers are classified as either
  - **heavyweight** – managed by the underlying operating system. For example: a frame.
  - **lightweight** – managed by the Java program. For example: a panel.

- A standalone GUI application creates a frame as its main window. A frame contains a titlebar, with buttons to resize and close the window. The frame object in Swing is called a `JFrame`.
- Examples: FrameExample1.java, FrameExample2.java
- The `JFrame` contains four panes: `Root Pane`, `Layered Pane`, `Content Pane`, and the `Glass Pane`. We will only be using the `Content Pane`.
- Typically, we will have the frame contain a panel that contains all the other components of our application. This allows our program to be more independent of the underlying operating system.
Example 1: A Complete Simple GUI

Let’s look at a simple example that contains all of the basic GUI elements

- the GUI presents the user with a single push button
- each time the button is pushed, a counter is updated and displayed

The example uses the following

- Events: ActionEvent (generated when a button is pushed or clicked)
- Listener: We write our own class that implements the ActionListener interface to react to the events.

Example: PushCounter.java, PushCounterPanel.java

Also see example: PushCounterPanel2.java
Example 2: Listening to Multiple Components

- We can use one listener to listen to two different components.
- For example: we have one label and two buttons
  - when the Left button is pushed, the label displays “Left”
  - when the Right button is pushed, the label displays “Right”

Example: `LeftRight.java`, `LeftRightPanel.java`

Now the `actionPerformed` method gets called for either button press. We use the `getSource()` method in the `ActionEvent` object to determine which button was pressed.
More Components

- **JTextField**: A text field that allows a user to enter input typed from the keyboard on a single line.
- **JTextArea**: A text area is a multi-line version of a text field.
- **JList**: A clickable list allows the user to select from a list of items.
- ** JScrollPane**: A scroll pane provides a scrollable view of a component. For example, for a text area with more text than fits in the display.
- **JCheckbox**: A button that can be toggled on or off.
- **JRadioButton**: Used with a group of radio buttons to provide a set of mutually exclusive options.
- **JSlider**: Allows the user to specify a numeric value within a bounded range.
- **JComboBox**: Allows the user to select one of several options from a “drop down” menu.
- **Timer**: Allows us to animate or automate things. Has no visual representation.
A text field generates an action event (ActionEvent) object when the Enter or Return key is pressed in the text field.

Note that the push button and the text field generate the same kind of event — an action event.

Example: Fahrenheit.java, FahrenheitPanel.java
JList and JScrollPane

- JList is a component that displays a selectable list of items.
- When a user selects an item, a ListSelectionEvent is fired so we can respond to the user’s action.
- We can set the items in the JList by passing in an array of objects.
- A JScrollPane can manage a JList to display scroll bars as needed or always.
JList and JScrollPane

Example: ColorJList.java, ColorJListPanel.java
Example: JListDemo.java, JListDemoPanel.java
JTextArea and JScrollPane

- JTextArea is a component that allows text to be displayed. The text can be set to be editable or not editable.
- A JScrollPane can manage a JTextArea to display scroll bars as needed or always.
- See sample code below:

```java
private JTextArea display = new JTextArea(10, 20);
display.setEditable(false);
JScrollPane scroller = new JScrollPane(display,
            JScrollPane.VERTICAL_SCROLLBAR_ALWAYS,
            JScrollPane.HORIZONTAL_SCROLLBAR_AS_NEEDED);
```

- Example: TextAreaTest.java
A layout manager determines how the components in the container are arranged visually. A layout manager determines the size and position of each component.

The layout manager is consulted when needed, such as when the container is resized or when a component is added.

Every container has a default layout manager, but we can replace it if desired.
Some of the layout managers in the Java API:

<table>
<thead>
<tr>
<th>Layout Manager</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FlowLayout</td>
<td>Puts components from left to right, starting new rows as needed</td>
</tr>
<tr>
<td>GridLayout</td>
<td>Puts components into a grid of rows and columns</td>
</tr>
<tr>
<td>BoxLayout</td>
<td>Puts components into a single row or column</td>
</tr>
<tr>
<td>BorderLayout</td>
<td>Puts components into five areas (North, South, East, West, Center)</td>
</tr>
</tbody>
</table>

Example: LayoutDemo.java, IntroPanel.java FlowPanel.java, GridPanel.java BoxPanel.java, BorderPanel.java
Example 3: Mini Color Chooser

- Uses an array of buttons laid out in a grid.
- The frame is divided into two panels: one for the grid of buttons, the other for a panel that shows the chosen color.
- Clicking a button sets the color of the panel to the right of the buttons panel.
- Example: MiniColorChooserV1.java
Design Example 1: Converter App (1)

- We will develop a series of GUI to illustrate several design principles.
- The GUI is a simple app that converts miles to kilometers and displays the result.

Example: converter1/Converter.java, converter1/MetricConverter.java
- Use the Model View Controller (MVC) design.
  - **Model**: MetricConverter.java
  - **View**: Setup of the GUI in the constructor for Converter.java
  - **Controller**: The listener code in Converter.java

- Identify improvements to the user interface.
Design Example 1: Converter App (2)

- We will add an `ActionListener` to the text field so that the user can use the app with only the keyboard.
- We will add an input keypad so that the user can use the app with only a mouse.

Example: `converter2/Converter.java`, `converter2/MetricConverter.java`

- Identify further improvements to the user interface.
Design Example 1: Converter App (3)

- Add better layout to the main panel.
- Add a scroll pane to the display area.
- Organize the code more. Add a private class for the Controller.
- Catch the `NumberFormatException` on the text field and report error to user.

Example: `converter3/Converter.java, converter3/MetricConverter.java`

- What else would you like to improve?
A check box generates an item event when it changes state from selected (checked) to deselected (unchecked) and vice versa. The `JCheckBox` class is used to define check boxes.

They produce `ItemEvent` events that use an `ItemListener` interface, which has one method:

```java
public interface ItemListener {
    public void itemStateChanged(ItemEvent event);
}
```

Example: `StyleOptions.java`, `StyleOptionsPanel.java`
More Components: Radio Buttons

- A radio button is used with other radio buttons to provide a set of mutually exclusive options.
- Radio buttons have meaning only when used with one or more other radio buttons. At any point in time, only one button of the group is selected (on).
- Radio buttons produce an action event when selected. Radio buttons are defined by the JRadioButton class. The ButtonGroup class is used to define a set of related radio buttons.
- Example: QuoteOptions.java, QuoteOptionsPanel.java
Borders

- Java provides the ability to put a border around any Swing component.
- Border provide visual cues as to how GUI components are organized.
- The `BorderFactory` class is useful for creating borders for components.

Example: `BorderDemo.java`
Design Example 2: Order Application

- This example illustrates layouts, borders, radio buttons and check boxes.

![Order Application Layout](image)

- **In-class Exercise**: Sketch the various containers, components and borders needed to produce this layout.
- **Example**: In the package `orderapplication`, see `OrderApplication.java` and `OrderApplicationPanel.java`.
More Components: Sliders

- A slider can be presented either vertically or horizontally. Optional features include:
  - tick marks on the slider,
  - labels indicating the range of values.
- A slider produces a change event, indicating that the position of the slider and the value it represents has changed.
- A slider is defined by the `JSlider` class. It produces `ChangeEvent` events that require a `ChangeListener` interface.

```java
public interface ChangeListener {
    public void stateChanged(ChangeEvent event);
}
```

- Example: `SlideColor.java`, `SlideColorPanel.java`
More Components: Combo Boxes

- A combo box allows a user to select one of several options from a “drop down” menu.
- When the user presses a combo box using a mouse, a list of options is displayed from which the user can choose.
- A combo box is defined by the `JComboBox` class. Combo boxes generate an action event whenever the user makes a selection from it.
- Example: `JukeBox.java`, `JukeBoxPanel.java`
Timers are defined by the `Timer` class and are provided to help manage an activity over time.

A timer object generates an action event at regular intervals.

Example: `Rebound.java`, `ReboundPanel.java`
Design Example 3: CircleMaker

- Design a GUI that allows the user to make the specified number of circles and color the biggest circle with a different color.

- **Model:** Circle.java
- **View:** CircleMakerPanel.java
- **Controller:** CircleMaker.java
More Events: Mouse and Mouse Motion

- Mouse actions generate **Mouse Event** objects.
- Two types of interfaces to deal with mouse events:
  - **mouse events** – occur when the user interacts with another component via the mouse: *pressed, clicked, released, entered, exited*. To use, implement the **MouseListener** interface class.
  - **mouse motion events** – occur while the mouse is in motion: *moved, dragged*. To use, implement the **MouseMotionListener** interface class.
Mouse Examples

- **Example:** Dots.java, DotsPanel.java
  - Clicking the mouse causes a dot to appear in that location and the coordinates to be displayed. Overall count of all the dots is also displayed.
  - The event object passed to the listener is used to get the coordinates of the event.
  - An ArrayList is used to keep track of the points.

- **Example:** RubberLines.java, RubberLinesPanel.java
  - As the mouse is dragged, the line is redrawn. This creates a rubberbanding effect, as if the line is being pulled into shape.

- **In-class Exercise:** Write a mouse odometer that displays (in pixels) how far the mouse has traveled!
More Events: Keys

- A key event (KeyEvent object) is generated when the user presses a keyboard key. This allows a program to respond immediately to the user while they are typing.

- The KeyListener interface defines three methods used to respond to keyboard activity:

```java
public interface KeyListener {
    public void keyPressed(KeyEvent event);
    public void keyReleased(KeyEvent event);
    public void keyTyped(KeyEvent event);
}
```

- Example: Direction.java, DirectionPanel.java

- In-class Exercise: Modify the example above so that the key image wraps around in either of the four directions.
A dialog box is a window that appears on top of any currently active window. A dialog box usually has a specific, solitary purpose, and the user interaction with it is brief. It may be used to:

- convey information (`JOptionPane`)
- confirm an action (`JOptionPane`)
- allow the user to enter data (`JOptionPane`)
- pick a color (`JColorChooser`)
- choose a file (`JFileChooser`)
JOptionPane dialog boxes fall into three categories:

- message dialog boxes – used to display an output string.
- input dialog boxes – presents a prompt and a single input txt file into which the user can enter one string of data.
- confirm dialog box – presents the user with a simple yes-or-no question.

These three types of dialog boxes are created using static methods in the JOptionPane class

Example: EvenOdd.java
A file chooser is a specialized dialog box used to select a file from a disk or other storage medium.

The dialog automatically presents a standardized file selection window.

Filters can be applied to the file chooser programmatically.

The `JFileChooser` class creates this type of dialog box.

Example: FileChooser.java
More Components

- A clickable list class: `JList`. See example `basics/ClickableListDemo.java`
- A split window example using `JSplitPane`: `basics/SplitWindows.java`
- A menu example using `JMenuBar`, `JMenu` and `JMenuItem`: `basics/MenuDemo.java`
A tool tip is a short line of text that appears over a component when the mouse cursor is rested momentarily on top of the component.

Tool tips can be assigned by using the `setToolTipText` method of a component.

```java
JButton button = new Button("Compute");
button.setToolTipText("Calculates the area under the curve");
```

A mnemonic is a character that allows the user to push a button or make a menu choice using the keyboard in addition to the mouse.

The user can hold down the Alt key and press the mnemonic character to activate (depress) the button. We set the mnemonic for a component using the `setMnemonic` method of the component.

Example: `LightBulb.java`, `LightBulbControl.java`, `LightBulbPanel.java`. 
Design Example 4: Choose Your Adventure!

- A detailed inclass case study of a GUI chosen by our instructor....
Summary

- **Containers**: JFrame, JPanel, JDialog, JWindow
- **Components**: JButton, JLabel, JTextField, JCheckBox, JRadioButton, ButtonGroup, JTextArea, JSlider, JColorChooser, JFileChooser, JOptionPane, JTabbedPane, JScrollPane, JSplitPane, JList, JMenu, JMenuItems, JMenuBar
- **Layout Managers**: FlowLayout, BorderLayout, GridLayout, GridBagLayout, BoxLayout, CardLayout
- **Events**: ActionEvent, ItemEvent, WindowEvent, MouseEvent, KeyEvent
- **Listeners**: ActionListener, ItemListener, MouseListener, MouseMotionListener, KeyListener
Exercises

- Read Chapter 6.

- **Recommended Homework:**
  - Exercises: EX 6.3, 6.6, 6.9, 6.10.
  - Projects: PP 6.5, 6.16, 6.21, 6.22.