MAHARISHI UNIVERSITY of MANAGEMENT

Engaging the Managing Intelligence of Nature

Computer Science Department

CS390 Foundamental Programming Practices (FPP)

Professor Paul Corazza

Lecture 5:
Building GUIs in Java with Swing

Wholeness of the Lesson

Swing is a windowing toolkit that allows developers to create GUIs that are rich in content and functionality. The ultimate provider of tools for the creation of beautiful and functional content is pure intelligence itself; all creativity arises from this field's self-interacting dynamics.

Introduction

- ***Sun's AWT.*** The original version of Java (jdk1.0) came with a primitive windowing toolkit (the AWT) for making simple GUIs. GUI components were built by using the native GUI toolkit of the target platform (Windows, MacIntosh, Solaris, etc). "Write once, run anywhere" was the goal.

- ***Problems with Peer-Based Approach.*** The effect of the peer-based approach was that GUI components looked like the GUI elements users of that platform were accustomed to. However, there were problems:
  - subtle differences in behavior of components like menus and scrollbars on different platforms made it difficult to create a consistent and predictable experience across platforms
  - in order to support plataforms in which the native GUI toolkit had limited functionality, Sun needed to limit the functionality of its toolkit as well
  - "write once, debug everywhere" became the slogan

- ***IFC.*** Various alternative windowing toolkits emerged in 1995, 1996, the most significant of which was Netscape's IFC (Internet Foundation Classes). Components in the IFC toolkit were painted onto blank windows – the native toolkit of the target platform was not used at all. This caused components and their behavior to be identical across all platforms.

- ***Swing.*** Sun worked with Netscape to refine the peerless IFC approach, producing, in the end, a new windowing toolkit called Swing. Swing was made available (1997) as an extension to jdk1.1, but in the end became part of an enormous upgrade to Java, known as JFC (Java Foundation Classes), which was released as part of jdk1.2 in 1999.

- ***AWT Still Used.*** Swing components still make use of aspects of the AWT – Swing is built "on top of" the old AWT. In particular, handling of events relies on the old event-handling model.

- ***JavaFX.*** In 2014, Oracle declared that Swing libraries would be developed no further, and that the windowing toolkit of choice had become JavaFX. JavaFX has more modern-looking components and has a more flexible API. Since Swing is still (as of 2016) far more widely used than JavaFX, Swing is presented here.

- ***Industry Standard.*** For standalone GUI development in Java, Swing is the toolkit most often used.

- ***Visual Designers.***
  - Most widely used (as of 2016) is Netbeans, which provides excellent visual support for Swing.
  - Visual designers are better for prototypes than for creating production-quality UIs that need to be maintained
  - Usually, to use a visual designer effectively, you need to have a good understanding of how to write code to produce the effects you want.
  - SceneBuilder is a visual tool that comes with JavaFX – to use this tool, it is essential that a developer already knows how to program in JavaFX.

Outline of Topics

- Swing Components and Containers
- Laying Out Components with Layout Managers
- Handling Events
- Additional Technique: Displaying Pop-up Windows
- A sample UI: UserIO.java
- Working with Lists in a UI

The Main Idea in Swing

- *Components and containers.* Swing provides components (like text boxes, buttons, checkboxes) and containers (frames, windows, panels, applets) in which such components can be placed.

- *Containers placed in other containers.* In Swing, a container is also considered to be another kind of component, so containers can be placed in other containers.

- *LayoutManagers for containers.* Every container supports the use of a layout strategy. To achieve the visual objectives in building Swing screens requires skillful use of layouts on multiple containers.

- *Listeners = Event Handlers.* A Swing GUI becomes responsive to user actions (like button presses, item selections, etc) by means of an event handling model. In this model, there are "listeners" for user actions (like button presses and mouse clicks). When a relevant user action occurs, the listener is informed and the code that you have written to handle the event will then be executed.

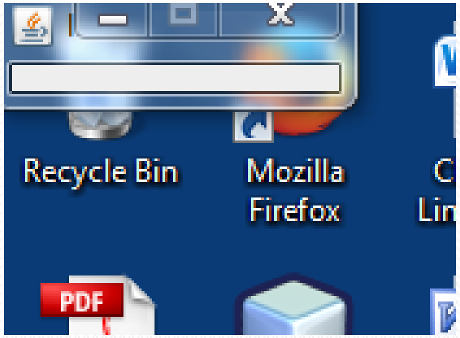
JFrames

- The top-level container class in Swing is `JFrame`. ("Top-level" means "not contained in any other containers.") JFrame is equipped with a title bar whose value can be modified. [See package lesson5 for all the code shown in these slides.]

```
class MyFrame extends JFrame {
    MyFrame() {
          setTitle("Hello World");
}
```

To see the result so far, create an instance of `MyFrame` and call the `setVisible` method on it. Because of the non-threadsafe nature of Swing components, all component-building (to be safe) must be done through the EventQueue, so we have to create our JFrame and make it visible with the following mysterious code, which places our GUI-building thread in Swing's event queue, where it will be executed in the proper order.

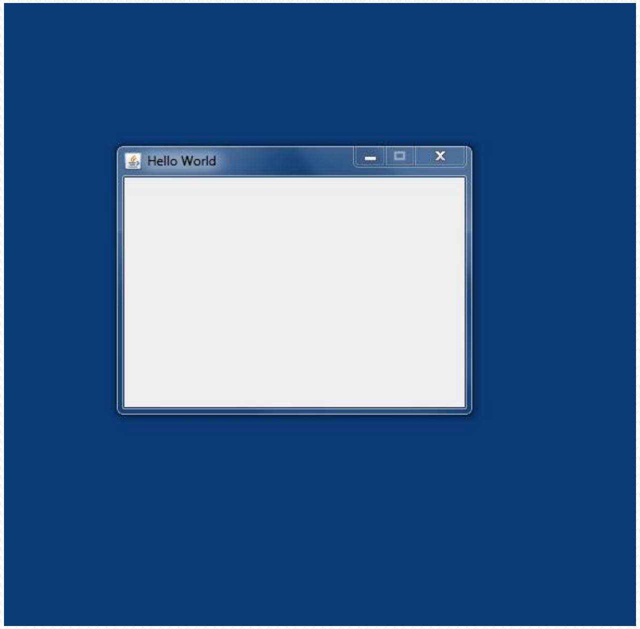
```
public static void main(String[] args) {
    EventQueue.invokeLater(new Runnable()
    {
        public void run() {
            MyFrame1 mf = new MyFrame1();
            mf.setVisible(true);
        }
    });
}
```



The JFrame that is created is placed by default in the upper left corner of the screen, squeezed into the smallest possible area

- Need to adjust size and position.

```
public class MyFrame extends JFrame {
    public MyFrame()
        setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        setTitle("Hello World");
        setSize(320,240);
        centerFrameOnDesktop(this);
        setResizable(false);
    }
    public static void centerFrameOnDesktop(Component f) {
        Toolkit toolkit = Toolkit.getDefaultToolkit();
        int height = toolkit.getScreenSize().height;
        int width  = toolkit.getScreenSize().width;
        int frameHeight = f.getSize().height;
        int frameWidth  = f.getSize().width;
        f.setLocation(((width-frameWidth)/2),
                    (height-frameHeight)/3);
    }
}

//To invoke, use the same main method as given above
```



Jframe is now centered in the desktop window and has the specified width and height

`Tips:`

- *Use* `pack()` *instead of hard-coding size*: Will make the window just large enough to fit in all the components.
- Call `pack()` after all components have been added to the container.
- Centering of window should be done *after* size has been set or `pack()` has been called

Adding Components

- Organize components into containers (called “panels”) and assemble panels into the main frame.

- Design Tip: Create a “top-level” panel that will contain all the other panels that you define.

- You can add components to your main panel, but they will be arranged according to a default layout (called `FlowLayout`). (Note: The default layout for the content pane of a `JFrame` is `BorderLayout`.)

```
//make the text field and label instance variables in MyFrame
JTextField text;
JLabel label;
public MyFrame(){
    //put initializations like setSize, setTitle, centerFrame here
        initializeWindow();

        JPanel mainPanel = new JPanel();
        text = new JTextField(10);
        label = new JLabel("My Text");
        JButton button = new JButton("My Button");
        mainPanel.add(text);
        mainPanel.add(label);
        mainPanel.add(button);

        getContentPane().add(mainPanel);
}
```

Main Point

Swing classes are of two kinds: *components* and *containers*. A screen is created by creating components (like buttons, textfields, labels) and arranging them in one or more containers. Components and containers are analgous to the *manifest* and *unmanifest* fields of life; manifest existence, in the form of individual expressions, lives and moves within the unbounded container of pure existence.

Layout Managers: FlowLayout and BorderLayout

A Layout Manager is a Java class that decides how components will be arranged in a container and to what extent the *preferred size* of these components will be honored.

- The preferred size of a component, is, roughly, the minimum size it can have and still be visually meaningful (for example, a button's preferred size is "just big enough" so that you can see the button's label)

- The general rule is that the components in a container will be given their preferred size unless the policy of the container's layout manager conflicts with this

FlowLayout Policy

- All components are given their preferred size
- When components are added to the container, they are added from left to right in horizontal rows; when a row is filled up, components are placed in a new line below the first
- The default distance between successive components (both horizontally and vertically) is 5 pixels – this quantity can be modified using setHgap, setVgap.
- The entire cluster of components in a row can be justified left, justified right, or centered using these arguments, respectively, in the FlowLayout constructor: `FlowLayout.LEFT, FlowLayout.RIGHT, FlowLayout.CENTER`

  Example:

  ```
  myPanel.setLayout(new FlowLayout(FlowLayout.LEFT));
  ```

BorderLayout Policy

a. When components are added, they are placed in one of 5 regions in the container, specified by

   `BorderLayout.NORTH, BorderLayout.SOUTH, BorderLayout.EAST, BorderLayout.WEST, BorderLayout.CENTER`

   If no region is specified, CENTER is the default. It is not necessary to populate every region with a component.

b. The preferred *height* of components placed North or South is honored, but the *width* of such components is made to be as wide as the container itself.

c. The preferred *width* of components placed East or West is honored. The *height* of such a component is forced to extend to the top and bottom of the container *unless* a component occupies North or South position. If North is occupied, then the height of West (and East) extends up to the North component. If South is occupied, the height of West (and East) extends down to the South component.
d. A component that occupies the Center position is stretched to fill out the region up to the components in the other positions.
e. The gaps between these regions is, as with `FlowLayout`, 5 pixels both vertically and horizontally.

Main Point

Components are arranged in a container through the use of *layout managers* that organize components in different ways. FlowLayout preserves the size of components and lays components out horizontally, from left to right. BorderLayout lays out components in five positions – north, south, east, west and center; to preserve the size of components, BorderLayout is used in conjunction with FlowLayout. Likewise, all of manifest life is conducted by a vast network of natural laws.

Applying Layout Managers

JTextField and Jlabel

Create the following panels in order to left justify the text field and label, placing the label below the text field :

- a `textPanel` that will have a `BorderLayout`, so we can arrange the text field and label vertically
- a `topTextPanel` that will allow us to control the position of the text field – we can specify that the text field should be placed at the far left of this panel, using a `FlowLayout`
- a `bottomTextPanel` that will allow us to control the position of the label – again we use a `FlowLayout`
- place the `topTextPanel` in the `NORTH` position and `bottomTextPanel` in the `CENTER` position of the `textPanel`.

```
JPanel topText = new JPanel();
JPanel bottomText = new JPanel();
topText.setLayout(new FlowLayout(FlowLayout.LEFT,5,0));
bottomText.setLayout(new FlowLayout(FlowLayout.LEFT,5,0));


text = new JTextField(10);
label = new JLabel("My Text");
label.setFont(makeSmallFont(label.getFont()));
topText.add(text);
bottomText.add(label);

textPanel = new JPanel();
textPanel.setLayout(new BorderLayout());
textPanel.add(topText,BorderLayout.NORTH);
textPanel.add(bottomText,BorderLayout.CENTER);
```

Layout of the textfield/label combination and the Button.

To place the textfield/label component in the upper left of the screen and to place the button in the middle of the screen, create the following panels:

- a `topPanel` to hold the textfield/label – use a `FlowLayout` to left-justify
- a `middlePanel` to hold the button – use a `FlowLayout` to center the button
- layout the `mainPanel` with `BorderLayout`, and place `topPanel` in the `NORTH` and `middlePanel` in the `CENTER`.

```java
public MyFrame(){
        initializeWindow();
        JPanel mainPanel = new JPanel();
        defineTopPanel();
        defineMiddlePanel();
        mainPanel.setLayout(new BorderLayout());
        mainPanel.add(topPanel, BorderLayout.NORTH);
        mainPanel.add(middlePanel, BorderLayout.CENTER);
        getContentPane().add(mainPanel);
}
private void defineTopPanel() {
        topPanel = new JPanel();
        defineTextPanel();
        topPanel.setLayout(new FlowLayout(FlowLayout.LEFT));
        topPanel.add(textPanel);

}
private void defineMiddlePanel(){
        middlePanel=new JPanel();
        middlePanel.setLayout(new FlowLayout(FlowLayout.CENTER));
        button = new JButton("My Button");
        middlePanel.add(button);

}
```

Main Point

Because containers are themselves a certain type of component, containers can be organized inside of other containers. Attractive visual design of GUIs is accomplished in Swing through the creative use of multiple layouts of container classes. The natural order of existence is created and maintained by the hidden dynamics of pure intelligence.

Handling Events

To get a response from a button click, we associate a “listener” to the button; the listener will be informed (by way of an `ActionEvent`) whenever the button is clicked at runtime.

Here is a detailed overview of event handling in the AWT:

- A listener object is an instance of a class that implements a *listener interface* – typical example: `ActionListener` -- used for the most common GUI components in Java. (An *interface* in Java is like a Java class except that it simply lists method signatures and return types without implementation. More about interfaces in Lesson 6.)

  Here is `ActionListener` from the source code for the Java libraries:

  ```
  public interface ActionListener {
          public void actionPerformed(ActionEvent e);
  }
  ```

  When a class *implements* an interface, it means that the class provides an implementation for each of the method declared in the interface.

  Note: Interfaces are discussed in detail in Lesson 7.

- An event source is an object that can register listener objects and send them event objects – examples: buttons, menu items, checkboxes, combo boxes

- The event source sends out event objects to all registered listeners when that event occurs – for instance, when a button is clicked, all listeners for this button receive an `ActionEvent` instance

- Listener objects may use the information in the event object received to determine their reaction to the event

Example of a Listener

For our GUI example, we register an `ActionListener` – named `MyButtonListener` – when we define our button. We specify the response to a button click in the body of the `actionPerformed` method.

ButtonListener Code

```
//define the listener class
public class MyButtonListener implements ActionListener {
    //the text field we are listening to
    private JTextField text;
    public MyButtonListener(JTextField text) {
        this.text = text;
    }
    public void actionPerformed(ActionEvent evt){
        String textVal = text.getText();
        final String prompt = "Type a string";
        final String youWrote = "You wrote: ";
        if(textVal.equals("") ||
                textVal.equals(prompt) ||
                textVal.startsWith(youWrote)){

            text.setText(prompt);
        }
        else {

            text.setText(youWrote+"\""+textVal+"\".");
        }
    }
}
```

Attaching the ButtonListener

```
//Inside MyFrame, register your new
//listener class when the button is defined
button = new JButton("My Button");

//because our text field is stored as an instance variable
//we can pass it in to the listener like this:
button.addActionListener(new MyButtonListener(text));
```

Running the Code

When the user clicks the button….

User types "Hello"

User clicks My Button

User clicks My Button a second time

Brief Introduction to Inner Classes: Listeners As Inner Classes

The class `MyButtonListener` is closely associated with `MyFrame` – it relies on the text field of `MyFrame` and has behavior that is customized to the requirements of this particular application.

It is therefore natural to think of `MyButtonListener` as an auxiliary class for the private use of `MyFrame`.

Java supports this need with *nested classes* – a nested class is a class that is defined within another class. When a nested class has access to all the instance variables of its surrounding class it is called an *inner class.*

If we make `MyButtonListener` an inner class of `MyFrame`, then there is no longer a need to pass a text field into the listener class since it will automatically have access to it.

Implementing Listener As an Inner Class

```
public class MyFrame extends JFrame {
    private JTextField text;
    private JLabel label;
    private JButton button;
    public MyFrame() {
        // . . .
    }
    private void defineMiddlePanel(){
        middlePanel=new JPanel();
        // . . .
        button = new JButton("My Button");
        button.addActionListener(new
                        MyButtonListener());
        // . . .
    }
```

```
// . . .
//now defined as an innner class
class MyButtonListener implements ActionListener {
    public void actionPerformed(ActionEvent evt){
        //automatic access to MyFrame's instance variables
        String textVal = text.getText();
        final String prompt = "Type a string";
        final String youWrote = "You wrote: ";
        if(textVal.equals("") ||
                textVal.equals(prompt) ||
                textVal.startsWith(youWrote)){

            text.setText(prompt);
        }
        else if(textVal.equalsIgnoreCase("error")){
            showMessage("An error has occurred!");
            text.setText(prompt);
        }
        else {

text.setText(youWrote+"\""+textVal+"\".");
        }
    }
}
```

Main Point

A GUI becomes responsive to user interaction (for example, button clicks and mouse clicks) through Swing's event-handling model in which event sources are associated with listener classes, whose actionPerformed method is called (and is passed an event object) whenever a relevant action occurs. To make use of this event-handling model, the developer defines a listener class, implements actionPerformed, and, when defining an event source (like a button), registers the listener class with this event source component. The "observer" pattern that is used in Swing mirrors the fact that in creation, the influence of every action is felt everywhere; existence is a field of infinite correlation; every behavior is "listented to" throughout creation.

Displaying Pop-up Messages

The Swing class `JOptionPane` makes it easy to pop up a standard dialog box that prompts users for a value or informs them of something (such as error messages). See the Java API docs for all the different options in using this class. We focus on one common usage here:

Example: In our example, we will add one more piece of functionality. When the user types in the word “error” in the text box, the GUI will respond by displaying a popup with an error message:

After the user presses MyButton, we see

When the user clicks OK, we see that the "Type a string" prompt appears.

To achieve this behavior, we modify the listener code to check for the input “error” like this:

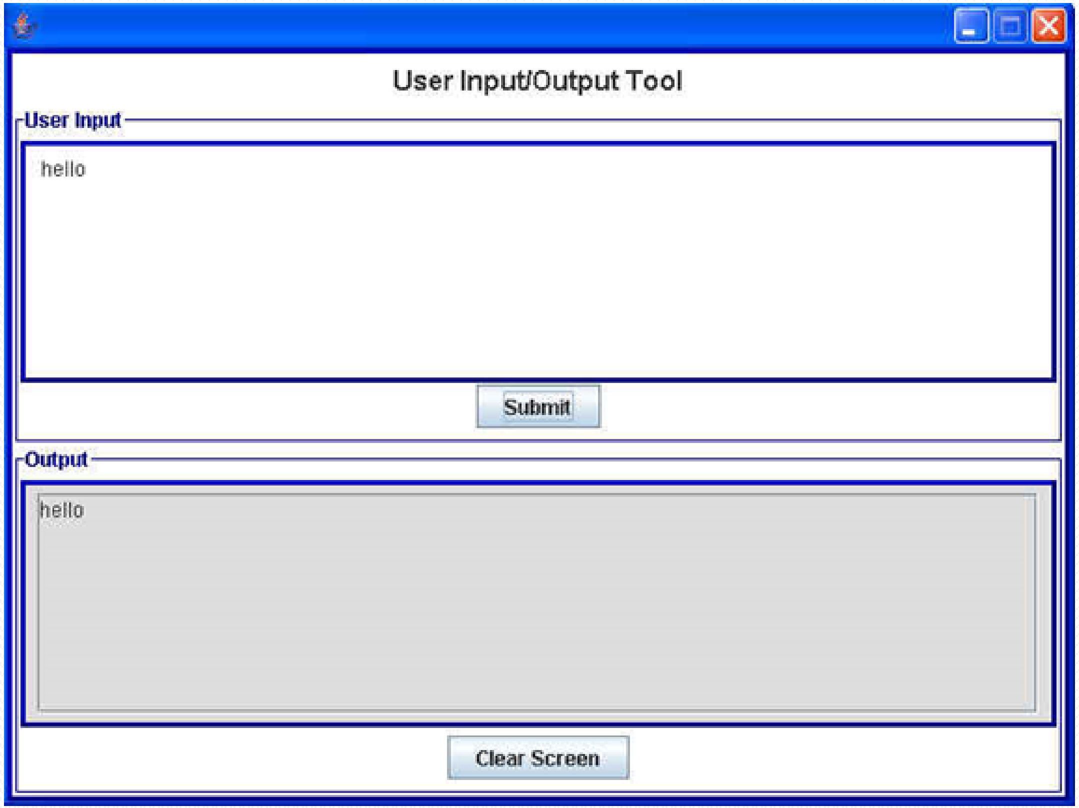
```
class MyButtonListener implements ActionListener {
    public void actionPerformed(ActionEvent evt){
            String textVal = text.getText();
            final String prompt = "Type a string";
            final String youWrote = "You wrote: ";
            if(textVal.equals("") ||
                          textVal.equals(prompt) ||
                          textVal.startsWith(youWrote)){

                  text.setText(prompt);
            }
            else if(textVal.equalsIgnoreCase("error")){
                  showMessage("An error has occurred!");
                  text.setText(prompt);
            }
            else {

                text.setText(youWrote+"\""+textVal+"\".");
            }
    }
}
```

- The work of displaying the message is encapsulated in the `showMessage()` method:

```
private void showMessage(String message){
    JOptionPane.showMessageDialog(this,
                message,
                "Error",
                JOptionPane.ERROR_MESSAGE);
}
```

The UserIO GUI

- The class `UserIO` is a simple GUI that we will use in class for some of the labs. It makes use of the principles described here, uses some additional techniques, and is well suited for displaying input/output behavior. See package lesson5.useriogui



Working with JLists in Swing

- A more sophisticated component in Swing is a JList, which displays selectable lists.

- JLists are normally embedded in a JScrollPane to support changes in the size of the list.

```
mainScroll = new JScrollPane(mainList);
```

- It is possible to load data for a JList directly, but the best practice is to load it using a *data model*.

```
JList<String> list = new JList<String>(listModel);
```

A data model keeps data separate from its presentation – this supports the MVC design pattern, which allows presentation and data and change independently. For example, you can present the same data in multiple ways.

See Lists.java in package lesson5

Summary

Development in Swing requires knowledge of three areas:

1. ***Containers and Components***. The elements that a user makes use of to interact with a UI – like buttons, textfields, etc – are *components,* which are arranged in Swing *containers.*

2. ***Layout Managers***. Design of a UI first requires the developer to visualize, and sketch out, the desired appearance of windows. This design is translated into Swing components and containers by skillful use of LayoutManagers, which provide rules that determine dimensions and positions of components on the window

3. ***Event-Handling.*** The functionality of a UI – by which a user can initiate an action to obtain a response – is achieved in Swing with *listeners.* Typically on a UI, *ActionListeners,* which are implemented with event-handling code, are attached to components. The event-handling mechanism of Java translates user actions into events that causes the ActionListener code to execute.

Connecting the Parts of Knowledge With the Wholeness of Knowledge

The self-referral dynamics
arising from the reflexive association of container classes

1. In Swing, components are placed and arranged in container classes for attractive display.
2. In Swing, containers are also considered to be components; this makes it possible to place and arrange container classes inside other container classes. These self-referral dynamics support a much broader range of possibilities in the design of GUIs.

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3. **Transcendental Consciousness:** TC is the self-referral field of all possibilities.
4. **Wholeness moving within itself**: In Unity Consciousness, all activity is appreciated as the self-referral dynamics of one's own Self.