10 Animation

What's in This Set of Notes ?

Besides stationary graphics, we may also need to display graphics that change over time. Sometimes the graphics must change on regular intervals (such as with a timer). We therefore must learn a little about animation. We will look here at some very basic 2D animation concepts and what is involved with implementing some simple "motion" aspects of graphics programming.

Here are the individual topics found in this set of notes (click on one to go there):

- 10.1 Animation Concepts
- 10.2 Simple Animation and Threads
- 10.3 Kinetic Animation

10.1 Animation Concepts

Simply put, computer animation is the term used when successive images are displayed consecutively to cause the appearance of "motion" in the image. Unfortunately for us computer science guys n' gals, all of the hard work in animation is in the drawing of the images, not displaying. So:

- BAD NEWS: computer animation is intended for the artistically inclined.

Nevertheless, a person that is "lame" at drawing can still do animation.

Computer animation has become quite popular. Almost all computer animation that we see these days deals with 3D objects. The objects are modeled in the computer and then manipulated as wireframes using many techniques and various physics models. The movements can be quite complex and much of this requires a

knowledge of 3D transformations (i.e., translations and rotations) in 3D. After the movement is completed, then coloring, lighting, shading and texture mapping is all applied. To complete a single fully rendered frame it can take many minutes depending on the machine. To make a 5 minute high quality computer animated video can take many hours to render with a single machine.

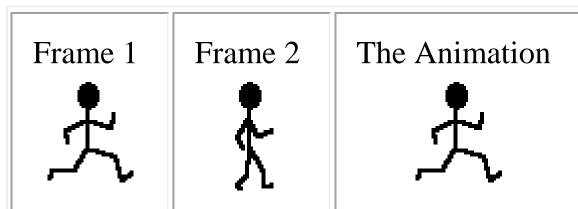
We will not deal with 3D animation at all here. We will simply animate 2D images (a.k.a. ***sprites***) and move them around on the screen.

The simplest form of 2D animation in JAVA is the use of animated gif files. We have seen this type of file with "brain.gif". Unfortunately, animated gifs are "stuck" in endless loops that do not allow user interaction. That is, we cannot control the sequence of images and hence the animation is very basic. We will therefore consider making our own animated sequences that are under user control.

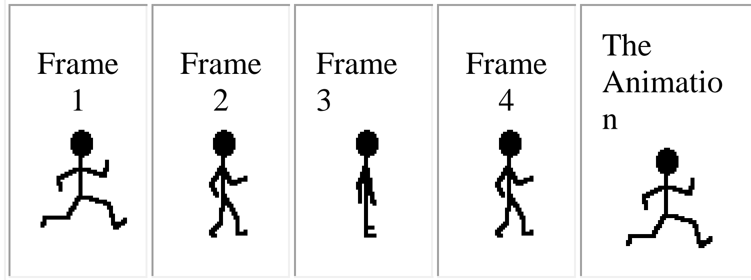
Frames:

The first step in animation is to draw a set of pictures that are called ***frames***. These frames represent the different "movements" of the object to be animated. By displaying these frames in sequence, we achieve animation!!

For example, consider a stick person walking. We can do this with only two frames and just swap between them:

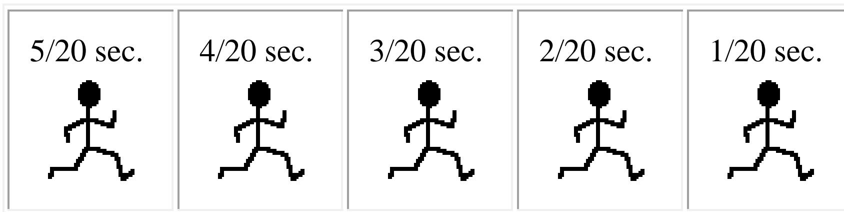


It is not too nice since it is a little "jumpy". The problem is that there is no smooth transition between the frames. We can make a big improvement just by introducing one more picture and duplicating the 2nd frame twice to produce a 4 frame sequence:



Notice that it looks much smoother. But hey, it seems slower! This is because in both cases we have introduced a 1/4 second delay between frames. In the 2-frame situation it takes 1/2 of a second to complete a cycle while in the 4-frame case, it takes a full second. We can reduce the inter-frame delay to 1/8 of a second and we will be fine.

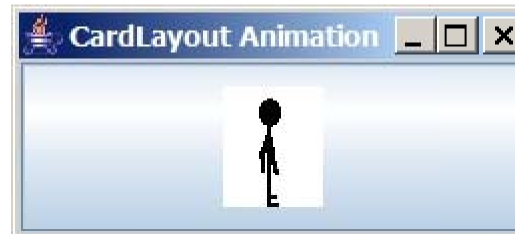
This change in time between frame displaying is known as the ***frame rate***. Here are some varying frame rates:

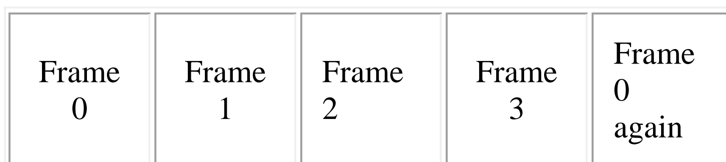


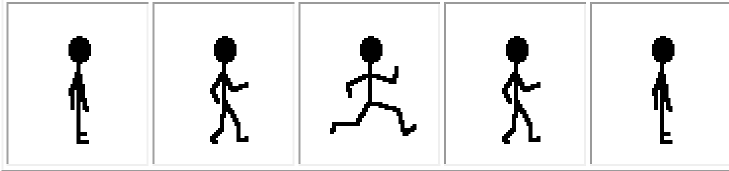
There isn't too much more to say about animation right now.

10.2 Simple Animation and Threads

Our first example is to use the **CardLayout** manager to display consecutive images one after another. We will place an **ImageIcon** on each of 4 buttons and when the button is pressed, we will cause consecutive images to be displayed by just showing the next card (i.e., button) in the layout. As long as the pictures represent consecutive images, we are fine. Here are the images that we will use, shown in order from 0 to 3:







```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
public class CardLayoutAnimation  extends JFrame implements ActionListener {
    private CardLayout  cardLayoutManager;

    public CardLayoutAnimation (String title) {
        super(title);
        cardLayoutManager = new CardLayout(0,0);
        setLayout(cardLayoutManager);

        // Add the 8 buttons, each with a different picture as the icon
        for (int i=0; i<4; i++) {
            JButton aButton = new JButton(new ImageIcon("Stick" + i +
".gif"));
            add(String.valueOf(i), aButton);
            aButton.addActionListener(this);
        }
        setDefaultCloseOperation(EXIT_ON_CLOSE);
        setSize(80, 120);
    }

    // Cause a 1/10 second delay when called
    private void delay() {
        try {
            Thread.sleep(100);
        }
        catch (InterruptedException e){ /* do nothing */ }
    }

    // Implements the listener behavior, e.g. go to next button in the stack
    public void actionPerformed(ActionEvent theEvent) {
        for (int i=0; i<4; i++) {
            cardLayoutManager.next(getContentPane());
            // Now redraw the window by updating its appearance
            update(getGraphics()); // a standard JComponent method
            delay();
        }
    }

    // Create main method to execute the application
    public static void main(String args[]) {
        new CardLayoutAnimation("CardLayout Animation").setVisible(true);
    }
}
```

Notice the use of **Thread.sleep(100)** to provide a 1/10th second delay between image flips. Also notice the use of **update(getGraphics())** to ensure that the frame is updated after every image change. This is a standard method available for all JComponents and it usually simply repaints the component immediately. Why do we need to do this redraw update for each image ? Remember, while executing code within an event handler, no other events can be handled, including events responsible for redrawing components. So we have to explicitly call this update method in order to see screen changes while we are still in our event handling code.

What happens if we increase the delay between images ? If the delay is too long, no events are handled and so the interface seems to lock up. Let us add another button that prints out a message when pressed.

We will increase the delay of the drawing so that this button becomes unresponsive while the animation is taking place. A similar kind of delay may occur when we need to do a lot of animating, or perhaps when the animation steps themselves require a lot of computation.

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class CardLayoutAnimation2  extends JFrame implements ActionListener {

    private CardLayout  cardLayoutManager;
    private JPanel  panel;

    public CardLayoutAnimation2 (String title) {
        super(title);
        setLayout(new FlowLayout());

        // Make a panel to hold the buttons using a card layout manager
        cardLayoutManager = new CardLayout(0,0);
        panel = new JPanel();
        panel.setLayout(cardLayoutManager);
        for (int i=0; i<4; i++) {
            JButton aButton = new JButton(new ImageIcon("Stick" + i +
".gif"));
            panel.add(String.valueOf(i), aButton);
            aButton.addActionListener(this);
        }

        // Make another button, then add the panel and this button to the
frame
        JButton b = new JButton("Press Me");
```

```
        add(panel);
        add(b);

        // Print a simple message when the button is pressed
        b.addActionListener( new ActionListener() {
             public void actionPerformed(ActionEvent theEvent) {
                System.out.println("Hello");
        }});

        setDefaultCloseOperation(EXIT_ON_CLOSE);
        setSize(80,160);
    }

    // Cause a 1 second delay when called
    private void delay() {
        try { Thread.sleep(1000); }
        catch (InterruptedException e){}
    }

    // implements the listener behavior, e.g. go to next button in the stack
    public void actionPerformed(ActionEvent theEvent) {
        for (int i=0; i<4; i++) {
            cardLayoutManager.next(panel);
            update(getGraphics());
            delay(); // Now a long delay
        }
    }

    public static void main(String args[]) {
        new CardLayoutAnimation2("Animated Title").setVisible(true);
    }
}
```

When the code runs, try pressing the "Press Me" button. It prints a message. Now try clicking the image button. Notice that the animation is now slower, since we lengthened the frame rate to 1 second. Try pressing the "Press Me" button a few times during the animating process. Nothing happens. That is because the events are being queued, but not handled. Once the animation stops, you will see that the queued messages are handled all at once. Try it again, this time try to close the window during the animation.

So ... clearly this is a problem. How can we fix it ? We need to create a separate thread (i.e., a separate process) to handle the animation, while the main process handles all other application events. Generally, whenever you need to have an event handler that is computationally intensive (i.e., it is slow at what it needs to do), you should make a separate thread to do it. Let us look at making a separate thread in our example.

One way to make a separate process for doing our animation is to make a separate class, which will be a subclass of the **Thread** class. We will make one called **AnimationThread** that will do the animation on the panel which we specify:

```
import java.awt.*;
import javax.swing.*;
public class AnimationThread  extends Thread {
    private JPanel aPanel;
    private CardLayout aLayoutManager;

    public AnimationThread(JPanel p, CardLayout c) {
        aPanel = p;
        aLayoutManager = c;
    }

    // Make a brief delay
    private void delay() {
        try { Thread.sleep(1000); }
        catch (InterruptedException e){}
    }

    public void run() {
        for (int i=0; i<4; i++) {
            aLayoutManager.next(aPanel);
            aPanel.update(aPanel.getGraphics());
            delay();
        }
    }
}
```

All **Threads** MUST have a **run()** method which contains all the code to be done in the thread. It is kind of like the "main" method of a **JFrame.** When it is done executing, the **Thread** is done too.

Now, we can change the listener in our **CardAnimationExample2** to be:

```
public void actionPerformed(ActionEvent theEvent) {
    new AnimationThread(panel, cardLayoutManager).start();
}
```

Try the code. You will notice now that as the animation is working, the application still responds to button clicks and window closing events.

A second way to do all of this would have been NOT to make a separate class of **Thread**, but in fact make our application implement the **Runnable** interface. We would still write a **run()** method, but everything goes into one class:

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
public class CardLayoutAnimation4  extends JFrame
                                   implements ActionListener,
Runnable {

    private CardLayout  cardLayoutManager;
    private JPanel  panel;
```

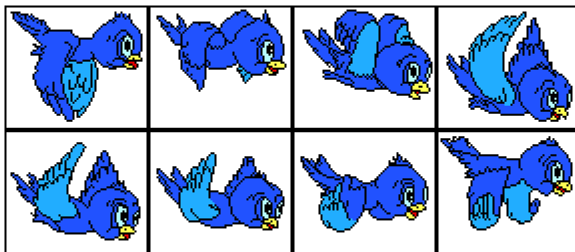
```
    public CardLayoutAnimation2 (String title) {
        super(title);
        setLayout(new FlowLayout());

        // Make a panel to hold the buttons using a card layout
manager
        cardLayoutManager = new CardLayout(0,0);
        panel = new JPanel();
        panel.setLayout(cardLayoutManager);
        for (int i=0; i<4; i++) {
            JButton aButton = new JButton(new ImageIcon("Stick" +
i + ".gif"));
            panel.add(String.valueOf(i), aButton);
            aButton.addActionListener(this);
        }

        // Make another button, then add the panel and this
button to the frame
        JButton b = new JButton("Press Me");
        add(panel);
        add(b);

        // Print a simple message when the button is pressed
        b.addActionListener( new ActionListener() {
            public void actionPerformed(ActionEvent theEvent) {
                System.out.println("Hello");
        }});

        setDefaultCloseOperation(EXIT_ON_CLOSE);
        setSize(80,160);
    }

    // Cause a 1 second delay when called
    private void delay() {
        try { Thread.sleep(1000); }
        catch (InterruptedException e){}
    }

    // Handle the animation
    public void run() {
        for (int i=0; i<4; i++) {
            cardLayoutManager.next(panel);
            panel.update(panel.getGraphics());
            delay();
        }
    }

    // implements the listener behavior, e.g. go to next button
in the stack
    public void actionPerformed(ActionEvent theEvent) {
        // Start a new thread using the run() method from this
class
        new Thread(this).start();
    }
```

```
        public static void main(String args[]) {
            new CardLayoutAnimation2("Animated
    Title").setVisible(true);
        }
    }
```

Often, this is the simplest way to do it :).

10.3 Kinetic Animation

We will now look at kinetic animation, that is ... animation that moves as opposed to staying in one location. Our task will be to move a bird around in a window. Here are the frames that we will use:



These frames are numbered 0 to 7 starting at the top left and numbering across first.

Getting this bird to fly in a single location on the screen is now easy. We can use the **CardLayout** manager if we want to ... however, we will want to make the bird move around. Our choice will be to display it on a **JFrame** or **JPanel**. We will write the code such that the user gets to make the bird fly by causing it to flap its wings whenever he/she clicks the mouse. Notice that our bird will only fly from left to right.

To start, let us consider making a **FlyingBird** class to represent the bird.

What information (i.e., instance variables) should we keep for the bird ?

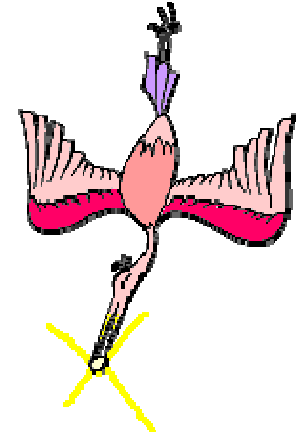
- `Point currentLocation;   // the bird's coordinate on the screen`
- `Image[] images;          // the frames of the bird (we will have 8)`
- `int currentFrame;        // the frame currently being displayed`

Here is the start of our code. We will make two class variables to keep track of how many frames the bird will have and the width of each frame (in pixels):

```
    public static int NUM_FRAMES = 8;
    public static int WIDTH = 78;
```

When making a bird, we must load up the images from the file and store them into the **images** array. We probably also want to choose some starting frame (in our case #4) as well as a starting location. We will not supply a "get" method for the image array. Instead, we will write a method called **appearance()** that will return the image corresponding to the current frame of the bird. Here is a start to our code:

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
public class FlyingBird  {
    public static int NUM_FRAMES = 8;
    public static int WIDTH = 78;

    // Instance variables
    private Point   currentLocation;  // the bird's coordinate on
the screen
    private Image[] images;           // the frames of the bird
(we will have 8)
    private int     currentFrame;     // the frame currently
being displayed

    // Default constructor
    public FlyingBird() {
        currentFrame = 4;
        currentLocation = new Point(100,100);
        images = new Image[FlyingBird.NUM_FRAMES];
        for (int i=0; i<NUM_FRAMES; i++) {
            images[i] = Toolkit.getDefaultToolkit().getImage(
                                        "BIRDX" + (i+1) + ".gif");
        }
    }

    public int getCurrentFrame() { return currentFrame; }
    public Point getCurrentLocation() { return currentLocation; }

    // Return the image representing the bird's current
appearance
    public Image appearance() {
        return (images[currentFrame]);
    }
}
```



So, each bird will keep track of its current frame, location and appearance. We will just need to supply some methods that we can call from the application that will tell the bird to ***advance*** its frame to the next one and move forward as necessary. For some added realism, we will have the bird "fall" when its wings are not flapping. That brings up some good questions:

- When is the bird flying and when is it falling ?
- What does it look like when its falling ?
- How do we make it fall ?

These are easily answered.

- The bird is flying when its wings are flapping down and falling otherwise.
- We will choose frame 3 to represent the "falling" frame.
- We make it fall by increasing the y value of the location.

Here is the **advance()** method that moves the bird forward while advancing the frame and also takes into accout gravity:

```
// This method allows the frames to advance as well as move the bird
public void advance() {
    // Move the bird forward 10 pixels
    currentLocation.translate(10,0);

    // Make gravity pull the bird down, unless its wings are flapping
    if (currentFrame > 3)
        currentLocation.translate(0,-5);
    else
        currentLocation.translate(0,5);

    if (currentFrame != 3)
        currentFrame = (currentFrame + 1) % 8;
}
```

We will also want to make the bird flap its wings. To do this, we can just "jump" to the frame that starts the flapping:

```
// Set the frame to show the bird starting to flap its wings
public void flapWings() {
    currentFrame = 4;
}
```

The "follow-through" from the flapping (i.e., the continuation and completion of the flapping motion) will be handled by successive calls to **advance()**.

Now that we have the bird working, let us get the interface going. We will make a **JFrame** and color the background white. We will set up a **Timer** that will cause the bird to advance every 1/5 of a second.

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
public class FlyingBirdApp  extends JFrame implements
ActionListener {
    private static int WIDTH = 600;
    private static int HEIGHT = 400;

    private FlyingBird aBird; // model
    private Timer  aTimer;
    private Image  background;

    public FlyingBirdApp (String title, FlyingBird theBird) {
        super(title);
        aBird = theBird;

        // We can use nice scenery for the background
        background =
Toolkit.getDefaultToolkit().getImage("beach.jpg");

        // Start the timer so that the bird comes to life
        aTimer = new Timer(100, this);
        aTimer.start();

        setDefaultCloseOperation(EXIT_ON_CLOSE);
        setSize(540, 210);
    }

    // This is the timer event handler
    public void actionPerformed(ActionEvent e) {
        aBird.advance();
        if (aBird.getCurrentLocation().x > WIDTH)
            aBird.getCurrentLocation().x = -1 * FlyingBird.WIDTH;
        repaint();
    }

    public void paint(Graphics g) {
        g.drawImage(background, 0, 0, null);
        g.drawImage(aBird.appearance(),
aBird.getCurrentLocation().x,
                        aBird.getCurrentLocation().y, this);
    }

    // Create main method to execute the application
    public static void main(String args[]) {
        new FlyingBirdApp("Flying Bird", new
FlyingBird()).setVisible(true);
    }
}
```

Notice that the **Timer** event causes the bird to advance and then repaints the frame. It also checks to see if the bird goes off the end of the frame and brings it back around to the left side again. The **paint()** method merely gets the appearance of the bird (i.e., the image) and displays it at the bird's current location. Note that we use **paint()** instead of **paintComponent()** since this is a **JFrame**, not a **JPanel.**

Now we just need to add the **MousePressed** event handler to make the bird flap its wings:

```
// Add a MousePressed event handler
addMouseListener(new MouseAdapter() {
    public void mousePressed(MouseEvent e) {
        aBird.flapWings();
}});
```

Here is the end result of our hard work: