

A Slider-Controlled Sharpening Program for Digital Photos

Learn how to write a Java program to apply a sharpening filter to your digital photos. The amount of sharpening is controlled by the user with a slider.

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Preface

General

This lesson is the next in a series (see [Resources](#)) designed to teach you how to write Java programs to do things like:

- Blur, soften, or sharpen your digital photos.
- Remove *redeye* from your digital photos.

- Distort the human voice.
- Display one image inside another image.
- Do edge detection, blurring, and other filtering operations on images.
- Insert animated cartoon characters into videos of live humans.

If you have ever wondered how to do these things, you've come to the right place.

What you have learned from earlier lessons

If you have studied the [earlier lessons](#) in this series, you have learned:

- How to download, install, and test a Java multimedia library from Georgia Institute of Technology.
- How to edit the pixels in an image on a pixel-by-pixel basis using a program written entirely in Java.
- Many aspects of image processing, including color distance, projecting 3D coordinates onto a 2D display plane, and edge detection.
- How to write an animated flocking program.
- How to blur or soften your digital photos.

What you will learn in this lesson

You will learn how to write a Java program to apply a sharpening filter to your digital photos where the amount of sharpening is controlled by the user with a slider.

In addition, you will see what happens when sharpening is overdone, causing the program to degenerate to an edge-detection program.

Viewing tip

I recommend that you open another copy of this document in a separate browser window and use the following links to easily find and view the figures and listings while you are reading about them.

Figures

- [Figure 1](#). Sample output from the program names Sharpen01.
- [Figure 2](#). From maximum sharpening to maximum softening.
- [Figure 3](#). Incremental changes in sharpening.
- [Figure 4](#). EdgeDetect03 program output for six sample slider values.
- [Figure 5](#). Changes in program code
- [Figure 6](#). The king with edge detection.

Listings

- [Listing 1](#). Beginning of the method named processThePicture.

- [Listing 2](#). Compute weighting factors for two different cases.
- [Listing 3](#). Compute weighting factors for the sharpening filter.
- [Listing 4](#). Apply the filter.
- [Listing 5](#). Remainder of the code for the program named Sharpen01.
- [Listing 6](#). Source code for the program named Sharpen01.
- [Listing 7](#). Source code for the program named EdgeDetect03.

Supplementary material

I recommend that you also study the other lessons in my extensive collection of online programming tutorials. You will find a consolidated index at www.DickBaldwin.com.

General background information

A multimedia class library

In this series of lessons, I will present and explain many of the classes in a multimedia class library that was developed and released under a **Creative Commons Attribution 3.0 United States License** (see [Resources](#)) by Mark Guzdial and Barbara Ericson at Georgia Institute of Technology. In doing this, I will also present some interesting sample programs that use the library.

Software installation and testing

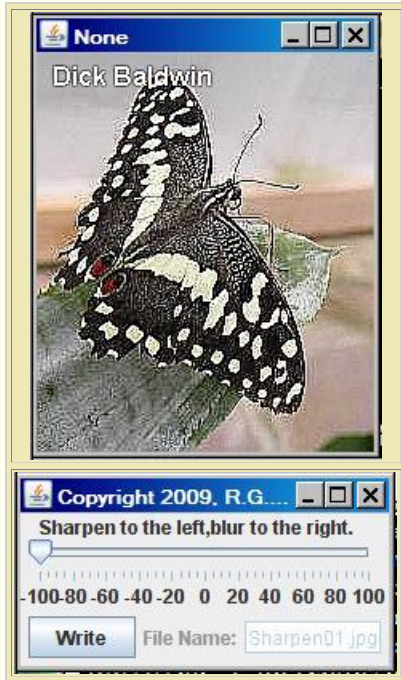
I explained how to download, install, and test the multimedia class library in an earlier lesson titled *Multimedia Programming with Java, Getting Started* (see [Resources](#)).

Preview

Two programs

I will present and explain two different programs in this lesson. In the first program named **Sharpening01**, I will show you how to write a program in which the user controls the amount of sharpening that is applied to a digital image using a slider. The results are immediately visible in a display of the image to which the sharpening is being applied as shown in Figure 1.

Figure 1. Sample output from the program names Sharpen01.

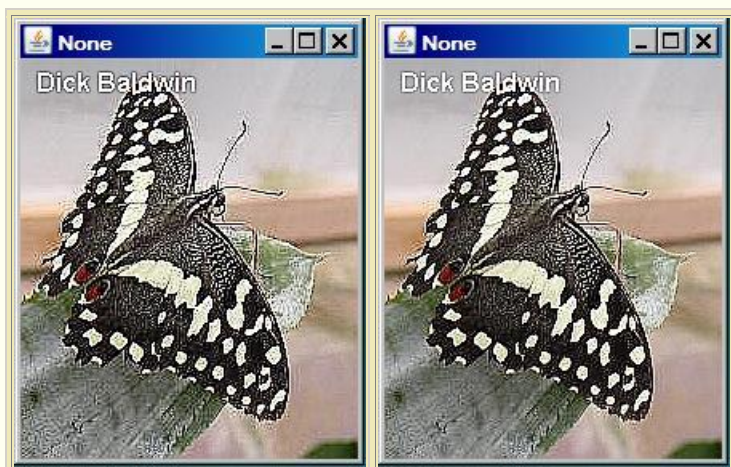


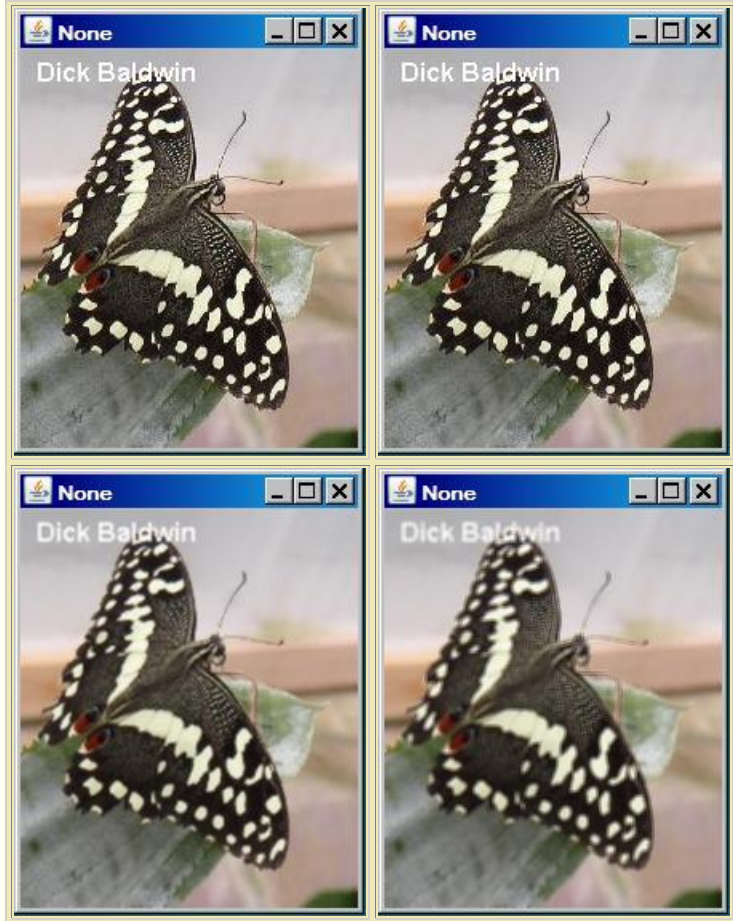
For convenience purposes, this program can also be used to apply a softening filter to the image as an alternative to the sharpening filter.

From maximum sharpening to maximum softening

Figure 2 shows a series of output displays for slider values of -100, -20, -1, +1, +20, and +100 going from left to right, top to bottom.

Figure 2. From maximum sharpening to maximum softening.





The picture in the upper-left corner shows maximum sharpening and the picture in the lower-right corner shows maximum softening. The two images in the middle should be identical with no sharpening or softening.

Incremental changes in sharpening

When applying sharpening to your digital photos, you will probably be working in the area closer to zero on the slider. Figure 3 shows a series of output displays for slider values of -1, -2, -3, -4, -5, and -6 going from left to right, top to bottom.

Figure 3. Incremental changes in sharpening.



No sharpening a the top left

No sharpening was applied to the image in upper-left corner. The sharpening was increased in slider-unit steps going from there to the bottom-right corner in left-to-right order.

Adjust the granularity

If those unit steps in sharpening are too granular, or not granular enough for your needs, there is a variable named [sensitivity](#) in the code that you can modify to decrease or increase the granularity. I will point it out later when explaining the code.

When sharpening is overdone...

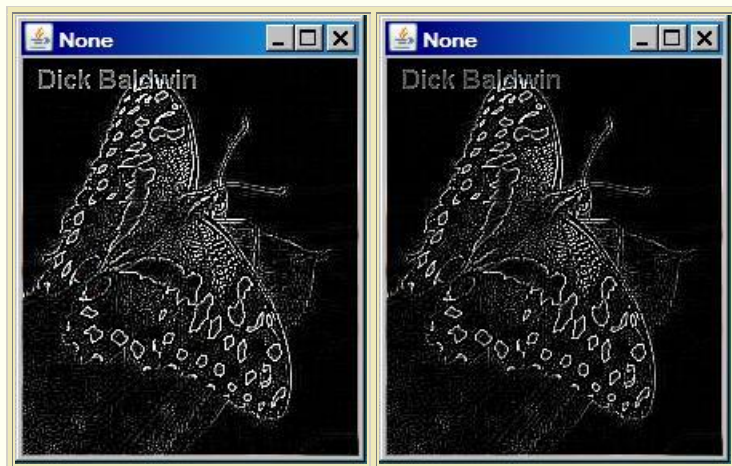
In the second program, I will show you one of the things that can happen if you get it wrong when writing a sharpening program. The result in this case is that the program degenerates into an edge-detection program. Once again, the results are immediately visible in a display of the image to which sharpening is being applied.

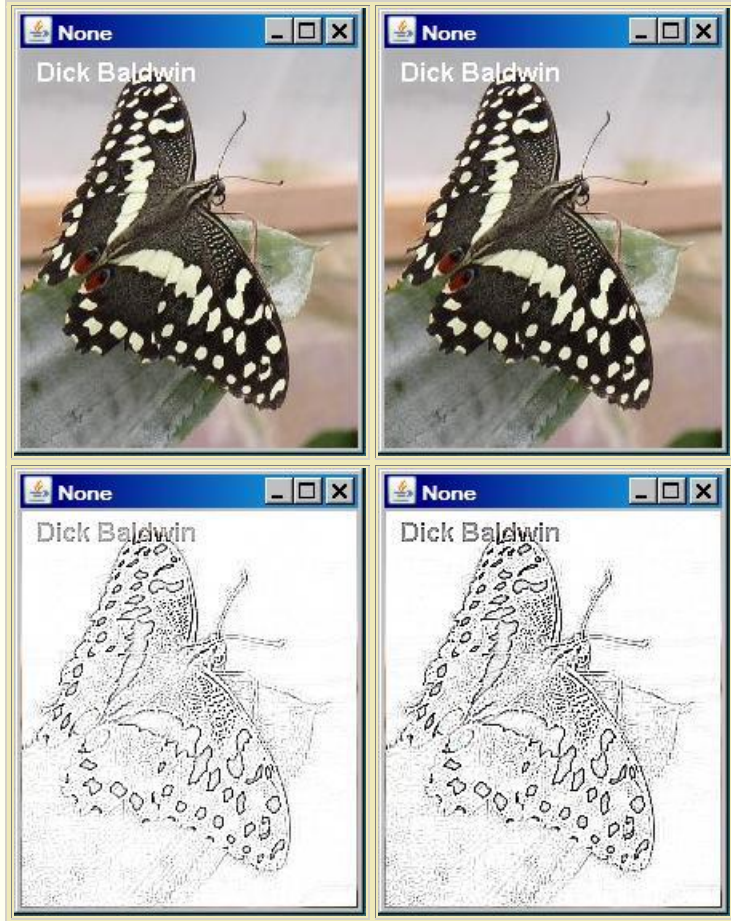
Figure 4 shows the output from the program named **EdgeDetect03** for slider values of -100, -20, -1, +1, +20, and +100 going from left to right, top to bottom.

EdgeDetect03 program output for six sample slider values

Figure 4 shows a series of output displays for slider values of -100, -20, -1, +1, +20, and +100 going from left to right, top to bottom. These are the same slider values that were used for the other program in Figure 2.

Figure 4. EdgeDetect03 program output for six sample slider values.





Maximum sharpening at the upper left corner

As before, the picture in the upper-left corner shows maximum sharpening. However, unlike the previous program, this program does not soften the image when the slider moves to the right of zero. Instead, this program applies the same algorithm for slider values on both sides of zero. However, when the slider is positioned to the right of +1, the color is inverted before storing it in the output display image. Thus, the bottom-right image is an inverted version of the top-left image.

Discussion and sample code

The program named Sharpen01

In an earlier lesson titled *A Slider-Controlled Softening Program for Digital Photos* (see [Resources](#)), I showed you how to write a program that will apply a softening filter to your digital photos.

Designing an effective *softening* filter is a cakewalk compared to designing an effective *sharpening* filter. I discussed the issues involved with sharpening filters in some detail

in an earlier lesson titled *Processing Image Pixels, Applying Image Convolution in Java, Part 1*, (see [Resources](#)), so I won't repeat that discussion here.

Started with the template program

This program was created using the program named **SingleSliderTemplate01** as the starting point. I explained that template in the earlier lesson titled *A Slider-Controlled Softening Program for Digital Photos* (see [Resources](#)).

Purpose of the program

The purpose of this program is to teach you how to write a slider-controlled program to apply a sharpening filter to your digital photos. The amount of sharpening is controlled by the user with a slider.

A dual-purpose program

In addition to applying a sharpening filter, the program is also designed to allow the user to apply a softening filter, (*as an alternative to the sharpening filter*), using an algorithm that was explained in the earlier program. In other words, this program can be used to either sharpen or soften a digital photo. The program requires access to Ericson's multimedia library.

This program was designed to emphasize an understanding of the image-sharpening process and was not designed for speed.

Two parts to the screen output

The screen output produced by the program consists of two parts as shown in Figure 1:

- A display of the picture being processed.
- A GUI that is used to control the process.

Configuration of the slider

As you can see in Figure 1, the slider ranges from -100 to +100. The initial position of the slider when the program starts running is 0. The program applies a sharpening filter when the slider is to the left of -1, and applies a softening filter when the slider is to the right of +1. No sharpening or softening occurs when the slider is between -1 and +1 inclusive.

The algorithms

The sharpening or softening algorithm is applied separately to the red, green, and blue color values of all the pixels. I will provide a detailed explanation of the *sharpening*

algorithm later. You can read about the *softening* algorithm in the earlier lesson titled *A Slider-Controlled Softening Program for Digital Photos* (see [Resources](#)).

Writing backup files

Positioning the slider at some point along its range and clicking the **Write** button in Figure 1 causes a bmp-formatted backup file to be written containing the current state of the display. See the explanation of the program named **SingleSliderTemplate01** in the earlier lesson for information regarding the number of sequential backup files that are saved and the names of those files.

Termination of the program

Clicking the large X in the upper-right corner of the display does not terminate the program. This simply hides the display and is of no practical use. The program is terminated by clicking the large X in the upper-right corner of the GUI.

Before terminating, the program writes an output file containing the final state of the display in the same format as the input file. The name of the output file is the same as the name of the input file except that the word FINAL is inserted immediately ahead of the extension.

This program does not modify the contents of the input file.

Will explain in fragments

As usual, I will explain this program in fragments. A complete listing of the program is provided in Listing 6 near the end of the lesson.

Because this program is based on the template from the program named **SingleSliderTemplate01**, and because you (*hopefully*) learned all about that template in the earlier lesson titled *A Slider-Controlled Softening Program for Digital Photos* (see [Resources](#)), I will only need to explain the method from Listing 6 named **processThePicture**.

The method named processThePicture

This version of the method named **processThePicture** applies both a *sharpening* algorithm and a *softening* algorithm to an image depending on whether the user selects sharpening or softening.

Convolution on images
You can learn more about image convolution in the lesson titled *Processing Image Pixels, Performing*

Convolution

Convolution on Images and the lessons following that one in [Resources](#).

In pure technical terms, this method convolves the pixels in the image with two different nine-point, two-dimensional convolution filters (*depending on the selection of smoothing versus sharpening*) having very specific characteristics. The convolution filters are applied separately to the red, green, and blue color values of the pixels.

More familiar terminology

Using terminology that may be more familiar to you as a programmer, each color value for each pixel is replaced by a weighted sum of the color value for that pixel (*referred to as the center pixel*) and the color values for its eight closest neighbors (*referred to as the neighbors*).

Characteristics of the algorithm

Some of the characteristics of the algorithm are:

- The center pixel and its eight neighbors constitute a 3x3 square of pixels.
- Equal weights are applied to each of the eight neighbors.
- The sum of the nine weights applied to the center pixel and its eight neighbors is 1.0.

Weighting factors are based on the slider value

The current value of the slider is used with a logarithmic algorithm to compute the weights that are applied to the pixel and its eight neighbors. However, different algorithms are used to compute the weights for *sharpening* and the weights for *softening*.

The slider is configured to range from -100 to +100 as shown in Figure 1, and the initial slider position is 0. (*This requires a minor change to the template program, which you can view in Listing 6.*)

No sharpening or softening in the middle

When the slider position is between -1 and +1 inclusive, a weight of 1.0 is applied to the center pixel and weights of 0.0 are applied to the neighboring pixels. No sharpening or softening occurs for this case.

Softening to the right

The softening algorithm is applied when the slider position is to the right of +1. The amount of softening increases as the slider is moved further to the right. When the

slider is at +100, a weight of 0 is applied to the center pixel and weights of 0.125 are applied to each of the neighbors. This results in maximum softening.

Sharpening to the left

The sharpening algorithm is applied when the slider position is to the left of -1. The amount of sharpening increases as the slider is moved further to the left. When the slider is positioned at -100, a weight of 5 is applied to the center pixel and weights of -0.5 are applied to the neighbors. This results in maximum sharpening.

Negative weighting factors

Note that negative weights may be applied in this case.

Brief operational description

A fresh display picture, based on the specified input file, is created and the method named **processThePicture** is called each time the user moves the slider to a new position. *(Code associated with the slider component prevents the method from being called while the slider is in motion.)*

Code in the method named **processThePicture** modifies the display picture and then repaints it on the screen. At that point, the program pauses, doing nothing until the user either moves the slider to another new position, clicks the **Write** button shown in Figure 1, or clicks the large X in the upper-right corner of the GUI in Figure 1.

If the user clicks the **Write** button, the program writes the current state of the display picture into an output backup file and pauses again.

If the user moves the slider to a different position, the method named **processThePicture** is called and the overall process repeats.

If the user clicks the large X in the upper right corner of the GUI in Figure 1, the final output file is written and the program terminates.

Beginning of the method named processThePicture

The method named **processThePicture** begins in Listing 1.

Listing 1. Beginning of the method named processThePicture.

```
private void processThePicture(){
    //Compute the weights that will be applied
to the
    // center pixel and its eight closest
neighbors.
    double centerWeight = 0.0;
    double neighborWeight = 0.0;
```

```

    //Get the current value of the slider.
Note that the
    // getValue method returns type int. It is
being cast
    // to double to make it compatible with
future
    // computations.
    double value =
(double) (slider.getValue());

```

No explanation should be required for Listing 1 beyond the embedded comments.

The filter for a flat color surface

Both filters are designed so that there is no change in the color of the center pixel when there is no change in the color of the input image in a 3x3 pixel area. In other words, working with the red, green, and blue color values independently, if the color value is constant across that nine-pixel square area, the corresponding output color value is the same as the color value across the area.

Changes in the output color values occur when there are changes in the color values across the nine-pixel square area. Depending on the weighting factors used, these changes can sharpen the image, soften the image, or do lots of strange and interesting things to the image. (See *the earlier lessons on processing image pixels in [Resources](#)*.)

Compute weighting factors for two different cases

Listing 2 computes the weighting factors for two different cases based on the value of the slider. The listing begins by computing the weighting factors for a softening filter when the slider is to the right of +1.

Listing 2. Compute weighting factors for two different cases.

```

    if(value > 1.0){
        //Compute weights for a softening filter
when the
        // slider is to the right of +1.
        centerWeight = 1.0 -
Math.log10(value)/2;
        neighborWeight = (1.0 -
centerWeight)/8.0;
    }else if((value >= -1) && (value <= 1)){
        //Make the filter a do-nothing filter
for the range
        // -1 to 1. This filter will not cause
sharpening or
        // blurring to occur.
        centerWeight = 1.0;

```

```
neighborWeight = 0.0;
```

The algorithm that is applied for that case is the same algorithm that you learned about in the earlier lesson titled *A Slider-Controlled Softening Program for Digital Photos* (see [Resources](#)). Therefore, no further explanation of the code for the first case in Listing 2 should be required.

Slider between -1 and +1 inclusive

The second case in Listing 2 is the case where the slider is between -1 and +1 inclusive. For this case, the weight that is applied to the center pixel in the 3x3 square of pixels is 1.0 and the weights applied to the remaining eight pixels is 0.0. Therefore, those eight pixels have no effect on the output and no sharpening or softening occurs for this case.

The sharpening filter

The code in Listing 3 computes the weighting factors for the sharpening filter. This occurs when the slider is to the left of -1.

To begin with, because the slider is to the left of -1, the value of the slider is negative. A positive value is needed for computation of the weighting factors, so I needed to change the algebraic sign of the value of the slider. I could have simply incorporated this into the computation that follows, but I elected to change the sign explicitly for clarity.

Listing 3. Compute weighting factors for the sharpening filter.

```
}else{
    value = -value;

    double sensitivity = 2.0;
    centerWeight =
        (1.0 +
Math.log10(value)*sensitivity);
    neighborWeight = (1-centerWeight)/8.0;
} //end else
```

The sensitivity factor

As I mentioned [earlier](#), I also decided to include a **sensitivity** factor for you to experiment with by changing the value of the factor and recompiling the program.

If you increase the value of the variable named **sensitivity**, you will increase the sensitivity of the sharpening process. In other words, you will cause the amount of sharpening to increase for the same amount of travel of the slider toward the left end of the slider. Similarly, decreasing the value will reduce the sensitivity of the sharpening process.

Increasing that value causes the value of the **centerWeight** factor (*which is applied to the center pixel in the 3x3 square of pixels*), which will, in turn, drive the factor that is applied to the other eight pixels in the 3x3 square in the negative direction.

Can produce negative weighting factors

If you examine the code in Listing 3, you should conclude that the weighting factors that are applied to the eight pixels around the edge of the 3x3 square can and often will be negative.

Image convolution with all positive weighting factors is relatively predictable and easy to understand because it is simply a weighted averaging process. However, as I explained in the earlier lesson titled *Processing Image Pixels, Applying Image Convolution in Java, Part 1*, (see [Resources](#)), strange things can occur when negative weighting factors are involved. One of the most obvious is that negative output values can result, which is not a legal color value for a pixel.

Approximates the first derivative

For those who remember their differential calculus, to a first degree of approximation, the application of the convolution filter for which the weighting factors were computed in Listing 3 approximates taking the first derivative of the color surface.

Proportional to the slope of the surface

As a result, the output is somewhat proportional to the slope of the surface at any given point on that surface. If the surface is flat (*the slope is zero*), the output is essentially the same as the input.

If the surface is not flat...

However, if the topography of the surface is changing rapidly, as is the case in those areas where the color of the image is changing, the magnitude of the output is greater and can be negative.

Some difficult concepts are involved

This concept alone can be difficult to wrap your mind around. Add to that the fact that there are three colors involved and only those output color values between 0 and 255 are allowed and things can become even more difficult for many of us to get a good grasp on.

Apply the filter

From here on, with one major exception, the code is pretty much the same as the code that you learned about in the earlier lesson on softening filters. That code continues in Listing 4.

Listing 4. Apply the filter.

```
//Declare some working variables.
int width = display.getWidth();
int height = display.getHeight();
int red = 0;
int green = 0;
int blue = 0;
Pixel pixel = null;
Pixel[] pixels = new Pixel[8];

//Create a temporary copy of the display
to serve as
// input to the computations that follow.
This will
// prevent the processing of one row from
having an
// influence on the processing of the next
row.
Picture temp = new Picture(display);

//Process each pixel.
for(int col = 1;col < width -1;col++){
    for(int row = 1;row < height - 1;row++){
        //Get and save the pixel at the center
of the
        // current nine-pixel group.
        pixel = display.getPixel(col,row);

        //Get and save the eight surrounding
pixels.
        pixels[0] = temp.getPixel(col-1,row-
1);
        pixels[1] = temp.getPixel(col,row-1);
        pixels[2] = temp.getPixel(col+1,row-
1);

        pixels[3] = temp.getPixel(col-1,row);
        pixels[4] = temp.getPixel(col+1 ,row);

        pixels[5] = temp.getPixel(col-
1,row+1);
        pixels[6] = temp.getPixel(col,row+1);
        pixels[7] =
temp.getPixel(col+1,row+1);

        //Compute the weighted sum of the red
values.
        red = 0;
        //First compute the sum of the color
values for
```



```

        // the eight neighboring pixels.
        for(int cnt = 0;cnt <
pixels.length;cnt++){
            red += pixels[cnt].getRed();
        }//end for loop
        //Now apply the weights and store the
resulting
        // value in the center pixel of the
nine-pixel
        // group in the display.
        red = (int) (red*neighborWeight
            +
pixel.getRed()*centerWeight);
        //Make certain that the color value is
within its
        // allowable limits of 0 to 255
inclusive.
        if(red > 255) red = 255;
        if(red < 0) red = 0;
        pixel.setRed(red);

```

The exception

The major exception that I mentioned earlier is shown in the first two of the last three statements in Listing 4. Because of the strong possibility of this algorithm producing negative output values or producing values greater than 255, I inserted the two statements in Listing 4 that clip the output color value to either 0 or 255 when that occurs.

Remainder of the code for the program named Sharpen01

When the code in Listing 4 finishes executing, the new red color value for a single pixel has been computed and set into the output display image.

Listing 5 uses the same approach to compute the output values for the green and blue colors, and iterates within the pair of nested **for** loops until all of the pixels in the picture have been processed.

Listing 5. Remainder of the code for the program named Sharpen01.

```

        //Compute the weighted sum of the
green values.
        // This is essentially the same
algorithm as for
        // the red values.
        green = 0;
        for(int cnt = 0;cnt <
pixels.length;cnt++){
            green += pixels[cnt].getGreen();
        }//end for loop
        green = (int) (green*neighborWeight
            +

```

```

pixel.getGreen()*centerWeight);
    if(green > 255) green = 255;
    if(green < 0) green = 0;
    pixel.setGreen(green);

    //Compute the weighted sum of the blue
values.
    // This is essentially the same
algorithm as for
    // the red values.
    blue = 0;
    for(int cnt = 0;cnt <
pixels.length;cnt++){
        blue += pixels[cnt].getBlue();
    }//end for loop
    blue = (int)(blue*neighborWeight
        +
pixel.getBlue()*centerWeight);
    if(blue > 255) blue = 255;
    if(blue < 0) blue = 0;
    pixel.setBlue(blue);

    }//end inner loop
} //end outer loop

display.repaint();

} //end processThePicture
//-----//
-----//

} //end class Sharpen01

```

Once all the pixels have been processed, Listing 5 repaints the display and the method named **processThePicture** terminates.

Wait for something to happen

As explained earlier, at that point, the program pauses, doing nothing until the user either moves the slider to a new position, clicks the **Write** button shown in Figure 1, or clicks the large X in the upper-right corner of the GUI in Figure 1.

If the user clicks the **Write** button, the program writes the current state of the display picture into an output backup file and pauses again.

If the user moves the slider to a different position, the method named **processThePicture** is called and the overall process repeats.

If the user clicks the large X in the upper right corner of the GUI in Figure 1, the program writes the final output file and terminates.

The program named EdgeDetect03

A complete listing of this program is provided in Listing 7 near the end of the lesson.

If you compare Figure 4 with Figure 2, you will see that the behavior of this program is radically different from the behavior of the earlier program named **Sharpen01**.

One statement makes all the difference

The critical difference in the behavior of the two programs is the result of the modification of a single statement in the computation of the weighting factor that is applied to the eight outer pixels in the 3x3 square of pixels.

Several changes made, only one was critical

The *softening* code on the right side of the slider was replaced by *sharpening* code with an inverted color output in this program. This resulted in some rearrangement of the overall structure of the code. However, neither of these changes was responsible for the difference that you see when you compare Figure 2 and Figure 4.

The critical difference

The critical difference is the difference in the two statements shown in Figure 5.

Figure 5. Changes in program code.

```
neighborWeight = (1-centerWeight)/8.0;  
neighborWeight = -centerWeight/8.0;
```

Computing neighborWeight in Sharpen01

The first statement in Figure 5 was extracted from Listing 3, which shows the computation of the weight that is applied to the eight outer pixels in the 3x3 square of pixels in the earlier program named **Sharpen01**.

Computing neighborWeight in EdgeDetect03

The second statement in Figure 5 shows the computation of the corresponding weighting factor that was extracted from Listing 7, which is the source code for the program that produced the output shown in Figure 4.

The weighting factor was used the same way in both programs

The most obvious difference between the two values of **neighborWeight** is as follows.

For the program named Sharpen01

For the first case shown in Figure 5, the sum of the weights applied to the nine pixels in the 3x3 square is equal to 1.0.

Therefore, when the weights are applied to an area of the image for which the color is relatively constant across the 3x3 square (*such as the area immediately to the left of the butterfly's left wing in the upper-left image in Figure 3*), the output color is essentially the same as the color at the center of the square.

When the square moves into an area where the color is changing (*such as the left edge of the butterfly's left wing in the same image*), the output color differs from the color at the center of the square

For example, if you examine the left edge of the left wing in the upper-left image in Figure 2, you will see that the wing is bordered by a narrow band of white (*or nearly*) white pixels. That band of white pixels doesn't exist in the original image shown at the left center of Figure 2.

For the program named EdgeDetect03

For the second case shown in Figure 5, the sum of the weights applied to the nine pixels in the 3x3 square is equal to 0.0 instead of 1.0.

Therefore, when the weights are applied to an area of the image for which the color is relatively constant across the 3x3 square (*again, such as the area immediately to the left of the butterfly's left wing in the upper-left image in Figure 3*), the output color is not the same color as the color at the center of the square. Instead, it is black or nearly black as shown in Figure 4.

When the square moves into an area where the color is changing (*such as the left edge of the butterfly's left wing in the same image*) the output color changes to something other than black.

As you can see in the upper-left image in Figure 4, the output color at that point changed to white (*or nearly white*) similar to the case for the upper-left image in Figure 2.

Why white?

The resulting white color in both cases is probably the result of the output color exceeding a value of 255 and being clipped to 255. If you use the second statement in Figure 5 with a much less sensitive sharpening filter, you are likely to see colors other than black and white as the filter moves across the color changes in the input image.

Why did I show you this?

I showed you this program mainly to illustrate the sorts of strange results that can occur when you overdo the sharpening process. However, this program isn't completely without some merit.

Figure 6 shows a picture of the king during his Army days, with the picture having been subjected to edge detection.

Figure 6. The king with edge detection.



If you were going to make a pencil drawing of the king, this might be a good way to get started. However, I doubt that you will create and save very many edge-detected pictures of your friends in your electronic scrapbook.

Run the programs

I encourage you to copy the code from Listing 6 and Listing 7, compile the code, and execute it. Experiment with the code, making changes, and observing the results of your changes. Make certain that you can explain why your changes behave as they do.

See if you can find ways to modify the algorithms to improve the speed without changing the behavior. For example, consider using the techniques described in the lesson titled *Using the Java 2D ConvolveOp Filter Class to Process Images* (see [Resources](#)).

Summary

I explained two different programs in this lesson. In the first program, I showed you how to write a program that can be used to either sharpen or soften a picture. The amount of sharpening or softening is controlled by the user with a slider.

The second program is similar to the first except that I showed you how sharpening can go terribly wrong if you don't program it properly. By making a seemingly minor modification to one statement in this program relative to the other program, I caused the sharpening algorithm to degenerate into an edge-detection algorithm.

On the other hand, if you are interested in edge detection, this could be a useful program.

What's next?

In the next lesson, you will learn more about the **Picture** and **SimplePicture** classes along with the **DigitalPicture** interface.

Resources

- [Creative Commons Attribution 3.0 United States License](#)
- [Media Computation book in Java](#) - numerous downloads available
- [Introduction to Computing and Programming with Java: A Multimedia Approach](#)
- [DrJava](#) download site
- [DrJava, the JavaPLT group at Rice University](#)
- [DrJava Open Source License](#)
- [The Essence of OOP using Java, The this and super Keywords](#)
- [Threads of Control](#)
- [Painting in AWT and Swing](#)
- [Wikipedia Turtle Graphics](#)
- [IsA or HasA](#)
- [Vector Cad-Cam XI Lathe Tutorial](#)
- [Classification of 3D to 2D projections](#)
- [200](#) Implementing the Model-View-Controller Paradigm using Observer and Observable
- [300](#) Java 2D Graphics, Nested Top-Level Classes and Interfaces
- [302](#) Java 2D Graphics, The Point2D Class
- [304](#) Java 2D Graphics, The Graphics2D Class
- [306](#) Java 2D Graphics, Simple Affine Transforms
- [308](#) Java 2D Graphics, The Shape Interface, Part 1
- [310](#) Java 2D Graphics, The Shape Interface, Part 2
- [312](#) Java 2D Graphics, Solid Color Fill
- [314](#) Java 2D Graphics, Gradient Color Fill
- [316](#) Java 2D Graphics, Texture Fill
- [318](#) Java 2D Graphics, The Stroke Interface
- [320](#) Java 2D Graphics, The Composite Interface and Transparency
- [322](#) Java 2D Graphics, The Composite Interface, GradientPaint, and Transparency
- [324](#) Java 2D Graphics, The Color Constructors and Transparency
- [400](#) Processing Image Pixels using Java, Getting Started
- [402](#) Processing Image Pixels using Java, Creating a Spotlight
- [404](#) Processing Image Pixels Using Java: Controlling Contrast and Brightness
- [406](#) Processing Image Pixels, Color Intensity, Color Filtering, and Color Inversion
- [408](#) Processing Image Pixels, Performing Convolution on Images
- [410](#) Processing Image Pixels, Understanding Image Convolution in Java
- [412](#) Processing Image Pixels, Applying Image Convolution in Java, Part 1
- [414](#) Processing Image Pixels, Applying Image Convolution in Java, Part 2
- [416](#) Processing Image Pixels, An Improved Image-Processing Framework in

Java

[418](#) Processing Image Pixels, Creating Visible Watermarks in Java

[450](#) A Framework for Experimenting with Java 2D Image-Processing Filters

[452](#) Using the Java 2D LookupOp Filter Class to Process Images

[454](#) Using the Java 2D AffineTransformOp Filter Class to Process Images

[456](#) Using the Java 2D LookupOp Filter Class to Scramble and Unscramble Images

[458](#) Using the Java 2D BandCombineOp Filter Class to Process Images

[460](#) Using the Java 2D ConvolveOp Filter Class to Process Images

[462](#) Using the Java 2D ColorConvertOp and RescaleOp Filter Classes to Process Images

- [506](#) JavaBeans, Introspection
- [2100](#) Understanding Properties in Java and C#
- [2300](#) Generics in J2SE, Getting Started
- [340](#) Multimedia Programming with Java, Getting Started
- [342](#) Getting Started with the Turtle Class: Multimedia Programming with Java
- [344](#) Continuing with the SimpleTurtle Class: Multimedia Programming with Java
- [346](#) Wrapping Up the SimpleTurtle Class: Multimedia Programming with Java
- [348](#) The Pen and PathSegment Classes: Multimedia Programming with Java
- [349](#) A Pixel Editor Program in Java: Multimedia Programming with Java
- [350](#) 3D Displays, Color Distance, and Edge Detection
- [351](#) A Slider-Controlled Softening Program for Digital Photos
- [352](#) Adding Animated Movement to Your Java Application

Complete program listings

Complete listings of the programs discussed in this lesson are shown in Listing 6 and Listing 7 below.

Listing 6. Source code for the program named Sharpen01.

```
/*File Sharpen01 Copyright 2009 R.G.Baldwin

This program was created using the program named
SingleSliderTemplate01 as the starting point.

The purpose of this program is to teach you how to write a
slider-driven program to apply a sharpening filter to your
digital photos. The degree of sharpening is controlled by
the user with a slider.

In addition to applying a sharpening filter, the program
is also designed to apply a blurring filter using an
algorithm that was demonstrated in an earlier program. In
other words, this program can be used to either sharpen
or blur a digital photo.

The program requires access to Ericson's multimedia
library.
```

The speed and smoothness of programs that you write using the template program will depend on a combination of your programming skills and the speed of your computer. This program was designed to emphasize an understanding of the image sharpening process and was not designed for speed.

The screen output produced by the program consists of two parts: a display of the picture being processed and a GUI.

See the comments at the beginning of the program named `SingleSliderTemplate01` for a detailed discussion of the components in the GUI.

The slider ranges from -100 to +100 with the initial position of the slider at 0. The program applies a sharpening filter when the slider is to the left of -1, and applies a blurring filter when the slider is to the right of +1.

No sharpening or blurring occurs when the slider is between -1 and +1 inclusive.

The sharpening or blurring algorithm is applied separately to the red, green, and blue color values of all the pixels.

A detailed description of the algorithm is provided in the comments at the beginning of the method named `processThePicture`.

Positioning the slider at some point along its range and clicking the Write button causes a backup file to be written containing the current state of the display. See the program named `SingleSliderTemplate01` for information regarding the number of sequential backup files that are saved and the names of those files.

Clicking the large X in the upper-right corner of the display does not terminate the program. This simply hides the display and is of no practical value.

The program is terminated by clicking the large X in the upper-right corner of the GUI. Before terminating, the program writes an output file containing the final state of the display in the same format as the input file. The name of the output file is the same as the name of the input file except that the word FINAL is inserted immediately ahead of the extension.

This program does not modify the contents of the original input file.

Tested using Windows Vista Home Premium Edition, Java 1.6x, and the version of Ericson's multimedia library contained in `bookClasses10-1-07.zip`.


```

*****/
import java.awt.Graphics;
import java.awt.Image;
import java.awt.BorderLayout;
import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
import java.awt.event.WindowAdapter;
import java.awt.event.WindowEvent;

import javax.swing.JFrame;
import javax.swing.JPanel;
import javax.swing.JSlider;
import javax.swing.JLabel;
import javax.swing.JButton;
import javax.swing.JTextField;
import javax.swing.event.ChangeListener;
import javax.swing.event.ChangeEvent;
import javax.swing.WindowConstants;

import java.io.File;

public class Sharpen01 extends JFrame{
    private JPanel mainPanel = new JPanel();
    private JPanel southPanel = new JPanel();

    private JLabel purposeLabel =new JLabel(
        " Sharpen to the left,blur to the right.");
    private JLabel fileNameLabel = new JLabel("File Name:");
    private JButton writeButton = new JButton("Write");
    private JTextField fileNameField =
        new JTextField("Sharpen01.jpg");
    private JSlider slider = new JSlider(-100,100,0);

    //A reference to the original Picture object will be
    // stored here.
    private Picture picture = null;
    //A reference to a modified copy of the original
    // Picture object will be stored here.
    private Picture display = null;

    //Miscellaneous working variables.
    private Image image = null;
    private Graphics graphics = null;

    private Pixel pixel = null;
    private int red = 0;
    private int writeCounter = 0;

    private Pixel[] pixels = null;

    private String fileName = "NONE";
    private String outputPath = null;
    private String extension = null;
    //-----//

```

```

public static void main(String[] args){
    new Sharpen01();
} //end main method
//-----//

public Sharpen01(){ //constructor

    //All close operations are handled in a WindowListener
    // object.
    setDefaultCloseOperation(
        WindowConstants.DO_NOTHING_ON_CLOSE);

    //Put the decorations on the slider. See the
    // documentation to learn how to decorate the slider
    // differently.
    slider.setMajorTickSpacing(20);
    slider.setMinorTickSpacing(5);
    slider.setPaintTicks(true);
    slider.setPaintLabels(true);

    //Construct the GUI.
    mainPanel.setLayout(new BorderLayout());

    mainPanel.add(purposeLabel, BorderLayout.NORTH);
    mainPanel.add(slider, BorderLayout.CENTER);

    southPanel.add(writeButton);
    southPanel.add(fileNameLabel);
    southPanel.add(fileNameField);
    mainPanel.add(southPanel, BorderLayout.SOUTH);

    //Disable the slider and the writeButton until the
    // user enters the file name. Put the focus on the
    // text field where the user will enter the file
    // name.
    slider.setEnabled(false);
    writeButton.setEnabled(false);
    fileNameField.requestFocus();

    //Set the size of the GUI and display it in the upper-
    // left corner of the screen. It will be moved later
    // to a position immediately below the display of the
    // picture.
    getContentPane().add(mainPanel);
    pack();
    setVisible(true);
    //-----//

    //Register a listener on the text field. When the user
    // enters the file name in the text field, set
    // everything up properly so that the program will
    // function as an event-driven picture-manipulation
    // program until the user clicks the large X in the
    // upper-right of the GUI.
    fileNameField.addActionListener(
        new ActionListener(){

```

```

public void actionPerformed(ActionEvent e){
    //Disable the text field to prevent the user
    // from entering anything else in it.
    fileNameField.setEnabled(false);
    fileNameLabel.setEnabled(false);

    //Get the file name from the text field and use
    // it to create a new Picture object. Display my
    // name in the image.
    fileName = fileNameField.getText();
    picture = new Picture(fileName);
    picture.addMessage("Dick Baldwin",10,20);

    //Get information that will be used to write the
    // output files.
    String inputPath = new File(fileName).
        getAbsolutePath();
    int posDot = inputPath.lastIndexOf('.');
    outputPath = inputPath.substring(0,posDot);
    //Write the first copy of the output backup
    // file.
    picture.write(outputPath
        + "BAK" + writeCounter++ + ".bmp");

    //Get filename extension. It will be used later
    // to write the final output file.
    extension = inputPath.substring(posDot);

    //Decorate the GUI.
    setTitle("Copyright 2009, R.G.Baldwin");

    //Create the picture that will be processed.
    // Note that the original image file is not
    // modified by this program.
    int pictureWidth = picture.getWidth();
    int pictureHeight = picture.getHeight();
    display = new Picture(
        pictureWidth,pictureHeight);

    //Draw the initial display.
    graphics = display.getGraphics();
    graphics.drawImage(picture.getImage(),0,0,null);
    display.show();

    //Adjust the width of the GUI to match the width
    // of the display if possible. Then relocate the
    // GUI to a position immediately below the
    // display.
    //Establish the preferred size now that the
    // input file name has been entered.
    pack();
    int packedHeight = getHeight();
    int packedWidth = getWidth();
    if((pictureWidth + 7) >= packedWidth){
        //Make the width of the GUI the same as the
        // width of the display.

```

```

        setSize(pictureWidth + 7,packedHeight);
    }//Else, just leave the GUI at its current size.
    //Put the GUI in its new location immediately
    // below the display.
    setLocation(0,pictureHeight + 30);

    //Enable the user input controls.
    slider.setEnabled(true);
    writeButton.setEnabled(true);

    }//end actionPerformed
    }//end new ActionListener
};//end addActionListener
//-----//

//Register an ActionListener on the writeButton.
// Each time the user clicks the button, a backup bmp
// file containing the current state of the display is
// written into the directory from which the original
// picture was read. The five most recent backup files
// are saved. The names of the backup files are the
// same as the name of the input file except that BAKn
// is inserted immediately ahead of the extension
// where n is a digit ranging from 0 to 4. The value
// of n rolls over at 4 and starts back at 0.
writeButton.addActionListener(
    new ActionListener(){
        public void actionPerformed(ActionEvent e){
            display.write(outputPath
                + "BAK" + writeCounter++ + ".bmp");
            //Reset the writeCounter if it exceeds 4 to
            // conserve disk space.
            if(writeCounter > 4){
                writeCounter = 0;
            }//end if
        }//end actionPerformed
    }//end newActionListener
);//end addActionListener
//-----//

//Register a WindowListener that will respond when the
// user clicks the large X in the upper-right corner
// of the GUI. This event handler will write the final
// state of the display into an output file of the
// same type as the original input file. The name will
// be the same except that the word FINAL will be
// inserted immediately ahead of the extension.
addWindowListener(
    new WindowAdapter(){
        public void windowClosing(WindowEvent e){
            display.write(outputPath + "FINAL" + extension);
            System.exit(0);
        }//end windowClosing
    }//end new WindowAdapter
);//end addWindowListener
//-----//

```

```

//Register a ChangeListener object on the slider.
//Each time the slider fires a ChangeEvent, this event
// handler creates a new display as a copy of the
// original picture and calls a method named
// processThePicture.
slider.addChangeListener(
    new ChangeListener(){
        public void stateChanged(ChangeEvent e){
            //Draw a new copy of the picture on the display.
            graphics = display.getGraphics();
            graphics.drawImage(picture.getImage(),0,0,null);
            processThePicture();
        }//end stateChanged
    }//end new ChangeListener
);//end addChangeListener
//-----//

}//end constructor
//-----//

```

/*This version of the method named processThePicture applies both a sharpening algorithm and a blurring algorithm to an image. In pure technical terms, this method convolves the pixels in the image with a nine-point, two-dimensional convolution filter having very specific characteristics. The convolution filter is applied separately to the red, green, and blue color values of the pixels.

Using terminology that may be more familiar to you, each color value for each pixel is replaced by a weighted sum of the color value for that pixel (referred to as the center pixel) and the color values for its eight closest neighbors (referred to as the neighbors). The center pixel and its eight neighbors constitute a 3x3 square of pixels.

Equal weights are applied to each of the eight neighbors.

The sum of the weights applied to the center pixel and its eight neighbors is 1.0.

The current value of the slider is used with a logarithmic algorithm to compute the weights that are applied to the pixel and its eight neighbors. However, different algorithms are used to compute the weights for sharpening and the weights for blurring.

The slider is configured to range from -100 to +100 and the initial slider position is 0.

When the slider position is between -1 and 1 inclusive, a weight of 1.0 is applied to the center pixel and weights of 0.0 are applied to the neighboring pixels. No sharpening or blurring occurs for this case.

When the slider position is to the right of +1, blurring occurs. The degree of blurring increases as the slider is moved further to the right. When the slider is at +100, a weight of 0 is applied to the center pixel and weights of 0.125 are applied to the neighbors. This results in maximum blurring.

When the slider position is to the left of -1, sharpening occurs. The degree of sharpening increases as the slider is moved further to the left. When the slider is positioned at -100, a weight of 5 is applied to the center pixel and weights of -0.5 are applied to the neighbors. This results in maximum sharpening.

```
*/
private void processThePicture(){
    //Compute the weights that will be applied to the
    // center pixel and its eight closest neighbors.
    double centerWeight = 0.0;
    double neighborWeight = 0.0;

    //Get the current value of the slider. Note that the
    // getValue method returns type int. It is being cast
    // to double to make it compatible with future
    // computations.
    double value = (double)(slider.getValue());

    //Compute weighting factors based on the value of the
    // slider. Make the response for both filters
    // equal to 1.0 when applied to a region of the
    // image where there is no change in a color value
    // across the 3x3 square of pixels. Colors values in
    // those areas will be reproduced with no change.
    if(value > 1.0){
        //Compute weights for a blurring filter when the
        // slider is to the right of 1.
        centerWeight = 1.0 - Math.log10(value)/2;
        neighborWeight = (1.0 - centerWeight)/8.0;
    }else if((value >= -1) && (value <= 1)){
        //Make the filter a do-nothing filter for the range
        // -1 to 1. This filter will not cause sharpening or
        // blurring to occur.
        centerWeight = 1.0;
        neighborWeight = 0.0;
    }else{
        //Compute weights for a sharpening filter when the
        // slider is to the left of -1.
        //Note that the value of the slider is negative here
        // so the sign of value needs to be changed to
        // positive. I could simply include this in the
        // computation but made it explicit for clarity.
        value = -value;
        //The sensitivity of the sharpening process can be
        // increased by increasing the value of the variable
        // named sensitivity and recompiling the program.
        // This causes the value of centerWeight to increase
```

```

// and drives the value of neighborWeight in the
// negative direction.
double sensitivity = 2.0;
centerWeight =
    (1.0 + Math.log10(value)*sensitivity);
neighborWeight = (1-centerWeight)/8.0;
} //end else

//Declare some working variables.
int width = display.getWidth();
int height = display.getHeight();
int red = 0;
int green = 0;
int blue = 0;
Pixel pixel = null;
Pixel[] pixels = new Pixel[8];

//Create a temporary copy of the display to serve as
// input to the computations that follow. This will
// prevent the processing of one row from having an
// influence on the processing of the next row.
Picture temp = new Picture(display);

//Process each pixel.
for(int col = 1; col < width - 1; col++){
    for(int row = 1; row < height - 1; row++){
        //Get and save the pixel at the center of the
        // current nine-pixel group.
        pixel = display.getPixel(col, row);

        //Get and save the eight surrounding pixels.
        pixels[0] = temp.getPixel(col-1, row-1);
        pixels[1] = temp.getPixel(col, row-1);
        pixels[2] = temp.getPixel(col+1, row-1);

        pixels[3] = temp.getPixel(col-1, row);
        pixels[4] = temp.getPixel(col+1, row);

        pixels[5] = temp.getPixel(col-1, row+1);
        pixels[6] = temp.getPixel(col, row+1);
        pixels[7] = temp.getPixel(col+1, row+1);

        //Compute the weighted sum of the red values.
        red = 0;
        //First compute the sum of the color values for
        // the eight neighboring pixels.
        for(int cnt = 0; cnt < pixels.length; cnt++){
            red += pixels[cnt].getRed();
        } //end for loop
        //Now apply the weights and store the resulting
        // value in the center pixel of the nine-pixel
        // group in the display.
        red = (int)(red*neighborWeight
            + pixel.getRed()*centerWeight);
        //Make certain that the color value is within its
        // allowable limits of 0 to 255 inclusive.

```

```

if(red > 255) red = 255;
if(red < 0) red = 0;
pixel.setRed(red);

//Compute the weighted sum of the green values.
// This is essentially the same algorithm as for
// the red values.
green = 0;
for(int cnt = 0;cnt < pixels.length;cnt++){
    green += pixels[cnt].getGreen();
} //end for loop
green = (int) (green*neighborWeight
              + pixel.getGreen()*centerWeight);
if(green > 255) green = 255;
if(green < 0) green = 0;
pixel.setGreen(green);

//Compute the weighted sum of the blue values.
// This is essentially the same algorithm as for
// the red values.
blue = 0;
for(int cnt = 0;cnt < pixels.length;cnt++){
    blue += pixels[cnt].getBlue();
} //end for loop
blue = (int) (blue*neighborWeight
              + pixel.getBlue()*centerWeight);
if(blue > 255) blue = 255;
if(blue < 0) blue = 0;
pixel.setBlue(blue);

    } //end inner loop
} //end outer loop

display.repaint();

} //end processThePicture
//-----//

} //end class Sharpen01

```

Listing 7. Source code for the program named EdgeDetect03.

```

/*File EdgeDetect03 Copyright 2009 R.G.Baldwin

This program was created by starting with the program
named SingleSliderTemplate01.

The purpose of this program is to teach you how to write a
slider-driven program to apply a sharpening filter to your
digital photos. The degree of sharpening is controlled by
the user with a slider.

```


The sharpening filter is so severe that the program tends to degenerate to an edge detector program.

The program requires access to Ericson's multimedia library.

The speed and smoothness of programs that you write using the template program will depend on a combination of your programming skills and the speed of your computer. This program was designed to emphasize an understanding of the image sharpening process and was not designed for speed.

The screen output produced by the program consists of two parts: a display of the picture being processed and a GUI.

See the comments at the beginning of the program named SingleSliderTemplate01 for a detailed discussion of the components in the GUI.

The slider ranges from -100 to +100 with the initial position of the slider at 0. The program applies a sharpening filter when the slider is to the left of -1 and also applies the same sharpening filter when the slider is to the right of +1. However, in the latter case, the color is inverted before being stored in the output display.

No sharpening occurs when the slider is between -1 and +1 inclusive.

The sharpening algorithm is applied separately to the red, green, and blue color values of all the pixels.

A detailed description of the algorithm is provided in the comments at the beginning of the method named processThePicture.

Positioning the slider at some point along its range and clicking the Write button causes a backup file to be written containing the current state of the display. See the program named SingleSliderTemplate01 for information regarding the number of sequential backup files that are saved and the names of those files.

Clicking the large X in the upper-right corner of the display does not terminate the program. This simply hides the display and is of no practical value.

The program is terminated by clicking the large X in the upper-right corner of the GUI. Before terminating, the program writes an output file containing the final state of the display in the same format as the input file. The name of the output file is the same as the name of the input file except that the word FINAL is inserted immediately ahead of the extension.

This program does not modify the contents of the original input file.

Tested using Windows Vista Home Premium Edition,
Java 1.6x, and the version of Ericson's multimedia library
contained in bookClasses10-1-07.zip.

*****/

```
import java.awt.Graphics;
import java.awt.Image;
import java.awt.BorderLayout;
import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
import java.awt.event.WindowAdapter;
import java.awt.event.WindowEvent;

import javax.swing.JFrame;
import javax.swing.JPanel;
import javax.swing.JSlider;
import javax.swing.JLabel;
import javax.swing.JButton;
import javax.swing.JTextField;
import javax.swing.event.ChangeListener;
import javax.swing.event.ChangeEvent;
import javax.swing.WindowConstants;

import java.io.File;

public class EdgeDetect03 extends JFrame{
    private JPanel mainPanel = new JPanel();
    private JPanel southPanel = new JPanel();

    private JLabel purposeLabel =new JLabel(
        "    Sharpen to the left,blur to the right.");
    private JLabel fileNameLabel = new JLabel("File Name:");
    private JButton writeButton = new JButton("Write");
    private JTextField fileNameField =
        new JTextField("EdgeDetect03.jpg");
    private JSlider slider = new JSlider(-100,100,0);

    //A reference to the original Picture object will be
    // stored here.
    private Picture picture = null;
    //A reference to a modified copy of the original
    // Picture object will be stored here.
    private Picture display = null;

    //Miscellaneous working variables.
    private Image image = null;
    private Graphics graphics = null;

    private Pixel pixel = null;
    private int red = 0;
    private int writeCounter = 0;

    private Pixel[] pixels = null;
```

```

private String fileName = "NONE";
private String outputPath = null;
private String extension = null;
//-----//

public static void main(String[] args){
    new EdgeDetect03();
} //end main method
//-----//

public EdgeDetect03(){ //constructor

    //All close operations are handled in a WindowListener
    // object.
    setDefaultCloseOperation(
        WindowConstants.DO_NOTHING_ON_CLOSE);

    //Put the decorations on the slider. See the
    // documentation to learn how to decorate the slider
    // differently.
    slider.setMajorTickSpacing(20);
    slider.setMinorTickSpacing(5);
    slider.setPaintTicks(true);
    slider.setPaintLabels(true);

    //Construct the GUI.
    mainPanel.setLayout(new BorderLayout());

    mainPanel.add(purposeLabel, BorderLayout.NORTH);
    mainPanel.add(slider, BorderLayout.CENTER);

    southPanel.add(writeButton);
    southPanel.add(fileNameLabel);
    southPanel.add(fileNameField);
    mainPanel.add(southPanel, BorderLayout.SOUTH);

    //Disable the slider and the writeButton until the
    // user enters the file name. Put the focus on the
    // text field where the user will enter the file
    // name.
    slider.setEnabled(false);
    writeButton.setEnabled(false);
    fileNameField.requestFocus();

    //Set the size of the GUI and display it in the upper-
    // left corner of the screen. It will be moved later
    // to a position immediately below the display of the
    // picture.
    getContentPane().add(mainPanel);
    pack();
    setVisible(true);
    //-----//

    //Register a listener on the text field. When the user
    // enters the file name in the text field, set

```

```

// everything up properly so that the program will
// function as an event-driven picture-manipulation
// program until the user clicks the large X in the
// upper-right of the GUI.
fileNameField.addActionListener(
    new ActionListener() {
        public void actionPerformed(ActionEvent e) {
            //Disable the text field to prevent the user
            // from entering anything else in it.
            fileNameField.setEnabled(false);
            fileNameLabel.setEnabled(false);

            //Get the file name from the text field and use
            // it to create a new Picture object. Display my
            // name in the image.
            fileName = fileNameField.getText();
            picture = new Picture(fileName);
            picture.addMessage("Dick Baldwin",10,20);

            //Get information that will be used to write the
            // output files.
            String inputPath = new File(fileName).
                getAbsolutePath();
            int posDot = inputPath.lastIndexOf('.');
            outputPath = inputPath.substring(0,posDot);
            //Write the first copy of the output backup
            // file.
            picture.write(outputPath
                + "BAK" + writeCounter++ + ".bmp");

            //Get filename extension. It will be used later
            // to write the final output file.
            extension = inputPath.substring(posDot);

            //Decorate the GUI.
            setTitle("Copyright 2009, R.G.Baldwin");

            //Create the picture that will be processed.
            // Note that the original image file is not
            // modified by this program.
            int pictureWidth = picture.getWidth();
            int pictureHeight = picture.getHeight();
            display = new Picture(
                pictureWidth,pictureHeight);

            //Draw the initial display.
            graphics = display.getGraphics();
            graphics.drawImage(picture.getImage(),0,0,null);
            display.show();

            //Adjust the width of the GUI to match the width
            // of the display if possible. Then relocate the
            // GUI to a position immediately below the
            // display.
            //Establish the preferred size now that the
            // input file name has been entered.

```

```

pack();
int packedHeight = getHeight();
int packedWidth = getWidth();
if((pictureWidth + 7) >= packedWidth){
    //Make the width of the GUI the same as the
    // width of the display.
    setSize(pictureWidth + 7,packedHeight);
} //Else, just leave the GUI at its current size.
//Put the GUI in its new location immediately
// below the display.
setLocation(0,pictureHeight + 30);

//Enable the user input controls.
slider.setEnabled(true);
writeButton.setEnabled(true);

    } //end actionPerformed
} //end new ActionListener
); //end addActionListener
//-----//

//Register an ActionListener on the writeButton.
// Each time the user clicks the button, a backup bmp
// file containing the current state of the display is
// written into the directory from which the original
// picture was read. The five most recent backup files
// are saved. The names of the backup files are the
// same as the name of the input file except that BAKn
// is inserted immediately ahead of the extension
// where n is a digit ranging from 0 to 4. The value
// of n rolls over at 4 and starts back at 0.
writeButton.addActionListener(
    new ActionListener(){
        public void actionPerformed(ActionEvent e){
            display.write(outputPath
                + "BAK" + writeCounter++ + ".bmp");
            //Reset the writeCounter if it exceeds 4 to
            // conserve disk space.
            if(writeCounter > 4){
                writeCounter = 0;
            } //end if
        } //end action performed
    } //end newActionListener
); //end addActionListener
//-----//

//Register a WindowListener that will respond when the
// user clicks the large X in the upper-right corner
// of the GUI. This event handler will write the final
// state of the display into an output file of the
// same type as the original input file. The name will
// be the same except that the word FINAL will be
// inserted immediately ahead of the extension.
addWindowListener(
    new WindowAdapter(){
        public void windowClosing(WindowEvent e){

```

```

        display.write(outputPath + "FINAL" + extension);
        System.exit(0);
    }//end windowClosing
} //end new WindowAdapter
); //end addWindowListener
//-----//
//Register a ChangeListener object on the slider.
//Each time the slider fires a ChangeEvent, this event
// handler creates a new display as a copy of the
// original picture and calls a method named
// processThePicture.
slider.addChangeListener(
    new ChangeListener(){
        public void stateChanged(ChangeEvent e){
            //Draw a new copy of the picture on the display.
            graphics = display.getGraphics();
            graphics.drawImage(image.getImage(), 0, 0, null);
            processThePicture();
        } //end stateChanged
    } //end new ChangeListener
); //end addChangeListener
//-----//

} //end constructor
//-----//

```

/*This version of the method named processThePicture applies a severe sharpening algorithm to an image. The algorithm is so severe that it often behaves as an edge detector causing pixels at locations where the color is changing to be displayed as black or white. In pure technical terms, this method convolves the pixels in the image with a nine-point, two-dimensional convolution filter having very specific characteristics. The convolution filter is applied separately to the red, green, and blue color values of the pixels.

Using terminology that may be more familiar to you, each color value for each pixel is replaced by a weighted sum of the color value for that pixel (referred to as the center pixel) and the color values for its eight closest neighbors (referred to as the neighbors). The center pixel and its eight neighbors constitute a 3x3 square of pixels.

Equal weights are applied to each of the eight neighbors.

IMPORTANT: The sum of the weights applied to the center pixel and its eight neighbors is 0.0. This causes the output color to be black when the filter is passing over a flat surface. Application of the filter often results in negative color values and color values greater than 255. When this happens, the color value is set to 0 or 255 as appropriate.

The current value of the slider is used with a logarithmic algorithm to compute the weights that are applied to the pixel and its eight neighbors.

The slider is configured to range from -100 to +100 and the initial slider position is 0.

When the slider position is between -1 and 1 inclusive, a weight of 1.0 is applied to the center pixel and weights of 0.0 are applied to the neighboring pixels. No sharpening occurs for this case.

When the slider position is to the left of -1, sharpening occurs. The degree of sharpening increases as the slider is moved further to the left. When the slider is positioned at -100, a weight of 5 is applied to the center pixel and weights of -0.625 are applied to the neighbors. This results in maximum sharpening, which often results in white edges on a black background.

When the slider position is to the right of +1, exactly the same sharpening algorithm is applied. However, in this case the color is inverted before being stored in the output display. This often results in black edges on a white background.

```
*/
private void processThePicture(){
    //Compute the weights that will be applied to the
    // center pixel and its eight closest neighbors.
    double centerWeight = 0.0;
    double neighborWeight = 0.0;
    boolean blackEdges = false;//Invert picture on true.

    //Get the current value of the slider. Note that the
    // getValue method returns type int. It is being cast
    // to double to make it compatible with future
    // computations.
    double value = (double)(slider.getValue());
    //Compute weighting factors based on the value of the
    // slider. Make the response for the filter
    // equal to 0.0 when applied to a region of the
    // image where there is no change in a color value
    // across the 3x3 square of pixels. Colors in those
    // areas will be converted to black.

    //The sensitivity of the sharpening process can be
    // increased by increasing the value of the variable
    // named sensitivity and recompiling the program.
    // This causes the value of centerWeight to increase
    // and drives the value of neighborWeight in the
    // negative direction.
    double sensitivity = 2.0;

    //Deal first with the area between -1 and +1
    // inclusive on the slider.
    if((value >= -1) && (value <= 1)){
```

```

//Make the filter a do-nothing filter for the range
// -1 to 1. This filter will not cause sharpening to
// occur.
centerWeight = 1.0;
neighborWeight = 0.0;
}else{
    //Now deal with the area of the slider to the right
    // of +1 and to the left of -1.
    if(value > 1){
        //Invert the colors of the processed image. This
        // will convert black to white and white to black.
        blackEdges = true;
    }else{
        //Change the sign on value to compensate for the
        // fact that the slider is in the negative
        // region.
        value = -value;
    }//end else

    //Now compute the weighting factors regardless of
    // which side of 0 the slider is on.
    //IMPORTANT: Note that the sum of the weights is 0
    // instead of 1 as was the case for the earlier
    // sharpening filter in another program. This will
    // cause the output to be 0 when the filter is
    // moving across a flat color surface.
    centerWeight =
        (1.0 + Math.log10(value)*sensitivity);
    //IMPORTANT: NOTE THAT THE FOLLOWING EXPRESSION IS
    // DIFFERENT FROM THE CORRESPONDING EXPRESSION IN
    // THE PROGRAM NAMED Sharpen01.
    neighborWeight = -centerWeight/8.0;
}

//Declare some working variables.
int width = display.getWidth();
int height = display.getHeight();
int red = 0;
int green = 0;
int blue = 0;
Pixel pixel = null;
Pixel[] pixels = new Pixel[8];

//Create a temporary copy of the display to serve as
// input to the computations that follow. This will
// prevent the processing of one row from having an
// influence on the processing of the next row.
Picture temp = new Picture(display);

//Process each pixel.
for(int col = 1; col < width - 1; col++){
    for(int row = 1; row < height - 1; row++){
        //Get and save the pixel at the center of the
        // current nine-pixel group.
        pixel = display.getPixel(col, row);
    }
}

```



```

//Get and save the eight surrounding pixels.
pixels[0] = temp.getPixel(col-1,row-1);
pixels[1] = temp.getPixel(col,row-1);
pixels[2] = temp.getPixel(col+1,row-1);

pixels[3] = temp.getPixel(col-1,row);
pixels[4] = temp.getPixel(col+1 ,row);

pixels[5] = temp.getPixel(col-1,row+1);
pixels[6] = temp.getPixel(col,row+1);
pixels[7] = temp.getPixel(col+1,row+1);

//Compute the weighted sum of the red values.
red = 0;
//First compute the sum of the color values for
// the eight neighboring pixels.
for(int cnt = 0;cnt < pixels.length;cnt++){
    red += pixels[cnt].getRed();
} //end for loop
//Now apply the weights and store the resulting
// value in the center pixel of the nine-pixel
// group in the display.
red = (int)(red*neighborWeight
            + pixel.getRed()*centerWeight);
//Make certain that the color value is within its
// allowable limits of 0 to 255 inclusive. If not,
// set it to the limit.
if(red > 255) red = 255;
if(red < 0) red = 0;
if(blackEdges){
    //Invert the color value for the right side of
    // the slider.
    pixel.setRed(255-red);
}else{
    pixel.setRed(red);
} //end else

//Compute the weighted sum of the green values.
// This is essentially the same algorithm as for
// the red values.
green = 0;
for(int cnt = 0;cnt < pixels.length;cnt++){
    green += pixels[cnt].getGreen();
} //end for loop
green = (int)(green*neighborWeight
            + pixel.getGreen()*centerWeight);
if(green > 255) green = 255;
if(green < 0) green = 0;

if(blackEdges){
    pixel.setGreen(255-green);
}else{
    pixel.setGreen(green);
} //end else

//Compute the weighted sum of the blue values.

```

```

// This is essentially the same algorithm as for
// the red values.
blue = 0;
for(int cnt = 0;cnt < pixels.length;cnt++){
    blue += pixels[cnt].getBlue();
} //end for loop
blue = (int) (blue*neighborWeight
              + pixel.getBlue()*centerWeight);
if(blue > 255) blue = 255;
if(blue < 0) blue = 0;

if(blackEdges){
    pixel.setBlue(255-blue);
}else{
    pixel.setBlue(blue);
} //end else

    } //end inner loop
} //end outer loop

display.repaint();

} //end processThePicture
//-----//
} //end class EdgeDetect03

```

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About the author

[Richard Baldwin](#) is a college professor (at Austin Community College in Austin, TX) and private consultant whose primary focus is object-oriented programming using Java and other OOP languages.

Richard has participated in numerous consulting projects and he frequently provides onsite training at the high-tech companies located in and around Austin, Texas. He is the author of Baldwin's Programming [Tutorials](#), which have gained a worldwide following among experienced and aspiring programmers. He has also published articles in JavaPro magazine.

In addition to his programming expertise, Richard has many years of practical experience in Digital Signal Processing (DSP). His first job after he earned his Bachelor's degree was doing DSP in the Seismic Research Department of Texas Instruments. (TI is still a world leader in DSP.) In the following years, he applied his programming and DSP expertise to other interesting areas including sonar and underwater acoustics.

Richard holds an MSEE degree from Southern Methodist University and has many years of experience in the application of computer technology to real-world problems.

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-end-