CS161: Introduction to Computer Science
Lab Assignment 10

Image Processor

In this lab, we'll be working with images! Images can naturally be represented using a 2-dimensional array of Pixel (short for *picture element*) values. This lab asks you to implement various image-transformation algorithms such as inverting the pixels in the image or rotating the image clockwise.

We'll be using an image format known as PPM (portable pixel map). PPM files are not as well-known as other file formats such as jpeg, gif, etc. However, PPM is an excellent educational format because PPM files are human-readable. The tradeoff is that even small images can be very large in size. To view a PPM file, you will need a special program:

- If you're working on a lab computer in Thompson 409, then the tools are already installed for you to open a `.pgm` file. If you're on Windows, double-clicking on any `.pgm` file will open up the file in Libre OfficeDraw.
- If you're working on your own computer, please download GIMP *before coming to lab*. You can download it for free at `http://www.gimp.org/downloads`. It is compatible with Mac, Windows, and Linux. After you install GIMP, double-clicking on any `.pgm` file will open up the file in GIMP.

For this lab, you'll be opening and reading in an image, transforming the image somehow (e.g. rotating it), and then saving the transformed image to a new file. To view the result of your transformation, you will need to double-click on the new file you created – i.e., you will not be able to view the transformed file in BlueJ but instead will need to manually open the file by double-clicking.

Getting Started

Download the starter code for this lab. After you unzip it, you should see the following files:

- `test.pgm, test2.pgm, test3.pgm`: Three small images for debugging.
- `grumpycat.pgm`: An image of Grumpy Cat.
- `nasa.pgm`: A washed-out aerial image from NASA.
- `Pixel.java`: This is a Pixel class that represents a single pixel
- `Image.java`: This is the Image class, which represents a greyscale image and has methods to manipulate the image. There are several methods left for you to implement.
- `Controller.java`: Put code here to test the methods in the `Image` class.

Double click on `grumpycat.pgm` and `nasa.pgm` to make sure you can open `.pgm` images. *If it's not working, first open GIMP and then open the file via GIMP.* If you still cannot open `.pgm` images, let me know.

The Pixel Class

The word "pixel" is short for *picture element*. A pixel represents a single dot on an image. Images are composed of hundreds of thousands of individual pixels that together form the overall picture.

Begin by opening up and looking through the `Pixel` class. Each pixel represents a greyscale value that ranges between 0 (black) to 255 (white).

The pixel class has methods for transforming the pixel in three ways: inverting the intensity of the pixel, computing the log intensity of the pixel, and computing the power law intensity of the pixel.

Image Class

Open the `Image` class that has been provided. Notice that the instance variables and the constructor have already been written for you. The instance variables are the 2-dimensional array of Pixels (representing the image) along with the height of the image (i.e. the number of rows) and the width of the image (i.e. the number of columns). In addition, at the bottom you will find the following methods already implemented:

- `public void open(String filename)`: Opens the given filename and reads it into the 2D array.
- `public void save(String filename)`: Saves the current Image to the given filename.
- `public String toString()`: Returns the image in String format.

You should briefly read through these methods to familiarize yourself but do not modify them!

Add the following methods to the image class:

- A method `inverseTransform()` that inverts all the pixels in the image. This method should take no inputs.
- A method `logTransform()` that takes as input a double named `coeff` and converts every pixel to the appropriate log intensity value.
- A method `powerLawTransform()` that takes as input two doubles `coeff` and `gamma` and converts every pixel to the appropriate power law intensity value.

To test your methods, you can add code to the `main()` method in the `Controller` class. For example,

```
public static void main(String[] args){
    Image img = new Image("grumpycat.pgm");
    img.powerLawTransform(.75, 1.5);
    img.save("grumpycat_transformed.pgm");
}
```

After running the `main()` method, double click on the `grumpycat_transformed.pgm` file and it should automatically open.

Flips and Rotations

Now let's implement transformations that flip or rotate the image. Add the following methods to the `Image` class:

- A method `flipVertical()` that flips the image across the vertical (y) axis. In other words, the pixels on the left-hand side of the image get swapped to the right-hand side and vice versa.

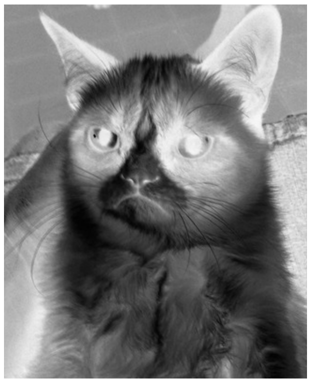
- A method `flipHorizontal()` that flips the image across the horizontal (x) axis. In other words, the pixels on the top of the image get swapped with the pixels on the bottom and vice versa.
- A method `rotateClockwise()` that rotates the image clockwise. Note that after rotating the image, the dimensions of the image should be swapped. For example, if the original image has 10 rows and 3 columns then the rotated image will have 3 rows and 10 columns.
- A method `rotateCounterClockwise()` that rotates the image counter-clockwise. Again, after rotating, the dimensions of the image should be swapped.

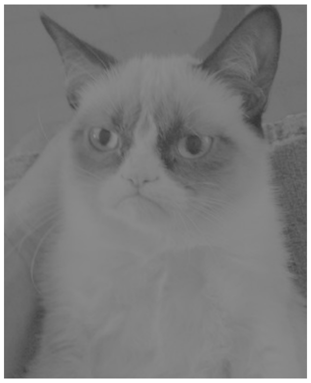
The next page shows what my program outputs after I perform each transformation on the grumpy cat.

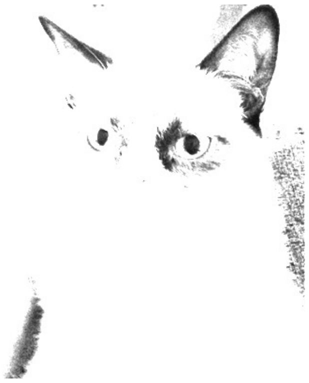
Debugging

For the flips and rotations, I highly recommend drawing out the 2-dimensional array of pixel values on a sheet of paper and then drawing what the 2-dimensional array should look like after the transformation. Where does each pixel get mapped to? Can you find a pattern – i.e., the pixel at row `i` and column `j` (i.e. `canvas[i][j]`) gets mapped to what row and what column?

There are also some test images included in the starter code. These are tiny images that you can use to debug your code.


(a) inverse


(b) log transform (25)


(c) power law (.75, 1.5)

(d) vertical

(e) horizontal

(f) clockwise

(g) counter

Submitting Your Lab

Rename your folder with both of your names and then upload it to Moodle.