AP® Computer Science A Picture Lab Student Guide

The AP Program wishes to acknowledge and thank Barbara Ericson of the Georgia Institute of Technology, who developed this lab and the accompanying documentation.

A3: Exploring a picture

Run the `main` method in `PictureExplorer.java`. This will load a picture of a beach from a file, make a copy of that picture in memory, and show it in the explorer tool (Figure 3). It makes a copy of the picture to make it easier to explore a picture both before and after any changes. You can use the explorer tool to explore the pixels in a picture. Click any location (pixel) in the picture and it will display the row index, column index, and red, green, and blue values for that location. The location will be highlighted with yellow crosshairs. You can click on the arrow keys or even type in values and hit the enter button to update the display. You can also use the menu to change the zoom level.

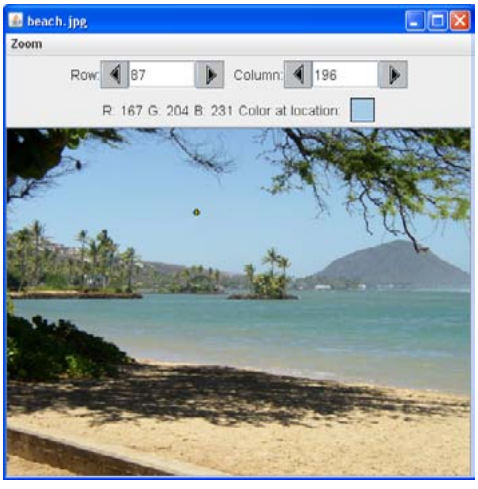

Figure 3: The Picture Explorer

Questions

1. What is the row index for the top left corner of the picture?
2. What is the column index for the top left corner of the picture?
3. The width of this picture is 640. What is the right most column index?
4. The height of this picture is 480. What is the bottom most row index?
5. Does the row index increase from left to right or top to bottom?
6. Does the column index increase from left to right or top to bottom?
7. Set the zoom to 500%. Can you see squares of color? This is called *pixelation*. Pixelation means displaying a picture so magnified that the individual pixels look like small squares.

Creating and exploring other pictures

Here is the `main` method in the class `PictureExplorer`. Every class in Java can have a `main` method, and it is where execution starts when you execute the command `java ClassName`.

```
public static void main( String args[])
{
  Picture pix = new Picture("beach.jpg");
  pix.explore();
}
```

The body of the `main` method declares a reference to a `Picture` object named `pix` and sets that variable to refer to a `Picture` object created from the data stored in a JPEG file named "`beach.jpg`" in the `images` folder. A JPEG file is one that follows an international standard for storing picture data using *lossy compression*. *Lossy compression* means that the amount of data that is stored is much smaller than the available data, but the part that is not stored is data we won't miss.

Exercises

1. Modify the `main` method in the `PictureExplorer` class to create and explore a different picture from the `images` folder.
2. Add a picture to the `images` folder and then create and explore that picture in the `main` method. If the picture is very large (for instance, one from a digital camera), you can scale it using the `scale` method in the `Picture` class.
   For example, you can make a new picture ("`smallMyPicture.jpg`" in the `images` folder) one-fourth the size of the original ("`myPicture.jpg`") using:

   ```
   Picture p = new Picture("myPicture.jpg");
   Picture smallP = p.scale(0.25,0.25);
   smallP.write("smallMyPicture.jpg");
   ```

How image processing is related to new scientific breakthroughs

Many of today's important scientific breakthroughs are being made by large, interdisciplinary collaborations of scientists working in geographically widely distributed locations, producing, collecting, and analyzing vast and complex datasets.

One of the computer scientists who works on a large interdisciplinary scientific team is Dr. Cecilia Aragon. She is an associate professor in the Department of Human Centered Design & Engineering and the eScience Institute at the University of Washington, where she directs the Scientific Collaboration and Creativity Lab. Previously, she was a computer scientist in the Computational Research Division at Lawrence Berkeley National Laboratory for six years, after earning her Ph.D. in Computer Science from UC Berkeley in 2004. She earned her B.S. in mathematics from the California Institute of Technology.

Her current research focuses on human-computer interaction (HCI) and computer-supported cooperative work (CSCW) in scientific collaborations, distributed creativity, information visualization, and the visual understanding of very large data sets. She is interested in how social media and new methods of computer-mediated communication are changing scientific practice. She has developed novel visual interfaces for collaborative exploration of very large scientific data sets, and has authored or co-authored many papers in the areas of computer-supported cooperative work, human-computer interaction, visualization, visual analytics, image processing, machine learning, cyberinfrastructure, and astrophysics.

In 2008, she received the Presidential Early Career Award for Scientists and Engineers (PECASE) for her work in collaborative data-intensive science. Her research has been recognized with four Best Paper awards since 2004, and she was named one of the Top 25 Women of 2009 by Hispanic Business Magazine. She was the architect of the Sunfall data visualization and workflow management system for the Nearby Supernova Factory, which helped advance the study of supernovae in order to reduce the statistical uncertainties on key cosmological parameters that categorize dark energy, one of the grand challenges in physics today.

Cecilia Aragon is also one of the most skilled aerobatic pilots flying today. A two-time member of the U.S. Aerobatic Team, she was a medalist at the 1993 U.S. National Championships and the 1994 World Aerobatic Championships, and was the California State Aerobatic Champion.

Glossary

1. Abstract class — You cannot create an object of an abstract class type. But, you can create an object of a subclass of an abstract class (as long as the subclass is not also an abstract class).
2. Abstract method — An abstract method cannot have a method body in the class where the method is declared to be abstract.
3. Algorithm — A step-by-step description of how to solve a problem.
4. AWT — The Abstract Windowing Toolkit. It is the package that contains the original Graphical User Interface (GUI) classes developed for Java.
5. Binary number — A binary number contains only the digits 0 and 1. Each place is a power of 2 starting with 2^0 on the right. The decimal number 6 would be 110 in binary. That would be $0 * 2^0 + 1 * 2^1 + 1 * 2^2 = 6$.
6. Bit — A **b**inary dig**it**, which means that it has a value of either 0 or 1.
7. Byte — A consecutive group of 8 bits.
8. Column-major order — An order for storing two-dimensional array data in a one-dimensional array, so that all the data for the first column is stored before all the data for the second column and so on. In a two-dimensional array represented using an array of arrays (like in Java) this means that the outer array represents the columns and the inner arrays represent the rows.
9. Digital camera — A camera that can take digital pictures.
10. Digital picture — A picture that can be stored on a computer.
11. Inheritance — In Java, a class can specify the parent class from which it inherits instance variables (object fields) and object methods. Even though instance variables may be inherited, if they are declared to be private they cannot be directly accessed using dot notation in the inheriting class. Private methods that are inherited can also not be directly called in an inheriting class.
12. Inner loop — In a nested loop (a loop inside of another loop) the loop that is inside of another loop is considered the inner loop.
13. Interface — A special type of class that can only have public abstract methods in it and/or static constants.
14. Lossy compression — Lossy compression means that the amount of data that is stored is much smaller than the available data, but the part that is not stored is data that humans would not miss.
15. Media computation — A method of teaching programming by having students write programs that manipulate media: pictures, sounds, text, movies. This approach was developed by Dr. Mark Guzdial at Georgia Tech.
16. Megapixel — One million pixels.
17. Nested loop — One loop inside of another loop.
18. Outer loop — In a nested loop (a loop inside of another loop) the loop that is outside of another loop is considered the outer loop.
19. Package — A package in Java is a group of related classes.
20. Pixel — A picture (abbreviated **pix**) **el**ement.
21. RGB model — Represents color as amounts of red, green, and blue light. It sometimes also includes alpha, which is the amount of transparency.

22. Row-major order — An order for storing two-dimensional array data in a one-dimensional array, so that all the data for the first row is stored before all the data for the second row, and so on. In a two-dimensional array represented using an array of arrays (like in Java) this means that the outer array represents the rows and the inner arrays represent the columns.
23. Subclass — A class that has inherited from another class.
24. Superclass — A class that another class has inherited from.
25. UML —Unified Modeling Language. It is a general purpose modeling language used in object-oriented software development.

References

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Quick Reference

DigitalPicture Interface

```
Pixel[][] getPixels2D()         // implemented in SimplePicture
void explore()                  // implemented in SimplePicture
boolean write(String fileName)  // implemented in SimplePicture
```

SimplePicture Class (implements Digital Picture)

```
public SimplePicture()
public SimplePicture(int width, int height)
public SimplePicture(SimplePicture copyPicture)
public SimplePicture(String fileName)
public Pixel[][] getPixels2D()
public void explore()
public boolean write(String fileName)
```

Picture Class (extends SimplePicture)

```
public Picture()
public Picture(int height, int width)
public Picture(Picture copyPicture)
public Picture(String fileName)
public Pixel[][] getPixels2D()         // from SimplePicture
public void explore()                  // from SimplePicture
public boolean write(String fileName)  // from SimplePicture
```

Pixel Class

```
public double colorDistance(Color testColor)
public double getAverage()
public int getRed()
public int getGreen()
public int getBlue()
public Color getColor()
public int getRow()
public int getCol()
public void setRed(int value)
public void setGreen(int value)
public void setBlue(int value)
public void setColor(Color newColor)
```

java.awt.Color Class

```
public Color(int r, int g, int b)
public int getRed()
public int getGreen()
public int getBlue()
```