Objects, Geometry, Abstract Art andBouncing Balls

Submission – 2/6/2024

In this assignment you will start working with **Objects**. You will define **Classes** and instantiate objects of those classes. The code in this assignment will be used in later assignments.

First, please read about working with multiple classes in the provided file (“MultFiles”). (You can ignore the mentioned `biuoop-1.4.jar` for now, wewill explain about it in Part 2.).

We supply a build.xml file for the assignment.
Recommendation: read the entire assignment before you start writing it.

Important Note

In this course, your plan should simply just work. Just like real programmers, you need to think about odd edge cases that might occur - **nothing should cause your program to crash**. It is your responsibility to deal with these edge cases.

Open your mind - in this assignment (and the following assignments), we provide you with some classes and methods which are **obligatory** in your implementation; but it is very likely that you need to implement other classes and methods to complete the assignment. Good design is key to your success in these assignments.

Signatures of methods must not be changed!

Don't forget JAVADOC.

Part 1: Geometry

The goal of this part is to develop a program to reason about points, lines, rectangles and their intersection.

You will define two classes: `Point`, `Line`.

We suggest that you work incrementally -- whenever you complete a method, see that everything compiles and that the method works as expected.

1.1 Point

A point has an `x` and a `y` value, and can measure the distance to other points, and if it is equal to another point.

```
public class Point {
   // constructor
   public Point(double x, double y) { }

   // distance -- return the distance of this point to the other point
   public double distance(Point other) { }

   // equals -- return true is the points are equal, false otherwise
   public boolean equals(Point other) { }

   // Return the x and y values of this point
   public double getX() { }
   public double getY() { }
}
```

Remember that the distance between two points `(x1,y1)` and `(x2,y2)` is the square root of: `((x1-x2)*(x1-x2))+((y1-y2)*(y1-y2))`. You can use the `Math.sqrt` method to get the square root of a number in Java:

```
double root_of_13 = Math.sqrt(13);
```

1.2 Line

A line (actually a line-segment) connects two points -- a start point and an end point. Lines have lengths, and may intersect with other lines. It can also tell if it is the same as another line segment.

```
public class Line {
   // constructors
   public Line(Point start, Point end) { }
   public Line(double x1, double y1, double x2, double y2) { }

   // Return the length of the line
   public double length() { }

   // Returns the middle point of the line
   public Point middle() { }

   // Returns the start point of the line
   public Point start() { }

   // Returns the end point of the line
   public Point end() { }

   // Returns true if the lines intersect, false otherwise
   public boolean isIntersecting(Line other) { }

   // Returns true if this 2 lines intersect with this line, false otherwise
   public boolean isIntersecting(Line other1, Line other2) { }

   // Returns the intersection point if the lines intersect,
   // and null otherwise.
   public Point intersectionWith(Line other) { }

   // equals -- return true is the lines are equal, false otherwise
   public boolean equals(Line other) { }

}
```

The `intersectionWith(Line other)` method is a bit complicated. You can find some hints about how to calculate the intersection between two line segments here.

Testing your code

You can perform some sanity-checks for your code using our provided *GeometryTester* class.

What to submit?

For this part, you need to submit the code for the `Point` and `Line` classes (and any additional classes you may write).

Note that no `run` target in the `build.xml` correspond to this task.

Notes & Edge cases

- If there are infinite intersection points (including cases of inclusion): 'intersectionWith' function will return null
  'isIntersecting' function will return true
- Lines are defined as equal if they are the same visually - that is, even if the starting point of one line is the end of another line & vice versa, they are considered equal.
- As you learned in “Introduction To Computer Science”, computers representation of number are finite, and thus not completely accurate. Therefore, it is common to compare doubles using a threshold. You can read more about it in google.

Part 2: GUI and Abstract Art

In this part, we provide you with some code (the GUI class) that handles drawing graphics to a window (The name GUI stands for Graphical User Interface). You do not need to understand how the GUI class works, but you do need to understand how to use it.

Here is a simple program that uses the GUI class:

```
import biuoop.GUI;
import biuoop.DrawSurface;

import java.util.Random;
import java.awt.Color;

public class SimpleGuiExample {

  public void drawRandomCircles() {
    Random rand = new Random(); // create a random-number generator
    // Create a window with the title "Random Circles Example"
    // which is 400 pixels wide and 300 pixels high.
    GUI gui = new GUI("Random Circles Example", 400, 300);
    DrawSurface d = gui.getDrawSurface();
    for (int i = 0; i < 10; ++i) {
       int x = rand.nextInt(400) + 1; // get integer in range 1-400
       int y = rand.nextInt(300) + 1; // get integer in range 1-300
       int r = 5*(rand.nextInt(4) + 1); // get integer in 5,10,15,20
       d.setColor(Color.RED);
       d.fillCircle(x,y,r);
    }
    gui.show(d);
  }

  public static void main(String[] args) {
     SimpleGuiExample example = new SimpleGuiExample();
     example.drawRandomCircles();
  }
}
```

This code is using packages (see the provided *Using Packages* file). In particular, it is using the `biuoop` package which we provide, as well as classesfrom the `java.util` and `java.awt` packages which are part of the java runtime environment (and are always available).

The `GUI`, `DrawSurface` and `Sleeper` classes belong to the `biuoop` package, which are defined in the provided *biuoop-1.4.jar* file. In order to use this code, java needs to know where to look for it. After you download the `biuoop-1.4.jar` file and put it in the directory of the assignment (**not** in the`src`), Compile and run the code using:

```
> javac -cp biuoop-1.4.jar:src src/SimpleGuiExample.java -d bin
> java -cp biuoop-1.4.jar:bin SimpleGuiExample
```

See the provided *MultFiles* file for an explanation.

Alternatively, you can run the following ant commands with the provided *build.xml*.

```
> ant compile
> ant run-gui-example
```

Make sure you are able to compile and run this code before you proceed.

Explaining the code example

The `java.awt.Color` class is a part of the Java JDK, and is used to represent colors. In the example, we used a predefined color (`RED`), which is defined in a static field of the `java.awt.Color` class. There are also constructors for creating colors based on proportions of red, green and blue components. See the `java.awt.Color` documentation for further details.

The `biuoop.GUI` and `biuoop.DrawSurface` classes are part of the `biuoop` package that we supply. Creating a new `GUI` object creates a screen, with a title and dimensions. In order to draw on the screen, you ask the `GUI` object for a `DrawSurface`.
The `DrawSurface` has several methods that you can use to draw lines, circles and so on.
Once you done drawing, you call the `show(DrawingSurface d)` method of the `GUI` object with your `DrawingSurface`, and the drawing is displayed on the screen.

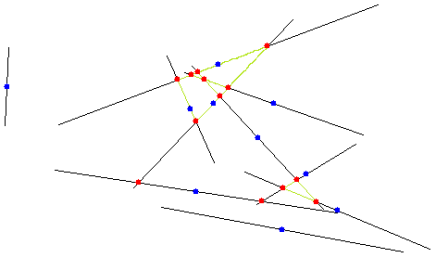
`Sleeper` is also a part of the `biuoop` package. This object allows us to halt the program execution for a specified number of milliseconds.

For further details, see the documentation for the biuoop package.

> ***Note**: This documentation is generated using JavaDoc.*

Your Task

Your goal is to use the GUI class to generate random pictures like the following:



In this image, we have 10 lines, drawn in black. The middle point in each line is indicated in blue, while the intersection points between the lines are indicated in red (the points are filled circles with a radius of 3), and the parts of the line that create the triangles between the intersection point drawn in green.

Modify the example code above to generate pictures such as this one.
Hints:

- You can draw lines with the `drawSurface.drawLine(x1, y1, x2, y2)` method.
- Use the Point and Line classes from the previous part.
- You probably want to keep an array of the previously drawn lines.
- You may find it helpful to define and use helper methods such as `Line generateRandomLine()` and `void drawLine(Line l, DrawSurface d)`.

If your intersection points are not correct, you may want to debug the Line class some more!

What to submit?

For this task, you should include all the relevant classes. The `run2` target in the `build.xml` would run the drawing code, which should reside in a class called `AbstractArtDrawing`.

(all tasks, including this one, will be submitted in the same zip file) In the final submission, you should have 10 lines and the screen size will be the same as the size defined in the task.

Notes & Edge cases

- All notes regarding the previous section still hold.
- Remember To use a threshold to compare doubles, your solution should treat 4.9999999 & 5 as equals.
- An intersection point at the end points of a line are still considered intersection points.
- Your code must draw **10 lines**.

Part 3: Animation and Bouncing Balls

In this part, you will draw balls (which are circles) and move them across the screen.

What to submit?

For this part, you need to include all the classes defined below.

The target `ant run3.2` will run the `BouncingBallAnimation` class, and `ant run3.3` will run the `MultipleBouncingBallsAnimation` class.

Task 3.1: Static Balls which you can draw.

Our main object will be a `Ball` (actually, a circle). Balls have size (radius), color, and location (a `Point`). Balls also know how to draw themselves on a DrawSurface.

You need to create a `Ball` class, with at least the following methods:

```
public class Ball {
   // constructor
   public Ball(Point center, int r, java.awt.Color color);

   // accessors
   public int getX();
   public int getY();
   public int getSize();
   public java.awt.Color getColor();

   // draw the ball on the given DrawSurface
   public void drawOn(DrawSurface surface);
}
```

Test your code with the following program, which will create 3 balls and show them on the screen.

```
import biuoop.GUI;
import biuoop.DrawSurface;


public class BallsTest1 {
   public static void main(String[] args) {
      GUI gui = new GUI("Balls Test 1", 400, 400);DrawSurface d
      = gui.getDrawSurface();

      Ball b1 = new Ball(new Point(100,100),30,java.awt.Color.RED);
      Ball b2 = new Ball(new Point(100,150),10,java.awt.Color.BLUE);
      Ball b3 = new Ball(new Point(80,249),50,java.awt.Color.GREEN);

      b1.drawOn(d);
      b2.drawOn(d);
      b3.drawOn(d);

      gui.show(d);
   }
}
```

> *Note: we do not provide you with the build commands or an Ant target - you should handle it yourself!*

Task 3.2: A simple animation loop with one ball

Animation is achieved by drawing different pictures on the same area one after the other. Using our graphical package, we can do animation using a loop such as the following:

```
   static private void drawAnimation() {
      GUI gui = new GUI("title",200,200);
      biuoop.Sleeper sleeper = new biuoop.Sleeper();
      java.util.Random rand = new java.util.Random();
      while (true) {
         DrawSurface d = gui.getDrawSurface();
         Ball ball = new Ball(rand.nextInt(200), rand.nextInt(200), 30, java.awt.Color.BLACK);
         ball.drawOn(d);
         gui.show(d);
         sleeper.sleepFor(50);  // wait for 50 milliseconds.
      }
   }
```

Put this into the main method of a class, compile, and run it.

The loop creates an empty drawing surface, create a ball with a random location, draws it on the surface, shows the surface, waits for 50 milliseconds and so on. Assuming that creating the surface and displaying the ball take roughly zero time, sleeping for

50 milliseconds gets us about 20 frames per second.

The animation is not really good -- things seem to jump all over the place. The problem is that the different frames are not related to each other.

Lets fix that and create an animation with a moving ball. In order to do that, we need to give our ball some speed and direction. The first step would be to define a Velocity class:

```
// Velocity specifies the change in position on the `x` and the `y` axes.
public class Velocity {
   // constructor
   public Velocity(double dx, double dy);

   // Take a point with position (x,y) and return a new point
   // with position (x+dx, y+dy)
   public Point applyToPoint(Point p);
}
```

Next, we add `Velocity`, as well as the following methods, to the `Ball` class:

```
public void setVelocity(Velocity v);
public void setVelocity(double dx, double dy);
public Velocity getVelocity();

public void moveOneStep() {
    this.point = this.getVelocity().applyToPoint(this.point);
}
```

Now change the animation code from above to:

```
   static private void drawAnimation(Point start, double dx, double dy) {
      GUI gui = new GUI("title",200,200);
      Sleeper sleeper = new Sleeper();
      Ball ball = new Ball(start.getX(), start.getY(), 30, java.awt.Color.BLACK);
      ball.setVelocity(dx, dy);
      while (true) {
         ball.moveOneStep();
         DrawSurface d = gui.getDrawSurface();
         ball.drawOn(d);
         gui.show(d);
         sleeper.sleepFor(50);  // wait for 50 milliseconds.
      }
   }
```

(question: what happens if we do not invoke setVelocity before the loop? make sure the program does not crash!)

This is much better! But the animation is over very quickly, because the ball goes outside of the screen. Change the `moveOneStep()` method so that the ball does not go outside of the screen -- when it hits the border to the left or to the right, it should change its horizontal direction, and when it hits the border on the top or the bottom, it should change its vertical direction. (Changing the horizontal direction can be achieved by setting the velocity's `dx` to `-dx`).

Create a class called `BouncingBallAnimation` with a main method that gets 4 integers from the command line and runs the `drawAnimation` method accordingly - for example, `java BouncingBallAnimation 1 2 3 4` would invoke `drawAnimation(new Point(1,2),3,4)`.

Note It is convenient to specify the velocity in terms and `angle` and a `speed`, so instead of specifying dx=2, dy=0, you could specify `(90, 2)` meaning 2 units in the 90 degrees direction (assuming up is angle 0). This can be achieved by creating a new constructor to Velocity, taking an angle an a speed. The problem is that angle and speed are two doubles, and we already have a constructor taking two doubles (dx and dy). In order to solve this, we can create a static method (belonging to the Velocity class) that will create new instances for us, instead of the constructor:

```
public class Velocity {
   ...
   public static Velocity fromAngleAndSpeed(double angle, double speed) {
      double dx = ...;
      double dy = ...;
      return new Velocity(dx, dy);
   }
}
```

We can then use this method to create velocities:

```
Velocity v = Velocity.fromAngleAndSpeed(90, 2);
ball.setVelocity(v);
```

This method is not a suggestion. You need to implement it.

Task 3.3: Multiple Balls

One ball is nice, but a bit boring. We want to see many bouncing balls. In this task, you should create a program called `MultipleBouncingBallsAnimation`. This program is invoked from the commandline, and each argument is a size of a Ball:

```
> java -cp biuoop-1.4.jar:bin MultipleBouncingBallsAnimation 12 2 3 4 2 9
```

This will create an animation with 6 balls, of sizes 12, 2, 3, 4, 2 and 9 respectively. Each ball will start in a random location on the screen. Each ball will start with a different speed -- we want larger balls to be slower (but balls above size 50 can all have the same slow speed). Each ball will change direction when hitting the window border.

Notice that the number of balls is not fixed -- use an array to store the balls.

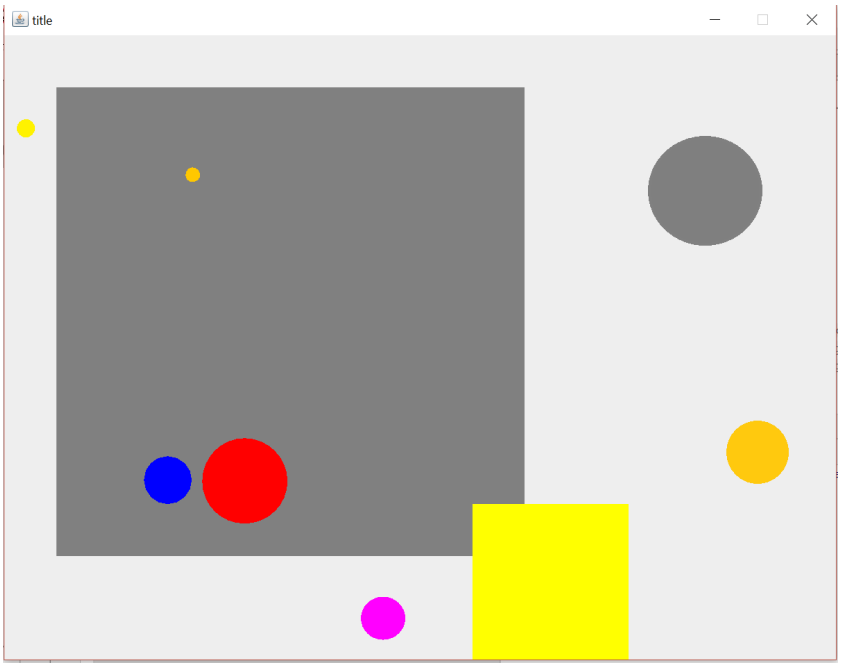
Task 3.4: Multiple Frames

Now we want to create two frames -- one of them is a grey rectangle from (50,50) to (500,500), and the other is a yellow rectangle from (450,450) to (600,600). We want the first half of the balls to bounce inside the grey rectangle, and the second half of the balls to bounce outside both rectangles (See image to understand better).

Your program should be called `MultipleFramesBouncingBallsAnimation`. As before, this program is invoked from the commandline, and each argument is a size of a Ball:

```
> java -cp biuoop-1.4.jar:bin MultipleFramesBouncingBallsAnimation 12 2 3 4 2 9
```

Your window should look something like this:



(As before, the number of balls is not fixed, but you can assume an even number of balls. We note that it is a much better practice to somehow handle also the case of a non-even number of balls.)

Special cases and notes

- Bullets in the yellow frame cannot collide with bullets in the gray frame - the yellow frame will simply hide them.

- The points you are given are not necessarily in the proper range & have the proper size, think about how to fix these edge cases. Any reasonable behavior will be accepted.
- Similarly to part 2, you must use a threshold to compare doubles in the relevant cases.

A note on checkstyle

For this assignment, because you do not know better yet, it is OK to have the checkstyle error:

> *Definition of 'equals()' without corresponding definition of 'hashCode()'.*

Summary

In addition to the `build.xml` file, your final submission should include (at least) the following classes (in the `src` directory), with at least the functionality and methods as described above.

- Point
- Line
- AbstractArtDrawing
- Ball
- Velocity
- BouncingBallAnimation
- MultipleBouncingBallsAnimation
- MultipleFramesBouncingBallsAnimation

Your `build.xml` includes the targets `compile` to compile everything, `clean` to delete the bin folder, `check` to run the checkstyle and `run-gui-example`, `run2`, `run3.2`, `run3.3`, `run3.4` as described above. Remember you can specify command line arguments like this:

```
> ant run3.4 -Dargs="4 12 26 10"
```

You do not need to include the file biuoop.jar, and can assume it is available in the same directory as `build.xml`.

**Make sure you submit the assignment according to the submission instructions. ** **Run the task on the university's servers (for example, with Mobox) and on the CMD and make sure that it runs with the runing command outside your workspace with the folder you're actually submit. **

Several End Notes

- Open your mind - in this assignment (and other to come), we provide you with some classes and methods which are **obligatory** in your implementation; but it is very likely that you need to implement other classes and methods to make the job right. Good design is a key to your success in the course assignments.
- You are welcome to search the web for technical issues, mathematical or programming questions, and pretty much everything. Use it. Google would be your mentor for all your professional life. (The only think you can't do is copy code from published solutions, but you can re-write same ideas in your own code).
- As (almost) all the following assignments will be built on top of this one (especially the `Line` and `Ball` classes), it is important you test them as much as you can. You'll get feedback on the assignment, but a 100 score does **not** guarantee

- that you don't have bugs, which you might only be aware of during the following assignments.You are not allowed to use the `java.awt.geom.Line2D` class.
- Think which cases can be problematic in your code and how you deal with them

Good Luck!