COMPSCI 718 Programming for Industry
Bounce: increment I and II

Code Deadline: Wednesday June 02, 23:59
Interview: Week 12
Report Deadline: Friday June 11, 23:59

January 24, 2021

Introduction

This project serves to reinforce skills in object-oriented programming. You will work with JDK libraries and the JUnit unit testing tool.

Bounce involves an animation comprising an extensible set of shape types. Shapes have in common knowledge of their position, velocity, direction and bounding box, while each kind of special shape has a specific way of rendering itself.

You will need to investigate a couple of `java.awt` classes: `Graphics` and `Color` to complete this part of the project. Browsing the online JDK API should be sufficient for the needs of this part.

Assessment criteria

Each task is associated with assessment criteria. In addition to the task-specific criteria you will need to demonstrate that you have understood the work in your reflective report.

Interview

You will have an interview in week 12 to demonstrate your understanding of the work you have done in Increment I and II. We will ask you questions in your scheduled interview slot. You must attend the interview session to have your work assessed. Failure to demonstrate work in the interview will result in a mark of zero for Increment I and II. Prior to your interview session, you should have everything ready – you will have no more than 5 minutes to convince us that you have met the stated assessment criteria.

Submission

You submit by ensuring your GitHub repository for Task One to Task Six is up-to-date. We will download your repository for marking on the due date.

The reflective report is due by 23:59 on Friday 11th June. The reflective report should include the class diagram, sequence diagram, answers to all questions, and reflections on your learning experience in this course. You should submit your report as a PDF to Canvas.

Constraints

The changes you make to the `Shape` class hierarchy should not break any existing code (e.g. the `AnimationViewer` class) that has been written to use the hierarchy.

Reflective Report

As part of the final project, you need to submit an individual reflective report that details your learning experience. In your report, you also need to model the bounce package and answer all questions relating to the project. The reflection part of your report should reflect your overall experience of this course. Here are some questions that might help you to reflect:

- What modules did you learned the most from?
- What was your favourite aspect of this course? Why?
- What concepts did you find straightforward / difficult?
- What did you enjoy the most / least in this course? Why?
- What would you like to learn further or do more in this course?

Please use the IEEE conference template for the final report, using A4 page format, 10pt font for the body, and conference style. The reflective part of the report should be not more than 2 pages using IEEE format.

Model the bounce package

Modelling is generally carried out when starting a new project to understand the problem to be solved and to assist with developing a software solution. However, modelling is also useful to help you understand how an existing piece of software works. This task involves *reverse engineering* a model from source code to help you understand the structure and behaviour of the Bounce application prior to developing it further in subsequent tasks.

You should construct a class diagram to model the static structure of the Bounce application, plus a sequence diagram to reveal how instances of the classes work together. Your class diagram should capture the key classes and interfaces and the relationships between them.

The sequence diagram should capture important interactions between key instances to effect the following scenario. The AnimationViewer's object knows of exactly two RectangleShape instances. The scenario starts with the Timer generating an Action event. The sequence diagram should expose object interaction in response to the ActionEvent that results in the RectangleShape objects being painted and moved.

Note that you only need to model the initial bounce package, i.e. only the given classes in Bounce I. The UML diagrams need not be created using a tool. Hand-drawn diagrams should be clear and legible.

Hints:

- Remember that models are by definition an abstraction of what is being modelled. Therefore a model should expose what is important and suppress irrelevant detail.
- Your class diagram need not include the classes associated with testing.

Questions on Increment I and II

1. What is the value of having the Painter interface?
2. Drawing on your work in Increment I and II, explain the term "information hiding".
3. Give an example of polymorphism from this part of the project.
4. Explain the changes you have made in Task Three and why the changes are in accordance with good object-oriented programming practice.
5. Justify a design decision that you have made in Task Six and why the decision follows good object-oriented programming practice.

Questions on Increment III

1. What is the name of the design pattern you have applied in Task One?
2. What is a key benefit of applying this design pattern in Task One? Explain the benefit in terms of the Bounce application.
3. Why is the Task One class not sufficient for the application to work as required? In other words, why is Task Two needed?
4. What design pattern has been used as the underlying architecture for the Bounce III application?
5. Why is multi-threading generally necessary in a GUI application?
6. Explain how you have used SwingWorker in this project.

Increment I

For this increment, you will need to clone the source code from GitHub Classroom.

Task One: Add an Oval shape

Write unit tests for OvalShape, a new type of Shape that moves like the other shapes but displays itself as an oval shape that fits into its bounding box. It must be possible to create an OvalShape using the same set of creation options as offered by class Shape. Implement OvalShape and include such a shape in your animation.

Assessment criteria

- The class hierarchy should be developed sensibly and in accordance with good object-oriented programming practice.
- The unit test(s) should demonstrate that an OvalShape instance paints itself correctly.
- The Bounce application should demonstrate correct functioning of an OvalShape instance.

Task Two: Add a Gem shape

Write unit tests for a GemShape, a new type of Shape which moves like the other shapes but displays itself as a hexagonal shape that fits into its bounding box. Again, it must be possible to give values for instance variables at construction time or rely on default values. Implement GemShape and include such a shape in your animation.

The GemShape is to be painted to fit within the given width and height, using drawLine() calls to the Painter. The lines of the gem are to be painted starting with the left-most vertex and proceeding in a clock-wise direction.

The definition of the coordinates of the points is phrased here in terms of (x,y,width,height):

> The top-left and bottom-left vertices of a GemShape are normally 20 pixels to the right of the left hand side of the shape. Similarly, the top-right and bottom-right vertices of a GemShape are normally 20 pixels to the left of the right hand side of the shape. However, if the width of a Gemshape is less than 40 pixels, the top-left and top-right vertices are both positioned at point (x+width/2, y). Similarly, the bottom-left and bottom-right vertices are both positioned at point (x+width/2, y+height). In other words, "small" GemShapes are four-sided figures.

Hints:

- When developing the unit tests for GemShape, you should include test cases to demonstrate that the "small" and "regular" GemShape instances are constructed correctly. One way of writing these tests is to use a MockPainter and to check that its log contains the correct line sequences for GemShape objects.

Assessment criteria

- The class hierarchy should be developed sensibly and in accordance with good object-oriented programming practice.
- The test cases should show that a GemShape paints itself correctly based on its width and height.
- The Bounce application should demonstrate correct functioning of a GemShape instance.

Task Three: Add a Dynamic Rectangle shape

Write unit tests for a DynamicRectangleShape, a new type of Shape that paints itself similarly to a RectangleShape. At construction time, an additional java.awt.Color argument can be supplied. If not given, the new RectangleShape object's color should default to black.

A DynamicRectangleShape moves like the other shapes, but it sometimes changes its appearance when it bounces. After it bounces off the left or right wall it paints itself as a solid figure, in the color specified at construction time. After it bounces off the top or bottom wall it switches its appearance to that of a RectangleShape, i.e. rendering itself with an outline. If it bounces off both walls, the vertical (left or right) wall determines its appearance.

Implement it and include such a shape in your animation.

Hints:

- To thoroughly test DynamicRectangleShape, you should prepare 8 test cases that verify that a DynamicRectangleShape instance renders itself correctly when bouncing off *one* wall: top, bottom, left and right. In addition you should develop a further four test cases to check that following a bounce of *two* walls (top-right, top-left, bottom-right, bottom-left) a DynamicRectangleShape object's appearance is consistent with its specification.
- To add support for color, introduce three new methods to the Painter interface: fillRect(), getColor() and setColor(). fillRect() should take the same arguments as awt.Graphics.fillRect(). getColor() should return a java.awt.Color value and setColor() should take a java.awt.Color argument. Using these methods, you can query the current color before setting a new color and drawing a filled rectangle. After drawing the filled rectangle, you can reset the current color to its original value.
- The MockPainter implementation of Painter should be extended to log color changes and drawing of filled rectangles. Class GraphicsPainter can implement the new methods to use its java.awt.Graphics object.

Assessment criteria

- The test cases should be sufficiently thorough to demonstrate that a DynamicRectangleShape meets the above specification.
- The implementation of DynamicRectangleShape and any changes you might make to Shape should be in accordance with good object-oriented programming practice. Note that this criterion will not be satisfied if you duplicate code in Shape and DynamicRectangleShape.

- The Bounce application should demonstrate correct functioning of a DynamicRectangleShape instance.

Task Four: Be imaginative!

Add a new and interesting kind of shape. Possible suggestions include (but are not limited to):

- An *aggrgrate shape* that contains two member Shapes. On bouncing, the aggregate shape toggles between its members and paints itself accordingly.
- A shape that displays an image. For this, you could investigate class java.awt.Image. There are several options for loading Image instances, e.g. javax.imageio.ImageIO.
- A *border shape* that displays a border around an existing shape. A really cool implementation would allow a Shape to be bordered an arbitrary number of times (borders around borders). On bouncing, none of the borders should pass beyond the world's boundaries.

Assessment criteria

For this task, you simply need to demonstrate an interesting shape that makes appropriate use of object-oriented principles. Of course, it is good practice to write unit tests, but they are not required for assessment purposes in this case.

Increment II

This increment involves applying design knowledge to evolve the Bounce application as follows. First, the Shape class hierarchy is to be extended to support the concept of a nesting shape – a shape that can contain other shapes, be they simple or nesting shapes themselves. Second, a text painting facility is to be integrated into the hierarchy.

For this increment, you will need to extend the code you have developed from Increment I. You may need to make some changes to your code.

The source code for TestNestingShape is available on Canvas. You can use this class to help identify any defects in your solution to Task Five.

Task Five: Introduce class NestingShape

Define a new subclass of Shape, NestingShape. A NestingShape instance is unique in that it contains zero or more Shapes that bounce around inside it. The children of a NestingShape instance can be either simple Shapes, like RectangleShape and OvalShape objects, or other NestingShape instances. Hence, a NestingShape object can have an arbitrary containment depth. A NestingShape object paints a rectangle at the edge of its bounding box and then paints its children.

The specification for NestingShape is given in Appendix 1. Given that a Shape object can now be a child of a NestingShape, also add and implement the methods specified in Appendix 2 for class Shape.

Once implemented, add a NestingShape instance, with a containment depth of at least three, to your animation.

Hints:

- A NestingShape has its own coordinate system, so that Shapes within it are within the coordinates of the NestingShape. So if a Shape with a location of (10,10) is in a NestingShape, it will be located 10 pixels below and 10 pixels to the right of the top-left corner of the NestingShape.

- In addition to implementing new methods in class NestingShape, methods handling painting and movement inherited from Shape will need to be overridden to process a NestingShape object's children.
- The method that Shape subclasses implement to handle painting should *not* be modified when completing this task. In other words, shapes should not have to be concerned with whether or not they are children within a NestingShape when painting themselves. One way of cleanly implementing NestingShape's painting behaviour is to adjust the coordinate system by specifying a new origin (the NestingShape's top left corner) that corresponds to a point in the original coordinate system. This can be achieved using Graphics' translate() method. Once translated, all drawing operations are performed relative to the new origin. Note that any translation should be reversed after painting a NestingShape.
- In implementing painting of a NestingShape as suggested above, the Painter interface will need to include a translate(int x, int y) method. In the GraphicsPainter implementation, this method should be implemented to forward the request to a GraphicsPainter's Graphics instance. For the MockPainter implementation, take a look at the provided test.
- Use the unit tests provided for class NestingShape to help locate any defects in your implementation.

Assessment criteria

- The class hierarchy should be developed sensibly and in accordance with good object-oriented programming practice.
- The unit test(s) should demonstrate that a NestingShape instance behaves correctly.
- The Bounce application should demonstrate correct functioning of a NestingShape instance, with a containment structure of three levels.

Task Six: Display text for any Shape

Develop the Shape class hierarchy to allow text to be displayed when a shape is painted. Text should be centred, horizontally and vertically, in a Shape's bounding box, but may extend beyond the left and right sides.

In this task, you need to guarantee that if a shape is associated with text it will always be painted. That is, this responsibility should not be left to the subclasses of Shape. Any Shape subclasses should be able to display associated text.

Hints:

- See the Java class java.awt.FontMetrics for details of how to cetre text.
- Add a method drawCentredText() to the Painter interface. In GraphicsPainter, implement this method to calculate the position at which to display the text and paint the text using the drawString() method of java.awt.Graphics. In MockPainter, either an empty drawCentered-Text() method or one that simply logs that a request has been made to draw centered text is fine. Note that it is not possible for MockPainter to log the coordinates that the text has been drawn at because this requires a FontMetrics object to extract data from to calculate the coordinates. A FontMetrics object can be obtained from a Graphics object – which is not available to a MockPainter.

Assessment criteria

- The class structure should be developed sensibly and in accordance with good object-oriented programming practice.
- The solution should guarantee painting of text for an instance of any Shape subclass that is associated with text.
- The Bounce application should demonstrate correct functioning of any Shapes with text.

Appendix 1

Listing 1: Specification for class NestingShape

```
/**
 * Creates a NestingShape object with default values for state.
 */
public NestingShape();


/**
 * Creates a NestingShape object with specified location values,
 * default values for other state items.
 */
public NestingShape(int x, int y);


/**
 * Creates a NestingShape with specified values for location, velocity
 * and direction. Non-specified state items take on default values.
 */
public NestingShape(int x, int y, int deltaX, int deltaY);


/**
 * Creates a NestingShape with specified values for location, velocity,
 * direction, width and height.
 */
public NestingShape(int x, int y, int deltaX, int deltaY,
    int width, int height);


/**
 * Moves a NestingShape object (including its children) within the bounds
 * specified by arguments width and height.
 */
public void move(int width, int height);


/**
 * Paints a NestingShape object by drawing a rectangle around the edge of
 * its bounding box. The NestingShape object's children are then painted.
 */
public void doPaint(Painter painter);


/**
 * Attempts to add a Shape to a NestingShape object. If successful, a
 * two-way link is established between the NestingShape and the newly
 * added Shape. Note that this method has package visibility - for reasons
 * that will become apparent in Bounce III.
 * @param shape the shape to be added.
 * @throws IllegalArgumentException if an attempt is made to add a Shape
 * to a NestingShape instance where the Shape argument is already a child
```

```
 * within a NestingShape instance. An IllegalArgumentException is also
 * thrown when an attempt is made to add a Shape that will not fit within
 * the bounds of the proposed NestingShape object.
 */
void add(Shape shape) throws IllegalArgumentException;


/**
 * Removes a particular Shape from a NestingShape instance. Once removed,
 * the two-way link between the NestingShape and its former child is
 * destroyed. This method has no effect if the Shape specified to remove
 * is not a child of the NestingShape. Note that this method has package
 * visibility - for reasons that will become apparent in Bounce III.
 * @param shape the shape to be removed.
 */
void remove(Shape shape);


/**
 * Returns the Shape at a specified position within a NestingShape. If
 * the position specified is less than zero or greater than the number of
 * children stored in the NestingShape less one this method throws an
 * IndexOutOfBoundsException.
 * @param index the specified index position.
 */
public Shape shapeAt(int index) throws IndexOutOfBoundsException


/**
 * Returns the number of children contained within a NestingShape object.
 * Note this method is not recursive - it simply returns the number of
 * children at the top level within the callee NestingShape object.
 */
public int shapeCount();


/**
 * Returns the index of a specified child within a NestingShape object.
 * If the Shape specified is not actually a child of the NestingShape
 * this method returns -1; otherwise the value returned is in the range
 * 0 .. shapeCount() - 1.
 * @param the shape whose index position within the NestingShape is
 * requested.
 */
public int indexOf(Shape shape);


/**
 * Returns true if the Shape argument is a child of the NestingShape
 * object on which this method is called, false otherwise.
 */
public boolean contains(Shape shape);
```

Appendix 2

Listing 2: Specification for new Shape methods

```
/**
 * Returns the NestingShape that contains the Shape that method parent
 * is called on. If the callee object is not a child within a
 * NestingShape instance this method returns null.
 */
public NestingShape parent();


/**
 * Returns an ordered list of Shape objects. The first item within
 * the list is the root NestingShape of the containment hierarchy.
 * The last item within the list is the callee object (hence this
 * method always returns a list with at least one item). Any
 * intermediate items are NestingShapes that connect the root
 * NestingShape to the callee Shape. E.g., given:
 *
 *    NestingShape root = new NestingShape();
 *    NestingShape intermediate = new NestingShape();
 *    Shape oval = new OvalShape();
 *    root.add(intermediate);
 *    intermediate.add(oval);
 *
 * a call to oval.path() yields: [root,intermediate,oval]
 */
public List<Shape> path();
```