

Report

3.1 Smoke Testing

3.1.1

The overall line coverage was found to be 82%. The `CollisionInteractionMap` and the `DefaultPlayerInteractionMap` both have 0% coverage. This is because `CollisionInteractionMap` is only used by `DefaultPlayerInteractionMap`, which, in turn, is never referred to by any classes that are instantiated during the smoke test.

We added the following error to the game: we replaced the direction in the `Game.move()` method to `Direction.NORTH`. The smoke test captured this with a failing test.

3.1.2

The `move()` method is covered. After commenting out the last line of the `move()` method, the smoke test generated the error:

```
org.junit.ComparisonFailure: expected:<[1]0> but was:<[]0> Expected
:10 Actual    :0
```

The trace reveals:

```
at nl.tudelft.jpacman.LauncherSmokeTest.smokeTest(LauncherSmokeTest.java:69)
```

which indicates that the test failed on line 69, which contains the code:

```
assertThat(player.getScore()).isEqualTo(10);
```

We can conclude that something must have gone wrong between the previous assertion (on line 65) and this one. The only line in between these two assertions in the smoke test is line 68:

```
game.move(player, Direction.EAST);
```

So, the smoke test tells us that we should investigate this method call further.

3.1.3

When we changed the `board.Direction.getDeltaX()` method, the smoke test failed in exactly the same way as in the previous exercise. So, while the smoke test *is* able to tell us that we should investigate the call to `game.move(player, Direction.EAST);`, it does not tell us whether the problem resides with the method itself or with the objects that are being passed *to* the method.

3.2 Feature-Based Testing

3.2.6

For the second **Given** statement in S2.4 it is hard to realise proper timing of movements, in order for the player to be next to a ghost. For the **When** statement in S2.5 it is hard to realise exact timing of movements, so that pacman has eaten all but one pellets, without colliding with a ghost.

3.2.8

All of the scenarios in User Story 3 pertain to ghosts, which are automatically moved around. Because of this, it is not possible to test the moves using `game.move()` as before. Moreover, Ghost itself is an abstract class, which means we would have to test the individual ghosts, thereby creating additional test cases. Furthermore, the Ghost classes do not have built-in methods to return the current square in the way that Player does. The situation is further complicated by the fact that the different Ghosts not only move differently from each other, but also differently depending on certain scenarios in the game.

3.3 Boundary Testing

3.3.9

| Boundary conditions for "x >= 0 && x < getWidth() && y >= 0 && y < getHeight()" | | | | | | | | | | | | |
|---|-----------|------|----------|-----------|----------|-----------|---------|---------|---------|----------|-----------------------|--|
| test cases (x, y) | | | | | | | | | | | | |
| Variable | Condition | type | t1 | t2 | t3 | t4 | t5 | t6 | t7 | t8 | | |
| x | >= 0 | on | | 0 | | | | | | | on => true | |
| | | off | | | -1 | | | | | | hence off => false | |
| | < width | on | | | width | | | | | | on => false | |
| | | off | | | | width-1 | | | | | hence off => true | |
| y | typical | in | | | | | width/3 | width/7 | width/9 | width/2 | random inpoints for x | |
| | >= 0 | on | | | | | | 0 | | | on => true | |
| | | off | | | | | | | -1 | | hence off => false | |
| | < height | on | | | | | | | height | | on => false | |
| Test outcome | | off | | | | | | | | height-1 | hence off => true | |
| | typical | in | height/2 | height/20 | height/3 | height/10 | | | | | random inpoints for y | |
| | | | in | out | out | in | in | out | out | in | | |
| | | | | | | | | | | | | |

Figure 1: Domain Matrix

3.4 Understanding your tests

3.4.11

If the test methods in a class start with duplicate initialization code this can be moved into a common initialization method with the `@Before` annotation, because this method will be executed before every single execution of a test

method. Also, when a method needs to be tested using multiple values as input (as in boundary testing for example), the test can be parameterized, which prevents writing same pieces of code around the input values.

3.4.12

Using clean instances of the class under test, is necessary for independence among tests. The impact that one test has on another should be minimized to be sure that when a test fails, it only fails because of that test.

3.4.13

The difference between `assertTrue(a == 1)` and `assertEquals(a, 1)` is that the `assertEquals` gives a comparison of the expected value with the actual value, whereas `assertTrue` does not. So `assertEquals` is more useful, as it provides information that can be used debug a failing test.

3.4.14

One could make the argument that it is not necessary to test the private methods of `MapParser` because all of the end-to-end tests rely on a `Launcher` which makes use of `MapParser`. So, we would expect a faulty `MapParser` to yield failing end-to-end tests. However, it is also the case that a faulty `MapParser` may make it difficult to debug the failing end-to-end tests, without having isolated tests of the private methods of `MapParser` itself. Furthermore, a passing test does not necessarily guarantee anything if the test itself has faults. So, a passing end-to-end test does not necessarily guarantee that `MapParser` would not fail an isolated test. In conclusion, it would probably be a good idea to test the private methods in isolation.

3.5

3.5.15

There is one warning that remains in IntelliJ. IntelliJ complains that `public class WithinBordersTest` can be private. We left this public because the comment in `ParameterizedAssignment` specifically states that it needs to be public.

In terms of the additional adequacy achieved thanks to our classes, we measured the new overall coverage to be 89%, with a line coverage of 84%. So, our efforts have contributed 2 percentage points to the overall line coverage, as compared to what we measured in question 3.1.1.

The continuous integration server confirmed that our builds worked properly in most cases. We generally tried to avoid successively failing builds on DevHub, as evidenced by the many green commits. We used Git very extensively. In general, we tried to make new branches for different exercises. This allowed us to divide the work effectively and gives a very clear record of what was done.

4.3 Testing Collisions

4.3.20

| | r1 | r2 | r3 | r4 |
|---------|-----------------------------|--|----------------------------|-------------------------------|
| player | collider | collider | collidee | |
| ghost | collidee | | collider | collider |
| pellet | | collidee | | collidee |
| outcome | player moves player dies | player moves player earns points pellet disappears | ghost moves player dies | ghost moves pellet remains |

4.3.24

| | framework line coverage | our line coverage |
|-----------------------------|-------------------------|-------------------|
| CollisionInteractionMap | 0% | 94% |
| DefaultPlayerInteractionMap | 0% | 100% |
| PlayerCollisions | 75% | 79% |

Line coverage on PlayerCollisions have somewhat increases (4%). The original jpacman-framework did only cover collisions in which the player was the collider. We covered collisions with a ghost as collider additionally.

The collision functionality that remains unchecked is the case when a pellet is the collider. This however, is not a functionality that is specified by the requirements and can therefore be left unchecked.

Also coverage on CollisionInteractionMap and DefaultPlayerInteractionMap have increased drastically, only by applying the PlayerCollisions testsuite on them too.

4.4 Complex Tests

4.4.25

It should not be the goal to achieve 100% test coverage, because this is very easily achieved by writing tests that are not meaningful.

An advantage of code coverage can be the ability to spot a decrease in code coverage of a pull request.

A disadvantage is that high coverage can provide a false sense of stability. 100% coverage for example does not imply an absence of faults.

4.4.26

`LauncherSmokeTest.smokeTest()` can become flakey as a result of an assumption that the call to `Thread.sleep(500L)` will be sufficient to bring the monsters within 20 steps of the player. Since the movement of the monsters depends on a random number generator, the movements of the ghosts are not explicitly guaranteed to meet this criterion. So, the call to `assertThat(player.isAlive()).isFalse()` can sometimes yield a failing test. The paper by Luo et al. identifies the three main causes of flakey tests as (1) “ASYNC WAIT”: asynchronous calls which do not properly wait for the resource being called, (2) concurrency and (3) test order dependency. Each type of flakey test has its own fix. For example, for ASYNC WAIT, a common fix prescribed by Luo et al. is to enforce the blocking of a given thread through `waitFor`. But, the overarching theme of these fixes is that we need to enforce determinism in our tests.

4.4.27

A test that needs to communicate with infrastructure dependencies like a database or http server will slow the entire test suite dramatically. To mitigate this issue, you can mock these dependencies and still test the interaction.

4.4.28

One disadvantage of using mocks is that one could make the mistake of testing a mock by accident without realizing it. When using the more advanced features of certain mocking frameworks there is a risk of misunderstanding what exactly that code is doing, which may result in green tests which don't actually test the software that is supposed to be tested. Furthermore, the overextensive use of mocking can lead to slower tests and possible problems that result from the interactions between the mocks themselves.

4.4.29

Mocking should mostly be done during unit testing, because it provides isolation of the class under test. Mocking can be done during integration testing for some dependencies that are not directly under test. Mocking should not be done during system testing, because the whole system should be under test and when using mocks, you are partly testing your mocks instead of the real implementation.

5.1 State Machines

5.1.31

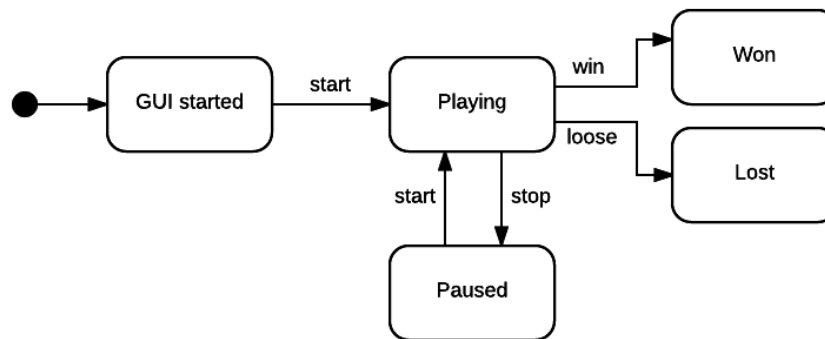


Figure 2: State Machine

5.2.32

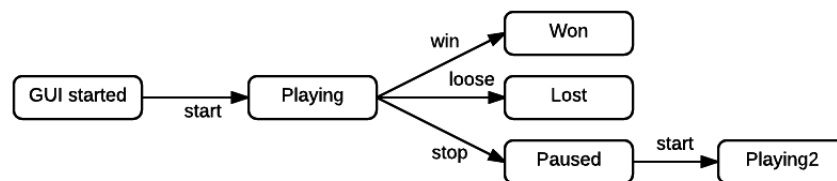


Figure 3: Transition Tree

| Test Case ID | Start State | Events | End State |
|--------------|-------------|--------------------|-----------|
| T1 | GUI Started | start, win | Won |
| T2 | GUI Started | start, loose | Lost |
| T3 | GUI Started | start, stop, start | Playing |

5.2.33

| States | Events | | | |
|-------------|--------|---------|-----|------|
| | Stop | Start | Win | Lose |
| GUI Started | | Playing | | |
| Playing | Paused | | Won | Lost |
| Paused | | Playing | | |

(state, event) pairs not contained in diagram:

(GUI Started, stop)
(GUI Started, win)
(GUI Started, loose)
(Playing, start)
(Paused, stop)
(Paused, win)
(Paused, loose)

5.2 Multi-Level Games

5.2.37

See <https://www.lucidchart.com/invitations/accept/b5a4efc0-83c4-47bf-9222-d37494b348f6> (image will be added to the report later)

5.2.38

| Test Case ID | Start State | Events | End State |
|--------------|-------------|-----------------------|-------------------|
| T1 | GUI Started | start, win level (<4) | Playing New Level |
| T2 | GUI Started | start, lose | Lost |
| T3 | GUI Started | start, stop, start | Playing Level |
| T4 | GUI Started | start, win level (=4) | Won Game |

T2 and T3 could almost be reused, since they don't involve any change in the level. But, it may still be necessary to modify them slightly, since they should make use of the MultiGameLauncher, rather than the Launcher, T1 would have to be modified further.

5.2.41

//TODO (depends on 34)

5.2.

//TODO (depends on 38)

5.3 Test Smells