University of Glasgow | School of Computing Science

Level 3 Project Case Study Dissertation

An Example Project

Jordyn Anne Brown
Nathan Gordon Kirkpatrick
Raza Ali
Scott Brown
Josep Perna Montane
Ruairi Gielty

9 January 2009

Abstract

The abstract goes here

1 Introduction

Software engineering

This paper presents a case study of...

The rest of the case study is structured as follows. Section **??** presents the background of the case study discussed, describing the customer and project context, aims and objectives and project state at the time of writing. Sections 5 through Section 9 discuss issues that arose during the project...

2 Case Study Background

Include details of

- The customer organisation and background.
- The rationale and initial objectives for the project.
- The final software was delivered for the customer.

3 QR Code Implementation

On the second customer meeting, Obashi told us that we should scatter the cubes in a wider area. The research done and different approaches taken for solving this problem are explained in the Cube Scattering section.

After doing research and trying the different approaches, we decided to use a QR code that would provide our application with the size of the room so that cubes could be scattered accordingly. To do this, when starting the application we place the QR code in the centre of the room and scan it before entering the AR Activity.

This left us with the need of implementing a QR reader in our application. Being this something that is implemented in many apps we decided to use ZXing[8], an existing QR scanning library. Implementing it was pretty straightforward thanks to all of the documentation provided in the repository. The only blocker that we found was that we had find a way of passing the measures retrieved from the QR scanner to the AR view. We used the extra field of the intent to do this. The extra field, contains a dictionary in which we could store the measures and then they could be retrieved in the AR activity and used to scatter the cubes.

4 Testing

When we set out to start writing tests for our application, we researched testing frameworks for AR applications but we realized that none were available. This is because testing an augmented reality application is quite a difficult task, due to the unpredictability and volatility of AR environments. Another big factor, is that AR environments are hugely continuous, it is very difficult to reach 100% test coverage when there are an almost infinite amount of states that an environment can be in. Moreover, AR applications are quite a new thing and a testing environment for them still hasn't had time to be developed[9].

We conducted two distinct types of tests: instrumented tests and unit tests. In Android, a unit test is just a regular JUnit test which runs on the hardware that an application is written on using the JVM or in a continuous integration environment. An instrumented test on the other hand, runs on a physical device or a device emulator which the app is designed for[5]. We tried to use unit tests in all of the cases possible, as they could be executed in the CI/CD pipeline.

In some cases such as the ArActivity, JUnit tests could not be used due to the Activity implementing a check for the version of OpenGL of the device that would close the application if it failed (we were not able to bypass this tests using mocking frameworks).

4.1 Unit Testing

After a lot of research, we found some frameworks that helped us build unit tests. Mockito is a unit based mocking framework[2] which gave us an excellent alternative to simulation of an AR environment for testing purposes. Mockito was invaluable in the cases where we wanted to test methods which are called in an AR environment, and operate on data from this environment.

Instead of actually simulating an environment for our app to interact with, Mockito gave us the functionality to create mock objects. A mock object is a dummy implementation of a class, where the output of its methods can be defined by us, the testers.

One example of our use of Mockito was when testing some methods that used the plane's dimensions, to scatter cubes. According to Google's ARCore developer references, a plane object describes the current best knowledge of a real-world planar surface[6]. Thus, a plane is an object which describes the plane that our app operates on. As it was unfeasible to create a plane using the provided AR Core API, we used Mockito to create a mock plane object that yielded the characteristics we needed for the tests[3].

This mock plane hugely simplified the testing process for any method which operated on a plane object, and also meant that tests were more consistent as we had the ability

to define what is returned by Google's ARCore methods; methods which are otherwise volatile.

We also used Robolectric, which is a powerful alternative to conducting tests instrumentally (on an android device or emulator)[7]. We used it to test application interactions such as intent passing (the construct used to move between activities and pass information between them). These require the android environment to be configured in a sandbox in order have the appropriate context for the methods to operate on.

Using Robolectric allowed us to add these tests to the CI/CD pipeline and remove the manual work required to run instrumented tests directly on the device or the emulator.

4.2 Instrumented Testing

We had to test two activities using instrumented testing, due to the constraints stated above. For it we used Espresso, an Android testing framework specially designed for UI testing. With it we were able to capture intents and analyze their correctness[4].

5 aaaa

ALICE [1] was beginning to get very tired of sitting by her sister on the bank and of having nothing to do: once or twice she had peeped into the book her sister was reading, but it had no pictures or conversations in it, "and what is the use of a book," thought Alice, "without pictures or conversations?'

So she was considering, in her own mind (as well as she could, for the hot day made her feel very sleepy and stupid), whether the pleasure of making a daisy-chain would be worth the trouble of getting up and picking the daisies, when suddenly a White Rabbit with pink eyes ran close by her.

There was nothing so very remarkable in that; nor did Alice think it so very much out of the way to hear the Rabbit say to itself "Oh dear! Oh dear! I shall be too late!" (when she thought it over afterwards it occurred to her that she ought to have wondered at this, but at the time it all seemed quite natural); but, when the Rabbit actually took a watch out of its waistcoat-pocket, and looked at it, and then hurried on, Alice started to her feet, for it flashed across her mind that she had never before seen a rabbit with either a waistcoat-pocket, or a watch to take out of it, and burning with curiosity, she ran across the field after it, and was just in time to see it pop down a large rabbit-hole under the hedge.

In another moment down went Alice after it, never once considering how in the world she was to get out again.

The rabbit-hole went straight on like a tunnel for some way, and then dipped suddenly down, so suddenly that Alice had not a moment to think about stopping herself before she found herself falling down what seemed to be a very deep well.

Either the well was very deep, or she fell very slowly, for she had plenty of time as she went down to look about her, and to wonder what was going to happen next. First, she tried to look down and make out what she was coming to, but it was too dark to see anything: then she looked at the sides of the well, and noticed that they were filled with cupboards and book-shelves: here and there she saw maps and pictures hung upon pegs. She took down ajar from one of the shelves as she passed: it was labeled "ORANGE MARMALADE" but to her great disappointment it was empty: she did not like to drop the jar, for fear of killing somebody underneath, so managed to put it into one of the cupboards as she fell past it.

"Well!" thought Alice to herself "After such a fall as this, I shall think nothing of tumbling down-stairs! How brave they'll all think me at home! Why, I wouldn't say anything about it, even if I fell off the top of the house!" (which was very likely true.)

Down, down, down. Would the fall never come to an end? "I wonder how many miles I've fallen by this time?" she said aloud. "I must be getting somewhere near the centre of the earth. Let me see: that would be four thousand miles down, I think-" (for, you see, Alice had learnt several things of this sort in her lessons in the school-room, and though this was not a very good opportunity for showing off her knowledge, as there was no one to listen to her, still it was good practice to say it over) " yes that's about the right distance – but then I wonder what Latitude or Longitude I've got to?" (Alice had not the slightest idea what Latitude was, or Longitude either, but she thought they were nice grand words to say.)

Presently she began again. "I wonder if I shall fall fight through the earth! How funny it'll seem to come out among the people that walk with their heads downwards! The antipathies, I think-" (she was rather glad there was no one listening, this time, as it didn't sound at all the right word) "but I shall have to ask them what the name of the country is, you know. Please, Ma'am, is this New Zealand? Or Australia?" (and she tried to curtsey as she spoke- fancy, curtseying as you're falling through the air! Do you think you could manage it?) "And what an ignorant little girl she'll think me for asking! No, it'll never do to ask: perhaps I shall see it written up somewhere."

Down, down, down. There was nothing else to do, so Alice soon began talking again. "Dinah'll miss me very much to-night, I should think!" (Dinah was the cat.) "I hope they'll remember her saucer of milk at tea-time. Dinah, my dear! I wish you were down here with me! There are no mice in the air, I'm afraid, but you might catch a bat, and that's very like a mouse, you know. But do cats eat bats, I wonder?" And here Alice began to get rather sleepy, and went on saying to herself, in a dreamy son of way, "Do cats eat bats? Do cats eat bats?" and sometimes "Do bats eat cats?" for, you see, as she couldn't answer either question, it didn't much matter which way she put it. She felt that she was dozing off, and had just begun to dream that she was walking hand in hand with Dinah, and was saying to her, very earnestly, "Now, Dinah, tell me the truth: did you ever eat a bat?" when suddenly, thump! thump! down she came upon a heap of sticks and dry leaves, and the fall was over.

Figure 1: Behind it was a little door

Alice was not a bit hurt, and she jumped up on to her feet in a moment: she looked up, but it was all dark overhead: before her was another long passage, and the White Rabbit was still in sight, hurrying down it. There was not a moment to be lost: away went Alice like the wind, and was just in time to hear it say, as it turned a comer, "Oh my ears and whiskers, how late it's getting!" She was close behind it when she turned the comer, but the Rabbit was no longer to be seen: she found herself in a long, low hall, which was lit up by a row of lamps hanging from the roof.

There were doors all round the hall, but they were all locked; and when Alice had been all the way down one side and up the other, trying every door, she walked sadly down the middle, wondering how she was ever to get out again.

Suddenly she came upon a little three-legged table, all made of solid glass: there was nothing on it but a tiny golden key, and Alice's first idea was that this might belong to one of the doors of the hall; but, alas! either the locks were too large, or the key was too small, but at any rate it would not open any of them. However, on the second time round, she came upon a low curtain she had not noticed before, and behind it was a little door about fifteen inches high: she tried the little golden key in the lock, and to her great delight it fitted!

Alice opened the door (see Figure 1) and found that it led into a small passage, not much larger than a rat-hole: she knelt down and looked along the passage into the loveliest garden you ever saw. How she longed to get out of that dark hall, and wander about among those beds of bright flowers and those cool fountains, but she could not even get her head through the doorway; "and even if my head would go through," thought poor Alice, "it would be of very little use without my shoulders. Oh, how I wish I could shut up like a telescope! I think I could, if I only knew how to begin." For, you see, so many out-of-the- way things had happened lately, that Alice had begun to think that very few things indeed were really impossible.

6 Choice of Colours

The following diagrams (especially figure 1) illustrate the process...

7 Managing Dress Sense

In this chapter, we describe how the implemented the system.

8 Kangaroo Practices

9 Knots and Bundles

10 Conclusions

Explain the wider lessons that you learned about software engineering, based on the specific issues discussed in previous sections. Reflect on the extent to which these lessons could be generalised to other types of software project. Relate the wider lessons to others reported in case studies in the software engineering literature.

References

[1] L. Carroll. *Alice's Adventures in Wonderland*. Macmillan, 1865.

[2] mockitoguy Et Al. Most popular mocking framework for unit tests written in java http://mockito.org. https://github.com/mockito/mockito. Version 1.x.

[3] Google Android Reference. Build local unit tests. https://developer.android.com/training/testing/unit-testing/local-unit-tests. Version updated on the 27/12/19.

[4] Google Android Reference. Espresso. https://developer.android.com/training/testing/espresso. Version updated on the 27/12/19.

[5] Google Android Reference. Fundamentals of testing. https://developer.android.com/training/testing/fundamentals. Version updated on the 27/12/19.

[6] Google ARCore reference. Plane. https://developers.google.com/ar/reference/java/arcore/reference/com/google/ar/core/Plane. Version updated on the 30/01/20.

[7] Roboelectric. Androidx test. http://robolectric.org/androidx_test/. Referenced on the 04/04/20.

[8] srowen Et Al. ZXing ("Zebra Crossing") barcode scanning library for Java, Android. https://github.com/zxing/zxing. Version 1.9.

[9] Tracy Watson. Specifics and challenges of augmented reality testing. https://skywell.software/blog/specifics-and-challenges-of-augmented-reality-testing/. Version updated on the 26/09/19.