In the first assignment, you started from a “skeleton” application which we had provided. In this assignment, you will complete an entire application yourself - including the design of the class model, and the user interface. We would expect a good solution to be possible with about three days work (24 hours), although you will probably need to spend longer if you are aiming for a particularly good mark, or don’t have a lot of previous experience.

Don’t be intimidated if you don’t have much previous programming experience – you do not have to complete all of the sections, and you may be surprised at how much you can achieve by working steadily and following the instructions carefully.

The assignment includes an advanced task (section 4) for those of you with more experience. It is possible to obtain a very good mark without attempting this, and you should only do so if you are confident that you have a solid design and implementation for the other sections - a bad solution to this section can complicate the structure and result in a worse overall mark.

It is important that you start thinking about the design in advance – you will need time to develop your design and discuss it with the demonstrators. You should read the relevant book chapters, watch the videos, and have a clear idea of your class structure before writing a lot of code.

For a pass mark, you will need a good object-oriented design and you will need to describe this clearly on the worksheet - it is not possible to pass without this, regardless of how well the application appears to run.

As with the previous assignment, tasks that you will need to do are marked with a ☑.

1 The Application Design

For this assignment, you will develop an application which allows the user to move around and manipulate objects in a very simple “virtual world”. The images will be two-dimensional, but the user should be able to move from one location to another and to look in different directions - similar to Google “Street View”\(^1\), but with discrete images. In addition to the skills that you developed in the first assignment, this will give you some experience with designing object-oriented solutions, using graphical user interfaces, and working with large libraries of external code.

1.1 Locations

[1] You will need to start by choosing a “theme” for your world. This should consist of a small number of connected “locations” and a set of images for each location which represent views in different directions. For example:

- The locations might be the rooms in your flat. You would need to have a set of images for each room, looking in different directions, and a “logical map” of the flat which shows how the rooms are connected.
- The locations might be an area around the University. Again you would need a set of photographs looking in different directions, and a logical map which shows how you can move from one location to another.
- You might create a completely fictitious environment, perhaps with hand-drawn locations.
- You won’t get extra marks for “imagination”, but creative scenarios are welcome!

If you decide to use images from elsewhere, make sure that you acknowledge the source of the images, and that you do not violate any copyright restrictions.

[2] Now think about the basic actions that the user will be allowed to perform - as a minimum, the user probably needs to be able to turn around (left or right) and move forward into the next location\(^2\). This requires some thought. What does “turn” mean? 90 degrees? What happens if there are two doors in the same wall - how do you distinguish between the directions? What happens if the user attempts to go forward when there is no exit? Is there an “up” and “down” as well?

[3] Now, think about the interface. It is useful to sketch on paper what you think this might look like. How will the user specify the commands? Buttons? Typing commands? Menu items? How do you prevent the user from taking impossible actions? How should the program react if they do?

1.2 Portable Items

Now that you are able to move about in your virtual world, let’s add some items that you can carry from one place to another. For example, one location might contain a chocolate rabbit\(^3\). We should be able to pick up the rabbit, move to a different location and put it down again. Providing that the rabbit doesn’t melt or get eaten, it should stay in the new location and be visible every time we return there. Of course, we should be able to pick it up again and move it somewhere else.

[4] Extend your interface design so that it displays any items which are present in the current location (whichever way we are facing). You might want to display your items overlaid on the main image, or in a separate section of the display, for example.

[5] Think about the additional actions that the user will need to perform, such as picking up and putting down items.

[6] Extend your interface design to support these actions. Use a different interface element for this interaction - for example, if you used buttons to move between the locations, you might use a

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\(^2\)Note that “turning” and always moving forward is much clearer than allowing the user to “move left” and “move right” (in which case it might not be clear whether they are looking in the same direction that they are moving!)

\(^3\)Rabbit icon from: http://www.iconfinder.com/icondetails/67005/128/_icon

Paul Anderson
menu, or a text command to select the item, or you may simply allow the user to click on the item. Make sure that your design is capable of supporting an arbitrary number of items.

2 Creating the Model

The design of the model is the most important part of this assignment – a good, well-reasoned choice of classes and methods is essential for a good mark, and these must be clearly described on the worksheet. The second lecture will include a discussion of this.

To model your world, you need to think about the design of the classes and how they would be used. For example, you may decide to have a class which models a Location. This would include a collection of images for the different views. What methods would be required? What are the different possibilities for storing the collection of images? Similarly, you may want to have a class which models the World. What methods would be required? How would this relate to the locations?

In practice, having a good design will make the coding much easier; a bad design will make it much harder. So, you will want to think carefully about the possible alternatives - consider how easy it would be to implement each of the actions you identified in tasks [2] and [5] using various different models. Read the appropriate book chapters. Think about nouns and verbs. Consider properties such as cohesion and coupling – how easy would it be for other people to use your classes in their own application?

In addition to the more concrete entities, such as locations and portable items, you will need to think carefully about the controller and the GUI. What methods should they support? Separating these clearly allows you to easily change the way in which the interface works - for example to change from a menu-based action to a button action. It also makes the system easier to test, and for multiple people to work on the same application.

If you think that you may attempt the advanced task, you will probably want to look ahead at section 4, since this may affect the decisions that you make about the representations used in your model. Thinking about the potential extensions in section 5 will also help you to evaluate the different possibilities.

You will need to describe your model clearly on the worksheet [15:1]. There are various ways of doing this formally4, but the main aim is to show what classes you have, what their responsibilities are, and how they relate. So a simple list of classes and methods, with brief descriptions, and perhaps an informal diagram, is sufficient in this case.

3 Implementation

We suggest that you start by implementing (only) those classes which are necessary to create the basic application (moving between locations), and leave the portable items until the basics are working. If you don’t have a lot of experience, you may find it difficult to implement the portable items, and it is possible to pass without doing this, providing that you have a sound design, and a working implementation of the basic locations.

In your implementation, you may find it useful to use or modify code from the first assignment (including the supplied code), or the JavaFx examples, or code from elsewhere. Of course, you will only be credited for code which you have written yourself, and you must make sure that you clearly state the source of any code which is not your own - you should do this both in the code (comments), and on the worksheet [15:3]. If you do use external libraries, make sure that these are included in your submitted jar file.

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4For example, UML: https://en.wikipedia.org/wiki/Unified_Modeling_Language
You will find it helpful to adopt a standard size for the main images (say 512 x 384) and the item images (say 64 x 64). This will make it much easier to share your model with others (see section 4). There is also a limit on the size of the assignment file which you can submit, and you will not be able to submit your assignment if it contains unnecessarily large image files. In addition, large images may also cause you problems with memory allocation in your program – there are ways of dealing with this, but keeping the images sizes small will avoid these problems. The (FAQ) explains how to pre-scale and compress your images.

[7] Implement the basic model classes.

In a real project, this would be a good time to write some unit tests - this would allow you to convince yourself that the model objects were working properly before you get involved in the complications of connecting them to the interface. Unless you are finding the assignment easy though, you probably want to move on and concentrate first on the following sections.

[8] Implement the GUI. You must use JavaFx for the interface, and create your design using SceneBUILDER.

You should now be able to check the appearance and some basic behaviour of the interface without writing any additional code. The Video page on the website has some videos and sample code to help you get started with JavaFx. This is probably new to most of you. This is intentional. It is deliberately intended to give you a realistic experience of working with an unfamiliar library using only the public documentation and support available on the web.

[9] Implement the controller.

You should now have a basic working application. You should save a copy of the code at this stage – this will give you a working copy to demonstrate for marking if you break things while attempting the following sections!

For a real project, you would almost certainly want to use a Version control tool\(^5\). This would allow you to save the state of your code every time that you make a change. This means that you can easily return to previous versions, and you can clearly see what was changed, and when. These tools are also particularly valuable in tracking and merging changes when multiple people are working on the same project. They do take some time to learn but if you intend to continue programming, you will almost certainly find this worthwhile at some stage.

[10] Once you have a working application which allows you to move between locations, you should extend this to include the portable items.

4 Loading the Model

This section is intended for those of you with more programming experience who would like to learn a little more about using Java in practical applications - specifically locating and using external libraries, and reading structured data in JSON format.

\(^5\)For example GIT: http://git-scm.com

Paul Anderson
It is possible to obtain a very good mark without attempting this section, and if it is implemented badly, it can spoil a good design of the basic program which may actually result in a lower mark! So, only attempt this if you are confident that you have a solid solution to all of the other parts of the assignment, and you are willing to spend additional time. You should save a copy of the code at this stage, so that you have a working copy to submit if you later decide that the extensions have resulted in a poorer class design, for example.

You will hopefully have realised from the first assignment, that it is useful to separate the “content” from the code: rather than “hard-wiring” the Munro names into the controller code, they could be stored in a separate property file. This allowed other people to easily change the data without understanding, or re-compiling your code. It also allowed the same data to be used with different implementations, simply by copying the property file.

In this case, our model is a little more complicated. It would be possible to represent this in a way which could be stored in a property file, but this would be rather awkward to deal with, and difficult for other applications to read. JSON\(^6\) is a standard way of representing structured data in plain text files. JSON libraries are available for most languages, so this makes it a convenient format to represent our model.

Figure 1 shows how a simple model might be represented in JSON\(^7\). This contains a number of rooms (bedroom, hall, ...). Each room specifies a collection of image files representing the view in different directions, from inside that room. It also has a number of exits (in different directions) leading to other rooms. And it has a list of items initially present in that room. The portable item records just define the

\(^6\)\url{http://www.json.org/}, \url{https://en.wikipedia.org/wiki/JSON}

\(^7\)There are, of course, many other possible representations
image file representing each item.

[11] Explore some of the JSON libraries which are available for Java and choose an appropriate one for your application. For example, simplicity is probably a useful criteria in this case, but high performance is probably not.

[12] Modify your application so that it reads the model from a JSON file in the same format as the one in figure 1.

If your application design is good, it should be possible to do this without major changes to the class structure. You may find the following hints helpful:

- The JSON entries (for example the exits) reference the rooms by their names. You will need some way of looking up the names to find the corresponding objects. And you will need to think whether it is better to store the names of the rooms (and look up the objects when you need them), or store the references to the objects themselves.

- Delegate the responsibility for interpreting the various parts of the JSON to the appropriate classes.

Your application should provide some method for the user to select different JSON files (and hence different models) - perhaps from a menu, or from a prompt when the application starts. If this is to be useful for sharing models, you will need to be careful about the location of the image files - you should assume that these will be in the same directory as the JSON file.

[13] See if you can find someone else who is attempting this section (try the Piazza forum), and exchange your model with theirs (do no exchange any code). Your applications should be able to display each other’s model.

You might find it fun to try and merge two models: you should easily be able to create a composite JSON file which allows to you to move between different worlds (via specific exits) in the same application!

### 5 Where Next?

*Do not implement any of the following suggestions as part of your submission* - but thinking about how the application might develop will help you to evaluate your own design. If you have a good design, the following extensions should not require big changes to your code, and should only involve a small percentage of your classes:

- Rather than retrieving the images from the local filesystem, could you fetch them from the web? Could you make use of any of the services from the first assignment to do this? You probably don’t use the same `Picture` class as the services, but could you create an “adaptor” class which translated the `Picture` objects into the format that you use?

- If you were fetching the pictures from the web, would any of the proxy classes (`CacheProxy, RetryProxy`) from the first assignment be helpful?

- Could you fetch the JSON model from the web as well? This would allow you to publish your model for others to use without requiring any local files at all.

- How easy would it be to replace the JavaFx with some other graphical interface? What proportion of your classes depend on JavaFx?

- Could you add an extra field to the JSON (for each room) containing some text to be displayed the first time someone entered that room? If this was added to the JSON, would your existing application still be able to read the JSON model (and just ignore the new field).

- How easy would it be for someone to create a game out of your application – for example, displaying
a score to show how many items had been collected?

- How easy would it be to write a test for the “consistency” of your model? i.e. if I leave a room by one exit, turn around and walk back, I should always end up in the same room that I started in.

6 Worksheet & Documentation

As well as submitting your code, you will also need to submit a worksheet with answers to a few questions. A pass mark requires a clear and well-written discussion of your model on the worksheet, so please pay particular attention to this, especially if English is not your native language. You may create the worksheet using any application that you like, but please make sure that it is in PDF format – the FAQ pages on the course website explain how to generate PDF – and make sure that it has no more than about 800 words:

- Make sure that your name and student number are clearly visible at the top of the worksheet.
- Answer the following questions on your worksheet. Please number the answers clearly:
  1. Briefly describe your class design, including the function and relationships between the important classes. You may do this using text and/or diagrams, but the result must be clear and concise.
  2. Briefly describe one or two significant choices that you had to make in the model design and explain why you chose your design over some plausible alternative.
  3. Add any extra comments that you would like to make about your solution, or the assignment in general. In particular, you should note any external resources from which you took code, and any significant collaborations with others.

7 Submission

You should attempt your submission well before the deadline to allow for any problems that you may have with the submission system. If you need to update your submission (anytime before the deadline), you can simply make a new submission which will replace the previous one.

Note that there will be no extensions for IJP assignments, and late submission will be awarded a mark of zero. This is because answers to assignment questions and feedback will be made available during the demonstration sessions in the following week.

Before you submit your assignment ...

- You may want to test your jar file on a different platform – for example, test it on DICE if you have developed on a Windows machine (or visa-versa). It should be possible to run your application simply by (double) clicking on the jar file. If your code is not portable and does not run on the markers machine, then we will rely on your demonstration for clarification.
- It is important that your code is easy for other people to read. This will form part of the assessment, so you may want to review your code style – see the relevant appendix in the textbook.
- Please make sure that you understand about good scholarly practice – see the information on the course website for further details. For this assignment, we will be using automated tools for checking both worksheets and code for potential plagiarism. If you are in any doubt about any part of your submission, please discuss this with the course lecturer.
- Generate a few screen dumps showing various screens from your application. These will show the marker what your application looks like if (s)he is unable to run your code.
- Create a ZIP archive (see the submission page on the website) containing the following (please
use these exact filenames:

- **src** - a directory containing all of the source files necessary to compile your application.
- **screendumps** - a directory containing images of a few screen dumps from your running application.
- **worksheet.pdf** - your answers to the worksheet questions.
- **assignment2.jar** - the jar file containing your runnable application.

The FAQ pages on the course web site explain how to create a zip archive. Be careful: you will not be credited for missing files, so you may want to unpack the archive again yourself to verify that it contains all of the files that you expect.

[21] Use the [online submission system](#) to submit your ZIP file.

### 8 That’s (almost) It

[22] In the final lab session, you will be asked to show your running application to a demonstrator and a small group of other students. This will give you an opportunity to explain any problems that you had with the code and to get some feedback on your solution. This is difficult to schedule, so please make sure that you attend this lab session on time, and that you have all of the necessary files to run and demonstrate the same version of your code as the one you submitted (we will check this).

The demonstrator will not be marking your assignment, but we will refer to the demonstrator’s notes if, for example, we cannot run your submitted assignment code on our systems. If you do not attend the demonstration, code which we are unable to run (for any reason) will not be awarded any marks.

[23] You will also be asked again to view and compare the readability of several solutions by other students. This will give you an opportunity to see a range of different coding styles, and to give (and receive) some feedback on how easy the code is to read. Your comments will not be marked, but participation is necessary for a good overall grade on the assignment.

Do not under-estimate the importance of these tasks. There will be significantly more variety in the submissions than there was for the first assignment. You should find it very helpful to see the different solutions, as well as the much wider range of readability which will be present in this more realistic code.

### 9 That’s (really) It!

We hope that you found this a useful and realistic exercise. Please do let us know what you think. Ask the lab demonstrators if you would like any further feedback, or use the forum to discuss any issues relating to this exercise.