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Department of Computer Science and Information Systems

Title: A modern version of Space Invaders

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Course: Computer Games Development LM110

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Project Summary

This project is an advanced version of the classic game Space Invaders. It will retain some of the core mechanics and add some features that will provide a challenge for the player.

There are two parts to this project, the game and the supporting website. The website is used to create accounts for players as well as having a leader board which displays data about the player (for example, their high score, time played and highest level achieved).

This project uses the same perspective as the original game (top down, two dimensional). The difference between this version and the original is that it will become harder to beat as the players score increases. The objective of the game is to survive as long as possible and achieving the highest score possible.

This project will use modern tools and techniques as this was a limiting factor in the original implementation. These factors are discussed in more detail in the Background and Research portion of this report.

Acknowledgments

I would like to acknowledge my family and friends for providing guidance and support for me during my years at college.

Declaration

This final year project is presented in partial fulfilment of the requirement for the Bachelor of Science in Computer Games Development. I herewith declare that I have produced this report without prohibited assistance of third parties and without making use of aids others than those specified. Where use has been made of the work of other people it has been fully acknowledged and referenced appropriately.

Signature: _____

Date: _____

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1 Introduction

1.1 General Introduction

This chapter will give a brief description of the chapters that follow. Chapter two discusses that background and research that went into this project. Chapter three will show case some of the design that went into this project. Chapter four will address some of the implementation and issues encountered. Chapter five will showcase the testing and evaluation used in the project. The final chapter discusses the conclusions and possible further development of this project.

1.2 Motivating Factors

The main motivation for undertaking this project was to improve the Space Invaders game. From the research completed (this is discussed in Chapter 3), many clones have a set difficulty. This results in an imbalance in the difficulty. A highly skilled player will be able to get a higher score quite easily. The result of this project has created a game that uses information collected by the player to make it more difficult for them to beat.

A secondary motivation to complete this project was to become familiar with using a modern game engine. It would be a useful skill to add to my repertoire, especially if I want to apply for a job in a game company after college.

Another motivation for doing this project is to increase my knowledge in web based technologies. As most companies have a web presence it would be useful to know about web technologies, especially those based around JavaScript.

The final motivation for completing this project is to combine the knowledge I have learned from various modules. This project incorporates aspects of Programming, Object Orientated Programming, Database Systems, Distributed Systems and Systems Analysis and Design. Principles learned from these modules will be applied in the project

1.3 Objectives of Proposed Work

This project has two main objectives with multiple elements to be completed. The two primary objectives are the game and the website.

The following list details the objectives to be completed for the game.

1. Programming the initial game using simple graphics.
2. Refining the game mechanics.

3. Program a login screen for the game to allow a player to login so their details can be recorded.

The next list details the objectives to be completed for the website.

1. Programming the website.
2. Programming the server.
3. Responding to any GET, POST, PUT and DELETE commands to make the website RESTful.
4. Creating the database and populate it with test data.
5. Use a testing framework to test if the correct data is being transferred to the various parts of the project.

2 Background and Research

The background and research section discusses the previous implementations of Space Invaders and the considerations that the original designer had to consider. It will also analyse the technologies that will power this project.

2.1 Analysis of Existing Products

The original Space Invaders was very primitive in its implementation. It was so primitive that it was unable to render many colours and had to rely on a colour overlay. (arcade-museum.com, 2016). The specification for some of the system is given below

- Processor: Intel 8080
- Raster graphics on a CRT monitor
- Texas Instruments SN76477

An interesting point to note is that the graphics were drawn using the processor. This was due to the lack of dedicated graphics processing units at the time. It also explains why the graphics were primitive by today's standards (for example, pixel based with little colouring).

In 1980 a version of Space Invaders was ported to the Atari 2600 (gamespy.com, 2016). This had a number of advantages over the original. The biggest advantage was that the colour palette was increased. Other hardware improvements included the addition of RAM and cartridges that could have memory included. (problemkaputt.de/, 2016)

At the time of writing this report, there are many clones that exist. These clones are available on many platforms from the original game to iOS (kotaku.com, 2016). These clones can differ in many ways from the original. Some will have different aesthetics while others will have different mechanics. The table below is a compiled list of some of the data available about space invaders clones (bandainamcoent.eu, gamespy.com, ign.com, kotaku.com, theisozone.com, 2017).

Name	Platform(s)	Released	Features
Space Invaders (Original)	Arcade, Atari 2600, Nintendo Entertainment System, iOS	1978, 1980, 1985, 2009	Raster graphics
Space Invaders Part II, Space Invaders Deluxe (USA)	Arcade, Game Boy	1979, 1990	Gameboy version allowed multiplayer, USA version had updated graphics
Space Invaders '95	Arcade	1995	Updated graphics
Space Invaders 1999, Space Invaders X (Japan)	Playstation, PC, Nintendo 64, Game Boy Color	1999	2D and 3D graphics, competitive mode, co-operative mode,
Space Invaders Evolution, Space Invaders: Galaxy Beat (Japan)	Playstation Portable	2005	Updated graphics, sounds and gameplay, multiplayer mode, rhythm action gameplay
Space Invaders Extreme	Nintendo DS, Playstation Portable, Xbox 360	2008, 2009	Integrated musical elements
Space Invaders Infinity Gene	iOS, Playstation 3, Xbox 360, Android	2009, 2010, 2013	Updated graphics

2.2 Unity Game Engine

The Unity engine is a multiplatform game engine. It allows developers to target a range of devices for example PC, Android, iOS and Xbox, to name a few. It uses one click deployment to build solutions for as many devices that are required. (<https://unity3d.com/>, 2016).

The engine supports a multitude of file formats for images, audio, video and text. The engine abstracts the more difficult aspects of creating a game such as optimisation and graphics rendering. For graphics, it targets APIs depending on which system is selected for the build. Windows can use both Direct3D and OpenGL, Android and iOS use OpenGL ES and consoles use proprietary APIs.

Programming in Unity can be achieved by using a number of languages. The most widely used language for Unity is C sharp. JavaScript can also be used; however, it is not the same JavaScript that is used for web browsers. It is commonly referred to as UnityScript. (answers.unity3d.com/, 2016). A third language called Boo is also available, however it is now deprecated. It is not documented by Unity anymore, although it will still compile. (forum.unity3d.com, 2016).

Due to its better support and documentation, C sharp will be the language used to implement the game portion of this project.

2.3 Unreal Engine

Another popular choice for developing games is Unreal Engine. It is one of the biggest competitors to Unity. It is also a multiplatform game engine and can export builds for a range of devices such as PC, Mac, Linux, XBOX and Playstation, to name a few. (https://www.unrealengine.com).

As with Unity, Unreal Engine supports many file formats. It also enables developers to accomplish more as the more difficult parts of game programming is abstracted. Programming in Unreal is achieved using two methods. The first is using C++ and utilising the Unreal API. The second method uses blueprints. Blueprints in Unreal are a style of visual coding where the developer drags, drops and connects nodes to get the desired functionality. However these blueprints are not as good performance wise when compared to C++. (https://forums.unrealengine.com).

2.4 MongoDB

MongoDB is a high performance, scalable, document orientated NoSQL database solution. (stackoverflow.com, 2017). MongoDB uses a JSON-like document with schemas. JSON is a lightweight data format that is easy for humans to read and write as well as to parse for machines. Figure 3.1 shows an example of some data in

the JSON format.

JSON is built upon two structures:

- A collection of key/value pairs that correspond to an object, record, dictionary, hash table, keyed list or an associative array, depending on which language is being used.
- A list of ordered values that correspond to an array, vector or similar data structure.

(json.org, 2017)

```
{  
  "firstname": "Jane",  
  "lastname": "Doe",  
  "age": 42,  
  "items": ["apple", "book", "cards"]  
}
```

Figure 3.1: Data in JSON format

Because MongoDB is a NoSQL solution the schema is not enforced as strictly as it would in a relational database. The dynamic schema means that each document can have different key/value pairs and can still be inserted into the database. The table shown below summarises the differences between a Relational Database Management System (for example, MySQL) and MongoDB.

Relational Database Management System	MongoDB
Table	Collection
Tuple or Row	Document
Column	Field
Primary Key	Key id provided by MongoDB

The `_id` provided by MongoDB is a 12 byte hexadecimal number which ensures the uniqueness of every document. This hexadecimal number is constructed as follows:

- The first 4 bytes are a timestamp since the ObjectId's creation. This uses the seconds elapsed since the Unix epoch.
- The next three bytes are a machine identifier.
- The following 2 bytes are a process ID

- The final 3 bytes are a counter that starts at a random value

If a document does not specify a unique `_id` field, MongoDB will generate an `ObjectId` for this field. This is because the `_id` is used as a primary key (docs.mongodb.com, 2016). Figure 3.2 shows the same data as Figure 3.1 but now includes an the `_id` field.

```
{
  id: ObjectId("57a634bb15e4f40670db36b2"),
  firstname: "Jane",
  lastname: "Doe",
  age: 42,
  items: ["apple", "book", "cards"]
}
```

Figure 3.2: Data including the 12 byte hexadecimal `_id` field. In this example the `_id` was automatically generated from MongoDB.

2.5 MySQL

MySQL is a free open source Relational Database Management System (RDMS) that uses Structured Query Language (SQL) to perform database operations. Unlike MongoDB, MySQL must follow a schema. A schema is a logical group of tables, procedures and views that relate to one type of object (for example an employee schema). (stackoverflow.com, 2017)

MySQL is also fully ACID compliant. ACID stands for:

- Atomic: a transaction that is either fully completed with all of its data modifications or not at all.
- Consistent: when the transaction is finished all data must be in a consistent state.
- Isolated: modifications to the data performed by a transaction must be independent of a different transaction.
- Durable: when the transaction is completed, effects of the modifications performed by the transaction must be permanent.

MongoDB is not as ACID compliant as MySQL. It is compliant at the document level. What MongoDB lacks is transactions. This is the ability to revert any updates to multiple documents. (stackoverflow.com, 2017).

Unlike MongoDB, when using MySQL the developer must decide on a primary key to use. This can be any value the developer chooses but a good practice is to use a type of user identifier that is automatically incremented when a new user is entered. The syntax for this statement might look like the following:

```
CREATE TABLE IF NOT EXISTS Users(  
  userID INT UNSIGNED NOT NULL AUTO_INCREMENT,  
  PRIMARY KEY(userID)  
);
```

2.6 ExpressJS

ExpressJS is a flexible JavaScript web application framework which uses NodeJS to create features for web and mobile applications (expressjs.com, 2017).

It is minimal and provides tools to build applications, with many more plugins available via the Node Package Manager (npm). ExpressJS is similar to Rails for Ruby and Django for Python. Unlike Ruby on Rails or Django there is no documented best way to use the ExpressJS framework. Because it is written in JavaScript and uses NodeJS, express is able to interact with MongoDB in order to retrieve, insert, update and remove documents from a database.

2.7 AngularJS

AngularJS is a client-side JavaScript framework that is developed by Google. HTML is useful for declaring static views but fails when trying to declare a dynamic view. Other frameworks deal with this issue by abstracting technologies to manipulate the Document Object Model (DOM). These solutions don't address the root problem which is HTML (angularjs.org/, 2017). AngularJS addresses this issue by extending HTML which is achieved by using directives and binds data to HTML using expressions.

AngularJS is used to develop the frontend elements of a system. Angular uses the Model View Controller (MVC) pattern in order to separate the representations of the data from how it is displayed to the user. Because it is JavaScript based, AngularJS is able to communicate with the other chosen technologies easily.

2.8 NodeJS

NodeJS is a server side solution for JavaScript. It is comparable to an Apache web-server for PHP. It is not a JavaScript framework but many of the modules it uses are written in JavaScript. It is built upon Google Chrome's V8 JavaScript engine. NodeJS

uses an event driven, non-blocking I/O model the makes it lightweight and efficient (nodejs.org/en/, 2017).

A non-blocking I/O (also known as an asynchronous I/O) means that an I/O request will be queued straight away and the function returns. The I/O is processed at a later point. A blocking I/O thread cannot process anything else until the I/O is complete. In the case of sockets, this could result in a long waiting time. NodeJS uses only uses one thread to service all requests. (stackoverflow.com/, 2017)

The advantage of using NodeJS is that it has its own package manager, similar to Ubuntu, called Node Package Manager (npm for short). This allows developers to share libraries of code as well as managing versions of the code. This is how the ExpressJS framework will be integrated into the project.

2.9 Apache Server

The Apache web server is a software product which aims to create a feature rich, robust, commercial grade, open source HTTP server. (httpd.apache.org, 2017).

The features which Apache supports are implemented in compiled modules which can range from server programming to authentication schemes. It is often used with MySQL and PHP to crate web applications.

Apache allows developers to control access to different web pages by using different modules that are provided, however it does not give as much control as a NodeJS server. Apache does allow developers to create their own modules however it is not as simple as using NodeJS.

2.10 Research Conclusions

From the research completed of the existing games, it is clear that many existing implementations don't address the fact that the difficulty stays the same for the game. The original Space Invaders did have a feature where the enemies would get faster the less there were, however this was a bug that the developer made a mechanic out of. Some solutions to address this problem include creating a template that uses the existing players data to instantiate a level based on this data. Another solution would be to change properties of the enemy as the game goes on.

The Unity game engine will be used to implement the functionality of the game . This decision is based on some of the pitfalls of Unreal engine. Although Unreal engine is a more commonly used solution, it didn't suit this project. This is because the blueprints technology used is too simplified and C++ can be over complicated. Unity is a happy medium between these as it uses the C# language for functionality. This also gives the advantage of accessing the .NET framework if necessary.

For the web application portion of this project, MongoDB, ExpressJS, AngularJS and NodeJS technologies will be used. This decision was based on a number of factors. Firstly is previous experience using these technologies. Secondly is the fact that all these technologies are JavaScript based and MongoDB uses JSON which enables data to be easily passed to and from the server. This is in contrast to using Apache, MySQL and PHP which use different technologies that allow the same functionality. The final factor influencing this decision is that JavaScript technologies are becoming more popular and further experience using these would be beneficial in a future career.

3 Design

The design portion of this report will deal with the various thought processes behind the design of the many parts in this project.

3.1 Game Design

Game design is the name given to the various parts of a game. These can include story and plot development, mechanics and aesthetics where applicable. As this game is an arcade game with no story, the design of the game will focus on the mechanics primarily and aesthetics secondly.

Questions that have to be asked in this section include the following:

- How does a player play the game?
- What are the rules of the game?
- How does the player increase their score?
- How does the difficulty change as the game is played?
- What makes the game challenging to the player?

Each of these questions will be answered in this section. By the end an in depth knowledge of how the game performs should be acquired.

3.1.1 How does the player play the game?

This project is being developed for the PC platform. Other platforms such as mobile (Android and iOS) were considered but presented some challenges for the outcome. Since a PC is being used, the player will have access to the input hardware that connects to that PC. In layman terms this means the keyboard and mouse. For the purposes of this project, the is only used to click buttons. The player player movements are done through the keyboard.

Before playing that game, the player must create an account on the website. When this is created the player can log into the game and read instructions or begin to play the game. The players spaceship moves left and right by pressing the left arrow key or right arrow key respectively. The A and D keys also provide this functionality for players who prefer using those keys. In order to shoot a laser, the player presses the Space key. While playing the game, the player can press the Escape key to end the round prematurely if it is required. This will log whatever their recent score is to the

database. When the players health becomes 0, the game will log whatever score is accumulated to the database and return to the menu screen.

3.1.2 What are the rules of the game?

The rules of this game will follow most of the rules of the original Space Invaders. The player can move left and right until they reach the edge of the screen. From there they will no longer be able to move in the direction they were. When they want to, the player can shoot a laser at the enemy spaceship. These are the only rules that are applicable to this project. Aside from this, players may have their own rules (also known as home brew. For example, players could choose the have a challenge where they can not have a continuous stream of lasers shooting).

One rule that was used in this project is the players most recent score will be logged. This means that many different players can be on top of the leader board. THIS NEEDS BETTER ENGLISH!!!!!!

3.1.3 How does the player increase their score?

The player increases their score by successfully shooting and eliminating an enemy spaceship. This will give the player a score increase of 10 points. This differs from the original implementation of Space Invaders where different enemies will give different values depending on their location. Low invaders will give 10 points, middle invaders will give 20 points and upper invaders will score 30 points. There is also a mystery ship that scores between 50 and 300 points.

3.1.4 How does the difficulty change as the game is played?

The game begins easy as all the values to be modified are at their default value. For every 100 points the player scores, one of these values will be randomly chosen and modified and changed. Because it is randomly chosen, the player won't know what values will be modified until it happens. See the appendix for a code snippet.

Another way that the difficulty changes as the game increases is that the players health never goes up as the game is played. This is in contrast to the original game where for every 1500 points the player scored, they would gain an extra life. This implementation does away with that mechanic as having a set health provides a survival challenge to the player.

3.1.5 What makes the game challenging to the player?

The challenge of this game is achieved by having the enemies randomly increase a value as the player scores more points. As the game progresses, they will become harder and harder to beat.

The other challenging part is the fact that only their most recent score will be saved. For example, if on one play through the player scored 1000 points, it would be saved. If the same player played again and managed to score 0 points, the 1000 points would be overwritten and saved with 0 points.

3.2 Database Design

When discussing database design for a Relational Database Management System (RDBMS) there are many different methods to decide what type of data should be stored in a table and how to determine their properties. Such techniques include finding properties such as:

- Super keys
- Candidate keys
- Primary keys
- Functionality dependencies
- Closures

With a NoSQL solution such as MongoDB, the same method is not as easily. Because of this, decisions had to be made about what types of data should be included. As previously discussed, MongoDB will handle creating unique primary keys which makes the task easier. Because this project has accounts user names and passwords are required. The possibility that two people will have the same user name is much less than the possibility that they have the same name.

At minimum, the database should contain user names and passwords. However, this is not enough information about the user. If something was to go wrong with the account or if the user wanted to delete their account, an email address would be needed. Although this could be achieved with a user name, the user name is public data which could result in other users deleting accounts which they do not own.

At minimum, that is the data the must be stored in the database. The next two data fields are used to collect data about how the player plays the game. As such, it is not as critical as the other data fields. Now a schema can be created for this data. As previously talked about, NoSQL does not strictly enforce this schema so other fields can be added to this. For the purposes of this project however, the schema will be enforced. This is achieved by not allowing the user to input any extra data than is needed. An example of what a document containing user data looks like is given below.

{

```
"_id" : ObjectId("58d106c002b9ed13e0dc37e3"),
"email" : "johndoe@gmail.com",
"username" : "JohnDoe",
"password" : "mynameisjohndoe",
"score" : 420,
"timePlayed" : 4.2
}
```

3.3 Website Design

The user interface of this website is as minimal as possible. This was decided upon for a number of reasons.

1. It will reduce confusion for new users about where to navigate to.
2. Because it will only display some user data and allow account creation, users may opt to use mobile devices to use this website. If there was too much to display, this would increase loading times for users and result in a negative experience.
3. Companies such as Apple strive for minimal design as it is pleasing to the user and reduces development time for different features. (developer.apple.com, 2017)

To achieve this minimal design, the leaderboard should always be displayed as that is the primary use of this website. The data should be displayed in a tabular format which will be pleasing to the user. The only data that will be displayed is the users user name, their current score and the total time they have played.

The second function of this website is to allow account creation. Because it is secondary, it should only be displayed if the user requests it. This means that there should be a button or text the user clicks to show a form of some sort. Within this form, there should be three text fields to input the some data (an email address, a user name and a password). To submit this data there should be a button which submits it. To appeal to the user, the content should be centered where possible.

To address the mobile issue, some Cascading Style Sheets (CSS) will be used. A framework that puts mobile content first is bootstrap, which will be used in this project. (getbootstrap.com/css, 2017)

4 Implementation

5 Testing and Evaluation

6 Conclusions and Further Development

7 Appendices

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