The University of Hong Kong
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Project: Open World Virtual Reality Role Playing Game

Interim Report
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SUMMARY

Virtual reality technology has received growing attention in the entertainment industry in recent years. Yet there are still numerous problems in areas such as locomotion method that affects the user experience in virtual reality games. Also, some genres including open world games are still unable to be well-supported by virtual reality technology. Hence the project team proposes to develop an open world role playing virtual reality game that is specifically designed to provide a more immersive experience to the player, along with an affordable and lightweight locomotion solution.

This report outlines the development process of the game, and investigates into the current problems of virtual reality games and their respective solutions. The project design and development process can be separated into three threads: (1) game development, (2) motion capture and (3) locomotion method. It then illustrates future plans for the project.

ACKNOWLEDGEMENT

This project is supervised by Dr. T.W. Chim. We would like to show him our gratitude for providing insights and expertise that greatly assisted our work. We could not finish this project without his guidance.
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1. **Background**

Virtual reality is the technology that uses computer generated sensations to replicate a realistic environment for the user. In recent years, various aspects of virtual reality have largely enhanced, for instance graphics and user interaction. However, there are still two major problems found in existing open world virtual reality games: poorly implemented in-game restrictions and logic, and lack of affordable and natural means of locomotion control.

In an open world game, there are often boundaries to restrict players from going out of the game map. However, many games use easy yet illogical implementation on these restrictions and rules. This adversely affects the immersiveness of game experience as players cannot perform actions they are normally able to perform in real life.

The use of unnatural navigation methods in virtual reality games would also largely damage the immersiveness of sensations and even cause motion sickness in some players. There are mainly two types of locomotion methods: artificial locomotion and real-world movement (appendix 7.1). Artificial locomotion makes use of controllers for in-game navigation, for example teleportation or mimicking of arm swinging movements when walking. Despite it is easier to implement these methods, they do not provide an immersive game experience. On the contrary, real-world movement locomotion solutions such as Virtuix Omni allow players to actually walk and move in a natural way on a static virtual reality platform. As the existing platforms are often large and expensive, most gamers are unlikely to purchase such platforms. Thus, although this solution provides the best and native immersiveness to players, the cost would adversely affect its dissemination.

The main purpose of this project is to develop an immersive open world virtual reality role playing game that can be accessible to the public. In order to achieve immersiveness, logical restrictions and gameplay rules should be implemented, and a control scheme that utilizes the lower limbs of able-bodied human for movement control within a virtual reality environment needs to be developed. This means the project includes platform and hardware development.

2. **Objective**

2.1. To explore the possibility of teaching selected set of skills using virtual reality.
2.2. To design an open world game dedicated for virtual reality gaming.
2.3. To implement a cheap solution for open world virtual reality gaming.

3. Methodology

In this project, the game will be run on a computer and streamed to the mobile phone in the VR headset via a Virtual Reality streaming application called KinoVR. A set sensor set will be chosen to capture player movement on the platform and use the data as control input. Hence, the deliverables of the project are divided into three major parts: the game, motion capture system, and motion platform.

3.1. Game

First, the Team will analyze the permitted movements inside the game, and derive the logical restrictions to be implemented. After control mechanics are established, the key elements of the game will be identified, for instance: tutorial, story propagation mechanics, tasks. Details of the elements will also be drafted.

Then in the design phase, the game story and conception of the game world will be written based on the decided mechanics and key elements. Graphic design and character design will also be involved. After designing, the Team will carry out a full review to evaluate the progress.

The development phase will start right after the design phase. Based on the past experience, the Team will choose Blender and makeHuman as the 3D modeling tools, and the game engine Unity 3D as the major development platform. The game will be divided into modules and developed accordingly. The modules should be of the scale suitable for one to two developers. Functional descriptions are to be highly valued and
monitored to lower the risk in the implementation phase. Individual testing shall be carried out for each completed modules and their related modules.

After development, the product will be tested. According to the result of testing, the Team may resume to the development phase to make modification until the product pass all the test cases.

3.2. Motion Capture

Different motion capture methods will be investigated for their suitability on the project. Criteria includes latency, size, capability, cost, obstruction to player, Unity support.

Selected motion capture method will be further investigated by prototyping and testing using a selected set of movements. If the method past this stage, a testing environment will be built to test its performance in open world scenario.

If the method passes all the tests, an user play test will be carried out with potential audiences, player response will be collected and evaluated.

3.3. Motion Platform

Posture study will be carried first to investigate how the human body perform several movements and the space requirement for the game’s motion.

A draft design of the platform will be produced and small scale prototyping will be done. Adequate adjustments shall be made as the team sees fit, based on safety concern and production difficulty.

Safety testing shall be conducted including load capability and potential injury situation. Related professionals shall also be consulted and adequate changes shall be made to ensure the safety of the player.

User play test will be carried along with the motion capture parts to ensure smooth integration of the two components.

4. Current Progress
4.1. Game

Limited by the development period of the project, only alpha version of the game, which only includes the survival tutorial and first scene of main branch story, will be developed by the end of the semester.

Story Background

With a survival background, we have designed a general background and main story of “Powerless”. The virtual world of the game is running out of energy source to generate electricity. The upper-class dominant the use of energy and only provide few batteries to the lower-class if the lower-class worked hardly for a day. The wall surrounding the city has separated the people of two classes.

The player was originally an upper-class citizen, but he was thrown out of the town because he wanted to fight for energy fairness. Hence, the player has to survive outside the city and to initiate a revolution to fight with the upper-class.

As we employed branching storylines of our game, we are currently planning the storyboard for main branch of story (See appendix 7.2). Other branches like hidden plot and minor missions will be designed in the beta game development phase.

Game Mechanics

For developing the survival tutorial, we are currently focusing on the survival system of the game. Combat system and other vital game mechanics will be designed and implemented in the next phase of development.

The implementation of the survival system is composed of three main factors, namely hunger, thirstiness and health. Hunger and thirstiness are just simple magnitudes for measuring the need of food and water of the character. The values of these two factors will decrease steadily. Only items that categorized as food or drink can increase the values. If either one of the values dropped to zero, the character will die.

The health system is more complicated. The character will be divided into 6 main parts to observe the health, including head, body and four limbs. Each part will be either classified into 5 status, namely healthy, minor injury, major injury, seriously injured and
dead. Different status at different parts will cause debuff for the character. In addition, low value in hunger and thirstiness will result in worse body health status.

<table>
<thead>
<tr>
<th></th>
<th>Minor injury</th>
<th>Major injury</th>
<th>Seriously injured</th>
<th>Dead</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Head</strong></td>
<td>Decrease combat status</td>
<td>+ Blurred Vision</td>
<td>+ Slow movement</td>
<td>Game Over</td>
</tr>
<tr>
<td><strong>Body</strong></td>
<td>Decrease combat status</td>
<td>+ Slow movement</td>
<td>+ Blurred Vision</td>
<td>Game Over</td>
</tr>
<tr>
<td><strong>Limb</strong></td>
<td>Slightly slower movement</td>
<td>Slow movement</td>
<td>Very slow movement</td>
<td>No response</td>
</tr>
</tbody>
</table>

(Table 4.1) Relation of Health Status and Debuff

To survive under the survival system, player must learn some survival skills through tutorials to recover the parameters of hunger, thirstiness and health.

<table>
<thead>
<tr>
<th>Tutorial Items</th>
<th>Survival Factor(s) Related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finding a Shelter and Dealing with Wild Animals</td>
<td>Health (indirectly by preventing dangers)</td>
</tr>
<tr>
<td>Hunting and Food Collect</td>
<td>Hunger</td>
</tr>
<tr>
<td>Water and Resources Finding</td>
<td>Hunger, Thirstiness</td>
</tr>
<tr>
<td>First-aid Basics</td>
<td>Health</td>
</tr>
<tr>
<td>Crafting Tools</td>
<td>Health (indirectly by facilitating other activities)</td>
</tr>
</tbody>
</table>

(Table 4.2) Game Survival Tutorial List

**User Interface**

User Interface components such as player status bar and game menu were added to the game. Players were allowed to use the game menu by keep the cursor on the button for a short period of time.

**Character Models and Animation**

With regard to the setting of the game story, the Team drafted and made the 3D models of some of the important characters in the game with makeHuman. After reviewing the models, the Team found the design of one of the character did not suit the background setting of the game story, the Team decided to modify that design. Other
character models were exported to Unity 3D in the format of Filmbox which can be used directly in Unity 3D.

After importing character models, suitable animations were chosen and the animation controller was added to the non-player character models, so that the models can do a series of preset actions. As the player character was supposed to move according to the motion capture, no animation implemented to it.

### 4.2. Motion Capture

After researching on various motion capture system, we had initially chosen Noitom’s perceptive neurons for our motion control purpose. It is an accurate and adaptive motion capture solution that uses small pieces of IMU for motion sensing. It also provide a library for unity development that would ease our integration process. However, the system costs USD 799, which is out of our budget range. So we chose another equipment, Kinect.

Kinect is a motion-sensing input device made for Xbox gaming. It uses webcam style peripheral and allows user to interact with the computer without any controllers or IMU attached to the player. But its reaction time is a bit slower than perceptive neurons. And the main problem is, as data analysis is done on 2D images, some player actions such as turning around maybe not be detected. The integration of Kinect data into our game is yet to be investigated and tested.

### 4.3. Motion Platform

Posture study was conducted and it was concluded different sizes would be needed for different body build, since the step length varies accordingly and thus the size of the platform. The team decided to build a medium sized platform for proof of concept.

The draft for such platform was then produced with length specifications. Hardware team proceed to build a small scale prototype of the platform without mechanical parts and revision of the design was conducted. The current iteration of such prototyping process was the fifth iteration and was proceeding to build a full scale platform for further safety assessments.

### 5. Future Development
5.1. Game

Game Mechanics and Tutorial

In the next phase of the development, we will try to implement the survival tutorials and the combat system of the game.

The survival techniques provided in the tutorials are one of the main feature of the game, which allows the players to learn how to survive in wild world under a safe virtual environment. For example, we will teach the player how to deal with wild black bear. Players should wave their arms slowly and walk slowly away from the bear. Once detected the player move quickly and run fast, the bear near by will automatically attack the player. Some other similar logics related to survival will be implemented in the coming development period.

For the combat system, we will adopt the general RPG character status system with health point (HP), skill point (SP), strength (STR), agility (AGI), vitality (VIT) and intelligence (INT) for quantization of attacks. Different from RPG with fantasy background, the game will not have any magical elements and the INT value will only affect the quality of skills learned. Leveling system will not be employed to give a more realistic survival environment. We will design a set of training actions for players to improve their character status.

As a VR based survival game, the combat system will be adjusted to cope with the control scheme supported. We are now only allowing some simple attack actions, like punch and kicking, limited by the motion capturing system. In the next phase, we are going to design the game mechanics to allow more attack actions, and the formulae for calculating the magnitude of injury taken.

Props Model

The Team will then prepare the models of the props which will appear in the game world, for example, weapons, food and torches. The models can be from assets store of Unity 3D or modeled with Blender.

Playtesting
Playtest will be carried out by inviting potential players based on the game’s target audience. Source of such players can include friends and family of the team, but must also include a significant portion of strangers to ensure fairness of the comments.

Testing will be conducted on the four criteria: information delivered, control scheme, aesthetics, and stage design. A tutorial stage and an alpha testing stage will be produced for the testing with tasks to guide the player through the playtest. A free-roam will be allowed after the guided test for the player to experience the open-world setting.

5.2. Motion Capture

More tests are needed to understand the features of using Kinect as our motion capture system. We will need to acquire a Windows Kinect adaptor to transmit the data from Kinect to the computer. We will also need to integrate the data into Unity development with Microsoft Kinect SDK.

Since it is hard to use Kinect to detect turn-around-action of the player, we might use head-tracking of the mobile phone to control the player turning movement instead. The rest of the game model movements will be controlled by data collected from Kinect.

5.3. Motion Platform

Safety Assessment

Loading test will be carried out using weighted backpacks, on the restraining rod and the platform floor.

One potential injury would be the player falling on his/her back and hitting their head to the vertical pole, which may cause impalement and serious injury. After consulting mechanical and posture professionals, a tester should try to fall on his/her back and see if the restraining rod performed well on preventing the player from hitting the pole.

Structural integrity will also be investigated after a playtest to assess the structural strength of the platform.

6. References


7. Appendix

7.1. Comparison between Locomotion Methods

<table>
<thead>
<tr>
<th>Description</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTC Vive</td>
<td>Movement determined by location of controllers within 16x16 foot, no locomotion control implemented</td>
<td>- Immersive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- No motion sickness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Simple setup &amp; implementation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Player can only move in a 16x16 foot area in virtual environment</td>
</tr>
<tr>
<td>HTC Vive - Teleport</td>
<td>Point at a location and your “body” will be transported there</td>
<td>- Fast exploration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Usable in small gaming space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Does not require sensors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Not how people move in real life</td>
</tr>
<tr>
<td>HTC Vive - Run in place</td>
<td>Player runs in place, sensor detects arm movement while controllers determines direction</td>
<td>- Usable in small gaming space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- More immersive than teleport</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Unnatural movement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Motion sickness</td>
</tr>
<tr>
<td>Virtuix Omni</td>
<td>A treadmill that allows user to walk/run on, a set of sensors will detect movements of body</td>
<td>- Highly immersive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Expensive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Equipment large in size</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Player cannot crouch</td>
</tr>
</tbody>
</table>

7.2. Storyboard of Main-branch Story
Scene 1: The Hidden Secret
Player reveal some of his memory, and found that he is the son of leader of former ruling party of the city.

Tutorial
Learn survival skills in tutorials.

Scene 2: Rebuild
Player go to meet some old members of the former ruling party and seek help from some NPC.

Scene 3: The Walled-City
Player decided to secretly join the party of upper class in the city and steal the information of power plant.

Scene 4: Growth of Leader
Player strategically accept the sub-missions provided by NPCs to gain popularity among the lower-class.

- Stolen the design map and key of the power plant.
- [Hidden Branch]
- [Game Over]
- [Multiple Branches according to the decision of the player]