VIRTUAL REALITY SIMULATION FOR MOTION SICKNESS

By

Maruf Hossain
19341024

A thesis submitted to the Department of Computer Science and Engineering in partial fulfillment of the requirements for the degree of
Bachelor of Science in Computer Science

Department of Computer Science and Engineering
Brac University
Sep 2019

Declaration

It is hereby declared that

1. The thesis submitted is my own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I have acknowledged all main sources of help.

Student's Full Name & Signature:

Maruf Hossain
19341024

Approval

The thesis/project titled "Virtual Reality Simulation for Motion Sickness" submitted by

1. Maruf Hossain(19341024)

Of Summer, 2019 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Computer Science on [26/15/2019].

Examining Committee:

Supervisor:
(Member)

Dr. Md. Ashraful Alam
Assistant Professor, Department of Computer Science and Engineering
BRAC University

Program Coordinator:
(Member)

Dr. Jia Uddin
Associate Professor, Department of Computer Science and Engineering
BRAC University

Departmental Head:
(Chair)

Mahbubul Alam Majumdar, PhD
Professor and Chairperson, Department of Computer Science and Engineering
BRAC University

Abstract

Motion sickness, sea sickness and flight sickness are some of the common phenomena are faced by many. However this type of sickness can be treated through regular encounters of different situations which trigger such sickness. Such situations can be virtually created with the help of VR technologies. My proposal was to design a game like virtual environment where situations are virtually created to trigger motion sicknesses which can then be gradually overcome while playing the game. The game generates a video output for the left eye and the right eye to give a stereo graphic effect which generates the virtual reality. The devices we may need to experience such environments are a graphics card with powerful rendering attributes and VR headsets for HTC vibe, Google cardboard or Samsung Oculus.

Acknowledgement

Firstly I need to express gratitude toward Almighty and also my thesis advisor Dr. Md. Ashraful Alam for his valuable guidance, feedback and support till now. Lastly my parents, friends and teachers were a big help during my thesis.

Maruf Hossain

Table of Contents

List of Tables, Charts & Graphs

List of Figures

Chapter 1

Introduction

1.1 Motivation

The main objective of this proposal is to create a virtual environment with elements which can trigger their visual senses to gradually experience motion sickness. The proposed model is designed for Virtual Reality of both smartphone devices and Computers. I have tried many virtual reality games and felt motion sickness while playing. From my experience I learned when it comes to virtual reality it is a very common problem. Motion sickness occurs as a result when people's sense feels disagreement between expected motion and motion that is actually experienced. One third of world's population suffers from motion sickness. So I wanted how to overcome the problem because a large number of people are facing the same problem. It is an issue to that has the necessity to be solved.

1.2 Overview

Virtual Reality has become a fairly new subfield of visual imagery. My area of work offers image processing for head-mounted displays along with the idea of having internal motion sensors for depth navigation. Previously Virtual Reality worked with the 360° surround view, and now we are intending to establish the ground where not only to work with the surround view, but also to go in depth and navigate to certain extends of depth using extra information extracted from the image. It is important we explore the possibilities of Virtual Reality for a better experience of view or simulation that can have multiple real life applications. For investigations, scientific research, multimedia and different kind of simulations, it has lots of applications.

1.3 Contribution Summary

Explaining what my project is meant to achieve, this paper will contribute in two ways: It will analyze how to invoke motion sickness in virtual reality applications, and how to avoid motion sickness from occurring. Both of this may contribute to further improve future virtual reality applications.

The remaining paper as follows: section 2 represents the Literature Review. Section 3 represents the evaluation procedure. Section 4 shows Implementation and Results. Section 5 concludes and presents future directions.

Chapter 2

Literature Review

There are several researches on motion sickness due to virtual reality environment. Each of them comes up with different approaches. My work is heavily influenced by earlier work of motion sickness and visual displays. According to a work there preliminary review synthesizes the available experimental evidence regarding the effects of VR exercise on anxiety- and depression-related outcomes. Findings favor VR exercise, as this small group of studies indicates improvements in mental health for those who had these two mental disorders. Yet, the paucity of literature on this topic and the need for higher-quality study designs among large samples necessitates further research prior to large-scale implementation of VR exercise treatments for anxiety and depression within clinical settings [1].

Another research sates that virtual reality technologies have been associated with motion sickness for more than 20 years. It is widely accepted that women are at greater risk of motion sickness than men. Documentation of these sexist effects, as in the present study, can motivate manufacturers to search for design changes that eliminate the discriminatory effects. Our results, together with those of Koslucheretal, suggest that solutions may be found by addressing aspects of design that influence user's ability to stabilize their own bodies [4].

Another research says that the theoretical foundations to unify the results for cyber sickness are lacking. This is a consequence of having a large number of potential factors which have spread experimental results out of necessity. This has limited the ability to create guidelines for any particular virtual environment implementation. Moreover, though there are few cross-display studies, these studies generally report differences among the displays, which results in a broad set of guidelines for virtual environments being unlikely in the near future. [5].

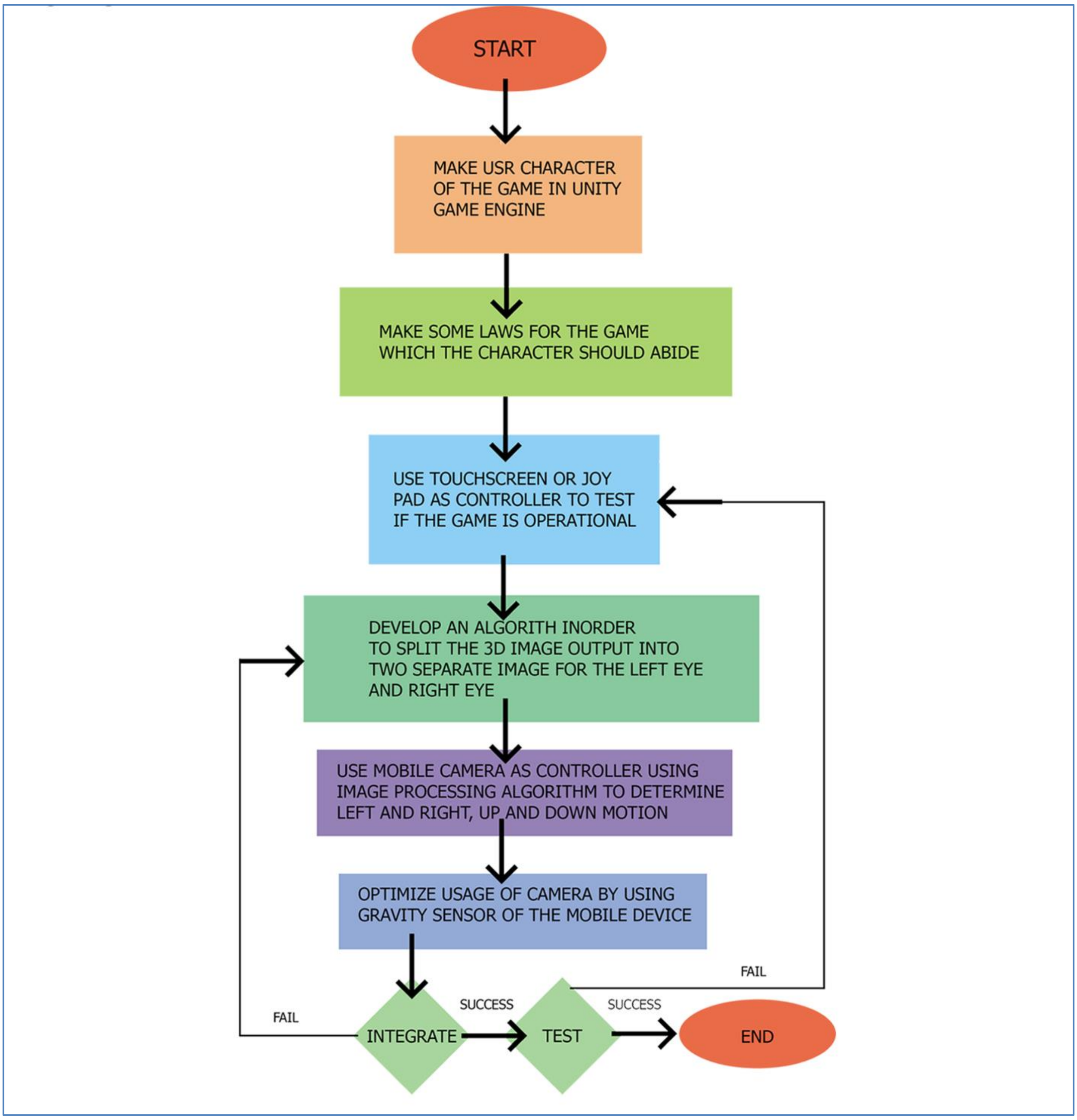


Figure 2.1 Work flow

Chapter 3

Proposed Model for Simulation

3.1 Motion Sickness in Virtual Reality Environment

Motion sickness occurs as a result when people's sense feels disagreement between expected motion and motion that is actually experienced. There are many theories about the real causes of Virtual Reality motion sickness and differences in how individuals use vision to maintain their balance may be one contributing element. The biggest contributing factor is thought to be caused by the sensory conflicts that send confusing messages to the brain. This is because even though the person's eyes may say they are walking around a virtual world, their body will tell them that they are actually sitting down and those conflicting sensory signals cause a feeling of illness. A pronounced feeling of illness typically occurs when the viewer is watching a digital representation of themselves appear to move quickly in a digital environment while the person's physical body remains stationary [27].

The physiology behind VR disorder isn't presently unmistakably comprehended. Luckily, researcher has revealed some reasonable signs of specific conditions that determine VR sickness. It appears that the pictures anticipated from computer generated reality majorly have impact on sickness. The refresh rate of on-screen pictures is regularly not sufficiently high when VR ailment happens. Since the revive rate is more slow than what the mind forms, it causes a disagreement between the handling rate and the refresh rate, which makes the user see glitches on the screen. At this point when these two segments don't coordinate, it can make the user experience the same feelings as simulator and motion sickness [28].

3.2 Developed System

To achieve my objective I developed a virtual reality simulation which has different sets of motion sickness invoke levels where people act and fill differently based on their situation and tolerance level. The motion sickness appears whenever brain gets the idea that it's moving because of the data from the eye but body is not moving at all.

3.3 Virtual Environment

I made a VR game called THE HAUNTED ISLAND as a simulation for motion sickness to invoke. There are different types of camera behavior and different types of motion behavior as well. Constant velocity and different acceleration combined with voluntary movement and involuntary movement did the invocation of motion sickness. Voluntary movement and involuntary movement of the camera and a constant velocity on the first person shooter was used to induce and reduce motion sickness. Making the enemies come from different direction did made an impact on making people dizzy. Lastly making the uses focuses on so many different targets did put a great pressure on the eye. Fig 3.3.1 gives a visual idea of the different camera movements

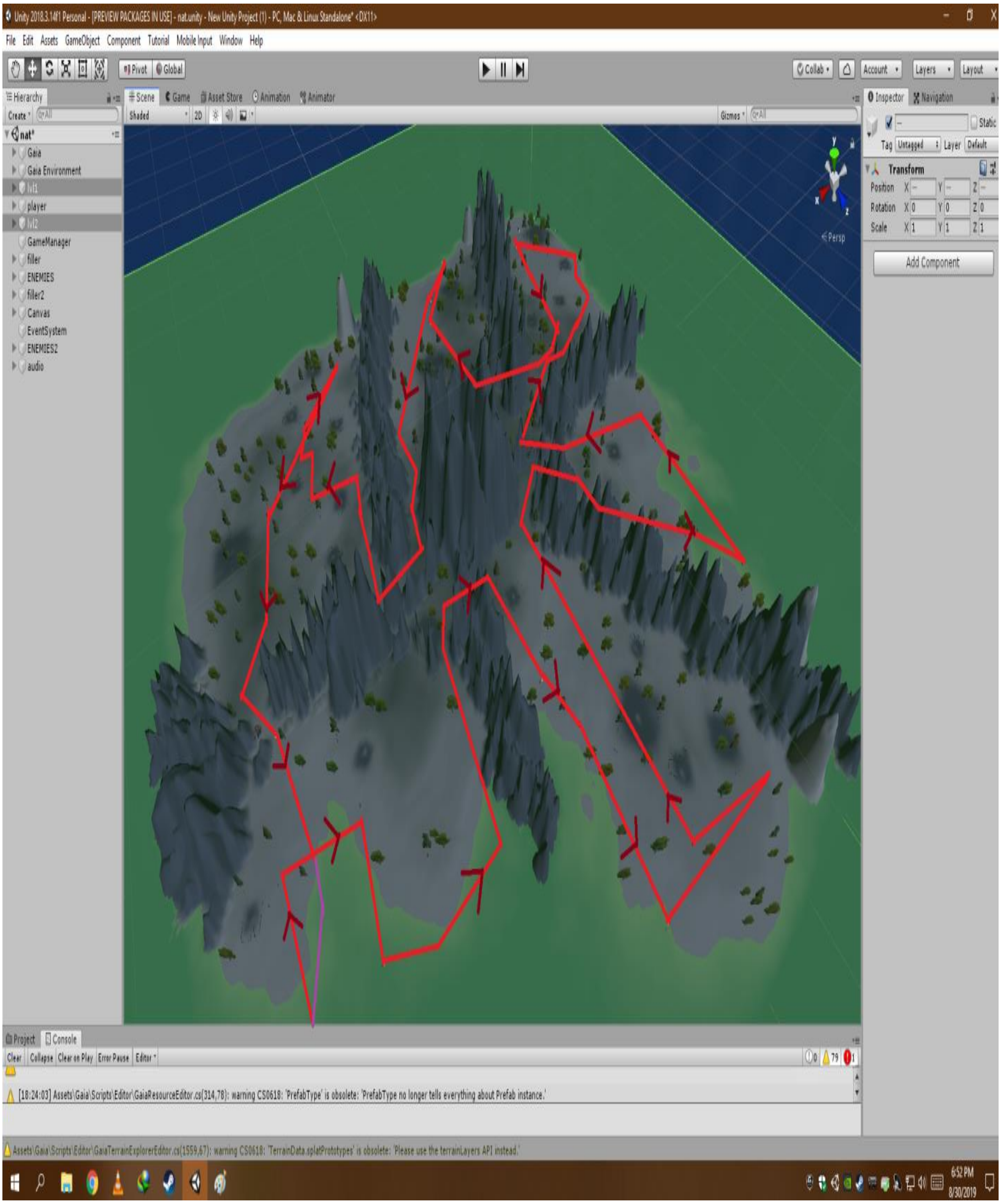


Fig 3.3.1 involuntary movement

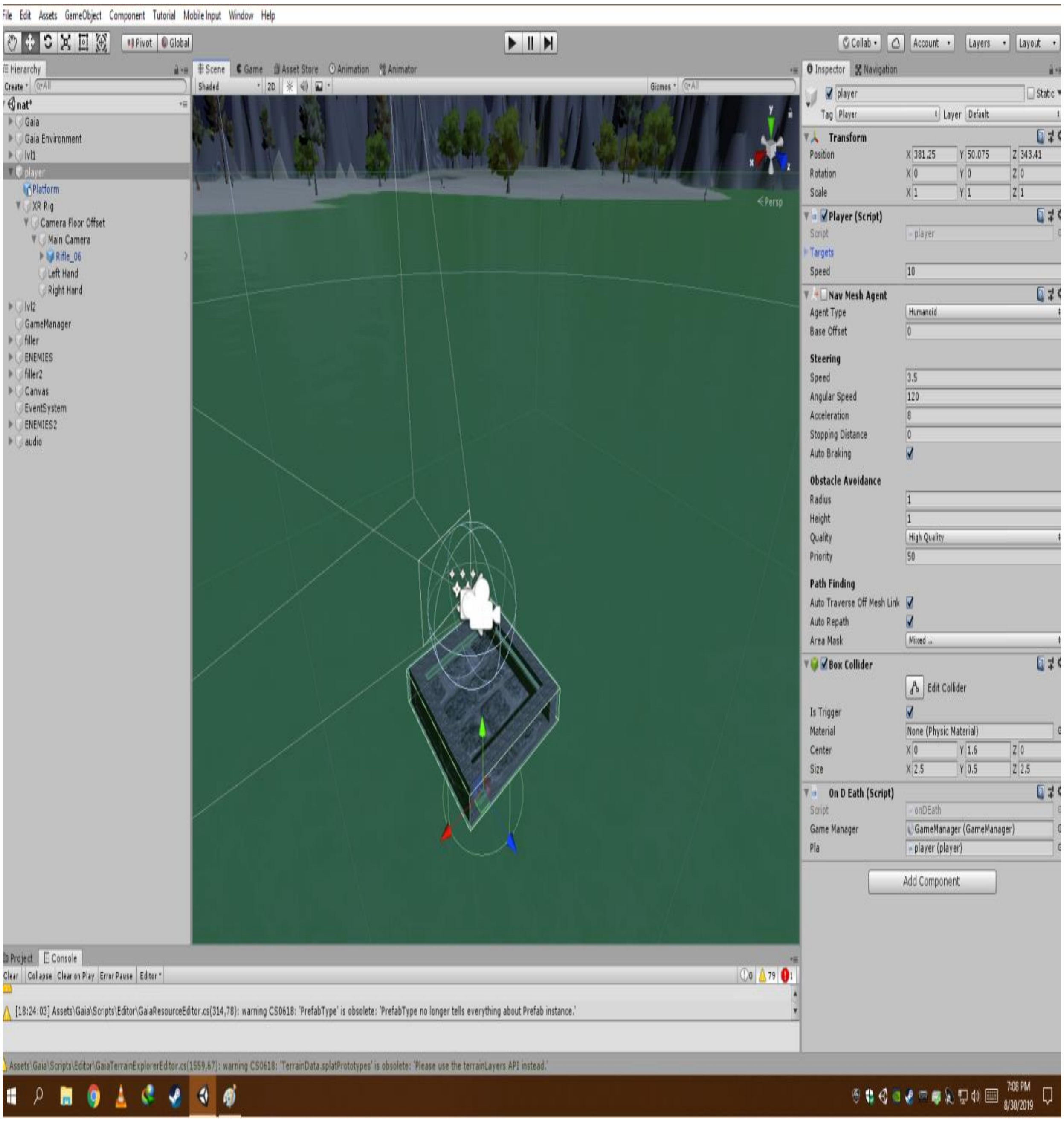


Fig 3.3.2 voluntary movement (FPS)

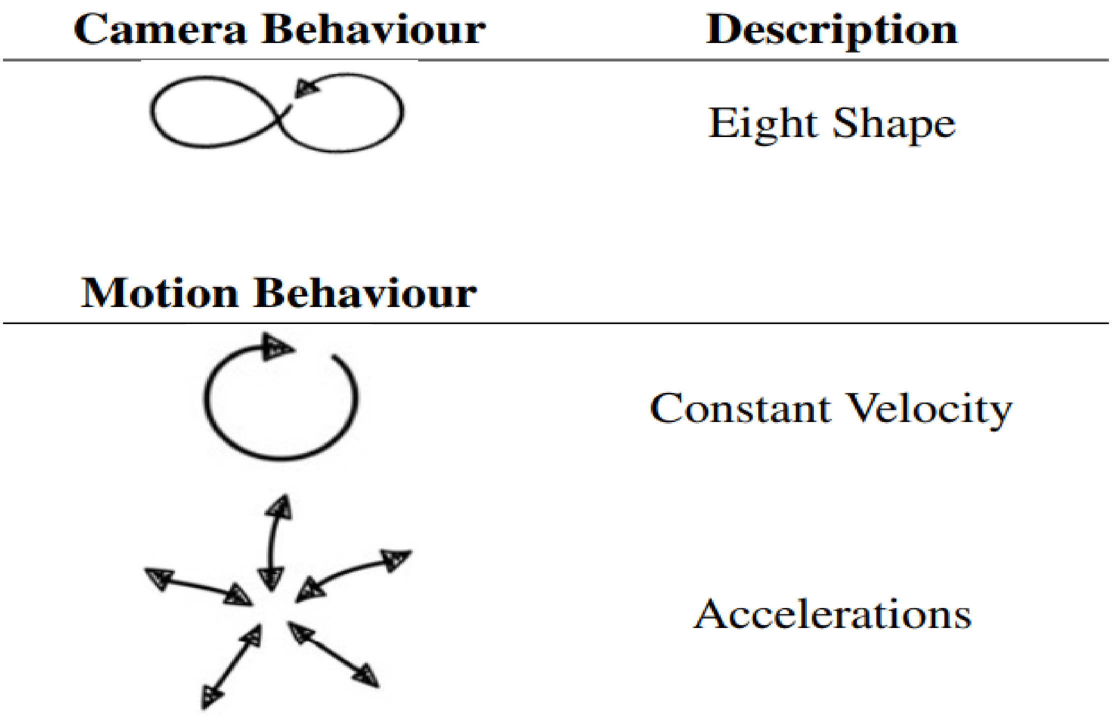


Fig 3.3.3 Camera Movements

Fig 3.3.4 User point of view

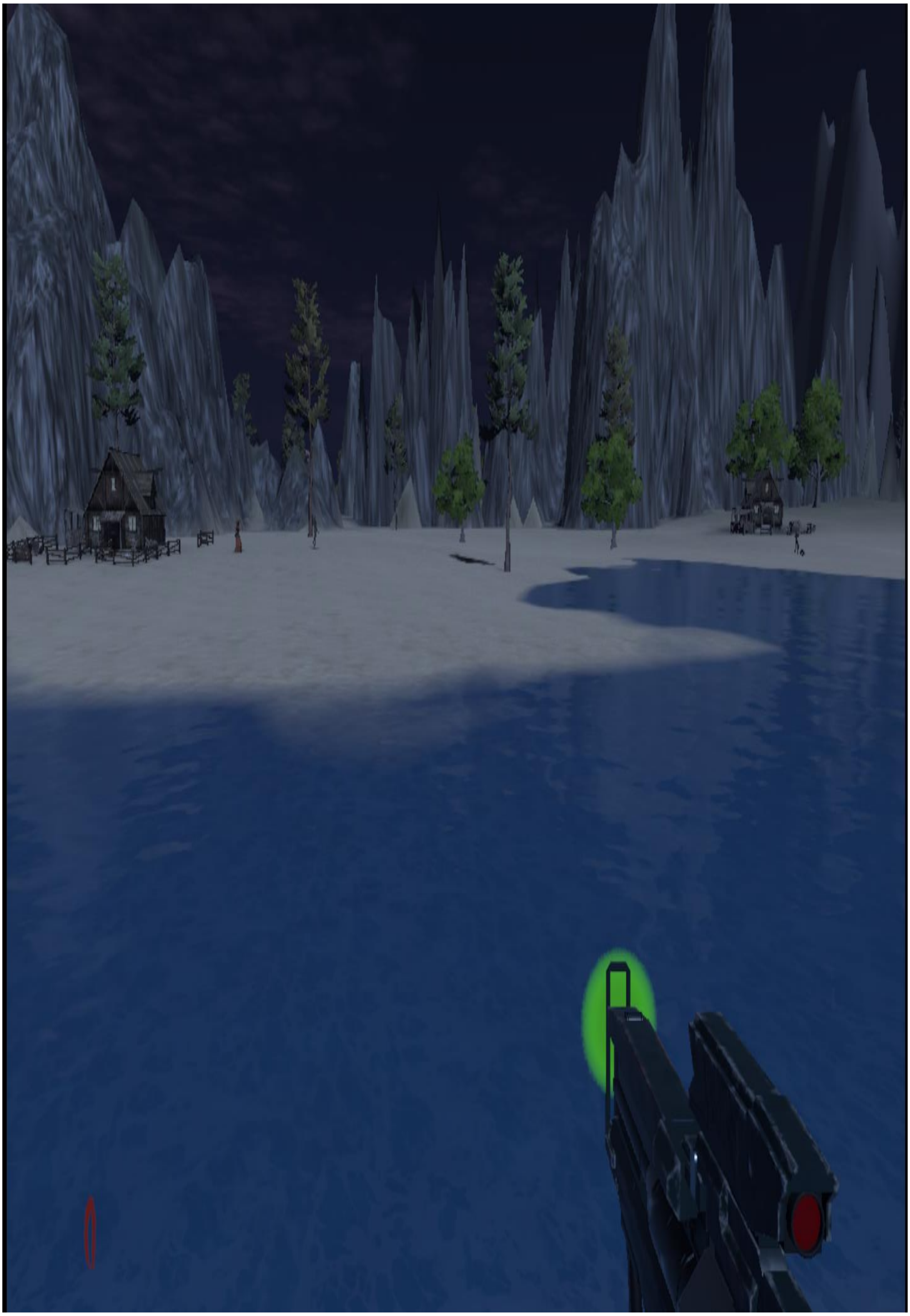


Fig 3.3.5 User point of view

3.4 Physiological Data

While playing the game we realized that the game is affecting various people differently. Because of the difference in their tolerance level for motion sickness different types of events occurred. There were many who felt slide changes in their physiology, when asked we got many answers such as sick to the stomach, faint like, annoyed, irritated, Sweaty, Queasy, Lightheaded, Drowsy, clammy, cold sweat, Disoriented, tired, fatigued, Nauseated, hot, warm, Dizzy, Spinning, Vomit, Uneasy are all the different statement we collected. After observing so many different statements we decided to use thermometer to check thermal changes inside the body and also use heartbeat reader so that we can detect the changes in the heartbeat rate of different volunteers. Based on the different result we came to an conclusion that all the symptoms that are occurring during the tests such as dizzy ness, drowsy ness, heart rate high, temperature up, annoyed, sweaty, Nauseated, Spinning, Uneasy and in some cases Vomit are all related to the symptoms of the motion sickness. After playing the game people felt disoriented for some time, it took at least 1 minute to recalibrate their brain . By making people experience different type of motion and acceleration as well as voluntary and involuntary camera movement I decided to make a survey list for all the symptoms and also decided to measure up the intensity level for their physiological changes. As the intensity of motion sickness of our realty is very mush superior to the motion sickness felt in VR the intensity level felt by the volunteers becomes inferior compared to the real life experience. We realized that it has around half of the intensity felt in real life. Depending upon the statement of the symptoms in order to find different intensity levels I devised a survey where intensity levels would be measured in a scale of 0 to 9, where 0 stands for very mild and 9 stands for extreme.

Different statement, symptoms, temperature and heartbeat rate directed me to a conclusion for the survey list, below are the 16 symptoms that were felt during an attack of motion sickness.

1. Sick to the stomach

2. faint-like

3. annoyed/irritated

4. Sweaty

5. Queasy

6. Lightheaded

7. Drowsy

8. clammy/cold sweat

9. Disoriented

10. tired/fatigued

11. Nauseated

12. hot/warm

13. Dizzy

14. Spinning

15. Vomit

16. Uneasy

Chapter 4

Implementation and Results

4.1 The development of the terrain

There is an asset in Unity game engine called "GAYA" which was used to design the terrain. Such assets are external libraries in Unity. In order to use these assets we need to import them from asset store in Unity. The elements created using Gaya are as follows:

I. Sea
II. Island
III. Mountains
IV. Different game Objects (house, rocks, farms etc.)
V. Texture
VI. Trees
VII. Global lighting probe
VIII. Ambient effects
IX. Directional Light
X. Shadow effect
XI. Global reflection probe
XII. Sky box
XIII. Underwater effect (sound and visual)

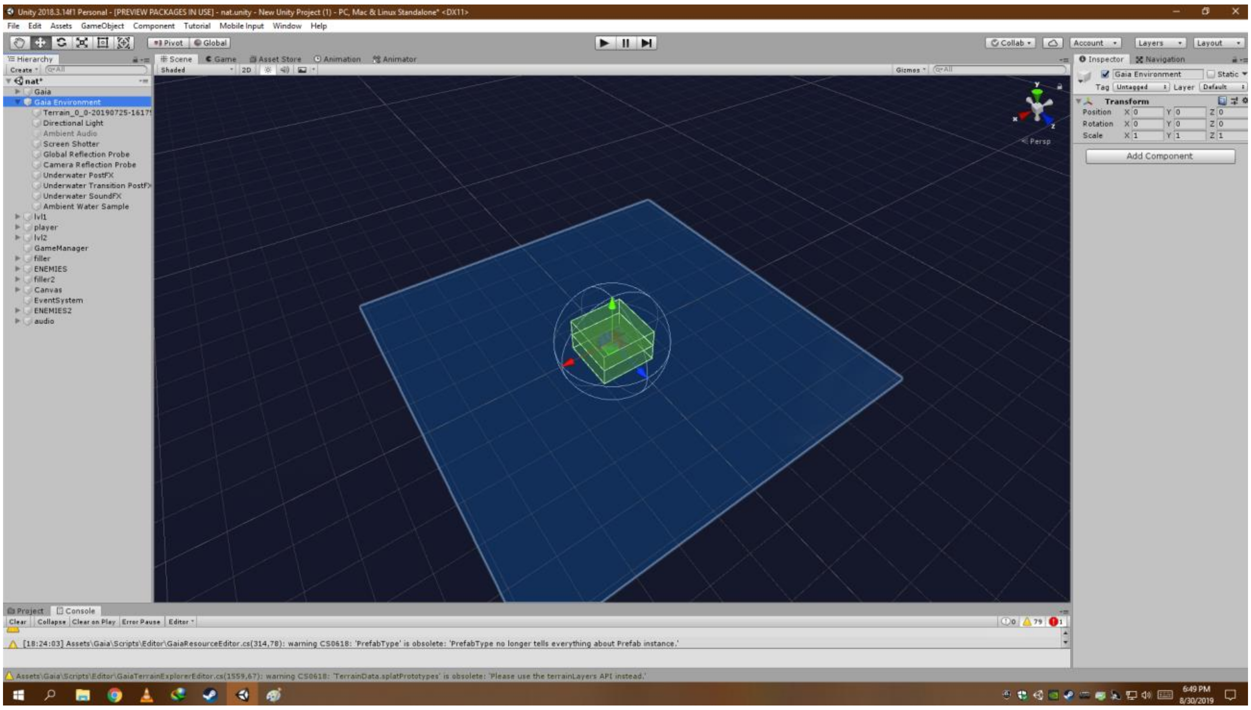


Fig 4.1.1: Gaia Environment

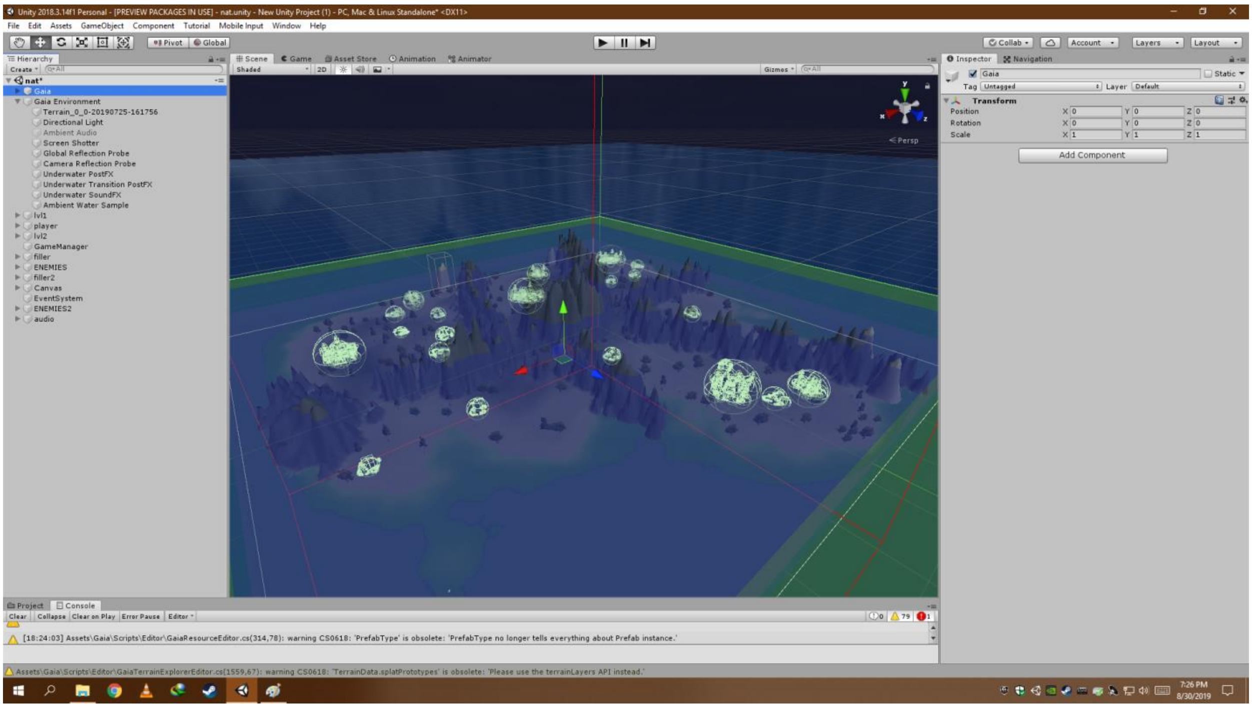


Fig 4.1.2: Gaia Environment

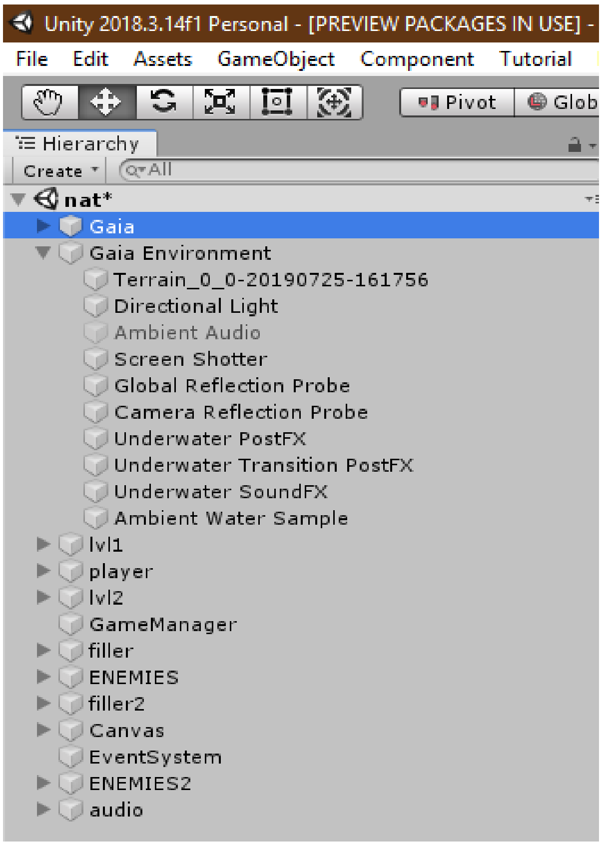


Fig 4.1.3: Game Environment Components

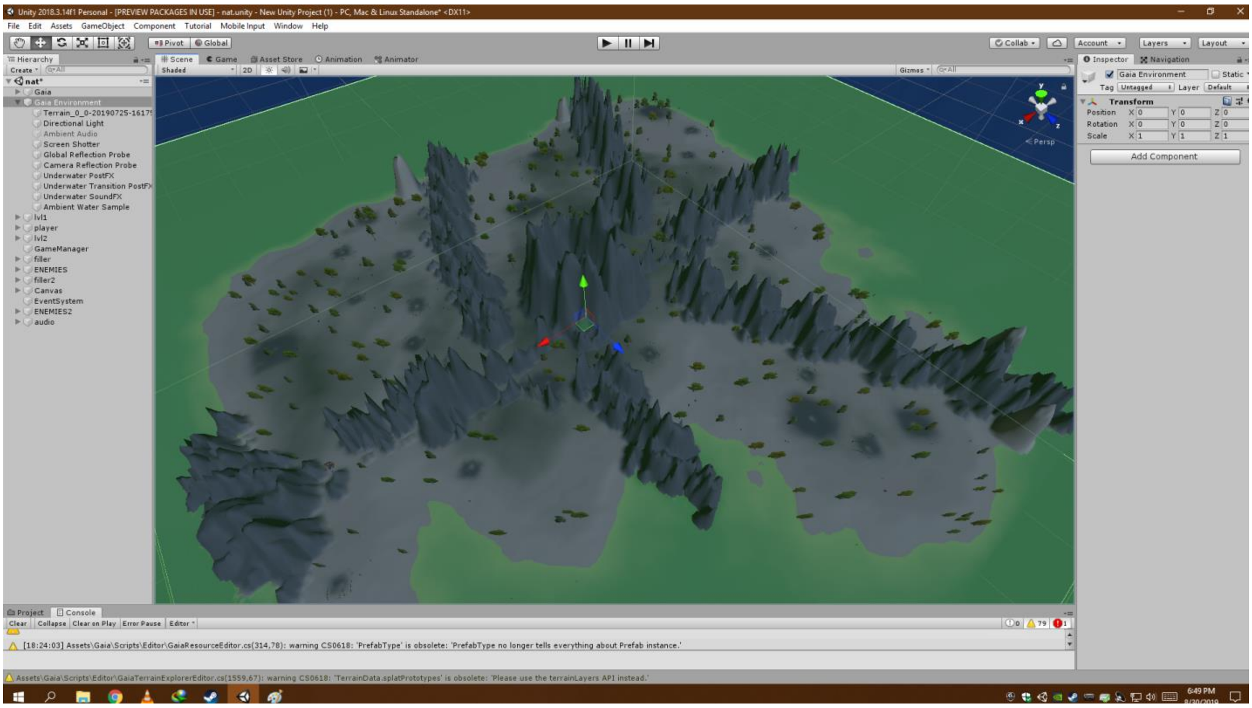


Fig 4.1.4: Terrain

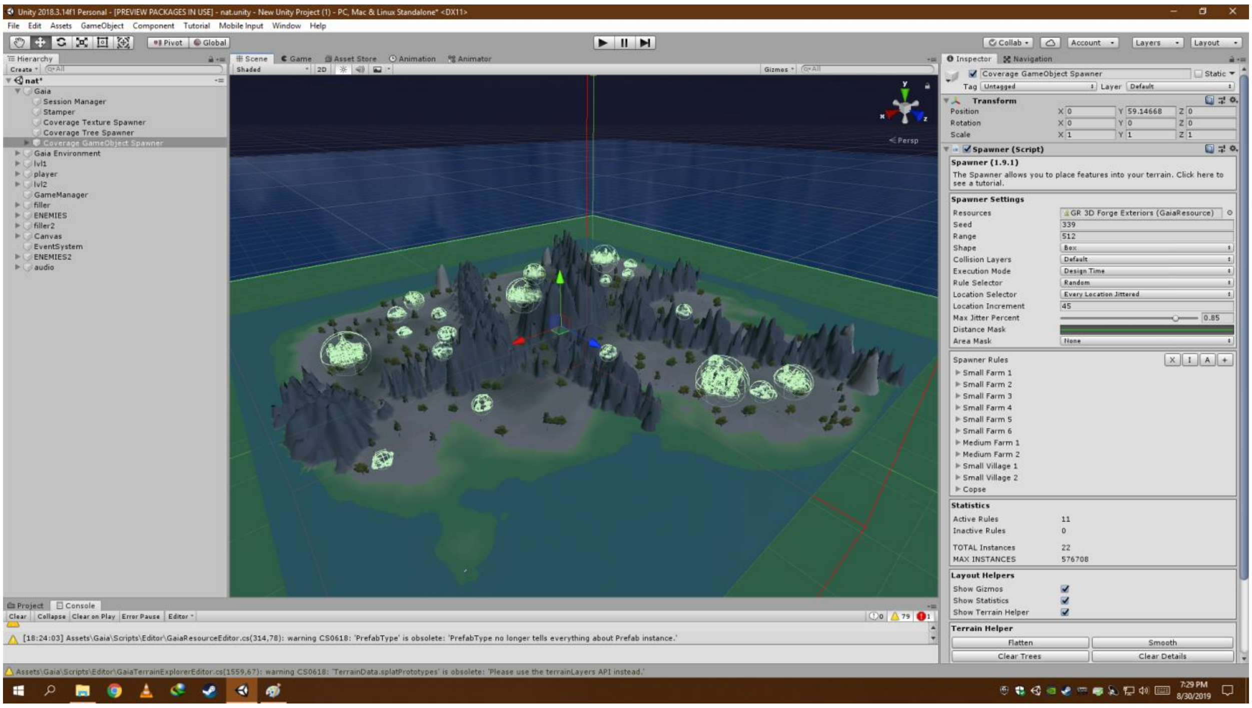


Fig 4.1.5: Terrain Game Object

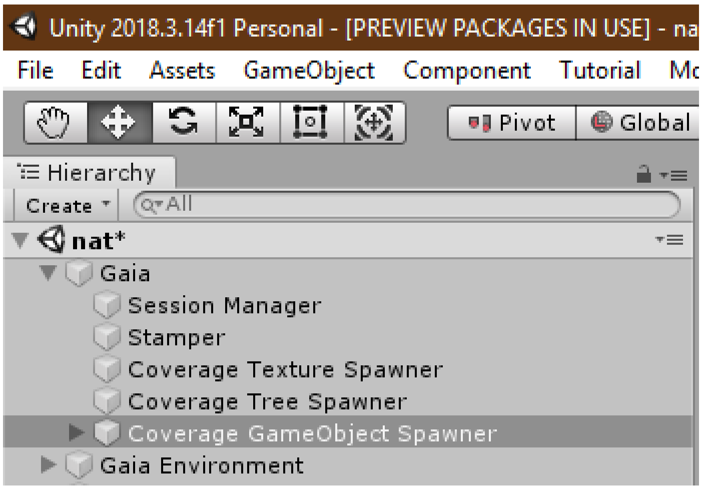


Fig 4.1.6: Game Object Spawner

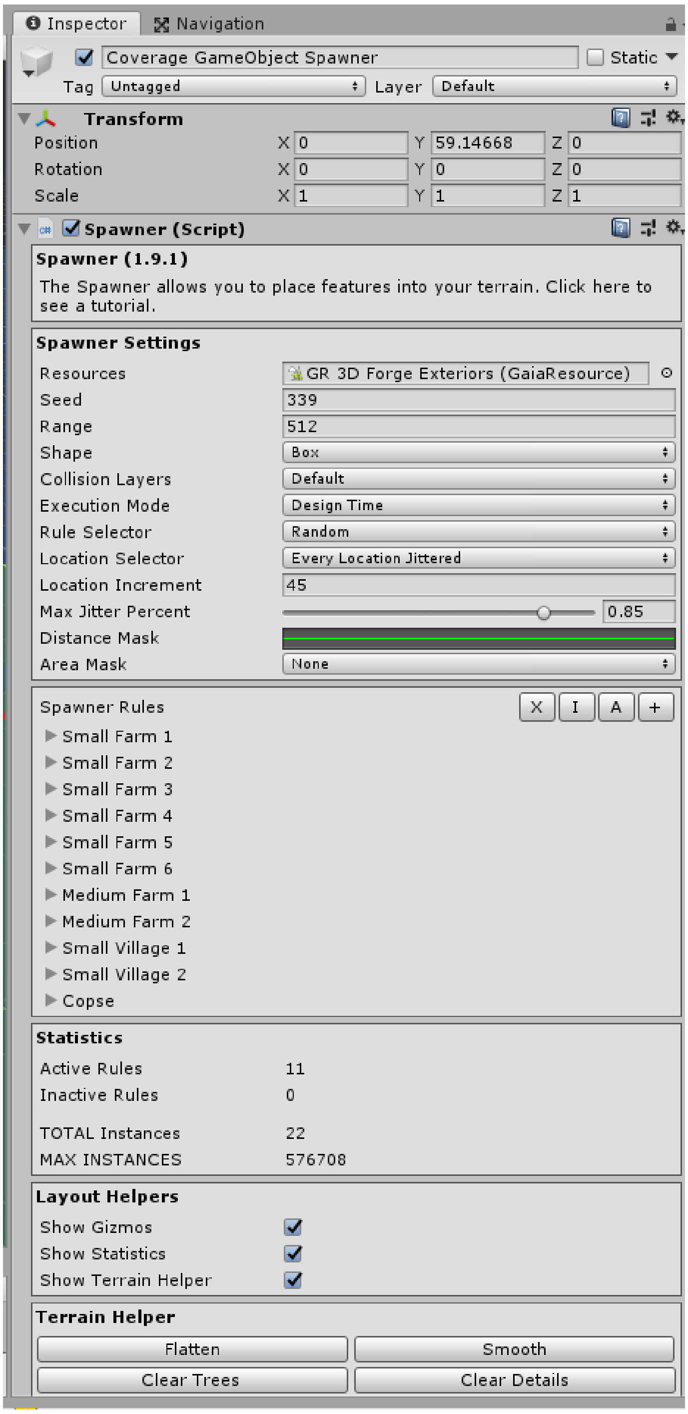


Fig 4.1.7: Game Object Spawner

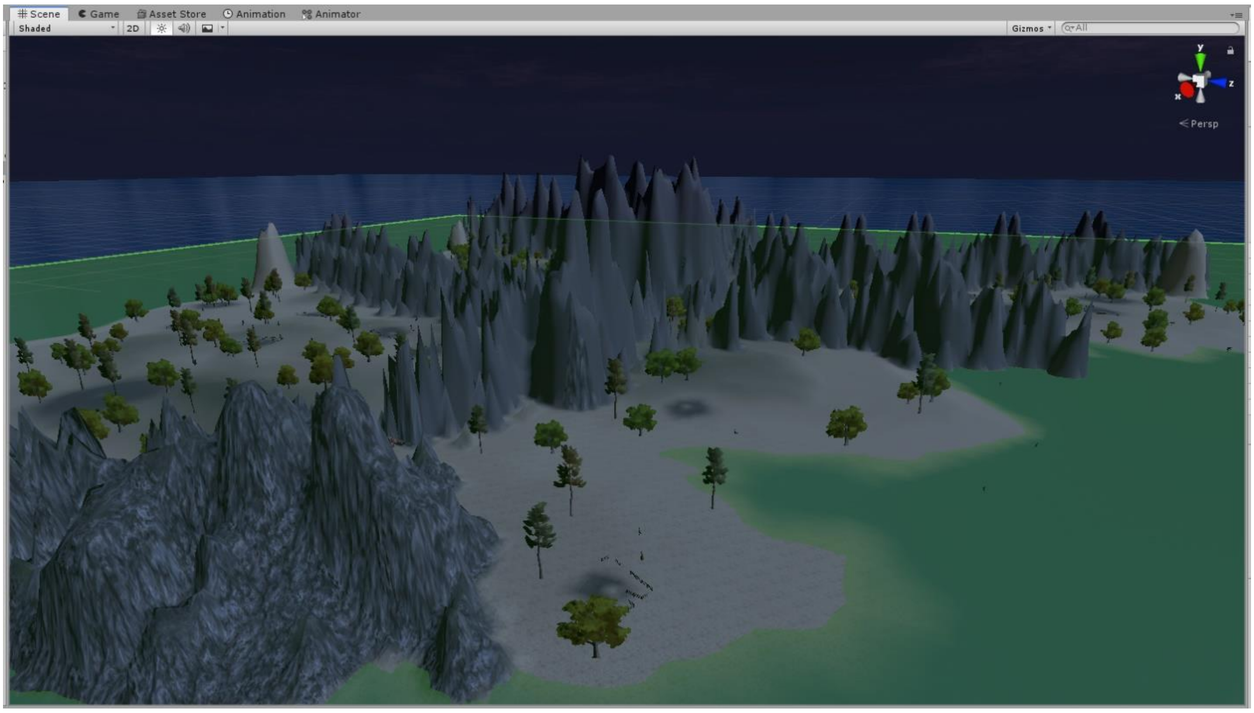


Fig 4.1.8: Terrain

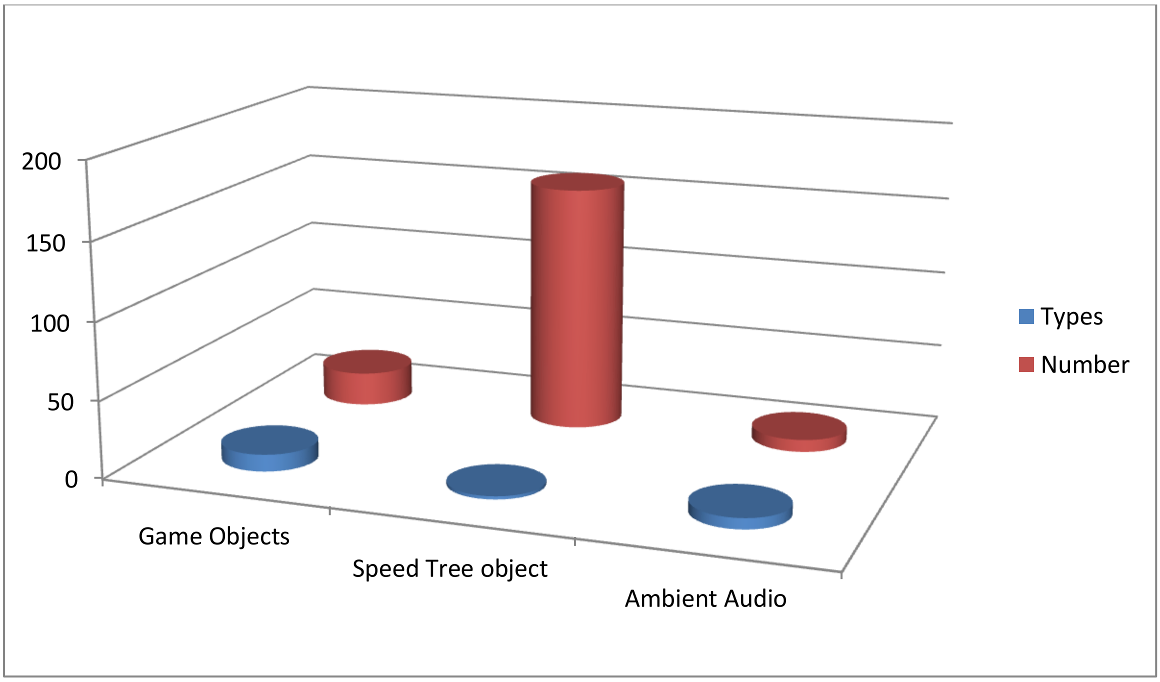


Chart1: Gaia Environment

4.2 Making the game character

The game character is a FPS (first person) character which is actually the camera. The camera is on a platform which moves around the terrain. The player game object is the parent of the camera and the platform as well. So whenever the player moves, the platform and the camera move along with it. A method called "transform" was to control the movement. A script called "player" was written with c sharp which was attached to the player game object in order to control it.

Therefore the video output from the camera creates an illusion of a first person character. A game object called "gun" was attached to the camera as a child object and a c sharp script called GUN was attached to it which creates the illusion of shooting. The method called ray cast was used to implement the shooting algorithm. An audio listener was attached to the camera and rigid body, Nav-mesh agent, capsule collider, was attached to the player game object in order to create the illusion of individuality inside virtual environment.

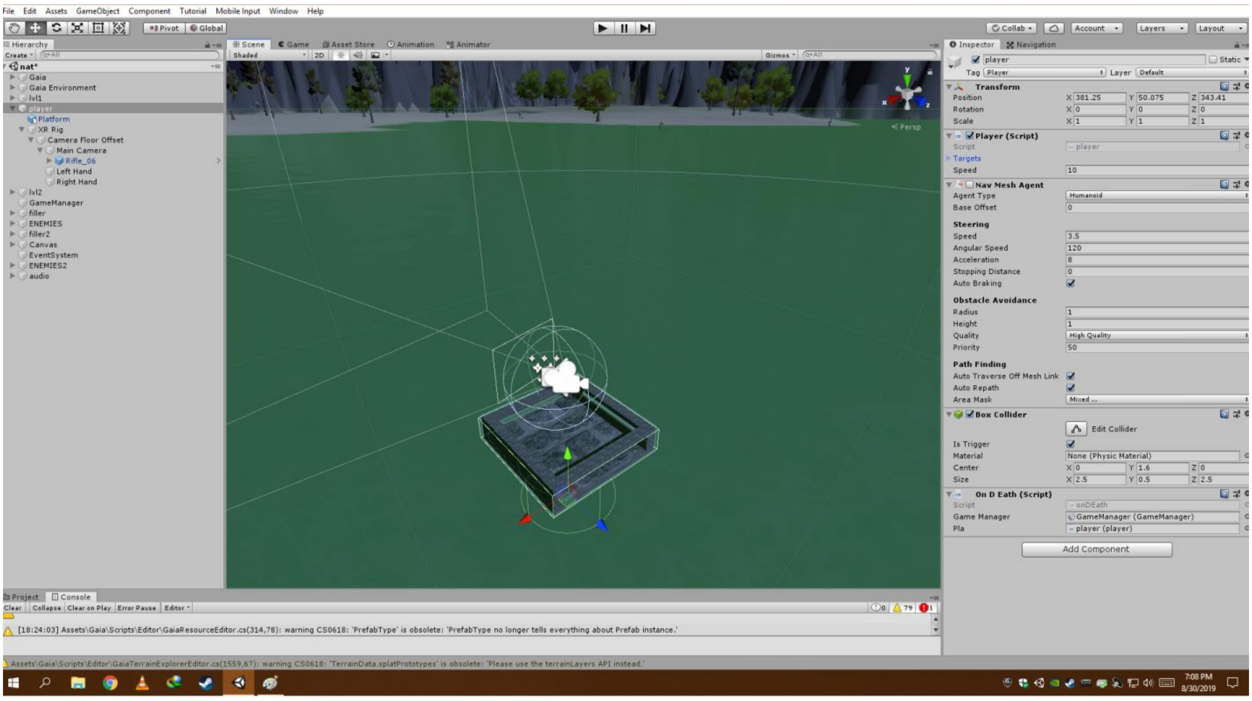


Fig 4.2.1: Player

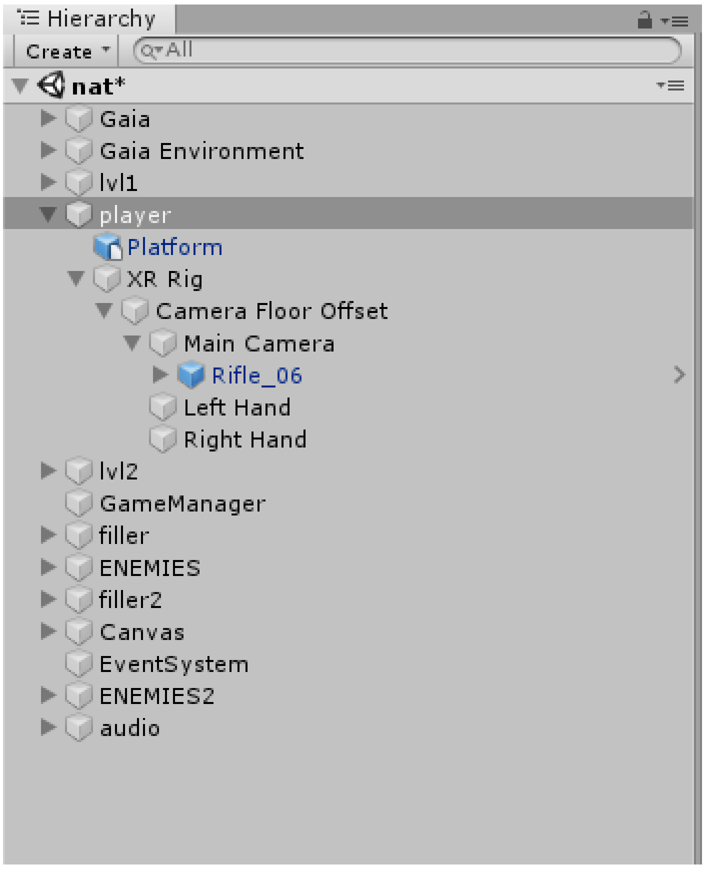


Fig 4.2.2: Player Components

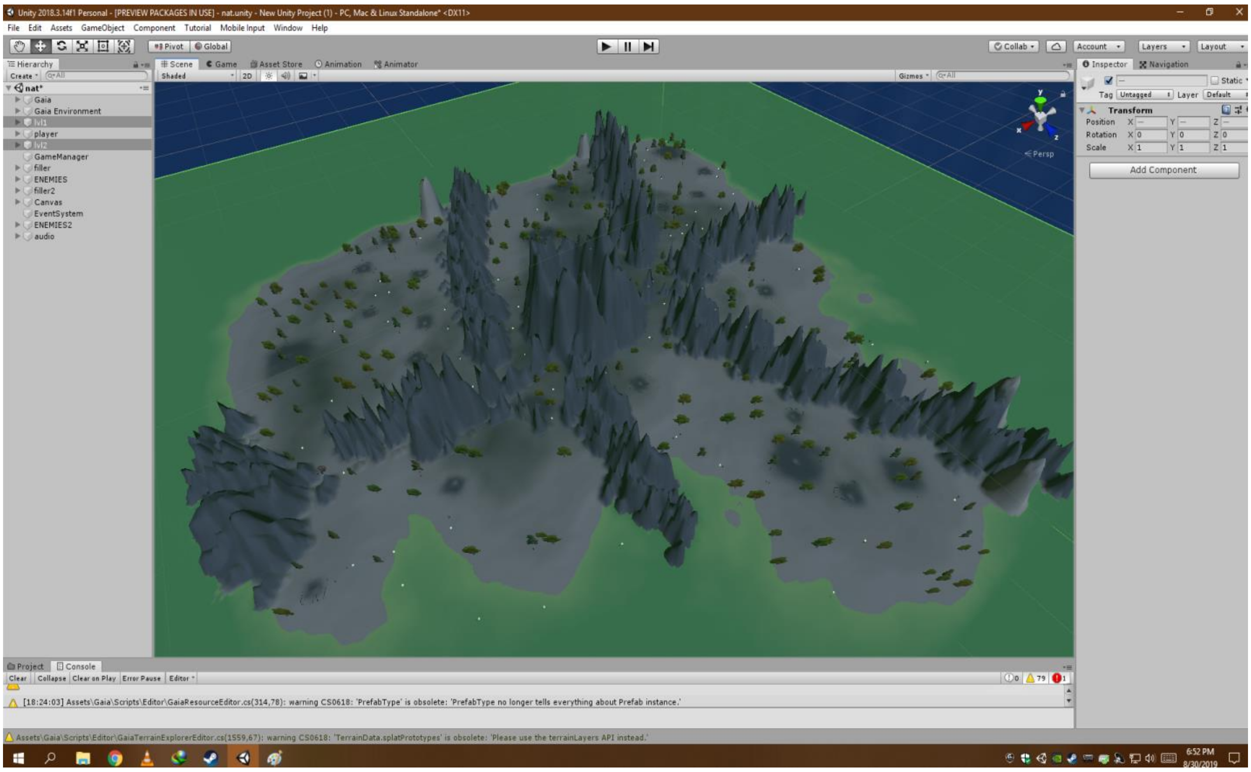


Fig 4.2.3: Player Path Empty Game Object

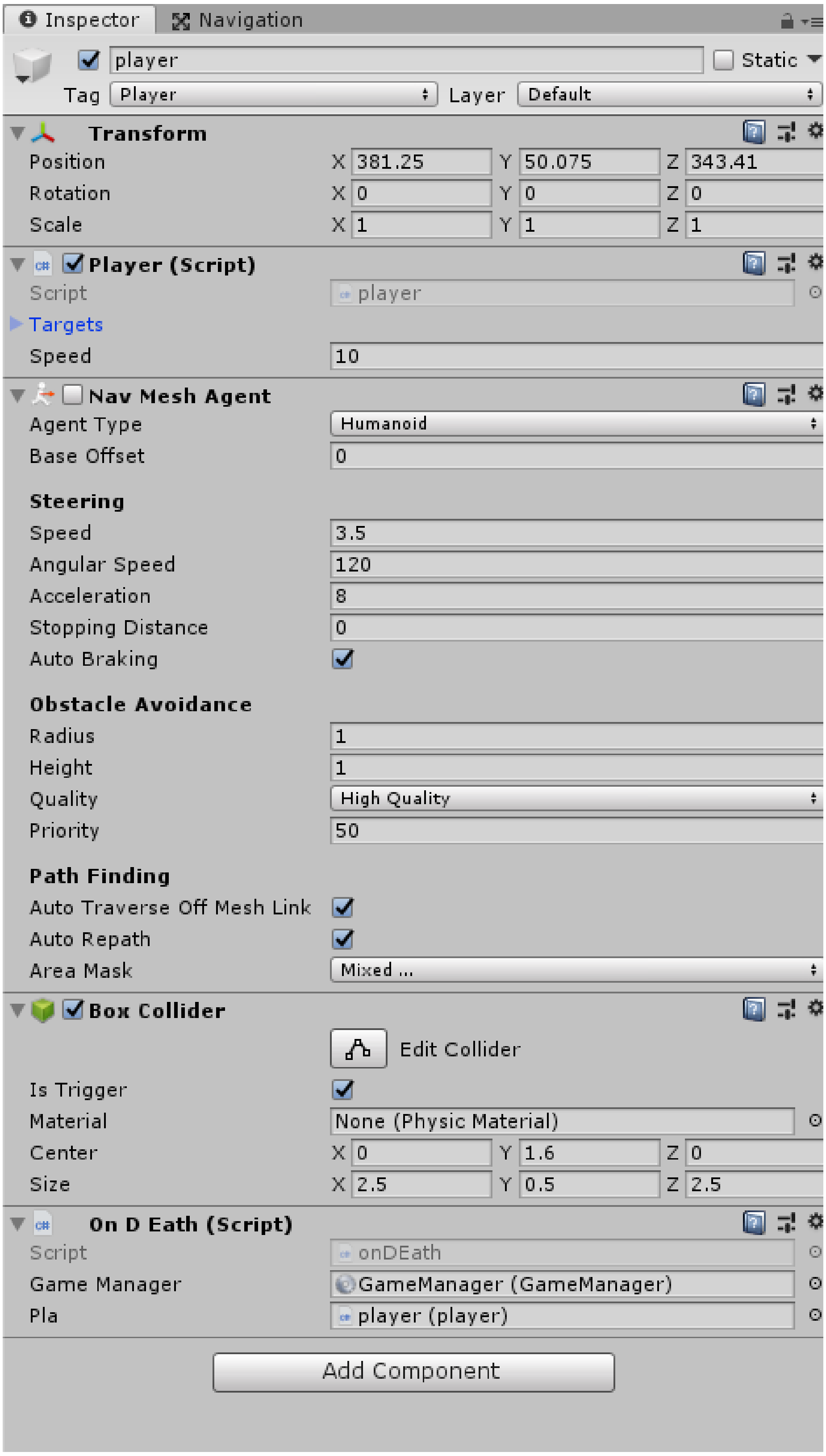


Fig 4.2.4: Player Scripts

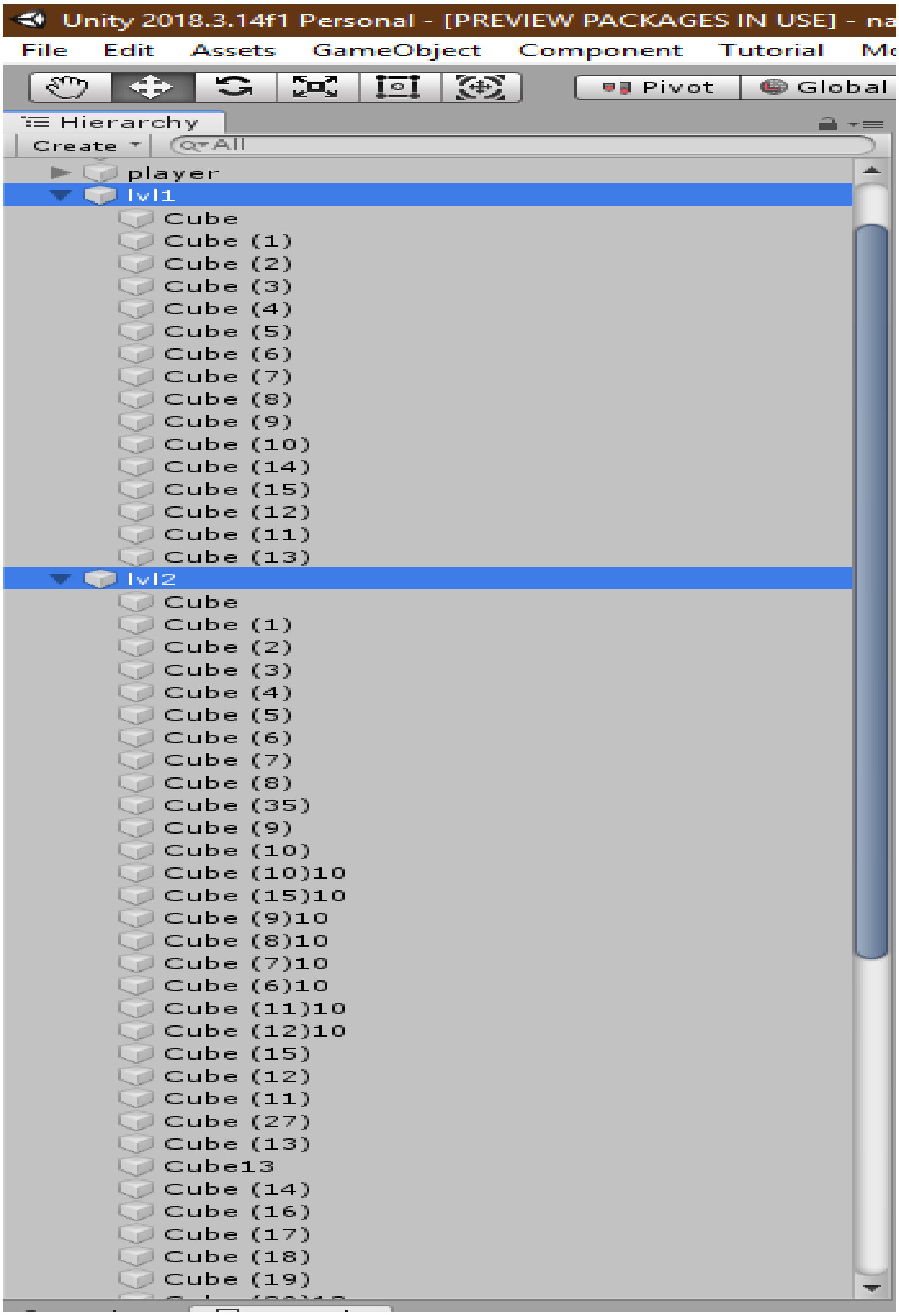


Fig 4.2.5: Empty Game Object for Player Path

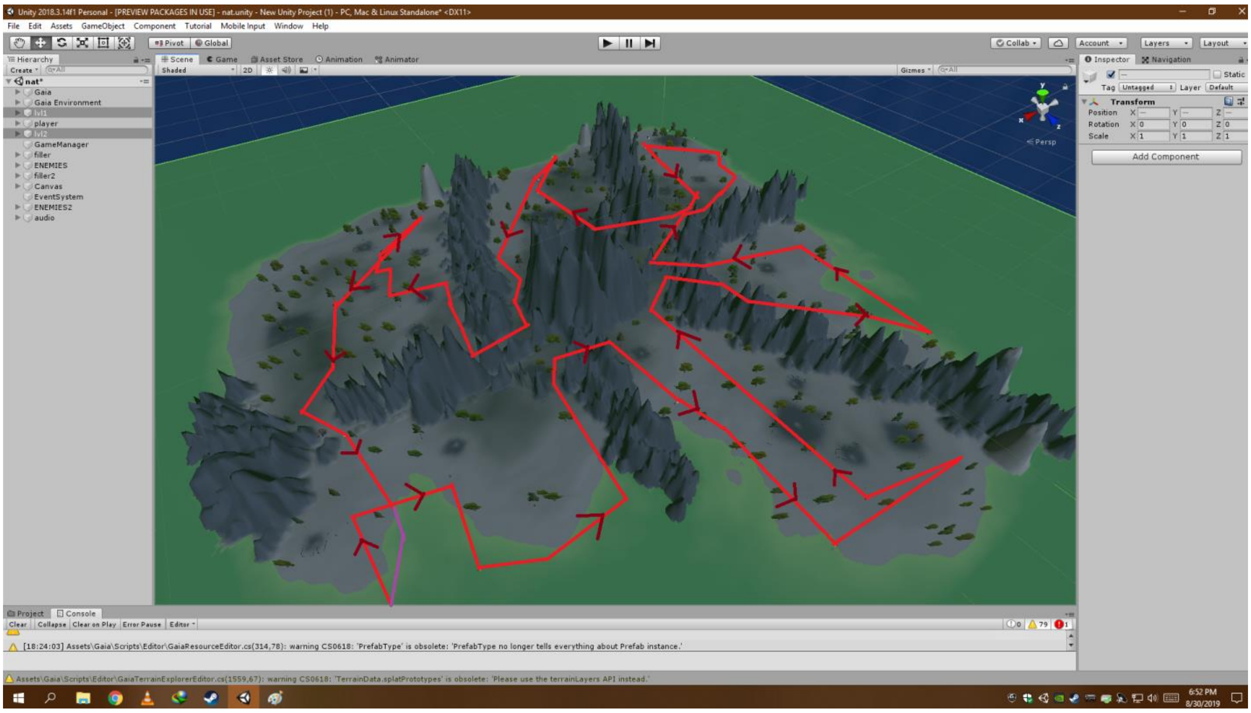


Fig 4.2.6: Player Path Direction

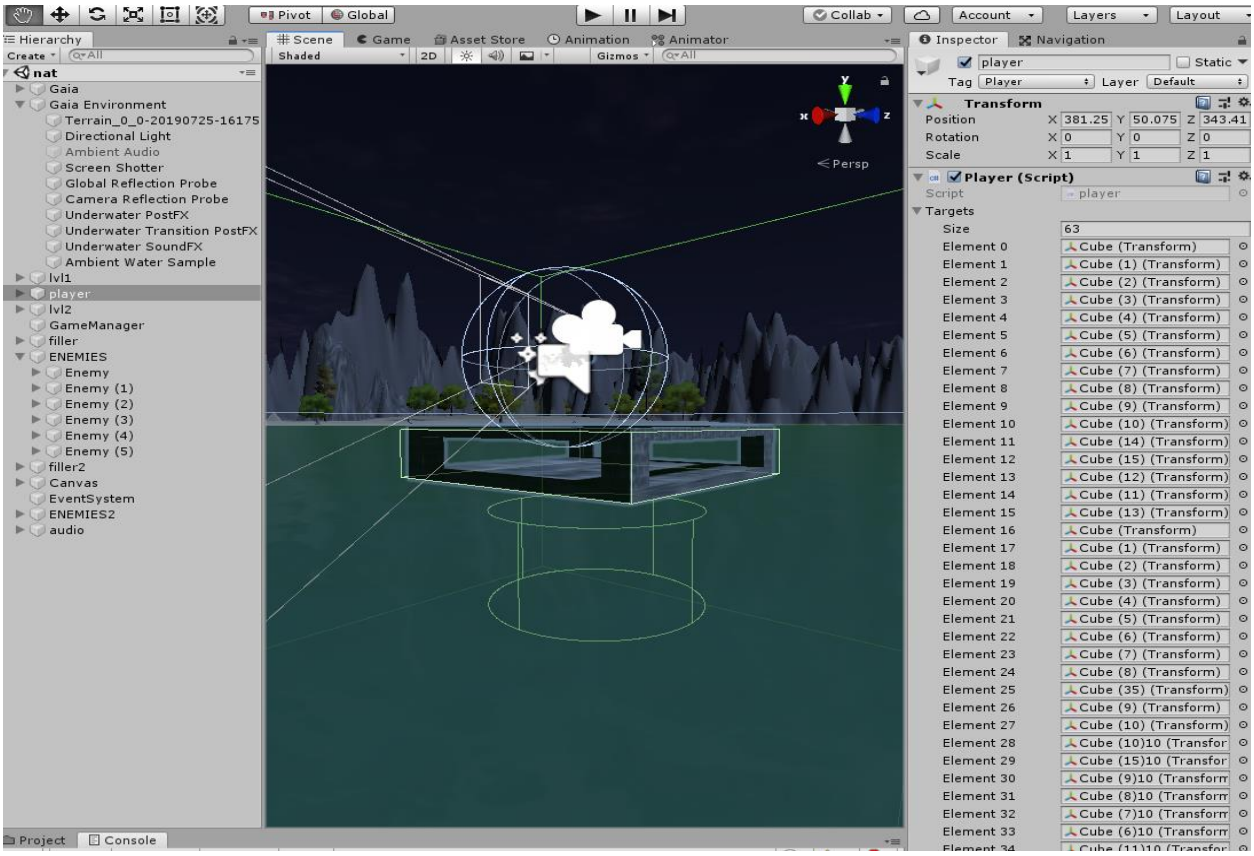


Fig 4.2.7 FPS character

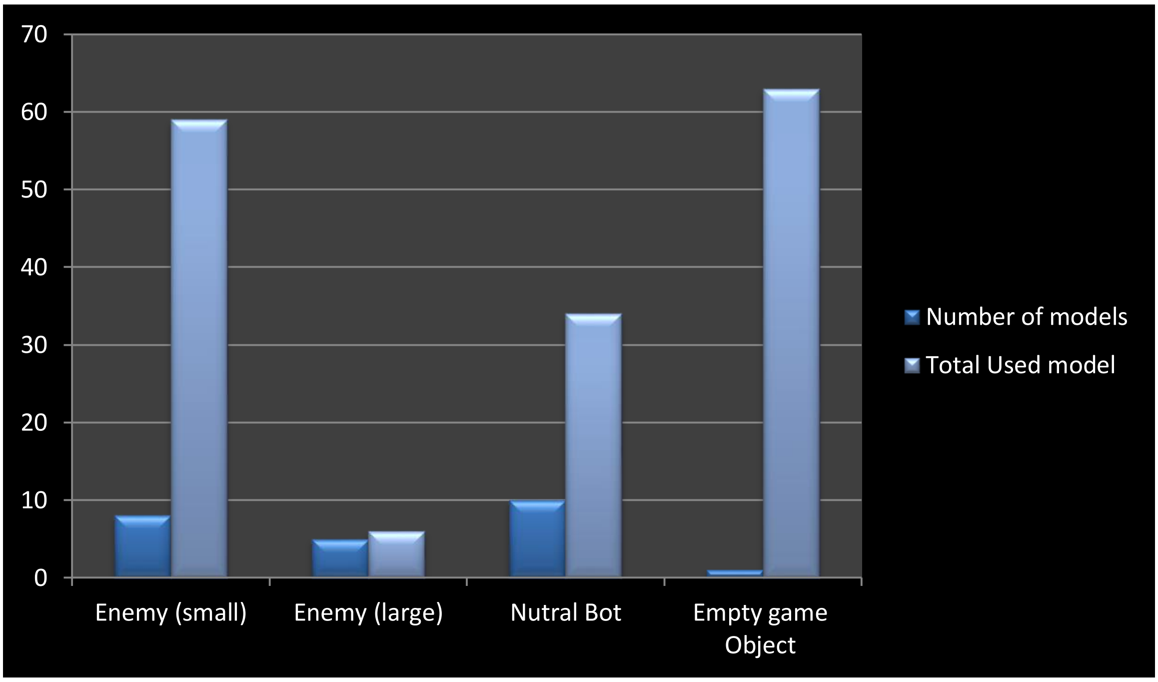


Chart 2: Non Environmental Game Objects

4.3 Creating the enemy AI

Firstly I started with creating an empty object called the enemy and inside that I took humanoid game object character and embedded different type of movement animation in it. And I attached rigid body, capsule collider and Nav-mesh agent component in the enemy game object and then attached a c-sharp script called “ENEMY”. The c-sharp script is just so that the enemy game object acts as if the character was alive. A radius was set in the “ENEMY” script and whenever the player game object enters the radius the enemy game object starts to run. The radius and the speed are set different from enemy to enemy. And lastly, if the enemy game object capsule collider collides with capsule collider of the player the player dies. Also, the enemy has a health attribute attached to it and therefore if the players shoots at the enemy, the enemy game object is destroyed and a dead animation is shown.

Fig 4.3.1 AI enemy

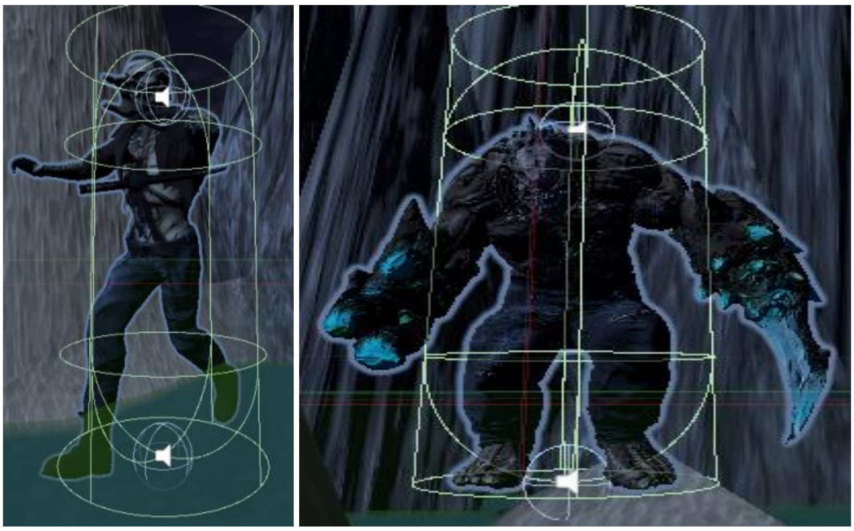


Fig 4.3.2 AI enemy

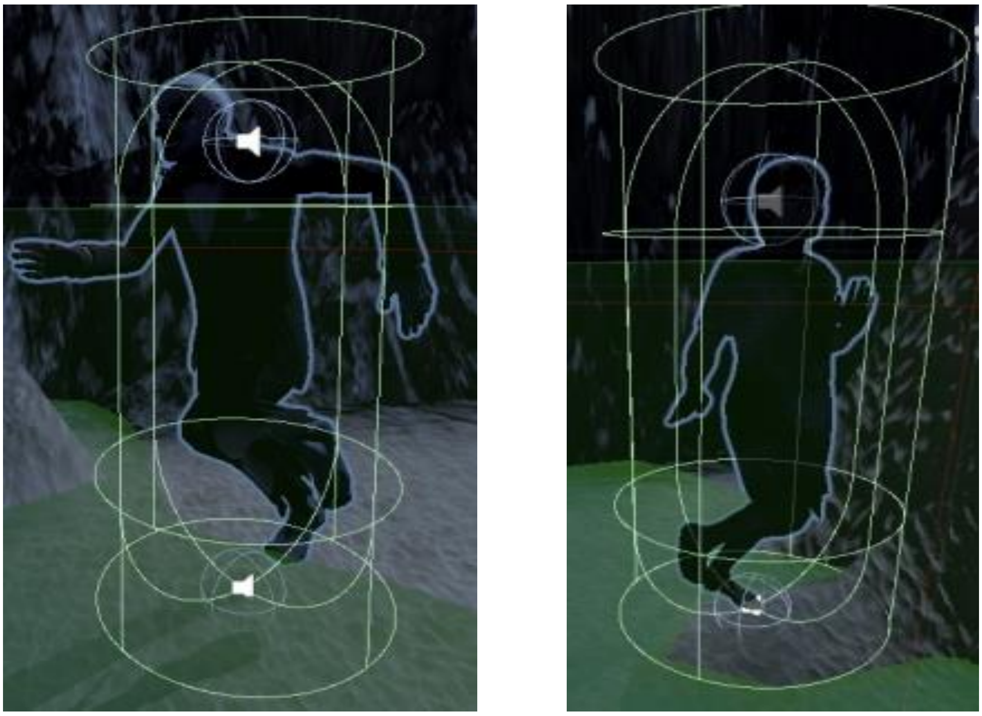


Fig 4.3.3 AI enemy

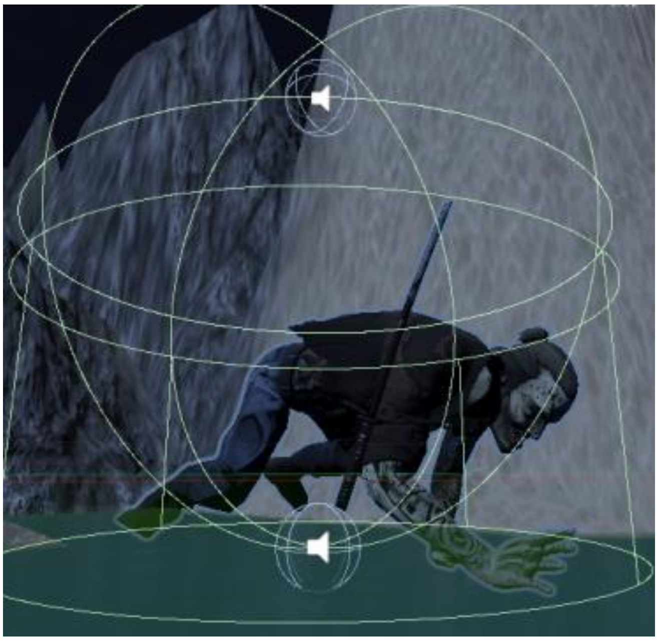


Fig 4.3.4 AI enemy

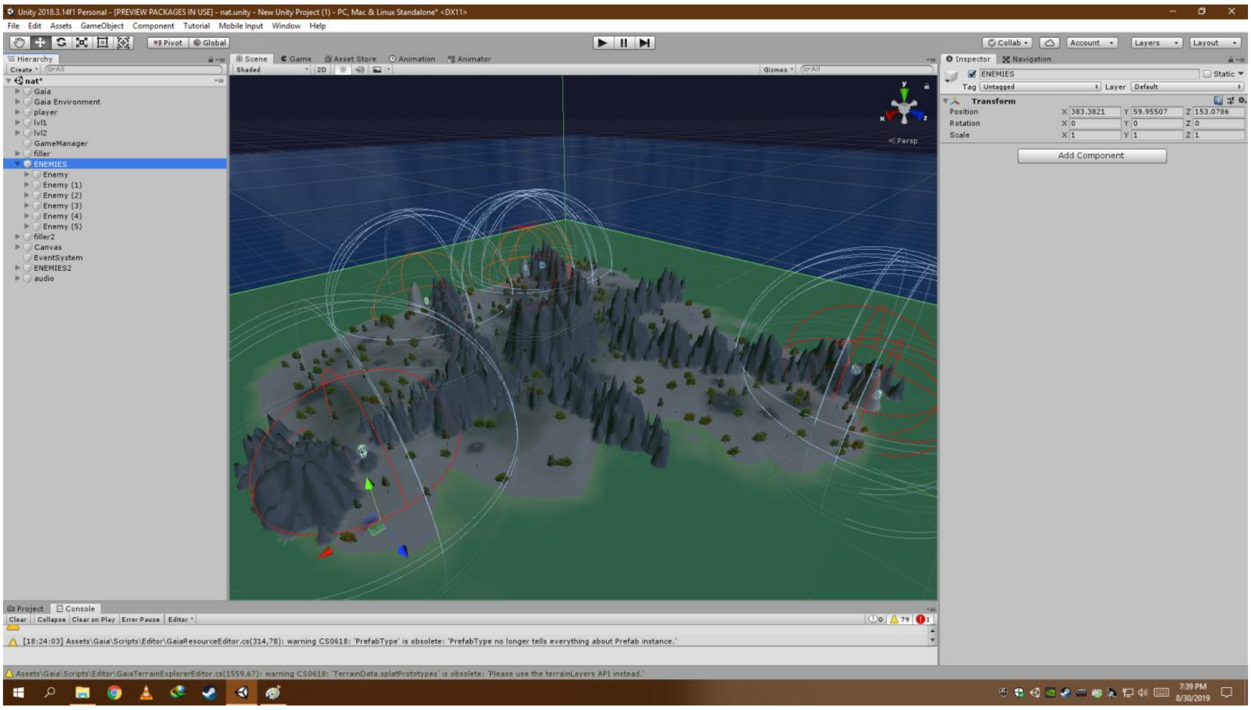


Fig 4.3.5: Enemy (Large)

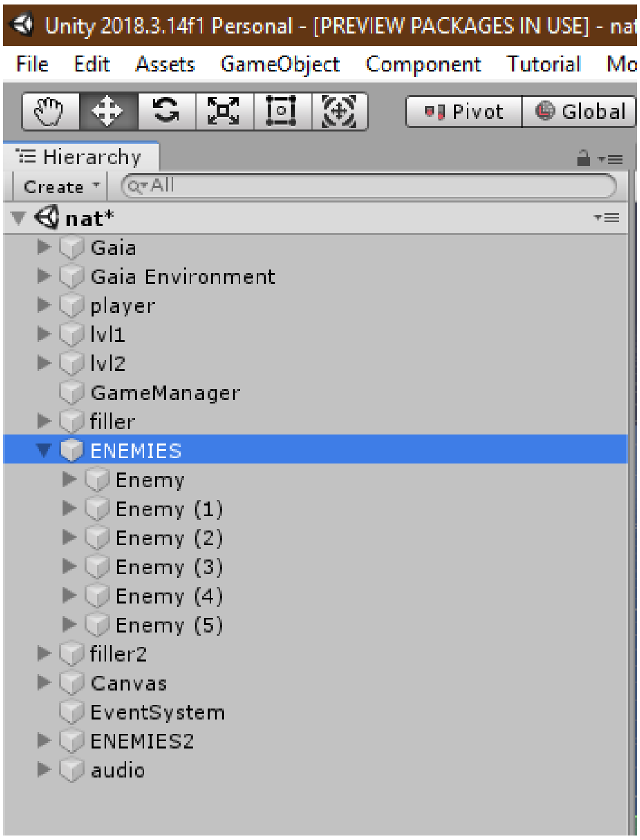


Fig 4.3.6: Enemy (Large)

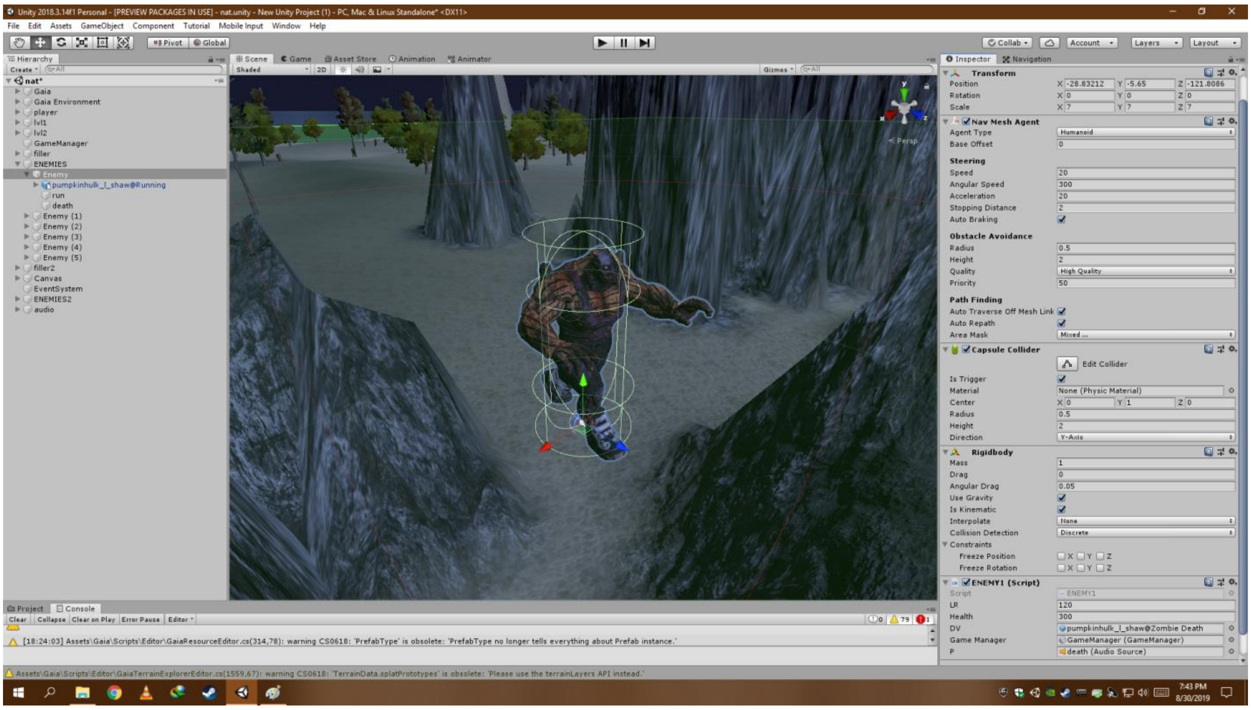


Fig 4.3.7: Component used for Enemy (Large)

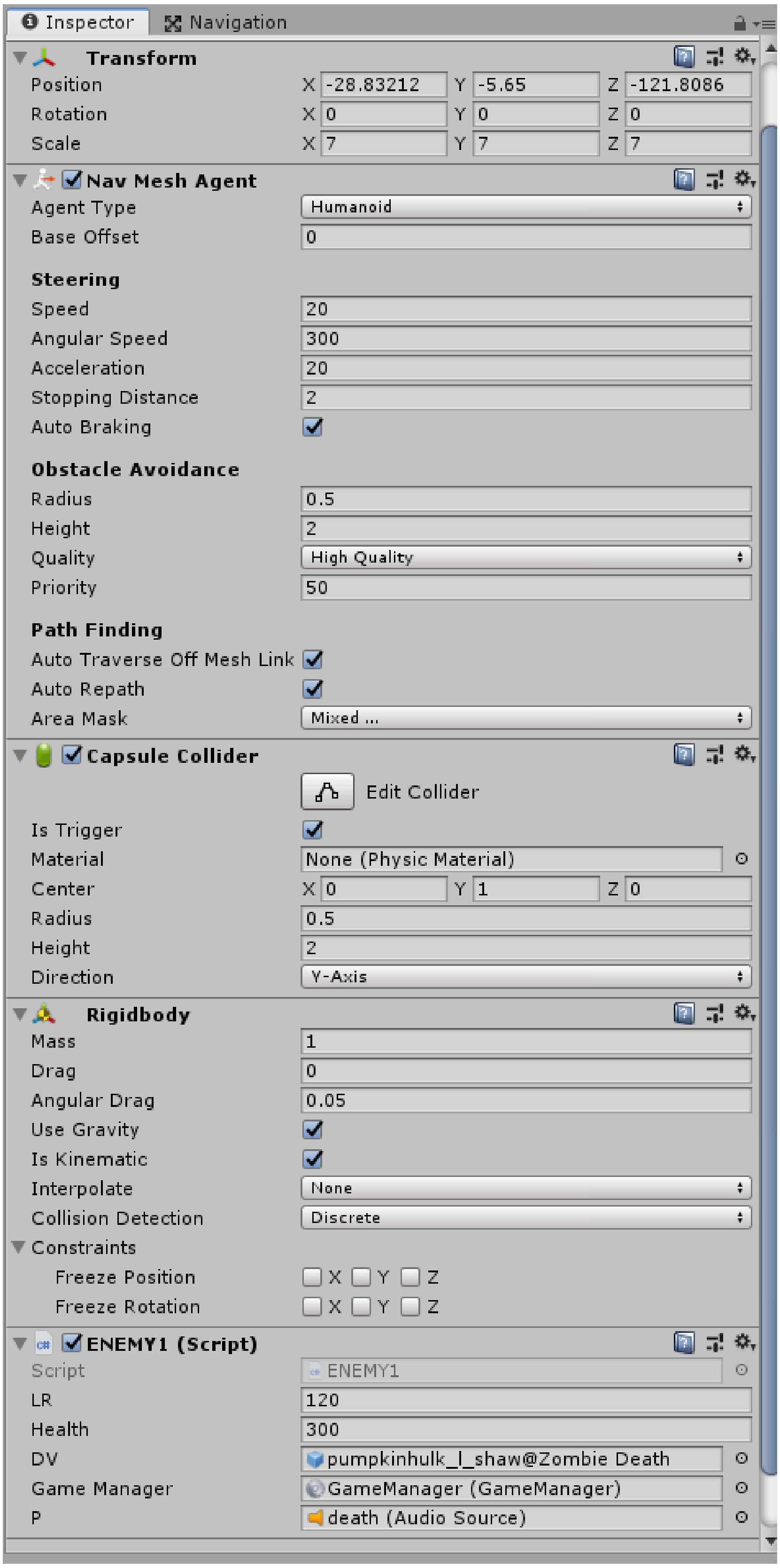


Fig 4.3.8: Script Used in Enemy (Large)

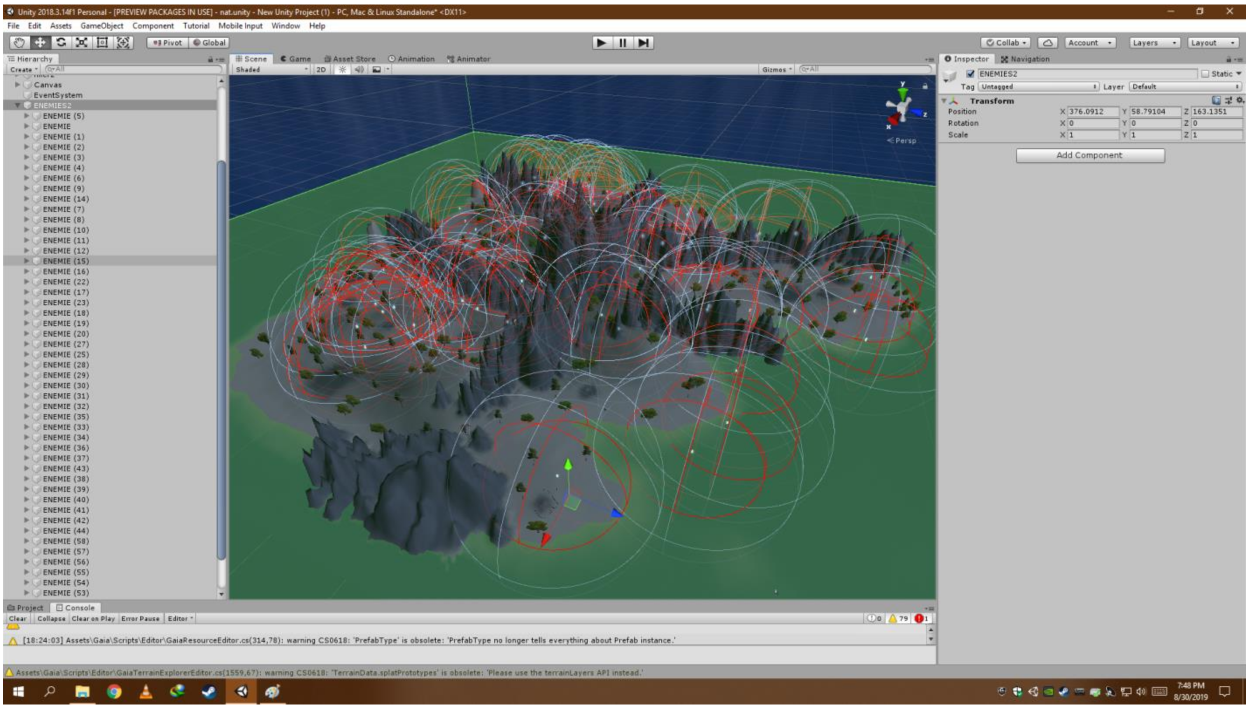


Fig 4.3.9: Enemy (Small)

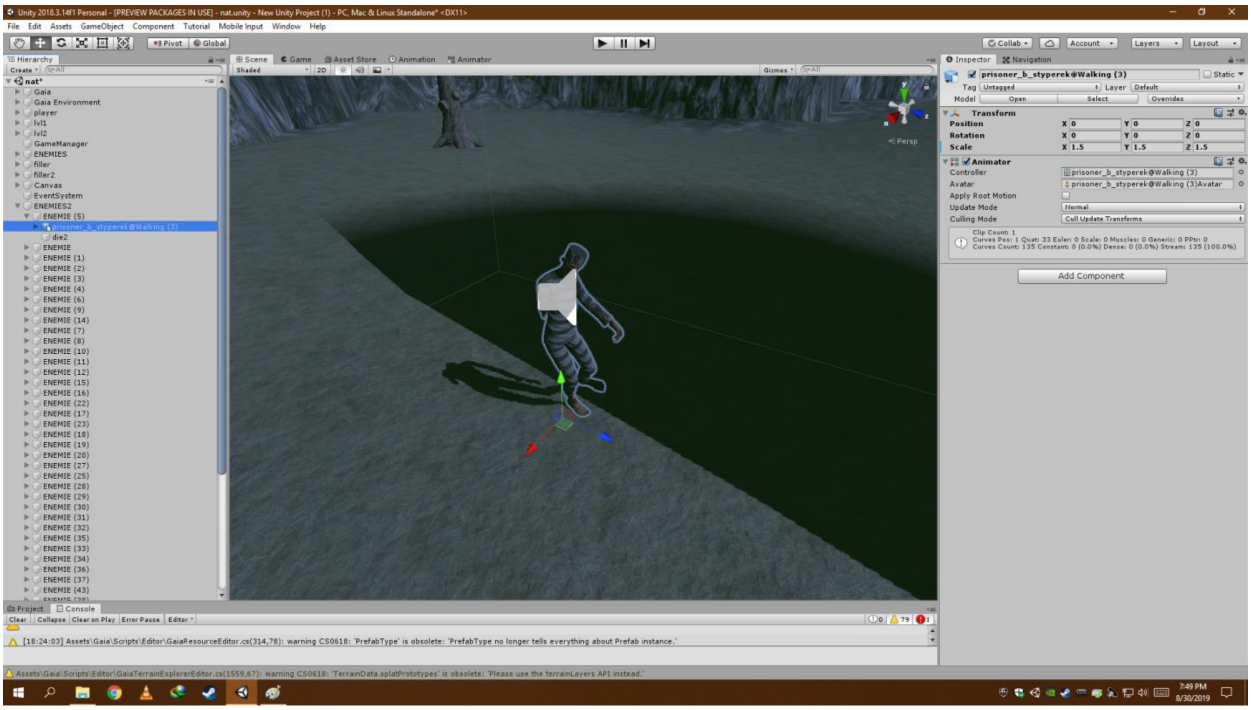


Fig 4.3.10: Component used for Enemy (Small)

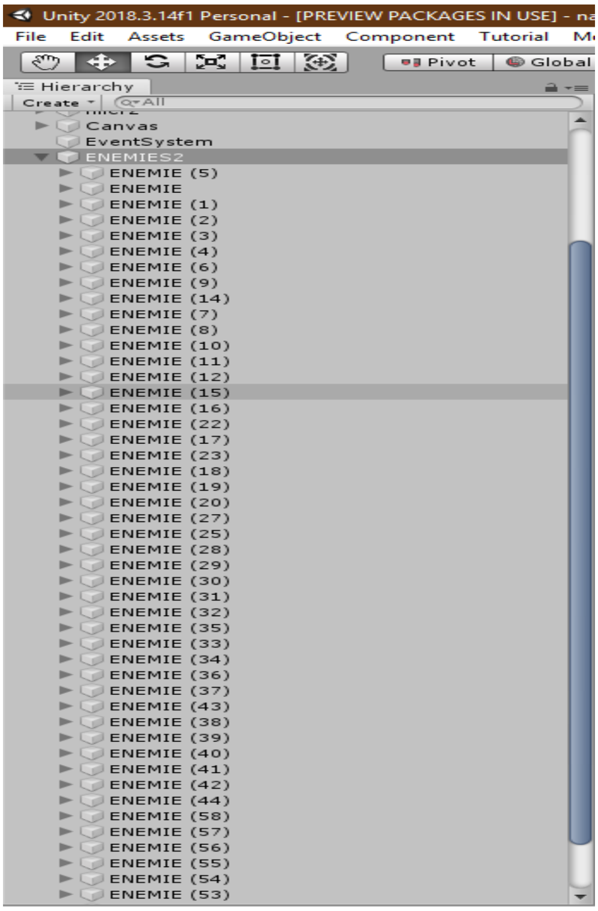


Fig 4.3.11: Component used for Enemy (Small)

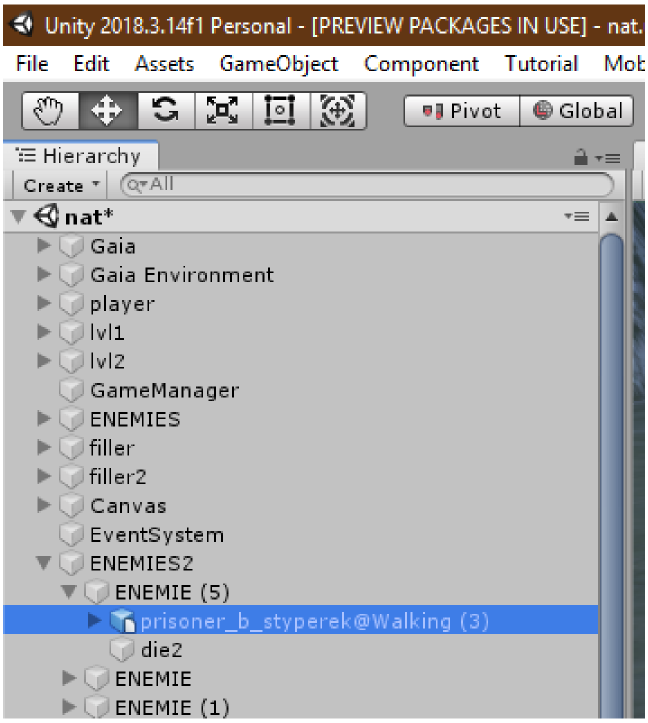


Fig 4.3.12: Component used for Enemy (Small)

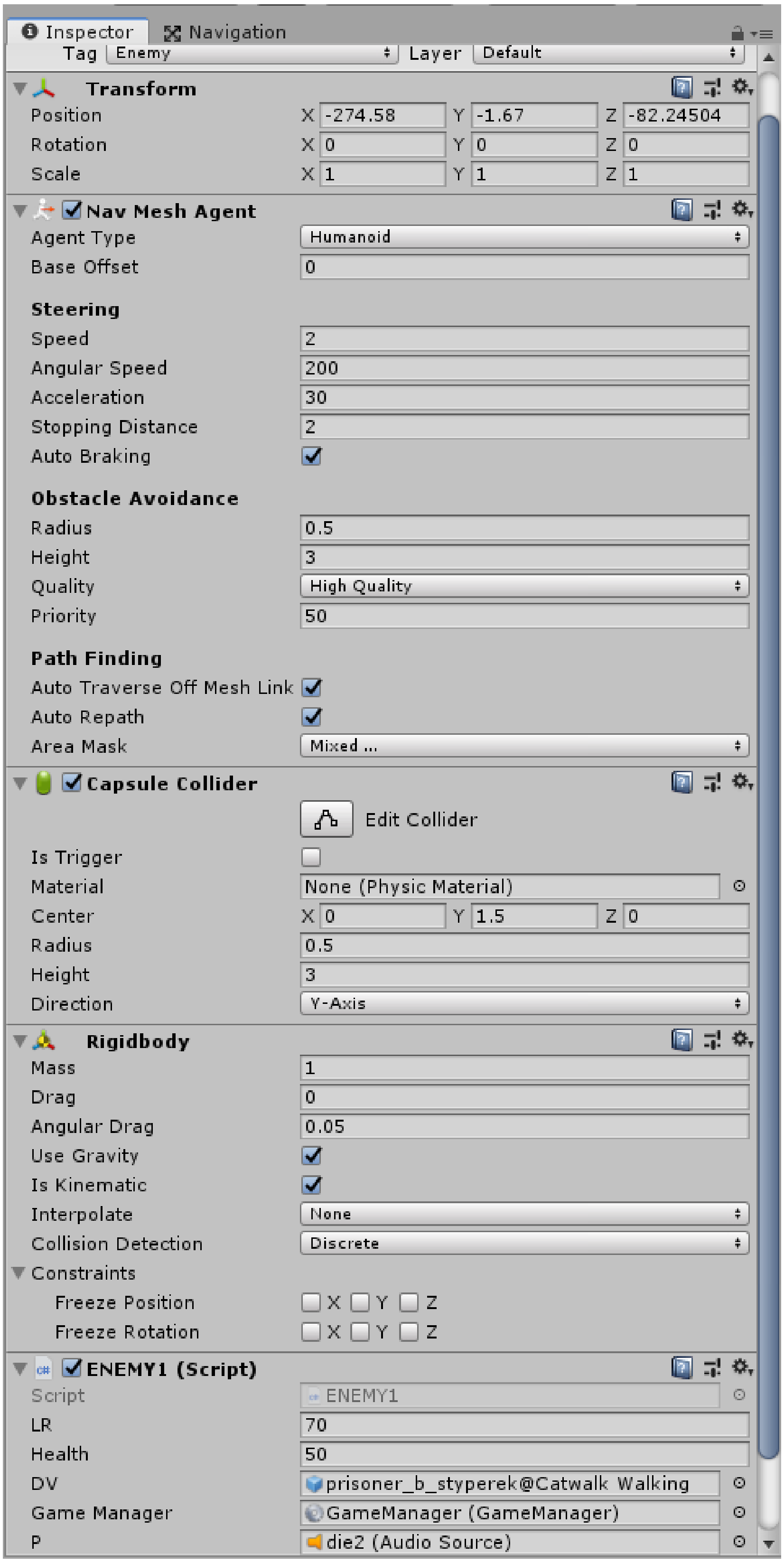


Fig 4.3.13: Script Used in Enemy (Small)

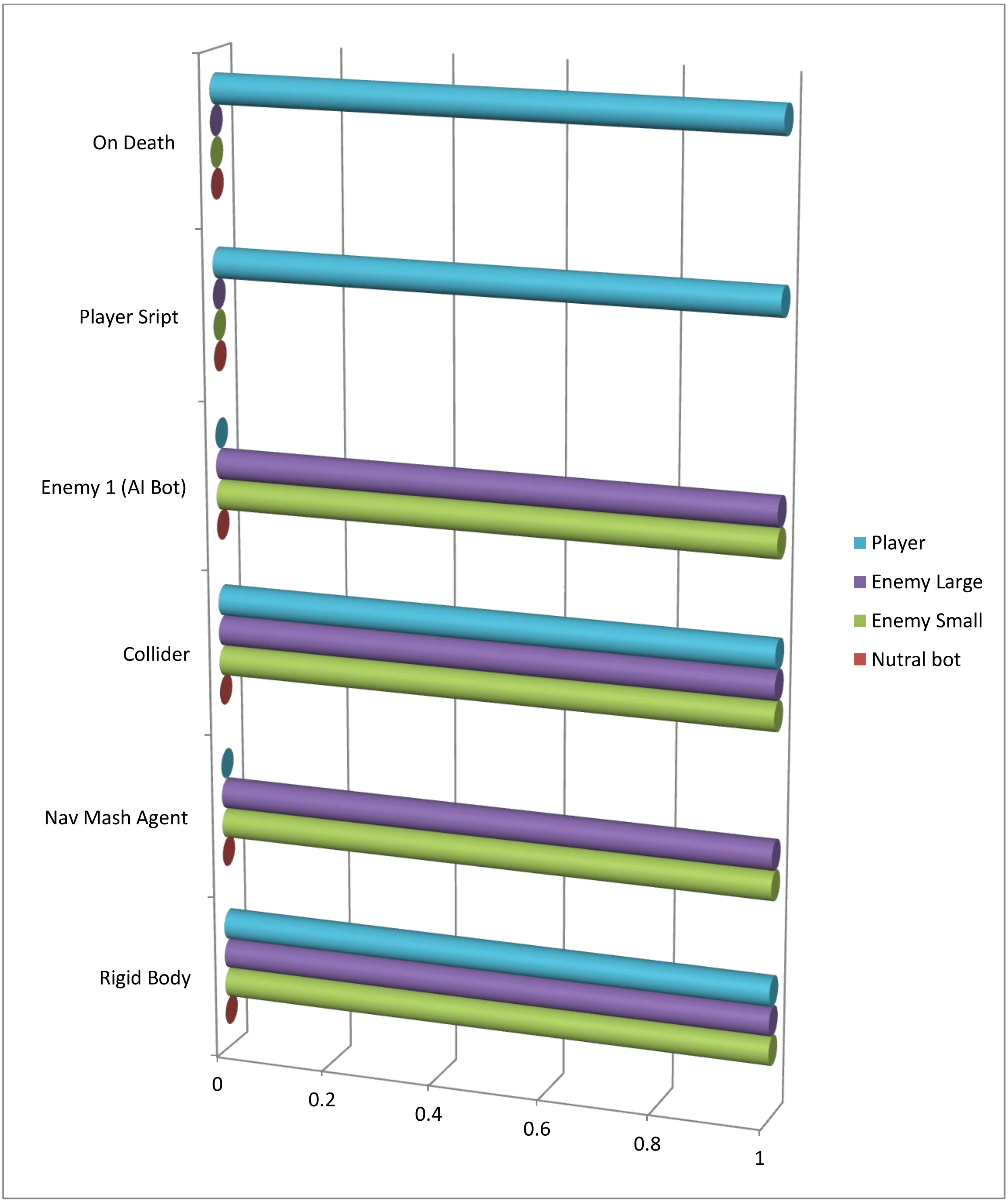


Chart3: Scripts Used

4.4 Level design

I have placed mountains in the terrain to surround each level. To create the illusion of different levels I have assigned each level with different sets of enemy game objects. Enemies in different levels differs in terms of health, speed, identification radius and audio effects.

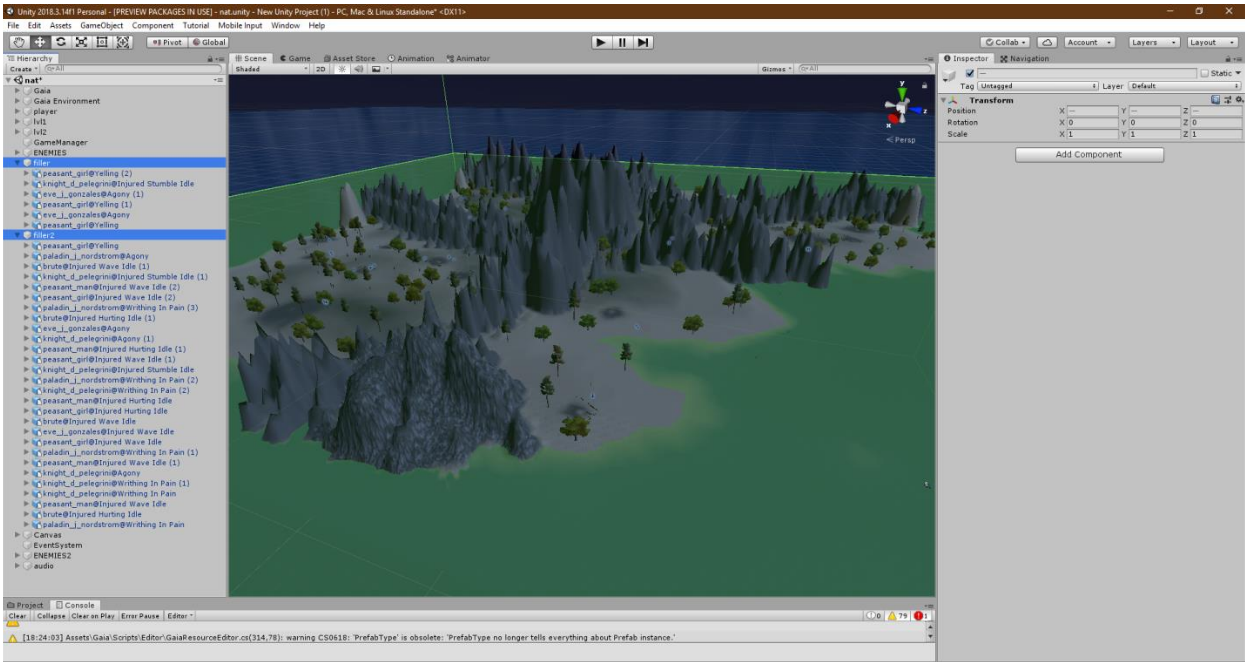


Fig 4.4.1: Neutral Bots

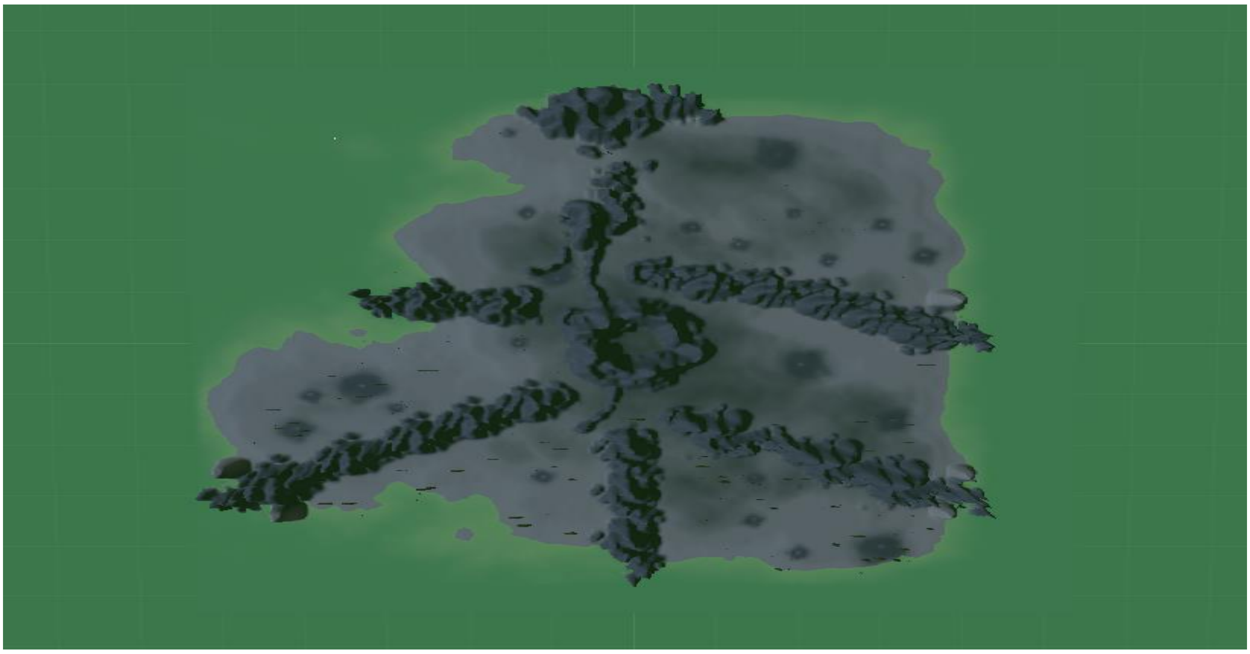


Fig 4.4.2: levels

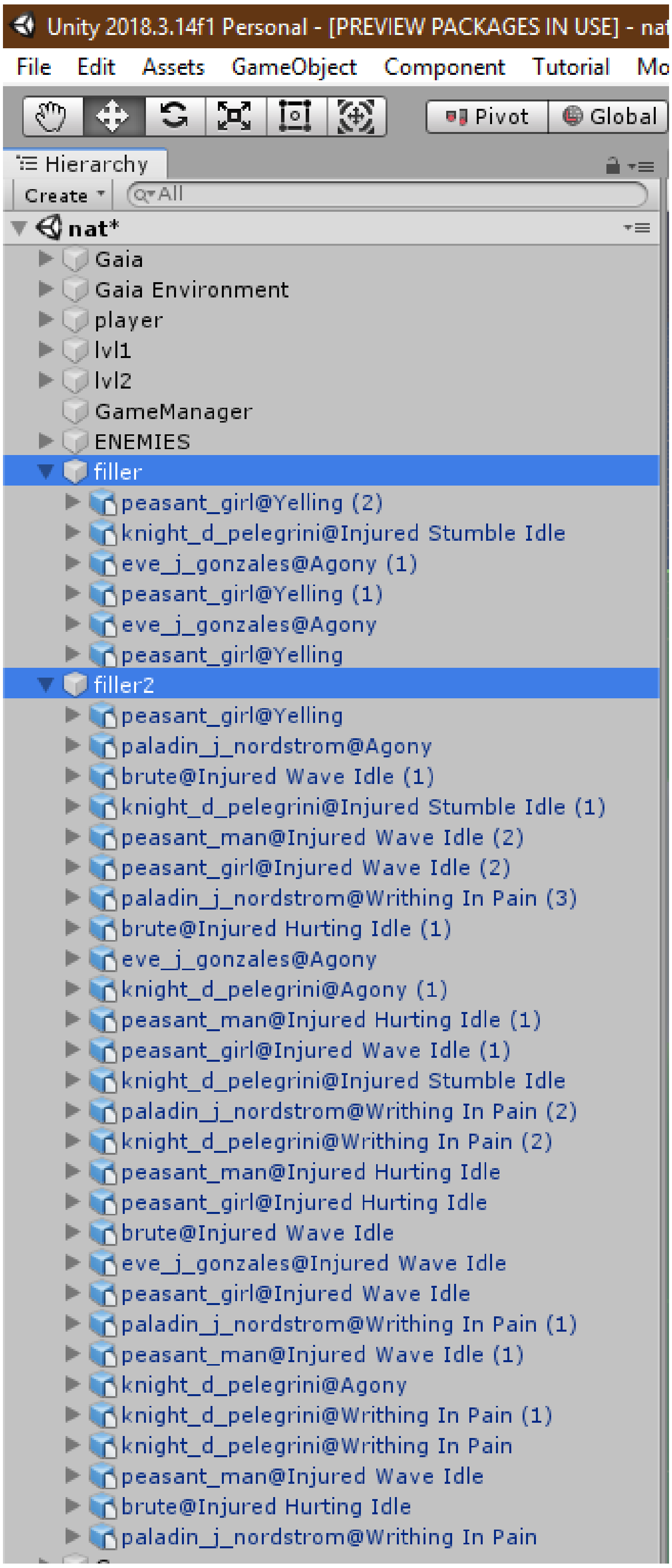


Fig 4.4.3: Components Used for Neutral Bots

4.5 Audio

Different type of audio file was attached in different level enemies and bullets. Each level has different type of ambient audio and each enemy has different SFX scream. The scream is invoked when they are being shot at. There are two types of bullets in the gun: shot range and long range each having its own dedicated sound effect. When the player dies a horrified death sound effect is played.

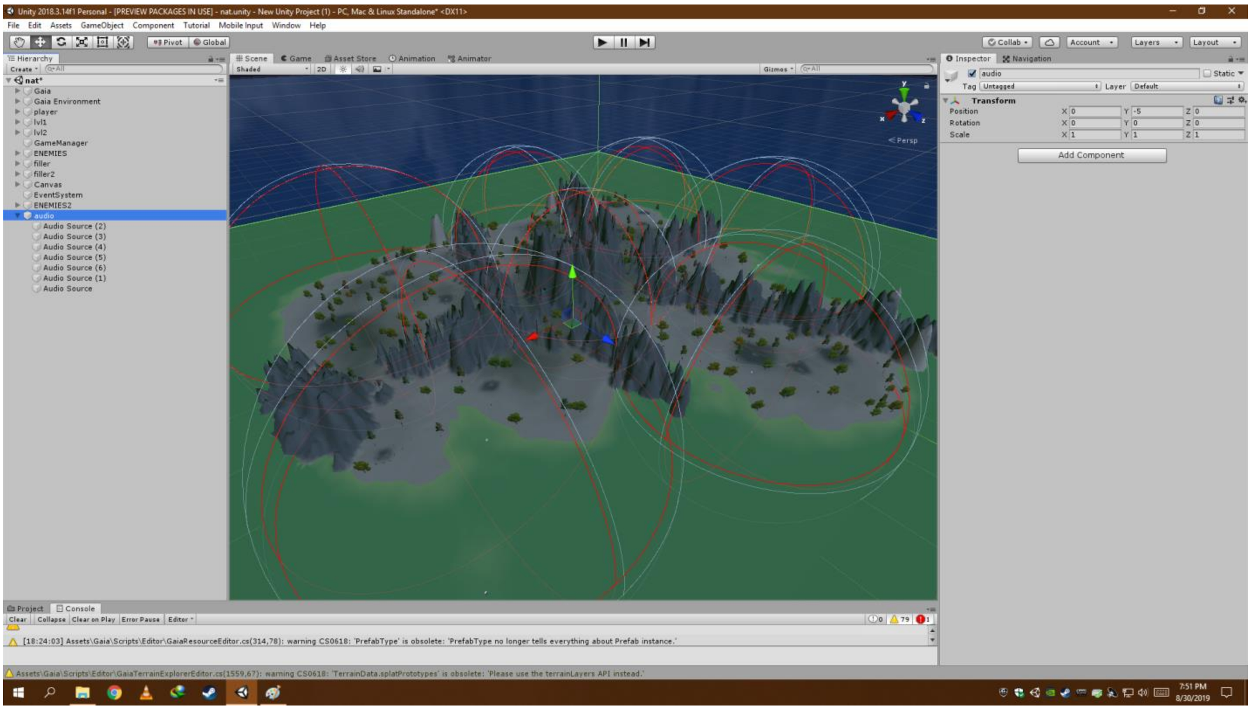


Fig 4.5.1: Different Audio Radius

4.6 Survey Data

I have devised a small survey with a group of people and the result is follows:

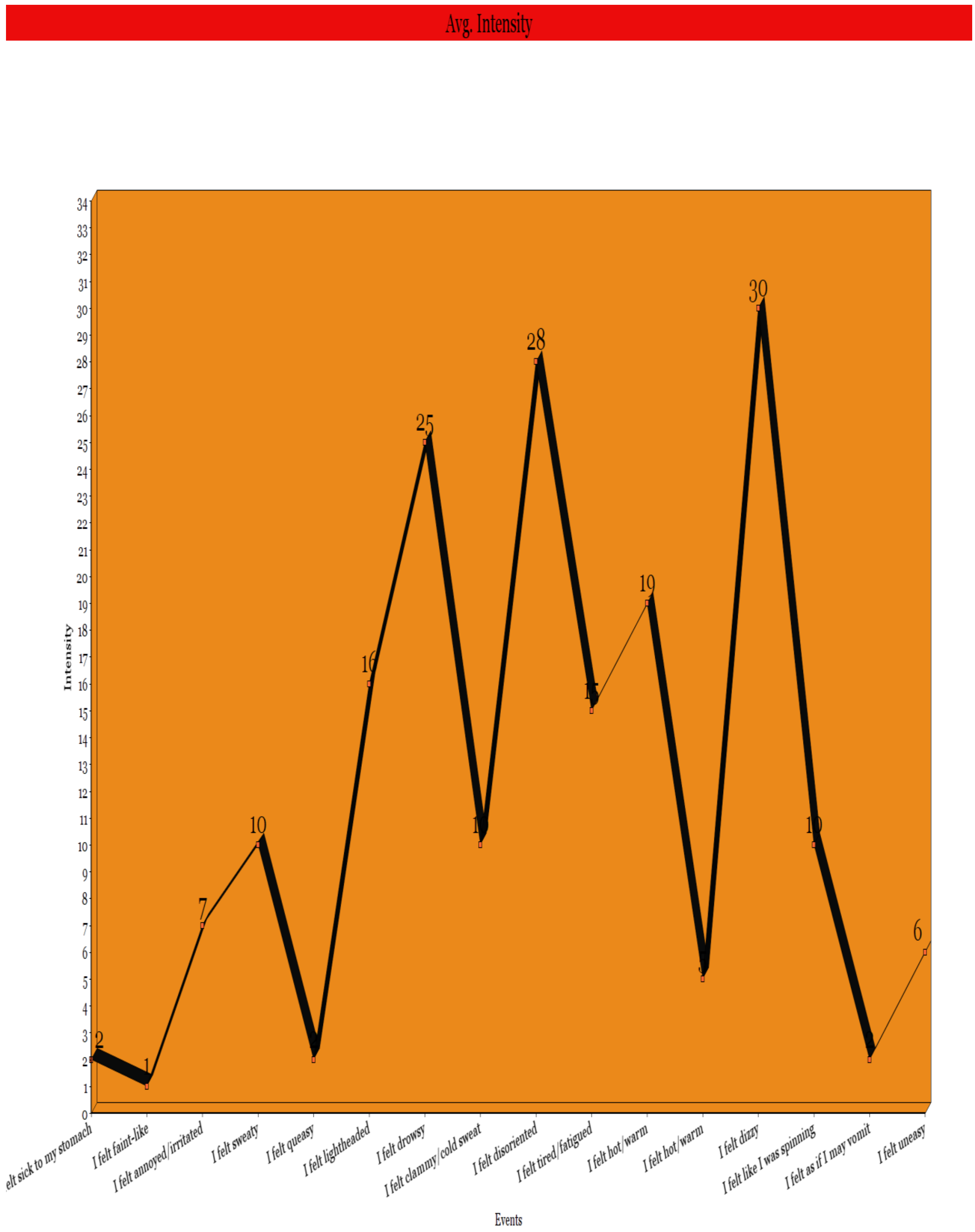
Sl.no.	Event description	Head count (%)	Avg. Intensity (1-9)
1	sick to the stomach	7%	1/very mild
2	faint-like	4%	1/very mild
3	annoyed/irritated	30%	1/very mild
4	sweaty	34%	2/mild
5	queasy	7%	1/very mild
6	lightheaded	54%	3/light
7	drowsy	83%	3/light
8	clammy/cold sweat	34%	2/mild
9	disoriented	97%	3/light
10	tired/fatigued	50%	2/mild
11	nauseated	67%	1/very mild
12	hot/warm	17%	1/very mild
13	dizzy	100%	4/moderate
14	spinning	34%	2/mild
15	vomit	7%	1/very mild
16	uneasy	21%	1/very mild

Table: Data Table

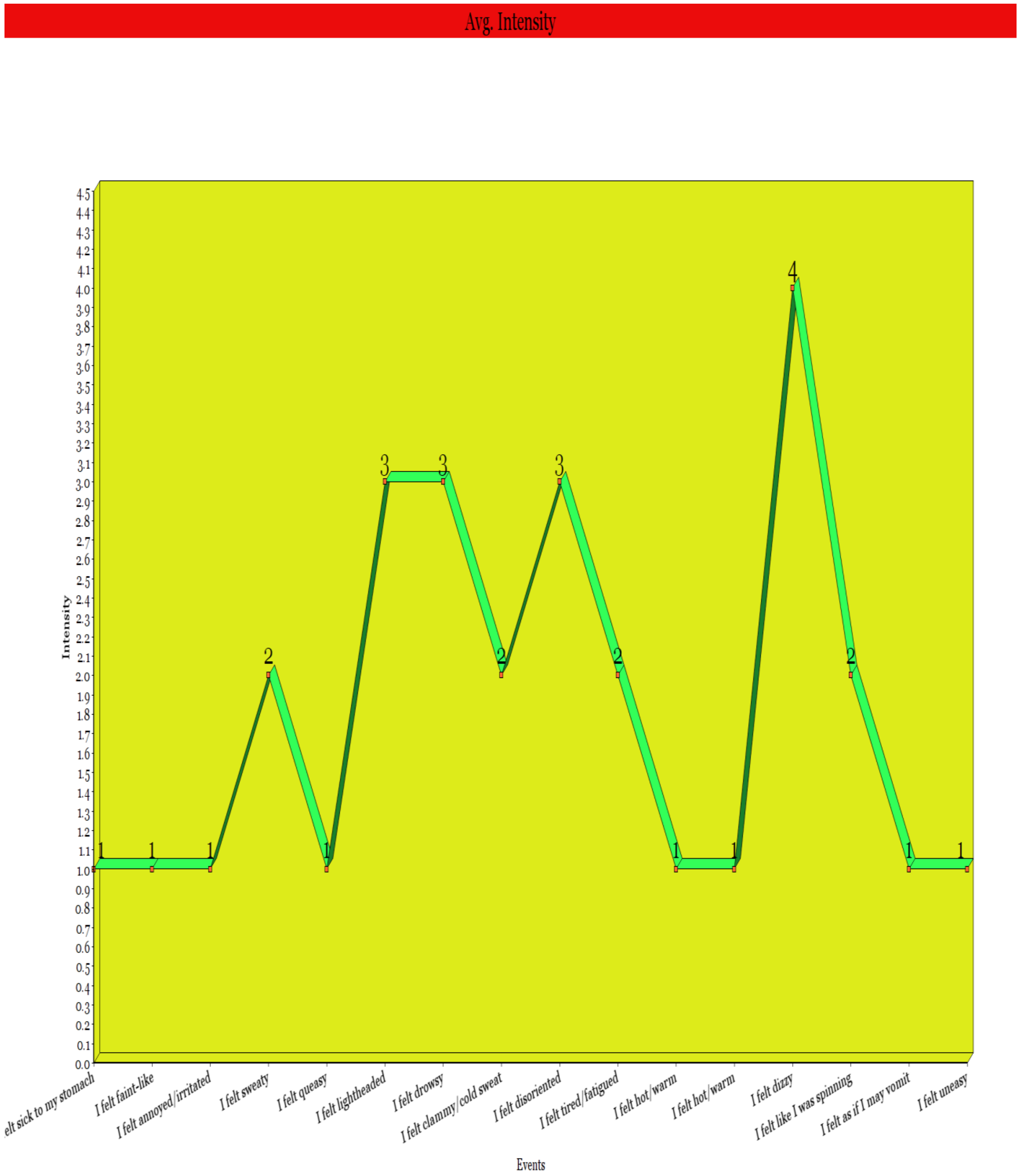
4.7 Result Analysis

From the survey data we can see that 7 percent of the people said they felt sick to their stomach and the intensity felt by them was on level 1. This feeling of intensity is very mild. The percentage is very minor. Another 4 percent of people said they felt faint-like which a minor percentage to consider and the intensity level was 1 which is a very mild felling. A group of 30 percent people said that they felt annoyed or irritated while playing the game which is also a small number of people and the intensity level was 1. Another 34 percent of the people felt sweaty which a big percentage to consider as a feedback is and the intensity level was 2. The feeling of intensity level is mild. Another 7 percent of the people felt queasy and the intensity level was 1. Another 54 percent of the people felt light headed which is a large number of positive feedback received and the intensity level was 3. Another 83 percent of the people said that they felt drowsy while playing the VR game and the intensity level was 3. The number of the people who gave this feedback is a very large and highly considerable. Again another 34 percent of people said that they felt cold sweat and the intensity level was 2. Another 97 percent of people said that they felt disoriented while playing the game which is a very big percentage to consider as a feedback and the intensity according to a table is on level 3. 50 percent of the people felt tired and the intensity level was 2. 67 percent of the people felt nauseated and the intensity level was 1. Another 17 percent of the people felt hot or warm and the intensity level was 1. 100 percent of the people felt dizzy and the intensity level was 4. The feeling is moderate in intensity level. 34 percent of the people felt they were spinning and the intensity level was 2. 7 percent of the people felt as if they may vomit and the intensity level was 1. 21 percent felt uneasy and the intensity level was 1.

Based on this survey we can say that motion sickness can be triggered in VR. Motion sickness can be dealt over time, so the simulation hunted island I have created can make people used to change of motion which will help them to deal with motion sickness.



Graph1: Head count



Graph 2: Intensity

Chapter 5

Conclusion

I have presented an explanation on how we are affected by motion sickness in VR. The developed simulation and the survey proved that there are several invoke points but it can be avoided and repeated invocation may quire people having motion sickness. By this we can say the relationship between VR and motion sickness can guide us for designing batter VR application and allow us to reduce discomfort.

5.1 Future Work

The way we are walking towards the future VR may become the center of our entertainment, if so then we can use my research to reduce the invoke points of dizziness in VR environment, for kids and armature VR explorer it may become a great help. Furthermore it will make VR more like our own reality.

Reference:

[1] Zeng, Nan, Zachary Pope, Jung Lee, and Zan Gao. ”Virtual reality exercise for anxiety and depression: A preliminary review of current research in an emerging field.” Journal of clinical medicine 7, no. 3 (2018): 42.

[2] U. Rajendra Acharya, K. Paul Joseph, N. Kannathal, Choo Min Lim, and Jasjit S. Suri. Heart rate variability: A review. Medical and Biological Engineering and Computing, 44(12):10311051, 2006.

[3] Ohyama, S., Nishiike, S., Watanabe, H., Matsuoka, K., Akizuki, H., Takeda, N. and Harada, T., 2007. Autonomic responses during motion sickness induced by virtual reality. Auris Nasus Larynx, 34(3), pp.303-306.

[4] Munafo, J., Diedrick, M. and Stoffregen, T.A., 2017. The virtual reality head-mounted display Oculus Rift induces motion sickness and is sexist in its effects. Experimental brain research, 235(3), pp.889-901.

[5] Rebenitsch, Lisa, and Charles Owen. ”Review on cybersickness in applications and visual displays.” Virtual Reality 20, no. 2 (2016): 101-125.

[6] G. Pratishtha and R.Manisha (2013,August). A Surve Of Techniques And Applications For Real Time Image Processing.

[7] Judy Barrett. Side effects of virtual environments: A review of the literature. Technical report, DTIC Document, 2004.

[8] K.AeHyun and B.JaeHwan (2014,March). Development Of Mobile Game Using Multiplatform (Unity 3D) Game Engine.

[9] Johnell O Brooks, Richard R Goodenough, Matthew C Crisler, Nathan D Klein, Rebecca L Alley, Beatrice L Koon, William C Logan, Jennifer H Ogle, Richard A Tyrrell, and Rebekkah F Wills. Simulator sickness during driving simulation studies. Accident Analysis Prevention, 42(3):788796,2010.

[10] June Edhouse, William J Brady, and Francis Morris. ABC of clinical electrocardiography: Acute myocardial infarction-Part II., volume 324. BMJ Books, 2002.
[11] Adam D. Farmer, Yasser Al Omran, Qasim Aziz, and Paul L. Andrews. The role of the parasympathetic nervous system in visually induced motion sickness: Systematic review and meta-analysis. Experimental Brain Research, 232(8):26652673, 2014.
[12] Lawrence J Hettinger and Michael W Haas. Virtual and adaptive environments: Applications, implications, and human performance issues. CRC Press, 2003.
[13] Senqi Hu, Wanda F Grant, Robert M Stern, and Kenneth L Koch. Motion sickness severity and physiological correlates during repeated exposures to a rotating optokinetic drum. Aviation, space, and environmental medicine, 1991.
[14] K Hugdahl. Cognitive influences on human autonomic nervous system function. Current opinion in neurobiology, 6(2):252258, 1996.
[15] B. M W Illigens and Christopher H. Gibbons. Sweat testing to evaluate autonomic function. Clinical Autonomic Research, 19(2):7987, 2009.
[16] D Longo and A Fauci. Harrisons Principles of Internal Medicine. New York: McGraw-Hill., 2011.
[17] Melody M Moore and Umang Dua. A galvanic skin response interface for people with severe motor disabilities. ACM SIGACCESS Accessibility and Computing, (77-78):4854, 2003.
[18] Samuel Pedro. Sensor-based Detection of Alzheimers Disease-Related Behaviours. Masters thesis, University of Coimbra, 2013.
[19] James T Reason and Joseph John Brand.Motion sickness. Academic press, 1975.
[20] Juan Sztajzel et al. Heart rate variability: a noninvasive electrocardiographic method to measure the autonomic nervous system. Swiss medical weekly, 134:514522, 2004.

[21] Mika P. Tarvainen, Anu S. Koistinen, Minna Valkonen-Korhonen, Juhani Partanen, and Pasi a. Karjalainen. Analysis of galvanic skin responses with principal components and clustering techniques. IEEE Transactions on Biomedical Engineering, 48(10):10711079, October 2001.

[22] Brenda K Wiederhold and Stephane Bouchard. Sickness in virtual reality. In Advances in Virtual Reality and Anxiety Disorders, pages 3562. Springer, 2014.

[23]F.Jesse, A.Dylan and N.B. Jeremy . Virtual Reality , A Survival Guide For the Social Scientist .

[24] http://www.rotoview.com/gravity_sensor.htm

[25] https://developer.mozilla.org/en-US/docs/Web/API/WebVR_API/Concepts

[26] https://newatlas.com/stanford-research-virtual-reality-light-field/38825/

[27]https://internetofthingsagenda.techtarget.com/definition/virtual-reality-sickness-VR-motion-sickness

[28]https://en.wikipedia.org/wiki/Virtual_reality_sickness#cite_not

[29] N.D. Ahuja, a.K. Agarwal, N.M. Mahajan, N.H. Mehta, and H.N. Kapadia. GSR and HRV: its application in clinical diagnosis. In 16th IEEE Symposium Computer-Based Medical Systems, 2003. Proceedings., 2003.