Creating educational games in virtual reality for cultural heritage knowledge

Traineeship report

Léo Massy

Supervisor : Mr. Niall McShane

Teacher : Mrs. Anne-Isabelle Llanta

ULSTER UNIVERSITY – INTELLIGENT SYSTEMS RESEARCH CENTRE

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IUT de Lannion – Département Informatique   *2018-2019*

Acknowledgments

First of all I would like to thank the UIT of Lannion and Ulster University for accompanying me, in the research internship and the opportunity to go abroad.

I would like to thank Mrs Anne-Isabelle Llanta for helping us during the internship, Mr Michael Callaghan and Mr Niall McShane for supervised us. And All my teammates, Hugo Boistuaud, Hugo Fauvel and Kévin Rolland.

And finally, I would also like to thank "Brackeys". He made a lot of top-quality game development tutorials on youtube for free on everything from Unity and programming to game design.

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Introduction

My name is Léo Massy and i'm currently in my second year of my computer science Technical University Diploma in the UIT of Lannion (a two years diploma). For this second year, I had to do an internship, I told myself that I preferred to go abroad if possible to improve myself in English and discover another culture. The possibility to interact with my English supervisor allowed me to improve my sentences orally.

As I said, I was very interested in improving my English, and I was also very motivated by the subject of the internship "Creating educational games in virtual reality for cultural heritage knowledge". Virtual reality, which is a fairly recent technology and a little expensive at the moment, and not too accessible for a student. Being able to work on virtual reality seemed very gratifying to me.

We worked on different projects with a commonality "virtual reality". The main project was called "Spirits of St.Catherines" and we worked five weeks on it. This main project is part of a larger project called "CINE project", which aims to numerically backup historical sites through the digital reconstruction process with the help of virtual reality and augmented reality and other technologies in the northern environnement.

In this internship report, first of all, I will presenting the Ulster University environnement. Then I will present all the projects I worked on. Thereafter, I will present how I organized those projects. And finally, I would show all the technical realization side of this internship.

Ulster University in Derry

Location

Derry, officially Londonderry is the second-largest[1] city in Northern Ireland with nearly 110,000 inhabitants. This town is particularly known for the siege of Derry in 1689 and the terrible episode of Bloody Sunday, 30th January 1972. The city has experienced a complicated geopolitical context with the annexation of Northern Ireland by the United Kingdom and the fact that many Northern Irish want the independence of Northern Ireland.

Figure 1: Derry and Lannion location (Source: Google Maps)

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[1] Belfast is the capital

The university is composed of four campuses: Belfast, Coleraine, Jordanstown and Magee. We were in the Magee campus which is located in the city of Derry which welcomes 5,000 students and if we add all the campuses of Ulster university at the same time no less than 27,000 students. In Derry, the Magee Campus there are various departments: Psychology, Drama, Sciences, Commerce, Social Sciences and Computer Science.

History

Created in 1868 as the New University of Ulster, we can trace its roots back as far as 1845, when Magee College was established in Derry. In 1984, it merged with Ulster Polytechnic incorporating its four Northern Irish campuses under the University of Ulster banner (Figure 2).

Belfast: The Belfast campus is located in the artistic and cultural center of the city, the Cathedral Quarter. Although traditionally associated with art, the campus spans an increasing and exciting range of subjects including architecture, hospitality, event management, photography and digital animation.

Coleraine: A wide range of subjects is available at Coleraine, which includes biomedical sciences, geography and environmental science, psychology, pharmacy, English, history, media and journalism, travel and tourism, and teacher training.

Magee: Magee College is the campus where we have been, where you can learn a lot about lot of things including business, cinematic arts, Irish, music, drama, computing, engineering, nursing and law.

Jordanstown: Jordanstown is the largest of Ulster's campuses, located just seven miles north of Belfast. The campus has a strong profile in computing,

built environment, business, engineering, social sciences, communication and academic disciplines relating to the science and coaching of sport.

Figure 2: Ulster University Campuses location (Source: ulster.ac.uk)

Ulster University is a public structure, mostly financed by government help and student fees. Its primary goals are student education and research in various fields. It is a public institution that provides services so Ulster University is situated in the tertiary sector.

With more than 2,500 employees, the University has a real impact on the Northern Irish economy, generating more than £203 millions in income in 2017. It also spent more than £190 millions in expenditure, and has generated more than 8,000 jobs.

ISRC - Intelligent Systems Research Centre

ISRC or "Intelligent Systems Research Centre" (Figure 3) is a part of the IT department of Ulster since 2017, which focuses on robotics, virtual reality and neurotechnologies applied to health.

Figure 3: ISRC's Logo (Source: ulster.ac.uk)

The research center provides a technologically advanced research environment, including laboratories for bio-inspiration and neuroengineering, brain-computer interfacing, computer neuroscience, cognitive robotics and evolution, as the installation of research in wireless and ambient intelligence.

Working Environment

We were working in a room called the computer science lab with many other students from other institutions, Ulster University was under renovation throughout the summer, so for practical reasons we were all together in a room with powerful computers for run Unity Engine.

At the beginning of the internship we were ten people, eight French and two Finnish. Mr. Michael Callaghan had personal problems during the first month of our internship, he was responsible of several project group including ours. It was

impossible for him to manage all the groups, so we changed the supervisor for the good of the project and the internship went off without a hitch.

Our new supervisor who greeted us the first day was Mr. Niall McShane, who is a game developer and a 3D designer. Three or four weeks after our arrival, twenty other students arrived in our room, they were practically all French and came from different places of France, like Montpellier, Poitiers, Caen. We were able to interact with them during our internship and learn about their internship, which was interesting.

Projects

Unity Environnement

What is VR[2] ?

First of all, VR stands for Virtual Reality, you put on an headset (Figure 4) and you will dive in 3D world, you can interact with it. VR is a simulated experience that can be similar to or completely different from the real world. Applications of virtual reality can include entertainment (like gaming) and educational purposes (like students projects, medical training or military training).

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[2] VR : Virtual Reality

Figure 4: Vive Headset with bases and controllers (Source: vive.com)

Unity and C sharp

Unity engine is a video game engine, it is a software that will simulate and calculate the geometry and physics used in the game in real time. The Unity Editor features multiple tools that enable rapid editing and iteration in your development cycles, including Play mode for quick previews of your work in real-time.

Unity supports both 2D and 3D development with features and functionality for your specific needs across genres but we used essentially 3D development for the VR environnement during our internship. With Unity, you can use two programming languages, C sharp or javascript, it is more advisable for beginners in unity to start coding with C sharp. So we wrote all our C sharp scripts in unity so each game entity could behave properly. Each C sharp script aims to limit or grant different movements or behaviors to one or several objects.

Figure 5: Unity Engine Logo (Source: unity.com)

SteamVR plugin

Steam VR is an library for unity that gives you a lot of Unity prefabs to help develop virtual reality. We decided to use this plugin in our project because it was free, very accessible and with great compatibility on most virtual reality headsets.

The biggest problem was understanding the documentation and matching it with the script we wanted to do. The documentation was entirely English with technical terms, it was sometimes very complex to understand the meaning of the sentence.

Figure 6: SteamVR Plugin for Unity Engine (Source: store.steampowered.com)

Paper Toss VR

It is our first video game coded in collaboration, "Paper Toss VR". The goal ? Sending the seven paper balls to the wastebasket, those paper balls were randomly generated throughout the room.

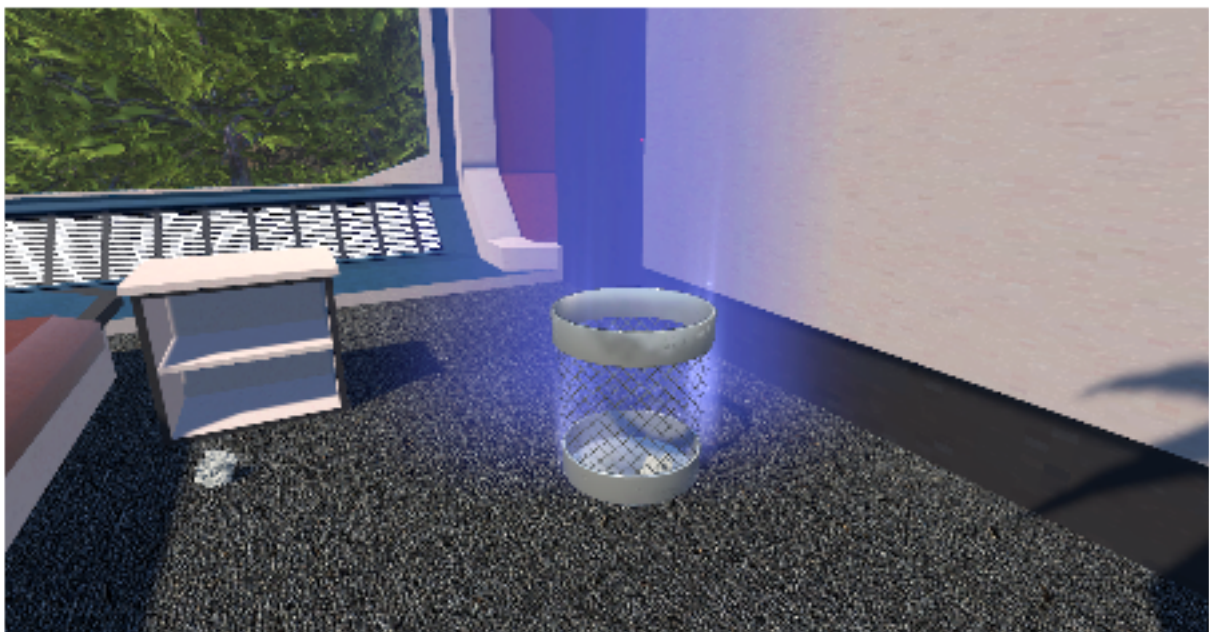Figure 7: Preview of "Paper Toss VR" (Source: Unity Editor)

Figure 8: Scored effect (Source: Unity Editor)

We must look for the paper balls and then pick them up and throw them as if we were in real life. When you make the basket with the paper ball, a light particle effect is emitted as well as a victory sound and your score is updated.

This project was our first project in collaboration, it was intended to teach us how to collaborate on the same Unity project and to train on the Unity environment to be more comfortable with it.

Road Safety First !

Kévin Rolland and I had the idea on our free time during the internship, to make a game based on road safety. Actually, the goal of the game is to cross the road in VR without getting run over by the car. To do this the player selects using the calculator the distance of the car and its speed and cross the road, if the player has time to cross and get to the other sidewalk, then the game congratulates the player, otherwise the car hits the player and a pop up on road safety appears.

Figure 9: Preview of "Road Safety First !" (Source: Unity Editor)

Spirits of St.Catherines VR

This project is a part of the CINE project. This is the digital reconstruction of St.Catherine's Church, the goal of the game Spirits of St.Catherines is to build a virtual museum.

Figure 10: CINE's Logo (Source: cine.interreg-npa.eu)

The game is divided into three distinct scenes, the first scene is the menu of the game (Appendix 1), you can walk in VR and start the game or leave it. The second scene is more interesting, it is a kind of waiting room or a hub with several activities inside (Appendix 2), you can for example see different photograph of the church as it is today or even move parts of a miniature church to see inside (Appendix 3). Finally, the third scene is the digitally reconstructed church, you can walk freely inside and outside the building (Figure 11).

This project when we was added to it was already began, it's the only project we did not create from scratch. So it was a bit difficult at first to understand how the old developer had worked on it, how their codes worked. We coded some new features like a mini game "Catch the spirit", this game consists of catching little spirits (Appendix 4) floating in the air with a butterfly net, once the spirit is caught, it returns to the top of his grave and an explanatory pop up appears.

Figure 11: Spirits of St.Catherines preview (Source: Trello Spirits of St.Catherines)

Ship versus Fortress VR

Ship versus Fortress is a mini game developed to be eventually implemented in the game Spirits of St.Catherines. For practical reasons and to avoid some conflicts when sharing through the collaboration tool, we decided to develop this mini game on a new unity scene.

The objective of the mini game is to sink the boat before it destroys our fortress. To sink the boat we have a cannon and all the tools to load the cannon and shoot with it (Figure 12). It will therefore put black powder in the cannon, then push the black powder to the bottom of the cannon with a stick provided for this purpose, finally it will only be left to load the cannonball and light the wick with the torch on fire; do not forget to aim of course.

Figure 12: Ship versus Fortress preview (Source: Unity Editor)

Project Organization

Trello

Trello is a task management app, it gives you a visual overview of what is being worked on and who is working on it. It can be represented as a whiteboard filled with post-it notes (Figure 13). Thanks to this system individuals or teams can track a project and collaborate or contribute more easely where they can be most useful or where it is most needed.
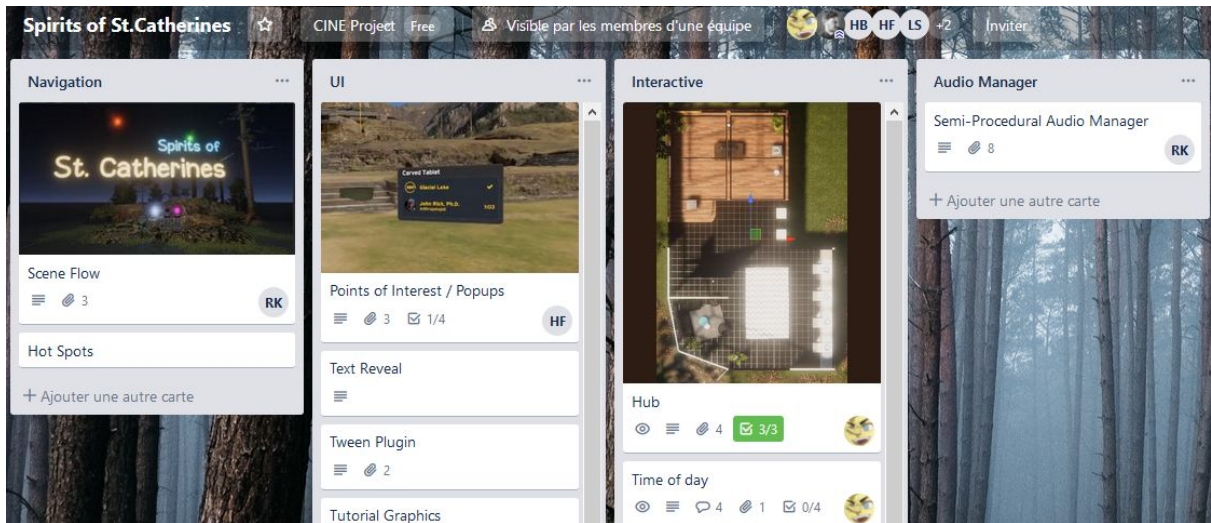
Figure 13: Spirits of St.Catherines' Trello (Source: trello.com)

Niall McShane, our supervisor, he sent us with Trello cards, the list of tasks to be done for the day or the week, we only had to check the corresponding checkbox each time we carried out the task. We had regular meetings with our supervisor, we showed him what we had done and he told us if changes were needed.

Gantt Chart

We never had the list of things we were going to do during the internship, we knew we were going to work on unity engine and we were going to work with virtual reality technology but that's all we have at the beginning. Mr. Niall McShane gave us tasks to do during the week, adding tasks progressively. We were therefore unable to produce a forecast Gantt chart. However after completing the internship we can realize a real Gantt chart without any problem.

The first week, we adapted to the Unity environment using different tutorials. The second week of internship we also followed a lot of tutorials but also we started and finished a concrete and collaborative project called Paper toss VR. This game was intended to teach us the basics of development in Unity engine and how virtual reality works.

The third week we started working on the main project "Spirit of St.Catherines". Our goal was to implement new features to the project and to complete some old functionality that had bugged with the Unity Editor update. A larger version of this Gantt Chart is available in the appendix (Appendix 5).
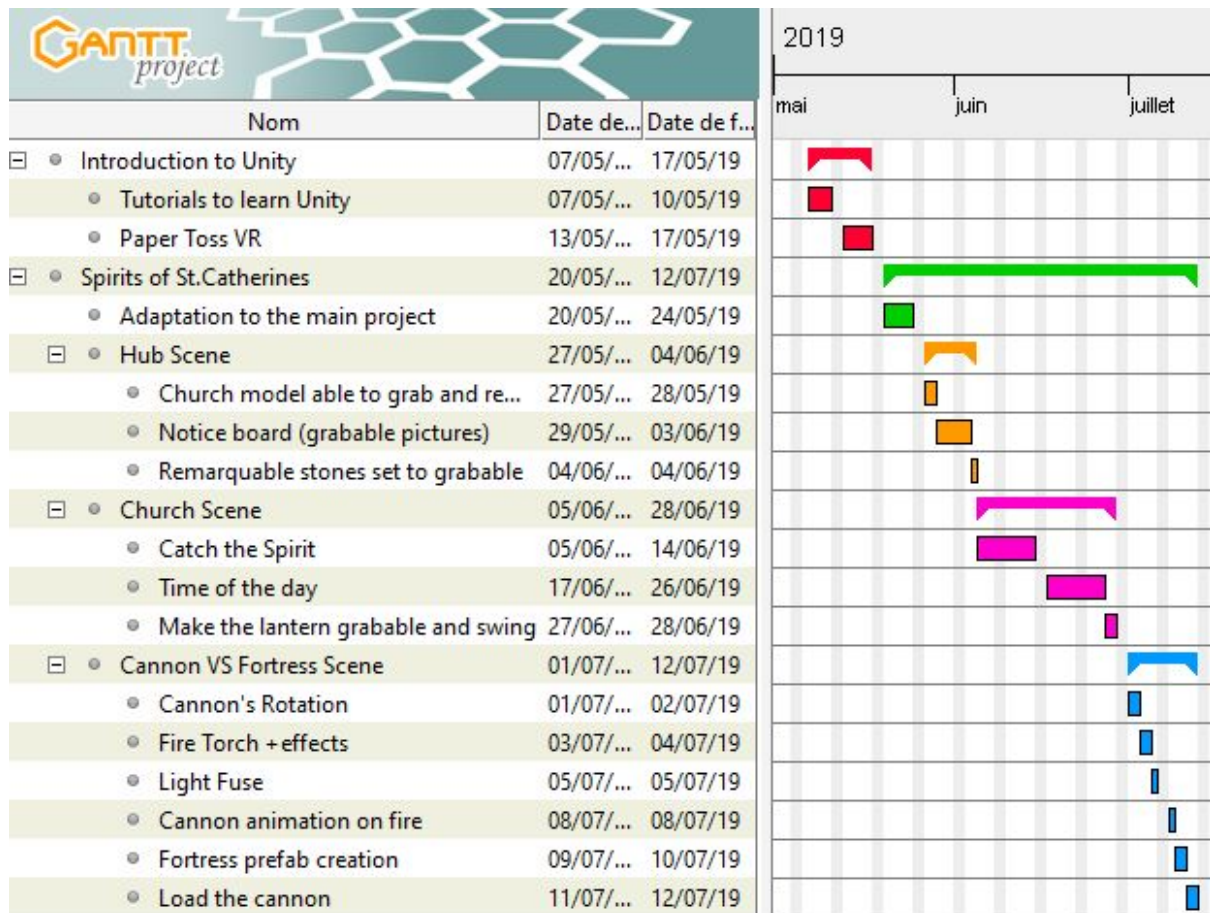

Figure 14: Gantt Chart compact edition (Source: GanttProject)

Developing in Unity

Unity is a software with a time of adaptation, when you open Unity editor for the first time, you are flooded with tabs that you do not understand.

First of all, you have a file manager that allows you to see all the files in the Unity project (Appendix 6). Then you have a hierarchy tab (Appendix 7) that allows you to see all the entities (GameObjects) in the Unity scene. A Unity project can have

multiple scenes, scenes can be represented by video game levels, for example Scene 1 is Level 1 in the game. To visualize all the graphic elements of the various GameObjects, the scene tab (Appendix 8) is essential, to know if the GameObject is placed at the right place in the game.

Finally the last tab is the inspector tab (Appendix 9), it allows to visualize all the components of a GameObject, the components are all the parts attached to the GameObject (a C sharp script, a position, a collisions, a rendering, a rotation ...), and modify the values if necessary. One of the tools we used a lot is Unity Collaborate tool, this allowed us to work on different parts of the project simultaneously and share it easily.
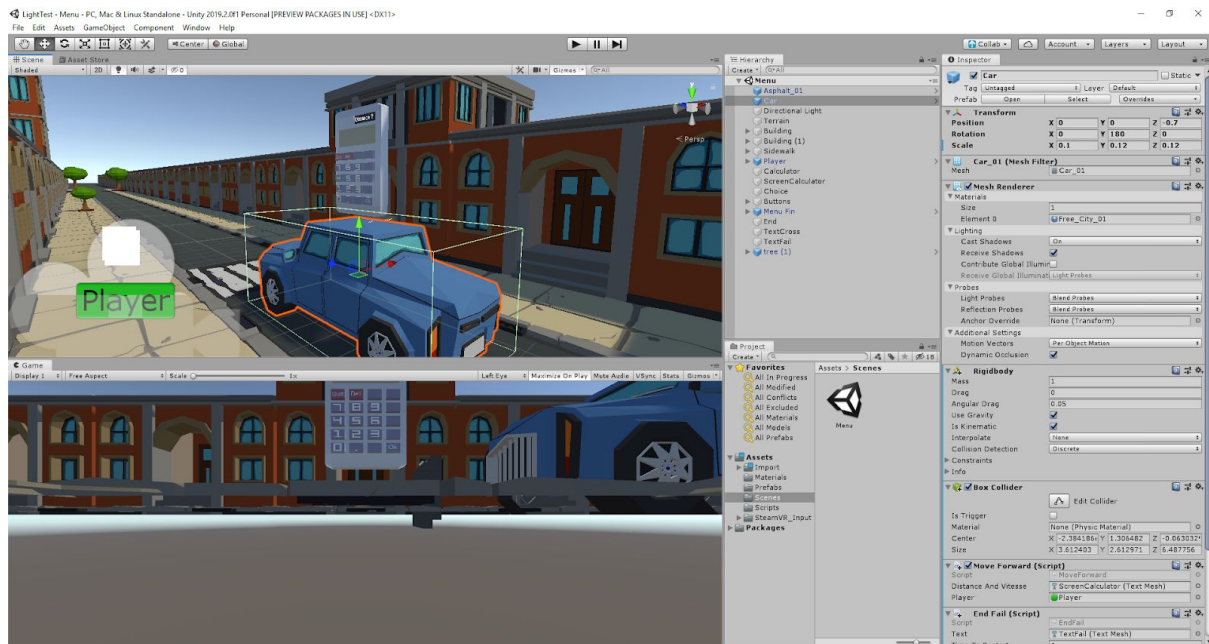

Figure 15: Unity Engine Editor (Source: Unity software)

For the C sharp scripting, we used the Visual Studio (Figure 16). It's an IDE, an integrated development environment developed by Microsoft and free to use. Visual Studio was very useful for its auto-completion feature (when you write a C sharp function, the specific words of the function are completed).

The compatibility of visual studio with Unity Editor was extremely practical, most of the functions were pre existing in the software so very easy to use and implement.

Figure 16: Visual Studio's Logo (Source: visualstudio.microsoft.com)

Technical Realization

Tutorials

To learn unity engine and C sharp, the two first weeks we have watched a lot of Brackeys' video (Figure 17). His tutorials were very easy to understood and very useful. The first week was essentially just us learning to code with the new environment that is Unity Engine.

The second week, we also saw many video tutorials but also we coded our first game in collaboration, indeed, we used "Unity Services Collaboration" (Appendix 10), an equivalent of the file versioning system "Git" set up by the developers of Unity software.

Figure 17: Brackeys tutorials' channel (Source: youtube.com)

Projects Realization

Paper Toss

This project was our first Unity project in collaboration, so there is a lot of problem that we caused by our ignorance of the software as conflicting errors when sharing changes to the project or code errors. Later in the project, we fixed all the problems that bothered us.

At first we started by setting up the virtual reality headset and understand how it works, then we set up a new scene with the implementation of the steamVr plugin and teleportations areas of a player entity to test our first game in a VR environment. The player can only teleport in teleportations areas (Appendix 11).

Hugo Boistuaud and I worked together on the graphical environment of the game or how to go look like the game (Figure 7). We have for this, download some free assets on the asset store available on unity editor directly. Then we put different Unity Prefab in the scene to make the game more attractive and nice for the player.

I coded a part of the script that allows to visualize graphically when the player scores a goal with a paper ball (Figure 8), a blue particle effect is then emitted from the top of the basket, signaling to the player that he scored. I also create the GameObject of the paper ball (Appendix 12) with the physics of a real paper ball and bounce so that it looks as real as possible. I also realized with the help of Kévin the

two buttons that allows the player to reset the game and the buttons that allows you to leave the game (Appendix 13).

Spirits of St.Catherines

In this project, we were already used to using virtual reality and we knew how it worked. The hard part was to understand the old C sharp script.

Hub Scene

I set remarquable stones to grabbable, those are scanned stones with a smartphone that have an extremely realistic texture, making them grabbable allows to observe them more closely (Appendix 14).

In the back of the room, there is a miniature model of St. Catherine's Church, I made each piece of this church miniature to be able to grab for the player. The player can interact and lift the roof or remove a wall with his controllers (Appendix 3 and 15).

I helped Kevin with the grabbable pictures of the notice board (Appendix 16). Each picture must come back with the help of a C sharp script in its original place, even if the player has rotated it or moved it in another room. The problem was that the rotation did not reset. We finally figured out where the problem was coming from and corrected it.

Church Scene

The first thing I did in this scene is the C sharp script to make the lantern grabbable and swinging, you can walk around the church with the lantern to see better (Appendix 17).

I have to coded a new feature, a radial menu (Appendix 18) on a controller that allows the player to change the day or the night according to what he wants to be able to see, the church on day or on night. Unfortunately with the upgrade of unity engine, it was impossible despite all our attempts for several days to change the day

and night dynamically, without it being sudden. It is my only regret for this internship, not having achieved this feature.

And finally I realized the GameObject of the spirit with some script attached to it. This mini game (catch the spirit) we coded it together (Appendix 2).

Ship versus Fortress Scene

The first thing I did on this scene is the cannon's rotation by the player with a limit, the cannon can not turn around completely to prevent him from shooting directly at the fortress. Indeed the cannon can only shoot towards the water, where the colonial ship is.

I also helped Hugo Fauvel in designing the trajectory of the cannonball, so the shot is as realistic as possible (Figure 12). The hardest thing was to calculate the trajectory, because each time we added a force to the cannonball and we make a rotation, the cannonball did not go to the right place.

I also created the fortress's gameObject by downloading a 3D fortress model and modifying all these components. The GameObject need to have some colliders, so the enemy cannonball can hit it.

I also work a lot on the cannon itself by creating the animation of the cannon when it shoots, the animation and the effects of particles of the wick when it lights up and some stages of the loading of the cannon. The longest thing to do was to create the fire torch (Appendix 19), it had to be able to light the cannon wick but also to have a really good texture and astonishing particle effects.

Virtual reality tests

We were able to start testing the virtual reality headset from the second week of the internship. The first week we only did unity tutorials and we did not need the virtual reality headset.

Our supervisor brought us two virtual reality headsets, an Oculus Rift (Appendix 20) and HTC Vive (Figure 4). We had to test on both headsets to see if our game was compatible, it was a requirement every time we developed a new feature. Virtual reality was a new technology that we only knew by name, so we did a lot of testing in the first weeks because every time we developed a feature, we were not sure if it worked in a virtual reality environnement.

Conclusion

I loved this internship which was extremely interesting, the fact that the internship was abroad was very positive for me, I knew a new culture and learn to manage myself when I had to interact with irish natives. We were four from the UIT of Lannion going together, which was less scary than going alone.

We have created a total of four games in virtual reality with a technology with great potential and extremely interesting to learn. Having worked in the IT department of the Lannion's UIT helped me a lot thanks to the knowledge of programming and project management.

This internship allowed me to discover another branch of computer science, the creation of video game. This gave me knowledge in this field that I would like to deepen in the future, either in a firm directly or by my own self-taught way.

With the Spirit of St.Catherines project, working on a project that links history and new technologies such as virtual reality was very rewarding. It allowed me to be

reconciled with History which is not too much my thing, by mixing learning with playfulness.

Finally, if I had to do an internship in the same conditions, it would be with pleasure and enthusiasm, it was an incredible discovery and I hope that my next internships will be as good as this one.

Résumé

J'ai effectué mon stage du 6 mai 2019 au 12 juillet 2019 en Irlande du Nord à Derry la deuxième plus grande ville d'Irlande du Nord dans L'université d'Ulster magee campus, c'est la plus grande université d'Irlande du Nord avec plus de 2 500 employés et pas moins de 27 000 étudiants.

J'ai commencé le stage par des tutoriels vidéo sur l'environnement Unity pour m'habituer et comprendre comment fonctionne le logiciel. À partir de la deuxième semaine, nous avons toujours codé tous les quatre sur les mêmes projets en collaboration. Le premier jeu que nous avons réalisé était là pour consolider les bases que nous avions apprises la première semaine et s'adapter à l'environnement VR. Nous avons eu quelques problèmes de conflits lors du partage, mais nous arrivions à chaque fois à les résoudre. La deuxième semaine c'est terminé sur la réussite de notre jeu Paper Toss VR qui fonctionnait parfaitement bien, Notre superviseur Monsieur Niall McShane était satisfait.

À partir de la troisième semaine nous avons commencé le projet principal qui s'appelle Spirits of St.Catherines, c'est un jeu vidéo en réalité virtuelle qui s'apparente à un musée virtuel d'une église, en l'occurrence, l'église Sainte Catherines qui est mauvaise état présente à Killybegs en République d'Irlande (Appendix 20). C'était une reprise d'un ancien projet, le plus dur était donc de comprendre comment certains anciens scripts avaient été fait, mais une fois que nous avions compris le fonctionnement nous avons pu avancer normalement sans aucun souci.

Pour finir, ce stage était vraiment bien et enrichissant, je ne me suis jamais ennuyé à faire mon travail, découvrir la manière de réaliser tel objet sous Unity était satisfaisante à chaque fois, et ce n'était jamais répétitif, on pouvait voir notre marge de progression au fur et à mesure que le stage avançait. La gestion de projet ainsi que la programmation que j'ai apprises durant mon DUT ont été très utiles pour ce stage. J'ai également amélioré mon anglais oral grâce aux rencontres professionnelles et personnelles que m'a apportés ce stage. Toutes ces compétences me seront bénéfiques dans mon avenir professionnel.

Abstract

I did my internship from 6th May 2019 to 12th July 2019 in Northern Ireland in Derry the second largest city in Northern Ireland in Ulster University magee campus, it's the largest university in Ireland North with more than 2,500 employees and 27,000 students.

I started the internship with video tutorials about the Unity environment to get used to and understand how the software works. We have always coded all four on the same collaborative project on every project. The first game we did was to consolidate the basics we had learned the first week and adapt it to the VR environment. We had some conflict problems during the sharing, but each time we managed to resolve them. At the end second week, we successfully finish our game Paper Toss VR that worked perfectly well, Our supervisor Mr. Niall McShane was satisfied.

At the beginning of the third week we started the main project called Spirits of St.Catherines, it's a virtual reality video game that looks like a virtual museum of a church, in this case St.Catherines Church which is a well damaged church in Killybegs in the Republic of Ireland (Appendix 21). It was an old project, the hard part

was to understand how some old script had been done, but once we understood how the scripts worked, we could proceed normally without any problem.

Finally, this internship was really good and rewarding, I was never bored to do my work, to find how to achieve such GameObject in Unity Engine was satisfying every time, and it was never repetitive, we could see our improvement as the internship was taking place. The project management and the computer science skills I learned during my two years diploma were very useful for this internship. I also improved my oral English thanks to the professional and personal contributors. All those skills will be benefit in my professional future.

Technical terms

Virtual Reality (VR): VR is a simulated experience, you put on an Headset and you will dive in 3D world, you can interact with two controllers.

C sharp or C#: Is a programming language

Unity Asset: An asset is a file of a Unity project (a music, a C# script, a 3d model…)

Unity Prefab: It is an Unity object with saved properties (preconfigured Game Object)

GameObject: Every object in your game is a GameObject. This means that everything you can think of to be in your game has to be a GameObject.

Component: A GameObject is a container; you add pieces to the GameObject container to make it into a character, a light, a tree, a sound, or whatever else you would like it to be. Each piece you add is called a component.

Collider: Collider components define the shape of an object for the purposes of physical collisions.

IDE (integrated development environment): It is a software application that provides comprehensive facilities to computer programmers for software development.

CINE project: Connected Culture and Natural Heritage in a Northern Environment (CINE), it aims to numerically backup historical sites through the digital reconstruction process with the help of virtual reality and augmented reality and other technologies in the northern environnement, like numerical museum.

References

Ulster University:

https://www.ulster.ac.uk

CINE project:

http://cine.interreg-npa.eu

Brackeys:

https://www.youtube.com/channel/UCYbK_tjZ2OrIZFBvU6CCMiA

Trello:

https://trello.com/

Unity:

https://unity.com/fr

Visual Studio:

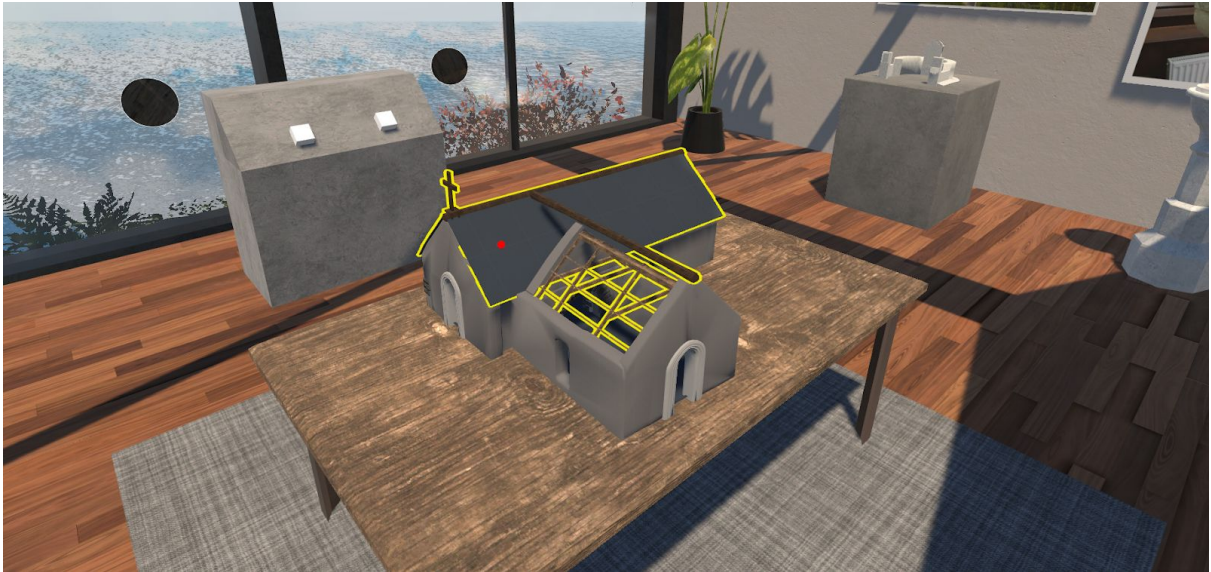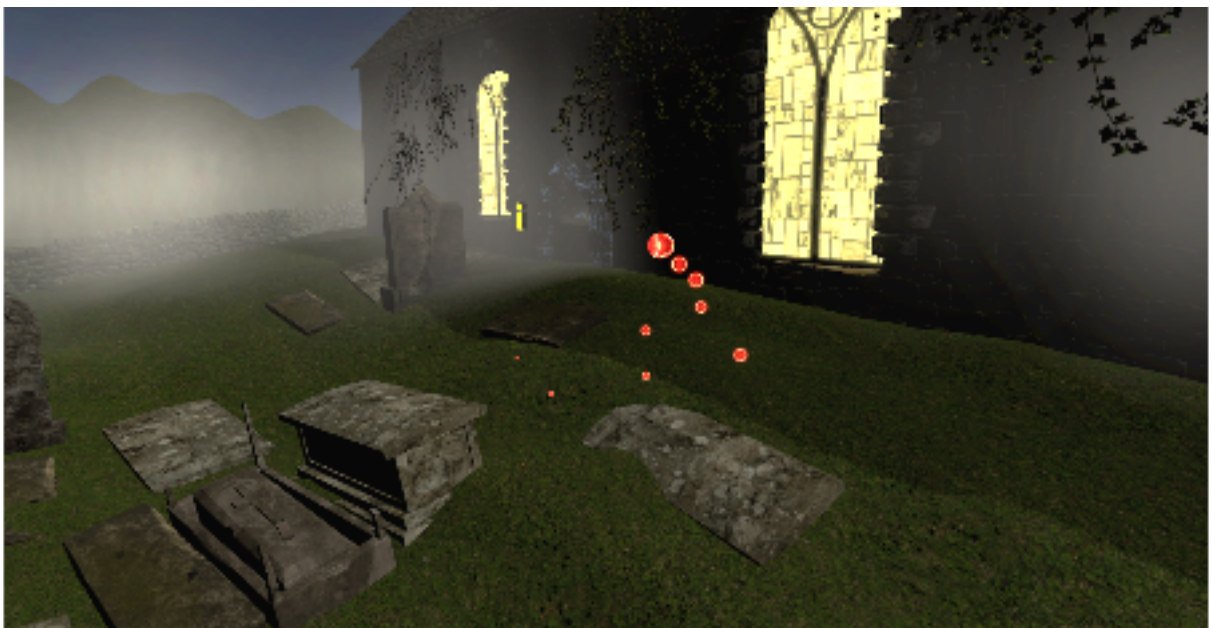https://visualstudio.microsoft.com/fr/

Appendices

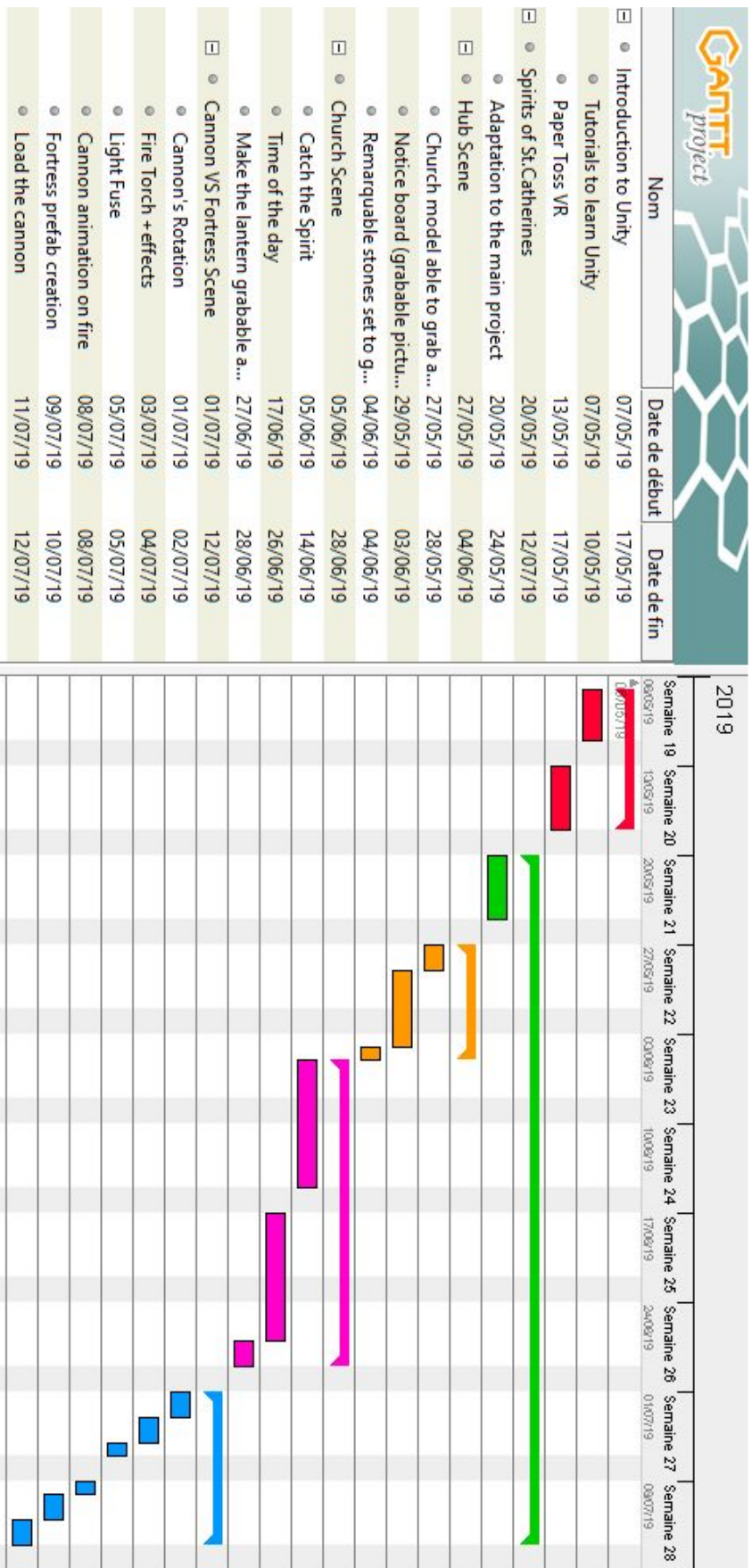Appendix 1: Title Scene (Source: Unity Editor)
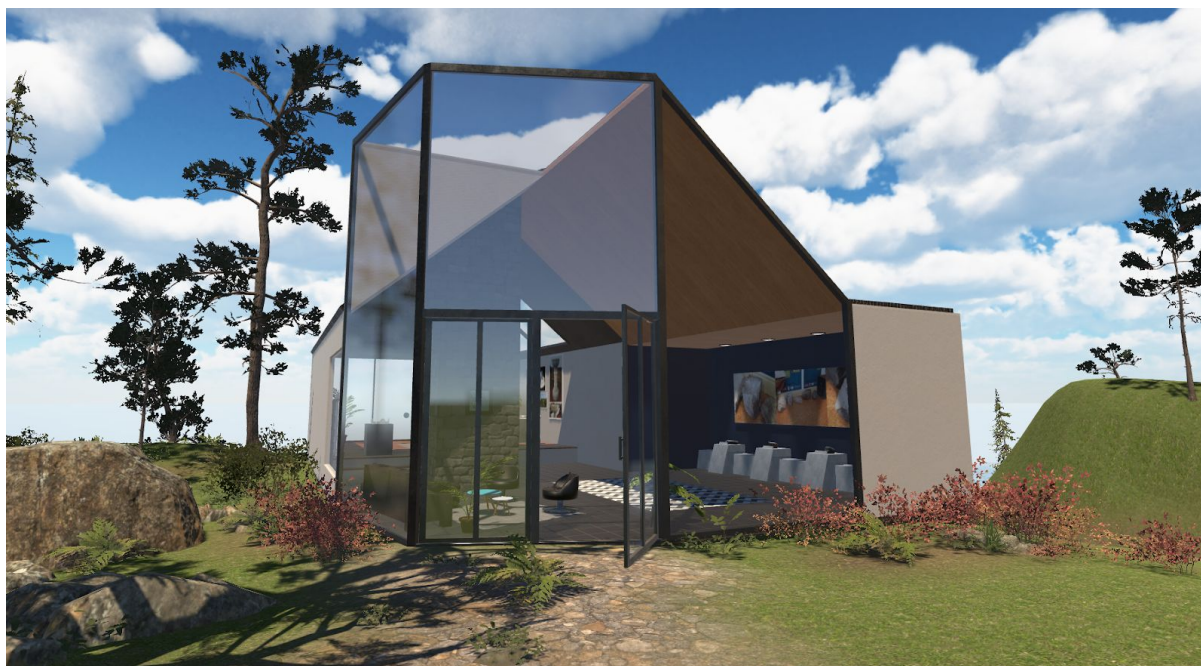
Appendix 2: Hub Scene (Source: Unity Editor)

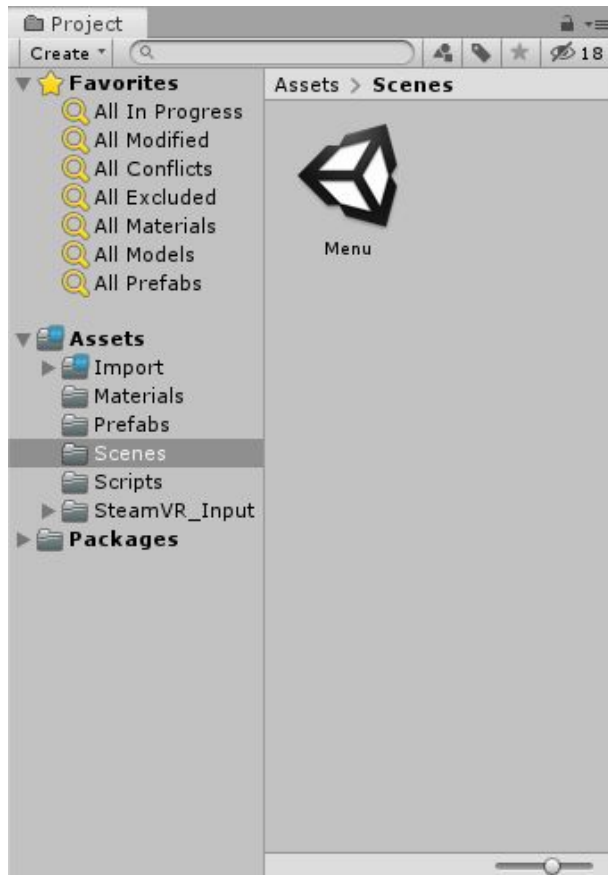Appendix 3: Miniature model of St. Catherine's Church (Source: Unity Editor)

Appendix 4: Spirit in the Church Scene (Source: Unity Editor)

Nom	Date de début	Date de fin
Introduction to Unity	07/05/19	17/05/19
Tutorials to learn Unity	07/05/19	10/05/19
Paper Toss VR	13/05/19	17/05/19
Spirits of St.Catherines	20/05/19	12/07/19
Adaptation to the main project	20/05/19	24/05/19
Hub Scene	27/05/19	04/06/19
Church model able to grab a...	27/05/19	28/05/19
Notice board (grabable pictu...	29/05/19	03/06/19
Remarquable stones set to g...	04/06/19	04/06/19
Church Scene	05/06/19	28/06/19
Catch the Spirit	05/06/19	14/06/19
Time of the day	17/06/19	26/06/19
Make the lantern grabable a...	27/06/19	28/06/19
Cannon VS Fortress Scene	01/07/19	12/07/19
Cannon's Rotation	01/07/19	02/07/19
Fire Torch+effects	03/07/19	04/07/19
Light Fuse	05/07/19	05/07/19
Cannon animation on fire	08/07/19	08/07/19
Fortress prefab creation	09/07/19	10/07/19
Load the cannon	11/07/19	12/07/19

Appendix 5: Gantt extended version (Source: Grantt Project)
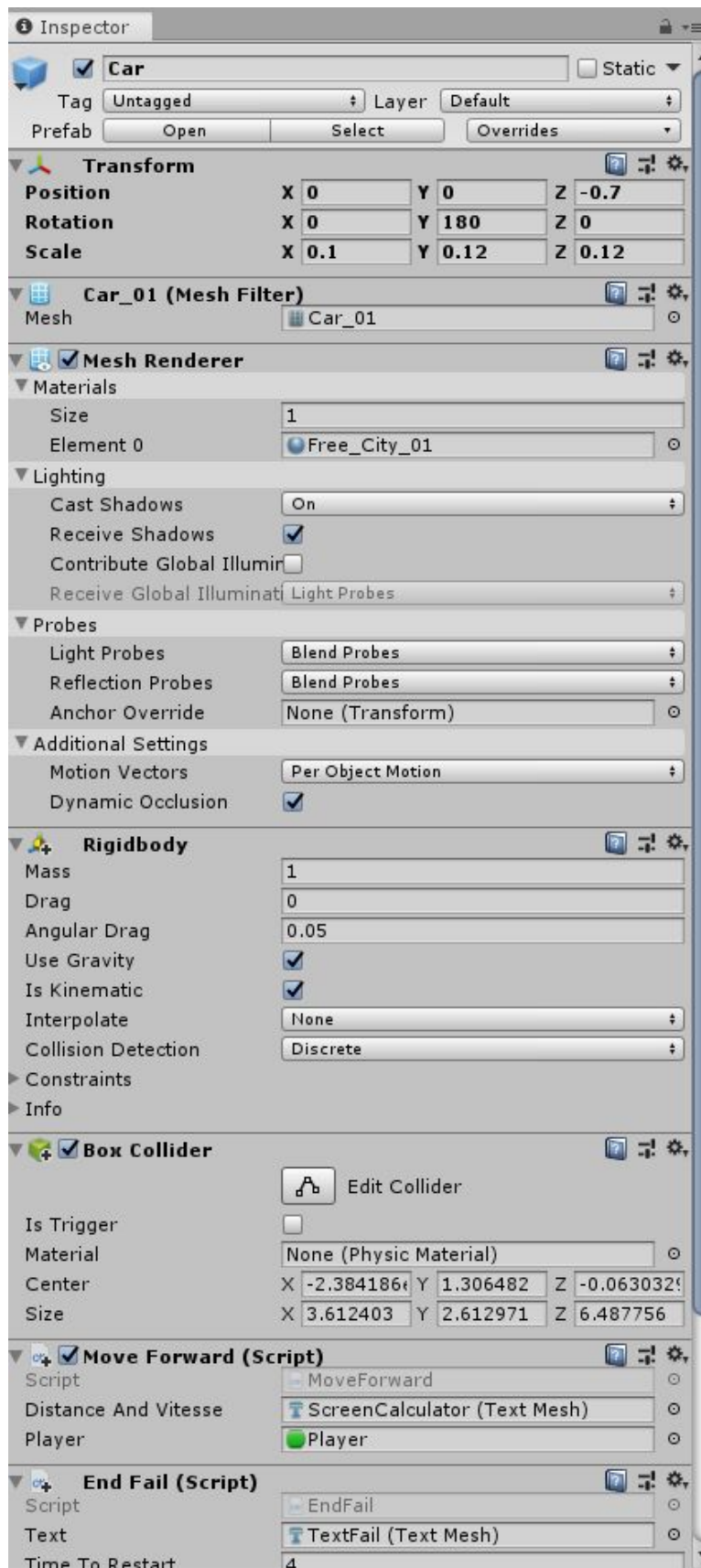
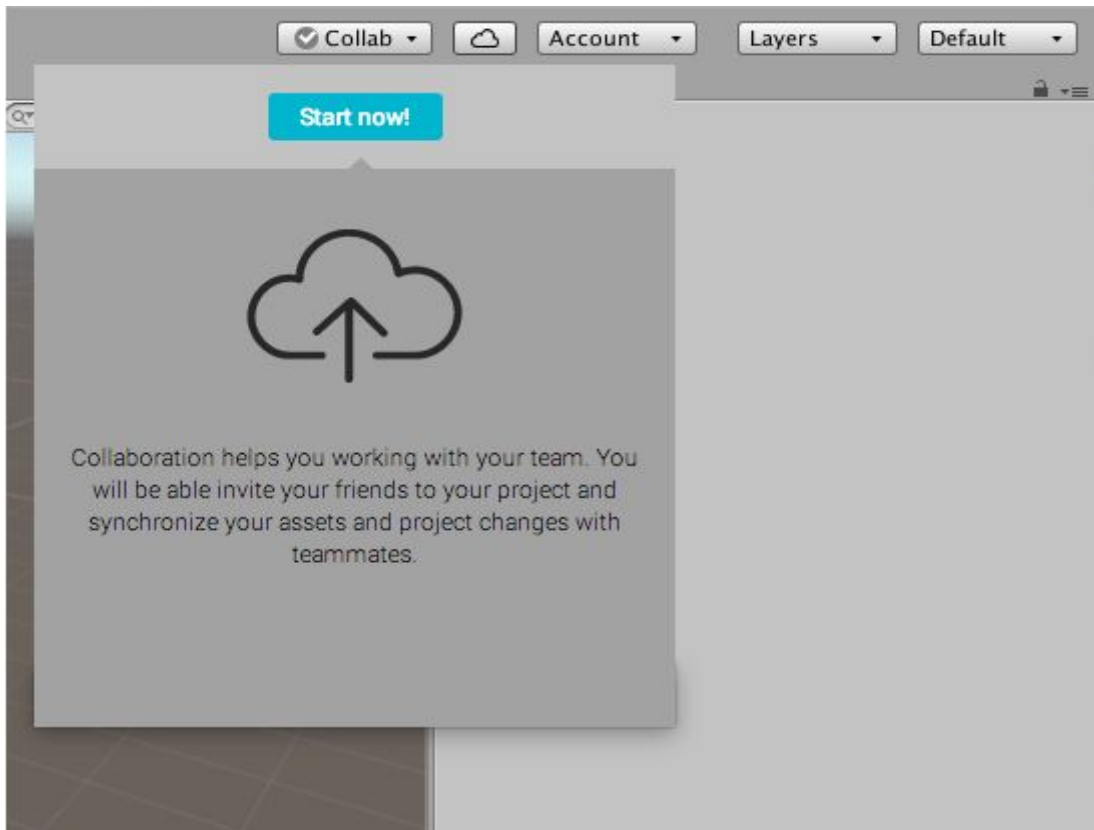Appendix 6: File Manager in Unity Editor (Source: Unity Editor)
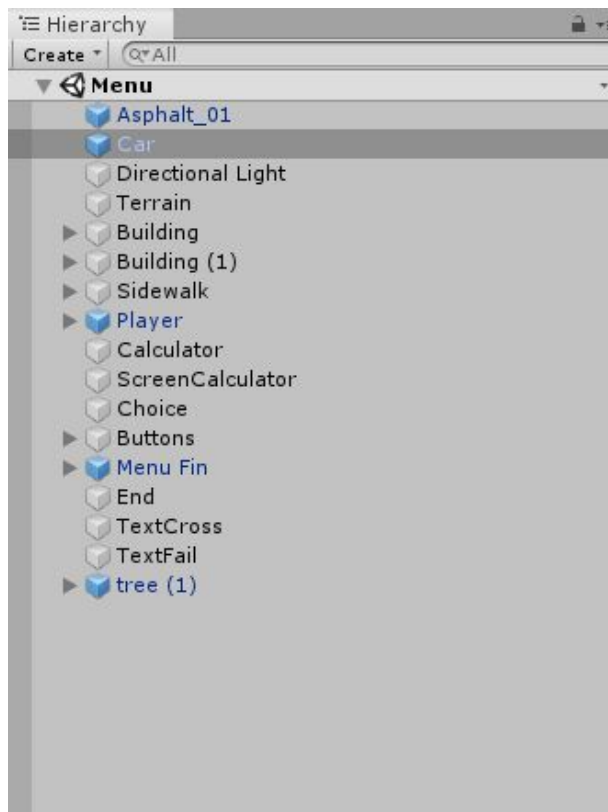
Appendix 7: Hierarchy tab in Unity Editor (Source: Unity Editor)
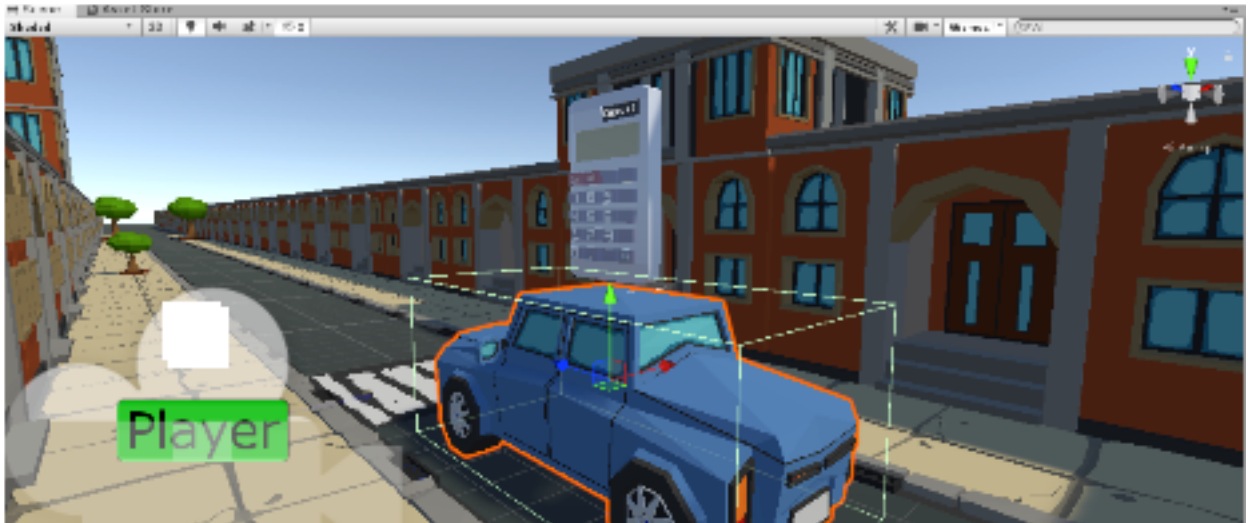
Appendix 8: Scene tab in Unity Editor (Source: Unity Editor)

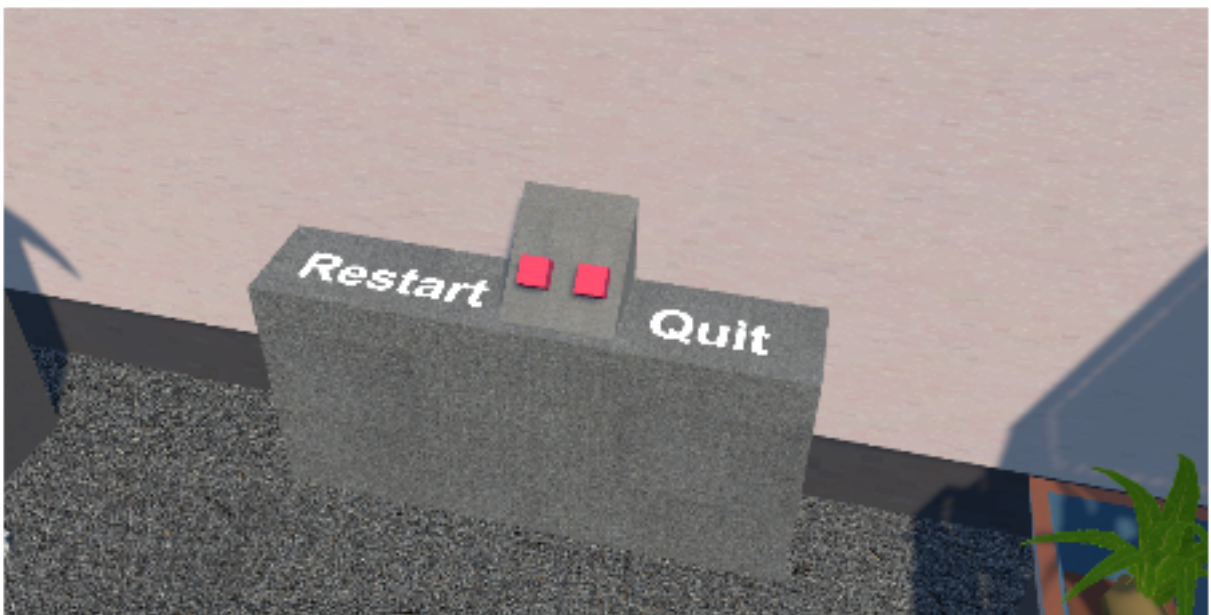Appendix 9: Inspector tab in Unity Editor (Source: Unity Editor)

Appendix 10: Unity Collaborate in Unity Editor (Source: Unity Editor)

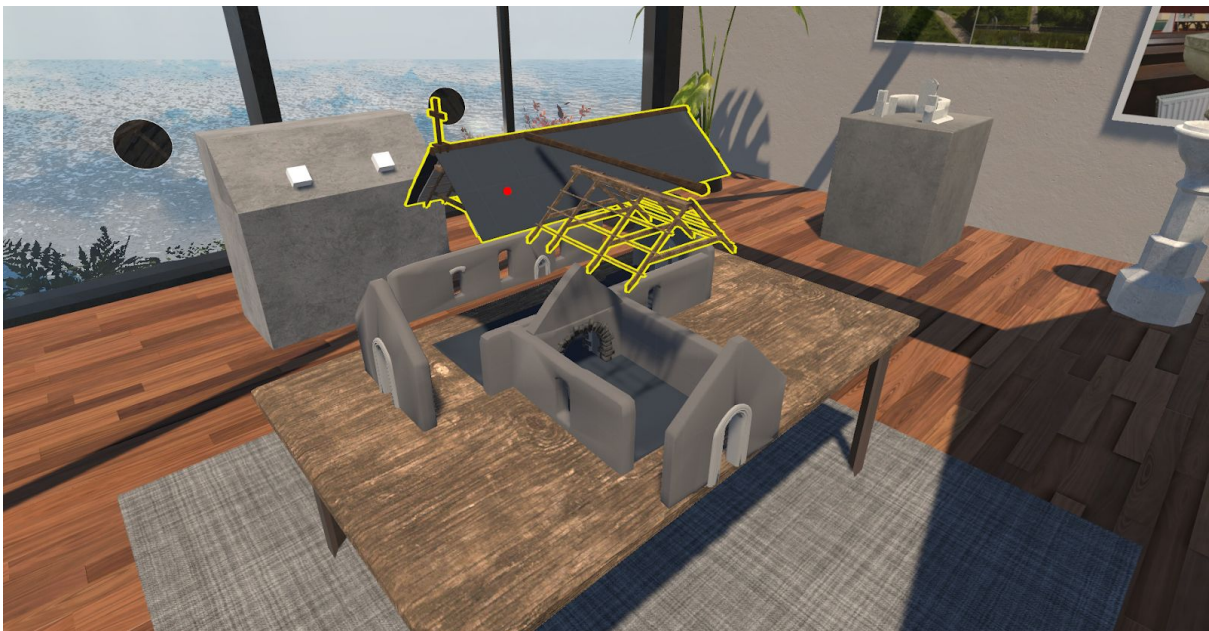Appendix 11: Unity Collaborate in Unity Editor (Source: Unity Editor)

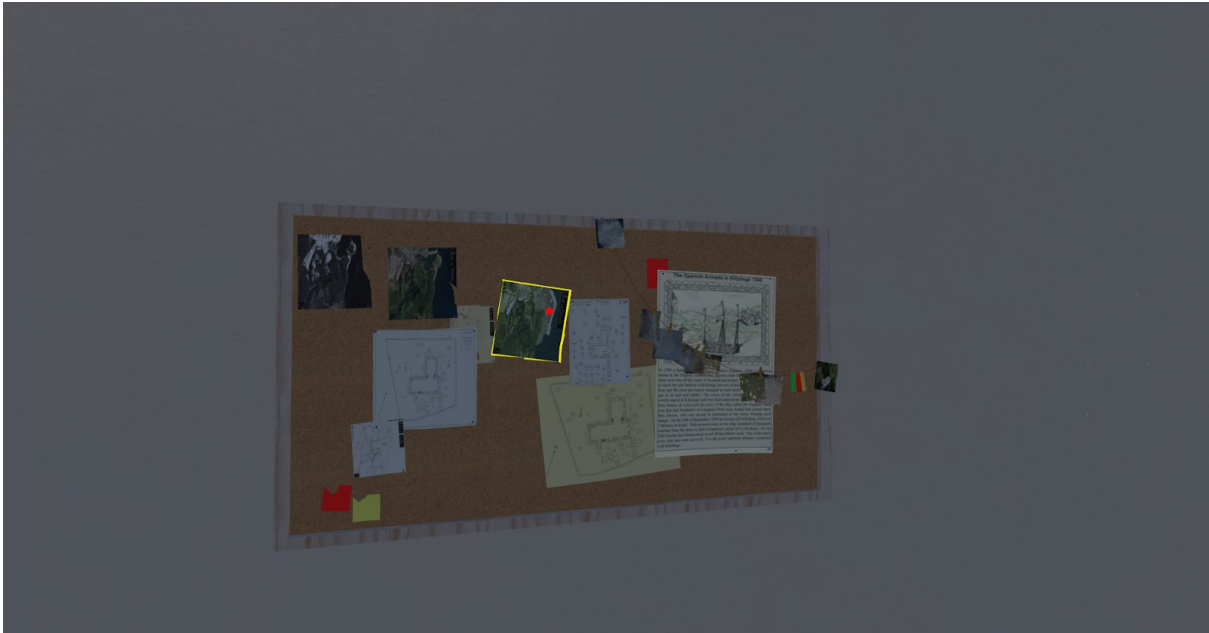Appendix 12: Paper ball GameObject (Source: Unity Editor)

Appendix 13: Restart and Quit buttons Paper Toss (Source: Unity Editor)

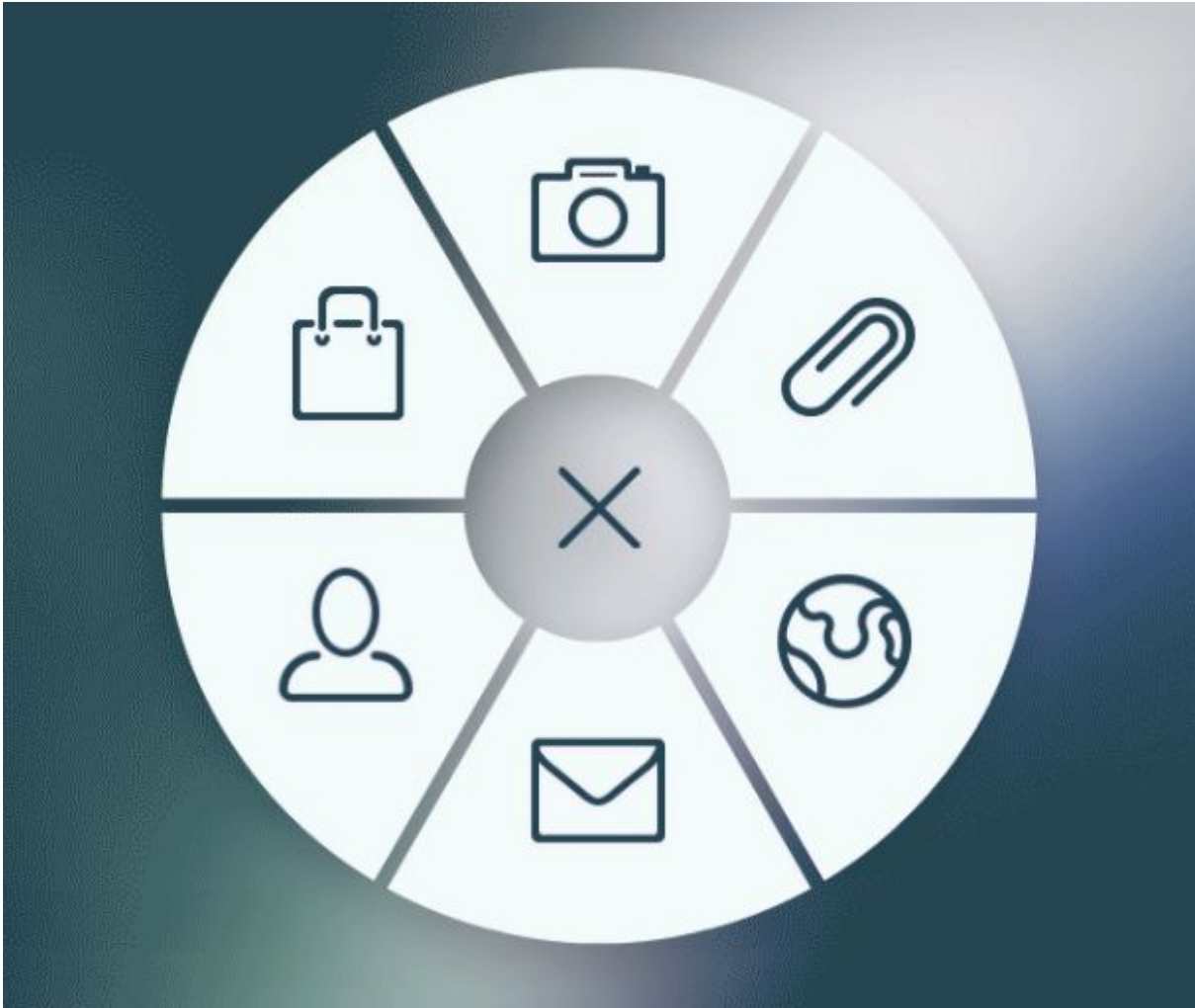Appendix 14: Remarquable Stones (Source: Unity Editor)

Appendix 15: Interaction with the roof and walls (Source: Unity Editor)

Appendix 16: Notice Board (Source: Unity Editor)

Appendix 17: The lantern in the church (Source: Unity Editor)

Appendix 18: Example of Radial Menu (Source: dribbble.com)

Appendix 19: Fire Torch (Source: Unity Editor)

Appendix 20: Fire Torch (Source: oculus.com)

Appendix 21: St.Catherines Church in real life (Source: trello.com)