Capstone Project 36

Virtual Reality Livestream

Requirements Document

Group 36:

Kaleb Graham

Alex Macdonald

Atif Murtaza Mahmud

Yingmin Tu

Andrey Varlamov

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Change Log

Date	Author	Location	Change
2019-11-23	AV	Sections 5.1 to 5.3	Functional and non-functional requirements, constraints were reconstructed and rephrased to address feedback and changes from Milestone 1: - Changed FR2 Connectivity to FR3 Instructor/student device(s) - Added FR2 Student Degrees-Of-Freedom - Moved FR3 Number of clients to non-functional (NFR4) - Added NFR5 Minimum Supported Specifications
2019-11-23	AV	Section 2	Modified the background section to information more relevant to requirements document specifically.
2019-11-23	AV	Section 4	Modified the project goals section according to feedback for Milestone 1.
2019-11-24	KG	Section 5.2	Updated NFR3 from smoothness to framerate, based off of discussions with the client.
2020-02-09	AV	Section 1.2	Added References
2020-02-09	AV	Section 4	Added info about wire/wireless and power consumption
2020-02-09	AV	Section 4.2	Change phrasing in NFR5
2020-02-09	AV	Section 5	Added Glossary
2020-02-09	KG	References	Reformatted reference page
2020-02-09	AMM	Background and Context	Updated Background and Context with more information
2020-02-09	AMM	Domain	Added IP and NDA details to Domain
2020-02-09	AMM	Project Goals	Updated project goals with envisioned use cases
2020-04-05	AMM	Client and Technology	Changed the order of appearance of sections

2020-04-05	AMM	Project Goals	Modified to be client and product oriented rather than technology oriented
2020-04-05	AMM	Requirements and Constraints	Updated to remove ambiguous descriptions
2020-04-8	KG	Requirements and Constraints	Add constraint C2. Add explanation for the source and reasoning for the requirements and constraints. Add C3 to specify that the student-side solution must support Android. Move Minimum instructor spec from NFR5 to C4
2020-04-8	KG	Appendix	Add appendix with network bandwidth constraint reasoning

1. Background and Context

1.1 Client and their Products

The Emerging Media Lab (EML) is a UBC-owned experimental space where faculty members collaborate with students to create VR applications to be used in classroom settings. Research has shown that virtual reality is very effective in learning. Inclusion of visual learning has been shown to improve the quality of pedagogy [1]. Additionally, VR technology has been shown to be effective in ease of learning [2].

VR can be effective in learning especially in cases where it allows users to simulate complicated environments or set-ups which are difficult to replicate in real life. For example, EML's flagship project is "Interactive VR Orchestra", where the application simulates an orchestra with the user acting as the conductor. This project is being developed in collaboration with UBC Faculty of Music to allow conducting students to practice without an elaborate setup.

Another example is "Jupyter 3D" which allows the user to view, rotate, and modify waves in a virtual environment. This allows students to get a deeper understanding of wave behaviour at an intuitive level.

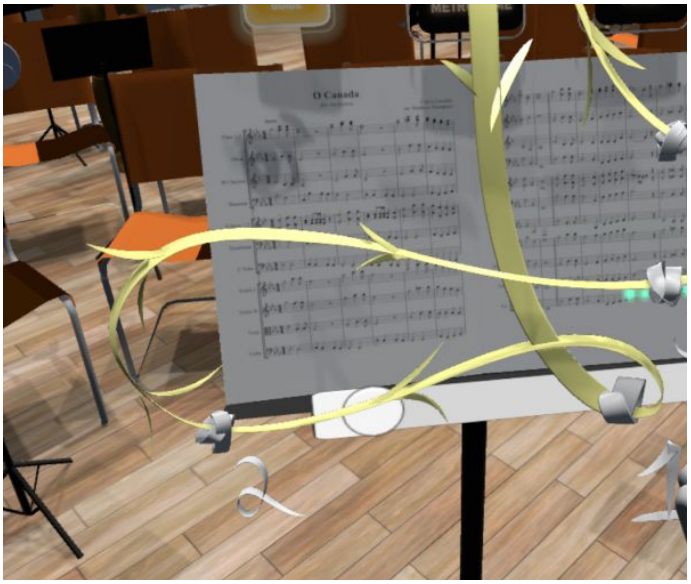

Figure 1: Interactive Orchestra tracks the motion of a VR controller to simulate a conductor's baton

1.2. Technology

Virtual Reality (VR) is a simulated experience which utilises *stereoscopic* vision on a set of goggles or headsets to give the user the impression that they are in a present in a different environment, i.e. the “virtual world”, which may or may not be significantly different from the environment they are physically present in. In addition, as shown in Figure 1, the users are able to interface with the virtual world and interact with the objects, by using specific controllers connected to the computer.

Figure 2: In stereoscopic view, each eye sees the image from a slightly different angle, giving the perception of depth

Figure 3: A person is shown using a VR setup consisting of a headset and controllers

Figure 4: The VR version of the popular mobile game "Fruit Ninja" allows users to control the swords with the controllers

1.3. Problem

A limitation of VR technology is that it is exclusive in nature. What that means is that only one person can use a VR setup at any given time, leaving the others to view a 2D representation of the 3D environment on a TV screen.

In the classroom setting, if the instructor uses a VR setup, the students would view everything in 2D on the screens, thereby nullifying any benefit they would draw from using a 3D VR application. Given the average size of modern classrooms, it is not feasible for students to take turns on the headset either, and as a result the problem still stands.

This limitation is hindering the widespread adoption of VR as a learning tool at UBC and is also a key blocker in democratizing VR technology around the world. As the magnitude of EML's positive impact on learning is directly tied to how much their applications are used, they are understandably concerned about allowing multiple people to use a VR application at any given time.

Figure 5: A bystander looks on as a student enjoys an immersive experience in VR

1.4. End-Users

The end users of this product would be instructors and students in classroom settings. Previously, an instructor would carry out a demonstration on a VR setup and the students would see it in 2D on the projector screen. When our solution is completed and handed over, the students will be able to view the demonstration in 3D on their phones by using a Google Cardboard VR Headset.

2. Domain

This project will be in the domain of “New Product Development”, specifically in the field of Emerging Media, as we are building a platform that supports applications in the field of emerging media.

While EML hasn’t enforced any NDA or IP rights on this solution, they will have unrestricted use of the project outcomes while ownership of the project resides with the development team. .

3. Project Goals

The goal of this project is to provide a way for multiple users to view a particular instance of a VR environment at the same time.

Previously, all EML demonstrations and educational sessions were run on a single device where users would have to take turns to try out a VR application or would simply view a 2D rendition on a screen. Our solution will enable them to effectively run larger demos where every participant can experience the immersivity provided by 360 degree video.

This would mean instructors would find incorporating VR into lessons much more feasible than before, leading to more widespread adoption of VR in education. This will allow EML to widen its portfolio, acquire more funding, and expand its range of operations, leading to better recognition as one of the pioneers of VR in education.

4. Requirements and Constraints

The requirements and constraints listed below describe the restrictions for our solution determined in our discussions with EML. We decided not to include the wired/wireless requirements, as they were not important to our client for this stage of the project. Additionally, we decided not to restrict our project by power consumption, because our application is already constrained to a specific engine and is intended only for short term usage.

4.1. Functional Requirements

All of the following functional requirements were determined based on a meeting with EML where they outlined the functionality required of our solution. “Client” in this context refers to client/server architecture, where the student is the client and the instructor uses the server.

ID	Requirement	Description
FR1	VR Viewing	Students can use a VR headset to view the same VR space as the instructor
FR2	Field-of-view on client side	Client side view must have 3-degrees of freedom: the student can look around independently but their movement in the environment is controlled by the instructor
FR3	Instructor/student Device(s)	The client and server side applications must run on separate devices (i.e, students viewing application on a headset connected to instructor device is not sufficient)

4.2. Non-Functional Requirements

In the following table, NFR1, NFR2, and NFR3 were all determined by EML based on their knowledge of VR applications. In terms of NFR4, this was chosen by EML, as the minimum number of clients that would verify the proof of concept.

ID	Requirement	Description
NFR1	Resolution	1080p minimum
NFR2	Latency	Maximum 5 seconds.
NFR3	Framerate	Minimum 30 frame per second
NFR4	Number of Clients	Minimum of 3 connected clients

4.3. Constraints

The following table shows the two constraints for the project. Please see the appendix for the source of Constraint C2, which is important in the case that the solution utilizes UBC’s network infrastructure. C3 was determined after a discussion between our team and EML. Note that IOS support was not deemed necessary. Lastly, C4 was specified by EML, as this is the specifications of the laptops they use internally for projects.

ID	Related Req.	Constraint	Description
C1	FR1	Format of Deliverable	The deliverable must be delivered as Unity game engine asset package (.unitypackage format), as EML uses Unity for all of their VR applications.
C2	NFR1-NFR4	Network Bandwidth	Maximum Required Network Bandwidth: 72Mbps
C3	FR3	Student-Side Platform	Student-side must run on a mobile phone running Android OS.
C4	FR3, NFR1-NFR4	Minimum Supported Specifications for Instructor device	Must satisfy the above requirements running on EML-given minimum specifications: Intel I7-7700 CPU, 16GB RAM, Nvidia 1070 GPU

5. Glossary

- **Google Cardboard VR Headset** - virtual reality (VR) platform developed by Google. Named for its fold-out cardboard viewer into which a smartphone is inserted, the platform is intended as a low-cost system to encourage interest and development in VR applications [3].
- **Stereoscopic** - noting or pertaining to three-dimensional vision or any of various processes and devices for giving the illusion of depth from two-dimensional images or reproductions, as of a photograph or motion picture [4].

6. Appendix

6.1. Network Bandwidth Calculation

The amount of data that can be sent over a network over a period of time is often referred to as the bandwidth of the network and is often measured in Megabits per second (Mbps). As the intended location of use for this project are classrooms at UBC, it is logical to use the bandwidth of the UBC network as a constraint on available bandwidth. According to UBC's website, their networks all support three versions of WiFi - 208.11b, 208.11g, and 208.11n [5].

Version 208.11n is the fastest of the three versions, was adopted in 2009, and has a maximum data rate of 72Mbps-600Mbps, depending on the network configuration and other parameters [6]. For this project, we will assume the worst-case of 72 Mbps. Also, as this version is now 11 years old, we will assume all client devices support this version. In conclusion, we will assume that the network has a total of 72Mbps of bandwidth that can be shared among client devices.

7. References

[1] E. Bobek and B. Tversky, “Creating visual explanations improves learning,” *Cognitive research principles and implications,* vol 1, no. 27, December, 2016. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5256450/ [Accessed Feb. 9, 2020].

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[3] D. Pierce, “Google Cardboard Is VR's Gateway Drug," *Wired.com,* May 28. 2015. [Online]. Available: https://www.wired.com/2015/05/try-google-cardboard/ [Accessed Feb 9, 2020].

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[5] “Quick Start Guide”, *ubc.ca*, [Online]. Available: https://it.ubc.ca/services/email-voice-internet/wireless-internet-access/quick-start-guide [Accessed Apr. 7, 2020].

[6] “Wifi”. *wikipedia.org*, [Online]. Available: https://en.wikipedia.org/wiki/Wi-Fi#Versions [Accessed Apr. 7, 2020].