University of Nevada, Reno
Computer Science and Engineering

Virtual Reality Physics Lab

Project Part 1: Revised Concept & Project Management

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February 9, 2018

Table of Contents

Abstract

The goal of Team 10's Virtual Reality Physics Lab is to utilize a new, revolutionary product for educational purposes. Virtual reality hardware, such as that in the HTC Vive, allows for personalized, immersive experiences which can address all forms of VARK (Visual, Aural, Read/write, Kinesthetic) learning. Very few environments outside of private tutoring have the same potential for an entertaining, educational experience. The VR Lab project will be filling this gap currently present in the virtual reality repertoire. The final product of the VR Lab will provide an immersive and educational experience into kinematic physics while promoting STEM (Science, Technology, Engineering, Mathematics) principles.

Project Description

Main Goals and Objectives

The main goal of this project is to create a game that will ultimately be both an educational and engaging experience for the user. The game would be a physics sandbox that would be created using Virtual Reality (VR) technology. The purpose of the game would be to educate those who do not have a strong understanding of physics. With the use of VR technology, the game would not only be educational but also provide for an entertaining and interactive experience that the player could enjoy. It is a significant project because it will allow its users to learn in an enjoyable manner and would potentially spark an interest in STEM education and careers for younger audiences.

Intended Audience

While the game will be made to be played by just about anyone from age 13 and up, the main target audience will be teenagers, young adults, or anyone who wants to learn more about physics. The concept of physics can be a difficult one to understand and in creating an engaging way to learn would hopefully help more teens and young adults gain interest in science and math.

Main Functionality and Characteristics

The game would function as an educational tool in which the user would be taught about different physics through interaction. It will be created to run on the HTC Vive VR headset and will be implemented using the Unity game engine. Characteristics of the game include a main/start menu where the user can choose from different activities that will each teach different concepts as well as contain realistic physics effects within the game play itself. It would be created in a way in which the concepts would be explained through actual interaction and not just through numbers and computation.

Technology Description

The technology that is intended for the development of this project is that of Virtual Reality (VR) technology. Specifically, the headset that is to be used for the project is the HTC Vive headset. For actual development of the game itself, we plan to use the Unity game engine as well as its assets. Also, we will use both Gaia and The Lab Renderer to create environments in which the user can enter to play the different activities. The environments will allow for a beautiful backdrop that will add to the overall game experience.

Dependability

Users will benefit from the project through interactive methods of learning. By providing the users with an interactive learning environment within the game, they should be able to not only learn the concepts presented but also have a enjoyable and safe time doing so. Unlike an individual sitting through a guided lecture, the user should have an easier time recalling the concepts introduced to the user in the game through both long and short term memory. The game will also be safe to play as the sensors will tell the users when they are getting too close to a real wall when they are playing the game.

Significance:

Our Virtual reality project is amazing in terms of significance to both our team in development and the end users in production. Our project provides an engaging and interesting form of learning physics concepts that will allow users/students to gain a better grasp of the concepts that were brought up in class. We are hoping to help bridge the gap between Virtual Reality as a game to Virtual Reality as a teaching tool, having realistic simulations and scenarios that will enforce concepts and ideas focused around a topic – in this case a physics game. It is an easy to load game, so if the student desired they could reload the game, revisit the worldspace, and reinforce their knowledge or interest for the concept at hand even after the lesson is "over".

On the development side, it is giving invaluable development experience for the team. We are learning to work in Unity and manage larger codebases than ever before. This project with having project deliverables, deadlines, and documentation helps surge forth the professional development of the team. This also gives great experience working in a team environment and building software together with more than one or two people.

Similar projects/applications

Currently there are several programs that simulate physics in 2D and 3D. Below is a list of a couple that could easily be turned educational, if given the proper support and changes:

1. **Surgeon Simulator**
   (http://store.steampowered.com/app/233720/Surgeon_Simulator_2013/)

   The website for surgeon simulator characterizes it as, "a darkly humorous over-the-top operation sim game" [1]. This is applies to our project since "Surgeon Simulator" uses real-time physics in VR like our physics simulator will be aiming for.

2. **Design Soft's: Newton Forces**
   (http://www.newtonlab.com/English/newton/)

   The website describes Newton Forces as, "Newton forces is a 3d physics engine and sandbox" [2]. Since Newton Forces shows that there is already a competition for 3D physics simulation we can use this as a means of creating something new but also know what is already in existence.

3. **Chroma Lab**
   (http://store.steampowered.com/app/587470/Chroma_Lab/)

   The VR game Chroma Lab is described on the website as a "VR particle physics sandbox" [3]. In the game, there are many colorful particles that stick together to make different objects which the user can interact with using different tools at their disposal. This is similar to our game as it demonstrates how physics works on different types of objects.

4. **The Lab**
   (http://store.steampowered.com/app/450390/The_Lab/)

   The Lab is a Virtual reality game that is a minigame galore: "Set in a pocket universe of Aperture Science, The Lab offers a wide range of ways to enjoy VR, all in one application" [4]. This game has quite a few simulations/game that are available, all with correct physics and immersive play that engages the user to an extent that they only get very into the game, but feel like they are actually within the lab - something we are aiming to do.

Market potential

For our product we plan to market this in educational institutions, primarily middle school and/or high school. This product will allow students within that age group to experience physics in a non-traditional manner and engrave some of the concepts presented in long term memory because when you actually do something, it stays in memory much better.

Potential for Further Development/Product Enhancements

For further development of our game, there are a few things Team 10 would like to add. Making the game accessible for all would be a high priority if we are going to use this in an educational setting, so adding compliance to ADA (American Disabilities Act) would be a needed addition. We would need to give access to full/partial blind, color blindness, and missing limb individuals and balance/adjust the game accordingly to these disabilities.

Using Unity allows our platform to be dynamic and a 'lite' or 'mobile' version of the full software could be offered to smartphones, tablets, or 2-in-1 laptops. With this development, additional modules and activities could be added will full support for additional purchases through microtransactions or "expansion packs". This would allow a much more widespread adoption of our software and allow for much more expansion and development down the road, potentially with post-secondary education and more advanced concepts.

Legal and Ethical Aspects:

Legal aspects of our project are actually quite simple. We own all of our Intellectual Property, have no NDA's signed, and are using a free-to-a-point game-engine. Unity's end-user agreement says that "The free version of Unity may not be licensed by a commercial entity with annual gross revenues (based on fiscal year) in excess of US$100,000, or by an educational, non-profit or government entity with an annual budget of over US$100,000" so we are able to use the product for free as we do not apply to either of those conditions [5]. However, if we plan to sell and market our game, we will need to ensure that we do not hit $100,000 in revenue for the product before we get a professional license from Unity - but if we do and buy the license, everything remains the same: we still own our Intellectual Property and we are not breaking any laws.

Ethically this project is a bit more advanced, as we are aiming to teach students. We have to ensure that our product is extremely accurate and as bug-free as possible before the initial release. To ensure we are following the PRODUCT clause in ACM's code of ethics, we will be doing rigorous testing both with ourselves and members outside of our group to get a better sample size and testing for bugs. Ensuring that best programming practices are used, proper refactoring of code, and simple yet effective design will be our best tools in creating a great end product. We will use our best judgement while developing to ensure that the product will be professional, clean, and well built at the end of development.

Changes and Progress since the Initial Project Concept

The project is going well so far, we are able to start the simulation and load into the generated worldspace that now has terrain. From there we can teleport around, move around (our local space), interact with objects (we have two objects as of now, a cube and sphere), show object information like velocity and position displayed on a "whiteboard" in-game, and everything is interacting with proper physics when moved/pushed/thrown.

Major Changes/Accomplishments

- Terrain was added to the worldspace for better immersion
- Teleportation around the world, as we would need to move large distances in VR.
- Whiteboard with object information, Velocity and Position, given in real time for specific objects
- Object interaction is available, with improvements in responsiveness and tracking when interacting with an object
- Object physics - Physics for objects should work correctly when picking up, throwing, colliding with the ground, ect.
- Game Saving and Loading are in development/testing at the moment

Planned Changes

- Introduction of a cannon - We plan to introduce a cannon to shoot the objects/projectiles to show the projectile motion needed for the physics learning experience
- Main Menu - We need to not load directly into the game, but rather a main menu with perhaps some configuration like sound or brightness and a way to load a saved game or launch a new one.
    - Game Load from saved game is important here.
- Enemies/Targets - What do you shoot the cannon at? Enemies, which we are in the process of implementing.
- Textures applied - Cell shading implementation to add "fake realism" and color to the world, right now we are running on using no textures with a very flat appearance that is extremely unappealing.
- Game Rules - We plan to make this an interactive experience so having some rules and game mechanics to shoot enemies down would be beneficial.

Project Responsibilities

User interaction - menus, interfaces, and player input - Will

Environment design - models, textures, and object interaction - Andrew

Gameplay - difficulty, balancing, and level design - Nick

Game engine - physics, user score, and save data

Project Monitoring and Risks

Project Monitoring.

Our project has a lot of small interconnected components that drive the larger simulation. To ensure completion of our project on time, we will be setting out dates, well in advance, for these modules/components to be finished by. Splitting up the work and breaking down the tasks is how we plan to manage this large endeavour. Ensuring everything is done well before it is due is the goal, and most time should hopefully be spent doing rigourous testing and refactoring of our Virtual Reality worldspace to ensure proper immersion.

Risk Register

ID	Risk	Likelihood	Impact	Severity	Status	Raised	Strategy
1	Failure to satisfy expectations	3	3	9	Open	2/9/2018	- Know the expectations - Communicate
2	Failure to meet deadlines	3	4	12	Open	2/9/2018	- Maintain a schedule
3	High demand for product	2	2	4	Open	2/9/2018	- Communicate
4	Unforeseen delays	4	4	16	Open	2/9/2018	- Adjust schedule - Distribute work
5	Loss of data	4	4	16	Open	2/9/2018	- Make backups regularly - Store backups separately
6	Incapacitated team members	3	4	12	Open	2/9/2018	- Work ahead of due dates - Distribute work

7	Lack of critical resources	2	4	8	Open	2/9/2018	- Redundancy
8	Scope creep	3	3	9	Open	2/9/2018	- Keep track of features - Communicate
9	Disasters	1	4	4	Open	2/9/2018	- Backup data - Remain safe
10	Internal disagreements	2	3	6	Open	2/9/2018	- Communicate - Compromise

Team Overview

These are the members of Team 10, who will be working on the VR Lab project:

Andrew Munoz:
Interests: video games, virtual reality, and STEM education
Notable courses: CS 480, CS 381, ENGR 301, and CS 302
Christopher Lewis:
Interests: education, virtual reality, human computer interaction, computer graphics, and interactive video games
Notable courses: CS 480, ENGR 301, CPE 481, CS 425, and CS 328
Nicholas Bolling:
Interests: video games, virtual reality, VR education and STEM integration
Notable courses: ENGR 301, CPE 301, CS 302, and CS 328
Willem Zandbergen:
Interests: video games, the potential of virtual reality, and furthering STEM education
Notable courses: ENGR 301, CPE 301, CPE 481, CS 302, and CS 328

As discussed in Team 10's charter, each member has been given a specific leading position based on their strengths as assessed by the Project Lead. Each member will also be held responsible for their own individual assignments and for their management positions as given by Project Lead. Each member's associated position and strengths are as follows:

Andrew: Programming Lead. Andrew's success in multiple, technically inclined computer science courses exemplifies his ability to properly plan programming assignments and solve complex problems. With his knowledge and as expected from his position, Andrew will be documenting, allocating, and troubleshooting Team 10's programming work.

Chris: Primary Contact. Chris's multiple sources of contacts and amicable behavior has naturally led him to being Team 10's primary contact. He will be managing all contact between Team 10 and their sponsors as well as coordinating meetings, work, and information between the two.

Nicholas Bolling: Resource Management. Nick's knowledge of multiple open source resources and where to find them will aid him in acquiring everything Team 10 will need for their project. This means that Nick will be in charge of Team 10's acquisition, allocation, and management of team resources as well as Team 10's budget.

Willem Zandbergen: Project Lead. Will was nominated as Project Lead by Team 10 after its members heard and witnessed his success in a previous project in which he had effectively managed that team and their goals. Will has been put in charge of Team 10's scheduling and in maintaining Team 10's efficiency in team meetings and individual work.

Advisory overview

The current advisor for our project is Eelke Folmer. Dr. Folmer specializes in Virtual Reality and can give insight on the design of our game. The design portion could be game logic and help making the game feel immersive and fun to play.
Another advisor that we have is Benjamin Brown. His experience with educational games and most importantly his master's thesis being based on educational games makes him a great advisor. Benjamin Brown will assist by giving knowledge on how make a game fun and engaging, but will still maintain the educational value.

Contributions of Team Members

Listed below are the total working hours each team member contributed to this project. Given below these hours are the specific parts each member worked on for this project prototype. Included in these times is the time spent as a group editing and formatting the final iteration of this paper.

Working hours:

Andrew: 4 hrs.
Cover page, Abstract, Project Description, Significance, Team Overview, and References.

Chris: 4 hrs.
Project Description, Significance, References, and Advisory overview.

Nick: 3 hrs.
Table of Contents, Significance, Legal and Ethical, and Changes and Progress since Initial Project Concept.

Will: 3 hrs.
Abstract, Project Responsibilities, Project Monitoring and Risks, Team Overview, and Contributions of Team Members

References

[1] Steam. (2013, April 19). Surgeon Simulator. Retrieved from (http://store.steampowered.com/app/233720/Surgeon_Simulator_2013/)

[2] Newton Lab. (2018). Design Soft's: Newton Forces. Retrieved from (http://www.newtonlab.com/English/newton/)

[3] Steam. (2017, Aug. 22). Chroma Lab. Retrieved from (http://store.steampowered.com/app/587470/Chroma_Lab/)

[4] Steam. (2016, Apr. 5). The Lab. Retrieved from (http://store.steampowered.com/app/450390/The_Lab/)

[5] Unity License Agreement. (2013, May 16). Unity. Retrieved from (https://unity3d.com/legal/eula-3.5)