University of Nevada, Reno
Computer Science and Engineering

Virtual Reality Physics Lab

Team 10 (VR Lab)
Andrew Munoz
Christopher Lewis
Nicholas Bolling
Willem Zandbergen

Sergiu Dascalu & Devrin Lee
Eelke Folmer

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1 Abstract

By: Willem Zandbergen

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.

2 Project Description

Main Goals and Objectives

By: Andrew Munoz

The main goal of this project is to create a game that will ultimately be both an educational and fun 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.

Main Functionality and Characteristics

By: Andrew Munoz

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.

Intended Audience

By: Andrew Munoz

While the game will be made to be played by just about anyone from age 10 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 a fun way of learning would hopefully help more teens and young adults gain interest in science and math.

Key Usability Goals
By: Andrew Munoz

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 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.

Potential for Further Development/Product Enhancements
By: Andrew Munoz

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 huge thing. We would need access to full/partial blind, color blindness, and missing limbs would be the main focuses.
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 (microtransactions or "expansion packs").

Challenges and Obstacles
By: Willem Zandbergen

Listed below are the potential challenges Team 10 could encounter as assessed by its Project Lead:

Distractions - Team 10 is excited to work with virtual reality and thusly strays off topic in group meetings when discussing the project.
Marketability - To properly utilize Team 10's product educational institutions would have to heavily invest in virtual reality hardware.
Technology - Team 10 will be utilizing the Unity development environment, which may prove difficult in simulating physically correct calculations for real world physics.
Multiple contacts - Team 10 would have to remember to always be respectful of their contacts' schedules and persons.

Technology Description
By: Andrew Munoz

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.

Team Overview
By: Willem Zandbergen

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, 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, 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 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

By: Christopher Lewis

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 could have in the future is Fred Harris. Dr. Harris specializes in Neuroscience and Computer Graphics which can help with the graphics side and also how the game will affect the learning outcome after playing. His passion for education is very clear and would also help with our project since its main focus is education by implementing a more kinesthetic experience using VR.

Note on professional growth
By: Nick Bolling

Working on this project, we are all gaining experience working on a Virtual Reality game and software in an agile development process. This will give great development experience and growth working in a team environment building software from near scratch and meeting deadlines like in industry.

3 Market potential or Open Source Significance

By: Chris Lewis

Market analysis

For our product we plan to place 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 maybe engrave some of the concepts presented in long term memory. Later this product can be applied to post-secondary education or college by adding more advanced concepts to the table.

When researching for our project it is important that we research other individuals interest in physics simulation. A couple are below:

1) **Bullet Physics Library (http://bulletphysics.org/wordpress/)**

   Bullet is known for its characterization on the website for "Real-Time Physics Simulation." Our product will be aiming for the same idea as Bullet by creating real-time physics simulation in Unity by making a VR game. Lately games have been using bullet like the recent game "Beach Buggy Racing" which has been released on the Nintendo Switch. This shows that Real-Time physics simulation is becoming a recent interest.

2) **PHET Colorado**

(https://phet.colorado.edu/en/simulations/category/new)

PHET has a set of interactive simulations like: Projectile Motion, Pendulum Lab, and States of Matter. These projects are pretty similar to what our product will be since one of these simulations, projectile motion, is very similar to what our product is aiming for. They have two dimensional kinematics with a cannonball and most of the data, including air resistance, is there for you, the user, to see.

Competitive analysis

Currently there are several programs that simulate physics in 2D and 3D. Below is a list of a couple:

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 w." 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." 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.

Competitive Advantage

The novelty of our program is that it is going to bring a new and innovative way of teaching school concepts, i.e. physics, by introducing a more kinesthetic environment that is both safe and fun for the individual. One quality that diversifies our product from other products is that our product will entirely based around bringing an interactive virtual reality experience that feels more like a learning sandbox that has a guided set of goals rather than a train ride. Another trait is that our product also allows the user to feel like he/she can learn at her own pace rather than a set pace.

4 Time Worked on Project Concept
By: Willem Zandbergen

Every member engaged in three group meetings related specifically to our VR Lab project. The first meeting's topics were potential advisors for this project and how to contact them. The second meeting's topics were the details of the VR Lab and the division of labor for this project

paper. The third meeting's goal was to format the contents of this paper. Additionally, each member worked for a certain amount of time on each part of this paper as listed below:

Andrew:	3 hrs.
Chris:	5.5 hrs.
Nick:	2.5 hrs.
Will:	3 hrs.

This makes each person's total working hours:

Andrew:	0.5 + 1 + 1 + 3 = 5.5 hrs.
Chris:	0.5 + 1 + 1 + 5.5 = 8 hrs.
Nick:	0.5 + 1 + 1 + 2.5 = 4 hrs.
Will:	0.5 + 1 + 1 + 3 = 5.5 hrs.

5 Budget and Budget Justification

By: Nick Bolling

Budget

- Unity Asset Budget - $500 for https://www.assetstore.unity3d.com/en/ assets
- Optional:
    - HTC VIVE - $599.00 (https://www.amazon.com/HTC-VIVE-Virtual-Reality-System-pc/dp/B00VF5NT4I?th=1)
    - VIVE sensor stands - $44.95 (https://www.amazon.com/Fovitec-StudioPRO-Light-Compatible-Carrying/dp/B01MFG14ZT/ref=pd_bxgy_63_img_2?_encoding=UTF8&pd_rd_i=B01MFG14ZT&pd_rd_r=YTPMRYY86X1J8HZ33A8F&pd_rd_w=5w03u&pd_rd_wg=1ga4M&psc=1&refRID=YTPMRYY86X1J8HZ33A8F&dpID=41XrmFUh4CL&preST=_SY300_QL70_&dpSrc=detail)

Total Budget: $500, up to $1143.95

Budget Justification

For our Asset Budget, $500 dollars should be sufficient, looking at average prices in the store the starting price is around $20 and varies up to around $150 dollars for more complete "whole" asset packages. This would allow us enough money to buy the larger more complete packs of models and assets for VR, while still having enough money to buy smaller more detail oriented options.

Optionally we are thinking about purchasing an HTC VIVE for the project. Currently there is only one available in the DeLamare library for checkout, and only 2 days at one time. This would mean potentially waiting long periods before testing interaction and full immersion in VR - hence the purchase of the equipment. There is also a VR lab opening in the @ONE, but again waiting in line and testing our own game on the machines would be difficult if at all possible.

6 Project Related Resources
By: Nick Bolling

Project Related Resources

- **"Problem-domain" book**
  - **The VR Book, Human-Centered Design for Virtual Reality.**
    by Jason Jerarld, Ph.D.
    - This book provides and in-depth look at the human element of virtual reality and the main principles of creating the best VR experiences rather than just a technical implementation.
  - **Unity Virtual Reality Projects**
    by Jonathan Linowes
    - This book helps readers to build their own VR games or applications. It provides step by step instructions for creating virtual reality environments and games.
  - **Learning Virtual Reality:**
    Developing Immersive Experiences and Applications for Desktop, Web, and Mobile
    By Tony Parisi
    - This book helps you to get a better understanding of UI design, 3D graphics and Unity 3D. It also provides valuable information for building apps for Oculus or Samsung Gear VR, as well as browser based applications using WebVR and WebGL.

- **Project reference articles**
  - **The NICE project: Narrative, Immersive, Constructionist/Collaborative Environments for Learning in Virtual Reality**
    https://www.evl.uic.edu/tile/NICE/NICE/PAPERS/EDMEDIA/edmedia.paper.html
    - This paper describes and discusses the NICE project, an immersive learning environment for children implemented in the CAVE and related multi-user virtual reality technologies. The NICE project provides an engaging setting where children construct and cultivate simple virtual ecosystems, collaborate via networks with other remotely-located children, and create stories from their interactions in the real and virtual world.
  - **Learning in Virtual Reality** https://eric.ed.gov/?id=ED359950
    - The essence of the computer revolution is yet to come, for computers are essentially generators of realities. Virtual reality (VR) is the next step in the evolutionary path; the user is placed inside the image and becomes a participant within the computational space.
  - **A Conceptual Basis for Educational Applications of Virtual Reality**
    http://www.hitl.washington.edu/research/education/winn/winn-paper.html~

        - This paper discusses the potential value of VR to education. It does so in the light of research conducted at the Human Interface Technology Laboratory at the University of Washington and on the basis of recent developments in cognitive theory that are relevant to human learning.The case is made that immersive VR offers very different kinds of experience than those students normally encounter in school. The psychological processes that become active in immersive VR are very similar to the psychological processes that operate when people construct knowledge through interaction with objects and events in the real world.
    - **Virtual Reality Simulations in Physics Education :** http://imej.wfu.edu/articles/2001/2/02/index.asp?referer=www.clickfind.com.au
        - A virtual reality physics simulation (VRPS) is an educational tool using a virtual reality interface that brings together a 3D model of real apparatus and a virtual visualization of physical situations in an interactive manner. VRPS enhances students' understanding by providing a degree of reality unattainable in a traditional two-dimensional interface, creating a sensory-rich interactive learning environment. In this paper, we present a computer-based virtual reality simulation that helps students to learn physics concepts such as wave propagation, ray optics, relative velocity, electric machines, etc. at the level of high school or college physics.

- **Project related websites with useful resources**
    - **Lynda.com** - AMAZING resource that we already pay for in our tuition, and we as a university have a subscription to. Has a ton of Unity related courses, and even courses in general programming (C, C++, C#, ect) that will be really useful.
    - **Unity 3d Asset Store** (https://www.assetstore.unity3d.com/en/) - Easily the most helpful website other than Lynda, here we can purchase already made and professionally (and community) developed assets like objects, models, scripts, ect. This will be useful for the initial prototype to ensure everything is working on time, as well as providing high-quality and accurate objects/models in-game.