Technical University of Košice
Faculty of Mining, Ecology, Process Control and Geotechnologies

Application of Virtual and Augmented Reality in Education

Master's Thesis

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Abstract

In this thesis we present possible applications of virtual and augmented reality (VR/AR) in higher education with focus on mathematics. First a brief history of VR/AR is described followed by overview regarding the current problems and use cases of VR/AR systems and overview of current commercially available headsets. Then the novel teaching methods are presented, utilizing the virtual user interfaces to provide strong visual representations and visualizations of parametrized functions, helping students to learn quicker and understand difficult math concepts. In the end of thesis we propose future possibilities and how the technology will shape student's knowledge.

Keywords

Virtual reality, Augmented reality, Education, Mathematics

Assign Thesis

Namiesto tejto strany vložte naskenované zadanie úlohy. Odporúčame skenovať s rozlíšením 200 až 300 dpi, čierno-bielo! V jednej vytlačenej ZP musí byť vložený originál zadávacieho listu!

Declaration

I hereby declare that this thesis is my own work and effort. Where other sources of information have been used, they have been acknowledged.

Košice, April 24, 2017 .....

Signature

Acknowledgement

I would like to express my sincere thanks to my supervisor RNDr Andrea Mojžišová, PhD, the main Supervisor. Special mention should go to RNDr Jana Pócsová, PhD. for his constant, and constructive guidance throughout the study. To all other who gave a hand, I say thank you very much.

Preface

Mathematical knowledge is often fundamental when solving real life problems. Especially, problems situated in the two or three-dimensional domain that require spatial skills are sometimes hard to understand for students. Many students have difficulties with spatial imagination and lack spatial abilities. Recently, a number of training studies have shown the usefulness of virtual reality in training spatial ability. Therefore I set myself a goal for finding inresections between virtual reality and higher education by building experimental virtual user interface(s) and testing them in educational environments, e.g. colleges and universities. In this thesis I'll focus on mathematics.

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List of Terms

Introduction

Our experimental project will be called MathworldVR, which sets to explore the possibilities and introduce novel methods of using web technologies for creating room-scale, immersive learning environment in virtual reality for helping students to explore, learn about and experiment with various parametrized functions. It's also a practical tool for teachers to showcase abstract concepts in concrete 3D space during lectures.

1 Theoretical analysis

Undoubtedly VR has attracted a lot of interest of people in last few years. Being a new paradigm of user interface it offers great benefits in many application areas. It provides an easy, powerful, intuitive way of human-computer interaction. The user can watch and manipulate the simulated environment in the same way we act in the real world, without any need to learn how the complicated (and often clumsy) user interface works. Therefore many applications like flight simulators, architectural walkthrough or data visualization systems were developed relatively fast. Later on, VR has was applied as a teleoperating and collaborative medium, and of course in the entertainment area.

One can say that virtual reality established itself in many disciplines of human activities, as a medium that allows easier perception of data or natural phenomena appearance. Therefore the education purposes seem to be the most natural ones. The intuitive presentation of construction rules (virtual Lego-set), visiting a virtual museum, virtual painting studio or virtual music playing (Loeffler, 1995) are just a few examples of possible applications.

Virtual environments are inherently three-dimensional. They can provide interactive playgrounds with a degree of interactivity that goes far beyond what is possible in reality. If using VR as a tool for mathematics education, it ideally offers an added benefit to learning in a wide range of mathematical domains (Kaufmann, 2011).

2 Analysis of current state of virtual and augmented reality

2.1 Building virtual reality applications and experiences

The leading platform for building VR experiences today is the game engine Unity, both because the company had the foresight to add support for the Oculus Rift development kit early on, but also simply because the early use cases from when Oculus Rift was still just a very successful Kickstarter project centered around video games.

2.2 Virtual reality on the web

WebVR provides support for exposing virtual reality devices — for example head-mounted displays like the HTC Vive or Oculus Rift — to web apps, enabling developers to translate position and movement information from the display into movement around a 3D scene in browser. As of today, support for both head-mounted displays is available in experimental or development builds of Chrome and Firefox, with official release planned for 2017. This has numerous very interesting applications, from virtual product tours and interactive training apps to immersive first person games. Unity, for instance, is able to make native builds for all major platforms from the same code base, including PC, Mac, Linux, iOS, Android and more. When made by professionals, such native builds will undoubtedly look better and run faster than a comparable VR experience built with WebGL and WebVR (at least AAA games or other experiences where high fidelity and performance are paramount).

The major advantage of WebVR over natively built experiences is the same as the web has always had over desktop apps and mobile apps today - no need to download

and install anything. User just needs to click a link, type in a url, and the application runs directly in her browser. There's no app store needed. Web developers can also take advantage of many open source libraries available on the internet.

3 Conceptualisation and design

3.1 Inputs and objections

3.2 Functionality planning

3.3 Virtual user interface

4 Implementation of virtual reality application

4.1 Technologies

4.1.1 A-Frame and Three.js

A-Frame is a web framework for building virtual reality experiences. It was started by Mozilla to make WebVR content creation easier, faster, and more accessible. A-Frame lets you build scenes with just HTML while having unlimited access to JavaScript, Three.js, and all existing Web APIs. It uses an entity-component-system pattern that promotes composition and extensibility. It is free and open source with a welcoming community and a thriving ecosystem of tools and components.

Three.js is cross-browser JavaScript library/API used to create and display animated 3D computer graphics in a web browser. It uses WebGL.

4.1.2 React

ReactJS is a javascript library for building user interfaces. It provides a way to write encapsulated components that manage their own state, then compose them to make complex user interfaces. It doesn't make assumptions about the rest of the technology stack, because it's just library. Since component logic is written in JavaScript instead of templates, we can easily pass rich data through our app and keep state out of the DOM.

4.1.3 Redux

4.1.4 Webpack

Webpack is a module bundler that takes modules with dependencies and generates static assets representing those modules.

4.1.5 Math.js

Math.js is an extensive math library for JavaScript and Node.js. It features a flexible expression parser with support for symbolic computation, comes with a large set of built-in functions and constants, and offers an integrated solution to work with different data types like numbers, big numbers, complex numbers, fractions, units, and matrices.

4.2 Test-driven development

4.3 Virtual calculator entity

4.3.1 Parsing equations with Math.js

4.4 Parametrized function grid entity

4.5 Interactive function settings panel entity

4.6 Building and deploying the application to web hosting

5 Conclusion

Táto časť záverečnej práce je povinná. Autor uvedie zhodnotenie riešenia. Uvedie výhody, nevýhody riešenia, použitie výsledkov, ďalšie možnosti a pod., prípadne načrtne iný spôsob riešenia úloh, resp. uvedie, prečo postupoval uvedeným spôsobom.

References

LOEFFLER, C. 1995. *Distributed Virtual Reality: Applications for Education, Entertainment and Industry.* http://www.nta.no/telektronikk/4.93.dir/Loeffler_C_E.html

KAUFMANN, H. 2011. *Virtual Environments for Mathematics and Geometry Education.* In: Themes In Science and Technology Education. Vienna : Klidarithmos Computer Books, 2011, Special Issue, pp. K 131–152