Honors Research Grant Proposal

Yueying Liu

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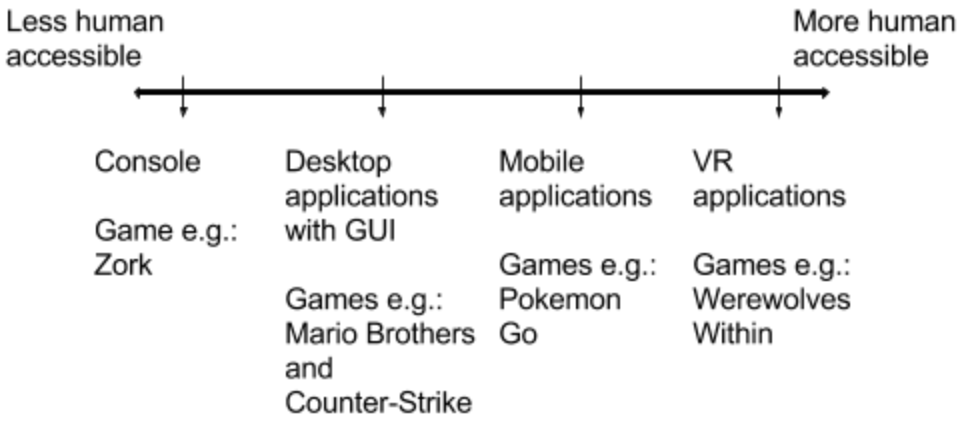
Background and Significance

It is a trend that computer programs are becoming more accessible to humans. At the very beginning, computer programs were executed using the console - people type in a command which is usually hard to understand and prone to errors, hit the enter key, and get the results. Consoles are still frequently used among programmers nowadays. This kind of programs are the most inaccessible for humans as the users need to memorize the computer commands in order to communicate with the computer. Gradually, with the introduction of Graphical User Interface(GUI) since 1963[1], desktop programs, whether running on a web browser or on its own as an executable program, transformed from text-only to using graphics and icons, which make visualization easier and can be understood by people speaking different languages. As the measurements of hardware running computer programs become smaller, mobile applications become popular, and their market is still expanding rapidly[2]. Mobile applications increase the human accessibility by its increased portability and the ability to sense the direction and orientation of the device with accelerometers. Nevertheless, the above-mentioned programs all require the user to view a two-dimensional(2D) interface from the three-dimensional(3D) world. Although with years of using the existing GUI, we are used to this form of abstraction, the most accessible programs for humans should be viewing from 3D to 3D. Virtual Reality(VR), whose foundation already laid down in 1838[3] but developed slowly through the years due to hardware constraints, is one of the hottest research area in computer science[4] and aims to allow the users to view the contents of the program in 3D directly. This is achieved by simulating how the 3D world is projected onto human retinas and interpreted into 3D setting by the brain: The user puts on a VR headset that displays two slightly different images, which belong to the same scene but viewed from the angles that simulate what the two eyes see, in front of the left and right eyes separately. The two images are called stereoscopic images. Human brains interpret the two images into a 3D setting.

Computer game, a subcategory of computer programs, follows the trend, too. Early console games like *Zork* have the same human-computer interactions as any other console programs. With GUI and a mouse which can locate any point on the screen, desktop games have a large variety, ranging from 2D games like *Mario Brothers* which abstract the world onto a 2D plane, to 3D model games like *Counter-Strike* which project a 3D world onto a 2D screen. The multitouch screen and accelerometers of mobile devices give the players more natural and direct control of the games. *Pokemon Go*, for example, utilizes the geographical location and its change of the player on the earth to simulate the player moving in the world similar to the earth but has additional gaming components. Again, all these games are limited by the hardware that even if the game creates a 3D world, the player could only see the 2D projection of the world. VR games, on the other hand, allows the players to immerse into a virtual 3D world just like they are in the real world. For example the players of the game *Werewolves Within* would find themselves gathered around a campfire in the medieval town of Gallowston. Standing-up, turn their heads around, lying down would directly change the view in the game. They just need to move as per normal to trigger the changes in the virtual world.



Spectrum of Computer Programs and Example of Games

The most avant-garde types of computer program today are VR and mobile, due to their novelty. Actually the term VR was coined only in 1987[5], and the first mobile application was released only in early 90's[6]. Being such new and blossom research areas, there are many things to learn and explore.

Currently the most prominent challenge for VR is ensuring fast real-time rendering and high resolution display, which contradict each other. In other words, when a person enters a virtual world, the person expects to see the world as clear and smooth as the real world. To see things clearly requires all objects in the virtual world to have high resolutions. To see things smoothly, the hardware needs to finish calculating the next frame to be displayed for both eyes within 1/60 seconds which is the frame rate for most of the games. The higher resolution of the objects, the slower the calculation. Every VR project face this challenge, and need to find the balancing point based on the content and purpose of the project.

Coincidentally, mobile development research is leaning towards VR and something slightly different: Augmented Reality(AR) which is displaying on the screen the reality with computer-generated data superimposed. For example, having a pair of rabbit ears during video chat. AR has the same calculation-resolution dilemma as VR. The dilemma is intensified by the dilemma for any mobile devices: having better hardware or having smaller sizes.

Unfortunately, perhaps because there is not a faculty member whose research crosses the boundary of mobile application and VR, the College of Information and Computer Sciences (CICS) does not yet have any courses directly related to these two areas.

What the Computer Science Department in CICS does have is an increasing emphasis on the "human" part of programming. From code readability to user-friendliness, the department emphasizes the human computer interaction in a variety of courses. There are courses like

Creative Game Design and Human Computer Interactions that teach the theory and build prototypes related to the “human” part, but these courses have little emphasis on implementation. Coding and design belong to separate courses in the department.

My project integrates most recent research areas in computer science and the increasing emphasis of the department: this project aims to build a VR game on a mobile platform, with consideration of enhancing the user gaming experience. The game is about a delivery man picking up and sending food around different mazes.

As a programmer trained on building desktop programs, I will study the difference between developing in mobile and desktop environments. At the same time, the differences in users’ experience on playing a VR game versus playing traditional desktop games will be studied during playtest to better understand the perception of VR for the general audience.

Objective

The goal of this project has three components:

On the technical level, the goal is to develop a 3D mobile game on the Android platform using a game engine, Unity. Google Cardboard will be used to create VR experience with a mobile phone. Research should be completed on using Unity, understanding the mobile platform, enhancing real-time rendering, and game design.

On the artistic level, this project aims to develop 3D modeling and design skills so as to give the players the best gaming experience. The art of camera angle, 3D model design, lighting, texturing, icon design and component arrangements will be studied and reviewed during playtest.

Last but not least, the research component will focus on comparing and contrasting the writing of a non-game application and the writing of a game application as a programmer, and the experience difference for players.

The hypotheses for the differences as a programmer are 1. the use of accelerometer is only possible on mobile devices; 2. due to hardware constraints, more consideration will be put on hardware usage and efficiency for mobile development; 3. user experience change the design of the program more.

The hypotheses for the difference as a player are 1. VR games are more brain-consuming as being in the 3D virtual world does not have an overview of the entire world; 2. mobile and VR games are more accessible than desktop games.

Methodology

In principle, the artistic designing and modeling will precede the programming, so it may provide data and testing later on in the project. Small and simple models will be built and imported into the game project for making a mini version of the game with the basic functionalities realized. After the codes successfully run on the desktop in the game engine, the game will be packaged and downloaded into a phone so as to test the game using the Google Cardboard. Google Cardboard (which is a cheap headset that holds a phone in front of the eyes and physically block the sight from the left eye to the right half of the screen and vice versa), paired with VR Cinema for Cardboard (which is a VR mode converter that splits the screen in landscape position into two smaller screens on the left and right which displays the stereoscopic images) will be used to test the VR experience of the game. Adjustments shall be made until the VR experience is optimized for the smaller version of the game. More detailed designs and other functionalities will be gradually added to the game until the technology required is too much for an honors project, or the hardware cannot handle the file sizes.

Throughout the process of building this project, similarities and differences between writing a non-game application and a game application will be noted. Attention shall be paid to the comparison between game engines and non-game development environments, unique adaptations to mobile hardware, and attention to user experience.

The Art Department at UMass Amherst provides computers with great performance for graphics intensive applications. 3D modeling tools like Maya are already installed in these computers, and free student version can be downloaded from Autodesk website. There is no need to purchase software for modeling. Art 374, Introduction to Computer Animation is the course that teaches 3D modeling using Maya, in preparation for the 3D animation production in the second half of the two-semester course sequence. I am taking this course this semester. I will be proficient in building 3D models mid-semester.

The learning of Unity, VR Cinema for Cardboard (the VR mode converter) and Android will depend on the Internet. There are plenty of video and word tutorials online, made by both the tool developers and experts in using certain tools. The VR in Cardboard on Android devices tutorial page on Unity website (https://unity3d.com/learn/tutorials/s/virtual-reality) is a great place to get started. NurFACE GAMES (https://www.patreon.com/nurfacegames) provides more sophisticated tutorials for Unity VR development. Online forums are also great places to ask questions. The Unity AR/VR Forum (https://forum.unity.com/forums/ar-vr-xr-discussion.80/), for example, is the official forum for Unity AR/VR development. Engineers who developed the tool would answer constructive questions in the forum. By searching others' posts, I can find answers to many of my questions.

As a junior in Computer Science major, I am familiar with multiple programming languages in various paradigms which prepare me to use different tools and learn new programming

languages. I have taken CS 326 Web Programming and currently I am enrolled in CS 320 Software Engineering. Both courses emphasize the software development workflow and the design and implementation of larger and more complicated systems.

Once a viable prototype has been developed, the playtest shall be conducted to ensure the game is user-friendly. As college students are the target audience of the game, UMass students will be invited to test the game. They will be given a Google Cardboard and a phone with the test version of the game installed, and play the game following the instructions in the game, with no help from the game developer. After the playtest for the VR game is done, testers will be invited to play the desktop console game *Zork*. They will play on a website which simulates the console environment. They will be surveyed on the differences between a mobile VR game and desktop console game. The survey results will be used to study the user experience differences between mobile VR games and desktop console games.

Testers' feedback on the VR game shall be analyzed during each round of testing and will be used as reference for any changes and improvements. Two major rounds of testing are expected and would happen in the Spring semester.

A journal will be kept for writing the final thesis and also to assist in the creative process. Every step will be recorded in the journal and will include the following: the tools and methods used, what they will be used for, the reasoning behind the choices or designs, the intended results, the actual results, and a following analysis. This will ensure that every decision will be justified and the journal shall act as a formal record for future decision making regarding this project.

Budget

A Samsung Galaxy Note 8, $929.99, not including tax which is not expected to exceed $50. No shipping fees.

This phone is chosen for the following reasons:

1. It has the highest RAM among all the phones accessible in the US. RAM is essential for program development. Optimization of a program is done after all its functionalities are finished. Before optimization, the program may consume high RAM, causing crashes. To avoid unnecessary crashes, a phone with RAM as big as possible shall be chosen.
2. Although it does not have the best battery capacity, its battery life is among the longest[7]. Battery life is essential for any mobile VR game, as the large number of calculations, graphical display, audio, touch sensors and accelerometer all consume battery very fast, especially before optimization.
3. It uses the latest screen technology, having the best screen resolution (1440 x 2960 pixels), better than full HD. This is the resolution trend for future phones, and enhances VR experience, reducing resolution problems due to the screen.

References

1. Sears, Andrew; Jacko, Julie A. (19 September 2007). *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications, Second Edition*. CRC Press. p. 5. ISBN 978-1-4106-1586-2. Retrieved 1 March 2013.
2. *Skogstad, T. (2016, March 17). Global Mobile Trends: Lessons for the West from Emerging Markets. Retrieved October 01, 2017, from http://www.phunware.com/blog/global-mobile-trends-lessons-west/*
3. *Virtual Reality Society. (n.d.). History Of Virtual Reality. Retrieved September 24, 2017, from https://www.vrs.org.uk/virtual-reality/history.html*
4. *Gherega, A. (2017, January 03). Hot research topics in CS for 2017. Retrieved October 01, 2017, from http://www.icslab.eu/computer%20science%20programming/2017/01/03/Hot-topics-in-Computer-Science.html*
5. *Virtual Reality Society. (n.d.). History Of Virtual Reality. Retrieved September 24, 2017, from https://www.vrs.org.uk/virtual-reality/history.html*
6. *Bates, S. (2016, March 08). The Current State of Mobile Application Development. Retrieved September 24, 2017, from https://manifesto.co.uk/state-of-mobile-application-development/*
7. *Spoonauer, M. (2017, September 05). Biggest Galaxy Note 8 Surprise? The Battery Life. Retrieved October 02, 2017, from https://www.tomsguide.com/us/galaxy-note-8-battery-life,news-25785.html*