AR & VR Laboratory Project Report

Brian Alexis Almaguer

Department of Engineering and Computer Science, Sacramento State

CSC 199: Special Problems

Course Professor – ECS Associate Dean Dr. Mariappan Jawaharlal

Project Advisor – ECS Director Lynne Koropp

May 20, 2022

Table of Contents

Introduction

The College of Engineering and Computer Science (ECS), though a proposal, procured two labs for the development and creation of an AR & VR laboratory space. Originally the laboratory was a CE/CM proposal that was turned into and ECS AR & VR laboratory for the college. Through this proposal, the ECS college had an opportunity to upgrade our very limited VR driving simulation rig into a more developed and multifunctional AR & VR laboratory space. The following report covers all the work done in researching, purchasing, and implementing the major and relevant equipment for the AR & VR laboratory as it pertains to a computer science special problems course. In order, the following sections will be covered: the first section is called AR technology where the background knowledge will be discussed follow by the list of components that were researched, purchased, and implemented. The AR technology section will then close with an overview of the hardware implementation. The second section covered is the VR technology section where the background knowledge will be discussed follow by the list of components that were researched, purchased, and implemented. Like the AR technology section, the VR technology section will close with an overview of the hardware implementation. Then, the third section covered is the Software implementation section where an overview will be given of the scope of software needed to be implemented before an analysis of each software is done. Finally, I will close the report with a conclusion of my final thoughts and call of recognition to the individuals involved in facilitating the development and building of the laboratory.

AR Technology

Background Knowledge

Augmented Reality (AR) is a tech experience where technology augments your perception of reality to convey an experience. These augmented experiences are available in three forms of augmentation: first is augmentation though a camera, second is augmentation of visual perception, and third is augmentation though an object manipulation.

Augmentation though a camera is usually a software AR that adds to a cameras feed showing information, objects, animals, or people that are not actually there. As a result, augmentation through a camera almost always comes in the form of Handheld AR technology where an example of Handheld AR software would be Pokémon Go. Handheld AR is more of a software technology than it is a hardware technology therefor, the most important factors to Handheld AR are the devices and OS platforms used. As a result, Handheld AR technologies are normally built for mobile OS platforms such as iOS and Android. This means that having both OS platforms available will always give the most access to Handheld AR software created by the business world and consumer market.

Then, there is augmentation of visual perception, where there is a heavy focus on AR Headgear. AR Headgear is what allows information, objects, animals, or people to be super imposed into one's personal perception. As a result, AR Headgear is more of a hardware focused technology with an emphasis on special purpose software. AR Headgear technologies are normally used standalone and almost always need software to be uploaded to the headsets. This means that having the software libraries and software development kits (SDK) are very important when creating and curating experiences that augment a person's visual perception.

Finally, there is augmentation through object manipulation, where these AR experiences focus on a specific objects or environments to augment. An example of this is an AR Sand Table where goal is to impose images on sand to augment our perception of what the sand is trying to convey or represent.

Components

Nreal Air

The Nreal Air developer kit is the first of two different wearable AR headgears purchased for the laboratory. The kit comes with several nose spacers, a prescription lens kit, and a compute unit powered by a Qualcomm Snapdragon 845; which, is a mobile chip used normally in phones and tablets. This high flexibility of fitment tools and a powerful mobile chip makes this kit perfect for a lab setting. Also, at the time of this report, the Nreal Air developer kit is the only consumer grade AR headgear in the market. The draw to this headgear was its prevalent use in multifunctional AR apps programmed and developed in Unity, a free and well documented game engine. Some of the most popular tutorials for programming an AR app for the Nreal revolves around interactive models. And since the easiest projects for the Nreal headset are interactive model design means that the Nreal Air is a great fit for one of the expressed desires from the DelNorte Lab Proposal of “Industry-Demanded Experiential Learning: Experiential learning though hands-on activities in the area of virtual design and construction. [Where] Students will have access to virtual reality and augmented reality headgear”. Finally, the Nreal Air is least expensive AR headgear which makes projects more accessible and distributable to the masses and other academic sectors.

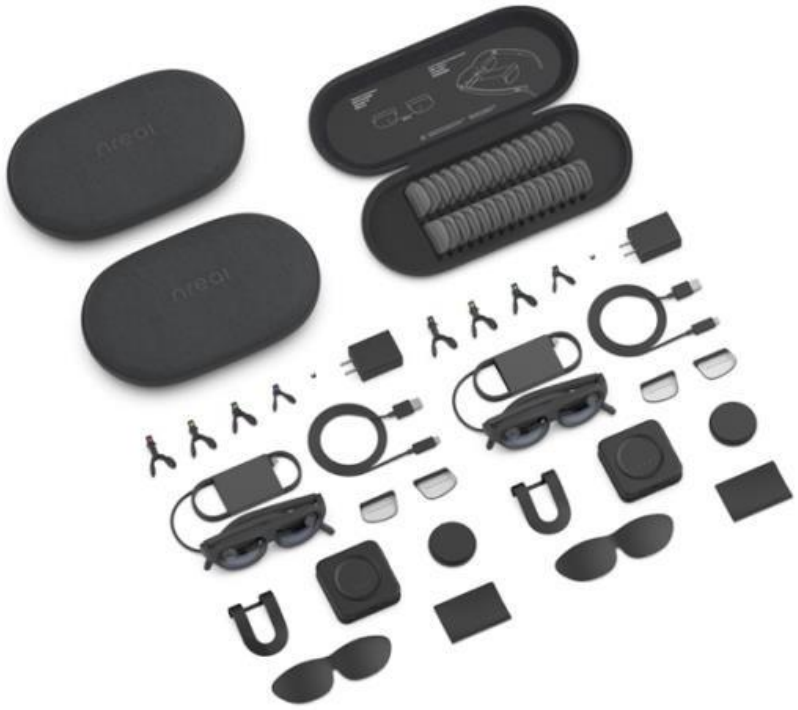

Figure 1 - Nreal Air Dev Kit with Lens Kit

MagicLeap

The MagicLeap is the second of two different AR headgears purchased for the laboratory. The MagicLeap comes with a controller, computer unit, and the headgear itself. Unlike the Nreal Air, the MagicLeap is an industry focused product that eventually became more adopted in the business and engineering space. This more prestigious start makes this headgear a common place tool used in various infrastructure demonstrations and developmental process. It is because of the background the MagicLeap has with business and engineering that brought us to purchase this piece of equipment. It also fulfills the DelNorte Lab Proposals expressed desire to provide "Enhanced Scholarly Activities Opportunities: [That] CM students will have access to powerful, high-tech tools to serve as a solid infrastructure for various process development studies and

demonstrations.” Not only does this provide CM students opportunities for solid development studies but rather all the joint projects between the ECS college.

Figure 2 - MagicLeap Headgear

iPad Air

The iPad Air is the first type of two different AR handhelds chosen for the laboratory. Since the iPad is an iOS device, it covers at least close to one half of major platforms that have AR software developed for Handheld use. It is because iOS is one of the major platforms used in Handheld AR software that we choose to purchase the iPad for the laboratory. The other reason why we are using iOS tables in the lab is because of it’s easy-to-use nature. Also, tables are a great tool for Stronger Recruiting because of its portable nature and easily recognizable interface. Having an iOS Handheld AR device extends the potential for using different AR software developed by other organizations and colleges.

Figure 3 - iPad Air Tablet

Samsung Tab S8

The Samsung Tab S8 tablet is the second type of two different AR handhelds chosen for the laboratory. Since the Samsung Tab S8 is an Android centric tablet, it covers at least close to one half of the major platforms that have AR software developed for Handheld use. It is because Android is one of the major platforms used in Handheld AR software that we choose to purchase the Samsung Tab S8 tablets for the laboratory. The other reasons why we considered using Android tablets in the lab is because of its easy-to-use nature. Also, Android tables are the best platform for distributing AR apps because of sideloading. Having an Android Handheld AR device extends the potential for using different AR software developed by other organizations and colleges.

Figure 4 - Samsung Tab S8

LulzBot Workhorse

The LulzBot Workhorse 3D Printer is a tool used for creating 3D objects. With the LulzBot Workhorse 3D printer we get an auto bed leveling, a large PEI printing surface, auto cleaning nozzle, and a printer that uses 2.95 mm filaments. Since the LulzBot printer can create 3D objects easily, we purchased it for our laboratory; its purpose is to create dioramas for our AR space since the DelNorte proposal outlined the need for physical desktop size models to be used with Handheld AR technology. It was outlined as the Multi-model Augmented Reality Space, or MARS for short. MARS was stated to "Features seven, desktop sized 3D-printed models (office building, roadways, dam, levee, water treatment plant, bridge, and airports.) with ten [tablet]" devices loaded with CAD models for each physical model. MARS is well thought out and explicit on what it needs, and the LulzBot Workhorse 3D Printer is one of the best printers we can acquire to fulfill those needs.

Figure 5 - LulzBot Workhorse 3D Printer

AR Sand Table

An AR Sand table is an AR Technology that augments the perception of an object which in this case is sand. This AR Technology was requested by Construction Management where they expressed interest in the original sand table project that came from UC Davis where they

used a Linux box, projector, and 4:3 depth sensing camera to super impose topography and land simulations on top of sand. Although the AR sand table created by UC Davis is exceptional for the time, it does not hold up to today's standards of a stable OS and it doesn't have a consistent development environment for further project upgrades. In order to provide an AR Sand Table to the laboratory, it was decided to go with an updated version of the UC Davis sand table from an organization called ar-sandtable.eu. ar-sandtable.eu updated the UC Davis project to be built and extendable using the Unity game engine. They also converted the software to run on windows calling it KinectSandbox. Also, in this new updated version of the software, they upgraded the 4:3 depth sensing camera to a 16:9 depth sensing camera. Not only will the working area be larger for the sand table, but the new camera is faster that has a larger, more well documented, and used SDK. With a supported software using Unity, all that was left was for a table to be built from scratch since buying a ready built table is next to impossible with these open-source projects.

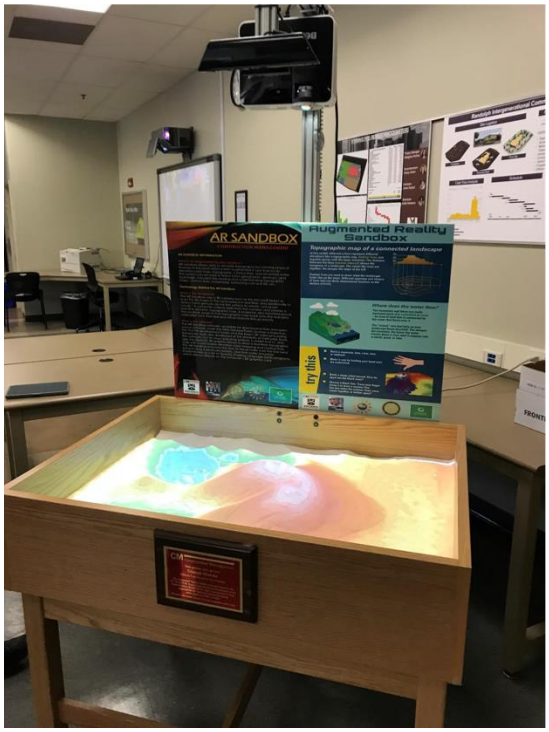

Figure 6 - Older 4:3 UC Davis Sand Table

Sand & Table

The Sand and Table both had very calculated requirements. Each requirement made was to capitalize on the largest table we could feasibly build in the Laboratory. After some conversion of the 16:9 ratio to inches and after some measuring of door and elevator entrances, it was found we could build a table 53 inches long by 30 inches wide table. From there I calculated how much sand would be needed which, came out to around 5.58 cubic feet worth of sand. So, after all these calculations, my sand weight requirement was for 550 pounds of play sand. Next, the frame for table needed to be built out of meatal in order to be mobile on caster as well as strong enough to hold up 550 pounds of play sand. The basic concept of the table design was for it to be made in two distinct halves. The first half is the Sand Table Frame which will hold the second half. The second half is called the sand bucket which will be the main container that will hold the sand. The Drawings were made in Solidworks and modeled by Brian Almaguer and design considerations were received and edited by Mike Newton from the MadLab and Jeffery Ortiz from the Machine Shop.

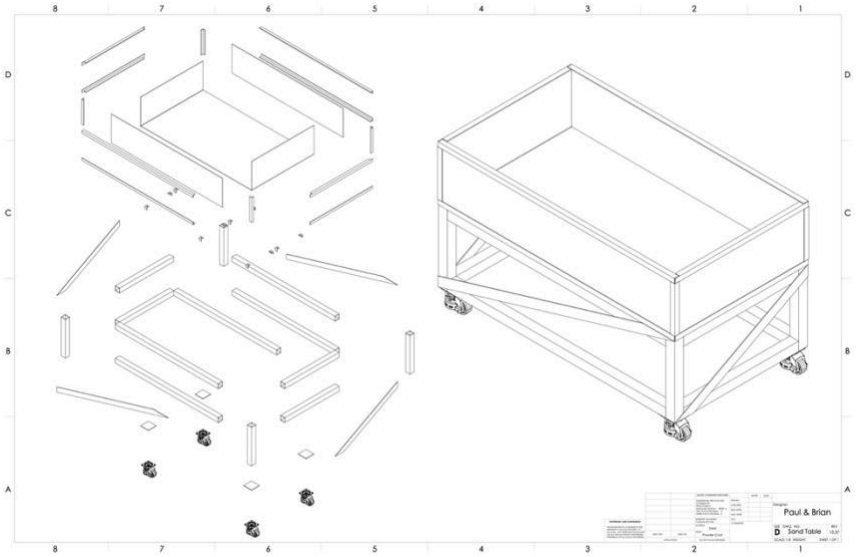

Figure 7 - Solidworks Sand Table Poster

Projector & Xbox One Camera

The project and camera were defined by the software we are going to use in the laboratory. The KinectSandbox software by ar-sandtable.eu uses a short throw projector with an Xbox One Kinect Camera. Obtaining the projector was not an issue since our college has a variety of short throw projectors to choose from. However, the Xbox One Kinect Camera is special. Although this camera is thought to be used mainly for the Xbox console, it is a massively utilized tool in the open-source community. Being the cheapest depth sensing camera with a large and well documented SDK from Microsoft, the Xbox One Kinect camera is a prime camera to perform any project that need a depth sensing camera. Also, the Kinect series of depth sensing cameras have some of the most tutorials out on the internet for game engines such as Unity. Because of the requirements the KinectSandbox software has, this project has decided to use an in-house project with the Xbox One Kinect Camera.

Figure 8 - Xbox One Kinect

Hardware Implementation

The laboratory's Augmented Reality tools and equipment requires a simple implementation into the rooms structure. The AR headgear, such as the Nreal Air and Magic Leap, are planned to be stored in the laboratory's lockable Husky tool chest inside their original boxes. The AR headgear will be kept in their original boxes as to make checking out and inventorying equipment simple, easy, and streamlined for instructors, students, and labbies. As for the Handheld AR gear, such as the iPads and Samsung Tables, they will be unboxed and kept in the lockable laptop cart. The reason we want to keep the Handheld AR gear in the laptop cart is because of its internal power strips, which with the power strip, we can keep our Handheld AR gear charged and ready for checkout. Then for the LulzBot 3D printer, it will be stored as close to the labbie work desk since, the implementation of the 3D printer will be operated by only lab assistants. As such, any request for parts, dioramas, and AR materials made by the 3D printer will be handled through requesting printing time from the ECS Help Desk. Therefore, the 3D printer needs to be located next to the labbies desk. Next, is the AR Sand Table which will be located close to all the storage furniture since, one of the constraints for the table was for it to be mobile. We can have it stored in any corner of the room and move it when needed. Unlike other equipment, the design of the AR Sand Table makes it very easy to work with since no checkout procedure is needed to use essentially use furniture in the laboratory.

VR Technology

Background Knowledge

Virtual Reality (VR) is a tech experience where an entirely virtual setting is created to convey an immersive experience. These virtual experiences very in two categories of: realistic

visual quality and, total field of view. The combination of these two categories creates a market where the quality of your VR experience is determined by what hardware you decide to operate. Although there are generic controllers one can use to control the actions one might have in a virtual experience, nothing compares to a specialized hardware designed to tie your tactility to Virtual Reality.

The realistic visual quality of a VR experience is completely determined by the quality of the displays in a VR headset. Thus, the range of a visual experience is determined by VR headsets display capabilities in color, pixel density, and screen real estate. Essentially one can have very realistic visuals in an VR experience when a headset the more colors, pixels, and screen real-estate.

The total field of view is also affected by the quality of the displays in a VR headset. Unlike the category of a realistic visual quality, the total field of view is only determined by the size of the screen real-estate available. Essentially, the larger the screen is in a VR headset, the larger the field of view will be for the VR experience.

Next is the rig used to operate oneself in an VR experience. The quality of one's immersion into a virtual space can be extremely different depending on what controller is used. For example, one will have a more immersive experience driving a car in virtual reality with a driving rig rather that a console controller. As such, the quality of a VR experience is also determined by the rig used in controlling an VR experience.

Finally, in today's VR spaces, VR experiences are run on ARM phone chips all the way up to top-of-the-line computer systems. Depending on what computing systems you have rendering your VR experience, whether it be low-end or high-end systems, will affect the quality of the VR experience regardless of the VR hardware. Understanding what computing hardware

affects is important for delivering the best VR experience. So, in a VR computing system, the CPU is what handles all the data that will be translated to a VR experience; data such as controller integration, positional data systems, and special vectors system. Then, the GPU is what handles the graphical virtual environment based on system calculations. Having a good GPU will give you a smooth visual experience while having a good CPU will provide the best data for the virtual simulation.

Components

Oculus Quest 2

The Oculus Quest 2 is one of the four different VR headsets purchased for the laboratory. The headset comes with inside-out tracking and is the lowest quality headsets in our VR lineup. The Quest 2's total resolution per eye is 1832x1920 pixels with a refresh option of 72Hz and 120Hz respectively. The Quest 2 also boasts a field of view of 89° (± 4°). However, even with lower specifications and quality visual experience compared to our other headsets, the Oculus Quest 2 is a stand-alone headset that can either be run on the onboard Qualcomm Snapdragon XR2 SoC or be run on a computer system directly. The Oculus Quest 2 is easily the most accessible VR headset available in the market at the time of this report and is a piece of kit that has the highest mobility and versatility in our lineup. As to why we decided to select the Oculus Quest 2, it is because of ability to run anywhere standalone. This extraordinary mobility and ease of setup make the Quest 2 a prime tool for Stronger Recruiting as it was expressed in the DelNorte proposal.

Figure 9 - Oculus Quest 2

Valve Index

The Valve Index System is the second of four different VR headsets that was purchased for the laboratory. The headset is a complete system coming with base stations, controllers, and the headset itself. Unlike the Quest 2 the Valve index is an outside-in tracking system, allowing for better body, hand, and head tracking. The Valve Index total resolution per eye is 1440x1600 pixels with a refresh option of 120Hz respectively. The Valve Index also boasts a field of view of 130°, which is 40% more field of view when compared to the Oculus Quest 2. The Valve Index however is considered a middle range headset when compared to the rest of or VR lineup. Nevertheless, the Valve index is still a massively popular VR system being one the best cost-efficient systems available for outside-in tracking on computer only VR systems. Also, unlike the rest of the headsets in our line up except for the Oculus Quest 2, the Valve Index is a complete system out of the box. With the purchase of the Valve Index, the laboratory aims to provide the following aspects defined by the DelNorte proposal of “HIGH TECH LEARNING” where we provide “The latest learning tools”.

Figure 10 - Valve Index

Pi Max 8K

The Pi Max 8K is the third of four different VR headsets that were purchased for the laboratory. The headset is a stand-alone device with no extra controller or base stations bundled with it. Like the Valve Index, the Pi Max 8k is an outside-in tracking headset. The Pi Max 8K's total resolution per eye is 3840x2160 pixels with a refresh option of 60Hz, 75Hz, 90Hz, and 114Hz respectively. The Pi Max 8K also boasts a wide field of view of 200° but a diagonal field of view of 170°. With specifications like these, the Pi Max 8K is very easily one of our two high end VR headset. The Pi Max 8K specifically is a system focused on a uses field of view where the goal is to provide the most surround-able virtual experience a VR system can provide. This why the Pi Max 8K was chosen to be added to our laboratory since it can easily fulfill one of the DelNorte proposal desired aspect of "HIGH TECH LEARNING".

Figure 11 - Pi Max 8K

Varjo Aero

The Varjo Aero is the fourth of four VR headsets that were purchased for the laboratory. The headset is a stand-alone device with no extra controllers or base stations bundled with it. Like the Valve Index and Pi Max 8K, the Varjo Aero is an outside-in tracking headset. The Varjo Aero also has a resolution per eye of 2880x2720 pixels with a refresh option of 90Hz respectively. The Varjo Aero also boasts a wide field of view of 115° but a diagonal field of view of 134°. Unlike any other headset in our lineup, the Varjo Aero is a headset made by company that, until recently, only made the high-end VR headsets for industry. As a result, the Varjo Aero has inherited all the bleeding edge technology industry is using today. The following specifications are what we gain from the Varjo Aero headset that cannot be gained on any other consumer grade headset on the market: first is that the displays are factory calibrated for 99% of the sRGB color range. Second is that the displays are also calibrated for 95% of the DCI-P3 color space which is mainly a variant created by Apple for the theatrical motion picture distribution color standard. Third is that the optics are custom-made variable resolution aspheric lenses meaning that as a result, our pixels per degree (PPD) is larger from the center of the lens out. A larger PPD is important since, where there is a larger PPD comes a more realistic image to the human eye. The fourth edge technology that comes with the Varjo Aero is built high fidelity eye tracking. With specifications like these the Varjo Aero is easily the most advance VR headset the laboratory has. Finally, the reason why we choose to go with the Varjo Aero was because it was the only possible piece of hardware that could be purchased that can truly fulfill the DelNorte proposals aspect of containing “industry-sanctioned software and virtual reality technologies”.

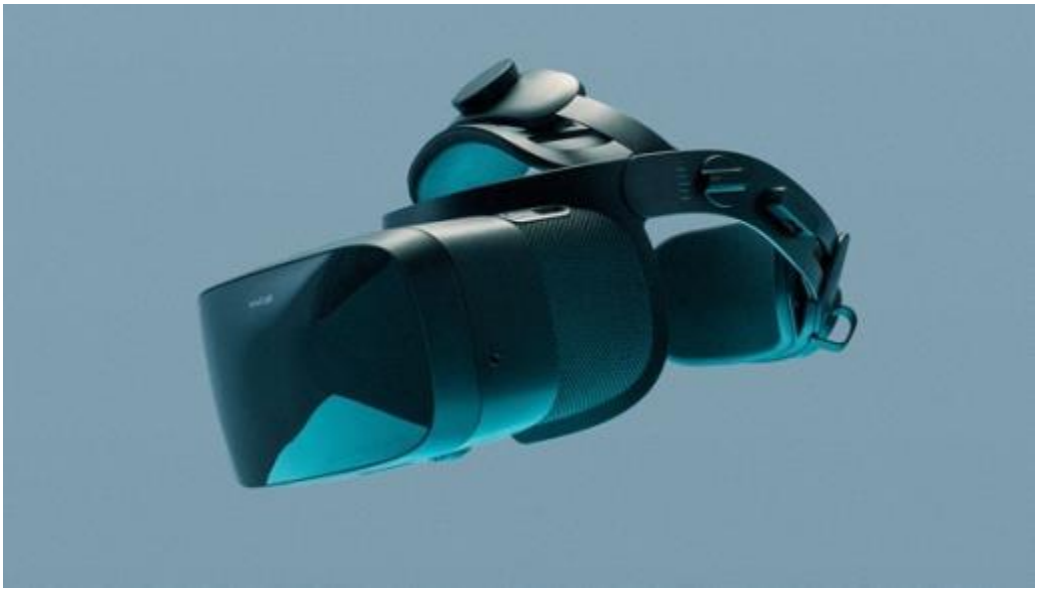

Figure 12 - Varjo Aero

H.O.T.A.S. Rig

Logitech X56

H.O.T.A.S. is an acronym that stands for Hands on Throttle and Stick. As such a H.O.T.A.S. is primary used for simulations software such as Microsoft Flight Simulator or even Tractor Simulator. This range of assailable control available on a H.O.T.A.S. rig makes it a very popular option for controlling a large Varity of software; H.O.T.A.S. rigs often provide a more tactile experience without investing to heavily in specialized hardware. So, knowing as such, the Logitech X56 H.O.T.A.S. was purchased for the laboratory because of its support for a large amount of software. Also, Logitech has some of the most supported controllers in the market and our laboratory would be unlikely run into an issue with controller incompatibilities using a Logitech controller. As to why we choose to support a HOTAS rig was to accommodate the DelNorte proposals promise of “Industry-Demanded Experiential Learning”.

Figure 13 - Logitech X56 H.O.T.A.S.

Driving Rig

OpenWheeler Simulator Cockpit

The OpenWheeler Simulator Cockpit is a piece of furniture that is oriented to mount driving simulation hardware in an ergonomic manner like that of a real vehicle. This piece of furniture was selected because it supported the driving simulation hardware we choose to use in the laboratory. The OpenWheeler Simulator Cockpit also has multiple points of adjustment to accommodate any size operator. The reason we decided to purchase a Driving simulator chair was to provide the already preexisting Joint Civil Engineering & Computer Science Student VR Driving Sim Projects better and more realistic equipment.

Logitech G923

The Logitech G923 racing wheel and pedals is a piece of our driving simulation rig. Specifically, this piece of Logitech hardware has features to create a more realistic and, most importantly, tactile driving experience with features such as force feedback pedals and wheel. In addition to being Logitech hardware, the reason we decided to purchase the Logitech G923 was

because of its ability to provide a more realistic driving simulation needed for our already preexisting Joint Civil Engineering & Computer Science Student VR Driving Sim Projects.

Logitech G Driving Force Shifter

The Logitech G Driving Force Shifter is a piece of our driving simulation rig. Specifically, this piece of Logitech hardware has features to create a more realistic and, most importantly, tactile driving experience with features such as force feedback shifting. In addition to being Logitech hardware, the reason we decided to purchase the Logitech G Driving Force Shifter was because of its ability to provide a more realistic driving simulation needed for our already preexisting Joint Civil Engineering & Computer Science Student VR Driving Sim Projects.

Figure 14 - In Lab Driving rig

Body Capture Rig

VIVE Trackers & Track Straps

The VIVE Trackers are devices used in an outside-in tracking setup that denote the position and orientation of an object or body in virtual space. One of these devices acts like a point of information for positional and gyroscopic data. The VIVE Trackers are also one of the most streamline pieces of hardware used for object and body positional tracing in outside-in VR setups. The most common use of the VIVE trackers is to do full body tracking rig. Therefore, the laboratory as opted to get Track Straps and VIVE Tracker. Both the VIVE Trackers and Track Straps are very important pieces to a full body capture setup. Also, a body capturing rig is one of the closest controllers we have to simulating our bodies in a virtual environment.

Figure 15 - VIVE Tracks and Strap

SteamVR 2.0 Base Stations & Stands

The Steam VR 2.0 Base Stations and Stands are a device used in creating an outside-in tracking setup. It is the Base Stations responsibility to gather positional data of an individual for the use in VR Software. Just like the VIVE Trackers, more Base Stations provide more information to a inside-out tracking system. The ability to increase our data collection in an inside-out tracking system is the reason why we decide to acquire more SteamVR 2.0 Base stations and stands. Also, Extra Base stations means we can run more than one VR headset at the same time since two of our three outside-in tracking headsets did not come with controllers or base stations.

Figure 16 - SteamVR 2.0 Light House

Allegro Pro 4 PCIe Card

The Allegro Pro 4 PCIe Card is a USB 3 hub card. What makes the Allegro Pro 4 PCIe Card special is its multiple USB controller chips on the card. The reason we care about multiple USB controller chips on one card is because, the less USB ports that are mapped to a chip, the less likely we will overload the chip with data to communicate to a computer managing an outside-in's VR tracking setup. This is the reason why we purchase the Allegro Pro 4 PCIe Card, without it our body capturing rig would be unreliable for projects and experiential learning.

Figure 17 - Allegro Pro 4 PCIe Card

OBSBot 4K & Tripod

The OBSBot 4K and Tripod are very important recording equipment for our body capturing rig. Since, in a body capturing rig involves an individual to be mobile it is unreasonable to use a normal camera with out tracking. The OBSBot 4K camera is a special camera with an AI to follow and Track individuals its recording. This feature is important for recording projects and experiments where the virtual object or person needs to be compared to the real object or person. Having a camera that follows an individual's movements benefits the not only the body tracking rig setup but all AR and VR simulation setups. This Camera and Tripod are important in securing media that can be used for recruiting.

Figure 18 - OBSBot 4K Camera

Green Screen Backdrop

The Green Screen and Backdrop are pieces of equipment that make recording any project or experiment more fun and easier to post process. Recording or Photographing work done using a green screen allows for the isolation of objects and distractions when curating materials for publishing. A green screen also helps isolate all unnecessary information a system my receive when in an ambient room. It is because of these reasons why a green screen backdrop is needed in the lab, without it we can't enhance scholarly activity opportunities.

Computers

XPS Desktop & Peripherals

The "New XPS Desktop" is the computer system we purchased for the laboratory because it offered more options for configuring a PC. The most compelling feature of this desktop was the option of an Intel i9-12700K processor. The Intel i9-12700K is a processor with 16 cores and 24 threads and is required, by dell, to have an AIO for thermals. This processor, during this report, is the best processor you can put in a dell desktop system. In addition to the CPU, all XPS systems have a four-year warranty for service and accidental damage. In addition, to pair our XPS systems, we opted to go with a Logitech G413 Carbon mechanical keyboard and a Logitech G Pro Gaming mouse. Both these peripherals were chosen because of their superior build quality and overall aesthetic it would bring the lab. Finally, a 27-inch dell monitor with build in USB C hub was purchased to provide an excellent and large enough display for operating any and all software related to VR projects and experiments.

Figure 19 - XPS Desktop

Figure 20 - Logitech Keyboard and Mouse in the Lab

RTX 3070 Ti Configuration

All configurations come with and Intel i9-12700K processors since our main concern for our computer stations is the GPU for operating the laboratory VR headsets. So, our first of three Dell XPS configurations has an RTX 3070 Ti. This RTX card has a total of 8 GB Memory and a total of 6144 NIVIDA CUDA cores. This configuration, compared to the other two configurations, is the least powerful GPU. As a result, this system will represent the minimum configuration needed to operate a VR system. And, for the reason why we want this configuration is to supply a choice when future projects and experiments operate in the lab as to not lock down a team to a specific computing device.

RTX 3080 Configuration

All configurations come with and Intel i9-12700K processors since our main concern for our computer stations is the GPU for operating the laboratory VR headsets. So, our second of three Dell XPS configurations has an RTX 3080. This RTX card has a total of 10 GB Memory and a total of 8704 NIVIDA CUDA cores. This configuration, compared to the other two configurations, has not the least or strongest GPU. As a result, this system will represent the average configuration needed to operate a VR system. And, for the reason why we want this configuration is to supply a choice when future projects and experiments operate in the lab as to not lock down a team to a specific computing device.

RTX 3080 Ti Configuration

All configurations come with and Intel i9-12700K processors since our main concern for our computer stations is the GPU for operating the laboratory VR headsets. So, our third of three Dell XPS configurations has an RTX 3080 Ti. This RTX card has a total of 12 GB Memory and a total of 10240 NIVIDA CUDA cores. This configuration, compared to the other two configurations, has the strongest GPU. As a result, this system will represent the highest configuration needed to operate a VR system. And, for the reason why we want this configuration is to supply a choice when future projects and experiments operate in the lab as to not lock down a team to a specific computing device.

Hardware Implementation

The laboratory's VR setup and simulation rigs implementation is only a little more complicated compared to the AR Hardware implementation. To start, the VR headgear, such as the Oculus quest, Valve Index, Pi Max 8K, and Varjo Aero, will be stored the same as the AR headgear; inside their boxes and locked inside the husky tool chests. The reason we keep out VR

headgear inside their boxes is to make checking out and inventorying equipment simple, easy, and streamlined for instructors, students, and labbies. Part of the VR hardware implementation is setting up the room for the two different tracking systems available. The first is inside-out VR tracking system which requires only clearing an area for movement. However, the second outside-in tracking system needs an area to be cleared and the SteamVR lighthouse's setup for play area tracking. Both the inside-out and outside-in tracking systems can have setup for the body tracking rig, driving rig, or camera with green screen setup included into their initial configuration when called for. The implementation of the different rigs will be handled by checkouts and, if they fit, will be stored in the husky tool chests. Larger pieces equipment's such as the driving simulation chair and green screen backdrop will, like the AR sand table be store in the corners of the rooms since they can be moved into place when needed. Finally, as the laboratory is being actively built, the organization of the furniture, wire organizers, and equipment designations is still being worked on and analyzed.

Software Implementation

Overview

Our laboratory's most vital equipment for operation is the Nreal Air, MagicLeap, iPads, Samsung Tablets, Oculus Quest 2, Valve Index, Pi Max 4K, Varjo Aero, driving rig, H.O.T.A.S. rig, and the body capturing rig. Each one of these pieces of equipment needs very specific software, drivers, Integrated Development Environments (IDE), and Software Development kits (SDK) for AR and VR to be operated and developed for. As such, the software's Steam, Oculus, Unity, and Unreal Engine will be discussed. Each one of these software will cover what exactly it will be used for and what exactly it needs in terms of drivers, SDKs, and IDEs.

Approach

Steam

Steam is a software a company where video games and most importantly VR video games are sold and facilitated. Steam, while also being a marketplace for games, orchestrates the use of VR hardware and drives. All the VR headsets and rigs in the laboratory communicate with Steam for the interfacing of hardware to software. To get steam to operate properly with our VR equipment, the utility called SteamVR needs to be installed on our computer systems after the installation of Steam itself. Also, since steam is a marketplace, it was found that there is no way to create a collection of accounts linked for lab or educational use and as a result, it is recommended that we either implement a single steam account for the entire lab or multiple steam accounts for out different computer systems. Essentially installing Steam and StreamVR is required for our hardware and drivers to work properly.

Oculus

Oculus is a hardware company specializing in VR Technologies that was acquired by Meta, formally Facebook, back in March 2014. Because of this acquisition, it has become required to have a Meta account to operate, install, or use most of the Oculus hardware. Using the Oculus app for our computer systems will provide our lab with all the tools and drivers necessary to operate and install software on our Oculus Quest 2 systems. As a result, it is recommended we have one Meta account to manage the Quest 2 across all the computer systems. This essentially the oculus software and Meta account are necessary for the operation of Oculus Quest 2 systems.

Unity

Unity is a company that created the Unity engine which is a software platform designed for making digital software and games. Unity as software development tool has been used in the gaming, automotive, architecture, and film industry for its exceptional ability to run pre-rendered and real-time rendered graphics with physics objects. Specifically for our laboratory's equipment, all our AR headgear, Handheld AR devices, and VR headgear have and use software designed from Unity. Today, Unity is the most common software to build AR and VR software since it has a large community of paid and opensource developers. So, it is recommended we install Unity and all the SDKs bundled with our AR headgear, Handheld AR devices, and VR headgear on our computer systems. As for licensing, Unity provides free licenses for organizations, students, and hobbyist that don't exceed a revenue stream of $100K from derived software.

Unreal

Unreal is a software that is a graphics and gaming engine created by the company Epic Games. Currently the software is on version 5 and is the leading software development tool for realistic real-time visuals and physics. Like Unity, the Unreal engine is also used in the gaming, automotive, architecture, and film industry. A good example of the Unreal engine being used is in the set of the TV show, The Mandalorian, where most outdoor settings were a virtual environment simulated and run real-time with the Unreal Engine. So, it is recommended we install the Unreal 5 and all the SDKs bundled with our AR headgear, Handheld AR devices, and VR headgear on our computer systems. As for licensing, Unreal 5 provides free licenses for organizations, students, and hobbyist however, the free licenses come with no support, private training, or custom license terms.

Conclusion

This project was fun since I ran into some challenges I have not experienced before. When identifying certain hardware, it never occurred to me that some requirements pose issues in finding an actual product. For example, the PCIe card with multiple USB chip controllers was an exceptionally hard piece of equipment to research and acquire because of the nature of requiring multiple controllers on one board. Or when it came to researching software for the AR Sand Table, it was a search to find an updated version of the UC Davis software that was not being monetized for an amount of money close to the entire labs budget. During this research work I put in the Spring 2022 semester I was able to understand and better identify AR & VR Technologies in a systematic way.

Also, at the time of this report, the final materials for equipment are currently being shipping. The AR Sand Table is under construction in the Machine Shop while the furniture is being assembled in lab. As such, the current state of the lab is under construction. Most of the equipment is accounted for and waiting to be stored in our new husky tool chests. The software currently being collected for potential SCCM deployment over summer. Finally, the 3D printer is built and ready for its first test print.

Finally, I would like to acknowledge all the individuals who have help me thought this course and project. Thank you Verionica Pruitt for helping make get into this Couse, Thank you Dr. Nikrouz Faroughi for approving my opportunity to enroll into this course and work with the amazing ECS Staff, Thank you to all the ECS Staff who answered my technical questions when trying to navigate my way through university procurement and quote making, Thank you Mike Newton and Jeffery Ortiz for advice and engineering review for my AR Sand Table design, and lastly Thank you Lynne Koropp and Dr. Mariappan Jawaharlal for working with me and

believing in ability to do the work needed to research, purchase, and implement the equipment for this instrumental AR & VR Laboratory for the College of Engineering and Computer Science.

Bibliography

AI-powered ptz webcam. OBSBOT Tiny 4K AI-Powered PTZ 4K Webcam. (n.d.). Retrieved May 24, 2022, from https://www.obsbot.com/obsbot-tiny-4k

Dell XPS desktops. Dell. (n.d.). Retrieved May 24, 2022, from https://www.dell.com/en-us/shop/desktop-computers/sr/desktops/xps-desktops

Enterprise augmented reality (AR) platform designed for business: Magic leap. Enterprise augmented reality (AR) platform designed for business | Magic Leap. (n.d.). Retrieved May 24, 2022, from https://www.magicleap.com/en-us/

Logitech G Driving Force Shifter for G29 and G920 steering wheel. (n.d.). Retrieved May 24, 2022, from https://www.logitechg.com/en-us/products/driving/driving-force-shifter.941-000119.html

Logitech G X56 VR Simulator compatible HOTAS joystick. Logitech G X56 VR Simulator Compatible HOTAS Joystick. (n.d.). Retrieved May 24, 2022, from https://www.logitechg.com/en-us/products/space/x56-space-flight-vr-simulator-controller.945-000058.html

Logitech G923 TRUEFORCE sim racing wheel for xbox, PlayStation and PC. Logitech G923 TRUEFORCE Sim Racing Wheel for Xbox, Playstation and PC. (n.d.). Retrieved May 24, 2022, from https://www.logitechg.com/en-us/products/driving/g923-trueforce-sim-racing-wheel.html

The most powerful real-time 3D creation tool. Unreal Engine. (n.d.). Retrieved May 24, 2022, from https://www.unrealengine.com/en-US/

Nreal Developer. Nreal Ltd. (n.d.). Retrieved May 24, 2022, from https://developer.nreal.ai/?lang=en

Quest 2: Our most advanced new all-in-one VR headset: Meta quest. Meta. (n.d.). Retrieved May 24, 2022, from https://store.facebook.com/quest/products/quest-2/

Smith, L. (2021, April 23). 2021 - DelNorte 2007-2009 Proposal. Sacramento; California State University, Sacramento College of Engineering & Computer Science Office of the Dean.

Technologies, U. (n.d.). *Unity Real-Time Development Platform | 3D, 2D VR & AR Engine*. Unity. Retrieved May 24, 2022, from https://unity.com/

Unreal Engine Powers Film & Television production. Unreal Engine. (n.d.). Retrieved May 24, 2022, from https://www.unrealengine.com/en-US/solutions/film-television

Valve index. Valve Index. (n.d.). Retrieved May 24, 2022, from https://store.steampowered.com/valveindex

Varjo Aero. Varjo.com. (2022, April 22). Retrieved May 24, 2022, from https://varjo.com/products/aero/

Vive Tracker (3.0): Vive United States. VIVE. (n.d.). Retrieved May 24, 2022, from https://www.vive.com/us/accessory/tracker3/

VR headsets, hmds & Equipment. Pimax. (2022, May 24). Retrieved May 24, 2022, from https://pimax.com/