Capturing our world through interactive virtual reality field trips

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ABSTRACT

A wide range of emerging technologies are available to create virtual reality experiences that can take us on journeys to explore regions of the world that we might never otherwise be able to visit ? ranging from polar ice caps to tropical forests. In particular, 360 imagery is becoming increasingly easy to capture, edit, and annotate to engage people in deeper, interactive virtual field experiences. This project will evaluate different techniques and methods for creating interactive virtual reality field trips, including experiences that integrate imagery and other content within the setting of the virtual world with an emphasis on educational field experiences.

And this is what references look like [2].

Index Terms: K.6.1 [Management of Computing and Information Systems]: Project and People Management—Life Cycle; K.7.m [The Computing Profession]: Miscellaneous—Ethics

1 INTRODUCTION

Due to the wider availability of virtual reality peripherals, virtual reality has become an assessable teaching tool. With the surge of consumer peripherals many different mechanics and technics have been developed for these products. This project will evaluate different techniques and methods for creating interactive virtual reality field trips, including experiences that integrate imagery and other content within the setting of the virtual world with an emphasis on educational field experiences. The paper evaluates different methods use for movement through a virtual environment, ways to interact with the objects inside of the virtual environment, and techniques used to integrate imagery into a virtual environment. The paper discusses the opportunities offered by virtual reality for the development of ?virtual fieldtrip? with a focus on geological education.

How can current VR mechanics be adapted to geoscience education?

Deconstructing popular VR games to improve virtual geoscience experiences.

Assessing VR mechanics with respect to mobility interactivity imagery for utilization in geoscience education.

2 METHODS

To start of the project I searched the web for highly rated VR experiences that were compatible with the HTC Vive, and had a free demo. To find these experiences I used websites that focused primarily on VR such as VU Dream ,VR Source and VR Today. Each of these sites had a list of experiences that hey recommended and gave short descriptions of each of the experiences. From there I went onto the Steam and Oculus store to get a sense of what users were saying about the experiences, and how many unique users have tried the experience. After reading some of the reviews and making notes of what users liked or disliked about the experience I tried the experience myself. After finishing the experience I wrote down all of the different mechanics used in the experience and gave short descriptions of how they were used in the context of the experience. Once I had played a few of the experiences I reviewed the mechanics and found patterns that I utilized to form categories in which the mechanics would be placed for abstraction. Once the mechanics where placed into each category I broke the mechanics down to their most basic form. Once the mechanics where simplified to the base level they could be rebuilt into any context desired. For the sake of this project the context was for geoscience education. Therefore the next step would be to look into what is currently being done with geoscience education. I reviewed class room assignments and virtual field trips that are either being used or are in development that where recommended to me by my advisors. Once I had a fair understanding of some of the activities that would be taught I could begin to construct the ideas for a VR experience that would function as the basis for future geoscience virtual experiences. Once a general framework was decided on the a demonstration was built to show how some of the mechanics can work together to make a unique experience.

3 MECHANICS

3.1 Mobility

Mobility in this context is defined as the ability to move through a virtual environment.

3.1.1 Teleportation

Teleportation is the utilization of instantaneous travel across the virtual environment. Teleportation has many variants however they all fall into one of two basic categories. The first form of teleportation relies on the user to specify the location that they wish to teleport to. This can be down by utilizing a reticle on the floor that the user can use to specify where they want to more or use a projectile that is fired in the desired location to teleport there. The other form of teleportation relies on the user interacting with a object or button to inform the game that the user wishes to teleport. This can be done using an in game button that the user presses to more to the next area or by placing a VR headset onto the users face. These two forms of teleportation make up the bases for all other variants and can be called either Controller based or Object Based as they either rely on user input to direct the teleportation or an object to control the teleportation.

Teleportation is the most common form of mobility that I found in the experiences. I believe this is due to the fact that the developer will have no way of knowing if the users will have room scale enabled nor how large of an area a user will devote to it. Teleportation allows the user to move around the space without move in the real world and with a reduced risk of cybersickness which is defined in the locomotion section.

3.1.2 Room Scale

Room Scale is movement inside of the room directly correlating to the movement in the virtual environment. Room Scale requires the use of sensors that are stationary and opposing one another requiring the user to stay inside of a ”playable area”. Room Scale is the

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most intuitive mode of movement as it allows the users to move around as they would normally. The limitation of this movement system is the physical space. Due to this limitation Room Scale is often accompanied by another form of movement the most common being teleportation.

3.1.3 Locomotion

Locomotion is moving from location A to location B over a period of time. This is the most common mode of transportation in other forms of virtualization. Locomotion is not as common in VR experience due to cybersickness. Cybersickness, is distinct form motion sickness in that the user is often stationary but has a compelling sense of self motion through moving visual imagery? [2]. However, this can be combated by giving context to the motion, for example placing the user in a vehicle or place the user on a moving platform. Locomotion also covers more unconventional forms of movement such as having the user pull them self along a rope, or having the user walk in place. The more unconventional means usually attempt to provide context to the movement by having the user mimic a movement that they would of used in that situation.

The biggest issue that I experienced with locomotion is the changes in acceleration. Having things move at a constant rate can help reduce cybersickness for some individuals. Using locomotion sparingly with another for of motion acting as the primary can work well. Using a moving platform in a experience where the user can teleport around is an example.

3.2 Interactivity

Interactivity is defined as the users ability to influence the virtual environment that they are placed in.

3.2.1 Object Based

Object Based interaction is dependent on the existence of a object that the user is able to reach. An example of object based interaction is picking up a dart to throw at a dart board. Object based interactions can come in many different forms and can be accomplished with many different forms of interactive interfaces for the user to use. Object based interaction can be done with the user looking at an object, having the user collide with an object, or having the user actively selecting the object using a controller.

Object Based interactions can make the world the user is interacting with much more realistic. If objects move or react the way the user is expecting them to they will become more accepting of the environment they are placed in. It is also important to define the rules of the object if it is not something they would find in the real world. For example if you set the precedent that picking up a sphere and placing it up to the headset loads the next level, it would be good to have all level selection revolve around something being placed near the headset.

3.2.2 GUI

GUIs or Graphic User Interfaces are 2 dimensional windows that the user can interact with. One of the most common examples of GUIs inside of VR are menus but can also be used for HUDs or Heads Up Displays, and overlays. Control overlays can be a great way to explain controller functionality to users and can be used to inform players when parts of a controllers functionality has changed. Heads Up User displays can be used to give the user important information for example giving the user a dot on their screen that acts as the cursor for experiences that only utilize a headset. Placing GUIs in a virtual environment can be tricky as most of the assets will be 3D. One way to give context would be to place GUIs onto items such as a cube to turn it into a display that can provide the user with updating information.

GUIs can be the best way to give the user information but it is important to try and direct the user without them. Good design will get your user to look the direction you want them to. For example in the demonstration that was built I placed the table in the corner that the brackets would appear in. By having the table be in a location and orientation that made it feel natural to stand facing the brackets it lead the user to the desired area without a intrusive HUD. Considering how you would want the user to move through the experience and what clues you will give them is a good way to start. If you feel a GUI is needed to guide the user try to give it some context in the experience. An example is a watch that might vibrate or make a noise, and give the users instructions when they look at it. This can give the user information and give the GUI some context without making things to complicated.

3.2.3 Controller Based

Controller based interaction relies on the user to have some sort of peripheral that can be used with the headset. The most common form of controller interaction relies on buttons or some other input that is placed on the device. Each of the buttons can be assigned a function such as pulling up a menu when a button is pressed. Another form of controller based interaction is room scale. Room Scale controller interaction uses room scale to track the controllers location allowing the user to point to a desired location for teleportation or knowing when a controller is placed in front of the users vision to activate a menu.

The controller model can be a great indicator for he function that the button does. For example placing a mouse wheel on the track pad will imply that the user can us it to scroll. Using visual queues to suggest the functionality of the controller can make the experience seem more natural as the users wont be distracted by floating text.

3.3 Imagery

Imagery is defined as the use of photos, or videos to create assets for the virtual environment.

3.3.1 Photogrammetry

"Digital photogrammetry is a generally accepted technique for the collection of 3D representations of the environment" [1]. The 3D representation can be built using many different methods however the most accessible method uses DSLR cameras. Using a standard DSLR a developer can quickly scan an area using multiple images at different orientations to give some software unique views that can be used to create a 3D model of the environment. It is important when capturing the images to make sure that their is some overlap that will inform the software how the images connect to one another. It is also important to keep the camera settings consistent through out the

Photogrammetry can be used to recreate anything. It can be used to create extremely realistic models of real world objects, including people. Photogrammetry can be used to recreate entire areas as well by taking multiple images.

In the demonstration photogrammetry was used to create the samples placed onto the table. One issue with photogrammetry is that the models will usually need to be cleaned up to remove artifacts or simplified to be used in a experience. The raw model will usually contain many more vertices than needed. The samples that were used in the demonstration had its vertices reduced by at least 95 percent. The more realist the model needs to be the more vertices you will want to use however there is a sweet spot for accuracy and performance that can be found depending the shape of the subject.

3.3.2 360 imagery

"3ODVs are typically recorded with cameras that cover up to 360 of the recorded scene" [**?**]. Recently many different cheap consumer cameras have become available. The final image can be placed into a sphere or cube which a user can be placed inside of. Allowing for a quick way to create experience that engulfs the user inside of the image.

When using most consumer 360 cameras it is very important to make sure the image is leveled If the image is not level maneuvering around the image will be difficult. This is due to the way the camera creates the image. Usually 360 cameras rely on extreme angle lens to gather as much information as possible. Due to this the bottom and top of the image is usually much more distorted than the middle of the image. This can be avoided by using a camera that utilizes many lens that need a smaller field of view or by utilizing a rotating camera. However, these cameras are usually more expensive and therefor less accessible to developers. The most accessible way to use 360 imagery is to utilize sites such as google street view to get the images straight from the internet. This can be a great way to use a location in the experience without having to pay for the travel to the location. The quality of the images you find online will vary and may not fulfill the desired purpose of the experience.

3.3.3 Sky-Boxes

A sky-box is a image that is placed on the outside of the playable area. Sky-Boxes are typically used to make the virtual environment seem larger than it actually is and to reduce the demands on the hardware Sky-Boxes can use pre-rendered images of a 3D model or can be images of the real world. Sky-Boxes are not necessary in indoor experiences. For outdoor experiences a sky-box will elevate the experience to the next level and give your user the feeling that their world continues way beyond what they are experience.

Using a skybox as the main factor used inside of the demonstration greatly reduced the load on the computer being used. The demonstration uses a 360 image from Google Street View as the skybox. The issue with using a skybox is that you loose the sense of depth. It is important to make the skybox be fare enough away from the user. Using a few rendered elements in that run into the skybox can be a great way to blur the line and make it more difficult for the user to tell where the mesh ends and the image begins.

4 Demostration

The goal of the demonstration is to teach users what layer each sample belongs to. The demonstration takes place inside of the Grand Canyon near Plateau Point. Users are placed on a floating platform with the rock samples placed on a table in the middle. If a user picks up one of the samples a bracket will appear showing the user which layer of rock the sample is from.

The demonstration was built in Unity 3D for the HTC Vive. The demonstration uses room scale as the means of mobility. The demonstrations was built using Valve's SteamVR plugin for Unity. The samples of the rocks are from the Grand Canyon where reconstructed into 3D models using photogrammetry. The sky box of the demonstration was gathered from google map's street view this image was taken by Richard Callingham. The issue with using 360 images is the fact that the user would be floating in the air. To get around this a Platform was built for the user to stand and walk around on. A table was constructed on the platform that held the samples. If one of the samples was grabbed a bracket would appear on the cliff to illustrate which layer the rock is from. The brackets do not overlap allowing the user to pick up multiple samples at once and have them display accurately.

The Demonstration is helps the users spatial thinking by giving them the google map to give the user their location and orientation in the real world. The demonstration also shows of the lateral continuity of stratigraphic units.

Future Improvements to the demonstration that can be done would be to add some activities to be performed at the site such as relative dating the samples presented. Another improvement would be to provide a date range that each layer would of been formed during. These are improvements that can be added to the current demonstration however new demonstrations at different locations can be added. A hub area will have to be built to allow the users to get to and from each of the demonstrations. Each of the locations can have a different purpose and teach different aspects of geoscience. Locations also do not need to be limited to field locations. It would be advantageous to create a lab scenario where the students can perform test and work with equipment hat they otherwise might not have access to. There could even be a story where the student go through each part of an experiment. They could start off collecting the samples in the field then move into the lab to run the tests needed.

5 Geoscience Education

Geoscience Education relies on its ability to teach students spatial thinking, temporal thinking,understanding Earth as a complex system, Learning in the field. [**?**] In the demonstration a google map is provided to give the user the physical location of the simulation that they are in. The demonstration also shows the users which stratigraphic unit a sample belongs to. The user can also see the lateral continuity of the stratigraphic units which allows them to make their own observations about the Grand Canyons history. The Grand Canyons is a stunning example of how the rock cycle and hydrosphere interact and the beautiful world we live on. The use of real world imagery in the simulation gives the user a real world example. It is also important to give people real world images as it will improve the user's signal-noise disembedding which is their ability to find the elements of relevance out in the field.

6 Conclusion

Virtual reality is an amazing tool that can give individuals experiences like no other. It is important to assess this technologies capabilities and potential role in education. Their are many opportunities that can be explored for geoscience education.

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