K-039

Using head-tracking to create a shareable virtual travel experience

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1 Introduction

Virtual Reality has drawn much attention in recent years. Gadgets like the Oculus Rift, development platforms like Google Cardboard among others have brought Virtual Reality to the masses, making them accessible to anyone that has an interest in it.

Virtual Reality and Virtual Environments are used in the computer community almost interchangeably and have several definitions[2]:

- Real-time interactive graphics with three-dimensional models, combined with a display technology that gives the user the immersion in the model world and direct manipulation.
- The illusion of participation in a synthetic environment rather than external observation of such an environment. VR relies on a three-dimensional, stereoscopic head-tracker displays, hand/body tracking and binaural sound. VR is an immersive, multi-sensory experience.
- Virtual reality refers to immersive, interactive, multi-sensory, viewer-centered, three-dimensional computer generated environments and the combination of technologies required to build these environments.

There are some differences between these definitions but they all agree in that Virtual Reality is characterized by two things: interactive and immersive.

This ability of Virtual Reality to be immersive has a lot to do with its popularity. From videogames to training simulations, immersion helps improve the experience in the opinion of a lot of people. This has given people the idea of Virtual Travel, which takes advantage of the simulated realities that VR can create and uses them to let people visit other places of the world.

The idea of Virtual Travel is not new. Attempts to make people feel like they are in a different place have been made since as early as the beginning of the 20th century. Rome through the Stereoscope [4] was a set of pictures and a guidebook that attempted to make people feel like they were visiting Rome.

With the growing availability of Virtual Reality technologies, the idea of Virtual Travel has gained strength and become a viable option. Tourism agencies can use Virtual Travel to make tourism available to more people, expanding the tourism demographic and allowing them to improve their earnings.

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For the purpose of this paper, the definition of Virtual Travel that we will use is the following: Virtual Travel is a way for people who are unable, either for economic, time, or any other reasons, to travel to any places in the world. The objective of virtual travel is to allow those people to see the sights and get information about them.

This paper presents a way to let the user share his/her experience at the same time with other people and through sharing with each other enrich their experience. The tool proposed here works by using a smartphone as a head-tracking device that allows a server to know what he/she is looking at. The intention is to use these devices inside a dome or a similar structure, where a projection of the place they are visiting is displayed. This will allow several people to experience the trip at the same time and talk about what they are seeing. At the same time, each user will receive information in audio and text form on a personal display device (PDD) which is updated using the head-tracking device's information.

The objective is to make Virtual Travel an attractive alternative to regular travel and accessible enough that people from all kinds of economic backgrounds can enjoy it.

2 Design

2.1 Objective

The objective of this system is to create travel experiences that can be shared among several people. Current Virtual Reality trends tend to focus on immersion and use headsets that block you from the outside world in order to achieve this. While this is a great way to create a very immersive experience, it has the disadvantage of not being able to be shared with other people in real time. In order to solve this, we propose a tool that will allow several people to use it at the same time while interacting with each other.

2.2 User

The target users of this system are regular people that want to experience Virtual Travel. This means that their technical knowledge will be average too. An average user of this system will be someone that probably enjoys traveling and that likes moving around and seeing the sights of the places he or she travels to. The user will also need to have information of what he or she is looking at.

The user will also share their space with other similar users at the same time and may be talking about what he/she sees or pointing other users in the direction of something he or she found useful. Since the user will be in a shared space, he or she will need to move around in order to see everything that he/she can and for this reason the system must keep track of their position inside the Virtual Travel environment.

2.3 Key factors to consider

There are several factors that we need to consider to make the system useful to the user. The characteristics this system needs are:

- Easy to learn: The user will be unfamiliar with how the system works and will have no previous knowledge of Virtual Travel. For this reason, our system must be simple and have the user interact with the minimum possible number of its elements.

- User freedom: When traveling, people are free to move and see things at their own pace so it follows that Virtual Travel will allow the user to see things at their own pace too. Another important aspect is that the user should be able to move around the environment. If not, then the experience would be reduced to nothing more than watching pictures or a movie.

- Shareable Experience: The user must be able to use this system alongside other people.

2.4 System

Based on what we want to have the users experience and the factors we need to focus on, the system we propose will consist of three main components that interact between them to give the user the travel experience: the server, the head-tracking device, and the display.

The components interact between them as shown in Figure 1. The user interacts with two of the three components (head-tracking device and display). However, the user does not need any kind of technical knowledge to use them.

The tool is meant to be used inside a dome where a 360-degree projection of the location is displayed. Inside the dome, the user wears the head-tracking device on his/her head while holding the display in his/her hands. When the user moves his/her head around the tool tracks where they are looking at and as soon as the user is looking at an interest point the information on that interest point is shown on the display.

The head-tracking device will keep track of the user's position inside the dome and of the user's head orientation (attitude). The device then will transmit this information to the server. In the server this information is processed and the information that the user will receive (if any) is decided. After this the server communicates with the display and tells it to show the chosen information.

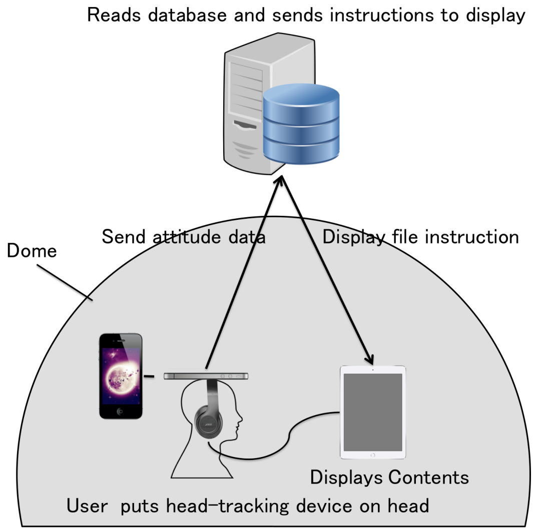

Figure 1: System Diagram

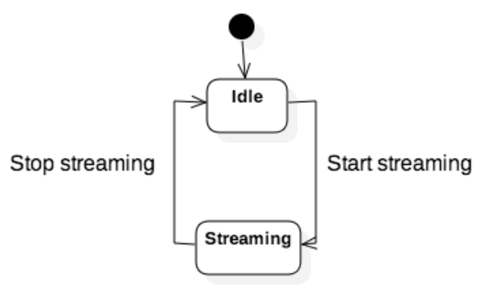

Figure 2: Head-tracking Device State Diagram

2.5 System Component's States

The three components on this system have different states depending on the function they are performing at the moment.

The head-tracking device is the simplest of the three components function-wise. It only has two different states: `Idle` and `Streaming` (Figure 2). The device starts its process in `Idle` until it is told to start streaming position and orientation information. Once its state has changed to `Streaming` the device will proceed to get the head attitude and position of the user at a constant pace and send that information to the server.

The server is where the data is processed in order to decide what information (if any) the display should show. The server has 4 states shown in Figure 3, three of which alternate quite rapidly between each other.

The server's default state is `Waiting for connection`. In this state the sever listens to the assigned port and waits for the head-tracker to start transmitting the data. Once the data streaming is in process the server starts a quick cycle

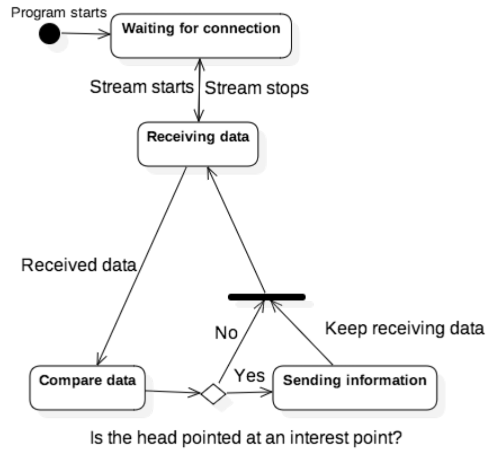

Figure 3: Server State Diagram

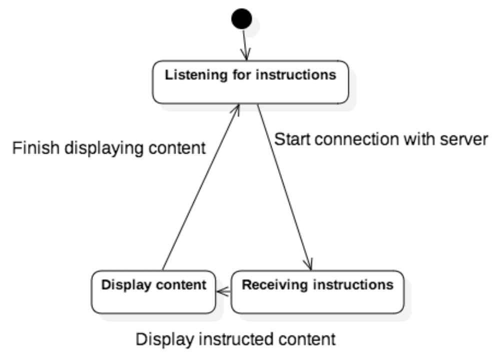

Figure 4: Display Device State Diagram

of state changes going around the cycle for each data package it receives. The first state in this cycle is the `Receiving Data` state in which it receives the data package sent by the head-tracking device and unpacks it into a list that contains all the required data (Roll, Pitch, Yaw). Then it changes to its next state, which is `Compare Data`. In this state, the server takes the Roll, Pitch, and Yaw of the current data package and compares it with all the entries in the database (an example of which is in Table 1). If it does not get a match for an interest point, then the server changes state to `Receiving Data` and moves on to the next data package. However, if it does get a match then it switches to the last state which is `Sending Information`. In this state, the server sends a message to the display to show the information of that interest point.

The third and last component of the tool is the display. As its name states, its job is to display information that the user can use to enhance his/her travel experience. The display is connected to the server and it receives the directions as to which content to display from it. Just as the server, the display is constantly listening to an assigned port for instructions. This happens during the `Listening for Instructions` state (Figure 4). Once the display hears an instruction coming to the server it changes to the state `Receiving instructions` where it unpacks the instruction and finds out what content it is supposed to show.

Lastly, the display changes to the state `Display content`, where it displays the content for a certain amount of time or until the user interrupts it, at which point it returns to the default state `Listening for Instructions`.

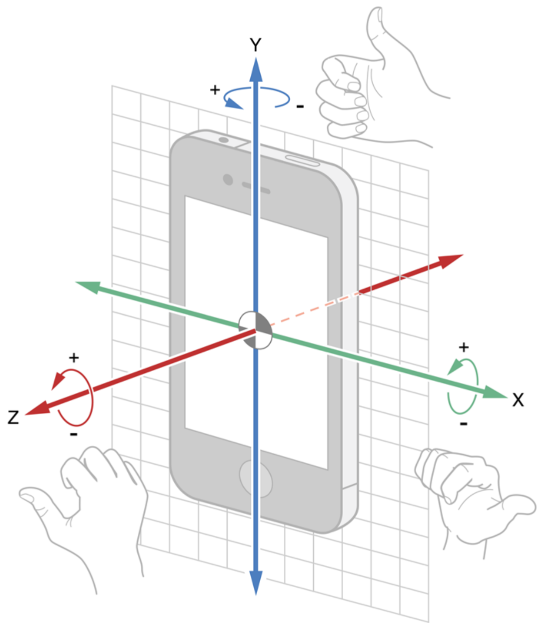

Figure 5: iPod Touch's Attitude

3 System Development

3.1 Head-tracking Device

For this system, the head-tracking device we used as an iPod Touch because its gyroscope and accelerometer are good enough to track the movement and it is small enough to be put on the users head without causing much discomfort.

The device uses the gyroscope to measure the attitude (or orientation of the head) of the user. This orientation is measured using Euler Angles. Euler Angles are a way to measure the orientation of any object in a three-dimensional space by using three values called roll, pitch and yaw. Each of these values represents the angle the object has with respect to one of the three axes (x, y, and z). In the case of the iPod Touch, these values are measured as shown in Figure 5.

Table 1: Database Table Example With Start Position Entry

ID	Desc	Roll	Pitch	Yaw	Acc_X	Acc_Y	Acc_Z
1	Strt P	0	0	0	0	0	0

The accelerometer is used to get the acceleration given by the user to the device. This acceleration is used to calculate the position of the user as he or she moves around.

The head-tracking device uses the User Datagram Protocol (UDP) to send information packages called datagrams to the server. Each of these datagrams contains the attitude and acceleration of the device at that moment. We use an application called Sensor Data developed by Wavefront Labs to measure and send the gyroscope and accelerometer's data. This application allows to send datagrams with a frequency of 1 to 100 Hz but for this system 30 Hz is the frequency that will be used.

3.2 Server and Display

The server receives the datagrams from the head-tracking device and unpacks them. Then it compares the attitude received at that moment with a database where "points of interest", that is, locations that have information on them available, are stored. If they coincide then the server sends the display instructions on what content to display using the UDP protocol.

The points of interest are stored in the database as a set of Euler angles that indicate what direction the user must be looking at. For example Table 1 shows an example of what the starting position of the user (looking directly to the front) would be stored as.

The display receives the instructions from the server, which consist of the ID of the content it needs to display, then the content is displayed.

3.3 User interaction

The user interacts with the system through the head-tracker and the display. When the user walks around the dome where the environment is displayed and looks around, the user is sending information to the server constantly. This lets the user decide on what he wants to see and get information of.

The other way is viewing the content on the display. If the content is not something that the user wants the user can skip it and view something else.

4 Conclusions and Future Works

This system was created with the intention of allowing people to experience Virtual Travel and share those experiences with other people. However, this system could be used in other ways as well.

This tool could be used in museums and similar places as a learning tool, allowing all kinds of people to visit places that would be difficult or even impossible for a regular person to go.

The tool can also be used by travel agencies to give their clients a "sneak peak" of places they can go. That way the clients can get interested in the place and be more motivated to hire the agency. It is an opportunity to allow clients to briefly experience a foreign environment and its highlights.

Another possible use for this tool could be in simulations. The user can practice in an environment that simulates reality without having to actually be there. This can help the user to avoid possibly dangerous situations or even avoid having to practice in places where people would be inconvenienced.

This tool could also be useful in research involving cognition. Proper testing should be conducted, but this tool may prove a useful and cheaper alternative to the more expensive eye-tracking tools already in the market.

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