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Abstract

Today more than ever people have a lot of information at their disposal. Presenting these data to the user is not an easy task, one must be careful not to overwhelm him with them. Augmented Reality proposes a way to mix information with the real environment world by using different techniques. By blending data with a live view of the real world, we can better integrate them and make it feel more natural for the user.

The rise of augmented reality (AR) will create the next generation of human-computer interaction, a 3D spatial medium in which we will physically live, work, and interact.

Although AR is in its teen years, it is developing very fast. With more and more people working on it, and many billion-dollar companies such as Facebook investing in it; it is very possible that in our lifetimes this industry will be a multi-billion dollar industry. With the development of smart-glasses, AR is most certainly going to be the next big thing.

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CHAPTER 1

Introduction

1. Introduction

In this project, a proof-of-concept of a Human Computer Interface is developed using AR technology. The goal is to develop an immersive and interactive computing experience marking the end of physical screens and devices. This is done by using a cardboard style Head-Mounted Display and the users smartphone.

Since this was an immersive experience, a more natural way of interaction was needed and hence using our very own hands was proposed. The hands of the user are tracked using external infrared sensors attached to front of the HMD.

1.1 Motivation

- Mobility

People who are constantly on the move and need updated information can find AR as an ideal solution. It is light in weight, water-proof in nature and with heads-up display keeping your hands-free.

- Multi-modal

AR devices can respond to taps, gestures, commands, head movements which means surgeons, clean-room workers, to labourers everyone can have great productivity using AR-enabled app/ device.

- Real-time information

AR is very useful and time-saver for workers who need have particular information from backend systems and this provides them real-time information of whats happening in and near their line of sight.

1.2 Constraints and Requirements

- Since a smartphone is being used, all the graphics processing and rendering are done on the smartphone's processors and also since immersiveness requires a stereoscopic view, the rendering has to be done twice in real time. This poses a great stress on the phones processors, and leads to rapid overheating.
- An external sensor is required to track your hands accurately as it is the primary form of input.

1.3 Problem Statement

To develop a Human Computer Interface proof-of-concept in Augmented Reality which will provide an immersive and interactive computing experience to the user.

1.4 Scope and Objectives

The objective is to provide the user with a more natural way of computing that is more immersive and interactive, and will help the user gain comprehensive views that was not possible by a traditional computer.

1.5 Proposed Model

The proposed model consists of :

- Smartphone
- Cardboard style Head-Mounted Display
- Hand Tracking sensor

1.6 Organization of Report

This report is divided into six sections.

1. Literature Review
    - I. A Comprehensive Survey on Leap Motion for Hand Tracking
    - II. A Comprehensive Survey on Spatial Computing for World Tracking
    - III. A survey on Image Tracking by Vuforia
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Chapter 2

Literature Review

2. Literature Review

2.1 A Comprehensive survey on Techniques for Hand Tracking

- The Leap Motion Controller was found to be the best device on the market to track hands and gestures.
- It comes with its own SDK for Unity.

From a hardware perspective, the Leap Motion Controller is actually quite simple. The heart of the device consists of two cameras and three infrared LEDs. These track infrared light with a wavelength of 850 nanometers, which is outside the visible light spectrum.

Due to its wide angle lenses, the device has a large interaction space of eight cubic feet, which takes the shape of an inverted pyramid – the intersection of the binocular cameras' fields of view. The range is limited by LED light propagation through space, since it becomes much harder to infer your hand's position in 3D beyond a certain distance. LED light intensity is ultimately limited by the maximum current that can be drawn over the USB connection.

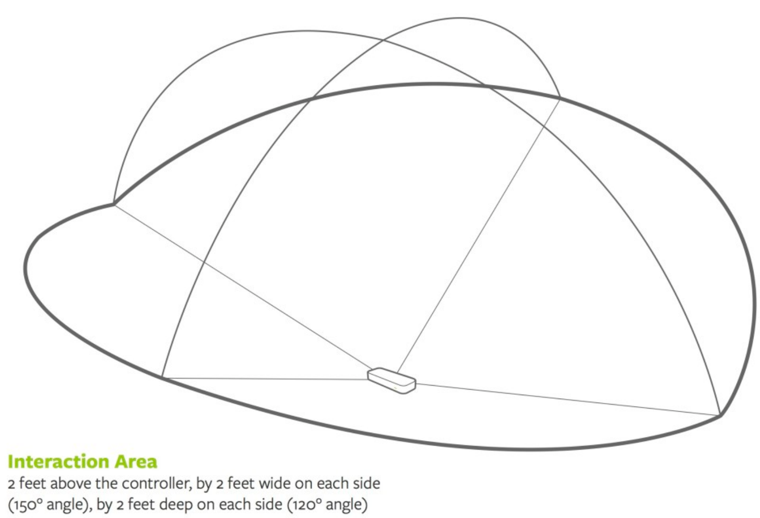

Figure 2.1.1 Leap Motion Interaction Area.

The Leap Motion Controller doesn't generate a depth map – instead it applies advanced algorithms to the raw sensor data.

The Leap Motion Service is the software on your computer that processes the images. After compensating for background objects (such as heads) and ambient environmental lighting, the images are analysed to reconstruct a 3D representation of what the device sees.

Next, the tracking layer matches the data to extract tracking information such as fingers and tools. Our tracking algorithms interpret the 3D data and infer the positions of occluded objects.

Filtering techniques are applied to ensure smooth temporal coherence of the data. The Leap Motion Service then feeds the results – expressed as a series of frames, or snapshots, containing all of the tracking data – into a transport protocol.

2.2 A Comprehensive Survey on Spatial Computing for World Tracking

The basic requirement for any AR experience is the ability to create and track a correspondence between the real-world space the user inhabits and a virtual space where you can model visual content. When your app displays that content together with a live camera image, the user experiences augmented reality: the illusion that your virtual content is part of the real world.

To create a correspondence between real and virtual spaces, Vuforia uses a technique called *visual-inertial odometry*. This process combines information from the device's motion sensing hardware with computer vision analysis of the scene visible to the device's camera. Vuforia recognises notable features in the scene image, tracks differences in the positions of those features across video frames, and compares that information with motion sensing data. The result is a high-precision model of the device's position and motion.

- Vuforia by PTC Inc. is the most widely used Augmented Reality platform and remains an optimal choice.
- It's also compatible with Unity.

2.3 A Survey on Image Tracking by Vuforia

Image Targets represent images that Vuforia Engine can detect and track. Unlike traditional fiducial markers, data matrix codes, and QR codes, Image Targets do not need special black and white regions or codes to be recognised. The Engine detects and tracks the features that are naturally found in the image itself by comparing these natural features against a known target resource database. Once the Image Target is detected, Vuforia Engine will track the image as long as it is at least partially in the camera's field of view.

Figure 2.3.1 Vuforia rendering 3D content on an Image Target.

Chapter 3

System Analysis and Design

3. System Analysis and Design

3.1 System Architecture

The System Architecture is outlined as follows:

The Leap Motion Controller tracks your hands through its sensors.

- The tracking data is sent to the laptop over a USB connection.
- The Server app running on the laptop, analyses the data and process it for further transfer.
- The Server pushes the data through UDP packets over a Wi-Fi connection to the Smartphone. (The Smartphone and the Laptop have to be on the same Wi-Fi network for this to work)
- The Vuforia AR application running on the Smartphone receives the data and computes the location and orientation of your hands and overlays it on the real world.

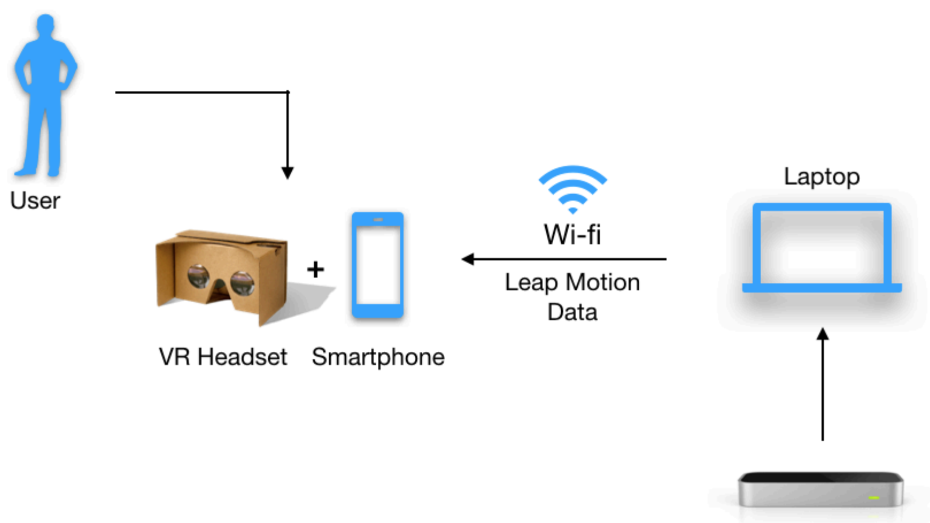

Figure 3.1.1 Flowchart of System Architecture

Chapter 4

Modeling and Implementation

4. Modeling and Implementation

4.1 Desktop Server App

- The desktop server app runs on the desktop/laptop and its sole purpose is to send the tracking data of the user hands from the Leap Motion to the smartphone.
- Both the server and the smartphone should be running on the same Wi-fi network.
- The server sends the data through UDP packets.

```
    IEnumerator SendData()
    {

        while (true) {

            if (transform.childCount > 0)
            {

                strMessage = "";

                if (transform.Find ("CleanRobotFullLeftHand(Clone)") != null)
                {

                    Transform leftHand = transform.Find ("CleanRobotFullLeftHand(Clone)").transform.GetChild(2);

                    Vector3 leftHandPosition = leftHand.position + offSetLeft;
                    strMessage += "l," + leftHandPosition.ToString() + "," + leftHand.rotation.ToString() + ",";

                }
                if (transform.Find ("CleanRobotFullRightHand(Clone)") != null)
                {
                    Transform rightHand = transform.Find ("CleanRobotFullRightHand(Clone)").transform.GetChild(2);

                    Vector3 rightHandPosition = rightHand.position + offSetRight;
                    strMessage += "r," + rightHandPosition.ToString() + "," + rightHand.rotation.ToString() + ",";

                }

            }
            else
            {
                //clear out message every iteration
                strMessage = "nothing";
            }

            byte[] data = Encoding.UTF8.GetBytes (strMessage);

            var message = client.Send (data, data.Length, remoteEndPoint);
            yield return message;
        }
    }
}
```

Figure 4.1.1 Code for Sending Data From Server

4.2 Smartphone App

```
    void ReceiveData()
    {
        client = new UdpClient(port);
        IPEndPoint anyIP = new IPEndPoint(IPAddress.Any, 0);

        while (true)
        {
            byte[] data = client.Receive(ref anyIP);

            string text = Encoding.UTF8.GetString(data);

            // split the items by comma
            sArray = text.Split(',');

            if (sArray[0] != "nothing"){

                shouldUpdateHands =  true;

            } else {

                shouldDestroyHands = true;
            }

        }
    }
}
```

Figure 4.2.1 Code for Receiving Data on the Smartphone

Chapter 5

Testing, Results and Discussion

5. Testing, Results and Discussion

5.1 Testing

5.1.1 Exploratory Testing

- It was found that the user could interact with the HCI in any way desired but the interaction was only limited to five minutes at a time due to overheating of the smartphone.

5.1.2. Unit Testing

- All individual units and components of the application were tested. It was found that each unit performed as designed.

5.1.3. API Testing

- It was found that the APIs met expectations for functionality, reliability, performance, and security.

5.1.4. UI/UX Testing

- The user interface still needs improvement and are limited by the smartphone's processing capabilities.
- Prolong use of the HMD can lead to eye strain and headaches because of the poor resolution.

5.2 Results and Discussion

- We were successful in implementing an immersive computing experience but there were several limiting factors.
- The smartphone overheats quickly as graphics processing load is high because we're rendering it twice and in real time.
- The resolution of the HMD was poor, this can be fixed with a higher resolution smartphone with an OLED display.
- The Leap Motion was not made to work on a mobile device and hence tracking is only limited to palms and latency is a given.

Chapter 6

Conclusion and Future Work

6. Conclusion and Future Work

6.1 Conclusion

- Augmented Reality HMDs (Smart Glasses) is still an emerging technology and it'll still be another 2 to 3 years before it's readily available to consumers.
- The main limitation is the bulkiness of the device and the high cost factor.
- With 5G technology becoming mainstream, the processing and rendering of 3D content can be done on the cloud, which will make the HMDs lighter and more comfortable.
- We believe our proof of concept will pave the way for further innovation.

6.2 Future Work

- Implement individual finger tracking as well.
- Make it more optimised by the use of multithreading.
- Try and improve the resolution.
- Try to implement Project NorthStar.

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