Imperial College London

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FINAL YEAR PROJECT

Inception Report: Virtual Air Sculpture

Project Supervisor:
Dr. Mark Witkowski

Project Second Marker:
Dr. David Thomas

Authors:
Zihan LIU (ZL6114) CID:00955065

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1 Abstract

The aim for this project is to develop a haptic device such that it can respond to a virtual object and further re-shape the object. This device has many potential usages and the initial idea is that this device could help the blind individual to better feel more objects and sculpt objects in the virtual world. There are two main difficulties in this project, the first difficulty is to tracing the virtual object and the haptic device, the second problem is designing the wearable haptic feedback device itself and the interaction between the physical and virtual world via this device. This report is a discussion about the solutions and ideas around it.

2 The Virtual Air Sculpture

For this project, ideally there will be a wearable device that interacts with the virtual object, the first step of this project is to make a device that can respond to the simple virtual object, e.g. a cubic. Then from there the complexity of the object is going to be increased, and the sculpting tool and sculpting functionality would be added to the overall design.

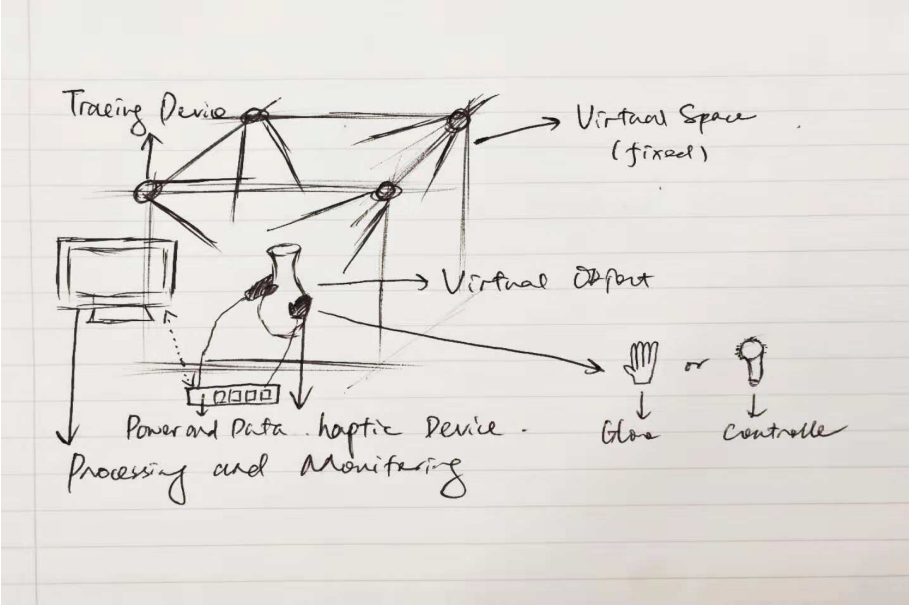

Figure 1: Design idea of this project

2.1 Tracing Device

A system is needed to keep track the physical coordinate of the device and map it to the virtual space to interact with the virtual object. Here are a few ideas that could achieve this goal. Currently, the idea of using Leap-Motion hardware to achieve this project is the most likely solution to this problem.

2.1.1 Leap-Motion

Leap Motion is a hardware designed by the Leap Motion Inc. In the device there are consists of 2 camera sensor and a few LED light, the 3d hand motion is reconstructed through the difference of image collected by the two cameras, and this device can achieve an accuracy of 0.7mm with average 200 frames per second data collection.

Figure 2: Image From: https://edgylabs.com/leap-motion-hand-vr

2.1.2 Wireless Tracking

Positional tracking can be achieved by using the wireless signal to mimic the GPS system, this method requires a few wireless routers to be placed at different locations, and wireless signal transducer to be placed on the device and constantly sending signals to the wireless router. Upon research, the best achievable accuracy currently for any wireless tracking system is 5mm, and the protocol used was not specified, possibly using the WiFi or ZigBee Technology with the IEEE 802.11 protocol.

2.1.3 Camera Matrix

Multiple cameras can be placed at different angles to reconstruct the physical location of any object in the virtual world. however, upon research, to purchase the camera system that could achieve the accuracy range for gesture reconstruction is very costly.

2.1.4 Inertial Tracking

Multiple or combined accelerometers and gyroscopes can achieve accurate positional tracking for one point. however, to reconstruct multiple points and potentially the full hand movement, the number of accelerometers needed and the calibration requirements are massive and out of the scope of manageable.

2.1.5 Sensor Fusion

Combine accelerometers, optical sensors, and other sensors could be a great way to achieve positional tracking. Currently, the HTC Vive tracker is using this sensor fusion technique to recreate single point positional tracking.

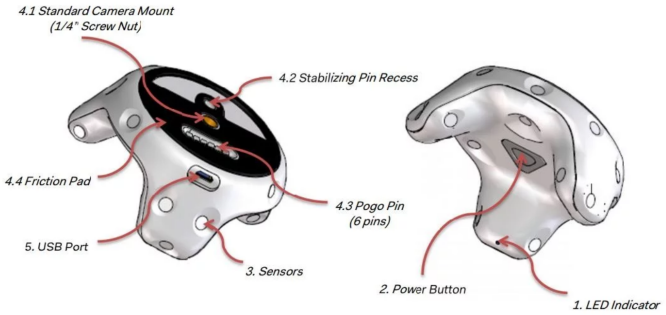

Figure 3: Image From: https://www.vrheads.com/everything-we-know-about-vive-tracker

2.2 Hap-tic Device Idea 1: Controller

Currently all Virtual Reality related hardware are using controllers, a few main stream examples are listed below.

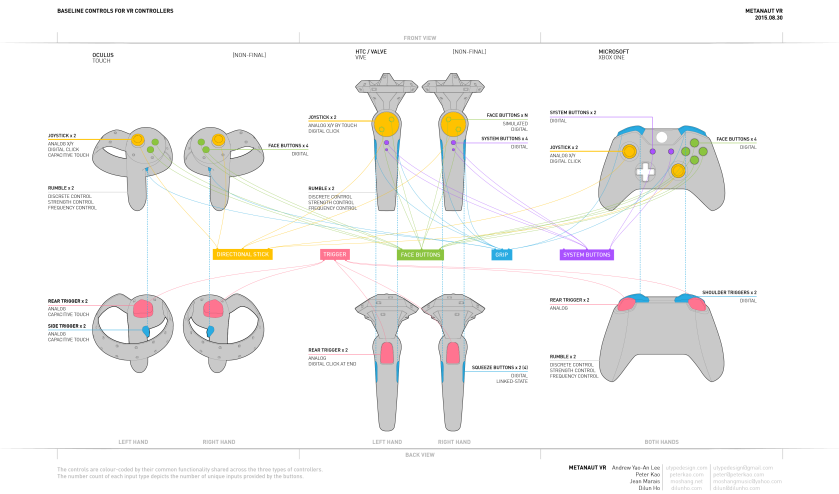

Figure 4: Image From: http://metanautvr.com/blog/2015/11/02/55387/

After careful consideration, the project is now focusing on the design of a pair of glove to interact with the virtual world instead of a controller, here are a few reasons:

- It is more natural for human being to feel object with hand.
- It is more user friendly for blind people.
- To avoid reinvent the wheel and provide new and better solution for the current generation of VR hardware.
- Personally more experienced to work with glove from third year embedded system course.

2.3 Hap-tic Device Idea 2: Glove

During the third year embedded course, we developed a glove controller using the flex sensor. The last generation of glove controller is from the Nintendo, called Nintendo power glove, which developed in 1989 with flex sensor and no other company had tried to produce such a product publicly again.

Figure 5: Image From: https://hothardware.com/news/nintendo-power-glove-hack-control-drones

The problem now is to simulate the sense of touch via different method.

2.3.1 Generate Feed-back via vibrator

Using the vibrator as the feedback is the most likely solution to the current problem, the idea is to allocate vibrator to the finger joints and palm, and use vibration to simulate the sense of touching an object.

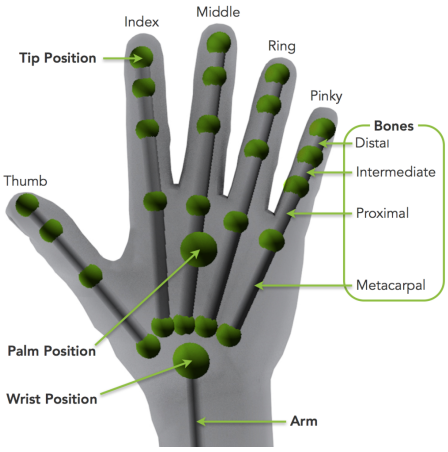

Figure 6: Image From: http://blog.leapmotion.com/getting-started-leap-motion-sdk/

By place vibrator to all the dot above, ideally, it would reconstruct a sense of touch via vibration when the position of the 3D object is matching the hand position in the physical space.

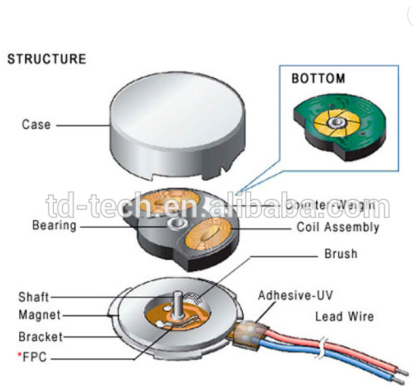

Figure 7: Image From: https://www.alibaba.com/product-detail/1020-small-vibration-motor-micro-vibration

The plan is to make sure that one vibrator performs with the system, then after one vibrator worked, step by step the amount of vibrator will increase and a multi-IO micro-controller will probably be used to control different vibrator and vibration force.

2.3.2 Pin with Electromagnets

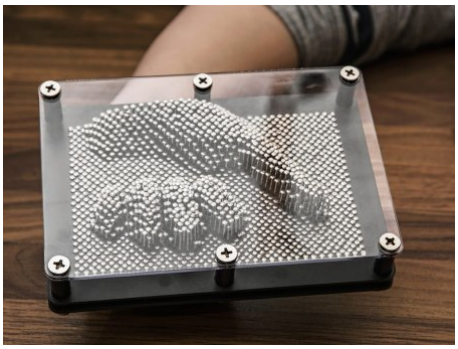

Figure 8: Image From: https://cn.depositphotos.com/97855378/stock-photo-retro-pin-board-toy.html

Similar to the idea of a pin-board toy, the glove can be developed as a pin board and the pin can be driven by magnets, so when the virtual object is contacting the physical glove, the part that is contacting can generate a magnetic force to push the pin toward the hand to simulate the sense of touching. However, it is difficult to achieve thus it is still in the idea form.

3 Similar Hardware/Product that is currently existed

3.1 Oculus Medium

Oculus Medium is a VR sculpting software for Oculus VR users, the difference between this product and this project is that the project is more focusing on the sense of touch and not rely on the visual data.

Figure 9: Image From: https://www.youtube.com/watch?v=XbkPbfTyFvE

3.2 The National Gallery of Prague

The national gallery of Prague had developed a set of virtual sculpture for historical sculpture and a glove device for people to touch them virtually. The difference here is that the device that the Prague national gallery developed can only track one point and have no ability to reshape the form of an object.

Figure 10: Image From: https://www.campaignlive.co.uk/article/vr-experience-allows-blind-see-world-famous-sculptures/1460678