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Proposing a Hand-Tracking Device using a Tangential Force Mechanical Sensor

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Abstract: Conventional hand-tracking devices are constructed with inertial measurement units, bending sensors, and optical technologies. However, these are limited by their high-cost and environmental factors. In this research, a hand-tracking device using a tangential force mechanical sensor is proposed.

Keywords : hand-tracking, wearable, sensor, virtual reality

1. Introduction

Motion tracking devices translate physical movements into computer-usable data. One example of a motion tracking device is the cyberglove (*aka*. Hand-Tracking Device, Data Glove). This is a wearable electronic device which frees up a user's hands for a more intuitive engagement with a virtual environment. This can promote a more natural user interface. A cyberglove requires structural conformity, must be comfortable for the wearer, should be soft, elastic, and aesthetically appealing. The aim of this research is to design, manufacture and test a consumer-friendly cyberglove for use in an immersive virtual reality environment.

2. Background

Our primary physical connection with the world is through our hands. With devices such as a mouse, trackpad or game controller, "little of the dexterity and naturalness that characterizes our hands transfers to the task itself" [1]. This observation still applies in the 21st century as exemplified by the Oculus Rift hand controller (see Figure 1).

Currently, cybergloves equipped with sensors, myoelectric potential sensors, and cameras are used as a method of acquiring the shape of the hand. In particular, with respect to cybergloves that can detect physical changes in the hand, there are products such as Cyber Glove from CyberGlove System, and Hi5 VR Glove from Noitom International.

In these cases, the bending condition of the finger is detected mainly by a change in resistance value of a bending sensor. In addition, the rotation and position of the hand itself are estimated by a detection method using a plurality of inertial measurement devices or image recognition using an infrared marker from an

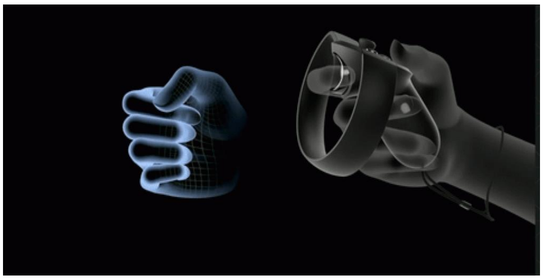

Figure 1. Oculus Rift input / hand controller

external camera. There are two problems with devices having these functions: the weight of the device itself and the high cost. In this research, in order to solve these two problems, we propose a glove-type device using a sensor that can detect movement of two types of joints. The first is to apply the technology of detecting the density of stretchable material with a photo reflector, as devised by Sugiura *et al.* [2], and change the density of the stretchable material by the movement of a joint to correspond to the angle of that joint. Second, a CMOS Image sensor used in an optical mouse or similar is used to detect the movement of the material in the vicinity of the joint and convert the information into the angle of the joint. Although both basically use an optical sensor, the sensing object is the movement or density of the object.

There have been many attempts at developing an affordable, consumer-friendly cyberglove, and a number of options are available on the market with varying benefits and limitations; as shown in Table 1.

Therefore, the goal is to design and manufacture a cyberglove using built-in sensors. The physical and also programmable challenges are acknowledged, and these will be tested during the product development. Of course, alternative proposals will be tested during the process (such as using Bluetooth beacon BLE technologies) but the overall goal remains: to design, manufacture and test a consumer-friendly cyberglove for use in an immersive virtual reality environment.

3. Related work

A number of research projects have also been undertaken in an attempt to develop a new cyberglove. Examples include,

- A Thin Stretchable Interface for Tangential Force Measurement [2].
    - This is a development paper which makes a new mechanical sensor with a photo reflector and stretchable cloth.
- ElectroDermis: Fully Untethered, Stretchable, and Highly-Customizable Electronic Bandages [3].
    - This is a wearable fabric device that can detect body movement, heart rate and other biodata.
- Rapid-Response, Widely Stretchable Sensor of Aligned MWCNT/Elastomer Composites for Human Motion Detection [4].
    - This project shows the making of stretchable Tangential Force Measurement sensor and detects motion faster than previous work.
- Xsens MVN: Full 6DOF Human Motion Tracking Using Miniature Inertial Sensors [5].
    - This paper shows full body tracking system with actor position in any environment.

However, an affordable cyberglove that can be used by consumers for interacting with immersive virtual reality environments remains elusive.

4. Method

In this research the Double-Diamond Design Process [6, 7] is used. As shown in Figure 2, the stages of the process are Discover, Define, Develop, and Deliver. This framework supports methodical approach to creative design and implementation.

4.1 Discover

The process starts with a general problem. The designer then undertakes some research by looking at similar problems, talking to more experienced designers, meeting users, and looking at current solutions. In this research a general problem of hand-tracking devices and current cyberglove solutions have been identified as dexterity, accuracy, cost and weight (see Section 2 above). A number of relevant tracking devices and cybergloves have been identified (see Table 1). Thereafter, a number of prior solutions were researched (see Section 3).

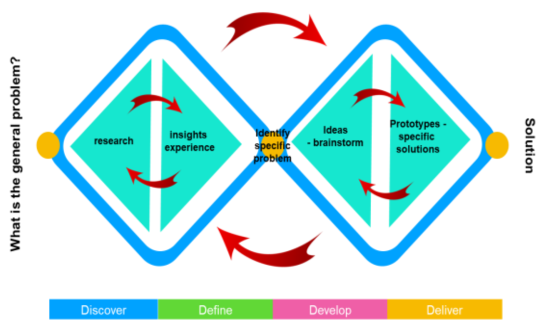

Figure 2. Double-Diamond Design Process

Table 1. Table of some current tracking devices and cybergloves

Name	Detection type	Control	Tech	Use Standalone	Haptics feedback	Cost
Oculus Touch	Out-in	Joystick, Button	IR Position Detect, IMU	No	Vibration	$125 ¥16,500
HTC VIVE Controller	Out-in	Track pad, Button	IR Position Detect, IMU	No	Vibration	$150 ¥19,500
Manus VR Glove	Out-in	Bending	Bending sensor, IMU	No (required VIVE tracker to detect position)	No	About $250 ¥27,000
Hi5 VR GLOVE	Out-in	Bending	IMU (each finger +1)	No (required VIVE tracker to detect position)	No	$1500 ¥160,000
Senso	In-out	Bending	IMU	Yes	Vibration each finger	About $300 ¥40,000
Cyber Glove III	Out-In	Bending	Bending Sensor	No	No	$1800/ ¥200,000 each hand
Plexus	Out-in	Bending	Unknown sensor (Silicone + Original Sensor)	No (required Oculus Touch or VIVE Controller)	Actuator	$249 ¥250,000
StretchSense	None	Bending	Stretch Sensing (Original Sensor)	Yes (No position detection)	No	$4900 ¥53,000

4.2 Define

The designer identifies a specific problem. In this case, an affordable cyberglove that can be used by consumers for interacting with immersive virtual reality environments remains elusive. The hypothesis therefore in this research is that human motion is collected easily by a new method of tangential force mechanical sensor.

4.3 Develop

The designer then brainstorms possible solutions. A prototype is created and tested. The designer obtains feedback data, reflects upon the solution, and modifies (or completely changes) the design. Another prototype is then created and tested. In this research to date, technical verification of Metaskin [2] and first prototype production were conducted.

4.3.1 Technical verification

First of all, it was necessary to reproduce how much expansion and contraction of Metaskin [2] occurs when in use. Therefore, a sensor was made and tested (Figure 3). The sensor was made using a SG-105 photo reflector and 20 Denier stocking. The environment was set to the same as in the original Metaskin research [2]. As a result, the value changed as shown in the graph of the PC screen of Figure 4. When the stocking is stretched by about 10 mm, and a small change is detected.

4.3.2 Prototyping

After technical verification, prototype production started. In order to obtain the degree of bending of the joint, the sensor was fixed on the joint, and then it was covered with stocking (see Figure 5). However, the value of the sensor was not changed because the distance itself does not change even if the finger is bent.

In the next prototype, the case was made to extend the stocking by bending the fingers (see Figure 6). The stretch of the stocking is changed by the distance from the joints. Value changes are now read by these changes. However, after a number of contractions, the stocking does not return to its original state.

4.4 Deliver

It is proposed that a solution can be found that uses a hand-tracking device using a tangential force mechanical sensor. This device can then be used for hand-tracking in Virtual Reality.

5. Discussion

The above-mentioned protypes revealed some limitations: stretchable material, accurate sensor tracking, and lack of consistent results. In future development, a more robust stretchable material will be tested, and a more effective sensor casing will be manufactured.

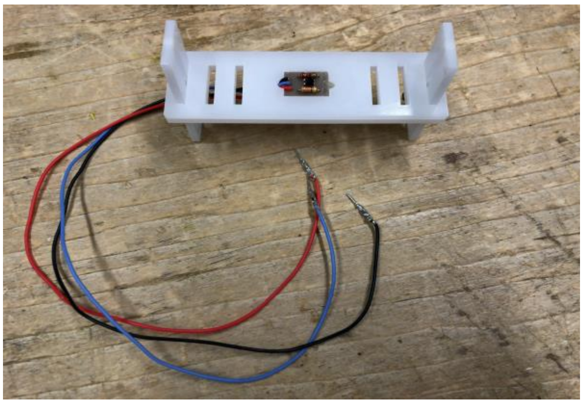

Figure 3. Metaskin Sensor test

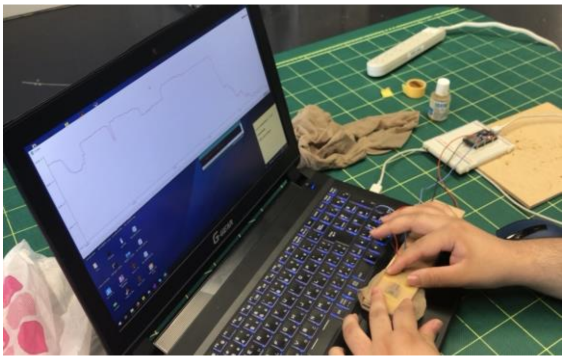

Figure 4. Metaskin technical verification

Figure 5. Sensor prototype 1

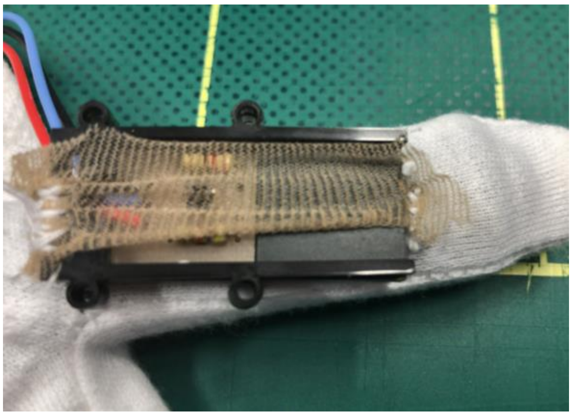

Figure 6. Sensor prototype 2

6. Conclusion

The paper has summarized research in proposing a hand-tracking device using a tangential force mechanical sensor. A number of past and current hand-tracking devices have been located. Limitations of current devices have been identified. The Double-Diamond Design process has been adopted for creative development of a new hand-tracking device that can be used in virtual reality by educators and trainers for a more natural user experience.

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