A Hat-shaped Pressure-Sensitive Multi-Touch Interface for Virtual Reality

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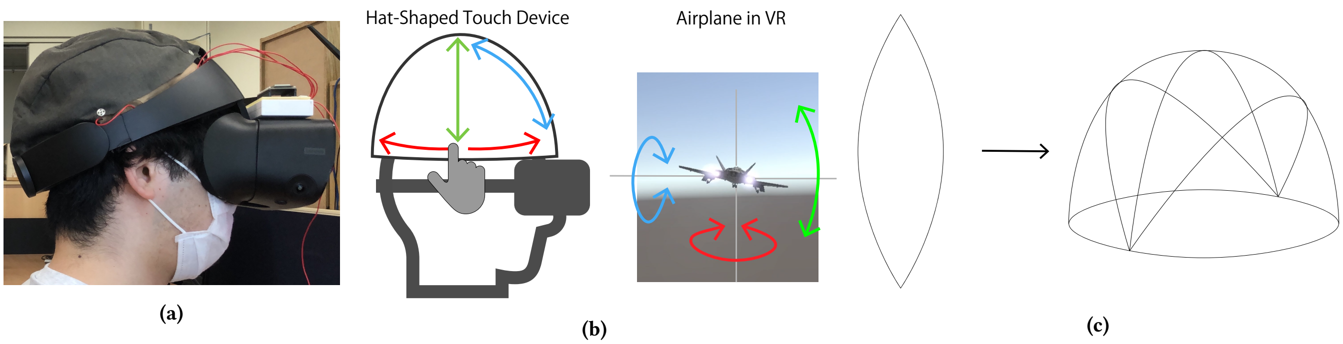

Figure 1: (a) An HMD and a hat-shaped touch device. (b) The direction of finger-dragging on the device and the corresponding rotation of a VR plane. When the user drags the device in the arrowed direction, the plane rotates in the same direction. (c) Pieces of conductive fabric were cut and sewn together to form the hat.

ABSTRACT

We developed a hat-shaped touch interface for virtual reality viewpoint control. The hat is made of conductive fabric and thus is lightweight. The user can touch, drag, and push the surface, enabling three-dimensional viewpoint control.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; *Interaction devices*; Gestural input.

KEYWORDS

virtual reality, touch interface, viewpoint control, multi-touch

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1 INTRODUCTION

In virtual reality (VR) that employs a head-mounted display (HMD), the viewpoint is generally controlled by head tracking. However, the active head movements required for viewpoint manipulation often cause fatigue and nausea.

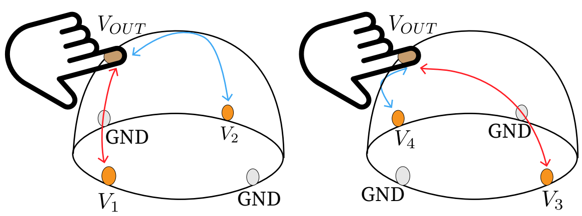
Several studies have sought to reduce active head movements. For example, Sargunam et al. [7] amplified small head rotations. Bozgeyikli et al. [1] used teleportation to control orientation-specific movement. Riecke et al. [6] used a chair that could be tilted to move the viewpoint. In a previous study [2], we presented a helmet with capacitive touch sensors; the viewpoint was controlled by touching the surface of the helmet. Thus, dragging the surface of the head directly controlled rotation of the viewpoint camera. However, the device featured only 54 touch points, compromising continuous finger tracking. In addition, the helmet was heavy and users became fatigued.

Here, we present a lightweight touch device made of conductive fabric; it is easier to use than the helmet. The new device continuously detects touch points and pressures at high resolution. By dragging the surface of the device, the user intuitively inputs the three degrees of freedom rotation.

2 IMPLEMENTATION

We created a hat-shaped touch device out of conductive fabric. Other studies have employed such fabric. The Textile++ device [4] features resistive sensors made of conductive fabric. Leong et al. [3] and Parzer et al. [5] used interwoven (striped) conductive and non-conductive fabrics, and piezoresistive fabrics, as touch sensors. We cut anti-static, ultra-fine, non-woven conductive fabric of surface resistance $3 \times 10^4 \Omega/sq$ using a paper pattern and made a hat from four cut sheets (Fig. 1). The hat is sensitive to touch and pressure.

The user wears the hat on the head (Fig. 1a). Conductive sacs are attached to the fingers. We attached four electrodes to the edge of the hat to measure voltage. The electrode positions are shown in Figure 2. We use two-dimensional coordinates (x, y) to describe the hemisphere: the left-to-right orientation is the X coordinate and the front-to-back orientation is the Y coordinate.



(a) V_1, V_2 for X coordinate **(b) V_3, V_4 for Y coordinate**

Figure 2: The positions of the hat electrodes and touch position acquisition by the electrodes. Electrodes that are inactive are set to ground.

When a finger touches the hat and a voltage is applied to the finger electrode, the device first measures the voltages at the left and right electrodes and then those at the front and back electrodes (Fig. 2). We obtain the touch position (X, Y) by deriving the ratio of the two voltages. In addition, as the contact resistance between the finger and the hat decreases as the touch pressure increases, the average acquired voltages increase when resistance decreases. Thus, the average voltage percentage reflects the touch pressure P. Multiple finger positions can be derived by delivering sequential voltages to each finger.

$$X = \frac{V_1}{V_1 + V_2}, Y = \frac{V_3}{V_3 + V_4}, P = \frac{V_1 + V_2 + V_3 + V_4}{4}$$

A microcontroller (ESP32) measures the voltages, calculates the touch position, and sends the data to a PC via Bluetooth. The touch coordinates are converted into rotation angles around the three axes using the Unity program. These values are used to rotate objects and present multi-touch gestures. Figure 3 and Figure 4 show plots of the touch positions and pressures.

3 APPLICATION

We implemented a VR flight game (Fig. 1b) whereby the user controls the direction of a flying plane. By dragging the surface of the device, the user can change yaw, roll, and pitch with a single finger. Pinch-in and pinch-out gestures (two-point touches) cause the camera behind the plane to move forward and backward.

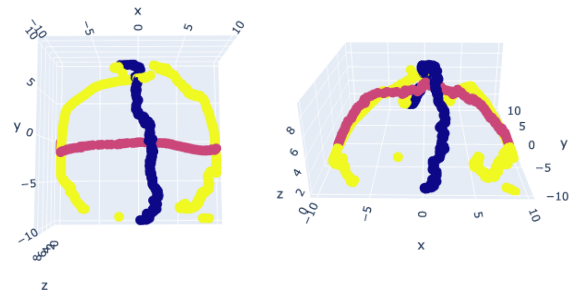


Figure 3: A plot of the touch positions acquired when the user drags on the hat in the yaw, roll, and pitch directions.

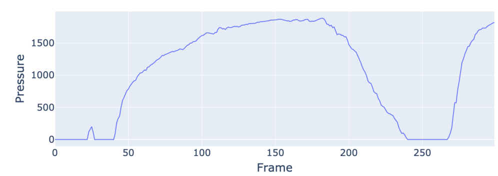


Figure 4: Changes in pressure while pressing the device.

4 CONCLUSION AND FUTURE WORK

We present a hat-shaped touch interface for VR viewpoint manipulation and a touch detection system featuring conductive fabric sensors. Our interface enables three-dimensional viewpoint control and object rotation.

In future work, we will compare our device with handheld controllers and head movement trackers. We will also investigate whether users develop fatigue or nausea, and the relationship between dragging direction and the direction of camera rotation.

REFERENCES

[1] Evren Bozgeyikli, Andrew Raij, Srinivas Katkoori, and Rajiv Dubey. 2016. Point & Teleport Locomotion Technique for Virtual Reality. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play* (Austin, Texas, USA) *(CHI PLAY '16)*. Association for Computing Machinery, New York, NY, USA, 205–216. https://doi.org/10.1145/2967934.2968105

[2] Takumi Kitagawa, Yuki Yamato, Buntarou Shizuki, and Shin Takahashi. 2019. A Viewpoint Control Method for 360° Media Using Helmet Touch Interface. In *Symposium on Spatial User Interaction* (New Orleans, LA, USA) *(SUI '19)*. Association for Computing Machinery, New York, NY, USA, Article 33, 2 pages. https://doi.org/10.1145/3357251.3360008

[3] Joanne Leong, Patrick Parzer, Florian Perteneder, Teo Babic, Christian Rendl, Anita Vogl, Hubert Egger, Alex Olwal, and Michael Haller. 2016. ProCover: Sensory Augmentation of Prosthetic Limbs Using Smart Textile Covers. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology* (Tokyo, Japan) *(UIST '16)*. Association for Computing Machinery, New York, NY, USA, 335–346. https://doi.org/10.1145/2984511.2984572

[4] Keisuke Ono, Shinichiro Iwamura, Akira Ogie, Tetsuaki Baba, and Paul Haimes. 2017. Textile++: Low Cost Textile Interface Using the Principle of Resistive Touch Sensing. In *ACM SIGGRAPH 2017 Studio* (Los Angeles, California) *(SIGGRAPH '17)*. Association for Computing Machinery, New York, NY, USA, Article 8, 2 pages. https://doi.org/10.1145/3084863.3084868

[5] Patrick Parzer, Adwait Sharma, Anita Vogl, Jürgen Steimle, Alex Olwal, and Michael Haller. 2017. SmartSleeve: Real-Time Sensing of Surface and Deformation Gestures on Flexible, Interactive Textiles, Using a Hybrid Gesture Detection Pipeline. In *Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology* (Québec City, QC, Canada) *(UIST '17)*. Association for Computing Machinery, New York, NY, USA, 565–577. https://doi.org/10.1145/3126594.3126652

[6] Bernhard E. Riecke and Daniel Feuereissen. 2012. To Move or Not to Move: Can Active Control and User-Driven Motion Cueing Enhance Self-Motion Perception ("vection") in Virtual Reality?. In *Proceedings of the ACM Symposium on Applied Perception* (Los Angeles, California) *(SAP '12)*. Association for Computing Machinery, New York, NY, USA, 17–24. https://doi.org/10.1145/2338676.2338680

[7] Shyam Prathish Sargunam, Kasra Rahimi Moghadam, Mohamed Suhail, and Eric D. Ragan. 2017. Guided head rotation and amplified head rotation: Evaluating semi-natural travel and viewing techniques in virtual reality. In *2017 IEEE Virtual Reality (VR)*. 19–28. https://doi.org/10.1109/VR.2017.7892227