Utilizing handheld wind feedback to expand the perception of environmental wind from stationary device

Chiao-En Hsieh
National Taiwan University

Yu-Ta Chen
National Taiwan University

Hao-Cheng Wang
National Taiwan University

Yang-Sheng Chen
National Taiwan University

Ping-Hsuan Han
National Taipei University of Technology

Yi-Ping Hung
National Taiwan University, Tainan National University of the Arts

ABSTRACT

In this paper, we present a hybrid-haptic feedback system with a stationary fan and wireless controller with a fan. To explore the possibility of using our system to expand the users' perception of environmental wind, we investigate the users' perception of the wind blowing area combined with different distances and handheld wind speeds. The results show that compared with using the stationary fan only, the perceptional winds area is increased by at least 59.9% when using our hybrid-haptic device.

CCS CONCEPTS

• **Human-centered computing** → **Virtual Reality**; • **Haptic Devices**;

KEYWORDS

wind sensation, hybrid-haptic, tactile illusion, virtual reality

ACM Reference Format:
Chiao-En Hsieh, Yu-Ta Chen, Hao-Cheng Wang, Yang-Sheng Chen, Ping-Hsuan Han, and Yi-Ping Hung. 2020. Utilizing handheld wind feedback to expand the perception of environmental wind from stationary device. In *Special Interest Group on Computer Graphics and Interactive Techniques Conference Posters (SIGGRAPH '20 Posters), August 17, 2020*. ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3388770.3407406

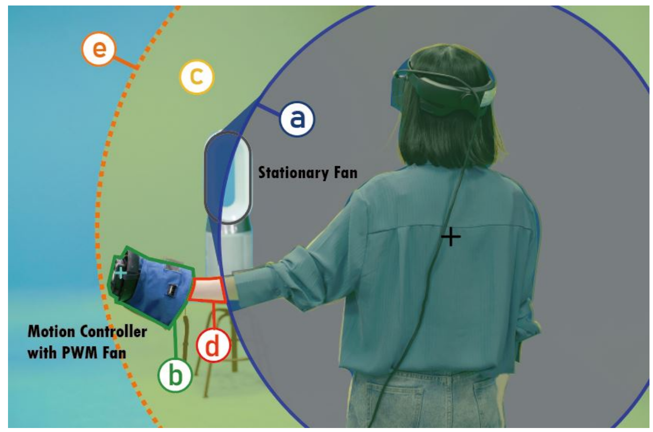

Figure 1: Our purpose hybrid-haptic feedback system. (a) Stationary wind feedback, (b) Handheld wind feedback, (c) Expansion area, (d) Windless area, (e) Perceptional wind area

1 INTRODUCTION

To enhance the immersive experience in VR, many research groups have shown the potential of utilizing haptic techniques with stationary devices and wearable devices. The stationary device system [Han et al. 2019] can simulate the wind feedback, but the energy may decrease as the distance between the user and the device increases. The wearable device system [Lee and Lee 2016] can affect a part of partial body haptic feedback only. Haptic Around [Han et al. 2018] utilized a hybrid-haptic feedback system to enhance the immersive experience. Based on hand to hand [Pittera et al. 2017] utilized the tactile illusions, we present a hybrid-haptic feedback system with a stationary fan and wireless controller with a fan. To explore the possibility of using our system to expand the users' perception of environmental wind, we investigate the users' perception of the wind blowing area combined with different distances and handheld wind speeds.

2 IMPLEMENTATION

Our hybrid-haptic system consists of a stationary device and the wireless controllers. We utilize Dyson DP01 as our stationary device (figure 1 (a)), in which the maximum wind speed is 2.3 m/s in one meter from the fan. For wireless controllers, we attach a PWM fan in front of the Windows Mixed Reality (WMR) controller, in which the maximum wind speed can reach up to 1.6 m/s. Additionally, the Arduino with Bluetooth and L298N motor module is used to control the wind speed by receiving the signal from the computer.

3 THRESHOLD MEASUREMENT

In this section, we ran the Absolute Detection Threshold (ADT) experiment [Lee and Lee 2016] to explore the minimum wind speed threshold where users can perceive the wind, and the just-noticeable-difference (JND) experiment to estimate how many different levels of the handheld wind speed users could distinguish. In both experiments, we recruited 12 participants (6 male, 6 female, age: 20–31, $\bar{x}$=25, SD=3.46). The ADT results showed 97.5% of users can notice the wind above 0.41m/s. The JND results showed 95%

SIGGRAPH '20 Posters, August 17, 2020, Virtual Event, USA

ACM ISBN 978-1-4503-7973-1/20/08.
https://doi.org/10.1145/3388770.3407406

of users can recognize the difference—at about a 3.1 offset to base wind speed ratio. To consider the user can walk far from the stationary device to a different distance in VR, we set the feedback of IoT Fan to the highest level and record the stationary wind speed at different distances. Our stationary device can provide the maximum (2.30m/s) and minimum wind speed (0.34m/s) at 1m, 4.6m from it, respectively.

4 USER STUDY

To explore the complementary effect of the hybrid-haptic feedback, we conducted a user study with three interfaces by adjusting the handheld wind speed: (1) **No Wind (NW)**: Only perceive the wind form the stationary device. (2) **Weak Wind (WW)**: Minimum wind speed (0.41 m/s) can be noticed by 97.5% of users (ADT). (3) **Strong Wind (SW)**: Maximum wind speed (1.6 m/s) and 3.1 times larger than Weak Wind interface (JND). All interfaces were run three trails at three distance, 1m, 2.8m (middle of 1m and 4.6m, 1.22m/s), and 4.6m, from the stationary device (with the highest level). The distances are counter-balanced by two orders, near-to-far or far-to-near, and the interfaces are counter-balanced by the Latin-square. In each trial, we placed a virtual ball towards the center of the stationary device and asked the participant to move it out of the perceptional wind area. During the process, they can perceive the wind with any part of their body and cannot move their feet. Finally, we record the distance between the ball and its original position as the radius of the perceptional wind area the participants feel. A total of 18 participants (7 male, 11 female) was recruited. Their age range from 19 to 25 years old ($\bar{x}$ = 20.56, SD = 1.42) and height range from 150.4 to 182 cm ($\bar{x}$ = 166.38, SD = 8.92).

5 RESULT AND DISCUSSION

We performed an ANOVA and Tukey test for analyzing the radius of the perceptional wind area that users perceived. The results (Figure 2) show that . SW can significantly expand the perceptional wind area compared to **NW** and **WW** at each distance, and **WW** can significantly expand the area compared to **NW** at 2.8m. We evaluated the growth rate of **WW** and **SW** compared to **NW**. The results of **SW** has shown the perceptional wind area increase 76.1%, 78.2%, 75.8% at 1m, 2.8m, 4.6m respectively (mean: 22.0cm), and the results of **WW** also increase 62.5%, 67.4%, 59.9% (mean: 8.6cm). We found that our handheld device will slightly affect the users' perception when it provides a weak wind. The handheld wind will make them stretch their hands out of the stationary wind area until they perceive the wind does not blow some part of their body. Moreover, when providing the stronger handheld wind, regardless of the stationary wind speed, our handheld device will have a greater impact on the users' perception of the stationary wind area and make them stretch their hands longer. Additionally, the expansion area of **SW** is significant larger than **WW**. Although the results have shown significant differences in **SW**, our handheld device can not provide stronger wind to investigate whether the area could be larger. Therefore, further study is needed.

6 CONCLUSION AND FUTURE WORK

In our study, we discovered that the users can perceive a broader area of perceptional winds when using our hybrid-haptic device; such results may be useful for multiple devices systems. However, this work did not investigate spatially specific stimuli, such as the direction of the wind and the place where the wind is blowing. Therefore, we will conduct further studies to investigate these factors to enhance the wind feedback system in VR.

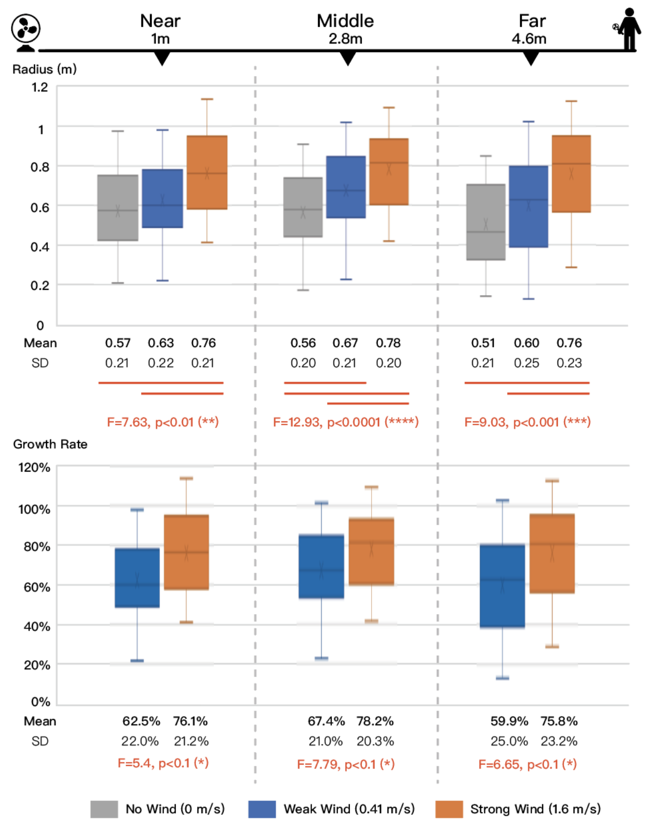

Figure 2: Results of wind range and growth rate. The interfaces at the two ends of bar have significant pairwise difference.

ACKNOWLEDGMENTS

This work was financially supported by the Ministry of Science and Technology of Taiwan under Grants MOST 109-2218-E-369-001 and 108-2218-E-369 -001.

REFERENCES

Ping-Hsuan Han, Yang-Sheng Chen, Chiao-En Hsieh, Hao-Cheng Wang, and Yi-Ping Hung. 2019. Hapmosphere: Simulating the Weathers for Walking Around in Immersive Environment with Haptics Feedback. In *2019 IEEE World Haptics Conference (WHC)*. IEEE, 247–252.

Ping-Hsuan Han, Yang-Sheng Chen, Kong-Chang Lee, Hao-Cheng Wang, Chiao-En Hsieh, Jui-Chun Hsiao, Chien-Hsing Chou, and Yi-Ping Hung. 2018. Haptic around: multiple tactile sensations for immersive environment and interaction in virtual reality. In *Proceedings of the 24th ACM Symposium on Virtual Reality Software and Technology*. ACM, 35.

Jaeyeon Lee and Geehyuk Lee. 2016. Designing a non-contact wearable tactile display using airflows. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology*. ACM, 183–194.

Dario Pittera, Marianna Obrist, and Ali Israr. 2017. Hand-to-hand: an intermanual illusion of movement. In *Proceedings of the 19th ACM International Conference on Multimodal Interaction*. ACM, 73–81.