Proposal for a Design Process Method Using VR and a Physical Model

Tetsuhito Yamauchi(✉), Takeo Ainoya, Keiko Kasamatsu, and Ryuta Motegi

Graduate School of System Design, Tokyo Metropolitan University, Hino, Tokyo, Japan
tystg1132@gmail.com, kasamatu@tmu.ac.jp

Abstract. Recently, studies on space evaluation using virtual reality (VR) are being performed for a wide range of subjects ranging from those for private houses through to cityscapes of entire towns, and their significance is becoming increasingly important. In addition, architects and interior designers are increasingly making use of simple VR kits to suggest new spaces to customers. However, such studies tend to be used for evaluation only upon personal sight of the virtual space, and joint ownership of the opinion with the designer is difficult to achieve, and there are occasions when there is a mismatch between the virtual reality and the actual reality. In this study, we conduct an experiment using the interior of a car space in which not only the impression of the space but also the operability of the space is evaluated by building a model having identical dimensions to those of the VR model so as to be able to gain an opinion of the sense of faithfulness the virtual space has to the actual (real) space. In addition, by means on an in-space experiment we receive feedback on differences in posture and confirm the usefulness of sense-of-touch feedback for each area of the vehicle's operation panel. We propose this combination of VR and a physical model as a new design inspection technique through which a designer can share consciousness with an evaluator by conducting a usability evaluation rather than being tied to the concept and practice of a subjective evaluation using a virtual space created by VR.

Keywords: Evaluation of sense of faithfulness · Sense-of-touch feedback · Joint ownership · Usability

1 Introduction

Evaluation techniques using virtual reality (VR) often only offer a visual impression for the evaluation of a proposal, and it is often difficult to perform a usability evaluation based solely upon a VR model. Research on design method using VR has been increasing in recent years. Murakami et al. [1] developed a wearable Augmented Reality (AR) system with haptic feedback as a research on constructing a significant interface in the work environment. They developed the system combining the wearable haptic feedback device and the markerless AR technology and evaluated the system from a different of the operability of virtual objects in the assembly task. As the result, they confirmed the significance on haptic feedback in the task using AR. Moreover, there is research focusing on sharing the consciousness of designers and evaluators in the virtual space.

S. Yamamoto (Ed.): HIMI 2017, Part I, LNCS 10273, pp. 313–321, 2017.
DOI: 10.1007/978-3-319-58521-5_25

"Dollhouse VR" [2] is composed of two viewpoints "space layout interface" and "immersive interface". "Spatial layout interface" allows multiple designers to change the spatial layout of walls, furniture, etc. from the bird's-eye viewpoint by operating with the multi-touch panel. The "immersive feeling interface" allows the user to immerse in the VR space laid out using the head mounted display, and can experience the space layout from the first person viewpoint. With this VR interface, the evaluator can directly recognize the space laid out by the designer. In response to these researches, this research aims to study the usefulness of tactile feedback during design work in virtual space and real space, and to construct a design work environment system utilizing these. Therefore, we construct a simple actual size model and VR together and conduct experiments targeting the operability of the in-car environment.

In an experiment we conduct in this study, we divide the interior environment of car into three areas: armrest/console box, air conditioner operation panel, and navigation monitor and then build a full-scale mockup of the mechanisms. The basic design and feeling of faithfulness to the VR design are then evaluated using a positioning scale as the basis of a design inspection technique that could be used for designing spaces in which the designer can share consciousness with an evaluator regarding the versatility of the bodily sensation evaluation. In addition, we perform a separate experiment for evaluations of the panel using a tactile sensor to inspect the usefulness of sense-of-touch feedback for each area of the operation panel.

2 Spatial Composition

Figure 1 shows the virtual space modeling of the vehicle interior, while Fig. 2 shows the experimental space, which consists of a 1:1 scale model of an air-conditioner operation panel and a dummy seat made from corrugated cardboard (Sect International), the picture presentation on a Thrustmaster T500RS Racing Wheel (THRUSTMASTER), the driving seat using HMD (HTC VIVE) [3–5]. Unity was used for the placement of each part used in the construction of a virtual space modeling a sport utility vehicle for use in an evaluation of space in the vehicle.

Fig. 1. In-car model in virtual space

Fig. 2. In-car model in real space

3 Evaluation of Immersion in Interior Space

3.1 Evaluation Measurement Method

For the evaluation of the impression of the virtual space in VR, we adopted seven phases of subjectivity evaluations using the SD method and had you describe a part to feel other sense of incongruity freely.

3.2 Experimental Procedure for Evaluation of Immersion

The experiment participants were five men and women (A - E) in their 20s. We had each participant sit in the driving seat in the true space wearing a head-mounted display and

Fig. 3. Experimental setup

conducted the evaluation in interview form while having the participant operate the air-conditioner operation panel (Fig. 3).

4 Experimental Result of Evaluation of Immersion

About the evaluation of the positioning (Fig. 4) of each part “navigator, some panels of the air-conditioner feel it with a picture toward you.” “I feel a real armrest to be in the depths.” All the participants gave evaluations in excess of five points, while there was opinion, and a result to be relatively appropriate about a feeling of size was provided.

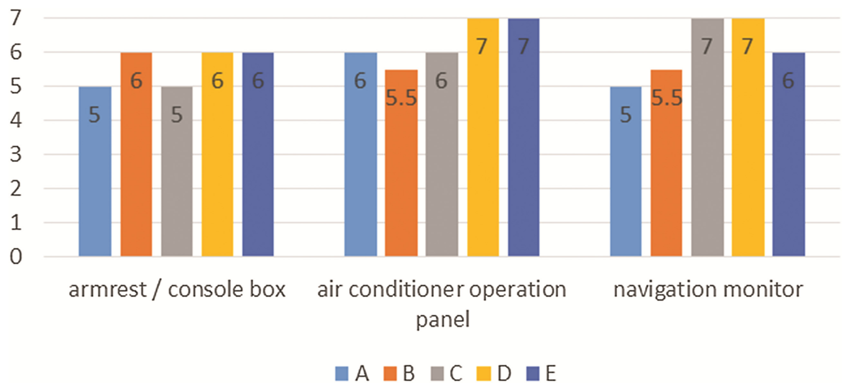

Fig. 4. Evaluation of positioning of each part

Figure 5 shows the evaluation of the size of each part. The virtual space model received a low evaluation in form (so that it is almost median 4 adequately) that we gave a high score for a model of the true space so as to be small so as to be big. It shows below the result. In this place “there is not the swelling of the armrest of the true space.” “Some steps of the true space are uncomfortable.” The evaluators felt that there was a sense of incongruity with respect to the size of the detail, part received a mean 4 for an armrest and the air-conditioner operation panel part which we made although there was it each, and a result to be almost appropriate about the scale was provided.

We evaluated the feeling of faithfulness of the virtual space as to whether it matched the true space after having evaluated positioning and size (Fig. 6). The scoring average was high, about 5.7, and the experiment participants felt the virtual space accurately reflected the real space—giving evaluations greater than five points.

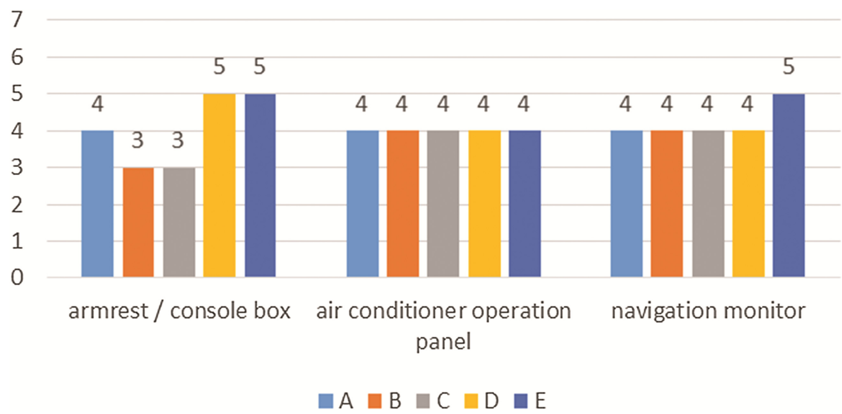

Fig. 5. Evaluation of size of each part

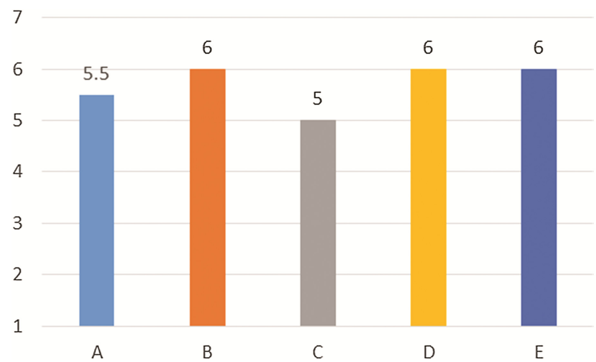

Fig. 6. Evaluation of immersive feeling of the virtual space

5 Preliminary Verification of Button Evaluation by Finger Pressure

The panels to be evaluated were presented in two types: a piano touch type; and a push button type. These panels were positioned on a desk and two kinds of operating methods were used: (1) manipulating in the standing position (Fig. 7); and (2) manipulating in the sitting position (Fig. 8). The sitting position used reflected the position of the seat in the vehicle.

Under these test conditions, the participants operated the two types of buttons to determine whether the inclination and height of the installation exerted an influence on finger pressure. Finger pressure was measured using Haplog (Kato Technical Center Company).

In the standing position evaluation, with the floor surface as a reference, the desk height was 71.5 cm, and the panels were arranged horizontally on top of the desk, and the participants operated the panels in this position. In the sitting position evaluation,

Fig. 7. Finger pressure measurement (standing position)

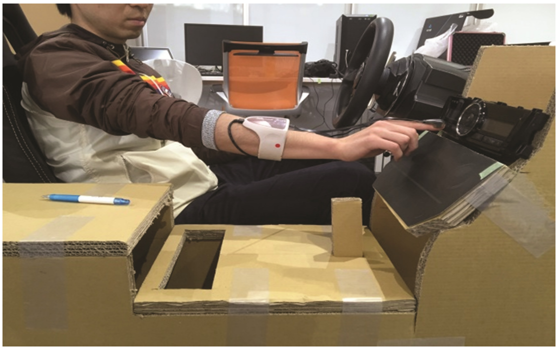

Fig. 8. Finger pressure measurement (sitting position)

the height of the center of the seat was 32 cm from the floor, and the panel was 69 cm from the floor, and the distance between the panels and the seat was about 70 cm. The panel was placed perpendicular to the cardboard model used in Sect. 2. Furthermore, the experiment participants were permitted to move the seat to a comfortable driving.

The participants were asked to make three evaluations for each of the two positions (standing and sitting).

6 Panel Evaluation Based on Required Finger Pressure

The results for the piano touch panel are shown in Figs. 9, 10 and 11, while the results for the push button panel are shown in Figs. 12, 13 and 14.

Although the reference value deviated in the standing position and the sitting position, it was found from the state of the amplitude that the finger pressure applied to the button was larger in the standing position than in the sitting position. In the sitting position, it is thought the buttons were operated using only the muscular strength of the arm and fingers, whereas in the standing position it is considered that bodyweight can be applied to the fingertip when pushing a button.

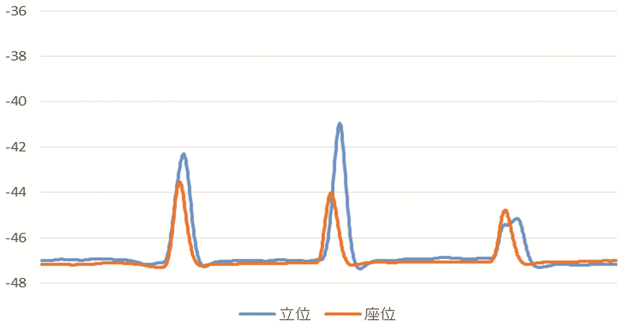

Fig. 9. Result for piano touch panel (participant A)

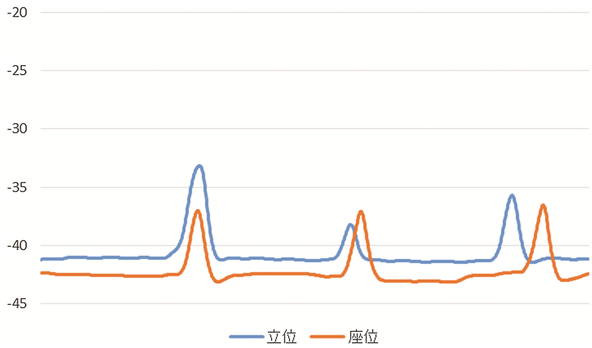

Fig. 10. Result for piano touch panel (participant B)

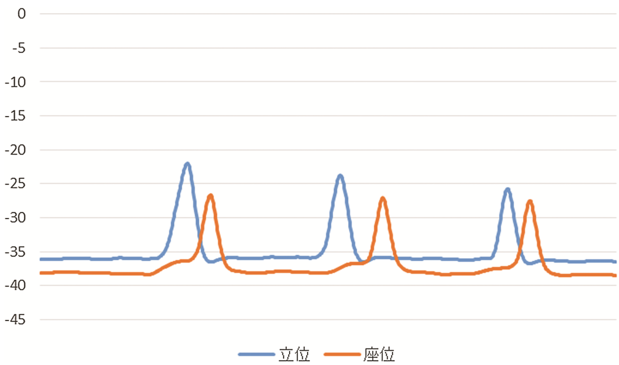

Fig. 11. Result for piano touch panel (participant C)

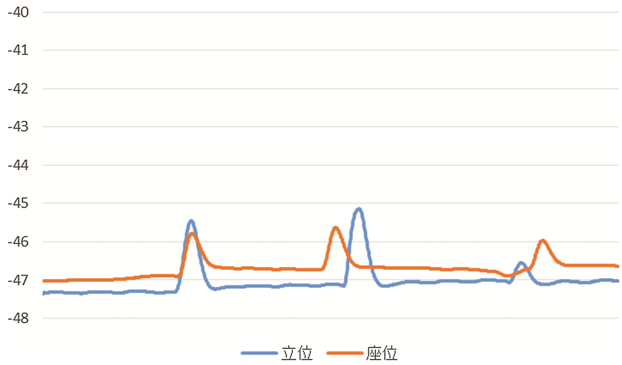

Fig. 12. Result for push button panel (participant A)

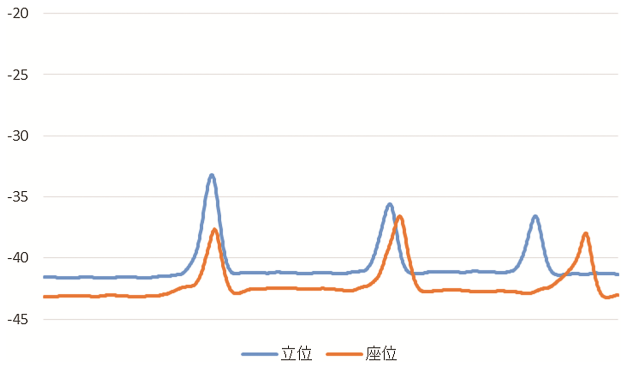

Fig. 13. Result for push button panel (participant B)

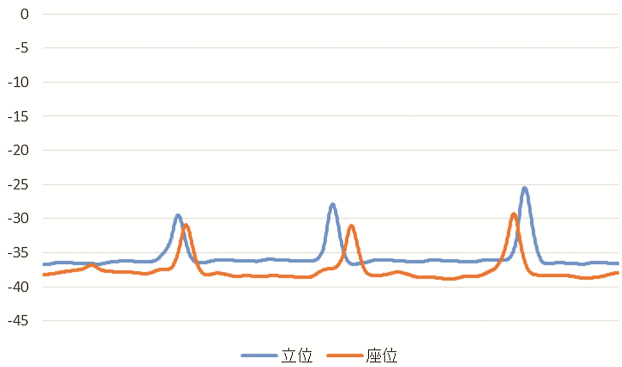

Fig. 14. Result for push button panel (participant C)

7 Conclusion and Future Works

Regarding the evaluation of the sense of immersion, we gained a high score in the evaluations of positioning and size, but the evaluation for the sense of immersion was 5 points. This is thought to be due to the fact that the real object was in a primitive shape and the difference in the texture of visual sense and tactile sense. However, a realistic feeling for placing the same environment in real space as in virtual space was obtained, and its significance could be evaluated in this experiment.

In the preliminary verification of the panel evaluation using the finger pressure measurement, a difference was seen in the finger pressure applied to each button in the standing posture and the sitting posture, so it is necessary to verify the inclination and sinking in further studies.

As a future work, we plan to consider the following items: The test participants' arms will be displayed in virtual space using motion capture; actual buttons will be placed in real space; and an evaluation of the feeling of presence, including the load placed upon the buttons, will be performed.

Our policy is to propose a design verification method that allows the evaluator and the designer to share consciousness.

References

1. Murakami, K., Kiyama, R., Imura, J., Narumi, T., Tanikawa, T., Hirose, M.: Wearable augmented reality system with haptic feedback, IEICE Techinical report, MVE2012-27, vol. 112(106), pp. 119–124 (2012)
2. Ibayashi, H., Sugiura, Y., Sakamoto, D., Miyata, N., Tada, M., Okuma, T., Kurata, T., Mochimaru, M., Igarashi, T.: Dollhouse VR: a multi-view, multi-user collaborative design workspace with VR technology. In: ACM SIGGRAPH ASIA 2015 Emerging Technologies (2015)
3. Automotive Engineering Society: Handbook of Automotive Technology Human Engineering, pp. 235–290 (2016)
4. Automotive Engineering Society: Ergonomics Technology for Automobiles, pp. 29–61 (1998)
5. Macey, S., Wardlle, G.: H Point, pp. 99–109 (2009)