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Evaluating user experience of different angle VR images

Yoshihiro Banchi, Takashi Kawai; Department of Intermedia Art and Science, School of Fundamental Science and Engineering, Waseda University; Tokyo, Japan

Abstract

This paper describes a comparison of user experience of virtual reality (VR) image angles. 7 angles conditions are prepared and evaluated the user experience during viewing VR images with a headset by measuring subjective and objective indexes. Angle conditions were every 30 degrees from 180 to 360 degrees.

From the results of the subjective indexes (reality, presence, and depth sensation), a 360-degree image was evaluated highest, and different evaluations were made between 240 and 270 degrees.In addition, from the results of the objective indexes (eye and head tracking), a tendency to spread the eye and head movement was found as the image angle increases.

1. Introduction

In recent years, VR is wide spreading in the world. In particular, VR images are contributed via some platforms with various VR format. Main VR formats are the VR180 in stereoscopic and 360-video in both mono and stereoscopic. The format is selected according to the content, such as VR180 for roller coasters and 360-video for landscapes and sightseeing.

In our previous study, the effects of the VR format were examined [1]. The four conditions were set in 180 or 360 degrees and monoscopic or stereoscopic, and evaluated the user experience. From the results of this study, angle and stereoscopy affected the user experience, and indicated the synergistic effect of them. And viewing behavior was different between 180 and 360-degree images.

2. Purpose

In the previous study, user experience was influenced by different VR format. And in user experience, 2D180 was the lowest, followed by 3D180 and 2D360 to the same extent, and 3D360 was the highest. So we questioned does VR really needs 3D 360-degrees. One of the problems with a VR image is that editing stitches are very costly. So if user experience were the same at 3D/350-degree and 360-degree, the stitching would be much easier. In this study, it is experimentally examined how angles needed in VR images.

3. Method

3.1 Equipment

Tobii Pro VR Integration (HTC Vive with Tobii Eye Tracking retrofit hardware), which can measure a direction of gaze, was used without headphones. The swiveling chair was used, and the position was fixed. The stimuli presentation environment was created by Unity using Tobii Pro SDK.

3.2 Stimuli

A 360-degree camera (Insta 360 Pro) was used to create stimuli that took full circumference 3D images. The stimuli resolution was 3840 × 3840 pixels in equirectangular format. 2 images and 7 angle conditions were prepared. Angle conditions were every 30 degrees from 180 to 360 degrees.

3.3 Evaluations

As a subjective index, the rating 7 scale was taken (Strongly disagree – Neutral – Strongly agree). The evaluation items were from the previous study on the evaluation of 3D images [2] – reality, presence, depth sensation.

As objective indices, gaze and head movement were measured with Tobii Pro VR Integration. The measurable field of view was 110 degrees which in full HTC Vive field of view, and the measurement frequency was 90 Hz.

3.4 Procedure

The participants were 19 university students with normal stereoscopic function. First of all, the purpose and method of the experiment were explained, and their consent was gained. Participants were familiarized with the experimental procedure through preliminary trials. The procedure was, participants gazed at a calibration marker for gaze tracking and then they watched each image for 30 seconds. The questionnaires were completed after viewing and participant got rest time. Considering the possible influence of viewing order, the image presentation order was randomized.

Figure 1. Experiment Layout

Figure 2. Image A in 360-degree image

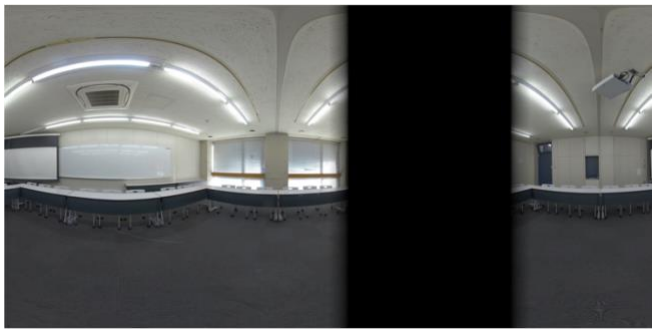

Figure 3. Image B in 270-degree image

4. Results

4.1 Subjective Index

A two-way ANOVA was carried out on the score of each subjective item. The result of each item is shown in the figures 4-6, and error bars are standard errors.

On reality, there was significant main effect of angle (Angle: $p<.001$, Image: $p=.904$, Angle × Image: $p=.649$). 360-degree image was higher than other angle condition ($p<.01$), 330-degree image was higher than 180-degree image ($p<.05$).

On presence, there were significant main effects of angle and image (Angle: $p<.001$, Image: $p=.042$, Angle × Image: $p=.995$). 360-degree image was higher than other angle condition ($p<.01$), 380-degree image was smaller than 270~330 image ($p<.05$).

On depth sensation, there was significant main effect of image (Angle: $p=.051$, Image: $p<.001$, Angle × Image: $p=.844$).

4.2 Objective Index

The result of horizontal distribution by kernel density estimation of gaze and head tracking data is shown in the figures 7-10. Vertical axis higher means the stay time is longer, and horizontal axis is about the direction angle.

In the gaze movements, near-180 degrees, the ratio of 330 and 360-degree images were larger than of others. The head movements were like the results of gaze movement, but in the 330-degree image, the difference was not so clear compared to the gaze movement.

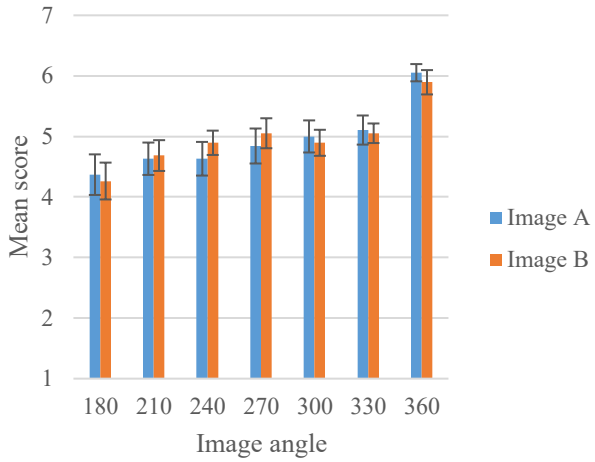

Figure 4. Result of Reality

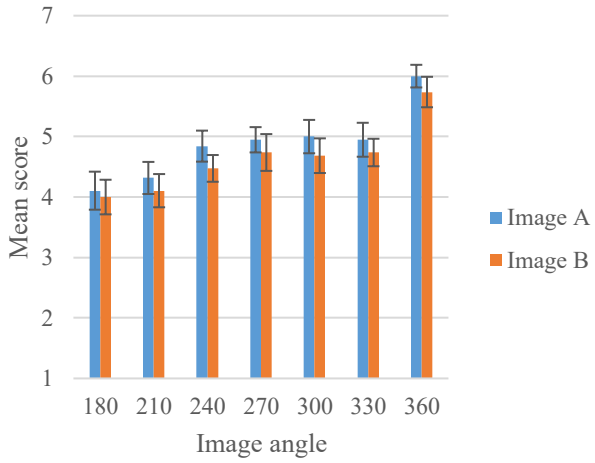

Figure 5. Result of Presence

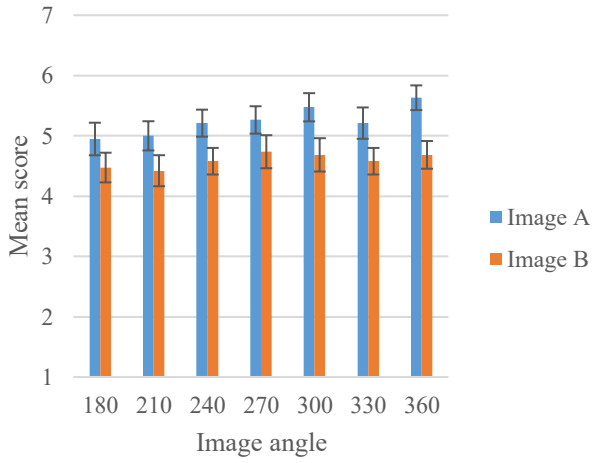

Figure 6. Result of Depth sensation

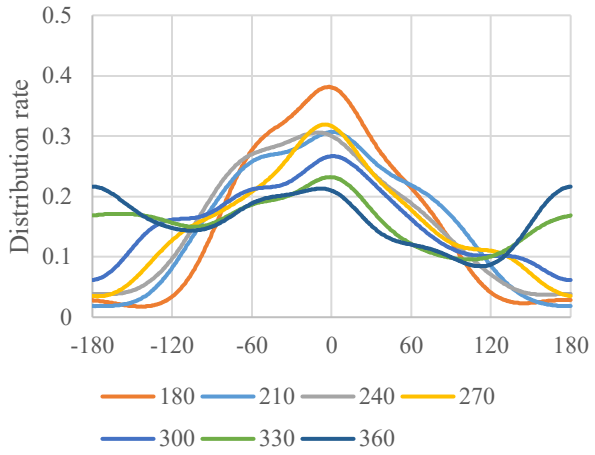

Figure 7. Gaze distributions on Image A

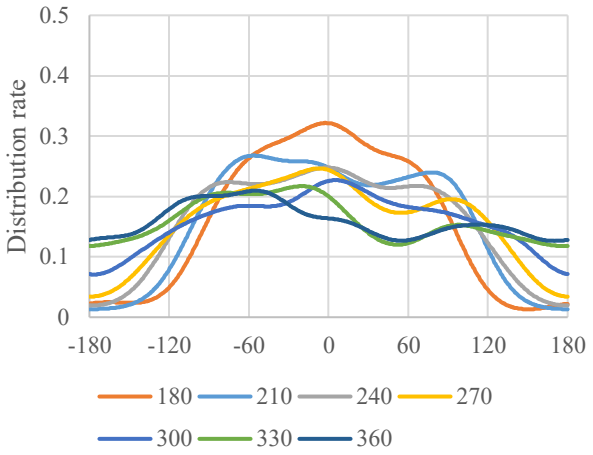

Figure 9. Gaze distributions on Image B

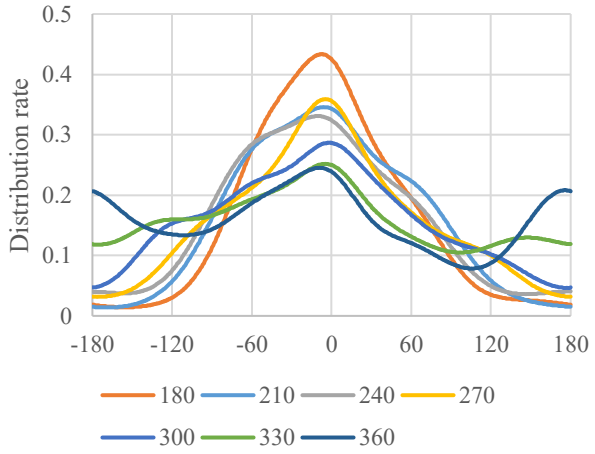

Figure 8. Head distributions on Image A

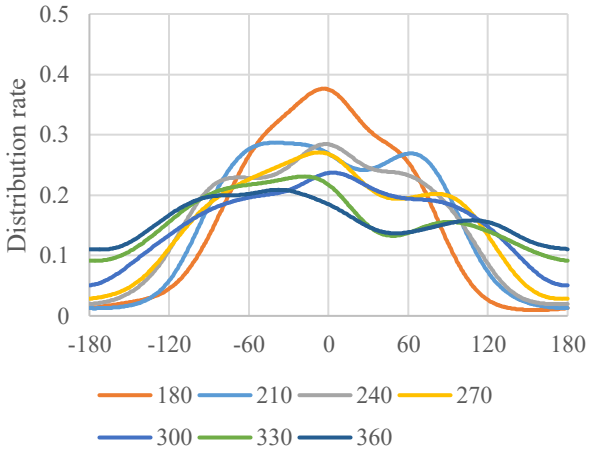

Figure 10. Head distributions on Image B

5. Discussion

As a result of reality, the score increased from 180 to 270-degree, and as a result of the presence, the score increased from 180 to 240-degree. These showed the angle improved user experience up to a certain angle. About 270 degrees was considered to be an angle that can be easily looking around by the interaction between the range of body motion and the field of view. In more image angles within a range of easy-to-see, user experience improved. As a result of both reality and presence, the highest score was in a 360-degree image. This showed the black mask had a big impact on the user experience. The image effect was affected by the depth distribution caused by the closeness of camera and object.

From the results of objective indices, viewing behavior changed at 330 and 360-degree images. In lower 300-degree images, the black mask covered half of the field of view looking at the border, but at 330 degrees, it can see the image on the other side when looking around the borders. So viewing behavior may be distracted by black covering more than half of the field of view. This may mean half of field of view determine the viewing behavior.

6. Conclusion

In this research, the user experience on different angles of VR images was examined. From the results, 3D and 360-degree images are important in VR. From the results, the following findings were obtained.

- The 360-degree image was the highest score, so that the user experience was very different between 360-degree and others
- User experience was improved up to about 270 degrees
- The black masks restrained the viewing behavior

These are regarded as a useful characteristic of user experience for VR content creation.

References

[1] Yoshihiro Banchi, Keisuke Yoshikawa, Takashi Kawai, “”, IS&T International Symposium on Electronic Imaging 2020, 2020(2), [SDA-244].

[2] M. Lambooij, W. IJsselsteijn, D. G. Bouwhuis and I. Heynderickx, "Evaluation of Stereoscopic Images: Beyond 2D Quality," in *IEEE Transactions on Broadcasting*, vol. 57, no. 2, pp. 432-444, June 2011.

Author Biography

Yoshihiro Banchi received his Master from Waseda University (2018). He is a Research Associate in the School of Fundamental Science and Engineering of Waseda University and Doctor student in Waseda University. His work has focused on the ergonomic study on psyco-physiological effects in virtual reality with an HMD.

Takashi Kawai is a Professor at Waseda University, Japan. He received Ph.D., M.A., B.A. in Human Sciences from Waseda University, in 1998, 1995, 1993. His research focuses ergonomics in immersion technologies, e.g. 3D, VR, XR. He is a Certified Professional Ergonomist. Currently he is in charging of Japan Committee Chair of Advanced Imaging Society, Executive Committee of International Ergonomics Association, and Conference Chair of Stereoscopic Displays and Application.

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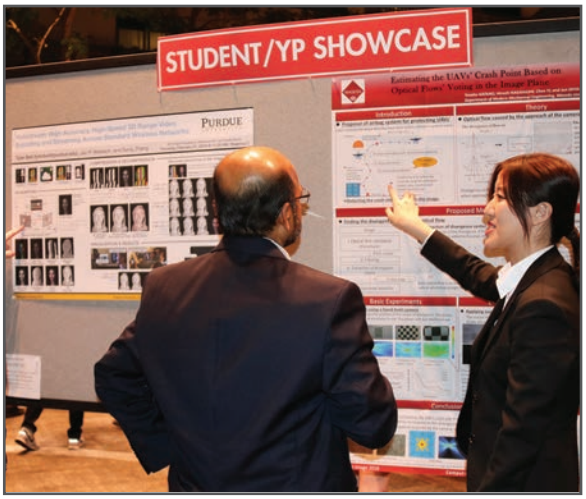

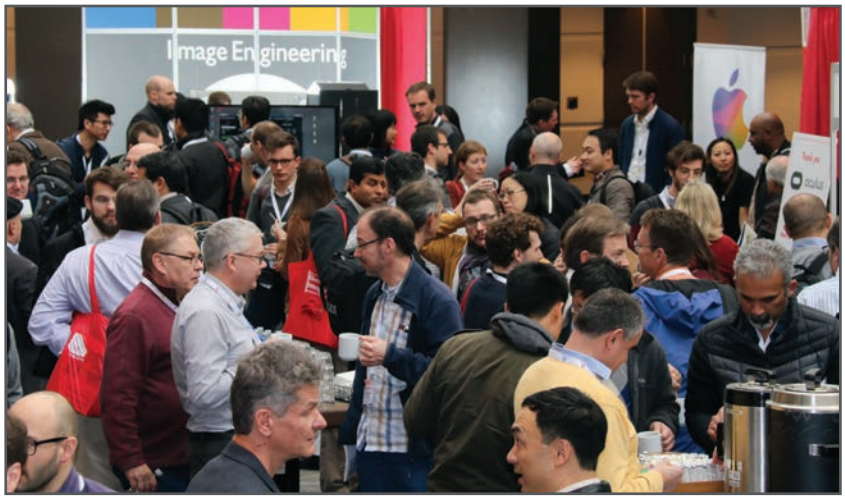

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