Individual Essay in HCI on "Interaction Techniques, Devices, and Modalities"

Enhance Virtual Reality User Experience

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Introduction

The subcommittee I chose is “Interaction Techniques, Devices, and Modalities”, which focuses on advances in interaction and enabling technologies, as well as, explorations of emergent computing domains and experiences. The topic of this paper is about enhancing the user experience (UX) in Virtual Reality (VR). By exploring the recent papers that describe substantive improvements on the current VR headset or user interact function, this paper would discuss about what we could do to create a better way for user to interact with VR environment and devices. Not only a more immersive environment experience, but also an efficient and natural interaction interface. The structure of the paper is as follows: Firstly, the papers about a better interface (hand track) would be discussed. Secondly, some interesting way of hacking human perceptron to achieve better VR UX would be introduced. Then, one of VR shortages would be pointed out, overcame by two different techniques. Last but not least, some suggestions about the future research will be given.

Literature Review

1. Natural Human Interface (NUI)

NUI is kind of user interface that remains invisible but drives user continuously learning complex interactions naturally. Comparing to the traditional Graphic User Interface (GUI), the interaction comes naturally while interacting with the technology. One of interaction methods that can be seen as NUI in VR is widely known as hand gesture motion. The following paper show the advantages of applying hand motion into VR by using hand tracking device called Leap Motion.

1.1 Po-Wei Lee et al [1] designed a new cross-dimensional VR interface concept called TranSection. In order to achieve a better immersive interaction environment when player plays a 2D puzzle platformer game, VR is applied to warp out the 2D world and simulate a gaming situation in real life.

TranSection enables realistic interaction with virtual objects through user’s own hand by incorporating the VR headset Oculus Rift and hand tracking device called Leap Motion. As Hand-based motion can be seen as a NUI, the fact that players are able to grasp and manipulate the virtual object does provide a more immersive VR game experience. They claimed that the 2D pop-up menu and selecting exit button are GUI but not NUI, thus breaking both consistency of interface and the immersive gaming experience. To enhance the NUI affordance and keep the gaming consistency, they proposed this cross-dimensional VR interface to enable immersive 2D interface manipulation rather than the traditional 3D immersive manipulation. In this case, they embed a virtual computer containing a 2D interface, showing the GUI on the top of that instead of in the air. Meanwhile, a virtual keyboard is embedded to represent the real-world keyboard. Moreover, the ability that the objects in different dimensions can interact with each other enhances

immersions and keeps the interface of the game consistent.

The evaluation of the TranSection was separated into interestingness and simulator sickness (SS). The mean of the experience fun level was 4.17 (SD = 0.94) while curiosity was 4.33 (SD = 0.9). 83 % of the players indicated the wish to play again. The result shows that the interface design is practical and interesting. Last but not the least, the interface also relieved the simulator sickness effect by making the player seat, rather than stand or walk. This 3D wraps 2D be a new modality to enhance UX in VR.

Han et al [2] claimed that the gaze-based hand interaction is helpful for improving the immersion of mobile VR content. By comparing the user satisfactions between gaze only and gaze-based hand interaction, they concluded that it has positive effect to the interaction interest and immersions and has no negative effect of causing VR sickness or dizziness.

The traditional mobile VR platform is usually using gazing as the main interaction method because of the device limitation. Although the limitation exists, the gaze does help user to concentrate on the important content. But with the help of hand interaction, it can enhance immersion while not interfering with the object control. By using the hand tracking device Leap Motion, the mobile VR headset has the ability to use hand as a interact method. They designed a card-type interactive experiment. One with hand control including card selection process and event gesture, while the other without those.

The result of the experiment is positive when the detailed psychological factors are analysed. 45.24% of respondents answered the hand interaction improved immersion, interest, control and experience of VR. Thus, a more direct control in the 3D virtual space is helpful for creating a more immersive content in mobile platform.

Regarding to the hand recognition, there are also some techniques such as Wi-Fi and RGB camera that can be used to achieve device-free, increasing the immersion of VR.

1.2 Handwriting recognition has been applied to Human Computer Interaction (HCI) application widely, and meanwhile, the mobile terminals need a more man-machine friendly interface mode. Fu et al [3] used pervasive wireless signals, especially Wri-Fi in their work, to achieve the device-free air-write recognition. The traditional air-writing recognition are susceptible to light conditions, normally sensor based, which are not able to achieve device-free and convenient usage. They improved the work of Sun et al, getting rid of the air-writing recognition application called MyScript that lacks research of the features of classification and letters. By proposing Wri-Fi system and

composing the signal for 26 letters, they finally conducted experiments and got 86.75 and 88.74 percent average accuracy in two different writing areas respectively. Although the air-writing system still can be affected by a small interference and can also be affected by the writing habitat and surrounding human motion, this new way of air-writing recognition may make a huge contribution to the mobile and VR platform as a new interaction method.

Apart from using the off-the-shelf Wi-Fi router system, Ferreira et al [4] claimed that a simple RGB camera can be used in the VR environment to recognise user's gesture, allowing user to interact with VR with NUI. By using OpenCV library functions calls, the face recognition can help searching whether there is a user get into the scene. Based on the face the system recognised, the hand, gesture and finger recognitions are implemented to control the virtual objects.

2. Hack Human Preceptron

The basic principle of VR device is to fool human's eye and brain. Based on these, if the sense of touching, listening and even smelling could be simulated according to the virtual scene, the immersion could be improved dramatically. However, it is always a challenge to achieve this. The following paper raised a modality that may solve the problem of providing enough passive haptic cue.

2.1 A proper way to enhance UX in VR is manipulating a virtual object with passive haptic cues. Unlike those active haptic cues such as hand control system, passive haptic cues are more like the static surroundings. Because of this, scaling such experiences to all static surroundings need a lot of precisely located haptic proxy object, and this is challenging. To solve this problem, Azmandian et al [5] showed a solution called haptic retargeting, which overcame the challenge by hacking human perception.

The haptic retargeting makes a single virtual prop provide passive haptics for multiple virtual objects. They provided three different approaches to aligning physical and virtual objects dynamically: body manipulation, world manipulation and hybrid manipulation. The body manipulation is incrementally shifting the rendering the scene to translating the user's hands and arms to the wanted direction. According to the experiment, this cannot only used to hack the direction of left and right, but also up and down. The world manipulation is quite different from the previous. It uses rotation gain between the realistic and virtual world to align the world coordination to the physical object. By guiding participants to read a billboard on the side, the big rotation provides rotation gain that can cause the illusion. The hybrid manipulation is the combination of the previous two.
The reaction of the experiment participants was generally enthusiastic and surprising. By analysing the hand path, it is showed that if the participants

hand moved too fast in the body warping, they would do a huge shift in the end to reach the target. The body warping guarantees the alignment but needs slow movement. Meanwhile, world warping will not miss the target but requires the rotation. Because of those reasons, the effect of the hybrid warping was the most outstanding comparing to the body wrapping.

The following paper tried to prove that the sense of smelling and touching can improve user experience in VR, especially the sense of presence. However, the result was not positive enough to prove that.

2.2 VR environment is usually used for mood induction procedure (VR-MIP) and proved effective in inducing relaxation. Serrano et al [6] designed an experiment to test whether the stimulation of the senses of touch and smell improves the efficacy in VR-MIP. They implemented a VR environment called "House of Relaxation" with four different experiment conditions: VR, VR + Smell, VR + Touch and VR + Smell & Touch. However, regarding the influence of stimulating touch and smell on VR-MIP and generating a higher sense of presence, there's no significant evidence showing that the simulation improves the sense of presence.

3. Overcome VR shortage

One of the VR usability challenges is a low users' capability to interact with and be aware of reality. When user put the Helmet-mounted Display (HMD) on, they may, for instance, hit someone by mistake. Unless they remove the HMD, it's hard to keep being aware of what is happening. The following papers used device such as Leap Motion, Microsoft Kinect, or deep learning technique to overcome this shortage in VR to improve UX.

3.1 McGill et al [7] selectively incorporated necessary elements of reality into VR when user engages with reality to overcome this problem, the process of which is called Engagement-Dependent Augmented Virtuality.

They performed three different design studies to address different usability concerns such as typing, interaction with reality and existence of others.

- In the typing study, they conducted it with four conditions for the further comparison: Reality, Virtuality, Augmented Virtuality (AV) Partial Blending and Full Blending. The result of the experiment shows that the Virtuality has significantly higher error rates and a large drop in typing rate (WPM). The two AV conditions reduces the error rate significantly and improved the WPM as well. The incorporation reality into VR preserves performance and the partial blending condition does not have too much negative effect to the immersive feeling comparing to the full blending conditions.
- In the interaction with reality study, they also considered different level of blending factor: Minimal, Partial and Full. The partial and minimal blending are proved better than full reality, which

demonstrates that limited reality is necessary to enable the capability for interaction when incorporating reality into virtuality. Moreover, the inferred engagement is proved superior to user control of engagement.

- In the existence of others study, they insert user silhouettes captured by Microsoft Kinect into VR scene and calculate the position by using Kinect tracking and depth-maps of proximate persons. They designed low engagement and full engagement experiments, although there's no significant difference between two conditions – low engagement did not perform as expectation. The results show that the incorporation improved awareness of proximate person. However, participants prefer a lesser or more casual state of awareness and the control of the awareness.

The paper provides a way for user to perform necessary interactions with reality without leave the VR experience or remove the HMD.

3.2 The shortage of the VR system about blocking the user's external view also affects the training process, as user cannot see the controllers, buttons or their hands. Ercan et al [8] described a design of a training system for aerospace industry that blends reality and virtuality, while the detection process is achieved by deep learning algorithms.

By using two different well-known deep leaning algorithms, YOLOv2 and MobileNet-SSD, the user's hand and the detect region can be recognized perfectly. The result shows that the accuracy of MobileNet-SSD is higher than YOLOv2, which is a satisfactory performance for this application. After the hands are detected, they will be blended into the virtual environment. The experiment result shows that the trainee can improve driving skills and learn driving a tow-truck. Participants are committed to make less mistakes with enough training. The rending method of blending real and virtual images does make simulation process more immersive.

Future Research Suggestions

As the literature review mainly covers three aspects: NUI, Human Perceptron and VR device shortage, the suggestions for the future research will be delivered in the same order.

Regarding to the interact interface of VR device, it is always hard for naïve user to learn how to use it in a short time. The HMD and controllers that containing GUI could be too complex for them to understand. Because of this, the main trend of VR's interaction method would be NUI, which allows user to learn how to engage with VR naturally, meanwhile, increase the immersive feeling. On one hand, the hand track based on extra device nowadays, Leap Motion for example, is mature enough to apply to the VR application. On the other hand, the device still can be improved in many aspects for enhancing the sense of presence. Other than using devices, the techniques or algorithms that can achieve device-free hand track would bring much lighter and unlimited UX with same amount of immersion.

As for human's sense aspect, it might not be a good idea to fully focus on simulating the smell of the scene. According to the previous paper, the sense of smell won't have significant help on improving sense of presence in VR, at least in VR-MIP. On the other hand, haptic sense does create a more immersive environment and encourage user to engage with the virtual object. The future research direction could be finding ways to label or blend the real object in the virtuality. The hack of human perceptron makes the mobile passive cue available as it needs fewer physical objects. So, in the future, it might be easy to set up a fully immersive VR environment anywhere and anytime.

The shortage of VR device effects UX a lot in many ways. Compared to fully blend reality into virtuality, partial blending might be a more suitable idea as it can make user be aware of the reality, and meanwhile, keep the immersion consistency. And it is enough to make user get awareness with limited reality. However, it has to be noted that the transparency of partial blending may not bring less distractions. Apart from this, it might not be necessary to take the actual reality into virtuality without any modifications. The main propose of the augmented virtuality is to keep users' awareness of what is happening around them. So, for the future research, the real object can be replaced by other things, a warning notification for instance, to achieve this propose. Moreover, the awareness dependent on the engagement would not only alerts user of the surroundings under their wishes or emergency, but also keeps the virtual content consistent.

Reference

[1] Lee, Po-Wei, et al. "TranSection: hand-based interaction for playing a game within a virtual reality game." Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems. ACM, 2015.

[2] Han, Seunghun, and Jinmo Kim. "A Study on immersion of hand interaction for mobile platform virtual reality contents." Symmetry 9.2 (2017): 22.

[3] Fu, Zhangjie, et al. "Writing in the air with WiFi signals for virtual reality devices." IEEE Transactions on Mobile Computing 18.2 (2019): 473-484.

[4] Ferreira, João PM, et al. "An RGB-Based Gesture Framework for Virtual Reality Environments." International Conference on Computational Science and Its Applications. Springer, Cham, 2018.

[5] Azmandian, Mahdi, et al. "Haptic retargeting: Dynamic repurposing of passive haptics for enhanced virtual reality experiences." Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. ACM, 2016.

[6] Serrano, Berenice, Rosa M. Baños, and Cristina Botella. "Virtual reality and stimulation of touch and smell for inducing relaxation: A randomized controlled trial." Computers in Human Behavior 55 (2016): 1-8.

[7] McGill, Mark, et al. "A dose of reality: Overcoming usability challenges in vr head-mounted displays." Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. ACM, 2015.

[8] Ercan, M. Fikret, et al. "Object Detection with Deep Learning for a Virtual Reality Based Training Simulator." International Conference on Computational Science and Its Applications. Springer, Cham, 2018.