HoVR-Type: Smartphone as a typing interface in VR using hovering

Youngwon R. Kim and Gerard J. Kim
Affiliation: Digital Experience Laboratory, Korea University, Seoul, Republic or Korea
kyw920@gmail.com and gjkim@korea.ac.kr

***Abstract*--We propose a text entry method for VR, using the smartphone and its hovering function, called the HoVR-Type. The hovering function effectively acts as the finger tracking sensor thereby allowing the user to type in the virtual space. When added with the additional phase to correct the initial touch input and having the final key entered upon the finger release, the proposed method showed competitive performance to that of the conventional "aim-and-shoot" method and also exhibited much higher usability. HoVR-Type also showed a significantly faster speed of input for the individual character. However, it remains to improve the interface with regards to reducing the error. Overall, the use of the smartphone leverages on the already established mobile user experience and can be further extended to other VR interaction techniques so that one can use the common smartphone as an all-purpose VR interaction device.**

I. INTRODUCTION

Fueled by the introduction of affordable head mounted displays (HMD), immersive virtual reality (VR) has attracted much attention as the next "big" thing to the mobile revolution. Likewise, different forms of new and improved interaction sensors and controllers are also appearing in the market. In fact, since virtual experience is often maximized through interaction, interactive techniques for VR have long been studied, e.g. particularly for the generic tasks of navigation, object selection and manipulation [2]. However, there has not been a satisfactory solution to the task of text entry in VR due to the difficulty in tracking individual fingers and providing even a minimal haptic/tactile feedback. Moreover, its utility had been relatively low and overlooked, while today, its importance has risen significantly by the prevalence of social networking.

In this paper, we propose to use the smartphone as an all-purpose VR interface including for the text entry. Using the smartphone has few advantages to begin with: almost everyone owns one these days. Smartphones are equipped with the multitude of sensors and displays (e.g. visual, aural and vibro-tactile) directly applicable to various forms of VR interaction. Indeed, there have already been such attempts, i.e. to use smartphones as the 3D and VR interaction controllers, using the acceleration and gyro sensors [8, 10].

More importantly, there is a distinct possibility to leverage on the already familiar form factor and highly usable touch oriented interactive techniques and experience of the mobile devices to those for VR (e.g. texting during VR usage). In this paper, we focus on the task of text entry as such a possibility.

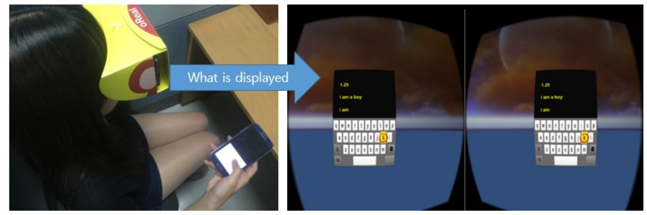

Fig. 1. The proposed method of text entry for VR using the smartphone.

Our proposed interface for text entry in VR using the smartphone resembles the way one makes input with one finger during actual mobile texting (see Fig. 1). The difference is in that the keyboard appears in the VR space (but input made on the hand-held touch screen). The hovering, not an uncommon function in today's smartphones [12], is used to indicate the approximate location of the typing finger with respect to the corresponding touch keyboard. Hovering (on the touchscreen of mobile device) refers to the sensing of the location of the proxy (e.g. fingertip) above the touchscreen, indicated as the closest perpendicular screen position downward from the proxy (e.g. the finger).

We conducted an experiment comparing our proposed text entry method to the conventional "aim-and-shoot" interface using special hand-held devices. The results will provide for a basis of future smartphone based interaction design for VR and furthermore, the intermixed use of mobile devices with VR headset.

II. RELATED WORK

There is a vast amount of pervious work on various VR interaction techniques [4, 13, 16]. For lack of space, we only outline notable works in text entry for VR. We also give a short introduction to the concept of hovering and how smartphone hovering can be used for various tasks.

The most popular and conventional way of text entry in VR setting (i.e. obstructed view to the real environment) is the "aim and shoot" style, in which a hand-held device or hand-mounted sensor is used to cast a virtual ray and select a particular key and making the final confirmation using a button (or other discrete input method) [6, 11]. A more direct method is to use a glove like device that attempts to sense individual finger movements and map them into the virtual space to realize virtual QWERTY style typing [3, 5, 14]. A slight variant is the hand-mounted but restricted set of buttons, each corresponding to an alphabetic key [1, 17]. Such a non-QWERTY method would require extensive training, however. Recently, improved external finger tracking sensing

978-1-5090-5544-9/17/$31.00 ©2017 IEEE

technologies have allowed the use of bare hands, relieving the user from having to use the cumbersome glove-like hand worn device [7]. However, these sensors are still not accurate enough, often need to be installed in the environment (making the input system not self-contained) and has a limited operating range. Combined with the lack of haptic feedback, such a scheme generally has low usability.

One other interesting approach is capturing and segmenting out the imagery of a real keyboard and using hands (using a computer vision method), and blending it into the virtual scene [9]. While such an approach makes it possible to use the familiar conventional keyboard, the keyboard (on a fixed desktop location) is not fit for active usage while navigating in the VR space.

The idea of the use of hovering for interaction is not new. For example, on the desktop interface, a hovering cursor can reveal the function or help information of what is underneath to help the user make right choices. The same technique can be applied to the mobile interaction with special sensor that can detect the proxy location slightly above the touchscreen. For example, Pollman [12] has suggested to use hovering on smartphones to make the keyboards more accessible. However, differently to the desktop case, users occasionally make mistakes while approaching one's finger to touching the intended key/object after aiming by hover (albeit a short distance). Such a usability problem has made the hovering function quite under-utilized [15, 18]. Nevertheless, the hovering sensor, as applied to VR, can act as a partial and natural sensing of the fingertip as the basis of our proposed text entry method.

III. The Proposed Text Entry Method: HoVR-Type

The proposed interface for text entry in VR uses a smartphone that has a hovering function. The user, wearing an HMD, would see, in the virtual space, a floating virtual keyboard in the standard QWERTY layout and e.g. holds the smartphone in one's dominant hand, typing on the touchscreen with one's thumb (an alternative is for the user to hold the smartphone in the non-dominant hand and use the index finger from the dominant hand to type). No visual feedback (e.g. key layout) is shown on the smartphone touchscreen itself as it does not matter anyhow, since the user cannot see the smartphone. The lower one third of the touchscreen space was used as the area where the QWERTY keyboard was laid out, as similarly as much to the actual touch keyboard in mobile usage. All in all, the method mostly resembles the way one makes input with one finger during actual mobile typing.

As the user moves one's finger toward or around a particular key (close enough to the touchscreen for the hover function to activate), its position relative to the key is obtained through the hovering function and indicated as such in various forms (e.g. virtual semi-transparent finger, circular cursor). When the key is indicated, it is also enlarged both in the virtual (visual) and interaction (touch) space, then the user would strike the finger down (if the indicated key was the desired one), with ease, to touch and make the corresponding key input. There are two variations in the final phase, i.e. the input is made: (1) as the finger strikes down and the touch is made (HoVR-Type-D), and (2) as the finger leaves the touchscreen (HoVR-Type-U). In the former case, the key at the initial touch position is entered, and for the latter, the user is allowed to adjust the key position in the touched state before the finger leaves, and the key at the final touch position is entered (Fig. 2). The current prototype is implemented on the Samsung Galaxy S4 running the Google Android operating system. It is linked, by the wireless communication, to the virtual reality content (implemented using Unity3D) seen through an HMD, from which the virtual keyboard can be invoked.

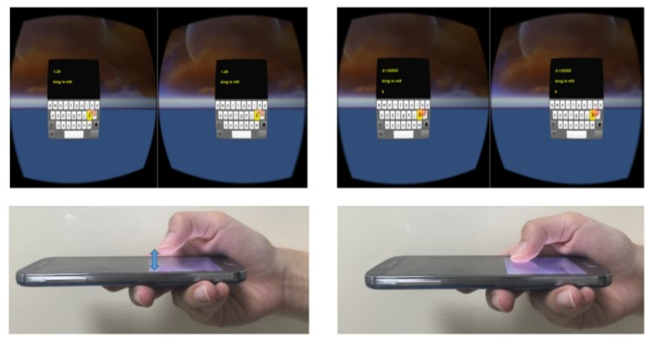

Fig. 2. (Left) Showing a transparent thumb indicator when the users' finger is hovering on the touch screen, (Right) Showing a transparent red circle to indicate the touch from the thumb.

IV. Experiment

The experiment compares the typing performance and usability as carried out in the virtual space using three methods: (1) conventional hand-held "aim-and-shoot" method (CONV), (2) HoVR-Type-D and (3) HoVR-Type-U (one-factor three-level repeated measure within subject). In the case of the CONV (which served as the base line condition), the Logitech air mouse MX Air was used with which the user aimed at the same virtual keyboard (also with the same enlarged indication of the aimed letter) and made the final selection by the left (or right depending on the user's dominant hand) button press (with the thumb). While the original purpose was to use an actual HMD, the experiment was run with the virtual space shown through a desktop monitor due to latency issues and experiment operational reasons. The subject was instructed to look at only the monitor screen (and not at the hand-held smartphone).

Ten paid subjects (5 men and 5 women between the ages of 25 and 30, mean = 28.3 / SD = 3.67) participated in the experiment. The subjects were briefed about the purpose of the experiment and given instructions and short training for the experimental tasks. All subjects were right handed and had prior experience of using smartphones with touchscreens.

In each trial, the subjects were asked to enter a phrase or sentence, comprising of 4~5 words each, as quickly and correctly as possible, within a nominal time out value (set empirically at 5 seconds per letter). The words were composed

978-1-5090-5544-9/17/$31.00 ©2017 IEEE

of only the alphabets (plus spacebar and backspace) but no digits nor other special characters. While entering the text, any erroneous input was highlighted in red to quickly inform of the user. The user was allowed to use the backspace to correct one's input. At the start of the trial, the elapsed time was displayed on top, the input goal phrase appeared in the middle, and the corresponding user input was made and shown in the last third row (see Fig. 1). As soon as the user input matched the goal text, the screen refreshed and displayed the next goal text. If the user did not finish the task in time, the input was simply recorded and the experiment moved on to the next trial.

Ten trials were administered in one block at a time for one of the three text entry interfaces. A total of three blocks of trials was carried out per interface. The order of the blocks was counter-balanced. The task completion time and the number of backspace entries were measured and a general subjective usability questionnaire was answered in a 7-Likert scale (details omitted).

We hypothesized the remote hand-held pointing (CONV) would incur relatively heavier overhead (and time) compared to using the fingers and making input more directly to the imminent touchscreen. Still, due to the reported problem (error emanating from small finger movement in the gap between the hovering finger and touch surface), we expected the HoVR-Type-D to produce significant amount of errors. The HoVR-Type-U was expected to reduce this error by giving the user another chance (while in the touched state) to make correction before the finger release (if needed), and also exhibit faster performance than the CONV even with this small additional step. This would lead to a conclusion (if verified as such) that HoVR-Type-U is a good alternative to the usual text entry method based on remote selection.

V. Results

Fig. 3 shows the average task completion time results of the three experimental conditions. A one-way repeated measures ANOVA was applied. Contrary to our hypotheses, the HoVR-Type (D or U) did not show faster performances. HoVR-Type-U showed slightly faster completion time than CONV but not in a statistically significant way ($p=0.541$), and likewise for error rates ($p=0.07$) as reflected by the number of backspace counts (Fig. 4).

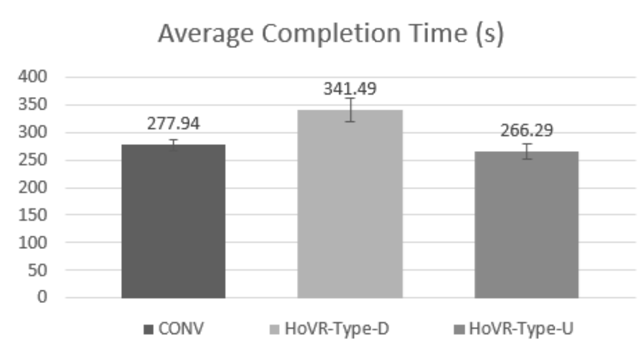

Fig. 3. Average completion times of the three interfaces.

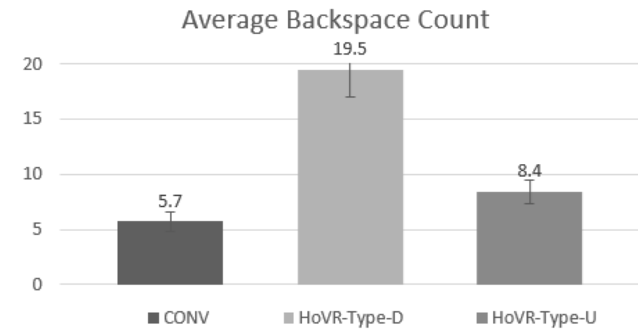

Fig. 4. Average backspace counts of the three interfaces.

We posit that the users were more familiar with the conventional pointing method than expected, especially compared to the use of hovering. HoVR-Type-D incurred many errors as expected and this also contributed to the lengthy performance with lots of corrections as also shown in Fig. 4. Such errors are also common regardless of the use of hovering in mobile usage even when the keyboard and finger are directly visible. In the case of HoVR (both D and U), the user also had to carefully situate one's finger above the touchscreen (without looking) to activate the hovering function and in turn show its position in the virtual space. The users seemed stressed trying not to accidentally touch the screen or deactivate the hovering function. Such mental effort was somewhat relieved for the HoVR-Type-U, but not entirely.

Disregarding the error, the entering speed of the HoVR-Type-U, as measured by characters per second, was significantly faster than the others as shown in Fig. 5 (one-way repeated measures ANOVA; vs. CONV: $p = 0.041$ and vs. HoVR-Type-D: $p = 0.025$). CONV and HoVR-Type-D did not show any significant difference ($p=0.716$). This validates part of our hypothesis that the overhead from the last correction phase of the HoVR-Type-U is relatively small. Again, it is the error derived from the aim-to-touch motion, which can possibly be reduced with improved hovering technology and additional provisions such as using larger keyboard layout or fish-eye enhancement.

The usability survey and post-briefing in Fig. 6 showed superior satisfaction owing to the mobile UX naturally transferred to the VR usage. Hence, while our hypotheses were partially rejected, the results are still promising in that the typing performance was still competitive (with a good potential for further improvement) to that of the conventional, and produced clearly higher usability.

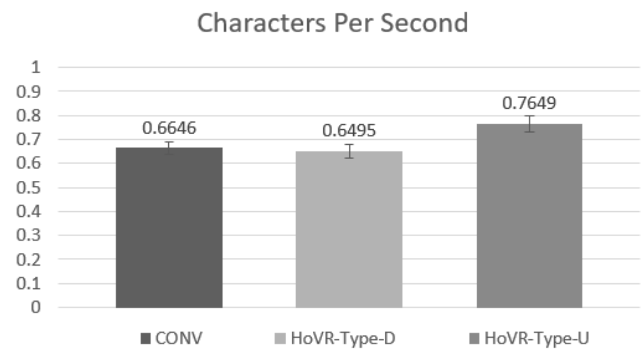

Fig. 5. Key entering speed (in characters per second) of the three interfaces.

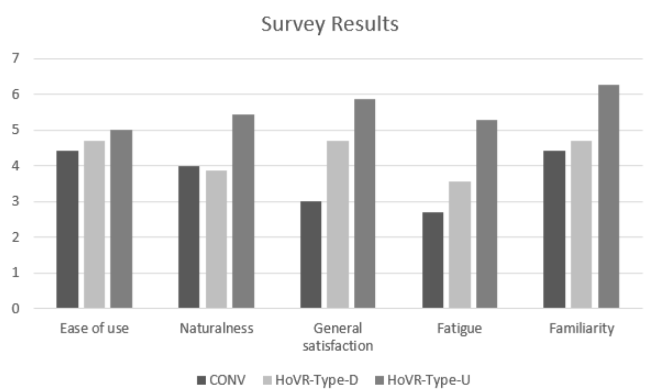

Fig. 6. Usability survey results of the three interfaces (in the 7-level Likert scale. Higher score means better usability).

VI. CONCLUSION

In this paper, we have proposed a text entry method for VR, using the smartphone and its hovering function. When added with the additional phase to possibly correct touch errors and enter input upon finger release, the proposed method showed competitive performance to that of the conventional method and also exhibited much higher usability due to the carry over effect from the mobile UX. It is our goal to utilize the smartphone as the all-purpose, not just for typing, interaction device for VR. Thus, if we can devise intuitive methods for other typical VR interaction namely such as navigation, object selection and manipulation, we can truly leverage on the mobile UX and this way, one can use both the mobile and VR device inter-mixingly. Such a direction is set for our future work.

ACKNOWLEDGMENT

This study was partly supported by the Global Frontier R&D Program grant from the National Research Foundation of Korea (MEST/NRF-2015M3A6A3076490, Human-centered Interaction for Coexistence), and was partly supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Science, ICT & Future Planning(No. 2011-0030079).

.

REFERENCES

1. Alphagrip. Retrieved May 10, 2016 from http://www.alphagrips.com/.
2. D. Bowman, E. Kruijff, J. LaViola Jr, and I. Poupyrev, 3D User Interfaces: Theory and Practice, CourseSmart eTextbook. Addison-Wesley, 2004.
3. D. Bowman, C. Wingrave, J. Campbell, M. J, V. Ly, and C. Rhoton, "Novel uses of Pinch Gloves™ for virtual environment interaction techniques," Virtual Reality, 2002, 6.3: 122-129.
4. A. Feiner, and S. Olwal, "The flexible pointer: An interaction technique for selection in augmented and virtual reality," In: Proc. UIST'03. 2003. p. 81-82.
5. B. Howard, and S. Howard, S, "Lightglove: Wrist-worn virtual typing and pointing," In: Wearable Computers, 2001. Proceedings. Fifth International Symposium on. IEEE, 2001. p. 172-173.
6. HTC VIVE User guide. Retrieved May 10, 2016 from http://dl4.htc.com/web_materials/Manual/Vive/Vive_User_Guide.pdf?_ga=1.64742511.1367646068.1462853716.
7. Leap Motion Developer, VR Keyboard. Retrieved May 10, 2016 from https://developer.leapmotion.com/gallery/vr-keyboard.
8. D, Lee, J. Hwang, G. Kim, and S. Ahn, S. C, "3D interaction using mobile device on 3D environments with large screen," In: Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services. ACM, 2011. p. 575-580.
9. M. McGill, D. Boland, R. Murray-Smith, and S. Brewster, "A dose of reality: overcoming usability challenges in VR head-mounted displays," In: Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. ACM, 2015. p. 2143-2152.
10. K. Pietroszek, J. Wallace, and E. Lank, "Tiltcasting: 3D Interaction on Large Displays using a Mobile Device," In: Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology. ACM, 2015. p. 57-62.
11. PlayStation4 User's Guide, Entering characters. Retrieved May 10, 2016 from http://manuals.playstation.net/document/en/ps4/basic/osk.html.
12. F. Pollmann, D. Wenig, and R. Malaka, "HoverZoom: making on-screen keyboards more accessible," In: Proceedings of the extended abstracts of the 32nd annual ACM conference on Human factors in computing systems. ACM, 2014. p. 1261-1266.
13. I. Poupyrev, M. Billinghurst, S. Weghorst, and T. Ichikawa, "The go-go interaction technique: non-linear mapping for direct manipulation in VR," In: Proceedings of the 9th annual ACM symposium on User interface software and technology. ACM, 1996. p. 79-80.
14. R. Rosenberg, and M. Slater, "The chording glove: a glove-based text input device," IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews), 1999, 29.2: 186-191.
15. Samsung's "Air View": Gimmicky, but with extraordinary potential. Retrieved May 10, 2016 from http://thedroideffect.com/samsungs-air-view-gimmicky-but-with-extraordinary-potential/.
16. B. Thomas, and W. Piekarski, W, "Glove based user interaction techniques for augmented reality in an outdoor environment," Virtual Reality, 2002, 6.3: 167-180.
17. Trewgrip. Retrieved May 10, 2016 from http://www.trewgrip.com/.
18. J. Williamson, "Fingers of a Hand Oscillate Together: Phase Syncronisation of Tremor in Hover Touch Sensing," In: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. ACM, 2016. p. 3433-3437.