2IMV25 - Interactive virtual environments

Initial Report: Problem, research questions, approach

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1 Introduction

Virtual reality (VR) often aims to create a realistic experience such that users can fully immerse themselves in an artificial world [1]. The level of immersion that can be achieved is influenced by various factors ranging from photorealistic graphical depictions of the environment itself to the ability to interpret user inputs and create believable outcomes from those actions [2]. One particular aspect of VR that has been explored by many researchers [3][4][5][6][7] is the latency of a VR system. [3][8] demonstrated that latency can negatively impacts user experiences and decreases user performance [9].
With constant technological improvements, VR market share keeps rapidly growing as VR increases in popularity [10]. Since this VR market mostly uses head-mounted displays (HMDs) which is considerably different to fish tank VR or CAVE, it requires some investigation on the effect of latency on performance. Our research will thus focus on the influence of latency on the performance of a 3D pointing task in VR using HMDs. This should give a more relevant insight into the effect of latency for the current trend of VR.

2 Problem statement

The increase in commercially available products such as Oculus Rift [11], HTC Vive [12] or SteamVR [13] popularised HMDs as the way to experience VR. HMDs allow for better user immersion as they can depict egocentric, first-person view thanks to which user can control and experience an artificial world through a virtual avatar.
In this work, Oculus Rift and HTC Vive are chosen as the experimental VR platforms. Both devices utilize input controllers which contain sticks and button similarly to standard video game controllers as well as provide six degrees of freedom (6DoF) information about user hands. Additionally, the HMDs also track user head with at least 6DoF [14].
Collection, transfer and processing of all these inputs as well as external factors, such as wireless communication or temporary unavailability of computational resources, introduce delays between physical user actions and their reflection in VR. As shown in other papers [3][5][9], those delays play important role in creating immersive VR experience and can highly impact usability of the system. Therefore, this work aims to further investigate the effects of latency and its impact on user performance.

3 Research questions

In order to investigate the impacts of latency on user performance, the main study objective and multiple sub-questions are defined.

3.1 Main research question

In this work, the following question is answered:

How does latency affect the performance of 3D pointing tasks?

3.2 Sub-question

To answer the research question, the following sub-questions are addressed:

1. *Is there a latency lower bound at which the pointing task performance no longer improves?*
2. *Does increased latency increase the time it takes to perform a pointing task?*
3. *Does increased latency decrease the accuracy of the pointing task?*
4. *How much latency is allowed before a user starts to notice a reduction in performance?*

4 Approach

To answer the research questions, a user experiment is designed in which a number of participants use an HMD to perform a 3D pointing task. The participants trace a predefined 3D line by utilizing the input controllers. During the experiment, each participant traces multiple shapes. For each shape, the latency of the controllers is altered. As the task is performed, the input accuracy and the total duration is measured. These metrics are then used to evaluate performance against the latency present in the system. The collected results are further analyzed and compared with literature to find a relation between latency and performance.

References

[1] G. C. Burdea and P. Coiffet, *Virtual reality technology*. John Wiley & Sons, 2003.

[2] H. Limbasiya, "Sense simulation in virtual reality to increase: Immersion, presence, and interactions," University of Dublin, Tech. Rep., 2018.

[3] C. Ware and R. Balakrishnan, "Target acquisition in fish tank VR: The effects of lag and frame rate," in *Proceedings of Graphics Interface '94*, ser. GI '94. Toronto, Ontario, Canada: Canadian Human-Computer Communications Society, 1994, pp. 1–7. [Online]. Available: http://graphicsinterface.org/wp-content/uploads/gi1994-1.pdf

[4] R. Teather, R. Allison, and W. Stuerzlinger, "Evaluating visual/motor co-location in fish-tank virtual reality," 10 2009, pp. 624 – 629.

[5] M. Meehan, S. Razzaque, M. Whitton, and F. Brooks, Jr, "Effect of latency on presence in stressful virtual environments." vol. 2003, 04 2003, pp. 141 – 148.

[6] B. PERROUD, S. Régnier, A. Kemeny, and F. Merienne, "Effects of Latency on Aiming Performance for CAVE-like Immersive Virtual Reality Systems and Driving Simulators," in *Driving Simulation Conference 2018 Europe VR*, Antibes, France, Sep. 2018, pp. 147–150. [Online]. Available: https://hal.archives-ouvertes.fr/hal-01939793

[7] C. Lee, S. Bonebrake, D. A. Bowman, and T. Hllerer, "The role of latency in the validity of ar simulation," in *2010 IEEE Virtual Reality Conference (VR)*, March 2010, pp. 11–18.

[8] R. Jota, A. Ng, P. Dietz, and D. Wigdor, "How fast is fast enough? a study of the effects of latency in direct-touch pointing tasks," 04 2013, pp. 2291–2300.

[9] I. MacKenzie and C. Ware, "Lag as a determinant of human performance in interactive systems," 01 1993, pp. 488–493.

[10] M. Intelligence, "Virtual reality (vr) market - growth, trends, and forecast (2019 - 2024)," 03 2019.

[11] Facebook Technologies LLC. Oculus Rift. Accessed: 2019-09-17. [Online]. Available: https://www.oculus.com/rift/

[12] HTC Corporation. HTC Vive. Accessed: 2019-09-17. [Online]. Available: https://www.vive.com/us/product/vive-virtual-reality-system/

[13] Valve Corporation. Steam VR. Accessed: 2019-09-17. [Online]. Available: https://store.steampowered.com/steamvr

[14] "A quick guide to degrees of freedom in virtual reality," Feb 2018, accessed: 2019-09-17. [Online]. Available: https://kei-studios.com/quick-guide-degrees-of-freedom-virtual-reality-vr/