Performance and QoE Assessment of HTC Vive and Oculus Rift for Pick-and-Place Tasks in VR

Mirko Suznjevic, Matija Mandurov, Maja Matijasevic
University of Zagreb
Faculty of Electrical Engineering and Computing Unska 3, Zagreb, Croatia
Email: {mirko.suznjevic, matija.mandurov, maja.matijasevic}@fer.hr

***Abstract*—In this short paper we propose several objective and subjective metrics and present a comparison between two "commodity" VR systems: HTC Vive and Oculus Rift. Objective assessment focuses on frame rate, impact of ambiance light, and impact of sensors' line of sight obstruction. Subjective study aims at evaluating and comparing the pick-and-place task performance in a virtual world. We collected user ratings of overall quality, perceived ease of use, and perceived intuitiveness, with results indicating that HTC Vive slightly outperforms the Oculus Rift for the pick-and-place task under test.**

Keywords*—*virtual reality, task performance, QoE

I. Introduction

In the past year or so, virtual and augmented reality seems to be finally taking off, although neither technology has yet gained a widespread adoption [1]. Head-mounted displays are still (relatively) heavy and awkward, as well as tethered, while head and/or hand tracking still leave much to be desired in terms of response time and precision. On the other hand, Young et al. (2014) have shown that, for certain tasks, consumer devices may perform on a par with expensive specialized hardware [2]. They compared a "commodity VR" Oculus Rift with a (two orders of magnitude) more costly research system Nvis SX60, for virtual object interaction, search, and viewing tasks in a virtual world, and found that the commodity system "consistently outperformed" the high-cost system, while also having higher resolution, and lower weight; conversely, the low-cost system was more likely to cause simulator sickness.

While those results clearly cannot be generalized, we were interested in how current systems perform in tasks which require some dexterity when interacting with objects in the virtual world, and also which parameters are (or may be) relevant for comparing different systems in real-world (indoor) use conditions. This short paper presents a (simple) performance assessment methodology and results for two VR systems under study: HTC Vive (www.vive.com) and Oculus Rift (www.oculus.com). Both systems consist of three components: *head-mounted display* (HMD), external *sensors* for position detection, and hand-held *controllers* for interacting with the virtual world. HTC Vive has two wireless controllers, and two sensors which track both the controller and the HMD positions, while the Oculus Rift that we use has one sensor for tracking the HMD position, and another one for tracking the controller (different from the previous Oculus Rift version, which used specialized hardware [3]).

QoMEX2017 – Erfurt, Germany; 978-1-5386-4024-1/17/$31.00 ©2017 IEEE

II. Methodology

We assessed and compared the objective characteristics of these two VR systems, as well as subjective parameters regarding interaction with objects in the virtual world. Firstly, we performed a set of objective measurements, considering the following parameters for comparison:

- Frame rate: we measured the frame rate for each system on the same PC and with the same application for 300 seconds, and compared the obtained values;
- Ambiance light: we evaluated VR system response in five lighting conditions: i) room with closed blinds, ii) room in daylight, iii) room in daylight and lights turned on, iv) industrial reflector directed at sensors, and v) other infra-red camera in the room;
- Sensor obstruction: we measured how the systems perform when one of their sensors has an obstruction in the line of sight (LOS).

The second set of measurements were subjective user measurements. We used a simple pick-and-place task, involving "grabbing" and positioning objects of variable size. This task was designed to measure both spatial and temporal characteristics of the interaction, as suggested by Chang et al. (2016) [4]. The measurement set-up was implemented in a 3D virtual world that was used for testing as illustrated in Figure 1. On the table there were three cubes ("small", "medium", "large") and a "button" for the user to mark the task completion. The goal of the task was pick the cube from the table and place it onto its respective stand, starting with the biggest box and ending with the smallest, as precisely aligned to the stand as possible, and to the press the button when done.

Listed objective and subjective parameters were measured:

- Spatial precision: how much was the parallel misalignment between the box and the stand, with respect to the centre of the box;
- Time to complete the task: how long it took to place a specific cube onto its stand;
- Quality of experience: subjectively perceived quality of experience;
- Intuitivness: subjective assessment as to how intuitive was the overall system to use;
- Ease of use: subjective assessment regarding how easy was the hand-held controller to use.

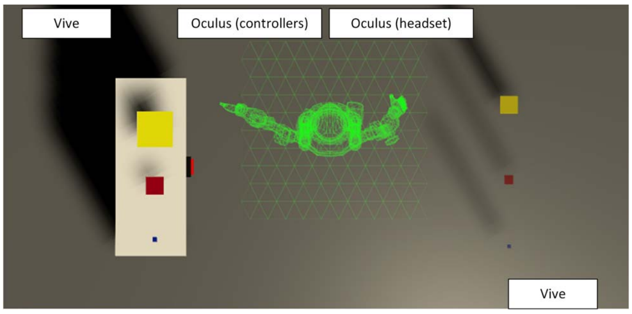
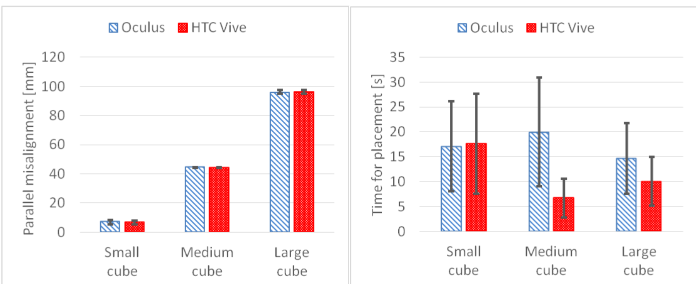


Fig. 1: Testing application with positions of sensors

Users were first shortly familiarized with the system with the help of an administrator (e.g., how to grab a cube). Once all the cubes were moved by the user using one VR device, he or she would repeat the process by using the other device. In the end, the user would rate the subjective parameters based on the 7-point Comparison Category Rating (CCR), similar to the ITU-T Recommendation P.800 [5]. (It is *similar* in the sense that, in proper CCR, it is unknown to subjects which sample is modified, which is not the case here, since it is obvious which device is used at any time.) The following scores (for second session as compared to the first) are applied: 3: *Much Better*, 2: *Better*, 1: *Slightly Better*, 0: *About the Same*, -1: *Slightly Worse*, -2: *Worse*, -3: *Much Worse*. The testing procedure lasted about 10 minutes. There were 13 participants (8 male, 5 female) of average age of 26 years. To get information regarding familiarity of the participants with virtual worlds we asked them about their previous experience in computer games because none of them had previous experience with VR. With respect to previous experience in computer games, 3 participants self-identified as *novice*, 3 as *intermediate* and 7 as *experienced*. Unfortunately, three (3) participants could not complete the experiment due to the onset of simulator sickness (only successful outcomes were taken into account).

III. Results

In terms of the frame rate, HTC Vive maintained between 99 and 101 frames per second (fps), while Oculus Rift maintained between 93 and 96 fps when the application was idle. The same difference (around 5%) was confirmed for another simple video-game. In terms of the ambiance light, our tests showed that both systems performed very well under all lightning conditions in the visible spectrum, but that in the presence of infrared cameras in the testing space (e.g., Microsoft Kinect 2 camera) tracking failed for both devices due to interference. As expected, LOS obstruction for both devices showed that HTC Vive performs better than Oculus Rift (as both of Vive's sensors track both the controllers and the HMD, while for Oculus Rift each sensor tracks only the HMD or only the controllers). Thus, the user could usually continue normal interaction even if one one sensor in HTC Vive was occluded, while occluding one of Oculus Rift's sensors resulted in the immediate loss of tracking for either the HMD or the controller. Figure 2 shows the results of objective measurements. Interestingly, in terms of spatial precision there is no major difference between devices. In terms of time to complete the task, more time is needed to move the cube with Oculus Rift then with HTC Vive, except for the smallest cube. It should also be noted that the only measurement in which confidence intervals are only slightly overlapping is the medium-size cube. This can be related to tracking for Oculus Rift: when taking the cube the users could choose to turn either clockwise either counterclockwise in the virtual world. When turning counterclockwise they would turn their back towards the sensors, which would then result in loss of LOS between the sensor and the controller (illustrated in Figure 1). Next time around, the users would have learned that, and thus take care to always face the sensor so as not to occlude it while picking the small cube. Finally, CCR evaluation data are shown in Figure 3. They are normalized so that the skew to positive values means that HTC Vive performs better, while the skew to negative values means that Oculus Rift performs better. In this case, HTC Vive performed better, but only slightly on all tested variables, and mostly on overall QoE. The most frequent users' complaint was due to the need to maintain LOS with Oculus Rift which limited their natural movement.



(a) Spatial precision

(b) Time to complete task

Fig. 2: Objective metrics

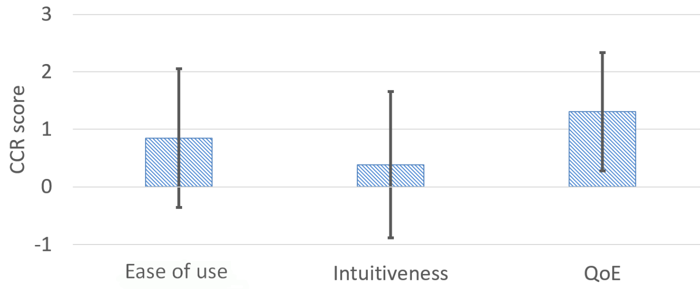


Fig. 3: Subjective metrics

IV. Conclusion

In this paper we presented and tested a simple methodology for measuring spatial and temporal characteristics of VR systems. The comparison study suggest that HTC Vive is better received by our test group on all subjective measures, as well on several of objective measures. This can be attributed to the sensor system which is more robust to loss of tracking for HTC Vive, and thus indicated that future devices should rely on design based on two sensors covering the whole area tracked so body occlusion does not block tracking. Therefore, for future room-scale experiments using Oculus Rift system we suggest using an additional sensor.

Acknowledgement

This work has been fully supported by Croatian Science Foundation under the project 8065.

REFERENCES

[1] J. Durbin, "Super data report: 6.3 million virtual reality headsets shipped in 2016," https://uploadvr.com/report-6-3-million-virtual-reality-headsets-shipped-2016/, 2 2017, accessed: 2017-04-10.

[2] M. K. Young, G. B. Gaylor, S. M. Andrus, and B. Bodenheimer, "A comparison of two cost-differentiated virtual reality systems for perception and action tasks," in *Proc. of the ACM Symposium on Applied Perception*. ACM, 2014, pp. 83–90.

[3] I. Hupont, J. Gracia, L. Sanagustin, and M. A. Gracia, "How do new visual immersive systems influence gaming QoE? a use case of serious gaming with Oculus Rift," in *Proc. of the 2015 Seventh Int'l Workshop on Quality of Multimedia Experience (QoMEX)*. IEEE, 2015, pp. 1–6.

[4] C.-M. Chang, C.-H. Hsu, C.-F. Hsu, and K.-T. Chen, "Performance measurements of virtual reality systems: Quantifying the timing and positioning accuracy," in *Proc. of the 2016 ACM on Multimedia Conference*. ACM, 2016, pp. 655–659.

[5] "P.800 Methods for subjective determination of transmission quality," *ITU-T Recommendation. International Telecommunication Union*, 1996.