Interaction for Extended Reality environments

Carlos Cortés
ccs@gti.ssr.upm.es
Universidad Politécnica de Madrid
Madrid, Spain

ABSTRACT

eXtended Reality (XR) brings new possibilities for classic telepresence and teleoperation environments. Thus, the development of new human-computer interfaces (HCI) techniques in these fields will be the key value for taking advantage of XR capabilities. Moreover, it is mandatory to maintain the sense of presence or immersion in the XR field. Since one of the factors of presence in XR is the embodiment, the ability to interact in XR using your own body is a current hot point in immersive HCI. However, the assessment of the Quality of Experience (QoE) in natural interaction methods remains unexplored. Therefore, the proposed research for the PhD thesis will focus on studying and evaluating the QoE of different natural interaction methods in XR.

CCS CONCEPTS

• **Human-centered computing** → **User studies**; **Visualization techniques**.

KEYWORDS

eXtended Reality, natural interaction, Quality of Experience, Virtual Reality, Augmented Reality

IMX-20, June 17–19, 2020, Barcelona, Spain

ACM ISBN 978-x-xxxx-xxxx-x/YY/MM...$15.00
https://doi.org/10.1145/nnnnnnn.nnnnnnn

ACM Reference Format:
Carlos Cortés. 2020. Interaction for Extended Reality environments. In *The Adjunct Proceedings of ACM TVX/IMX 2020, Barcelona (Spain), June 2020. Copyright is held by the author/owner(s).*. ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/nnnnnnn.nnnnnnn

INTRODUCTION

The recent emergence of virtual reality (VR) devices like head-mounted displays (HMD) has triggered a wave of deployments in classic environments to boost their performance. Furthermore, to take advantage of all the possibilities of mixing virtual worlds (VR) and real worlds (AR) by means of different types of sensors, a joint paradigm called extended reality (XR) has been defined [4]. Specifically, the appearance of such devices in the fields of teleoperation, telepresence, and teleteaching has sparked growing interest in the ways in which people interact within VR devices [7]. However, XR performance is highly related to one of VR's key factors, which is immersion.

The analysis of immersion lies, among others, in the fields of VR, computer graphics, and human-computer interaction, since immersion helps to achieve a sense of presence [15]. The thesis will approach the immersion from the study, development, and evaluation of different techniques integrated into XR looking for enhancing the sense of presence for interaction and XR environments [8]. Another element affecting immersion is cybersickness, that is, the discomfort generated by the conflict between three sensory systems, namely visual, vestibular, and embodiment [3]. The compendium of these factors and their impact on the user's final performance is defined as "Quality of Experience" (QoE). To measure the QoE [3] in XR environments, specifically presence and cybersickness, presence tests such as the "Presence Questionnaire" (PQ) [12][13] or cybersickness dizziness tests such as the "Sickness Simulator Questionnaire" (SSQ) [6][11] are used.

Focusing on the problem of how to fit the body into VR, there are numerous efforts to introduce the hands of users so that they can interact with objects [1]. Most of these methods use object recognition, reconstruction, and estimation of the hand pose to introduce a representation of the hands into XR. These methods usually use images from an egocentric point of view [1]. Besides, this interaction becomes relevant in XR when it brings the possibility of interact with objects. Therefore, interaction within XR environments requires the seamless integration of the representation of the remote objects (real ones) within the local mixed environment. Milgram et al. [9] include varying degrees of mixing between virtual and real environments, which will be studied for the purpose of generating and measuring immersive sensation[14].

Evaluation of methods for introducing real elements into XR [5] [10] is usually done through comparison with annotated databases, their real-time capability and the realism with which they are achieved. However, the evaluation of the quality of experience, and ultimately, of how the various methods improve upon immersion, is often overlooked [1].

RESEARCH QUESTIONS

As a result of the study of the above-mentioned parameters that may affect the QoE in XR environments, the following questions are defined:

- What are the parameters of interaction that guarantee QoE in immersive envrionments?
- Which tools of QoE assessment methods can be applied in natural interaction?

The experiments considered in the research work are planned to answer these questions. We will begin with the initial hypothesis that a XR environment with the correct parameters in terms of delay, presence and cybersickness should provoke an enhancement on the training and performance of teleoperation scenarios. At the end, a teleoperation scenario will be used as a test platform gathering all the conclusions achieved by running the experiments.

WORK PLAN

The doctoral work began with the study of the best parameters for QoE in XR environments. So, a specific scenario for XR interaction such as the immersive teleoperation was considered. Looking to guarantee a good experience for the user in terms of presence and cybersickness, the thesis explores methods for generating different kind of scenarios in order to measuring the QoE. Therefore, time has been devoted to study the state of the art in aspects related to measure the QoE in immersive environments. Besides, some time was also spent studying the Unity3D graphic engine that enables the development of XR environments. The first advance in this aspect has been the development of a customizable subjective assessment tool for VR environments following the ITU Recommendation draft for VR subjective assessment [2]. This tool is currently being used in the VQEG Immersive Media Group worldwide tests for QoE assessment for 360° content. Recently, this tool has also been used to assess the effect of motion-to-photon latency in immersive video transmission. Specifically, the experiments include typical immersive video transmission scenarios such as tiled video transmission and the use of pan tilt zoom (PTZ) cameras.

The next step will be the evaluation of different neural network architectures for the virtualization of elements from images from different types of cameras. They will be selected according to the results previously obtained and their impact on the sensation of immersion. In addition, the evaluation of their impact on the presence will be carried out. In these implementations, special consideration will be given to the elements that affect XR. These elements will have been previously studied and selected to evaluate the QoE. To evaluate the different scenarios proposed in the previous point, the parameters studied and tools developed will be used to evaluate the QoE in immersive self-presence environments. The idea is to measure the QoE and time of achievement in an environment in which you can manipulate objects from the real environment using your hands.

Finally, a teleoperation environment similar to Figure 1 will be proposed applying the results obtained from the different steps previously explained. So, the proposed environment must guarantee

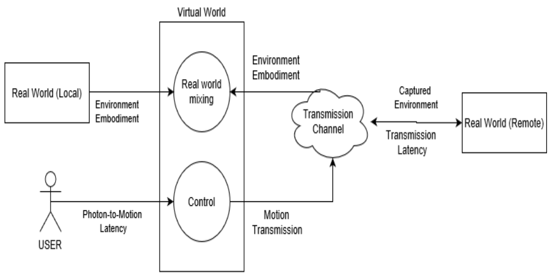

Figure 1: Teleoperation scenario

a QoE level to assure the satisfactory use of the teleoperation. Therefore, the implementation of the teleoperation scenario will imply the study and development of techniques to improve key aspects for the QoE such as motion-to-photon latency, reduction of cybersickness and improvement of the sense of presence in distributed environments.

As a result, the thesis will help achieve improved immersion in XR environments by providing specific parameters to achieve natural interaction. In addition, it will provide a methodology for evaluating performance in teleoperation based on the assessment of QoE immersion in XR.

ACKNOWLEDGMENTS

This work has been partially supported by the Ministerio de Ciencia, Innovación y Universidades (AEI/FEDER) of the Spanish Government under project TEC2016-75981 (IVME).

REFERENCES

[1] A. Bandini and J. Zariffa. 2019. Analysis of the hands in egocentric vision: A survey. *arXiv preprint arXiv:1912.10867* (2019).
[2] C. Cortés, N. García, and P. Pérez. 2019. Unity3D based app for 360VR subjective quality assessment with customizable questionnaires. *IEEE Int. Conf. on Consumer Electronics Berlin, ICCE-Berlin 2019, Berlin, Germany* (September 2019).
[3] A. Doumanoglou, D. Griffin, J. Serrano, N Zioulis, T.K. Phan, D. Jimenez, D. Zarpalas, F. Alvarez, M. Rio, and P. Daras. 2018. Quality of experience for 3-d immersive media streaming. *IEEE Transactions on Broadcasting* 64, 2 (2018), 379–391.
[4] A. Fast-Berglund, L. Gong, and D. Li. 2018. Testing and validating Extended Reality (xR) technologies in manufacturing. *Procedia Manufacturing* 25 (2018), 31–38.
[5] P.H. Han, Y.S. Chen, H.L. Wang, Y.J. Huang, J.C. Hsiao, K.W. Chen, and Y.P. Hung. 2017. The design of video see-through window for manipulating physical object with head-mounted display. *ACM SIGGRAPH 2017 Posters* 1 (2017), 1–2.
[6] R. Kennedy, N. Lane, K. Berbaum, M. Lilienthal, S Kevin, and M. Lilienthal. 1993. The International Journal of Aviation Psychology Simulator Sickness Questionnaire : An Enhanced Method for Quantifying Simulator Sickness. *The International Journal of Aviation Psychology* 3, 3 (1993), 203–220.
[7] H. Khan, G. Lee, S. Hoermann, R. Clifford, M. Billinghurst, and R. Lindeman. 2018. Evaluating the Effects of Hand-gesture-based Interaction with Virtual Content in a 360° Movie.
[8] K. Marriott, F. Schreiber, T. Dwyer, K. Klein, N. Riche, T. Itoh, W. Stuerzlinger, and B. Thomas. 2018. *Immersive analytics*. 357 pages.
[9] P. Milgram, H. Takemura, A. Utsumi, and F. Kishino. 1994. Mixed Reality (MR) Reality-Virtuality (RV) Continuum. *Proceedings of SPIE* 2351, Telemanipulator and Telepresence Technologies (1994), 282–292.
[10] F. Mueller, F. Bernard, O. Sotnychenko, D. Mehta, S. Sridhar, D. Casas, and C. Theobalt. 2018. GANerated Hands for Real-time 3D Hand Tracking from Monocular RGB. (2018). arXiv:1712.01057
[11] P. Pérez, N. Oyaga, J. Ruiz, and A. Villegas. 2018. Towards Systematic Analysis of Cybersickness in High Motion Omnidirectional Video. *2018 Tenth International Conference on Quality of Multimedia Experience (QoMEX)* 7 (2018), 1–3.
[12] J. Steuer. 1992. Defining Virtual Reality: Characteristics Determining Telepresence. *J. Communication* 42, 4 (1992), 73–94.
[13] B.G. Witmer and M.J. Singer. 1998. Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments* 7, 3 (1998), 225–240.
[14] L. Xiao, A. Kaplanyan, A. Fix, M. Chapman, and D. Lanman. 2018. DeepFocus. *ACM Trans. Graphics* 37, 6 (dec 2018), 1–13.
[15] C. Youngblut. 2003. Experience of Presence in Virtual Environments. *Virgina Institute Defense Analyses* Sep. (2003), 158.