Using Gameplay and Players Data to Recommend Strategies to Reduce Cybersickness

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***Abstract*—Virtual Reality (VR) is an upcoming trend in games and entertainment applications as the use of head-mounted displays becomes accessible for the mass market. These systems aim to provide immersive experiences, but they still do not provide a completely seamless experience, mostly due to sickness symptoms that can be experienced by the players. Cybersickness (CS) is one of the most critical problems that make the game industry fearful for higher investments. In this work, we made a critical study on the theories and causes of CS in virtual environments. We unified in a paper most of the leading hardware and software proposals to identify, quantify and minimize the main sickness problems. We also provide clarification about the most relevant measurement tools used to quantify the level of sickness for one or more players through specific questionnaires. We also developed a demo plugin for a commercial game engine to collect relevant data in a VR game to use as a database to future research approaches to enhance user experience in head-mounted displays.**

***Index Terms*—head mounted displays,sickness theories,motion sickness,virtual environments,user experience, cybersickness**

I. Introduction

We are experiencing the inclusion of a new entertainment way in most of the systems. VR is an important area to deliver immersive 3D graphics in entertainment applications, serious games, and applications to training people (in health, technological, military or scientific domains).

In the meantime, most of head-mounted displays users feel one or more symptoms of sickness, primarily if the user uses them for an extended time [10]. According to Ramsey et al. [16], on average, eighty percent of participants who experienced VR with HMDs felt discomfort after the first 10 minutes of exposure to the virtual environment. Therefore, more extensive VR experiences tend to cause more considerable discomfort than shorter experiences. However, this discomfort may vary from individual to individual, as some people are more sensitive than others when using these devices.

In the bibliography there are some theories [9], [12] about ways and causes of visual discomfort in VR that points to sensory confusion between the vestibular and vision systems as the responsible for most frequent problems that cause discomfort to HMD users. Jerald et al. [7] associate the sensory conflict to high latency resulting in an incorrect content presentation related to the movement made with the HMD device and possibly generated sickness.

II. Motivation

According to Hua [6], minimizing sickness in virtual and augmented reality applications is an unresolved challenge. Discomfort resulting from VR can be originated from three leading causes: motion sickness, cybersickness (CS), or simulator sickness.

For this reason, many researches involving sickness in HMDs have been done recently in order to minimize sickness in these devices [8], [18], [1]. In this research, we map the various causes and symptoms of sickness that occurred during the use of HMDs (be it machine or human actions) [17], [21], [13], [3].

We investigate the causes and solutions in literature [11], [19], [4], [20], [14] in order to expose possible methods towards quantifying sickness.

We believe with this based-literature study, it'll be possible to construct a machine learning model to predict and suggest comfort techniques to minimize CS in VR environments.

III. Related Work

The literature still lacks a comprehensive bibliography about this subject, with most works consisting of empirical observations and reports.

Padmanaban et al. [15] derived a study to design a VR sickness predictor. They used insights from the current simulator sickness literature. According to Padmanaban, they do not focus on minimizing sickness based on VR headset estimated evolution. They use the approach to create a dataset, some questionnaires to evaluate physiological causes of sickness and individual historical elements to get a more precise result from users. They combine two sickness questionnaires: MSSQ and SSQ to find a single sickness value. They measured SSQ scores from various individuals through stereoscopic content. They used Flownet [2] to calculate optical flow vectors (they calculate optical flow from one frame to the next, which measures pixel speed).

Garcia-Agundez et al. [5] done research to classify CS and determine if the CS occurred after the gameplay in a VR scene. The model was based on a combination of bio-signal and game settings. They collected user signals data (like respiratory and skin conductivity) from a total of 66 participants. As a result, they mentioned a classification accuracy of 82% for binary classification and 56% for ternary.

IV. Proposed Solution

We propose creating a real-time comfortable gameplay user experience thought the CS prediction and comfort techniques suggestion. For this reason, we aim to overcome the following challenges:

- **Investigation:** An in-depth literature investigation to associate CS causes to minimizing techniques.
- **Dataset Definition:** Relevant data selection (player profile data and gameplay data) to create a dataset.
- **Development:** The development of plugin to capture and export gameplay and user profile data into a robust dataset.
- **Dataset Training:** Train of the generated dataset with two or more neural network models and compare each other to choose the best-fit model.
- **Cybersickness (CS) Prediction:** Use of the best neural network model to predict and identify CS in real-time during the gameplay.
- **Strategy Suggestion:** Develop an automatic strategies suggestion for minimizing CS during the gameplay.

Different from Padmanaban, we intend to classify and quantify the CS level using game scene parameters and player profile data. Garcia-Agundez is more closely related to our work. However, both of them aims to classify the user's CS before or/and after the experience. We focus on the classification in real-time during the exact moment of the experiment. We also intend to develop an independent solution of external equipment (like medical-biological signal measuring equipment) as the works mentioned.

V. Preliminary Results

We made a critical study and associated the most relevant CS causes to solutions. We developed a plugin for a commercial game engine able to collect player profile and gameplay data and export each experience in a XML file. While we are researching about the best-fit machine learning model, we make some preliminary user's test with six individuals in a pilot test. We reconfirm some of the CS causes before related. However, the number of individuals was not enough to make a definitive conclusion. For this reason, we still have to overcome many challenges.

VI. Conclusion

In this work, we study some strategies that can minimize the causes of discomfort in virtual environments. Through the current bibliography, we have gathered the main ways of measuring discomfort in VR environments. As a result, we develop a plugin for a commercial game engine that works with most of the VR games and collect relevant data during the gameplay experience. With this data, we intend to create a robust database for CS identification.

References

[1] H. Buhler, S. Misztal, and J. Schild. Reducing vr sickness through peripheral visual effects. In *2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pages 517–9. IEEE, 2018.

[2] A. Dosovitskiy, P. Fischer, E. Ilg, P. Hausser, C. Hazirbas, V. Golkov, P. Van Der Smagt, D. Cremers, and T. Brox. Flownet: Learning optical flow with convolutional networks. In *Proceedings of the IEEE International Conference on Computer Vision*, pages 2758–2766, 2015.

[3] J. Drexler. Identification of system design features that affect sickness in virtual environments. 2006.

[4] A. S. Fernandes and S. K. Feiner. Combating vr sickness through subtle dynamic field-of-view modification. In *2016 IEEE Symposium on 3D User Interfaces (3DUI)*, pages 201–210. IEEE, 2016.

[5] A. Garcia-Agundez, C. Reuter, H. Becker, R. Konrad, P. Caserman, A. Miede, and S. Göbel. Development of a classifier to determine factors causing cybersickness in virtual reality environments. *Games for health journal*, 2019.

[6] H. Hua and B. Javidi. A 3d integral imaging optical see-through head-mounted display. *Optics express*, 22(11):13484–13491, 2014.

[7] J. Jerald and M. Whitton. Relating scene-motion thresholds to latency thresholds for head-mounted displays. In *Virtual Reality Conference, 2009. VR 2009. IEEE*, pages 211–218. IEEE, 2009.

[8] J. Kim, W. Kim, S. Ahn, J. Kim, and S. Lee. Virtual reality sickness predictor: Analysis of visual-vestibular conflict and vr contents. In *2018 Tenth International Conference on Quality of Multimedia Experience (QoMEX)*, pages 1–6. IEEE, 2018.

[9] E. M. Kolasinski. Simulator sickness in virtual environments. Technical report, DTIC Document, 1995.

[10] P.-Y. Laffont and A. Hasnain. Adaptive dynamic refocusing: toward solving discomfort in virtual reality. In *ACM SIGGRAPH 2017 Emerging Technologies*, page 1. ACM, 2017.

[11] E. Langbehn, P. Lubos, and F. Steinicke. Evaluation of locomotion techniques for room-scale vr: Joystick, teleportation, and redirected walking. In *Proceedings of the Virtual Reality International Conference-Laval Virtual*, page 4. ACM, 2018.

[12] J. J. LaViola Jr. A discussion of cybersickness in virtual environments. *ACM SIGCHI Bulletin*, 32(1):47–56, 2000.

[13] J. J. Lin, H. Abi-Rached, and M. Lahav. Virtual guiding avatar: An effective procedure to reduce simulator sickness in virtual environments. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 719–726. ACM, 2004.

[14] N. Norouzi, G. Bruder, and G. Welch. Assessing vignetting as a means to reduce vr sickness during amplified head rotations. In *Proceedings of the 15th ACM Symposium on Applied Perception*, page 19. ACM, 2018.

[15] N. Padmanaban, R. Konrad, T. Stramer, E. A. Cooper, and G. Wetzstein. Optimizing virtual reality for all users through gaze-contingent and adaptive focus displays. *Proceedings of the National Academy of Sciences*, page 201617251, 2017.

[16] A. Ramsey, S. Nichols, and S. Cobb. Virtual reality induced symptoms and effects (vrise) in four different virtual reality display conditions. In *Proceedings of HCI International (the 8th International Conference on Human-Computer Interaction) on Human-Computer Interaction: Ergonomics and User Interfaces-Volume I-Volume I*, pages 142–146. L. Erlbaum Associates Inc., 1999.

[17] L. R. Rebenitsch. *Cybersickness prioritization and modeling*. Michigan State University, 2015.

[18] A. N. Ryge, C. Vollmers, J. S. Hvass, L. K. Andersen, T. Berthelsen, J. R. Bruun-Pedersen, N. C. Nilsson, and R. Nordahl. A preliminary investigation of the effects of discrete virtual rotation on cybersickness. In *2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pages 675–676. IEEE, 2018.

[19] R. J. Teather. Viewpoint snapping to reduce cybersickness in virtual reality.

[20] H. T. Tran, N. P. Ngoc, C. T. Pham, Y. J. Jung, and T. C. Thang. A subjective study on qoe of 360 video for vr communication. In *2017 IEEE 19th International Workshop on Multimedia Signal Processing (MMSP)*, pages 1–6. IEEE, 2017.

[21] T. Zhang, H. T. Nefs, and I. Heynderickx. Human discrimination of depth of field in stereoscopic and nonstereoscopic photographs. *Perception*, 43(5):368–380, 2014.