Position Paper: Remote Collection of Physiological Data in a Virtual Reality Study

Collection of physiological data in a fully remote setting via bio signal enabled virtual reality headset

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Recent pandemic related events have effectively put a stop to most in-lab data collection which has a profound negative impact on many research fields. Online and remote data collection, without the need to travel to a laboratory, starts to be used as a valuable alternative in some scenarios. This approach does not only help to resume some research activities, it also has an enormous potential to change how research is conducted in future. With the use of our biometric sensing system for Virtual Reality (emteqGO), we designed a VR experience autonomously guiding participants through the study. The combination of hardware posted to participants, alongside software solutions handling the setup, data collection, quality assurance and upload for immediate access enables a fully remote, unsupervised approach to data collection. While this approach might be the only feasible solution for some researchers, it has also laid the groundwork for possible future direction of research where remote data collection is a new way to enhance access to participants who typically would not travel to the laboratories. In designing these solutions, we found that for unsupervised remote data collection to work effectively, setup procedures must be easy to follow to obtain high quality data and the entire process must be highly robust, reliable, and built with a high degree of redundancy. Post-pandemic, there are many benefits of an ongoing use of remote research paradigms. These include ameliorating the diversity problem afflicting current research by widening the participant pool, improved research quality by collecting data in more naturalistic environments, and improving protocol standardisation using virtual reality.

CCS CONCEPTS • hardware~communication hardware, interfaces and storage~sensor devices and platforms • hardware~emerging technologies~analysis and design of emerging devices and systems~emerging tools and methodologies • Human-centered computing~Human computer interaction (HCI)~Interaction paradigms~virtual reality

Additional Keywords and Phrases: remote data collection, virtual reality, XR, biometrics, EMG, PPG, IMU

ACM Reference Format:
First Author's Name, Initials, and Last Name, Second Author's Name, Initials, and Last Name, and Third Author's Name, Initials, and Last Name. 2018. Position Paper: Remote Collection of Physiological Data in a Virtual Reality Study: ACM Conference Proceedings Manuscript Submission Template: Collection of physiological data in a fully remote setting via bio signal enabled virtual reality headset. In Woodstock,'18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY. ACM, New York, NY, USA, 10 pages.

1 INTRODUCTION

Data collection from participants in a lab setting has not been feasible due to the currently imposed restrictions on travel and social distancing. In order to continue with our research that requires physiological data collection while wearing a VR headset, a shift to remote data collection was necessary. This resulted in a redesign of our VR study as well as the underlying architecture.

2 RELATED WORK

Virtual and augmented reality technologies (VR and AR) are standardly used in many research communities across many different fields such as computer science, engineering, neuroscience, surgery, education and rehabilitation to name a few [1]. This can be partially attributed to continued technological improvements, reduced cost, ecological validity [2] and an ability to replicate real environments in controlled setting at a fraction of the cost [3]. The COVID-19 pandemic has had a massive impact on all research, redirecting focus and resources prioritising COVID-19 activities, while curtailing all other research through travel restrictions alongside social distancing measures preventing effective participant recruitment [4], [5]. Remote research aims to tackle some of these challenges [6] by removing the requirement of physical presence of researchers during data collection with potential to carry out fully automated, unsupervised studies.

3 PARTICIPANT RECRUITMENT

Participants were recruited online from UK general population using a survey. Equipment delivery was scheduled for a specific data collection day. Participants were asked to repackage all equipment and courier collection was arranged (Appendix A1). As most headsets have focal length set between 1-2 meters, participants who can see clearly at that distance should not need any eye correction with no distant objects used in the study. As our study involved self-rating of emotional response, Toronto Alexithymia Questionnaire [7] was also included in order to exclude participants with alexithymia (score 51/61 low/high alexithymia). Participant recruitment was a multistage process that required a large amount of participant involvement and continuous communication with the research team. This can seem complicated to participants, reducing likelihood to participate. In future, using a device that participants already own would drastically improve this process but due to the desire to use our own custom biosensing hardware, this was not an option.

4 DATA COLLECTION HARDWARE

The EmteqGO device was chosen for this remote VR study. It features a Pico G2 4k headset which is a self-contained 3Dof (Degrees of Freedom) device. This headset was chosen because (1) no additional hardware was necessary and (2) to have a stationary setup up (avoid danger of falling due to movement in limited space). The EmteqGO device has the unique capabilities of replicating many in-lab data collections remotely, where physiological data is captured through its sensors built into the device. Placement of multiple sensors is a critical task to ensure good data quality, usually carried out by trained researcher. Having untrained and unsupervised participants handling this step could result in low quantity of usable data. EmteqGO has all biometric sensors built into a single device that attaches to a virtual reality headset thus avoiding multiple components connected by wires which increase complexity and introduce sensor noise. Data is recorded and saved onto the local device storage. If Wi-Fi connection was established, data will be automatically deleted from the device and uploaded to cloud storage where it can be instantly accessed without having to wait for the device to be shipped back. This can also work as a failsafe in case data was corrupted or of an insufficient quality by checking data either manually or through an automated process before sending the device back. While the study was designed to be run unsupervised, as this is a novel approach, online supervision was carried out to monitor the process.

5 SOFTWARE DESIGN AND ARCHITECTURE REQUIRMENTS

EmteqGo wearable device is not physically connected to the PC and communicates over a wireless network (Figure 1). An instance of DLS (Device Link Service) android application is running on the device's operating system. DLS communicates to ECS across the internet using a custom messaging library over WebSockets (for raw and event data) and via HTTP REST for other messages (e.g., pairing and CRUD operations).

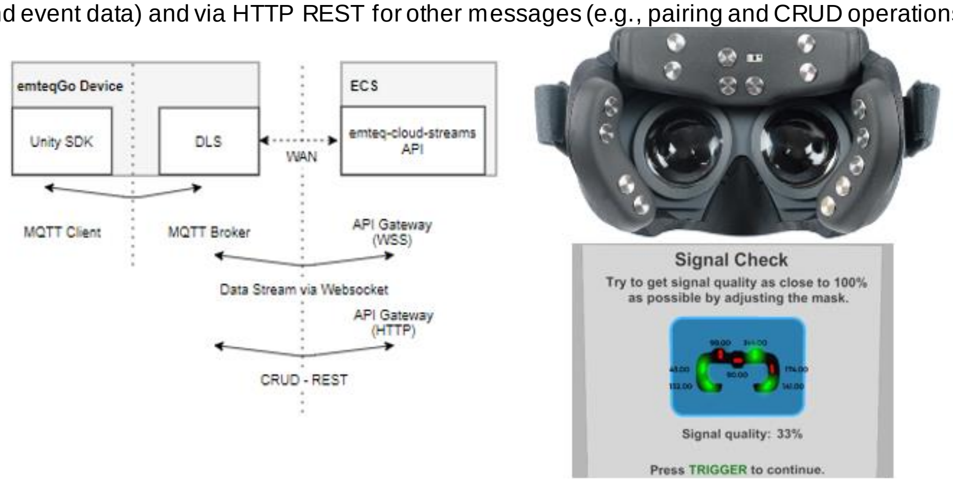

Figure 1: System architecture diagram, emteqGo device and in game-engine signal check tool.

One of the most important requirements for our remote study was temporal correlation between events in virtual reality and physiological data. As the application is driven by user input, each participant will go through the study at a different pace. This was a necessary step as unsupervised studies require training, where participants are introduced to controls and different tasks they are expected to perform. Additionally, participants were given an option to repeat this training stage until they felt comfortable to begin the main study. The consequence of this non-linearity is the inability to use starting time as a reference point for all events. A custom event system (EventMarkers) was designed and implemented into Unity SDK where chosen events triggered a timestamp and a custom message to be recorded. These timestamps were then used to correlate events to the physiological data. EmteqGo provides quality assurance and status verification for each sensor in real time which can be used to monitor signal quality. Participants were presented with a UI window where desirable signal quality for each sensor was shown using red/light sensors in addition to the overall quality. It is possible to prevent users from progressing until a threshold is met but we deemed it was not necessary given online supervision in this iteration of the study as well as a reluctance to exclude participants whose signal might have been below assumed quality expectation. The same system can be used throughout the study if the signal quality suddenly deteriorates. Different approaches could be implemented where participants are asked to correct fit, but a specific threshold would have to be determined and disadvantages from interruptions and obtrusiveness would have to be considered.

6 DISCUSSION

The pandemic has brought forward many innovations. Remote research is now commonplace in situations where data collection is conducted solely using a computer or smartphone. Virtual and augmented reality are the next interaction platforms and initiatives such as the XR Distributed Research Network (xrdrn.org) is extending data collection to those who already have VR devices. As biometric VR will become increasingly commonplace, we are at the cusp of a new paradigm where many of the disadvantages of laboratory research (lack of participant diversity, non-generalisable results, data collected under non-naturalistic settings, poor control of subject attention, use of subjective measures rather than objective data) can be resolved.

ACKNOWLEDGMENTS

This work is supported by Bournemouth University and Emteq Labs. via the Centre for Digital Entertainment (EPSRC Grant No. EP/L016540/1).

REFERENCES

[1] P. Cipresso, I. A. C. Giglioli, M. A. Raya, and G. Riva, "The Past, Present, and Future of Virtual and Augmented Reality Research: A Network and Cluster Analysis of the Literature," *Frontiers in Psychology*, vol. 9, no. NOV, p. 2086, Nov. 2018, doi: 10.3389/fpsyg.2018.02086.

[2] G. Menshikova, Y. Bayakovski, E. Luniakova, M. Pestun, and D. Zakharkin, "Virtual Reality Technology for the Visual Perception Study." Accessed: Jul. 28, 2020. [Online].

[3] C. J. Wilson and A. Soranzo, "The Use of Virtual Reality in Psychology: A Case Study in Visual Perception," 2015, doi: 10.1155/2015/151702.

[4] D. L. Weiner, V. Balasubramaniam, S. I. Shah, and J. R. Javier, "COVID-19 impact on research, lessons learned from COVID-19 research, implications for pediatric research," *Pediatric Research*, vol. 88, no. 2. Springer Nature, pp. 148–150, Aug. 01, 2020, doi: 10.1038/s41390-020-1006-3.

[5] L. Harper *et al.*, "The impact of COVID-19 on research," *Journal of Pediatric Urology*, vol. 16, no. 5, pp. 715–716, Oct. 2020, doi: 10.1016/j.jpurol.2020.07.002.

[6] J. Ratcliffe, F. Soave, N. Bryan-Kinns, L. Tokarchuk, and I. Farkhatdinov, "Extended Reality (XR) Remote Research: a Survey of Drawbacks and Opportunities," Jan. 2021, doi: 10.1145/3411764.3445170.

[7] R. M. Bagby, J. D. A. Parker, and G. J. Taylor, "The twenty-item Toronto Alexithymia scale-I. Item selection and cross-validation of the factor structure," *Journal of Psychosomatic Research*, vol. 38, no. 1, pp. 23–32, Jan. 1994, doi: 10.1016/0022-3999(94)90005-1.

A APPENDICES

A.1 Study flow chart