2023 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW) | 979-8-3503-4839-2/23/$31.00 ©2023 IEEE | DOI: 10.1109/VRW58643.2023.00352

VRdoGraphy: An Empathic VR Photography Experience

Kunal Gupta*
Empathic Computing Lab, University of Auckland

Yuewei Zhang†
Empathic Computing Lab, University of Auckland

Tamil Selvan Gunasekaran‡
Empathic Computing Lab, University of Auckland

Prasanth Sasikumar§
Empathic Computing Lab, University of Auckland

Nanditha Krishna¶
Amrita Vishwa Vidyapeetham

Yun Suen Pai‖
Keio University Graduate School of Media Design

Mark Billinghurst**
Empathic Computing Lab, University of Auckland

Abstract

This demo presents VRdoGraphy, a VR photography application where the environment and virtual companion adapt to provide empathic interactions. Using the Galea VR HMD with a range of biosensors, we fed the user's EEG, EDA, EMG, and HRV biosignals into a live emotion prediction system estimating the user's emotions. The VR environment and virtual companion adapt their appearance & tone based on the user's emotions. It shows how VR HMDs with integrated biosensors can provide empathic interactions.

Index Terms: Human-centered computing—Virtual reality—Biosignals—Empathic Interactions

1 Introduction

This demonstration shows how a Virtual Reality (VR) head-mounted display (HMD) with a range of different integrated physiological sensors can be used to create emotionally responsive VR environments and support Empathic Interactions (EIs). EIs are human-computer interactions that adapt to the emotional states of the human involved. These interactions could be with the environment in the form of audio and visual adaptations, with non-player components (NPCs) in the form of empathic conversations, and with voice or avatar-based virtual companions in the form of empathic assistance. In all cases, understanding the user's real-time emotional state is necessary to provide continuous empathic interactions.

With advances in sensing technologies, VR HMDs are beginning to have systems integrated into them for capturing the user's biosignals. For example, the Meta OuestPro can measure eye gaze and face expression [8], and the HP Omnicept can measure Heart Rate Variability (HRV), eye gaze, pupil dilation, and face expression [2]. Additional sensors can be added to VR HMDs to provide these capabilities, such as the Looxid Link [3] which adds Electroencephalogram (EEG) sensing to HTC Vive HMDs, or the emteqPro [1] which can add Electromyography (EMG), Photoplethysmogram (PPG) and eye-tracking to the Pico VR HMD. Research prototypes such as the PhysioHMD [5] integrate EMG, EEG, Electrodermal Activity (EDA), electrocardiogram (ECG), and eye-tracking sensors into a VR HMD. Past researchers have used these real-time physiological signals to predict emotional states in VR [6].

However, one important research question is how to have the VR application respond to the user's different emotional states as captured by these sensors. Previous research has demonstrated VR environments [7] or virtual characters in VR that react to user emotions [9]. In our research, we have created a platform for creating Empathic Interactions in VR based on the physiological sensor input from the VR HMD. To demonstrate this we have created a VR photo-taking application with both an emotion-adaptive virtual environment and an empathic companion.

This research uses the Galea VR HMD [4] 1, which contains the widest range of physiological sensors integrated into a VR display to date, with EEG, EOG, EDA, HRV, EMG, and Eye gaze biosignals. The Galea uses the Vajeo Aero HMD, which has a 115-degree field of view, a resolution of 2880 x 2720 pixels per eye, and 35 pixels per degree. It also has integrated eye-tracking at 200 Hz with sub-degree accuracy. The Galea has 8 EEG sensors across the top (2 sensors) and the back (6 sensors) of the head, where the visual cortex is. In the faceplate of the HMD, there are two additional EEG sensors, four EMG sensors, two EDA sensors, four EOG sensors, and a PPG sensor. Figure 2 shows the sensor placement.

The demonstration uses a machine-learning (ML) live emotion recognition system modeled with EEG, EDA, HRV, and Eye gaze biosignals to estimate the user's emotional state. The VR environment adapts the color of the scene and audio components to respond to the predicted emotional state. For example, when the user is feeling happy the scene has a yellow tint, while it turns green when the user is feeling relaxed. The user is also accompanied by an empathic companion attached to their viewpoint, and represented by an abstract circular image. When the user asks for assistance, a virtual companion's voice and visual appearance adapt as an empathic response. For example, if the user is happy the companion's voice will have a happy tone, and the circle is coloured yellow. See figure 3 showing the changing scene colours and character representation based on user emotional state.

Through this research project, we want to investigate the impact of these empathic interactions on the emotional states, game experience, presence, engagement, cognitive load, and trust level of the companion when the user interacts with this virtual experience. The main novelty of this research is using a single VR sensor package to capture physiological cues (the Galea HMD), creating an ML module that can estimate emotional state (arousal and valence) from a range of different cues, and having a VR application (VRdoGraphy) that adapts both its environmental state, and virtual characters based on user emotions.

*e-mail: kgup421@aucklanduni.ac.nz
†e-mail: yzhb544@aucklanduni.ac.nz
‡e-mail: themastergts007@gmail.com
§e-mail: psas598@aucklanduni.ac.nz
¶e-mail: nandithakrish4@gmail.com
‖e-mail: yspai1412@gmail.com
**e-mail: mark.billinghurst@auckland.ac.nz

979-8-3503-4839-2/23/$31.00 ©2023 IEEE
DOI 10.1109/VRW58643.2023.00352

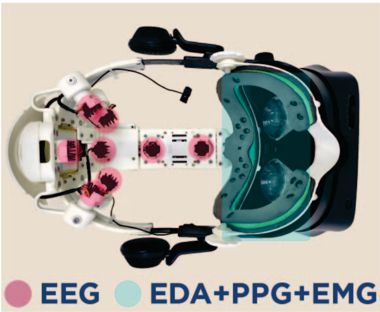

Figure 1: Galea HMD (bottom view): Red circles show EEG electrodes, and Blue rectangles show EMG, EDA, and PPG sensors

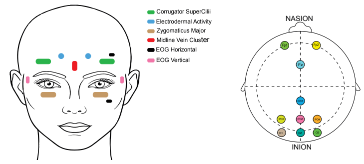

Figure 2: Galea electrode placement. (Left) Galea Sensors sensor touch-points including Fp1 and Fp2

Figure 3: VRdoGraphy VR view. The environment changes its color tint based on the user's real-time emotional states. The empathic companion adapts its color and speaking tone based on emotions.

2 Design and User Experience

The VRdoGraphy demo provides an immersive monument hunt scenario, where users are tasked with taking the best possible virtual photographs of two monuments on a virtual island. However, they can only take eight photos and have a limited time (7 minutes). In addition, they have a virtual companion to help them with navigation, timer, and photo-taking. The demo is designed to explore the role of empathic interactions, such as emotion-adaptive environments and empathic voice assistants, on the flow state, engagement, enjoyment, and as a positive technology when the user interacts in VR.

In the experience, the user begins at a camping site on the island. They have 7 minutes to search for the two monuments and take photographs. In one of their virtual hands, they have a camera that will take virtual photos when they raise it to their face and push a button on the VR controller. Every time the user clicks a photo, their virtual companion will inform them of the remaining photos and ask if they want to keep the picture. While the user interacts with the environment, the Galea HMD streams their EEG, EMG, HRV, and EDA information to the emotion recognition system. The predicted emotion will adapt the VR environment's visual elements and the empathic component in the virtual companion. Users can ask the companion about the direction to the next monument, and it will respond in an empathic tone with the relative path. The companion also informs the user when half the time is over, when 60 seconds are left, and when the last 10 seconds are left, increasing their stress.

3 Implementation

This demo has three main elements: the BioSignal Processor (BP), the Emotion Predictor, and the empathic adaptor. In the BP, the Galea headset collects the EEG, EMG, EDA, and PPG and streams it to a python-based signal processor through Lab Streaming Layer (LSL) protocol. In the signal processing layer, BioSignal features are extracted from the raw signals through data cleaning, preprocessing, and feature extraction steps. These features are tested through the Emotion Predictor element's pre-trained ML-based emotion classification model. The predicted emotional state is shared with the Empathic Adaptor embedded in the VR via LSL protocol.

Emotion Predictors can report 'excited' ($Valence >= 5/9, Arousal >= 5/9$), 'stressed' ($Valence < 5/9, Arousal >= 5/9$), 'bored' ($Valence < 5/9, Arousal < 5/9$), and 'serene' or 'relaxed' ($Valence >= 5/9, Arousal < 5/9$) emotional states. In the Empathic Adaptor, we reflected the user's current emotional state via a color tint filter applied on their eyes, I.e., yellow tint for 'excited,' red tint for 'stressed,' blue tint for 'bored,' and greenish-yellow tint for 'relaxed' as per the Itten's Color system adjusted to fit Russell's circumplex model of affect [10]. After a pilot test with 4 participants, we used a 'cheerful' emotional tone for 'excited,' 'empathetic' for 'stressed,' 'hopeful' for 'bored,' and 'excited' for a 'relaxed' emotional state. We used Microsoft's Speech SDK to implement the companion's voice. The entire experience is developed on Unity3D version 2020.3.28f and viewed on the Galea VR HMD via SteamVR.

4 Research Plans

VRdoGraphy demonstrates the use of physiological sensing and empathic feedback in a photo-taking VR application; the most important aspect is developing a sensing and ML platform that could be applied to many different types of VR applications. In the future, we look forward to using this to explore the application space. We are interested in understanding the impact of empathic interactions on the users' emotions, engagement, immersive, flow state, and cognitive load in VR. Through this demo project, we will collect the audience's physiological responses when interacting in VR environments to improve our emotion-recognition system. The data will be made publicly available for the research community.

References

[1] Emteq pro. https://www.emteqlabs.com/emteqpro.
[2] Hp omnicept and hp reverb g2 omnicept edition. https://www.hp.com/us-en/vr/reverb-g2-vr-headset-omnicept-edition.html.
[3] Looxid link. https://looxidlink.looxidlabs.com/.
[4] G. Bernal, N. Hidalgo, C. Russomanno, and P. Maes. Galea: A physiological sensing system for behavioral research in virtual environments. In *2022 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pp. 66–76. IEEE, 2022.
[5] G. Bernal, T. Yang, A. Jain, and P. Maes. Physiohmd: a conformable, modular toolkit for collecting physiological data from head-mounted displays. In *Proceedings of the 2018 ACM International Symposium on Wearable Computers*, pp. 160–167, 2018.
[6] K. Gupta, J. Lazarevic, Y. S. Pai, and M. Billinghurst. Affectivelyvr: Towards vr personalized emotion recognition. In *26th ACM Symposium on Virtual Reality Software and Technology*, pp. 1–3, 2020.
[7] K. Gupta, Y. Zhang, Y. S. Pai, and M. Billinghurst. Wizardofvr: An emotion-adaptive virtual wizard experience. In *SIGGRAPH Asia 2021 XR*, pp. 1–2. 2021.
[8] Meta. Meta quest pro: Built with privacy in mind. https://www.oculus.com/blog/meta-quest-pro-privacy/.
[9] K. Skiers, Y. Suen Pai, and K. Minamizawa. Transcendental avatar: Experiencing bioresponsive avatar of the self for improved cognition. In *SIGGRAPH Asia 2022 XR*, pp. 1–2. 2022.
[10] A. Ståhl, K. Höök, and P. Sundström. A foundation for emotional expressivity. In *DUX, Designing for User Experience*. AIGA, 2005.