

AFFECTIVE VISUALIZATION IN VIRTUAL REALITY SYSTEMS

vorgelegt von

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Certificate of Original Authorship

I, Andres Pinilla Palacios declare that this thesis is submitted in fulfilment of the requirements for the award of doctorate degree, in the Faculty of Engineering and IT at the University of Technology Sydney, and the Faculty of Computer Science and Electrical Engineering at the Technische Universität Berlin.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of the requirements for a degree at any other academic institution except as fully acknowledged within the text. This thesis is the result of a Collaborative Doctoral Research Degree program with the Technische Universität Berlin.

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Zusammenfassung

Eine Reihe von Forschungsarbeiten auf dem Gebiet der Mensch-Computer-Interaktion (HCI) legt nahe, dass es möglich ist, durch die Analyse der elektrophysiologischen Reaktionen der Benutzer in Echtzeit auf einige Merkmale ihrer mentalen Verfassung zu schließen. Es ist jedoch unklar, wie die aus den elektrophysiologischen Signalen gewonnenen Informationen genutzt werden können, um die Stimuli innerhalb einer virtuellen Umgebung entsprechend dem affektiven Zustand des Benutzers anzupassen. Daher ist das Hauptziel dieses Forschungsprojekts zu verstehen, wie ein VR-System entwickelt werden kann, das sich automatisch an den affektiven Zustand des Benutzers anpasst. Es wird eine Referenzimplementierung einer Neurofeedback-VR-Erfahrung zum Training der affektiven Selbstregulierung vorgeschlagen. Diese Erfahrung zielt darauf ab, die Fähigkeit der Benutzer zu trainieren, ihre affektiven Zustände freiwillig zu regulieren. Die wichtigsten Beiträge sind (1) die Entwicklung einer Technik zur Erkennung affektiver Zustände bei VR-Nutzern nahezu in Echtzeit; (2) eine virtuelle Umgebung zur visuellen Darstellung affektiver Zustände; und (3) die Implementierung der Technik zur Erkennung von Affekten und der virtuellen Umgebung für die Entwicklung einer Neurofeedback-VR-Erfahrung.

Abstract

A cluster of research in Human-Computer Interaction (HCI) suggests that it is possible to infer some characteristics of users' mental states by analyzing their electrophysiological responses in real-time. However, it is unclear how to use the information extracted from electrophysiological signals to adjust the stimuli inside a virtual environment according to the user's affective state. Therefore, this research project's main objective is to understand how to develop a VR system that adapts automatically to the user's affective state. A reference implementation of a neurofeedback VR experience for training affective self-regulation is proposed. This experience aims to train the ability of users to regulate their affective states voluntarily. The main contributions are (1) the development of a technique for near real-time detection of affective states in VR users; (2) a virtual environment for visual representation of affective states; and (3) the implementation of the affect detection technique and the virtual environment for the development of a neurofeedback VR experience.

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Acronyms

- Action Unit (AU)
- Artifact Subspace Reconstruction (ASR)
- Brain–Computer Interfaces (BCIs)
- Electrocardiography (ECG)
- Electroencephalography (EEG)
- Electromyography (EMG)
- Evaluative Space Model (ESM)
- Facial Action Coding System (FACS)
- Head–Mounted Display (HMD)
- Heart Rate Variability (HRV)
- Human Computer Interaction (HCI)
- Independent Component Analysis (ICA)
- International Affective Pictures System (IAPS)
- Long Short-Term Memory Recurrent Neural Networks (LSTMRNN)
- Low Frequency / High Frequency ratio (LF/HF ratio)
- Ortony, Clore & Collins theory of emotions (OCC theory)
- Pick a Mood (PAM)
- Positive and Negative Affect Schedule (PANAS)
- RR-Intervals (RRI)
- Root Mean Square of Successive Differences (RMSSD)
- Self-Assessment Manikin (SAM)
- Standard Deviation of NN intervals (SDNN)
- Virtual Reality (VR)

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