Human Behavior Modeling by Fusing Physiological Signals and VR Data Within a Self-Awareness Framework

University of Genoa + VR-prepared partners

Our live demonstration showcases a novel framework that integrates simulated VR environment data with physiological signals for anomaly detection and behavior characterization within a Bayesian self-awareness approach.

This work presents a platform that seamlessly combines immersive virtual reality (VR) environments with real-time and multisensor physiological monitoring, enabling transparent and interactive analysis of human behavioral responses. Using BIOPAC MP hardware, the system acquires high-fidelity signals, including electrocardiography (ECG), electrodermal activity (EDA), photoplethysmography (PPG), and respiratory patterns, as participants experience diverse VR serious-gaming scenarios developed within the European B-prepared project (VR-prepared is the VR serious-game component of the B-prepared project, designed to provide an immersive and interactive disaster-preparedness experience). These scenarios are designed to evoke a wide range of behavioral and physiological reactions. In this context, participants engage in VR games that expose them to critical situations or crises that may occur in real life following catastrophic events. They are challenged to apply critical thinking, teamwork, and communication skills to respond effectively to emergencies. Real-time data streams coming from the VR environment are also enriched with visual event markers and triggers.

The core innovation of our work lies in the fusion of both multisensor physiological data and physical VR data to develop data-driven models that can be incrementally learned across different experiences for improved human-computer interaction. During the demo, participants will interact with VR challenges while their physiological signals are monitored live using the AcqKnowledge software. They will be able to observe how their cardiac, dermal, and respiratory signals evolve in response to distinct virtual situations. Event markers allow the system to correlate VR events with physiological responses, clearly illustrating how heart rate, skin conductance, and respiration vary during challenging moments. More specifically, our work employs a Hierarchical Coupled Dynamic Bayesian Network (HCDBN) to model temporal fusion and causal relationships among multiple physiological features and VR contextual variables. This probabilistic modeling approach enables higher-order inferences: after initial monitoring and event correlation, the system incrementally learns patterns in user behavior and detects anomalies or significant changes in human responses.

In summary, our demo illustrates a step forward toward next-generation and self-aware human–machine interaction systems.