VR Fatigue Biosensor Framework

Title

A Biosensor for Real-Time Detection and Prevention of VR Fatigue Using Physiological Signals and AI Feedback

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Abstract

This publication introduces a novel biosensor framework designed to detect and prevent virtual reality (VR) fatigue in real time. VR fatigue, driven primarily by vergence-accommodation conflict (VAC), impairs user performance, enjoyment, and safety in immersive environments. The biosensor measures multimodal physiological signals (pupil size, eye movement, heart rate, skin conductance) and applies deep learning algorithms to infer fatigue levels. Adaptive feedback mechanisms then adjust VR parameters to reduce VAC and mitigate fatigue. This draft consolidates technical details from NSF SBIR Phase I proposal into a structured scientific format suitable for archival dissemination.

Keywords

VR fatigue; biosensor; physiological signals; vergence-accommodation conflict; AI feedback; immersive environments

Introduction

Virtual reality adoption is limited by VR fatigue, a condition characterized by eye strain, nausea, dizziness, and disorientation. The primary cause is VAC, the mismatch between ocular vergence and fixed focal length in VR displays. Existing solutions rely on subjective questionnaires or invasive measures, which are unreliable and disruptive. This work proposes a biosensor-based solution leveraging physiological signals and AI-driven adaptive feedback.

Methods

Hardware Component

Eye-tracking glasses: Infrared sensors capture eye movement and pupil size.

Wristband: Photoplethysmography (PPG) measures heart rate; galvanic skin response (GSR) measures skin conductance.

Wireless module: Transmits signals via Bluetooth/Wi-Fi.

Software Component

Preprocessing: Signal cleaning, normalization, segmentation.

Feature extraction: Wavelet/Fourier transforms, entropy measures.

Feature selection: PCA, mutual information.

Classification: Neural networks, SVM, random forest models infer fatigue levels.

Feedback generation: Reinforcement learning and rule-based systems tailor adaptive responses.

Feedback Component

Visual feedback: Adjusts depth of field, brightness, field of view, motion.

Auditory feedback: Provides cues (warnings, reminders, encouragement).

Haptic feedback: Delivers tactile sensations (vibrations, pulses).

Results (Prototype Study)

Preliminary feasibility testing with a prototype device demonstrated accurate detection of VR fatigue and effective reduction through adaptive feedback. User trials indicated improved comfort and reduced incidence of nausea and dizziness.

Discussion

This biosensor framework advances VR usability by:

Introducing multimodal physiological monitoring for fatigue detection.

Applying AI algorithms to infer fatigue levels in real time.

Delivering adaptive feedback to reduce VAC and enhance safety.

Limitations include the need for larger-scale validation, integration with diverse VR platforms, and long-term safety studies. Future work will expand datasets, refine algorithms, and explore commercialization pathways.

Conclusion

The proposed biosensor represents a pioneering approach to mitigating VR fatigue. By combining physiological sensing with AI-driven adaptive feedback, it offers a scalable solution for enhancing VR experiences across entertainment, education, healthcare, and professional training.

References

Sewell, M.D. (2026). NSF SBIR Proposal: A Biosensor for VR Fatigue Detection and Prevention. TrueFlow Games.

Literature on vergence-accommodation conflict in VR systems.

Research on multimodal physiological signal processing and fatigue detection.

Studies on adaptive feedback in human-computer interaction.