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An Integrated Platform for Assessing the Efficacy of Immersive Virtual Reality Experiences through Biometric Response Analysis

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Abstract

Virtual reality (VR) is increasingly utilized in the construction industry for diverse applications. Immersive virtual reality (IVR) offers practical experiences and educational opportunities for workers, enhancing productivity and safety. Efforts to optimize IVR involve analyzing biometric responses to monitor concentration, assess learning efficiency, and deliver personalized content. However, IVR faces challenges such as high production costs and prolonged production periods. Additionally, integrating biometric response recording into IVR experiences requires separate modules, further extending production timelines.

To address these challenges, an integrated platform is necessary to streamline IVR production, user experience, and biometric response setup and recording. This study introduces such a platform designed to enhance the efficacy of IVR experiences through real-time biometric response analysis. The proposed platform comprises three main processes: (i) IVR content production using Unity; (ii) biometric response definition; and (iii) IVR content experience accompanied by generated logs for biometric responses. Firstly, IVR content production using Unity involves the development of IVR environments and scenarios. The platform incorporates diverse 3D models, including urban landscapes, building elements, and furniture, as the basis for IVR environments. Scenarios are constructed by integrating events into these environments, triggered by conditions such as reaching specific locations, the passage of time, or user interactions. Upon event activation, participants are presented with description UIs, quiz UIs, or route guidance, facilitating engagement and progression through interaction. Secondly, biometric responses encompass eye tracking and EEG. Eye tracking captures pupil diameter and fixation status on Areas of Interest (AOI), defined during IVR content production. EEG recording options include signals from each channel by default, as well as frequency-specific signals and EEG metrics such as attention, stress, fatigue, valence, and arousal. The platform supports the addition of new EEG metrics, enhancing customization and recording capabilities. Lastly, IVR content can be experienced alongside generated logs for biometric responses. The dataset enables monitoring and evaluation of participants' learning performance during IVR experiences, with the potential to enhance worker safety and productivity through immersive practical training and education.

Key words: Immersive virtual reality; Biometric responses; Electroencephalogram (EEG); Eye tracking; Learning performance