Virtual Reality and Biofeedback for Automotive Experience Assessment in Industry 5.0

Gabriel de Brito
SENAI CIMATEC University Centre
Salvador, Bahia, Brazil
gabriel2@aln.senaicimatec.edu.br

Rafael Miguez
SENAI CIMATEC University Centre
Salvador, Bahia, Brazil
rafael.miguez@aln.senaicimatec.edu.br

Felipe Leão Dias
SENAI CIMATEC University Centre
Salvador, Bahia, Brazil
felipe.dias@aln.senaicimatec.edu.br

Daniela Rodrigues
Studio Design
Salvador, Bahia, Brazil
dev.danielarodrigues@gmail.com

Márcio Soussa
SENAI CIMATEC University Centre
Salvador, Bahia, Brazil
marcio.soussa@doc.senaicimatec.edu.br

Ingrid Winkler
INCITE INDUSTRIA 4.0/ SENAI CIMATEC University Centre
Advanced Knowledge Center for Immersive Technologies/ AKCIT
Salvador, Bahia, Brazil
ingrid.winkler@doc.senaicimatec.edu.br

ABSTRACT

In this session of XR Experience, we share our innovative industrial project that integrates biofeedback into a VR-based vehicle experience assessment carried out by the automotive industry. Our research group integrates Pico 4 Enterprise or Meta Quest Pro HMDs with Samsung 7 smartwatch, to showcase the analyses of participants' heart rate and eye tracking data, offering insights into their stress levels, attention, and relaxation responses, surrogating their sense of presence in the immersive automotive experience.

CCS CONCEPTS

• **Applied computing** → **Interactive learning environments**.

KEYWORDS

Virtual Reality, Automotive Industry, Biofeedback

1 INTRODUCTION

The measurement of the sense of presence is essential for the evaluation of virtual reality (VR) environments, as the greater the presence, the higher the user's engagement. A high sense of presence brings benefits such as increased engagement, excitement, satisfaction, and more intense reactions to actions performed in VR. However, presence is often measured only through subjective questionnaires, which do not capture the full complexity of this assessment [1].

In the industry, VR plays an important role by enabling digital transformation and promoting sustainability. The automotive industry, for instance, uses virtual reality to conduct usability and user experience tests [2] [3]. One limitation of these activities is that they heavily rely on the self-reported perceptions of the participants in the experiments regarding their interaction with the vehicle. Moderators evaluate user behavior based on the users' own perceptions, using forms such as the System Usability Scale (SUS).

The integration of measures such as Heart Rate Variability (HRV) and eye tracking can enhance such immersive simulations of industrial scenarios, providing valuable insights into users' behaviors and physiological and behavioral responses. HRV, which measures the variation in time between each heartbeat and reflects the activity of the autonomic nervous system, can be used in immersive simulations of industrial activities to monitor stress and personalize the intensity of the experiment based on the user's physiological responses, maintaining an optimal state. In this context, monitoring HRV helps ensure that users remain engaged and immersed in the immersive environment, leading to more natural physiological responses. Eye tracking, in turn, monitors where and for how long the user's gaze is focused on the immersive environment, tracking attention and providing detailed feedback on areas that require more focus or understanding.

Therefore, an opportunity to understand virtual reality drivers' behaviour is to collect both self-reported data and physiological metrics. Leveraging physiological measures is crucial for evaluating the user experience. With the rise of consumer-level VR and the increasing prevalence of wearable physiological sensors, these metrics are becoming powerful tools for creating personalized and adaptive experiences [4].

However, there are open questions on the measurement of presence in VR, such as the fact that physiological measures can only be used to infer presence in limited circumstances—in particular, for environments that cause measurable arousal. Would immersive environments for critical situations like car accidents be capable of causing measurable arousal allow us to adopt heart rate variability to infer presence in VR-based assessments?

2 OBJECTIVES

We will showcase the analyses of participants' heart rate and eye tracking data to offer insights into their stress levels, attention, and relaxation responses, surrogating their sense of presence in an immersive automotive experience.

3 MATERIALS AND METHODS

Our research group will bring Pico 4 Enterprise or Meta Quest Pro HMDs, integrated with new released Samsung 7 smartwatch, in an immersive environment resembling a vehicle interior (Figures 1,2,3,4). For more information, a supplementary video is available at https://youtube.com/shorts/zHAiAgCsu4g.

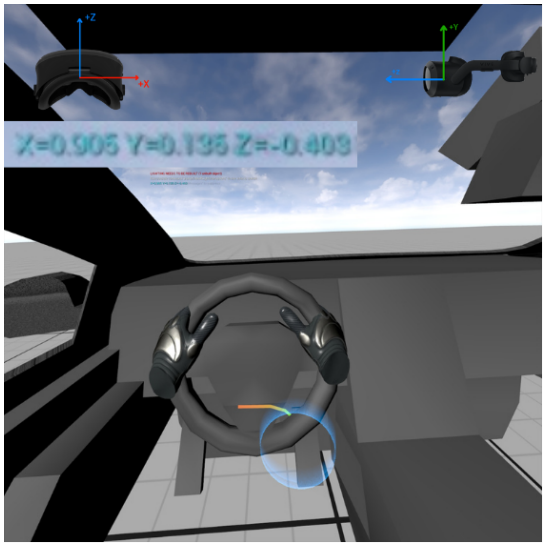

Figure 1: Eye tracking in action

Figure 2: Use of the PICO 4 Enterprise for VR

Figure 3: Experimenting with Audi Vehicle

Figure 4: Experimenting Audi Vehicle and Samsung 7 smartwatch

We will analyse participants' heart rate across three conditions (Heart Rate, Relaxation Responses, and Stress Monitoring) and eye tracking, integrating these data to analyse physiological responses during the XR Experience, for recommending improvements in the current automotive usability and user experience testings.

4 FINAL CONSIDERATIONS

Our XR Experience contributes to understand the users' behaviour in immersive environments.

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