Covid-19 - VR Strikes Back: innovative medical VR training

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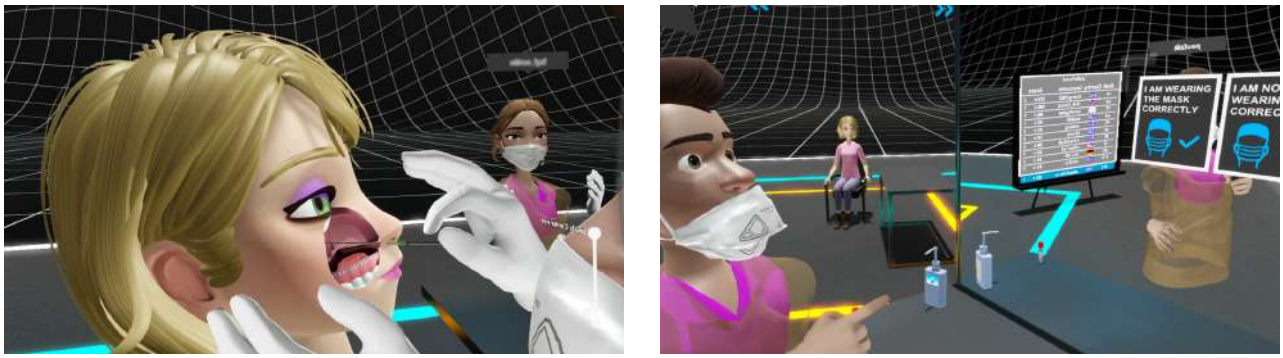

Figure 1: (Left) The instructor demonstrates how to properly perform the swab test. (Right) Use of cognitive questions and the reflective mirror contribute to a more effective learning procedure.

ABSTRACT

In this work, we present "Covid-19 VR Strikes Back" (CVRSB), a novel Virtual Reality (VR) medical training application focusing on a faster and more efficient teaching experience for medical personnel regarding the nasopharyngeal swab and the proper Personal Protective Equipment (PPE) donning and doffing. Our platform incorporates a diversity of innovations: a) techniques to avoid the uncanny valley observed in human representation and interactivity in VR simulations, b) exploitation of Geometric Algebra interpolation engine capabilities and c) supervised machine learning analytics module for real-time recommendations. Our application is publicly available at no cost for most Head Mount Displays (HMDs) and Desktop VR. The impact and effectiveness of our application is proved by recent clinical trials.

CCS CONCEPTS

• **Applied computing** → **Interactive learning environments**; *Collaborative learning*; *E-learning*.

KEYWORDS

Virtual Reality, medical training, Covid-19

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1 INTRODUCTION

The ongoing Covid-19 pandemic stressed the frail healthcare system to its limits. Along with the pre-existing deficiency in medical personnel, doctors are called to improvise and deal with the hot subject of educating the next generation. The need for efficient training of medical postgraduates and nurses, especially regarding Covid-19 related procedures is more imperative than ever.

The ability to swiftly and effectively determine if someone is a carrier via a swab is the key to contain the virus newly-emerged variations from spreading. Joining the global effort, we present "Covid-19 - VR Strikes Back" (CVRSB), a novel Virtual Reality (VR) application, as a reliable method to train medical personnel in Covid-19 testing and protective measures, based on the strict healthcare protocol[Hong et al. 2020]. CVRSB, based on the MAGES SDK [Papagiannakis et al. 2020], provides the benefits of VR training [Besta 2021] and yields performance results similar to the traditional training methods .

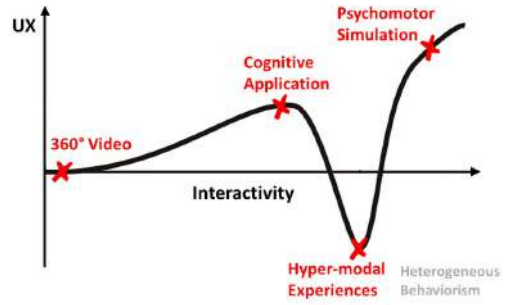

Figure 2: The Uncanny Valley of interactivity as presented in [Zikas et al. 2019].

2 NOVEL FEATURES

According to the uncanny valley of interactivity for VR training phenomenon [Zikas et al. 2019], the user experience augments as the interactivity of the VR application grows but only up to a point - called the "uncanny valley" (see Figure 2). The design of CVRSB was done bearing in mind this point at which the application is too advanced and complex for the user to understand and perform the tasks with ease. The respective uncanny valley point of human representation is avoided using our novel "hybrid inside-out" (HIO) rendering methodology for virtual reality characters. A key insight of HIO is that non-anthropomorphic external character appearance (out) and realistic internal anatomy (inside) can be combined in a hybrid VR rendering simulation approach for networked, deformable, interactable psychomotor and cognitive training simulations. Based on HIO, we introduce non-photorealistic modelling and rendering of non-anthropomorphic embodied conversational agents, avatars and AI agents that distract trainees' attention from UV effects and redirect it on the learning objectives and the training outcomes.

A majority of novel features derive from the fact that the CVRSB application is based on MAGES, a VR software development kit (SDK), developed by ORamaVR, is ideal for rapid code-free creation of prototypes of VR psychomotor simulations of medical operations, due to the embedded visual scripting engine.

The under-the-hood Geometric Algebra (GA) interpolation engine, allows for up to 4x improvement on reduced data network transfer and lower CPU/GPU usage with respect to traditional implementations. As a consequence, a higher number of multiple concurrent users in the same collaborative virtual environment is supported. CVRSB is tested to work with at least 20 users from different countries and with different headsets. Using GA representation to store and transmit rotation and transition data also enables a set of diverse modules [Kamarianakis and Papagiannakis 2020] that can be used in creative way to enrich the immersive experience.

The MAGES incorporated analytics engine allow for efficient detection and logging of the user actions in a format suitable for further processing.

The supervised machine learning module is employed to detect deviations from the expected action courses, e.g., a warning UI will advise a trainee that tries to move close to the examinee without using PPE.

Figure 3: Instructor demonstrates proper disposal of PPE in a virtual classroom.

3 EFFECTIVENESS

The Department of Telemedicine at the Emergency Department of the Inselspital, University Hospital Bern, Switzerland employed CVRSB in a pioneering controlled pilot study among medical students to explore and compare its benefits with respect to traditional teaching methods. The survey concentrated mainly on the short- and long-term effectiveness regarding the teaching of proper hand hygiene and PPE donning/doffing as well as the correct acquisition of a nasopharyngeal specimen for Covid-19 testing. Preliminary unpublished study results reveal a statistically remarkable improvement on sensorimotor performance of VR trainees (about 16%) compared to the traditionally trained ones, while the participants of the VR group also demonstrated higher satisfaction. The full trial results are currently under publication in a scientific journal and will act as affirmation of the efficacy of our VR simulation.

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