



XR in the era of COVID-19

Konstantinos Koumaditis, Christos Mousas & Francesco Chinello

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EDITORIAL

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The COVID-19 pandemic forced many countries worldwide to take restrictive measures from securing borders and minimising movement, cancelling public gatherings, controlling citizens' movement, and even in many cases closing down parts of the business sector. These isolation measures rapidly changed human behaviour concerning conducting business, attending events and meetings, communicating, socialising, and even entertaining themselves.

Subsequently, self-isolating individuals and families explored new technologies and methods to accommodate their needs (Deutrom, Katos, and Ali 2021). Innovative technologies as Virtual, Augmented, and Mixed Reality (VR/AR/MR or, as unified referred, eXtended Reality – XR) have reportedly been utilised to assist this change (Matthews, See, and Day 2020). Virtual conferences, classrooms, workspaces, and meeting rooms have been increasingly populated during this period. Their participants gather to conduct business, research, socialise and even exercise. Additionally, XR solutions assisted remote cooperation and minimised physical human interaction in areas like training, education, manufacturing, and rehabilitation and healthcare services (Radhakrishnan, Chinello, and Koumaditis 2021). Along the same lines, virtual social meeting spaces have seen an upsurge in avatar creation and users' interaction.

Our special issue received several articles from all over the world and after a rigorous double-blind review process, six research papers have been selected to be included in the special issue covering a broad spectrum of XR applications and the way that it is linked with the COVID-19 era.

In the article titled 'The sense of being there during online classes: analysis of usability and presence in web-conferencing systems and virtual reality social platforms' (by Manuela Chessa and Fabio Solari) the authors analyse two modalities that can be used to provide an online university lecture: a standard web conferencing system and a VR social platform. This investigation is focusing on the 'sense of presence' in students (i.e. on the ability to induce the sense of being in a classroom together with the teacher and their classmates). The experiment presented in this

paper allows us to open a wider discussion about the modalities to improve engagement in online lectures either in a 2D virtual environment or in a more immersed version with the use of Head Mounted Displays (HMDs), as the authors mention. A list of lessons learned provides an account of the overall process and may act as inspiration for future research (Chessa and Solari 2021).

The ageing population and the promotion of a healthier lifestyle through the use of a VR application is the subject of the article titled 'Comparison of the usability and flow experience of an exercise promotion virtual reality programme for different age groups' (by Yu-Min Fang and Yen-Jung Huang). This study depicts the design of a VR exercise software programme and sequential comparison with conventional exercise equipment, to assess usability and immersion perceived by older, middle-aged, and young adults. The findings indicate that software usability and immersion hold significant differences between the age groups. In fact, the mean interface learnability score of the young adults is significantly higher than that of the middle-aged and older adults and the mean scores of the overall immersion and the four indicators for the VR exercise were higher than those for the physical exercise, regardless of whether the scores were examined among all participants or for the two age groups separately. The results of this study may assist developers with insights into the design of VR software for older adults (Fang and Huang 2021).

Being trained to perform cardiopulmonary resuscitation can be a lifesaving skill. Yet, such training during the COVID-19 period might be challenging. In the paper titled 'The effects of pre-training intervention in immersive embodied virtual reality cardiopulmonary resuscitation training' (by Qian Liu, Qingyang Tang, and Yanyun Wang) an alternative solution with the use of VR is investigated. The authors led a comparison experiment showing that, regardless of the media immersion level, embodied training is effective in improving self-efficacy, knowledge retention, and skill transfer. Thus, one may depict that the media immersion level and pre-training intervention strategy have a significant interaction effect on the level of skill transfer

and that pre-training intervention promoted skills transfer in VR training but did not have a similar effect on video embodied training. These results indicate that incorporating a pre-training intervention by providing preparatory information can enhance the learning outcomes in VR training (Liu, Tang, and Wang 2021).

During the COVID-19 pandemic, various in-person virtual reality studies were turned into online. Along this line, the paper titled ‘An On-site and Remote Study During the COVID-19 Pandemic on Virtual Hand Appearance and Tactile Feedback’ (by Cui and Mousas) explored the effects of virtual hand appearance and tactile feedback on ownership, external appearance, and tactile sensation dimensions of embodiment both in a lab and remote (online) settings. The authors investigated three virtual hand appearances and two tactile feedback dimensions, composing six experimental conditions. Among others, the results of this study showed that the participants in the lab setting rated the external appearance of a realistic hand model higher than the remotely recruited participants. In addition to the reported findings of this study, the authors provide design considerations for virtual reality applications that consider virtual hands and tactile feedback (Cui and Mousas 2021).

The article entitled, titled ‘GaitWear: a smartwatch application for in-the-wild gait normalisation based on a virtual field study assessing the effects of visual and haptic cueing’ (by Ana de Oliveira, Mohamed Khamis, and Augusto Esteves), explores the potential of Virtual Field Studies as an alternative method to real-world field studies. The authors of this article try to assess four different cues: the visual and haptic cues, that have been traditionally used in previously conducted studies and two novel haptic cues that combine temporal and spatial feedback. To assess the cues, the authors collected the gait and gaze performance of the participants, as well as self-reported ratings including usability, perceived workload, and participant preference. The authors found that the baseline haptic feedback had similar effect to previously conducted studies and that the haptic baseline setting was the one that participants preferred. Lastly, the authors discussed the implementation of GaitWear, a smartwatch application that can be used to produce this haptic baseline on the fly (de Oliveira, Khamis, and Esteves 2021).

Lastly, the article titled ‘A systematic review of immersive virtual reality for industrial skills training’ (by Unnikrishnan Radhakrishnan, Konstantinos Koumaditis, and Francesco Chinello), presents a systematic review of 78 studies that were analysed to explore the potential of virtual reality to provide effective industrial

skills training with a special research focus on remote training. The authors’ work begins by reporting the filtering process that was used to identify the papers for their detailed review. By analysing the research outcomes of the selected papers, the authors attempt to answer their research question. Specifically, based on the conducted review, the authors found that immersive virtual reality (IVR) could be considered a method that can be used for industrial skills training due to its high effectiveness rates. The systematic review also revealed a number of domains that should be further explored to improve the use of IVR in industrial skills training. Among them, the authors report the need for new learning theories and additional metrics for evaluating IVR training. Lastly, the authors discuss less-explored domains that could potentially improve the effectiveness of IVR for industrial skills training, such as using haptics to increase the interaction realism and biosensors for physiological data collection (Radhakrishnan, Koumaditis, and Chinello 2021).

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Konstantinos Koumaditis
Aarhus University, Aarhus, Denmark
✉ kkoumaditis@btech.au.dk

Christos Mousas
Purdue University, West Lafayette, IN, USA
id <http://orcid.org/0000-0003-0955-7959>

Francesco Chinello
Aarhus University, Aarhus, Denmark
id <http://orcid.org/0000-0001-8166-8835>