Extended Reality Solutions in Medical Context and Educational Approaches

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Abstract. The healthcare sector is growing in importance as people continue to age and pandemics complicate the boundary conditions of such systems. The number of innovative approaches to solve singular tasks and problems in this area is only slowly increasing. This is particularly evident when looking at medical technology planning, medical training and process simulation. In this paper a concept for versatile digital improvements to these problems by using state of the art development methods of Virtual Reality (VR) and Augmented Reality (AR) are presented. The programming and design of the software is done with the help of Unity Engine, which provides an open interface for docking with the developed framework for future work. The solutions were tested under domain specific environments and have shown good results and positive feedback.

Keywords. AR/VR, Hospital Planning, Medical Training, Medical Innovation

1. Introduction

The healthcare systems are under pressure, as available trained staff is scarce [1] and the time resources decrease. Highly trained medical professionals are of core importance for a well working healthcare system. In order to train those specialists, several didactic and technological approaches [2] are used. The golden standard nowadays is the inclusion of on-site simulation methods, based on medical case studies. These are usually linked to blocked rooms and staff members over a longer period of time, including briefing and debriefing phases. These bound resources represent one of the main reasons to include novel technological approaches. Digitalization of health services in general became a major part of the health care sector, especially during the COVID-19 pandemic. Not only was digitalization necessary to keep up medical supplies, but it also promoted increased research in this field, like augmented-, mixed- and virtual reality solutions [3]. Lockdowns and reduced mobility options also limited the educational sector. Therefore, research was performed and intensified to find new ways to improve distant learning [4] also in the healthcare sector [5].

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This paper presents possibilities to improve processes like medical training and planning processes in healthcare. To accomplish this task, different kinds of VR and AR prototypes were created.

2. Methods

The central approach for the created solutions was user-centered design to achieve precise and decisive decision-making regarding user experience, as the presented framework builds on requirements determined by possible users in design, development and evaluation. Thereby, the focus was put on two evaluation groups, namely the engineering focused users, which enriched particularly the design and development phases, and the medical personnel, which centered themselves more on the design and evaluation phases. Furthermore, close contact with medical technicians in Austrian hospitals was held, who advised on the technical as well as medical surroundings and circumstances. To evaluate the space planning solutions, the System Usability Scale (SUS) was applied, which was adapted to this project's needs. This allowed a direct comparison between traditional space planning utilities [6] and the presented novel approach, therefore fostering the belief in the validity of digitally facilitating medical problem situations.

In order to achieve scalability and maintainability the Unity Engine was used, which enables the separate applications to be merged at will, while still having the ease of use and performance of working on single subprojects. To facilitate and mainstream Virtual Reality development the Virtual Reality Tool Kit (VRTK) Version 4 was included. Finally, to enable the user to experience AR, the AR Foundation framework was used. This provides functionality to easily determine features in the surrounding area which can then be made the target for 3D-model simulation and visualization. The used methods and technical frameworks allowed iterative production steps, including expert reviews, as well as user experiences.

3. Results

The result of this project is six different working prototypes using virtual and augmented reality to prove the benefits of innovative digital solutions for the healthcare sector. The prototypes can be classified into three categories, namely space planning in medical healthcare, digital copies for improved learning outcome and communication training for medical related scenarios.

The solution created for space planning involves software to give planning professionals the power for designing rooms and healthcare professionals the ability to view and interact in those rooms in VR. This supports spatial imagination and therefore facilitates the planning process. The tests conducted in two hospitals showed positive results. The planning professionals (n=21), who used the configurator software to create medical rooms, reported that the software was simple to use and met their requirements regarding the adaptation of the room for their customers' needs. The healthcare professionals (n=38), who used the VR app to view the created rooms, reported far better understanding of how the room is going to look like in comparison to viewing the room only a 2D map shown in Figure 1. The biggest advantage of this solution has been
identified, to be provided by the possibility to interact with the medical devices and room specific components.

**Figure 1.** Advanced space planning in VR. a) configurator view for planning professionals, b) user of the VR application adjusting a lamp in tailored room setup.

To promote learning of medical devices prototypes for medical devices such as an ECG, shown in Figure 2a, and a lung simulator were created. Two VR apps for learning the functionality of an ECG overall and setting the electrodes in particular, were implemented and are already being successfully used in two study programs at the University of Applied Sciences Technikum Wien. Students reported an overall better understanding of the devices using the apps.

**Figure 2.** a) a fully functional digital copy of an ECG monitor, b) a medical professional using a VR communication training.

To offer a benefit for training medical related scenarios e.g., treatment of a patient inside an ICU a system consisting of a VR app, a moderator app (PC) and a configurator, for configuring medical scenarios, were created (shown in Figure 2b). This setup allows for training of communication between the medical staff in VR while being moderated by a professional. This solution was evaluated by including 23 students of three universities and two knowledge sectors with the focus on education and additional 20 medical professionals (physicians and nurses) with a training focus.

4. Discussion

The results of the presented solutions and their evaluations showed overall a high acceptance and positive feedback for such AR/VR based setups. However, the evaluation phase is an ongoing process and further tests have to be performed. The presented
communication focused training scenarios, including a moderator, were evaluated positively, but needs refinement. Specifically, two aspects have been highlighted by the test users: The environment should be realized with higher fidelity to experience a more intense immersion in the setting. Moreover, singular tools and devices have to be included as tangible and interactable objects, as their proper handling is an important component of the process training overall. Regarding the presented planning solution for medical rooms, the used VR device (Oculus Quest 2) showed some limitations, specifically concerning seamless hand tracking. The observed problems especially occur in case of direct sunlight and heavy reflections of artificial lighting systems. Therefore, further development steps, will include other VR devices and more specific user handbooks to ensure a positive and advantageous experience. Moreover, the developed training solutions are planned to be integrated as additional qualifications in certified continuing education programs, as it is recommended by IMIA [7].

Acknowledgement

The project MedTech-mR has been funded via the Austrian Research Promotion Agency FFG within the program COIN (COIN Aufbau 8. Ausschreibung “FH-Forschung für die Wirtschaft”) by the Austrian Ministry Digital and Economic Affairs (BMDW).

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