Applicability of Mixed Reality in Operating Room

Renato Magalhães, Rita Veloso, Adélio Vilaça, Ana Oliveira, and David Terroso

LabRP, Center for Rehabilitation Research, School of Health, Polytechnic of Porto, Porto, Portugal
Executive Board Member, Centro Hospitalar Universitário Santo António, Porto, Portugal
Orthopedic Department, Centro Hospitalar Universitário Santo António, Porto, Portugal
Porto School of Engineering, Polytechnic of Porto, Portugal
Academic Clinical Center ICBAS { CHUdSA, Porto, Portugal
Correspondence: rfm@ess.ipp.pt

DOI: *https://doi.org/10.17979/spudc.000024.11*

Abstract: Mixed Reality (MR) technology has emerged as a promising tool for enhancing surgical procedures and training in the operating room (OR). The applicability of MR in the OR has potential benefits and challenges. In this study, we conducted a systematic review to comprehensively evaluate the use of MR in the OR, specifically focusing on training, remote support, and surgical planning. Additionally, we analysed available tools, assessing their usability and integration into existing workflows. The analysis highlights MR solutions that improve surgical precision, visualization, decision-making, and educational experiences. The conclusions derived from the systematic review are presented, emphasizing the applicability of MR in OR and its potential contributions to training and surgical planning.

1 Introduction

Over the years, surgical practise (and consequently how it is taught) and the intraoperative space have changed as technology has evolved following the great advances in the field, and seeking safer, faster, and easier methods to succeed in the OR (Roberts et al., 2006). Recently, with the increasing development of computers and related technologies, such as smartphones and tablets, the drive to use them in the OR has followed the trend to take advantage of the main benefits that these devices bring: easily accessible information (Tahamtan et al., 2017).

MR was first mentioned in 1994 by Paul Milgram, and is a blend of physical and digital worlds, unlocking the links between human, computer, and environment interaction (Milgram and Kishino, 1994) and allows clinicians to do something that was previously unthinkable: be in two places at once, without ever leaving one location.

Extended reality can be briefly defined as the use of technology that expands what we feel in the real world with cues from a virtual environment. These cues can be visual, auditory and, in some cases, even haptic or olfactory (Alizadehsalehi et al., 2020).

Traditionally, doctors and students develop theoretical knowledge by participating in real-life clinical scenarios and classroom simulations using mannequins. However, these forms of training have some limitations. The OR could use this kind of technology as a teaching or support tool to give the surgeon access to information, in a completely manipulative way, that would allow him to consult annotations of the surgical technique, contact with other specialists via online, and have access to the patient's information, all within his point of view and without the contact with the device, using gestures, voice commands or even the retina movement. This would allow a better preparation and a flattening of the learning curve for the youngest surgeons, through an immersive experience, filling the void of information access and contact with other specialists with ease, that exists in the modern OR.

2 Methods

To support the development of our work, a systematic review was initially carried out on the use of MR in the OR.

The review goals were defined following the PICO methodology. PICO stands for patient/population, intervention, comparison and outcomes. The PICO methodology is a technique used in evidence-based practice to contextualize and answer clinical questions in terms of specific patient problems that are clinically relevant to evidence in the literature (Roever, 2018).

The first topic we wanted to be answered was in which areas MR applications could be used and be helpful in the OR. The second was what solutions are already implemented and the third was what technical challenges and limitations the MR users face. The fourth topic was what are the effects of MR and its costs and the fifth and final question was what effectiveness was demonstrated to have been achieved.

After this work, applications were developed with the aim of demonstrating the use of the tools in the context of training and surgical planning.

2.1 Transmission to Microsoft HoloLens 2® x-rays obtained during surgery, in real time, into the field of vision

The developed application places the image present in the x-ray monitor, connected to the c-arm in the operating room, but also supports the professional with help exterior to the referred room, with theoretical support and communication via wi-fi, recording or livestreaming the surgeon's point of view, creating more interactive and ludic content for the medical students. To show the x-ray images present on the monitors tower in the surgeon's point of view (Figure 1), it was used a DVI to HDMI converter, where the DVI was connected to the monitors tower or the C- arm, and the HDMI cable would be connected to the video converter from HDMI to USB-C that connected to the computer (Figure 2). The computer would then have a Microsoft Teams® account set up, different from the one logged in the HoloLens 2®, where the video camera exposed on the call was setup to the USB-C port. This will live stream the screen where the DVI cable is connected to the call and show the x-rays from the c-arm monitor on the HoloLens 2®, in real time.

Since Microsoft Teams® was already being used, another functionality was added: implement communication. Since it uses wi-fi connection, the user could communicate with other professionals and technical support, while using the HoloLens 2®. This ability was also used for livestreaming the procedure: allowing two-ways communication between the surgeon and the students, who may want to ask some questions, and the visualization of the professional's point of view. In case the livestreaming function is not possible due to any reason, the HoloLens´ recording functionalities would be used. Although it is not as interactive as the livestreaming, it still shows the professional's point of view.

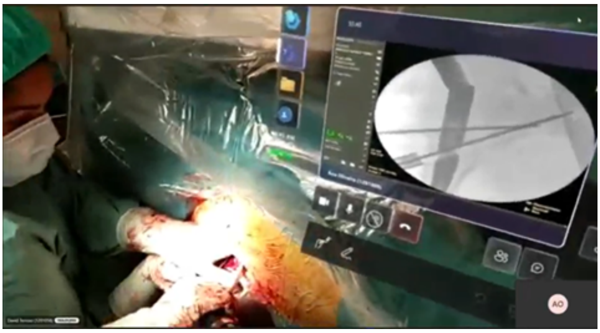

Figure 1: Example of the use of HoloLens to visualize x-rays, intraoperatively.

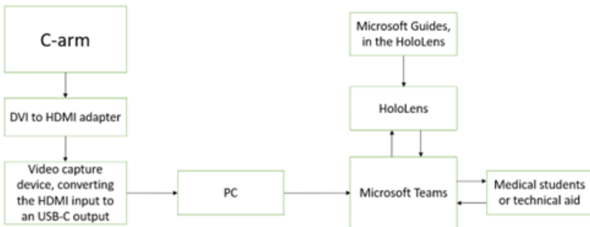

Figure 2: - Relationship between the components of this project.

2.2 Microsoft Dynamics Guides® and HoloLens 2® to create new teaching and training tools for medical education

Microsoft Dynamics 365 Guides® was used to create new teaching and training tools for medical education.

It was created a MR tutorial on Dynamics 365 Guides® about the origin, insertion, nerve supply and actions of the obturator muscles. The 3D model of the pelvis and the muscles was manually segmented from a real patient DICOM image using 3D Slicer next, the image was optimized using Blender and upload to Dynamics 365 Guides®.

The operator starts by scanning the QR code (Figure 3), which functions as an anchor, previously placed by the author in the physical skeleton model. Instructions of this teaching session content showed in the HoloLens 2® in front of the operator whilst an embedded image of the step is shown to the left of the instructions and 3D model of the muscles is displayed (Figure 4). The operator can go to the next step by gazing at the arrow button. The important muscles in the 3D hologram are highlighted in blue.

During the session, students can also interact with healthcare professionals, professors, and colleagues around the world anytime.

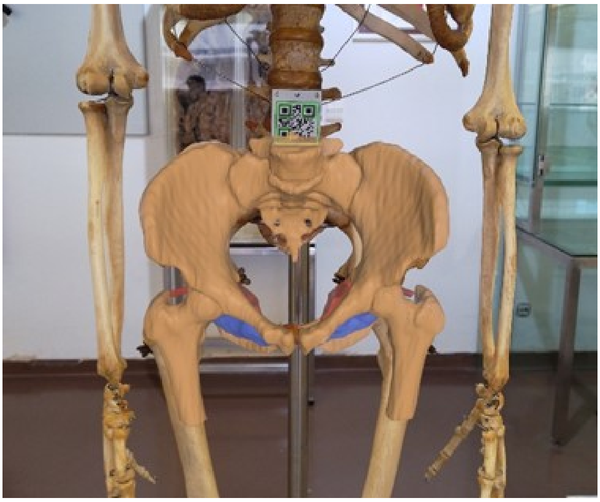

Figure 3: Example of QR Code and position

Figure 4: Example Microsoft Dynamics 365 Guides® preview

3 Results

3.1 Transmission to Microsoft HoloLens 2® x-rays obtained during surgery, in real time, into the field of vision

When implementing the described application, the aim is to diminish the strain and the risk of injury resulting from the unnatural movement present in the OR when the surgeon wants to visualize the image shown in the x-rays monitor. This action can occur multiple times during the intervention, which could lead to errors related to the performance, since redirecting the action may cause loss of concentration in the procedure and parallax errors.

This implementation also seeks flatten the learning curve of the surgical procedure, supporting the learning medics with theoretical support during surgery, allowing the HoloLens 2® user to visualize, while conducting the surgery, theoretical contents, or annotations regarding the procedure. While conducting the first procedures, the surgeons have support of a more experienced professional who needs to be there. However, with this implementation the support does not need to be present, extending the possibilities, but also diminishing the number of people present in the room.

In the field of education, this use case pursuits to create contents of better quality for the medical students. While being present in the OR may be a physical experience to the students, it is not very clear to watch the surgery. Occupying a lot of space in the room, the students can barely see what the surgeon is doing. By recording or livestreaming the procedure from the surgeon´s point of view, it is expected to supply the students with a much more perceptive experience, understanding what is, in fact, happening. The streaming functionality is more interesting than recording, allowing two-ways communication between the students and the surgeon, giving a better insight into the procedure.

The communication between the team members, the team's level of experience, equipment failures, the interaction between the team, the machines and the equipment, and team stress management were the main issues appoint to surgery scenario. Technology can help solve these problems according to the experts that have also agreed that the maintenance of the equipment could be beneficial, as well as easier access to patient information.

3.2 Microsoft Dynamics Guides® and HoloLens 2® to create new teaching and training tools for medical education

The interactive tutorial had good feedback from the professors and doctors that tested it.

A key limitation of this study was provided by the technology itself which remains in relative incipiency. The velocity of the device and other technical aspects of its operation were principal concerns. In a future investigation, it would be interesting to use the tracking function instead of anchors so that the holograms can follow the physical skeleton.

4 Conclusion

Holographic technologies in healthcare emerge as promising solutions and may be alternatives to traditional solutions.

The developments presented received very positive feedback from professionals who tried them. Although more tests must be done in this field, to evaluate the advantages and disadvantages that may arise.

The surgeons who tested it were satisfied and enthusiastic with the application developed for viewing x-rays, as well as the interactive use of the holographic image and the script with Microsoft 365 Guides®.

As future work, an integrated application will be designed in a specific area with options to better satisfy the needs of the surgeon and medical student without compromising surgical performance. After its use in a simulation environment, a tool usability questionnaire will be presented to these professionals to evaluate the impacts of using these tools on training and surgical planning.

Bibliography

S. Alizadehsalehi, A. Hadavi, and J. C. Huang. From BIM to extended reality in AEC industry. *Automation in Construction*, 116, 2020.

P. Milgram and F. Kishino. Taxonomy of mixed reality visual displays. *IEICE Transactions on Information and Systems*, 1994.

K. E. Roberts, R. L. Bell, and A. J. Duffy. Evolution of surgical skills training. *World Journal of Gastroenterology*, 12(20), 2006.

L. Roever. PICO: Model for clinical questions. *Evidence-Based Medicine*, 3(2), 2018.

I. Tahamtan, S. Pajouhanfar, S. Sedghi, M. Azad, and M. Roudbari. Factors affecting smartphone adoption for accessing information in medical settings. *Health Information and Libraries Journal*, 34(2), 2017.