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Proof-of-Concept: Conceptual design and realisation of an educational augmented reality (AR) application for anaesthesia induction

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Abstract: Increasing patient safety during operations is an inevitable topic in anaesthesiology. The cockpit strategy presented by Vogelsang et al. addresses this issue with elements such as closed loop communication and the use of checklists. In this paper, the use of checklists is taken up further. An AR application is presented that augments checklists for anaesthesia induction into the user's field of view. The application is to be implemented in teaching and help prospective physicians to internalise the workflows in anaesthesiology more quickly and sustainably. A working prototype has been created and loaded onto the HoloLens 2. The prototype is being assessed and evaluated by an anaesthetist. The feedback will be included into the following development steps. The application will be further adapted to the needs and requirements of the users. In order to evaluate the usability and the user experience, students and medical professionals should test and evaluate the application repeatedly.

Keywords: anaesthesia induction, augmented reality, hololens, checklist

1 Introduction

With 17 million anaesthesia procedures performed annually in Germany [3], patient safety plays a major role in preventing anaesthesia-related and anaesthesia-associated deaths. With the cockpit strategy, Vogelsang et al. [13] present tools that are intended to optimise the processes in anaesthesia induction and make them safer. The implementation of these already existing tools within AR applications should contribute to internalising the routines and processes more quickly and sustainably. The AR application presented here is based on checklists for the check phase that have been established by Vogelsang et al. [13] in everyday clinical practice. These checklists are to be augmented into the user's field of view and, in particular, provide medical students and newcomers to the profession with the necessary support in simulated anaesthesia to work through and follow the checklists completely. The application is being developed in accordance with the human-centred design process DIN EN ISO 9241-210 [5] in order to develop an application that can be used both in teaching as well as in the induction of anaesthesia and that meets the requirements of the users.

1.1 AR in medical education

The term augmented reality was first used at the beginning of the 1990s [6] and describes systems that overlay reality with virtual content [1]. With the further development of technologies, the first AR glasses such as Google Glasses (2012) or the Microsoft HoloLens (2015) were developed [6]. The use of smartphones and tablets as AR devices expands the availability of AR devices and enables a more widespread use of AR [6].

Thus, numerous studies on the use of AR are also being conducted in medical education. Study results show that even if there is no significant learning success compared to conventional learning, AR has added value in teaching. Students are more motivated by the use of AR [2, 8] and enjoy learning more [2, 4, 11]. This results in added value for the sustainability of what is learned and the learning success.

1.2 State of the art

AR applications that present checklists or instructions already exist in non-medical contexts, for example as maintenance instructions for household appliances [9, 12] and in medical con-

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texts, as instructions for medical procedures or explanations for the use of medical instruments [10].

In the field of anaesthesiology, Zhang et al. [14] place an AR application that conveys and tests theoretical knowledge about anaesthesiology. Furthermore, anaesthesia inductions are simulated. For example, the preparation for anaesthesia, the start of induction and discharge are implemented [14]. Zhang et al. [14] augment text, voice and video elements into the user's field of view.

Another support system worth mentioning for anaesthesiology is the application/web application eGENA (electronic cognitive aid for emergencies in anaesthesia). Once an emergency has calmed down, the checklists and instructions stored in the application can be used to check the previously performed interventions for completeness and correctness [7]. Furthermore, in less urgent emergencies, the instructions can be read out by a team member and then followed [7]. Away from emergencies, the application can also be used for further training [7].

The purpose of our presented application is to create a learning environment that closely resembles reality. It is designed to be used in combination with existing simulations with simulation mannequins, resulting in an optimal learning experience. Multimodal learning with digital content and practical simulation is intended to further promote learning. This feature distinguishes the AR application we present from Zhang et al.'s [14] purely digital application.

2 Materials and methods

2.1 Materials

The AR application is being developed for the Microsoft HoloLens 2. The Unity software in version 2020.3.42f1 is used as the development environment. Furthermore, Visual Studio 2022 (version 17.4.1) is used to compile applications and load them onto the HoloLens. For the graphical components of the application and interaction profiles for the HoloLens 2, the Mixed Reality Toolkit 3 (MRTK3) is used. At the time of conceptualisation, the toolkit is in public preview. This means that some functionalities planned for MRTK3 are not yet available.

2.2 Concept

The application is to be developed primarily for medical students with an interest in anaesthesiology who are taking corresponding elective courses as part of their studies. In addition, the application should also serve as an aid for newcomers to the profession of anaesthesiology in order to quickly find their way around the daily routine of an anaesthetist and to get to know the processes of anaesthesiology. Based on the level of knowledge of the user, it should be possible to choose whether more or less help and explanations are given for the checklist items. Furthermore, the checklist for the control phase can be selected via a menu (see Fig. 1). The menu offers space for further checklists and assistance that can be implemented in the future. The checklists are displayed in a movable and scalable window. To ensure clarity, only 3 elements are displayed in a checklist at a time. Completed elements can be selected with a tap and marked in colour. A progress bar shows the progress of the checklist.

3 Results and discussion

With the MRTK3, an AR application for the HoloLens 2 was successfully created using the Unity software. The application can be started and augments a checklist that is element of the cockpit strategy (see Fig. 2 - 6).

3.1 Results

In the created application, the main menu is opened via a hand gesture. The user can select his experience level and the desired checklist. It is also possible to display information on how to use the application. The described concept was successfully implemented. Using available components (prefabs) from the MRTK3 determines the visual design. The majority of the application consists of panels on which buttons are placed. Button prefabs of MRTK3 have audio-visual feedback that indicates to the user when a button is pressed. The created application is finally evaluated by an anaesthetist. During the initial evaluation, the anaesthetist was first introduced to the control of the AR application. The anaesthetist then had the opportunity to test the application in a neutral environment, separate from a simulation. He thoroughly explored each menu item and provided feedback during a subsequent open discussion.

3.2 Discussion

Evaluation by medical professionals familiar with the cockpit strategy helps to improve the application in terms of content and usability. It turns out that gesture control is rather difficult to implement for an application in a medical context because these additional movements are perceived as disturbing during the induction of anaesthesia. At this point, voice control should

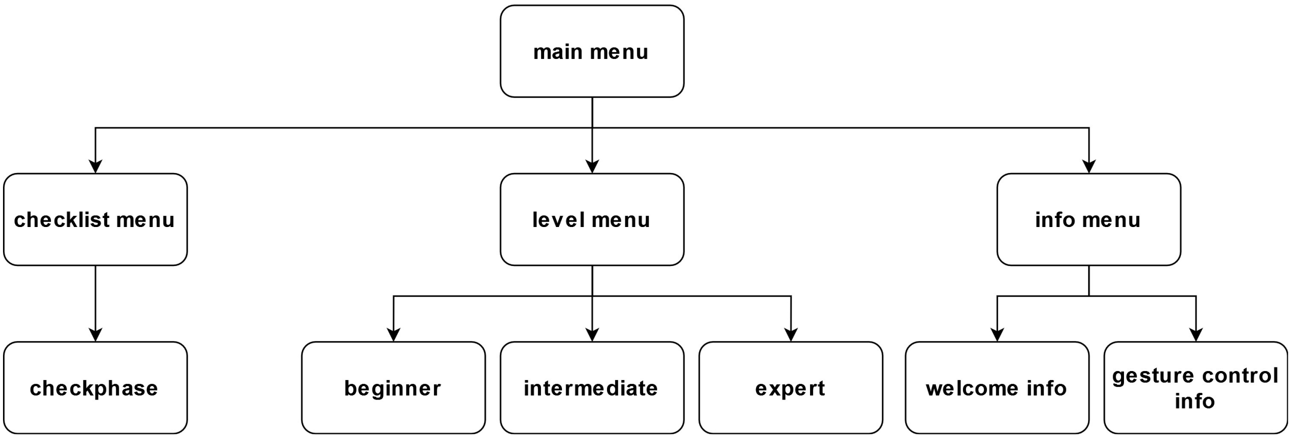

Fig. 1: Menu structure of the conceptualised AR application

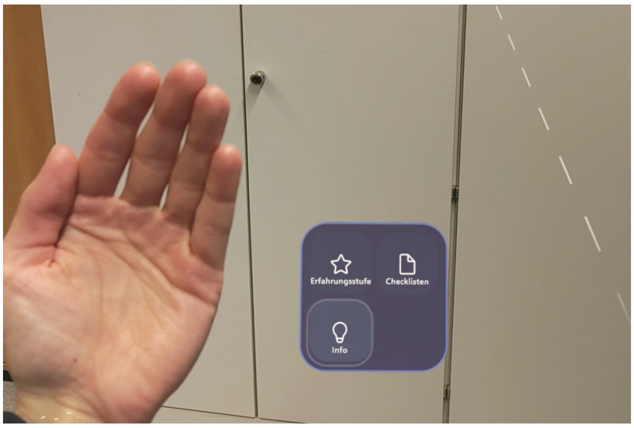

Fig. 2: main menu shown when the ar glasses recognise the palm

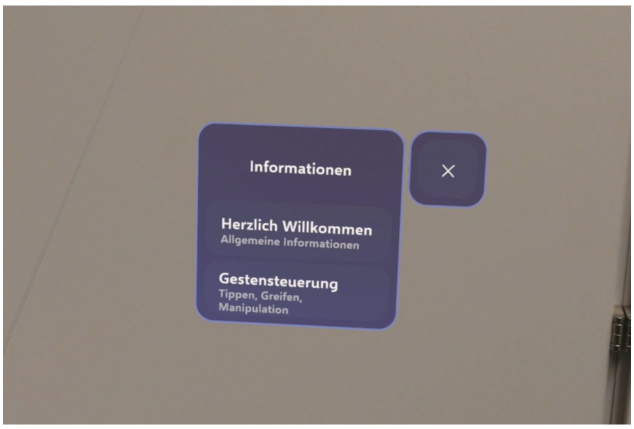

Fig. 3: Menu for more background information

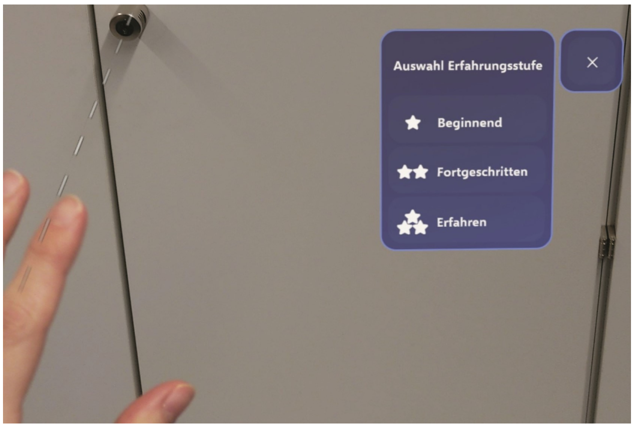

Fig. 4: Menu for selecting level of experience

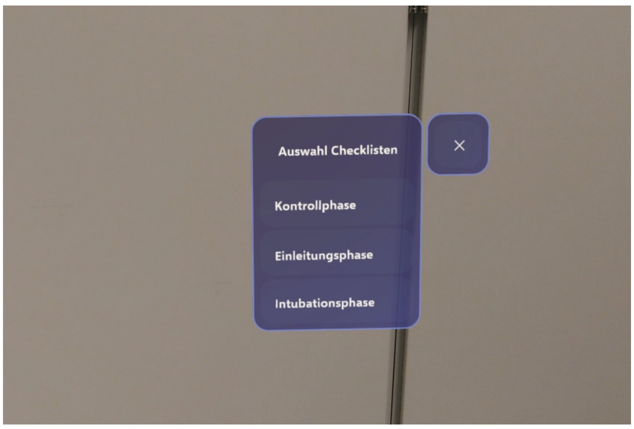

Fig. 5: Menu for selecting a checklist

Fig. 6: Augmented checklist, check phase

be considered as an additional option. There is further potential for improvement, particularly with regard to the usability of the application. A possibility to undo work steps or to simplify the change of checklists would increase the usability. An evaluation by the defined target group is still pending and is planned for the future development steps of the application.

4 Conclusion

Overall, the application created is a good proof-of-concept. It is shown that the realisation of an AR application for displaying checklists in anaesthesia induction or in the medical teaching of anaesthesiology is feasible. Goals to be pursued in the future are the improvement and extension of the current applications with functions such voice control, as well as evaluation with users from the target group.

Author Statement

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