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Visualisation methods for patient monitoring in anaesthetic procedures using augmented reality

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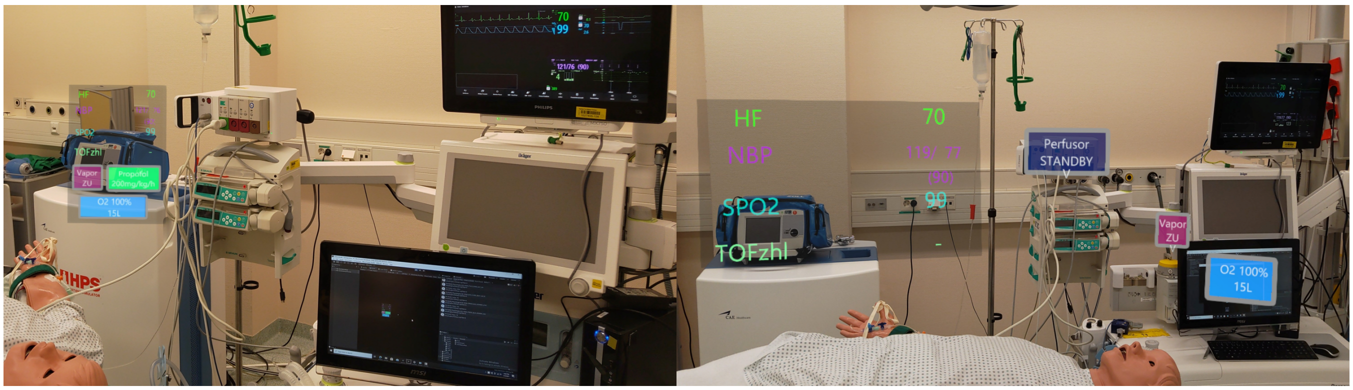

Figure 1: View of the AR patient and device monitoring. (Left: Head-stabilized, Right: World-stabilized)

ABSTRACT

In health care, there are still many devices with poorly designed user interfaces that can lead to user errors. Especially in acute care, an error can lead to critical conditions in patients. Previous research has shown that the use of augmented reality can help to better monitor the condition of patients and better detect unforeseen events. The system created in this work is intended to aid in the detection of changes in patient and equipment-data in order to increase detection of critical conditions or errors.

CCS CONCEPTS

• **Human-centered computing → Mixed / augmented reality**; *Information visualization.*

KEYWORDS

augmented reality, safety-critical-systems, health care

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1 INTRODUCTION

Even though mobile based Augmented-Reality (AR) is leading research efforts, head-mounted-display (HMD) research is close behind, with medicine and industry being the top research areas in that field[2]. Both can be classified as safety-critical, as they are domains where "[...] failure could result in loss of life, significant property damage, or damage to the environment" [5]. Operator error accounts for 60% of deaths and serious injuries in hospitals related to medical devices in the United States according to Lin et al. [6]. They also found that medical devices often promote human error and show that applying human factors design to the interfaces can lead to lower mental workload and fewer errors, therefore increasing patient safety. Especially in emergency surgeries like in the trauma room, a patient monitoring system may be obscured or out of reach, or general distractions might arise due to the amount of people on the room. The use of AR HMDs could help increase safety and reduce errors by providing more easily accessible information about the patient and the medical devices. To evaluate this potential of AR HMDs, we designed an AR monitoring system using a world-stabilized and head-stabilzed presentation of knowledge. We assessed whether the AR monitoring system can aid anesthesiologists in increasing awareness in anesthetic inductions, primarily the detection of abnormal events and deterioration of the patient.

2 RELATED WORK

It has been shown that the use of HMDs can lead to increased safety in such safety-critical-systems: Having a virtual agent displayed in AR giving safety instructions led to a lower number of safety violations, when compared to regular warning signs placed in the work environment [3].

Pascale et al. [8] found that using a HMD which continually displayed patients vital signs helped physicians prioritize clinically relevant alarms over non-relevant alarms and increased awareness of status changes of the patient.

Liu et.al [7] showed benefits in using AR-headsets in anesthetic procedures, especially when paired with the conventional monitoring system. In their study the anesthesiologists detected changes in patients vitals signs faster while wearing a HMD compared to other participants without one. In this study a HMD without tracking was used, so body- or world-stabilized visualization could not be evaluated.

3 METHODS

To improve the safety for the patient and reduce operator errors, a system was implemented with which supervising anesthesiologists could monitor a patient in surgery using an AR headset. Several devices are used which need to be monitored by the supervisor: a patient monitor, anesthesia machine and medicine pumps. The patient monitor provides critical patient information (like heartrate and blood pressure) necessary to assess the patient's status. The anesthesia machine displays the patient ventilation and the medicine pumps display the medication running into the patient. Vital signs were captured using VSCapture [4] running on a PC connected to the patient monitor. Anesthesia machine and medicine pump data could not be captured, so for evaluation the displayed data was set using a Wizard-of-Oz approach. Data was then sent to a Microsoft Hololens 2 headset using Photon Networking. The application on the Hololens was made using Unity 2019.4.18f1 and the Mixed-Reality-Toolkit 2.4. Billinghurst et al.[1] present three ways to display information with an AR-headset:

- Head-stabilized: Information is fixed to the users viewpoint.
- Body-stabilized: Information is fixed to the users body.
- World-stabilized: Information is fixed to real world locations.

For this system a world-stabilized and head-stabilized view was implemented (see Fig. 1). Doctors at the University Clinic had already tried older AR hardware which featured head-stabilized visualization so it was chosen to be a good point of comparison. World-stabilized was chosen because it could augment the devices the doctors were already used to looking at. Acquiring anesthesiologists for evaluation was complicated due to the ongoing pandemic, so a body-stabilized view was not implemented to not require even more participants for the experiment. In the world-stabilized view, each information panel in AR is displayed on or above the corresponding machine in the operating room, with the exception of the patients vital signs, which are displayed above the patient to encourage more contact with the patient.

In the head-stabilized view, a panel containing all the data was placed in the peripheral vision of the user and moves directly with the head movement.

It is standard practice for anesthetic inductions to be carried out by assistant doctors with one senior anesthesiologist supervising several inductions. We performed an between-subjects-experiment with senior anesthesiologists (n=26) at the simulation center in the University Clinic, where such procedures can be accurately simulated. In the experiment the participants would act as the supervisor for a routine induction, with two actors playing the roles of assistant doctor and nurse. The actors would wilfully deviate from standard procedure to produce abnormal events that would negatively affect the patient. It was researched if the AR monitoring would affect the detection rate and speed of the events and if different visualisation methods would provide different results. After each scenario the participants were interviewed about their experience with the system.

4 PRELIMINARY RESULTS

Testing showed that participants with the AR headset did not experience a change in the perception of abnormal events. These results can be partially explained by some of the participants comments after the experiment. Several said that they felt they got no benefit from the system or did not pay attention to it, because they were not used to it and preferred to look at the regular monitoring. Others stated that they forgot the AR was there after a while because they never looked at it to get information. Out of those participants, many found the system to not be "smart enough", because it was only mirroring values that were already accessible with the regular equipment. To have a benefit from the system, it "should focus more on alerts". Because this scenario was a routine induction and all the instruments were easily accessible, most participants were used to specific routines that they follow under normal circumstances. Adding a new device into such a routine would take getting used to. One participant stated: "It wouldnt benefit me after doing this for twenty years.". But while the system did not influence performance, many participants expressed their interest in the system and said that they enjoyed using it, with one saying "this is really cool, can we keep it?" and another saying "this would be very helpful if I was used to it". They noted that if such a system was available in a form factor like regular glasses, they would gladly use it in their work. Participants also made suggestions for improving the system such as adding certain values or display changes.

5 CONCLUSION

The aim of this work was to research if an AR monitoring system can assist anesthetic supervisors in an induction to better identify abnormal events. For this, a system was developed which displays patient and device data on an AR-head-worn-display. An experiment showed no performance differences when using the AR-monitoring. Participants were positive towards the system and several expressed their wish to use such a system in their work. In the future the system should be improved based on feedback of the participants. A body-stabilized visualization could also be implemented and evaluated.

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