Work-in-Progress—Volumetric Communication for Remote Assistance Giving Cardiopulmonary Resuscitation

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***Abstract*—We present our work in progress, a real-time mixed reality communication system for remote assistance in medical emergency situations. 3D cameras capture the emergency situation and send volumetric data to a remote expert. The remote expert sees the volumetric scene through mixed reality glasses and guides an operator at the patient. The local operator receives audio and visual guidance augmented onto the mixed reality headset. We compare the mixed reality system against traditional video communication in a user study on a CPR emergency simulation. We evaluate task performance, cognitive load, and user interaction. The results will help to better understand the benefits of using augmented and volumetric information in medical emergency procedures.**

***Index Terms*—volumetric communication, mixed reality, emergency assistance**

I. Introduction

Video communication has become increasingly important over the past years. Online meetings became part of our everyday lives. The Covid-19 pandemic forced students to learn remotely and many professionals to join business meetings from home.

Similar to video, volumetric communication is becoming more important in many industries such as medicine, education, and logistics. Compared to video, volumetric communication contains spatial information and allows for more natural and intuitive communication. Combined with mixed reality glasses, volumetric communication aims to make the parties feel as they are co-located. In this paper, we examine the benefits of volumetric communication in combination with mixed reality glasses for remote assistance in emergency situations. We propose a mixed reality system that captures a person giving CPR to a patient and sends it over to a remote expert that guides the local person through the steps. The local scene is shown in fig. 1. In many countries, cardiopulmonary heart diseases are the main cause of death. According to the WHO [1] about 17.9 million people (around 32% of all deaths worldwide) die of such diseases every year. Therefore, an early performed CPR can increase the chances of surviving a cardiac arrest.

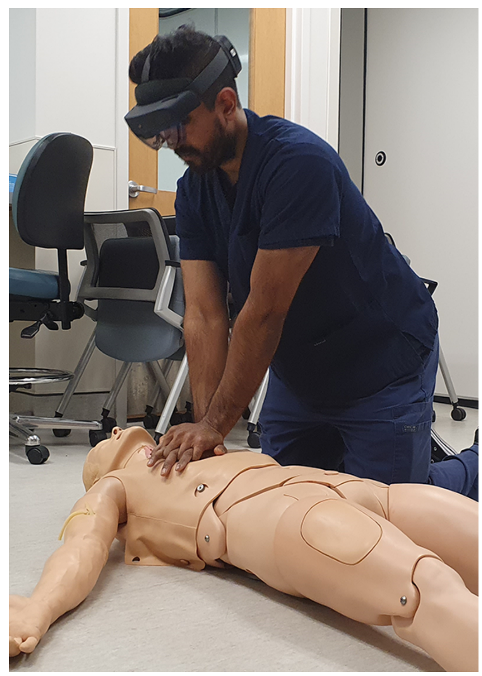

Fig. 1: Giving CPR on a mannequin while getting instructions from a remote expert through mixed reality.

We compare how the mixed reality performs in remote emergency procedure assistance compared to video commu-

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nication. We are particularly interested in measuring cognitive load and overall task performance.

The main contribution of this paper is the proposal of a volumetric communication system for remote assistance in a medical CPR emergency situation. Moreover, we contribute a study design for comparing volumetric against traditional video communication for emergency assistance.

II. Related Work

Volumetric communication contains spatial information compared to video communication. The spatial view can be used to augment objects in 3D. Thus, the communication parties can interact with virtual objects. A remote operator is able to point at different locations. This technique is used in the medical field [2], [3] as well as for technical procedural tasks [4].

In the past researchers focused on Cardiopulmonary resuscitation (CPR) training [5]–[7] in virtual reality. We present the first system to support real-time assistance for emergency CPR in mixed reality. In contrast to current mixed-reality approaches [8], [9], a remote expert can give individual guidance to a local operator throughout the CPR procedure.

III. Method

We develop a mixed reality system to allow for real-time communication between a local learner and a remote instructor. The learner is located where the procedural task takes place. Only the learner can physically work on the task. The learner and the instructor communicate using mixed reality glasses. The communication takes place using visuals and audio.

The objective of this method is to make the communication feel as seamless as if the instructor and learner collaborate in person. The instructor should be able to teach the learner without any limitations related to the fact of not being co-located. Similarly, the student should not feel the need for the instructor to help through parts of the tasks in person.

A. Instructor's View

The instructor's virtual view consists of a volumetric representation and video screens of the local scene. The volumetric view is provided by two cameras capturing the learner working on the procedural task from different angles. The instructor can switch between the cameras depending on which camera provides a better view of the scene during a given operation. The volumetric view allows the instructor to get a 3D view of the scene by looking through mixed reality glasses. The spatial information allows the instructor to get a better understanding compared to traditional video.

B. Learner's View

For the learner, the physical, real-world view is more important than the virtual view. The learner sees the object that is manipulated through the mixed reality headset. In addition to the physical view, the learner gets virtual information from the instructor. The learner sees the virtual hands of the instructor to get the information about where the instructor is positioned spatially relative to the procedure. Moreover, the virtual hands provide the learner with directions from the instructors. Besides the hands, the learner's virtual view contains procedure-specific virtual objects that are used by the instructor to guide the learner. The objects are used, for example, to show which tool to use, to show how to use a tool, to abstractly illustrate concepts of the procedure, and to give directional guidance.

C. Interaction

The interaction between instructor and learner is verbal and visual. The verbal interaction is the same as in video communication. The visual communication happens through gestures, object manipulation, and the actual observation of the procedure by the instructor. The gestural communication is bi-directional. The instructor observes the learner's gestures through the 3D camera view. The learner sees the virtual hands of the instructor. The gestures include beat gestures that support speech as well as deictic, iconic, and metaphoric gestures. The virtual hands encourage the interaction with deictic, iconic, and metaphoric gestures when providing procedural guidance to a learner. Besides the hands, the instructor interacts with the student using virtual objects. The objects consist of tools and annotations. The instructor uses the tools to explain how the tool is used.

D. Hardware and Technology

The instructor and the learner use the Microsoft Hololens 2 mixed reality headset to communicate. The Hololens 2 provides a 2048 x 1080 pixel resolution per eye and 52 degrees field of view (FoV). Two Microsoft Azure Kinect cameras are placed at the local site to record a 3D view of the learner and the procedure. The 3D view contains 1920 x 1080 pixel color information and 320 x 288 pixel depth resolution. The limitations of the current camera setup are the resolution and the quality of the time-of-flight depth sensor. Small details on the volumetric view are lost and distorted because of the low depth resolution. Another limitation of the time-of-flight technology is the difficulty of capturing reflective and transparent surfaces.

IV. Experiment

We conduct a user study in which we compare mixed reality against video communication in an emergency situation. The emergency situation the student is facing is Cardiopulmonary resuscitation (CPR). Through mixed reality, CPR assistance becomes intuitive because the remote expert can guide the local operator by giving directions in their field of view. Hence, the local operator can keep his focus on the patient and the task. Compared to in-person assistance, virtual assistance has the advantage of less space taken away and less distraction.

A. Setup

We prepare an emergency situation, the local operator has to face without prior notice. The situation consists of a mannequin on which the CPR has to be given and an automated external defibrillator (AED) next to the patient. The operator will be instructed to give CPR first and apply the AED later. Next to the procedure, two 3D cameras will be positioned, one on top of the patient, providing a bird view, and one side camera providing a horizontal view for the remote expert. The local operator will be wearing a mixed reality headset. The headset will be put on and adjusted before the operator is entering the emergency situation.

For the video baseline sessions, the camera positions will be the same, but instead of the 3D cameras, traditional 2D cameras will be used. Moreover, the local and the remote instructor will not be wearing mixed reality headsets.

B. Participants

We recruit CPR students who are mainly in the age group between 18 and 25 years. The CPR students in this age group are required to learn about the procedure as part of their driver's license or medical school education. The students are not required to have any prior knowledge about CPR. However, the students are asked if they have had any prior CPR training in post-procedure questionnaires. The students are divided into two random groups, that will perform mixed reality and video training separately. We use experienced CPR experts to assist the students through the emergency situation. The experts will lead both the mixed reality and the video procedure.

C. Evaluation

We evaluate the performance of the procedure, the cognitive load, and the mixed reality interaction. The performance of the student on the procedure itself is measured objectively and used to compare video and mixed reality for this specific task. The quality of the CPR is determined using a Laerdal Little Anne QCPR [10] mannequin. The sensors in the mannequin give instructors detailed feedback measuring pressure, rate, and ventilation. In addition to the objective measure, we evaluate the cognitive load of the learner and the instructor. The cognitive load is measured with the NASA TLX [11] and the SIM TLX [12] questionnaires. The cognitive load evaluations measures how much additional stress is added when using digital communication during a CPR emergency. In addition, we also develop a task-specific rating questionnaire that allows us to gather quantitative results on how the mixed reality communication is utilized throughout the different parts of the procedure.

V. Conclusion

We presented a mixed reality real-time communications system for medical emergency procedures. The system consists of 3D cameras that record a volumetric view of the procedure that is sent over to a remote expert who assists the local operator. The communication is based on audio and mixed reality using the Microsoft Hololens 2 headset. We evaluate our system on a CPR emergency simulation. In our study, we compare mixed reality with traditional video communication. We measure procedure performance, system interaction, and cognitive load. The results will show us what benefits mixed reality can offer compared to video communication in a CPR emergency situation. In future work, we plan on integrating an avatar representation of the remote expert, animated from speech [13], [14].

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