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Challenges and Findings in Creating Smart Assistants for Mixed Reality Training Apps

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Abstract. Mixed Reality (MR) headsets such as Microsoft's HoloLens have not only revolutionized the immersive experience for entertainment but also been adopted by various industries to improve work procedures. One of the particularly popular types of MR apps among industries is the training app. In this pilot study, we created and tested a prototype to expand such MR training apps from simply being a hologram manual to an assistant that recognizes if the user provides the task correctly. We first obtained feedback from participants in a user study regarding the design, usability, and experience of the app. We then fed the videos recorded in the user study to train an object recognition model via transfer learning. In addition to participants' positive feedback on the design and promising results on object recognition, we also identified unexpected but important issues for MR app design and programming, including trade-offs between the user's workflow and the accuracy of the smart assistant.

Keywords. Mixed reality, artificial intelligence, object recognition, human factors

1. Introduction

Mixed reality headsets offer highly interactive and immersive experiences that make games and entertainment much more enjoyable for the public. Beyond the entertainment context, these headsets have been increasingly adopted into daily operations in various industries such as by the medical fields for surgical training [1]. Unlike virtual reality, augmented/mixed reality can overlay digital information onto the real physical space. This allows the user to perform their task as they normally do but with the assistance or guidance from the headset. However, simply overlaying information onto the screen is only turning the device into an interactive "manual." It is solely the user's responsibility to open to the right "page" of the interactive manual; otherwise, the information shown on the headset is irrelevant, thereby confusing or overwhelming the user.

Creating such a MR smart assistant is more than simply adding artificial intelligence (AI) to the app. To be an effective assistant, it needs to communicate with the user in a non-intrusive, easy-to-understand manner. In addition, despite the recent breakthroughs in AI, AI is not accurate all the time. Lastly, the MR headset hardware also creates unique challenges to what the user and AI can do. Despite existing literature has addressed design considerations to provide the best MR experience for the user [2, 3], the best practices remain under-researched.

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2. Smart Assistant for Step-by-Step MR Training Apps

To simulate a generic MR training app, we created a HoloLens 2 app that provides participants with step-by-step instructions to assemble geometric shapes into a certain configuration. Two tasks were designed with different levels of difficulty: (a) the easy task with distinctive colored shapes and (b) the hard task with monochrome shapes as shown in Figure 1. A user study was conducted in the lab (see Figure 1 c) in which the participant followed the instructions in the app to complete the assembly task. To incorporate the smart assistant, each step consists of two periods: the *work* period when the participant worked on what needs to be assembled; and the *check* period when the participant was required to look at the configuration after he or she finished the step.

A total of seven participants were recruited and completed the experiment. They are university students aged between 19 and 23; six are female and one male. Participants first spend five minutes on average in the HoloLens practice session before the assembly task. Overall, participants were satisfied with the UI design and the clarity of the instruction. However, we observed that moving the HoloLens 2 window to a preferable location presented a steep learning curve for all participants. A sample video recorded from the participant's headset can be view here[2].

For building the custom object recognition model, we conducted transfer learning by freezing the top ten layers of YOLOv5s [4] and trained it with the leave-one-out strategy: using a participant's video to test the model that is trained on videos from all the other participants. Figure 2 shows the detection accuracy for each participant in the *work* and *check* periods, respectively. It can be observed that the accuracy in the *check* period is much higher than the one in the *work* period. This was because participants tended to look around or work using their peripheral vision during the *work* period, while the *check* period provided much clearer images of the shapes. Since the *check* period is essential to the smart assistant, how it can be integrated naturally into the process without letting users feel interrupted is crucial for future research on this topic.

(a) the easy assembly task (b) the hard assembly task (c) using the app to perform the task

Figure 1. (a) the easy and (b) hard assembly tasks and (c) the user performing the task.

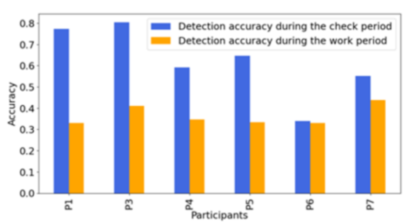

Figure 2. The accuracy of the object detection model for the *work* and *check* periods.

[2]https://drive.google.com/file/d/1Ql5JSTKNaVO_ptS5-GrxwY9Kls1kUavw/view

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