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Remote Collaboration using Mixed Reality: Exploring a shared model approach through different interaction methods

João Barroso, Luís Fonseca, Bernardo Marques, Paulo Dias, Beatriz Sousa Santos
IEETA, DETI, University of Aveiro, Portugal
Contact Author: joao.barroso@ua.pt

Abstract. In many situations, performing maintenance procedures can be facilitated by providing on-site professionals with the possibility to request assistance from remote experts, thus performing the task collaboratively. Since remote experts don't have access to the local environment, they need additional mechanisms to provide instructions and guidance in such context. In this ongoing work, we present a Mixed Reality (MR) platform that explores the use of a shared model approach for collaboration scenarios. The platform uses predefined 3D models, which can be accessed by remote experts using Virtual Reality (VR) and by on-site users through Augmented Reality (AR). In addition, the remote expert can manipulate virtual models using different interaction methods and devices, as a mouse and a keyboard (computer), an interactive projector (touch) and controllers (Head Mounted Display). Our goal was to enrich his experience and improve collaborative awareness. We conducted a preliminary user study to evaluate collaboration, and different interaction methods, using as case study the assembly of Lego blocks.

Introduction

In remote collaboration systems, users are in different physical locations. Mixed Reality (MR) systems can be applied to industry in order to help maintenance and training functions and guide on assembly tasks. In this scenario, the local user, has access to real physical objects and needs instructions from the remote expert (typically a qualified technician) to complete the task successfully. (Kim et al., 2018; Ens et al., 2019). Literature reports some examples of solutions for this kind of situation. In (Masoni et al., 2017), the authors describe a system where remote experts create annotations (text and sketch) in an image sent by the local user. Then, instructions are sent and shown through AR to the local user.

Some authors explored other techniques, like 3D shared virtual objects for interaction with the remote technician. This approach allows major accuracy in the instructions location, since it has one more dimension in relation to traditional 2D approaches (image-based). In (Ferrise et al., 2013) the remote expert interacts with a 3D virtual model of a washing machine through a multimodal system. This system allows the remote technician to train another operator who sees the instructions about how the operations should be correctly performed, which are superimposed onto the real product (AR). Another solution for guiding a local user was proposed by (Oda et al., 2015), allowing to assist with placing the top of an aircraft combustion engine. The remote expert has access to a virtual replica of the physical object, that they can manipulate to give instructions to the local user.

In this paper, we describe an Mixed Reality-based platform for remote collaboration, inspired by the above mentioned examples, which explores a shared-model approach. We also present the results of a preliminary user study to evaluate usability, and obtain insights on the features of the framework.

Exploratory Platform for Remote Collaboration

This section describes an initial effort towards the creation of MR platform for remote collaboration (Figure 1). This platform is based on a 3D shared model approach and client-server architecture, focusing on simplicity and scalability.

The server side contains information about all shared objects, which clients (local user and remote expert) can access and change. The remote expert can manipulate and change 3D shared models through VR using three different types of interaction. An interaction based on 2D approaches: mouse and keyboard (computer) and touch (projector); 3D approach using controllers (Head Mounted Display - HMD) was implemented. This diversity of ways of interaction allows the remote expert to select the most appropriate one, based on the context (being the long goal of this on-going research the comparison of such methods). The remote expert has the possibility to send instructions, to add and remove different types of virtual objects with 6DoF. The local user can use a handheld device to visualize the instructions through augmented reality in real-time. A scenario of Lego Blocks assembling was selected as case study to get some insights on the platform.

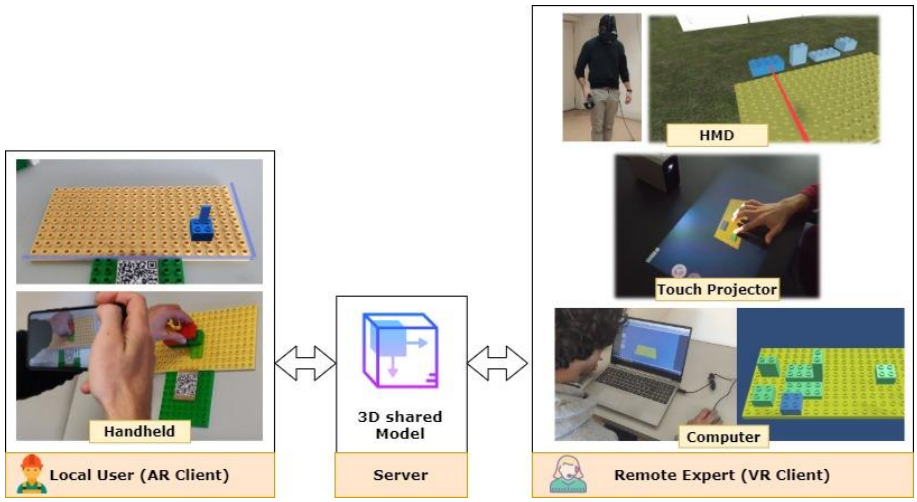

Figure 1. Overview of the MR platform. The Local user can visualize the shared instructions in an AR setting. The Remote expert can provide instructions using three different VR methods.

User Study and Preliminary Results

A preliminary user study was performed with 1 pilot, plus 5 participants (3 female) to access usability, and understand if the platform was robust to be used as a collaborative tool in a real remote setting.

Participants were professionals in UI & UX, AR \& VR, as well as people without any knowledge in the area, in order to obtain more relevant feedback to improve our platform. Participants performed the tasks as remote (i.e. provided a set of instructions using different interaction methods sequentially) and on-site (i.e. follow instructions from remote user to perform an assembly with real Lego blocks) users, while an experimenter was the counter part. Both collaborators were back-to-back one the same room, separated by a panel. We used a within-subjects design. Lego arrangements were completely different between all methods, but were the same for all participants.

Participants were instructed about the experimental setup, the task and gave their informed consent. Afterwards, the task was completed, while being observed by the experimenter, who assisted them if they asked for help and made annotations using a standard form. Immediately after finishing, participants answered a post-task questionnaire. The data collection was conducted under the guidelines of the Declaration of Helsinki.

All participants were able use the platform and finish the assembly task collaboratively. On average, each participant took 10 minutes to complete the tasks. On the local side, the major difficulty felt was distinguishing between the instructions to add/remove pieces. On the remote side, participants found it difficult to perceive when instructions were completed, especially using interaction through controllers (HMD).

Concluding Remarks and Future Work

Mixed-Reality technologies have the potential to improve remote collaboration between distributed team-members. The platform presented in this paper explores a shared model approach, allowing a remote expert to guide an on-site user in assembly tasks using three VR interaction methods. Initial results show that the platform can be used to assist in assembly scenarios and that participants in the role of remote user preferred the use of particular devices according to the task. According to the questionnaire, users found easier to use the mouse and keyboard to correctly position the pieces. However, to control the camera perspective, it was easier with controllers interaction. This reinforces the initial motivation to explore different interaction methods, which can be used based on the context of the remote user.

In addition, this study is being expanded to support scenarios in which multiple remote users can interact at the same time, using ownership mechanisms. Thus, ensuring the on-site user knows who gave instructions. Furthermore, we also intend to perform user study to compare the different interaction methods to be used in different types of tasks.

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