Can I get You Anything Else? — Increasing Human's Trust in an Autonomous Robot by the Use of an Avatar

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Fig. 1. A virtual assistant – avatar – superposing a robotic arm.

Living independently and self-determined in one's own home is crucial for social participation. For people with severe physical impairments, such as tetraplegia, who cannot use their hands to manipulate materials or operate devices, life in their own homes is only possible with assistance from others. The user group often refuses to use robotic devices for manipulation tasks because of feeling uncomfortable in the vicinity of such machines. In this paper, we are planning an ethnographic lab study if an Augmented Reality solutions can increase the level of comfortable while a robotic arm is serving a glass of water to the participants' mouth by displaying an avatar.

CCS Concepts: • **Human-centered computing**; • **Computer systems organization** → *Robotics*;

Additional Key Words and Phrases: augmented reality, avatar, human-robot interaction, trust

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1 INTRODUCTION

Robotic solutions are becoming increasingly prevalent in our personal and professional lives, and have started to evolve into close collaborators [2, 10**?**]. In addition, they can make a significant contribution to improving care by relieving and supporting care assistants (e. g. nurses or relatives) and having the potential to improve the quality of life of those in need of care [3]. The use of robotic systems benefits in particular people with severe physical impairments, who can not use their hands to interact with physical materials by supporting in Activities of Daily Living (ADLs), such as

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grabbing and manipulating objects or drinking and eating [17]. This group includes also people with multiple sclerosis, muscular dystrophy, and diseases with similar effects.

A growing body of literature has examined the impact of assistive robotic systems in supporting people with physical impairments. Work done by Chen et al. [5] for the *Robots for Humanity* project and Fattal et al. [8] looked into the feasibility and acceptance of robotic systems as assistive technologies. A common finding was that the robotic devices are often designed to assist with several activities of daily living. These devices are usually large; consisting of a robotic arm on a mobile module. They require a barrier-free environment and rooms with sufficient space to fit into and be able to move around safely. In contrast, Pascher et al. noted the potential of smaller, lightweight solutions designed for individual tasks [16, 19], indicating that a specialized aid would be more accessible in terms of size and portability.

However, new potential issues arise when cobots are tasked with (semi-)autonomous actions, resulting in added stress for end-users [20]. Particularly close proximity collaboration between humans and cobots remains challenging [11]. These challenges include effective communication to the end-user of (a) motion intent [1] and (b) the spatial perception of the cobot's vicinity [18].

Our aim is to use avatars – artificial computer-animated representations of humans within virtual environments – to increase the trust in a close body environment when confronted with a robot's motion intent.

2 RELATED WORK

Previous research in human-robot interaction delivered a great amount of knowledge in understanding human response in human-robot collaborations. Mainprice et al. found in their research, that the feeling of safety is highly dependent on the humans personality, his physical capabilities and his actual states. Furthermore, the feeling of safety differs highly during sitting compared to standing [15]. Another outcome is that humans, who have the robot in their field of view, generally feel more comfortable.

In this section we first examine previous work done with Augmented Reality (AR) in the field of Human-Robot Collaboration (HRC). In a second step, we present projects that already analysed the use of robotic devices to support people with disabilities and how these aids are valued by their users. During the third part, we report previous research of human-system trust and how to increase it.

Avatars, artificial computer-animated representations of humans within virtual environments, are sometimes presented as simple means to enrich user experience and build trust [4, 13, 24, 26]. Our aim is to use such an avatar to increase the trust in a close body environment with an robotic arm.

2.1 Robotic Support in Domestic Care

A growing body of literature has examined the impact of assistive robotic systems in supporting people with motor impairments. Work done by Chen et al. [5] for the *Robots for Humanity* project and Fattal et al. [9] looked into the feasibility and acceptance of robotic systems as assistive technologies. Both found that the robotic devices are often designed to assist with several different ADL, often leading to larger robotic devices and typically requiring a robotic arm mounted on a mobile unit. Moreover, Drolshagen et al. investigated the acceptance of robots in sheltered workshops, finding that robots are accepted quickly and close proximity can be preferred [7].

2.2 Augmented Reality in Human-Robot Collaboration

Over the last decades, AR technology has been frequently used for human-robot collaboration [6]. Previous work focused mainly on the use of Head-Mounted Display (HMD)s and the visualization of robot motion intent, e. g. [11, 21, 25]. For example, Rosen et al. showed that AR is an enhancement compared to classical desktop interfaces when visualizing the intended motion of robots [21].

2.3 Trust in Autonomy

Human trust towards AI has been studied in different types of AI system, from automation, robotic, to medical system. Previous research that examined the factors influencing trust in human and automatic system interaction, suggested that trust has three main components: dispositional trust, situational trust, and learned trust [12, 22]. Dispositional trust is related to the individual, such as their personality, background, attitudes, and capabilities. Situational trust is related to the situation or environment, such as the complexity of the task. Learned trust relates to the system itself, such as its behavior, reliability, transparency, and performance.

3 PROTOTYPE

The main idea of this work is to use AR to increase the level of comfortable of the participant while a robotic arm is serving a glass of water to their mouth.

3.1 Avatar

For the purpose of evaluation, we developed a AR application that shows an avatar, a virtual character, to the participants (see Figure 2a). We chose the avatar of a waiter because we thought this would be related to the task the best. This holographic visualization is superposing the robotic arm, which is mounted next to a table, in a way the robot is pushed out of the focus of any participant. The AR application is running on the *Microsoft HoloLens* (see Figure 2b) which enables the user to move freely around instead of a fixed setting. To mime some "life" in the avatar we micro-moved the eyes and the head smooth random times and performed blinks.

(a) Avatar: Virtual waiter.

(b) *Microsoft HoloLens* head-mounted display.

Fig. 2. AR setup with (**a**) showing the avatar which superposes the robotic arm while serving a glass and (**b**) *Microsoft HoloLens* with attached tracking markers.

3.2 Robotic Arm

For our research we are using the *Arduino Tinkerkit Braccio*. The robotic arm has six degrees of freedom (6DOF) and is able to freely move around and lift weights until 150 grams. This is enough to lift an plastic cup with some water. The motors and axis of the robot represent the different part of the human/avatar arm. The first and second motor represent the shoulder joint (M1: turning the arm; M2: lifting the arm). The movement of the elbow joint is done by motor M3 and the wrist joint by the fourth and fifth motor (M4: tilting; M5: rotating). The robotic arm also has a gripper for manipulation objects. The gripper is controlled via motor M6. The arm was mounted to a tripod system to work horizontal to mime a human assistant (see Figure 3). To compensate the additional gravity of mounting the robotic arm horizontally we

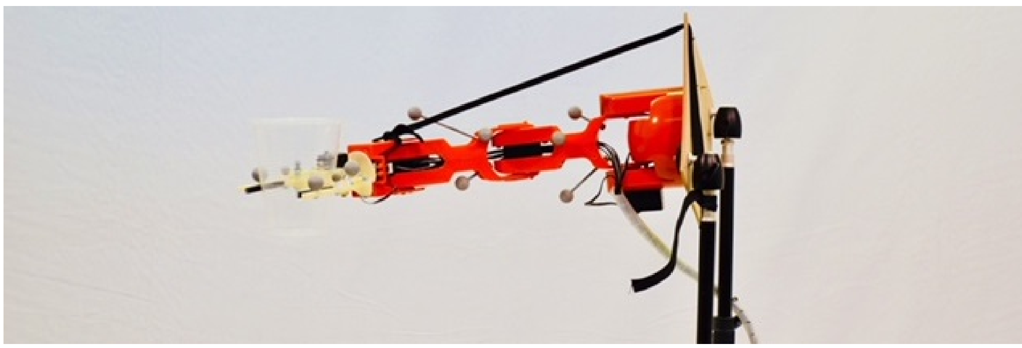


Fig. 3. *Arduino Tinkerkit Braccio* with attached tracking markers mounted on a tripod system.

3.3 Tracking System

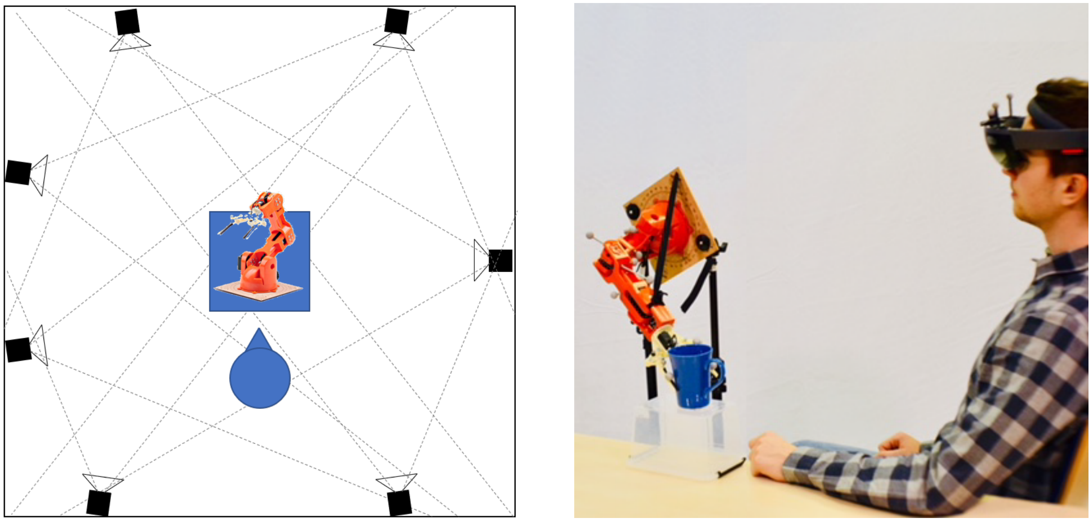
The position, pose and moving of the holographic avatar and the robotic arm are synchronized by seven *OptiTrack Prime 13* infrared cameras and several *19 mm (3/4") M4 Markers* in a certain arrangement to track position and orientation of the components of the robotic arm. The markers are groped in rigid bodies for the upper arm, forearm, and hand of the robotic arm (see Figure 3). The position and rotation data is streamed by a tracking server to a middle-ware which prepossesses the data and sends them via UDP to the *Microsoft HoloLens*. The prepossessing is necessary to ensure the right transformation of the streamed quaternion-data in a data format the *Microsoft HoloLens* can process. The table with the robotic arm next to it is placed within our labs tracking area (see Figure 4a). The participant is sitting in front of the table in a distance of 30cm, so that the robot could reach the motion range of the human.

4 EXPERIMENT

In the following, we describe the experiment of the use of an avatar. Our goal is to investigate how to increase user's trust in a robotic arm by superposing a virtual assistant during close-body collaborations.

4.1 Study Design

In our study we like to compared two conditions – a) participants are wearing the *Microsoft HoloLens*, but no avatar was visualized during the trial; b) the avatar was visualized. Participants will be asked to complete two questionnaires



(a) The scenario within the tracking area with *OptiTrack Prime 13* infrared cameras with robot and participant in the center.

(b) Participant wearing the *Microsoft HoloLens* sitting in front of the robotic arm.

Fig. 4. Study setup. Left: showing the overview of our setup; right: participant sitting in front of the robotic arm during the study.

to assess and evaluate the study. The first questionnaire is the User Experience Questionnaire[1] [23], which measures the participant's experience regarding the use of the product/technology of the study. The second questionnaire is the Trust in Automation Questionnaire[2] [14]. This questionnaire measures how much trust the participant has in the technology/product and how comfortable they felt conducting the study. After both conditions we are planning to conduct an interview to gain some more qualitative insights

4.2 Hypotheses

For this study, we ask: **(RQ) Does the use of an avatar increase user satisfaction?** To compare the two conditions, we have developed a set of hypotheses:

- H_1 We hypothesize the trials with avatar result in higher user experience.
- H_2 Because of the familiarly to a waiter, we expect that the trials with avatar result in higher trust in automation scores.

4.3 Procedure

Before the experiment start, the participants willk be informed about the study and the experimental setup to give their consent. After a short demographic questionnaire, participants start with the first condition. The robotic is serving a glass of water to the participant's mouth. After this, we ask participants to complete the UEQ and TiA questionnaires. The entire process will be repeated with the remaining visualization method. The order in which the two conditions are

[1]User Experience Questionnaire (UEQ). https://www.ueq-online.org/, last retrieved February 21, 2023

[2]Trust in Automation Questionnaire (TiA). https://github.com/moritzkoerber/TiA_Trust_in_Automation_Questionnaire, last retrieved February 21, 2023

counterbalanced using a Latin-square design. Afterwards, we plan to ask five open-ended questions in an interview about the avatar's suitability for everyday use and the impression it makes.

5 CONCLUSION

This work proposes an avatar visualization with the aim of increasing the trust in a close body environment when confronted with robot's motion intent. We presented our study setup and design for an ethnographic study. In an first proof-of-concept study, six participants were of the opinion that the avatar visualization makes the robot look more human. They can imagine that this technology can be used in everyday life, for example, to handing things or lifting or carrying heavy objects, for example. heavy objects.

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