

Evaluation of Media-Based Social Interactions in Virtual Environments

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Fig. 1. In-game shot from experimenter's avatar point of view of two participants collaborating on the puzzle task

The evaluation of users' experiences in virtual environments is an important task for researchers in the fields of human-computer interaction and extended reality. It can be used to understand and enhance the quality of users' mediated interactions and communications. In a constantly evolving world, where people are growing with technology, it is important to understand, evaluate and enhance the use of immersive media. In the research agenda of this Ph.D. thesis, the challenge of developing multi-user experiences in virtual environments and setting evaluation metrics for researchers are considered. This Ph.D. thesis showcases an interest in how to enhance trust formation in media-based social environments. The findings of this Ph.D. are expected to help create new open-source tools to facilitate the understanding of individuals and groups in extended reality applications.

CCS Concepts: • **Human-centered computing** → **Human computer interaction (HCI)** ; **Interaction paradigms** ; **Virtual reality**.

Key Words: Computer Supported Cooperative Work, Social Virtual Reality, Avatars;

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1 INTRODUCTION

This Ph.D. takes place in the context of the Marie Skłodowska-Curie Actions, Innovative Training Networks, Horizon 2020 Creating Lively Interactive Populated Environments (CLIFE) project. CLIFE is addressing the challenges of designing the next generation of VR-ready characters and developing new techniques to create and control interactive virtual characters. It benefits from emergent technologies in domains such as human digitization and displays, as well as recent progress of artificial intelligence. The topic of this Ph.D. thesis will specifically address the social evaluation of populated virtual environments. This Ph.D. is supervised by Professors Anthony Steed and Ifat Yasin in the Virtual Environment and Computer Graphics (VECG) group at University College London (UCL). The duration of the contract as Marie Curie Fellow between Lisa Izzouzi and UCL is 3 years (November 2020-2023). The expected date of graduation is mid-2024.

2 MOTIVATION

Social Virtual Reality (or SVR) applications create collaborative situations that allow better communication and interaction compared to solely audio or video-based communication methods. This is mainly due to their immersive nature and users' representation by virtual avatars. SVR applications have been used for almost as long as VR has been around. These days, they bring millions of daily users and more commercial content can be found online. Yet, these applications fail to provide standardized designs for users' representation, locomotion, interaction design, and social structures. Indeed virtual worlds attract thousands of companies and content creators who want to invest in what is called today the metaverse. Hoping to be the next big name in the industry. However, the concept of metaverse is not new. It has been first described in the novel Snow Crash in 1992. The metaverse is considered the next evolution of the internet. It will take many forms, including gaming, online communities, and business meetings where people collaborate via digital replicas or avatars of themselves.

In this context, we decided to investigate SVR systems and small-group interactions. Our mission is to create multi-user applications and to evaluate social interaction. Thus, to propose a new set of evaluation tools, and guidelines to enhance collaboration and communication between users. For this purpose, we seek to develop a set of various open-source multi-user applications and define metrics to evaluate the media-based social behaviors of users in virtual environments. This research work can be summarized as follows: Section 3 will introduce the research question. Section 4 will present the methodology chosen to approach the research problems. Section 5 will present the current research situation and findings. Finally, Section 6 will introduce future work planned for the year 2023.

3 RESEARCH QUESTION

In the early stages of this thesis, the challenge of the lack of standardized evaluation metrics for social meetings and collaboration in SVR rose. To tackle this problem, collaborative scenarios were first elaborated and implemented in an open-source SVR platform. The objective was to obtain immersive applications supporting multi-user interactions to evaluate easily groups of users in SVR. The second stage of this thesis is to develop appropriate evaluation metrics using objective and subjective methods. To assess the quality of social interactions in virtual environments and to find

ways to enhance individuals' and groups' behaviors. The goal of this research project is to determine how social virtual reality can be used to enhance trust formation in small group interactions. We want to know what features of social virtual reality support trust formation. For this, we assess performances of social tasks focusing on trust formation, leadership, task performance, and collaboration.

4 METHODOLOGY

During this Ph.D. journey, we want to conduct research step by step. First, by setting simple collaborative tasks in a social virtual platform and collecting users' data. Second, by reviewing existing and refining used social evaluation methods. Third, by running more social experiments on diverse research topics. Finally, by using collected data to propose our own evaluation methods for social xr experiences.

4.1 Social Virtual Reality Systems

SVR platform comparison and evaluation taxonomies have highlighted that there is yet to exist a standardized design for SVR features [7]. Nevertheless, there are common usability problems in SVR platforms like spatial navigation, communication coordination, and joint manipulation [8]. Conveying gestures and emotions remains a challenge in VR. Supporting facial tracking, hand and finger tracking [9], but also including proxemics systems and posture control [16] would allow the support of better non-verbal communication cues in SVR. SVR users might feel conscious of the self-disclosure of their data and digital identities online and might not feel confident disclosing their emotions or experience on commercial platforms. In this context, it is important for SVR to become a safe environment for users to act more naturally and feel comfortable building meaningful and healthy relationships [2]. Thus, building our own SVR platform would help us to provide users' security and privacy, to control experimental conditions, and to evaluate easily social behaviors. We are developing an open-source VR platform and a set of collaborative experiences that can be used by creators and researchers to run their own experiments.

4.2 Evaluation methods

Measures will be made using subjective and objective data. Subjective data will be measured using self-reported questionnaires. We will analyze presence [13][12], co-presence [1]. Objective data will be measured using screen video recordings, audio recordings, in-app recordings, and in-app logs methods. Logs will measure users' behavioral data such as physical movements, eye tracking, proxemics, or interactions. We will also conduct surveys with users of SVR platforms and SVR creators.

5 CURRENT RESEARCH SITUATION

In a preliminary phase, work was done to help build Ubiq [3] to run distributed and remote MR experiences. Ubiq is an open-source tool is a SVR platform that offers key features to support synchronous and asynchronous experiments. Ubiq also offers a variety of tools for the experimenters to facilitate the operation and documentation of the experimental sessions. Scene management tools and user-management tools were developed with the objective to be used by experimenters to ease the management of multi-participant studies. Additional functionalities of the existing record and replay tool were developed, allowing the recording of Ubiq networked messages. Finally, Microsoft Rocketbox avatars [4][6] were implemented to Ubiq in order to offer an alternative user representation to the existing cartoony avatars. These have been rigged using the commercial plugin FinalIK.

A first experiment partly based on a previous study [15] was run. It investigated what happens when a small group of participants meets to carry out a joint poster task in a virtual environment [14]. In that study, two participants used a desktop system while one participant used an immersive system, Oculus Quest 2. All participants were using Ubiq floating cartoony avatars of different colors. They met in a virtual office room and must collaborate to solve a series of riddles written on pieces of paper stuck around the walls. On each piece of paper, there was a set of words prefixed by a number. The goal for the participants was to find and rearrange all the words with the same number to form the completed sentences. Participants are asked to collaborate to solve the task efficiently, as it would be difficult for one participant to remember all the words in one phrase alone. The main measure was the responses to a post-study questionnaire. Participants were asked to self-report presence, co-presence, embodiment, and enjoyment of the task. We also asked participants to assess their own degree of talkativeness and whether they considered themselves leaders of the task. We wanted to evaluate the impact of the level of immersion of participants on the metrics evaluated in questionnaires, on task performances, and on group dynamics. Unlike the prior work [15], subjective responses collected showed no significant difference between desktop and immersed users for the measures of presence, co-presence, embodiment, accord, enjoyment, and leadership. However, objective data revealed that VR users tended to be more talkative and had a higher level of activity.

Following this study, a second experiment based on two studies was run, the poster task [15] and puzzle task [10]. In that study, two participants used Oculus Quest 2. We used two types of avatars, the floating cartoony ubiq avatars, and realistic rocketbox avatars. Indeed we wanted to observe the impact of avatar realism and the correspondence of the virtual representation of participants for immersive collaborative scenarios. Similar evaluation methods to the first run study were used for the latest one. Data are currently being analyzed and results have yet to come out.

6 EXPECTED NEXT STEP, OPEN QUESTIONS, AND CHALLENGES

Following the current work conducted for this Ph.D. thesis, the next step of this research will be to develop a questionnaire and set of metrics to evaluate social interactions in virtual reality. This project is inspired by the questionnaire produced by Gonzalez-Franco and Peck [5][11] as the field needs more guidelines for researchers. We will first do a review of the literature of various fields evaluating social interactions and co-presence, then we will run an online study targeting researchers and VR users to analyze how they view the currently used questionnaires. The final step will be to publish our own evaluation guidelines.

These evaluation guidelines will be tested in studies run during the following academic year. These studies will have the common topic of social interactions in XR. These studies will be run in collaboration with other laboratories to efficiently target several topics of my interest that I could not work alone on within the Ph.D. timeline. The first study will be about virtual meetings between 4 participants in VR and MR. This project will have two phases. The goal will be to extract individuals' and groups' social behaviors in the first phase to teach virtual agents how to behave in social meetings in the second phase. The second study will be about developing trust with self-disclosure in virtual spaces. Another interesting topic to target would be exploring the creation and customization process of users' virtual representation and their effect on both individuals and groups in collaborative experiences.

This Ph.D. thesis could lead to cross-disciplinary collaboration and to the implementation of new elements. For instance, we focus on real user studies. But running those studies with mixed groups of real users and virtual agents

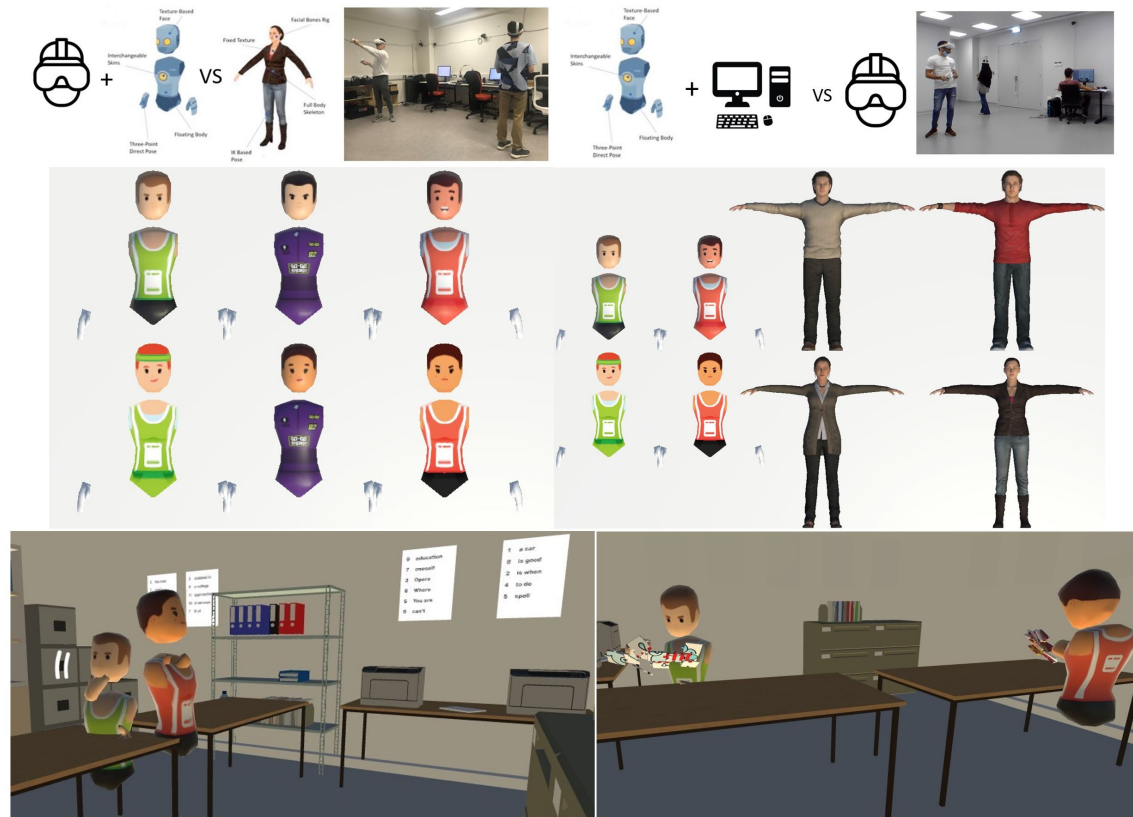


Fig. 2. Images from the experiments and environments. (a) Explanation of design for the first experiment (b) Explanation of design for the second experiment. (c) Used avatars for the first experiment. (d) Used avatars for the second experiment (e) Shot of the environment for the poster task study. (f) Shot of the environment for the puzzle task study.

would be of our interest. Especially, to investigate how virtual agents could learn social behaviors from real users. Also, we are using collaborative scenarios for groups of strangers. Yet, it would be interesting to focus on existing social groups such as friends, family, couples, or "enemies". This could open perspectives to work on societal problems and evaluate after-exposure effects on individuals in the real world. The challenge of this research topic lies in the complexity of human beings, and in the difficulty of conducting real-time evaluation of behaviors of one real person, let alone groups. We are tackling this challenge by taking inspiration from research done, efficiently in the field of virtual reality, but also in human-computer interactions, social science, economic science, etc. We hope that this work will lead to more research on SVR, and on reproducing and applying these studies to other fields.

7 CONCLUSION

To conclude the expected contributions of this Ph.D. thesis are to offer a set of objectives and subjective evaluation tools to assess media-based social interactions in virtual environments. We will support these tools with feedback and results from reproducible multiuser studies. The personal interest of the main Ph.D. contributor Lisa Izzouzi would be to use the work of this Ph.D. thesis to apply SVR research findings to health and education fields. Indeed, educating users

of all ages on how to behave properly in online virtual worlds is paramount. Furthermore, the exposition to virtual scenarios has an after-exposure effect in real life. The long-term plan would be to use virtual reality as an educative and therapeutic tool to tackle the topic of sexual relationships and health education (RSHE), a controversial, yet key pillar element in creating an inclusive, safe, and respectful society.

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