Remote You, Haru and Me: Exploring Social Interaction in Telepresence Gaming With a Robotic Agent

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Figure 1: Conceptual illustration of a telegame application, with two human players in distinct locations and their colocated social robot companions.

ABSTRACT

Novel forms of two-player telegame interaction might extend and enhance social connection between physically separated persons. We examine the potential of a Rock-Paper-Scissors game conveyed via an embodied telepresence agent. We compare a game interaction with an autonomous robot and a game interaction with a teleoperated version of the same robot. Both systems are equipped with a perception module that processes and recognizes the hand movement of the human players colocated with the robot. In the classic interaction, the robot acts as the opponent player. In the telegame setting, the robot represents and mirrors the actions of the remote human player as the opponent. We integrate the systems on the tabletop robot platform Haru and evaluate user impressions with respect to game experience and robot sociality. Results show that the telegame is perceived more positively, indicating its potential for physically distant, but socially enhanced interaction in the future.

CCS CONCEPTS

• **Human-centered computing** → Empirical studies in HCI; Collaborative and social computing systems and tools; Activity centered design; Gestural input; • **Computer systems organization** → Robotics.

KEYWORDS

telepresence, social engagement, collaborative gaming, hand gesture recognition

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1 INTRODUCTION

Covid-19 and social isolation are main cause leading to mental health problems within a large number of people [14, 21]. Telepresence gaming could be one way to remedy the negative mental impacts of social isolation by making people feel more socially connected to others, thereby decreasing loneliness, and providing some entertainment and diversion from anxiety (Fig. 1). Telepresence gaming with robots, through their embodied presence, could in particular help people feel that, even though they are physically distant, they are in the presence of others. Autonomous social robots

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have also been suggested as a potential aid in coping with feelings of social isolation and loneliness.

In this paper, we explore people’s perceptions of robots both as engaging autonomous gameplay partners, and as telepresence devices who can mediate gameplay among remote human partners. We are interested in understanding people’s experience of gameplay in these two situations, and also their perceptions of the robot’s sociality. We use the robot Haru [8] as an embodied social platform. Haru’s emotive features [7] make it a particularly appropriate candidate for both social telepresence interaction and autonomous companion-style engagement.

The presented study uses the Rock-Paper Scissors (RPS) game as a collaborative task, which allows for immersive, yet relatively simple embodied interaction and has been previously used in studies with social robots [1, 20]. We present the results of our work as a proof of concept that can guide further development of telepresence human-robot gameplay.

2 BACKGROUND

Robots of various types have been studied as potential assistive devices that can help people address social isolation. Several studies have explored the use of robots by older adults in their homes [17] and in care institutions [18] to address loneliness and increase social participation [15]. Social robots as mediators of social interaction and communication with others have also been shown to have positive effects on social isolation among adolescents [5] and young adults [11]. A recent survey study [12] explored people’s willingness to engage with robots as communication devices and companions while social distancing during the COVID-19 pandemic. Results suggest that people would be accepting of social robots managing and mediating their connections with others. They also desired robots to provide companionship, emotional support, and engaging activities for them as they socially distanced from others. Social robots could, therefore, potentially play a role in reducing social isolation both as social mediators for other people and as social companions in their own right.

Robots have been incorporated into gameplay as partners, opponents, and even referees (e.g. [4, 22]). Prior research has shown that people engaging in gameplay with robots can experience social engagement and other cognitive and physical benefits. Devasia, Ali and Breazael [6] showed that peer-like gameplay with a socially embodied robot could support children’s creativity. Gameplay with robots has also been used in educational [9, 10] and socially assistive [19] contexts. A study of gameplay to support therapeutic rehabilitation showed that people preferred to play with another human while using a robot, rather than with the robot alone, due to the increased opportunity for social interaction and talk [13]. These prior studies also show that, in the course of gameplay, the robot’s ability to provide affective and other social feedback can be an important factor in its ability to engage people and immerse them in the game.

3 SYSTEM SETUP

We integrated two versions of a RPS game onto the social tabletop robot platform Haru. The first variation constitutes a classic two-player game, in which Haru acts and reacts in lieu of a second

Figure 2: For the telegame setup, hand movement recognition results are sent between computers via TCP to control the interaction flow of the respective remote agent by a designated behavior tree.

human player. The second variation constitutes a telegame variation, in which the robot is controlled by a second player in a remote location, and therefore mediates gameplay between two humans. The flow of both games is unified and only differs with respect to the internal handling of information processing, result display, and synchronization. Overall, the game mechanics and any delay in play or result display was similar in both versions.

The perception system underlying both game variations is based on a modified version of the RPS game framework introduced in [2]. Hand data is tracked utilizing a Leap Motion device, and subsequently processed for hand shape recognition. We trigger shape classification by a simple velocity-based threshold. As such, a motion detector is activated when the human player starts to actively move their hand, and deactivated as soon as the hand movement approaches zero. Once deactivated, incoming hand features are frame-wise evaluated by a pre-trained CNN hand shape classifier. Next, the recognized hand shape is distributed to the remainder of the overall game pipeline.

3.1 Shape Information Processing

Labeled hand shape results are used within a custom-made behavior tree to a) convey information on both players’ choices, and b) to initiate an emotive and social interaction via the embodied agent. In the classic two-player interaction, the robot’s game choices are drawn from random sampling before game play. In the telegame setup, the recognized hand information of the remote player is sent via TCP to determine the choice of their representative telepresence agent, and vice-versa (Fig. 2).

Figure 3: Sample information display as projected onto the external monitor. Top row: result display of the classic interaction setting. The winner is highlighted in green color. Middle row: variation of the result display for the telegame setting. Bottom row: system stand by information used for synchronisation of the telegame.

3.2 Result Display

We make use of the visual and emotive exhibition channels of the robotic agent to convey necessary information and create an illusion of liveliness and telepresence, respectively. With the end of the colocated player’s hand movement, Haru exhibits either its own or the remote player’s choice as 3D animation via its LCD eye panels, followed by a descriptive animation of the game outcome (e.g. rock beats scissors). Simultaneously, Haru performs a pre-animated routine representing joy, happiness, sadness or frustration in accordance with the respective game result. When losing, Haru e.g. looks down and moves his body side wards, resembling the human shaking of the head. When winning, Haru e.g. smiles and moves his neck, resembling a slight satisfied head nod. In case of the telegame, Haru’s reactions similarly mirror the potential reactions of the remote player. The overall result of the current game is projected onto a nearby external monitor in form of a split-screen visualization with color highlighting (Fig 3 top and middle row). Lastly, with the designated end of a game interaction, Haru expresses a final winning or losing reaction. This reaction is a more intense variation of the previous animation routines, accompanied by an appropriate happy or sad sound design.

3.3 Synchronization

To create a smooth and immersive game experience, it is imperative that movements and actions between players and agents occur in a timely manner. Therefore, the game flow includes a number of feedback mechanisms. In both the classic and the telegame setting, the initiation of the player’s hand movement is elicited by an external countdown signal. For the telegame, additional control loops within

the behavior tree keep the system in sync between single plays. This is necessary since the lengths of the robot animation routines differs. Before the start of a play, information on the own and the opponent’s system stand-by state is displayed on the external monitor (Fig. 3 bottom row). As soon as both systems are ready to send and receive new data, the new play starts. This procedure also helps to compensate eventual delays caused by signal transmission or user play style and ensures the appropriate timing of game result display.

4 METHODOLOGY

We performed a user evaluation with 23 volunteers (17 male and 6 female, between 20 to 69 years of age) recruited through in-house communication channels. All participants reported to have previous experience in playing Rock-Paper-Scissors, and a minimum knowledge about robots acquired through media consumption. Eleven participants reported to have already interacted with a robot beforehand. Five of these participants furthermore own at least one robot, and eight of them work with or build robots.

4.1 User Evaluation

To avoid side-effects such as fatigue, boredom or learning, we chose a between-subject study design. All users were randomly distributed to one of the two game variants (telegame setup: 12 participants, classic setup: 11 participants) and informed about the respective game setting and game flow. This means the participants were aware about the general process of the game, and the functionality of the embodied agent.

The experiment started with a short introductory training phase supervised by an instructor for system familiarization. Here, all participants were asked to play with the robot until they showed a stable understanding of the game interaction. The phase was supported by the experimenter, who advised participants on their hand movement whenever necessary in order to ensure the best possible system accuracy. The familiarization phase usually took between two to four best-of-three RPS games. Subsequently, participants were asked to freely play five best-of-three RPS games for evaluation. In the classic setting, participants played directly against the robot. In the telegame, participants played against the experimenter in a nearby room. The experimenter aimed to adapt their speed of play to the participant as observed during familiarization phase to provide a similar game flow to the classic game. The experiment was closed by a feedback questionnaire assessing subjective impressions of the robot and gameplay using both forced choice and open-ended questions. The forced choice questions evaluated either the game play, or various perceived attributes of the robot’s sociality as listed in Table 1. Gameplay was evaluated using selected aspects from the Game Experience Questionnaire (GEQ) [16] and two statements regarding naturalness and interactivity of the game, rated on a scale of 1 (not at all) to 5 (extremely). Robot sociality was evaluated using the ROSAS scale [3] from 1 (strongly disagree) to 7 (strongly agree). The open-ended questions were the following:

- C1 Is there something you would like to change about the game?
If yes, what?
- C2 Did you feel like you were playing with another person?
If yes, when? If no, why not?

ID	Description	Components
A1	Immersion	GEQ Items 27, 30
A2	Flow	GEQ Item 5
A3	Challenge	GEQ Items 11, 26
A4	Negative Affect	GEQ Items 7, 8, 9, 16
A5	Positive Affect	GEQ Items 4, 6, 20
A6	Naturalness	"It felt natural."
A7	Interactivity	"I thought it was interactive."
B1	Warmth	"Happy", "Feeling", "Social", "Emotional"
B2	Competences	"Capable", "Responsive", "Interactive"
B3	Discomfort	"Strange", "Awkward", "Dangerous", "Aggressive"

Table 1: Evaluated aspects of user impression. A1-A7: game experience aspects as largely derived from the GEQ. B1-B3: robot personality aspects as grouped under the ROSAS.

Figure 4: Averaged evaluations of the game play. Negative affect (A4) and positive affect (A5) were evaluated differently between conditions with statistical significance.

4.2 Results

For the forced choice questions, we determine the mean values and their respective variations per group. For the open-ended questions C1 and C2, we count the absolute numbers of yes/no answers. We furthermore test all results for statistical significance using an independent sample t-test with p -value 0.05, whereas the null hypothesis assumes no difference in the distribution of user responses between the classic game and telegame condition.

For aspects A1 to A7, we observe that the telegame achieved higher average scores with respect to flow, positive affect, naturalness and interactivity, whereas the classic setup achieved higher average scores with respect to immersion, challenge and negative affect (Fig. 4). Statistical significance was given for the score distribution of negative and positive affect, with $p = 0.005$ for A4 and $p = 0.046$ for A5. Differences in the ratings B1 to B3 of robot personality were only present with respect to discomfort aspect B3. Here, the classic game achieved significantly higher scores with $p = 0.039$ (Fig. 5).

For questions C1 and C2, the distribution of yes and no counts is of no statistical significance. However, it stands out that the telegame achieves a higher number of yes counts with respect to the impression of human-likeness (7 vs. 3, Fig. 5). Analyzing

Figure 5: Left: Averaged evaluations of the perceived robot personality. Discomfort (B3) was evaluated differently between conditions with statistical significance. Right: absolute number of yes counts for the open-ended questions.

the open-ended explanations given by participants, we discovered that all yes counts of the classic game condition were justified by the emotive expressions of the robot after winning and losing. Under the telegame condition, 3 participants explained their choice with the emotive capability of the robot, whereas 4 participants mentioned predictability of the opponent's next play. This is aligned with the general setup of the classic interaction, which is currently based on random play selections of the robot opponent.

5 DISCUSSION AND FUTURE WORK

Our analysis provides promising results and encourages further in-depth research on the potential of telegaming with robotic agents. Results show that users perceive gaming against a teleoperated robot more positively than gaming against an autonomous robot agent. This difference might be due to a more authentic game play of the teleoperated agent, or due to an enhanced feeling of social presence under the remote game setup. In the next step, the reasons for such difference should be investigated in more detail. Specifically, we plan to increase the number of subjects and extend the study design by adding further control scenarios, e.g. playing against a human. We furthermore hope to implement and evaluate other (more complex) telepresence games. This also supports our long-term goal of building a collection of meaningful social game applications that can be enjoyed by two (or more) remote users utilizing a social robot platform such as Haru.

6 CONCLUSION

We implemented a system to play Rock-Paper-Scissors with two remote users and their respective robotic telepresence agents. To assess its potential, we obtained user impressions about the game experience and perceived robot sociality, and compared it to the user assessment of more classic Rock-Paper-Scissors play with an autonomous robot. Our analysis shows that the novel tele-version of the game is subject to more positive and less negative affect than a direct human-robot game interaction. As such, our proposed setting might be a suitable approach to connect people in remote locations, and hence improve human well-being or reduce feelings of loneliness caused by social isolation. More detailed studies on the mechanisms of telegaming via an embodied robotic agent should be conducted in the future. Here, we also hope to expand our analysis to other types of game interactions.

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