Groups of Humans and Robots: the AMIGOS Project

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Abstract— **This paper describes the AMIGOS project that is investigating the role of social interactions, emotions and adaptation in robots interacting over long periods with a group of users, thus contrasting to the typical one robot one-user paradigm in Human-Robot Interaction (HRI). In this paper, we present the initial work of the AMIGOS project and describe two studies conducted with autonomous robots acting in groups (composed by humans and robots) in an entertainment scenario. The first study explores the trust levels towards a robotic partner in a team game, and how it differs from trust levels towards a human partner. Results suggested the trust towards a robotic partner was linked not only with performance aspects, but also with other factors (e.g. previous knowledge/interaction). In the second study, we analysed team formation and team preferences in the same team game scenario, where two autonomous robots, embedding personalities with different goal-orientations, were both opponents and partners of the participants. We believe the results from both studies yield important findings within the goals of the AMIGOS project, and more broadly, for the area of human-robot groups.**

Keywords - HRI, groups, entertainment, membership, team, trust

I. INTRODUCTION

Robots and becoming increasingly common tools for education, assisted living, and entertainment.In the recent years, there has been a growing interest in studying the interaction between humans and robots in real-world settings such as homes [1], workplaces [2], elderly-care facilities [3] and schools [4]. And, as robots are deployed in unstructured social environments for weeks and months, their ability to interact with different users at the same time acquires a fundamental importance. However, only a few set of projects is investigating issues associated with robots interacting with multiple users in open-ended environments. One example is the work by Kanda et. al. [4] showing how a social robot (Robovie) was able to engage children over the two-month period. Findings of such work suggest that the introduction of adaptive and social behaviours in a robot play an important role on the relationships established between users and social robots. Recent findings suggest that children behave differently when interacting alone or in dyads with a social robot [5].

Furthermore the need for deploying robots in social settings is fostering research on socially aware perception systems that capture specific aspects of the users state. In parallel there has been new developments in decision-making algorithms that allow a robot to behave in a socially coherent manner. That means that skills, such as the capability to perceive others, the capability to respond according to the situation and context, or to express verbal and nonverbal cues, are now the focus of a significant research effort within the area of social robotics. And as these capabilities become more established, they become essential when robots need to interact in groups.

This paper describes the AMIGOS project that is investigating the role of social interactions, emotions and adaptation in robots interacting over long periods with a group of users, thus contrasting to the typical one robot one-user paradigm in Human-Robot Interaction (HRI). Despite the complex social challenges that long-term HRI will soon bring, so far little is known about how perception and action selection systems, typically designed for one-to-one interactions, will perform in multiparty settings. Recent studies in this area indicate that data-driven perception mechanisms trained with information from individual interactions do not generalise well in group settings [6], raising the need to investigate new adaptive mechanisms for long term interaction of robots with groups of users.

II. THE AMIGOS PROJECT: GENERAL OVERVIEW

In the AMIGOS project we address the issue of social adaptation for robots in group settings focusing on computational modelling of emotions. Since emotions play a critical role in interaction, many authors have highlighted the relevance of emotions in the establishment of social interactions between one robot and one user[7]. Yet, research

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is necessary to investigate if the role of emotions still holds (1) when the robot is in the presence of a group of people, and (2) when aiming for long-term social interactions. In the AMIGOS project we aim to provide a robot the ability to cope with changes in the number of users around it, adjust its behaviour, depending on both contextual factors (i.e., the number of users in the environment) and the preferences of a particular user, to generate adaptive social responses. Such adaptive responses contrast with many approaches on rule-based stereotypes that have been developed in social psychology, or on the result of a process of optimisation that computes the "best" intervention depending on the situation. Those approaches become insufficient as the social environment around the robot becomes more complex, for example, as the number of users around the robot increases.

Our goal is to investigate if a robot can capture the dynamics of the social and affective interactions in a small group and is able to adapt its behavioural responses accordingly in order to sustain the interaction with people for long periods of time.

In this paper, we present initial work of the AMIGOS project and describe two studies with groups of humans and robots in an entertainment scenario.

III. Studies with Groups of Humans and Robots

To understand the social dynamics of humans and robots interaction in groups we have build a natural setting where teams can play a card game and interact in a natural way. We will present two studies conducted where we have examined how users respond to a robot in an group context in such entertaining scenario. In both studies, we have used the SUECA card game game[1] scenario to test and study group effects, varying the groups and team formations characteristics.

A. Study 1: Trust in Human-Robot Group Interactions during Card Game Playing

Trust is an important factor affecting social and emotional interactions in groups. Humans should be able to trust that a robot makes the most effective usage of its capabilities [8], in order to accomplish a common goal between them, especially in the case of a human-robot teams. Indeed, trust in human-robot interaction is a complex construct comprised of a constellation of three factors: human-related (e.g., personality traits), robot-related (e.g., performance), and environmental factors (e.g., type of task) [8]. Given that in AMIGOS we wanted to explore the social and emotional dynamics of human and robot teams, we designed a scenario where theses aspects were considered in their elements of trust. In the first AMIGOS study, we have considered *trust* as a construct that informs us about the quality of the human-robot interaction in comparison with human-human interaction [9]. Our initial goal was to create an autonomous robot that was able to play the SUECA card game on a touch table, and socially interact with its partner and its two opponents in the context of the game. By using an emotional agent architecture (the FAtiMA architecture [10]). We have thus designed and developed the robot social and emotional behaviours. Such behaviours were inspired in the behavioural analysis of groups of humans playing the same card game (a user-centred study was conducted and several videos were used as a dataset of behaviours of people playing cards). This informed the development of the verbal and non-verbal behaviours of the robot for the specific SUECA card game scenario in which the robot acted more competitive towards the opponent and encouraged its partner in the game. In order to create a natural scenario, our second concern was to develop a game interface that would handle the human-robot interaction while respecting the usual game dynamics. Playing cards should be done with physical cards and in the physical world. So, using our previous user-centred analysis, we have also analysed where players displayed their cards in the table, the manner of playing, etc. As a result, the architecture of the system integrated both the social behaviours of the robot and the game play interface for which a multitouch table was used. Therefore, the game of SUECA is played by four players, in which one of them is a robot. The robot partners with one of the humans and the two other humans are its opponents [11]. This natural scenario of 4 players is ideal to investigate the dynamics that occur as a robot interacts in a multi-party setting.

Fig. 1. Setup of the first study.

The study was conducted with 60 people (20 females, 39 males, 1 unknown; M=24.31, SD=3.852), out of which 20 had the robot as a game partner and 40 had a human partner. Having 20 human-robot teams, as well as 20 human-human teams, we were able to compare the levels of trust each participant had towards his partner before and after the experiment. The results in [9] suggested that humans trust a robot as a partner in the SUECA card game, but the degree of trust varies according to their previous knowledge of interaction with the same robot ($F(1;49)$=7.093, sig=.010). Therefore, participants that had already interacted with the robot, showed an increase level of trust after the game more than those who had already interacted with human partners. In contrast, participants without previous knowledge of their robotic partner did not increase their trust levels, suggesting

[1] https://en.wikipedia.org/wiki/Sueca_(card_game)

that the development of trust towards robots may need longer interactions. These results are in line with previous theories of trust, in which this concept appears as a complex construct, and thus, it is dependent on more than one factor. Therefore, trust in robots appears to be associated with performance. Since the robot had a good performance during game playing, humans trusted it to be their partner. Between humans, trust seemed to be connected not only with performance but also linked with other factors (e.g., personality traits). This interpretation might be one of the reasons why trust between humans involve more than simply relying on their performance during game playing [9].

B. Understanding Membership Preferences and Team Formation

In the second study we investigated multi-robot and multi-person interactions by studying people's preferences for robots with different goals [12]. The motivation behind studying social preferences in team formation relates with the fact that partnering with someone on a team depends on many different factors, including the characteristics of the individuals, their emotions, and the tasks to be executed. Henceforth, differences in the social competencies or personalities of the partner robots may influence the degree of willingness to have a robot as part of a human-robot team. Indeed, when humans select a team member to partner with, we usually privilege homogeneous groups with high indicators of competence and with greater similarity and familiarity [13]. These preferences reflect not only our preferences but also our attempt to make choices that will maximise our expectation of success. Previous research in Human-Robot Interaction has suggested that users tend to prefer robots whose personalities match with theirs in terms of introversion/extroversion [14].

Thus, to investigate the dynamics of social interactions in multi-robot multi-party settings, we designed a study to investigate team formation with different robot characteristics and personalities. We have used the same setting and the same card game of SUECA , but instead of having just one robot, we included two humans and two robots (Emys and Glin- as shown in Figure 2). Each robot was built with a different and specific goal orientation, allowing them to autonomously select their actions accordingly. The robot Emys had a more competitive and performance goal orientation, whereas the robot Glin had a more relationship-driven personality [15]. The study was conducted with 61 participants (59 university students and 2 workers; 38 male and 23 female; $M = 23.66$, $SD = 3.24$) that played three session with the robots, organised in the following order: (1) in the first session a human partnered with another human and the two robots were their opponents; (2) in the second session each robot partnered with a human, randomly chosen; (3) in the third session humans switch robot partners.

The results of the study showed that the partner choices appear to be guided by different factors, depending on the context. In the first session, when the participants had both robots as opponents and had not yet created a partner relationship with either, they chose the preferred robot (for an hypothetical partnership) based exclusively on their character (either the relationship-driven or the competitive driven robot). At that point, Glin, the relational robot, was the preferred partner ($\chi^2(1)$=4.267, sig=.039). This result is in line with previous research that postulates that we tend to prioritise members for our team that have prevalent relational features [16]. Yet, at the end of the third session, when they had to choose the preferred partner again, additional factors came into play, and people's preferences changed. Although neither of the robots was preferred over the other ($\chi^2(1)$=1.667, sig=.197), we found some statistically significant associations between their choices and other factors. The results suggested that participant's personal characteristics, and team performance took higher precedence when they had experienced partner-partner relationships with the robots. In particular, participants with higher levels of competitiveness preferred the competitive robot (sig=.005), the same way the robot winning perception was associated with the preferred one (sig=.008). In conclusion, the results from this study, presented in [12], have important implications for the creation of robotic teammates, including the need to develop robots that will be able to adapt their characteristics to their human partners' characteristics and preferences.

Fig. 2. Setup of the second study in session 1.

IV. WORK IN PROGRESS: UNDERSTANDING GROUPS OF HUMANS AND ROBOTS

To understand how humans interact with robots in small groups it is important to examine the dynamical transaction processes and the different patterns of their verbal and nonverbal communication dynamics while taking into account human and robot characteristics. However, most studies conducted so far in HRI have focused on dyads, and the majority has also analysed few dimension of their behaviour, such as the eye gaze and body movements [17]. Analysis of the dynamics of small groups adds complexity in the communication process, given that all humans and robots involved in the transactions will play an important role in influencing each other. Thus, a deeper understanding of these processes becomes increasingly important. In our studies we aim to review methods on observational and coding analysis for human-robot social interaction in small groups for testing and improving robot designs and interactive capabilities for HRI. The identification of the relevant dimension that apply to HRI in small groups is crucial, and several approaches from the field of psychology of groups processes and analytical groups research are being taken into account, such as the Interactive Process Analysis [18], the Time-by-Event-by-Member Pattern Observation [19], the Cassel Competence Grid [20], and the Discussion Coding System [21]. At this stage, video recordings of HRI in a multi-player card game setting are also being analysed by two independent coders using the Noldus Observer XT 11.5 system [22]. With this work in progress we expect to address assessment challenges for capturing a deeper understanding of intragroup dynamics in HRI.

V. Conclusions

In this project we will continue to investigate the intragroup dynamics in HRI by designing robots with characteristics that will be able to match users preferences, choices and needs. Designing robots to be able to capture the dynamics of the affective interactions in small groups and to adapt its emotional behaviour accordingly is also central because it seems to predict user's willingness to sustain the interaction with the robot for longer periods of time, which may bring us closer to the establishment of sustainable and engaging long-term interactions. Furthermore, our studies have also shown that the individual characteristics of participants affect their preferences and choices for partnership. For example, in [12], competitive individuals evaluated more positively a robot that also matched this competitive trait, after playing with two different robots that were designed to display contrasting traits (competitive vs. cooperative/relational). These results highlight the importance of personalization, by showing that robot's "traits" can be important for team formation and for the development of the interaction. Understanding how people relate with social robots in small groups and designing them in a personalised way may provide more positive experiences for users, which can have important implications in many different areas of HRI.

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