Synchrony and reciprocity for social companion robots: benefits and challenges

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1 Introduction

Companion robots are thought to be designed for assisting humans in various domains of daily life. Domains of interest are for example teaching, household assistance and guidance but also elderly care, psychological and physical therapy and sometimes even mere social contact. The benefits for the human are clear: there is work to be done which can be taken over by a machine. The downside however is, that there is a machine acting in our close surrounding. This does not only cause the need for high safety standards, this is also something that the human has to actively want because otherwise, the robot, as a technical device, will not be used. And if the robot should even play a role in therapy, especially in a psychological way, it is essential that the human does not only accept the robot, but also attributes a certain trust into its abilities. Furthermore, if taking "companionship" to its peak – the human has to accept the robot as a social entity.

It has been proposed that one key issue is achieving mutual compassion[1] between the human and the robot. This would imply not only the robot taking care for the human; this would also include the human taking care for the robot. Compassion however is a very unique human emotion that makes us understand each other due to an assumed similarity between actors and the ability to take each other's perspective. Among humans, this ability is, to a certain extent, expressed and even induced by forms of synchronization and reciprocity (i.e. mirroring, imitation) [1]. Thus, by enabling synchronization and reciprocal behavior between a human and a robot, the idea is to induce compassion from the human to the robot and vice versa. However, the argument of this article will be that it is not *compassion* that we need to induce for successful social companion robotics, but rather a certain *understanding* which a human should be able to derive from robotic action. In this context, synchronization and reciprocity can help building an intuitive understanding between human and robot which will

[1] In this article *compassion* is understood as expressed by the German translation *"Mitgefühl"*- which not only but also expresses the ability for interpersonal empathy. Translated literally *"mitfühlen"* is to feel for and with somebody. It lacks however the component of suffering with somebody, which could also be associated to the expression "*compassion"*.

adfa, p. 1, 2011.

increase the value of the interaction to the human. Therefore, in the following, the mechanisms of human synchronization behavior and related work in HRI are briefly reviewed and discussed in the context of their social benefits.

2 Social effects of synchronous behavior in humans

Human interaction is widely studied in the social domain. Without any doubt it is clear that successful human interaction also requires reciprocity, both in terms of emotions and behavior. This is especially standing out when interacting with people who suffer from autism spectrum disorder, a disease which causes deficits in social interaction due to the incapacity of patients to react to their surrounding as expected [2]. However, although synchronizing one's own movements with another person is something people do on a very frequent basis, the systematic research on effects of movement coordination and mirroring on social interaction is still quite new. Thinking for example of two people walking next to each other, they automatically synchronize their gait [3]. In this context it has been shown that people synchronize their movements in many test beds (see [4] for a review) and that it is even impossible to avoid synchronization, once movements are happening in each other's visual field [5]. Besides all behavioral effects, synchronous behavior was also found to have a social impact. By establishing a feeling of similarity and affiliation, movement synchronization modulates compassion and altruism [1]. But there is more to it: for example, children do imitate their mothers already shortly after birth. This behavior is not only considered as learning behavior, it was also shown that this imitation and mirroring happening in a mother-child relationship plays a role in the development of a emotional bonding between them [6]. And it might be that this behavior also creates a "like me" feeling [7] and a feeling what somebody else feels (theory of mind), [2].

3 Synchronization in Human-Robot Interaction

Movement synchronization between humans has many features and causes behaviors that are very important for human robot interaction [8]. However, in this context two perspectives can be taken: the human and the robot side.

3.1 Focus on the robots' side

Movement synchronization for robotic actions has been studied for various applications. For example, [9] developed a neural network architecture that, through activation and inhibition of perception action coupling, enables turn-taking between two robots, [10] used movement synchronization for selecting an interaction partner from a crowd of people and [11] used imitation for robotic skill acquisition.
However they all have in common, that they focus on the behavior of the robot, and the success of the study depended on whether or not the robot was able to i.e. imitate a human's behavior. The human preferences are not considered. While there is no

doubt that we can represent a robot's action like our own [12], it is not known whether the human appreciates the robot's behavior and if he/she would be consciously or unconsciously willing to integrate the robot's action into the own action plan and to react appropriately.

3.2 Focus on humans - The problem of mutuality and reciprocity

In the human interaction literature it is argued that movement synchronization can only be established if both partners participate in this action and with this share the mutual adaptation effort [13]. In this context, we already showed that humans *do not* automatically take the whole adaptation effort in synchronizing to a non-adaptive robot [14]. Thus, if we want a mutual adaptation, which includes reciprocal behavior from both sides, the robot needs to be able to adapt to the human movements by itself. And furthermore the human must be willing to adapt his/her behavior to the robot. Using data gathered from an experiment of human movement interaction in a goal-directed tapping task [15], we developed a model of human movement adaptation based on coupled oscillators [16]. After the model was implemented on a robotic platform, movement synchronization emerges [17]. However it is hard to disentangle robotic adaptation from human input. Also, participants' behavior differed depending on whether they recognized the robot's adaptation behavior or not.
Thus, if only the robot adapts to the human behavior, how can we make sure that this is what the human wants? Also, how can we make the human engage in the interaction? And how can we make sure, that the benefits mentioned above really apply? These questions not only express the need for a deeper understanding of human adaptation triggers and mechanisms, but also the need for the development of new qualitative and quantitative measures of interaction to access the idea of mutuality in more depth.

4 Discussion

If we want to create robots that act in our close surrounding it might be helpful to attribute a certain kind of sociality to their behavior. In this context, movement synchronization offers a promising approach. However we have to ask several questions when being at the crossover from a companion to a social companion: 1) Do we really want to induce a feeling for compassion for robots? - Or is it rather a reciprocal understanding that we are aiming for? 2) Do we really want the human to attribute live and feelings to the robot? - Or would it be enough to understand what the other will do next?
Addressing the need for mutual compassion between humans and robots is going one step too far if this means that taking care for the robot goes beyond taking care for technological needs. However the benefits of mutual understanding and the ability to predict the next action may facilitate interaction tremendously. Synchronization and reciprocity provided by the robot as a naturally appearing behavior to react to human behavior seems to be a good way of approaching and improving social companion

robots. It might provide an intuitive way of understanding each other and of inducing mutuality between agents. However we have to keep in mind that robotic adaptation/imitation can also be interpreted as persuasive and creepy. In order not to enter another dimension of the uncanny valley, we should put an emphasis on understanding human adaptation and imitation in more detail.

5 References

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