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A framework for designing socially assistive robot interactions

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Abstract

Robots are increasingly tested in different socially assistive scenarios. Future applications range from dieting, coaching, tutoring to autism therapy. In such applications the success of the system is commonly evaluated by the ability to encourage the user to keep up with a task. Hence, one important requirement for supportive systems is to have an interactional motivational model that formalizes the way how users can be assisted. In this paper we describe our framework for coordinating motivational interaction scenarios with socially assistive robots (SAR) in the context of sport assistance. We exemplify three different sport scenarios where we have used the same motivational interaction model. Furthermore, we show how this model can be used to systematically test the different aspects of motivation in the context of SAR in sport domains. Therefore, we have conducted an experiment to evaluate the importance of acknowledgement from SAR for human interaction partners. The results show that users exercise longer if acknowledgment is included into the motivational model.

Keywords: Human-robot interaction; System design; Socially assistive robots

1. Introduction

Research in Socially Assistive Robotics (*SAR*) targets scenarios where robots instruct people during tasks that benefit from some social assistance like rehabilitation, dieting or cognitive tasks (Feil-seifer & Matarić, 2005; Kidd & Breazeal, 2008; Leyzberg, Spaulding, & Scassellati, 2014). Those systems are often built from scratch and implemented interaction patterns are hand-crafted for each scenario or new application. This leads to recurring implementations of interaction structures that are difficult to compare across different systems or use cases. If we take a closer look, we see commonalities between the different scenarios that require social assistance. In the examples mentioned above we see that in all scenarios users are working towards a task goal. While the tasks (e.g. dieting, rehabilitation, cognitive or engagement tasks) are different, all share common attributes (see Table 1). They have a beginning, measurable parameters and a goal. Thus, the social assistance relates to these values and the task goals and support (e.g. acknowledgment, feedback or reparation) can be triggered to help the user reach the goal. The question is if there are common motivational patterns that capture the interactional requirements necessary to keep a user motivated to work on a task. And if so, can this concept help to systematically test the important aspects of social support?

In previous work we have developed a motivational interaction model which we have evaluated in an extended long-term study (Süssenbach et al., 2014). While the previous implementation focused on a single use case, we have now worked on the reusability of this model in the scope of a modular framework. In this work we describe a gen-

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Table 1
Comparison of different tasks, measures and supportive behavior in SAR scenarios.

Reference	Task	Measures	Supportive behavior
Kidd and Breazeal (2008)	Dieting task	Daily calory income and exercising	Suggestions, advices
Leyzberg et al. (2014)	Nonogram puzzle	Puzzle state, time, skill assessment score	Instructions, strategy lessons
Chan and Nejat (2012)	Pairs	Puzzle state, stress	Instruction, help, acknowledgment, encouragement
Leite et al. (2011)	Chess	Winning, game state, getting better/worse, valence	Encouragement, feedback, suggestions
Midden and Ham (2009)	Laundry	Energy consumption	Positive/negative social feedback
Fasola and Matarić (2013)	Exercise games	Arm position	Corrections, praise, guidance, encouragement
Schneider et al. (2012)	Mental rotations	Correct answers, time	Guidance, suggestions

eral formalized framework for SAR and introduce three scenarios that made use of it. Furthermore, we want to show that the modularization of the motivational interaction patterns allows to systematically test different aspects of interactional motivation.

We propose that re-usability of common motivational concepts and frameworks could help to systematically carry out experiments, measure the scientific progress and be reused in other domains.

The paper is organized as follows: First we will give a brief introduction of motivation as a key component for building SAR robots. Afterwards, we will explain our prior research efforts in this domain. In Section 3 we explain our current framework for designing SAR robotic scenarios. In Section 4 we will show the current usage of our framework as well as an evaluation on how this framework can be used to verify the importance of different interactional aspects of our modular motivational interaction patterns. In the last section, we will give a conclusion.

2. Related and previous work

2.1. Motivation: a key component for SAR

To develop a common concept of motivational support for SARs it is indispensable to identify the key components of motivation from an interdisciplinary perspective. There exists a wide variety of different motivational theories. For example, Scholl and Barbuto (1998) discriminates motivation in extrinsic and intrinsic motivation with further subdivisions. Motivation can also be influenced by the goals for a task (Locke & Latham, 1990) and the intention to show a certain behavior can be influenced by the expectations of a a significant other (Ajzen, 1991). Lastly, motivation is varied by a person's high or low self-efficacy belief toward the behavior (Bandura, 1986). Besides the amount of different motivational theories that could be applied to SAR recent research has mostly incorporated intrinsic motivation (and specially the theory of flow Csikszentmihalyi, 2000) for their task assistance to adapt the task difficulty to match the user's individual optimal challenge (Fasola & Matarić, 2013; Lopes, Clement, Roy, & Oudeyer, 2013). The general definition claims that motivation is a force which drives human behavior but this perspective focuses mostly on the internal states of an individual person. However, in socially assisted scenarios one main goal is to collaboratively achieve a goal. Therefore, also a sociological and linguistic perspective which analyze the different multi-modal cues during interactional processes have to be considered. Some form of communication which helps express one's desires and intentions has to be established. Therefore, future systems need to deal with miscommunication, need to have repair mechanisms and require a concept of when to trigger which kind of supportive feedback in a multi-modal manner in order to achieve a goal-oriented interaction (Schegloff, 2000).

In conclusion, the diversity and complexity of the different motivational theories show that it is a challenging task to apply one that could help to keep a trainee motivated to exercise. Depending on the task, the user group or the environment a different kind of theory might be suitable. Thus, it is difficult to implement a single theory of motivation into a SAR system because both a global and a local view on motivation are important. However, to narrow the current work we are focusing only on local motivation between a trainer and a trainee from an instructional perspective.

2.2. Approaches in SAR systems

How did other researchers tackle the problem of incorporating motivation in their work on SAR? Jayawardena, Kuo, Broadbent, and MacDonald (2014) propose a three layered architecture for rapid prototyping of SAR systems and easy to use behavior description for subject matter experts (SME). A similar approach was reported from Mead et al. (2010). However, both approaches focus on the realization of an architecture and not on a formalized behavior description for motivational instruction patterns robots could use to provide support. In these cases motivational instructions are designed by some experts. Others focus on reinforcement learning approaches to learn which behavior is motivating the user the most by e.g. reducing the user's stress or changing the user's valence (Chan & Nejat, 2012; Leite et al., 2011). Leyzberg et al. (2014) proposes the usage of bayesian models to provide a suitable assistance based on the user's task experience. Looking at these examples one could wonder whether there is no con-