Evaluation of the acceptance of a social assistive robot for physical training support together with older users and domain experts

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Evaluation of the acceptance of a social assistive robot for physical training support together with older users and domain experts

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Abstract. According to recent studies a strength of socially assistive robots (SARs) is the ability to motivate users to perform tasks in a multimodal manner. Within this paper the evaluation of a SAR based prototype for support of physical therapy of older users at home is described. By performing a user study with a training system consisting of a social assistive robot (NAO[2]) in combination with the Microsoft Kinect[3], the acceptance of human robot interaction (HRI) within the field of physical training as well as the impact on user motivation was evaluated. Results regarding motivational abilities of a SAR and the user acceptance towards the system are given.

Keywords. Human robot interaction, physical training, acceptance of socially assistive robots

Introduction

Physical inactivity is a risk factor for development of chronic diseases and leads to a higher risk of falls in daily life. Even slight physical training is sufficient to counteract this progress. Regular physical activity reduces the risk of falls of people aged 65+ by nearly 30% [1]. The success of the undertaken therapy is largely dependent on the patient’s training compliance and competence, which in daily practice results in a high variance of the training results.

It was shown that socially assistive robots (SAR) are capable of motivating users to perform certain tasks by facilitating human like interaction such as gestures, eye contact and speech together with common motivation strategies [2]. In the presented project a SAR based prototype system for physical training support and motivation at

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2 http://www.aldebaran-robotics.com/
3 http://www.microsoft.com/en-us/kinectforwindows/

home was developed and evaluated within a user study. The following research questions were used to drive the evaluation.

RQ1: To what extend is a social assistive robotic solution for physical training support at home **accepted** by a target group of older users?

RQ2: To what extend is a social assistive robotic solution **able to motivate** users to perform training at home regularly?

1. State of the art

Presenting physical exercises via video is a widely used approach and has the advantages of low prices and high accessibility (e.g. via Youtube, video recorder), but lacks the ability to control the quality and quantity of the executed exercises.

Several Exergaming systems target this shortcoming by augmenting video display of physical training with movement measurement based on parameters such as acceleration, pressure or visual detection to track body movements and to provide feedback about the performance of exercising [3], [4], [5]. Systems like Nintendo Wii and Xbox Kinect have permeated the mass market and are used for gaming exercises in context of increasing physical activity levels or computer-based rehabilitation [6]. The game character increases the motivation to perform more physical activities [3] and is effective to enhance adherence and several markers of health status [7]. The project 'Motivotion60+'[4] is such a training system that was specially developed to motivate older people.

One recent trend is the development and application of socially assistive robots (SAR) that interact with people, participate and give support in everyday life [8], [9]. The goal of using HRI to realize physical training is to facilitate human robot interaction to motivate the person to interact with the robot for a period of time which encourages the achievement of e.g. physical therapy goals. Research projects like KSERA [5], SERA[5] or COMPANIONABLE[6] work on HRI optimization for an application of SARs in the home environment of older people.

2. The prototype system

The prototypical training system, see figure 1, composed of the SAR NAO and a Kinect sensor has been developed to accomplish the following tasks:

- presentation of physical exercises
- detection and interpretation of user movements
- motivation of the user to perform the exercises.

The physical exercises, including a verbal description of each exercise are presented by NAO, the SAR trainer. NAO offers verbal and visual real-time feedback about the execution quality and quantity as well as improvement suggestions, a concluding training feedback and motivates the user to perform exercises.

4 http://www.motivotion.org/site/

5 http://project-sera.eu/

6 http://www.companionable.net/

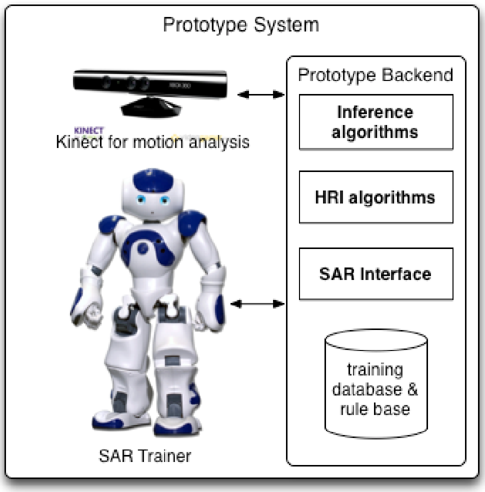

Figure 1. Prototype design of training system (Image source: Microsoft, Aldebaran).

The central component is the social assistive robot NAO from the French company Aldebaran with a weight of 4.5 kg and a height of 58 cm. The humanoid physique of the biped robot, 25 degrees of freedom and multimodal input- and output-channels like loudspeaker and microphone, various sensors for position- and movement-recognition as well as the capability of showing emotional expressions qualify NAO for presentation of physical exercises and for motivation tasks [10].

The core element for data acquisition is the Kinect sensor, a motion sensing input device by Microsoft, with an RGB camera and a depth sensor. With the OpenNI[7] framework and appropriate middleware components depth data from the Kinect sensor, represented as 3D joint positions, are available.

3. Methods

Two experiments were conducted to evaluate acceptance, motivation and adoption of the system in real-life. Within these experiments physical exercises were conducted with the older users together with the robot by mimicking the movements of the robotic assistant. Experiment 1 (EXP1) was conducted within single user test sessions and with an earlier stage of the prototype that did not involve training feedback, whereas experiment 2 (EXP2) was conducted in a group session with 14 participants with the final prototype.

During the user study quantitative results regarding the acceptance of the robot as trainer were generated by the use of standardized questionnaires (Godspeed [11], PANAS [12]) and specifically introduced ad-hoc questionnaires [13] based on Heerink et al. [14] during interviews before and after the demonstration of test scenarios. In addition to open questions within the questionnaires, the method “thinking – aloud”

[7] http://openni.org/Documentation/

[15] was used during the performance of the training session to generate additional qualitative data.

3.1. Test setup

EXP1 was conducted in a room mimicking a room of a real user’s apartment, EXP2 was conducted in a gymnasium that fitted the group size.

In both settings, the SAR is positioned opposite the person to establish eye contact while presenting the exercises. The distance between NAO and the person(s) imitating the shown exercises is about 2.4 to 3 meters. The execution poses of the exercises were sitting, standing or in a supine position depending on the motor abilities of the users.

3.2. User involvement

An end-user study was undertaken together with 30 users whereof 16 older users (n=16) with an average age of 77 (avg age=77), 13 female and three male, took part in EXP1 and a group of 14 users (n=14) (7 female, 7 male) and an average age of 69 (avg age=69) took part in EXP2.

The inclusion criteria to participate in the study have been being at least 65 years old and cognitively healthy, which was evaluated by means of the WHO quality of life questionnaire [16]. Furthermore the physical abilities should permit to conduct simple physical exercises. The involved users had only minor motor problems; one user was not able to walk without a walking frame.

4. Results

Specific questions about motivation were inquired after the demonstration of training support within EXP1. Figure 2 shows the relevant questions and illustrates the results. Fig. 2a shows that 71% of the trial participants think that NAO was motivating them “very much” or “a lot”. As an expected result within Fig 2b 70% of the trial participants say, that a human trainer would motivate them more than NAO. However Fig 2c depicts that 78% of the participants rated NAO to be the better motivator than standard training plans, which they use in daily life.

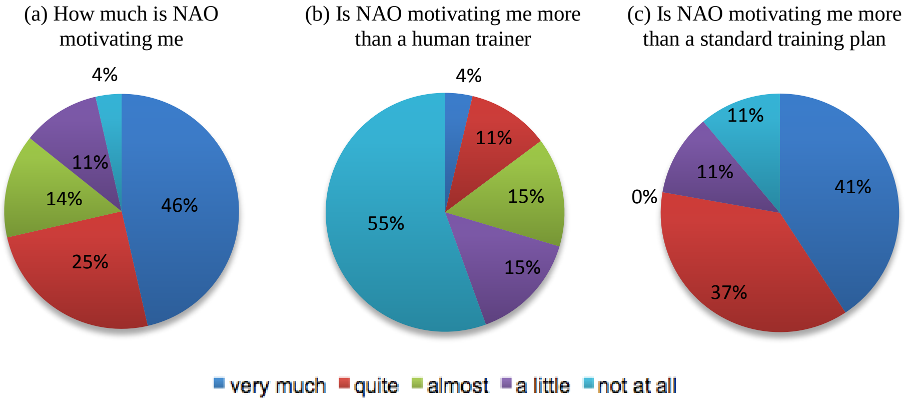

Figure 2. NAO's motivational skills.

Figure 3 shows results of a comparative questionnaire conducted after EXP2. As shown in Fig. 3a most participants prefer conventional systems for their regular training at home. As reasons they stated that the accuracy of displayed exercise movements is higher in the video version and they can use video and paper together. Fig. 3b shows that they found the video solution and the robot to be nearly equally motivating with a small preference for the video version. Fig 3c shows that over 3/4 of the users would prefer the robot if they could choose one system to take home.

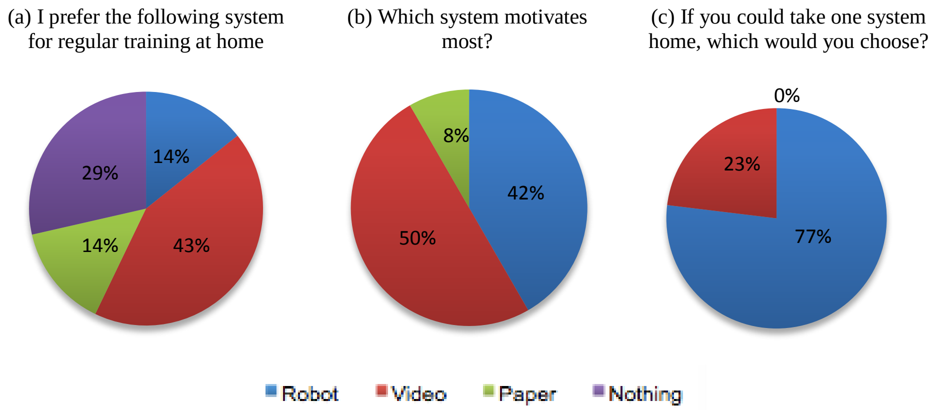

Figure 3. Comparative analysis of different ways of training support

5. Discussion

Research question 1 – "Is the system accepted by the users?" – can be partly answered given the results. A full analysis of acceptance related factors was not yet undertaken but clues are already given in the presented results. Although users prefer video or paper based systems for training at home and although they find video based systems approximately equally motivating, the majority of users would choose the robotic solution if asked which they would want to take home. This suggests that they did feel confident in handling the system at home and also accepted the robotic solution for physical training support.

Research question 2 – "To what extend is the system motivating?" - can be answered in that the users find the system highly motivating, but not significantly more motivating than comparable similar systems such as video based systems and less motivating than a human trainer. During the qualitative interviews the ability of the robotic system to automatically approach the user and remind them of performing exercises was commented positive and rated as one benefit of the system over current video based solutions.

For reasons of limitations of the degrees of freedom of the used robotic agent, some of the physical movements could not be shown absolute correctly by the robot. The participants noticed this fact but stated, that it would be good to train with the robot, as they would easily remember the correct movements by themselves and would be motivated to make the training together with their SAR trainer (see also [17]).

6. Conclusion

The results of the conducted user study point out, that a SAR for physical training is motivating and accepted by the end users. The proposed solution provides a training environment in which, under the guidance of a coach or therapist, success of training in terms of raising the motivation to actually perform the prescribed exercises can be increased.

Future studies are suggested to evaluate the results on longer term at home usage. Currently this seems not to be feasible from a technological perspective for issues of reliability and technical support. Further studies are planned with secondary users such as coaches and therapists to evaluate their willingness to involve a SAR in their training- or therapy-concepts.

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