Tangible Robots Mediated Collaborative Rehabilitation Design: Can we Find Inspiration from Scripting Collaborative Learning?

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Abstract

Due to the high intensity and repetitiveness of the exercises, rehabilitation process may be frustrating for the patients and it may results with poor treatment results. One promising way to increase motivation to provide social support through game-play. In this paper we provide an overview of previous work on collaborative and competitive games designed for rehabilitation and identify current needs of the area to increase the usability of inter-player rehabilitation games. We also discuss the use of tangibles in rehabilitation and collaborative learning and raise an idea of designing collaborative scripting components for rehabilitation game design by drawing inspiration from collaborative learning.

1 Introduction

In a rehabilitation process, it is very crucial to keep the patients engaged with the training program to achieve a better recovery. In our project we investigates how motivational aspects, namely gamification, adaptation and social interaction supporting collaboration/competition, implemented with a tangible robot platform can effect engagement in the task and effectiveness of the rehabilitation.

We use Cellulo as a rehabilitation tool since the platform allows the introduction of gaming factors into the rehabilitation session to enhance engagement. Another benefit is that, the system can be set up in 5 minutes on top of a table and does not need any special space or room, which might be very useful for home-therapy as well.

In our initial studies, we iteratively designed and tested an upper limb game together with 7 therapists, 2 neourologists and several patients with upper limb impairment such as stroke, brachial plexus and cerebral palsy.

In the next step, we will focus on integrating multiuser aspects into the rehabilitation training for motor learning and visio-motor coordination. More precisely, we aim to investigate to what extent the collaborative training may contribute to a successful rehabilitation.

In the following sections, we first provide an overview of research that has studied multi-user games for rehabilitation and then discuss tangible devices proposed by previous studies for rehabilitation. Lastly, we discuss how we can integrate collaborative activity design methodologies within collaborative rehabilitation concepts.

2 Collaborative Rehabilitation with Whom? with Which Medium?

Previous studies show that social interaction within the multi-player game concept is a potentially very important aspect of motor rehabilitation. Van den Hoogen et. al. [17] conducted a requirements analysis and showed that social support is critical for patient motivation in order to adhere to the necessary regime of rehabilitation exercises in the chronic phase of stroke. They also indicated that there is a need to engage in meaningful activities within the intimate social network (e. g. family and friends) around a patient.

Social interaction can be provided through a "social play medium" where the patient and his/her supporting partner or another patient are expected to collaborate while performing the rehabilitation exercises. Collaborative rehabilitation concepts were suggested as early as 2006 with wearable robots through Internet [4]. Furthermore, Vanacken et al. have investigated the potential of social rehabilitation training between a patient and a healthy partner and designed a game-like collaborative balance pump game where the patient uses a HapticMaster and the healthy person uses a WiiMote as input devices [18]. Similarly, Octavia et. al. [15] propose an adaptive difficulty in collaborative training where a patient and his/her therapist play the social maze game. Ballester et.al showed that upper limb exercises performed by the patients in multiplayer mode reached wider elbow flexion/extension movements than the ones performed during the single-player game session [2]. Although the long-term impact of this enhanced motivation needs to be further assessed, their results suggest that the inclusion of social factors such as multi-player capabilities is an important factor for the rehabilitation process and might have an impact on both performance and mood of stroke patients.

Even-though the multi-player rehabilitation systems are shown to be effective in patient's motivation, feasibility of those systems depend on their affordability. For instance, multi-player games with robotic arms may not be very feasible, since only a few rehabilitation centers may own more than one robotic arm for two-player rehabilitation games. Moreover, if we want to use these systems to engage home-rehabilitation they may not be very feasible in terms of cost as well as the set-up. Telerehabilitation and on-line VR based systems [2, 12] are proposed as alternative low-cost solutions where the user can play games through the Internet with another patient or his/her therapists. However, this may be frustrating for older people, who find playing with people in the same room more enjoyable than on-line play [8].

Another low-cost solution may be to create an artificial intelligence that plays with or against the user. Previous studies investigated whether users prefer play against humans or against artificial agents. [12] investigated long-distance collaborative play with able-bodied users and showed that the users prefer playing a rehabilitation task against a human than against a computer. [14] also showed that playing multi-player game with a person is more appealing for impaired chronic stroke patients compared to game against computer, as they enjoy being able to talk and interact with the person. Therefore, providing collaborative games against an intelligent agent may not be the optimum solution for multi-player rehabilitation.

Cellulo platform can be a low cost and easy to set up tangible medium for interactive multi-player rehabilitation.

3 Tangibles in Rehabilitation

Conventional physical and occupational therapy methods include the manipulation of real objects of daily life and require a tangible setup where the user grasps, holds and moves objects [19, 21]. For a more intuitive home-rehabilitation, recent studies combine low-cost materials with small interactive tangible devices. Studies show that using tangible objects that the elderly are familiar with and providing a simple tangible interface with simplified elements may reduce the learning curve among elderly [1, 11, 20].

Recent studies explore tangible objects to provide motivating technology supported training systems at home by aiming accessible and affordable setups [3, 19]. [20] showed the acceptance of a tangible board game by stroke survivors. Direct contact via touch interfaces is claimed to need lower cognitive loads and a more suitable and intuitive alternative, especially for elderly users [9]. However, there is not enough research evidence about the motor learning impact of tangible robots in a collaborative game concept. We will investigate if tangible robots (Cellulo) can motivate and provide an efficient rehabilitation through collaborative games.

4 Why We Focus on Collaborative Instead of Competitive Rehabilitation?

Designing a two players rehabilitation game requires deep evaluation since the resulting game may affect motivation positively or negatively. Competitive or cooperative game-play may be either fun or frustrating depending on the game features, the personality of the user or the relationship or the harmony of the player groups. A very recent study compared competitive and cooperative rehabilitation game played with a patient and a unimpaired person [10]. Out of 29 impaired participants, 12 chose the competitive game as their favorite, 12 chose a cooperative game as their favorite and 5 chose single player game. Participants who chose the competitive game showed increased motivation and exercise intensity in that game compared to other games. Participants who chose a cooperative game as their favorite also showed increased motivation in cooperative games, but not increased exercise intensity. However, they proposed that such games need to be tested in longer, multi-session studies to determine whether the observed increases in motivation and exercise intensity persist over a longer period of time and whether they positively affect rehabilitation outcome. Therefore, in order to provide a more effective rehabilitation game, determining the preferences of the user is important. However, this process might not be very easy especially for children and suggesting a competitive game to a less competitive users may result with negative effects rather than positive effects. A recent study show that the competitive context provided positive exergame experiences to competitive individuals, whereas it had detrimental effects for less competitive participants [16].

With the light of these results, the effect of collaborative games on both competitive and less competitive people should be investigated throughly to provide a safer option. In addition, collaborative rehabilitation games should be designed carefully to provide more intensive exercise as much as competitive rehabilitation games.

5 Can We Get Inspiration from Collaborative Learning?

Indeed, it is established in the literature that collaboration is beneficial for learning [5, 6]. However, collaboration does not happen spontaneously [7]. One promising way to enhance the effectiveness of collaborative learning is to structure interactions by engaging students in well-defined scripts. A collaboration script is a set of instructions prescribing how students should form groups, how they should interact and collaborate and how they should solve the problem [7]. Scripts aim at increasing the probability that collaboration triggers knowledge generative interactions such as conflict resolution, explanation or mutual regulation [13].

Even-though the origin of scripting design comes from the cognitive mechanisms triggering learning, we believe that it can inspire us to create gamified collaborative scripts to create more effective collaboration. By bringing scripting theory into the domain of rehabilitation, we may be able to create more interdependence between the collaborative groups, which has been shown to positively impact learning.

Scripting requires five attributes: the task that students have to perform, the composition of the group, the way that the task is distributed within and among groups, the mode of interaction and the timing of the phase [7].

We can integrate these attributes into the design of a collaborative game. For instance, within a game, the tasks can be designed in an order and gradually may effect the next tasks input therefore we can create a set of rehabilitation tasks have to be performed in a given order. Group formation can be done by measuring the latest performances of the users and it can be provided as a recommender system to therapist by suggesting collaborative game groups for current week. Task distribution can be done by assigning different roles or activities to each user in such a way that we can manipulate interdependence between users. Mode of interaction can be verbal, through tangibles or even physical mostly if one of the player is the therapist. Timing of the game tasks can be designed according to the needs of the user and may provide a better solution for the home-therapy requirements.

6 Planned Study Group

Since our main focus is motor learning, we will continue to study with stroke survivors need upper arm rehabilitation to investigate the effect of adaptive collaboration games on the motor performance of the patient. In addition, during our visits to rehabilitation centers, occupational therapists suggested to use the platform to contribute to upper limb coordination therapies of children with Developmental Coordination Disorder (DCD). Our plan is to design different scripted collaborative games and evaluate the effects on patient's motor skills and visio-motor coordinations.

Acknowledgments

This work has been partially supported by the Swiss National Science Foundation through the National Centre of Competence in Research Robotics and also partially supported by the Defitech Foundation (Morges, Switzerland).

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