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„Arm Therapy Robot ARMin: A Tele-Game to Increase Patient Motivation“

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Arm Therapy Robot ARMin: A Tele-Game to Increase Patient Motivation

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MOTIVATION

ARMin is an arm therapy robot that is used for the rehabilitation of upper extremities in neurological patients, e.g. patients after stroke. There are two devices currently in use, ARMin I with four actuated degrees of freedom and ARMin II with six actuated degrees of freedom. Both devices have an exoskeleton structure with the patient sitting in its wheelchair and having one arm connected to the device. An audiovisual display provides additional feedback to the patient.

The goal of this therapy is to induce long-term brain plasticity and to improve functional outcomes. Important factors are that the therapy is intensive, of long duration and highly repetitive [1]. To meet these requirements, it is crucial that the patient is motivated to participate actively in the training. Several game scenarios have therefore been developed and evaluated with stroke patients [2]. These scenarios take advantage of the human play instinct in order to motivate the patient to do the training. In these games, the patients play against the computer.

It is hypothesized that the patient motivation could even be higher if the patient would play against a human opponent. This abstract describes therefore the development of a tele-rehabilitation game application [3-5]. The goal is that a patient can play a rehabilitation game against another person at a remote location. This can be another patient in the same or another hospital or a therapist, who may use this possibility to assess the therapy status of the patient. A ball game has been selected, since we achieved good results in the past [2].

METHODS

Two ARMin devices are installed at different locations (ARMin II, ETH Zürich and ARMin I Balgrist University Hospital, Zürich) and a UDP connection is established (Figure 1). The graphical screens show the scenario including a virtual table, a moving ball and two handles (h_I and h_{II}). At game start, the ball B has an initial velocity and rolls either towards patient I or II.

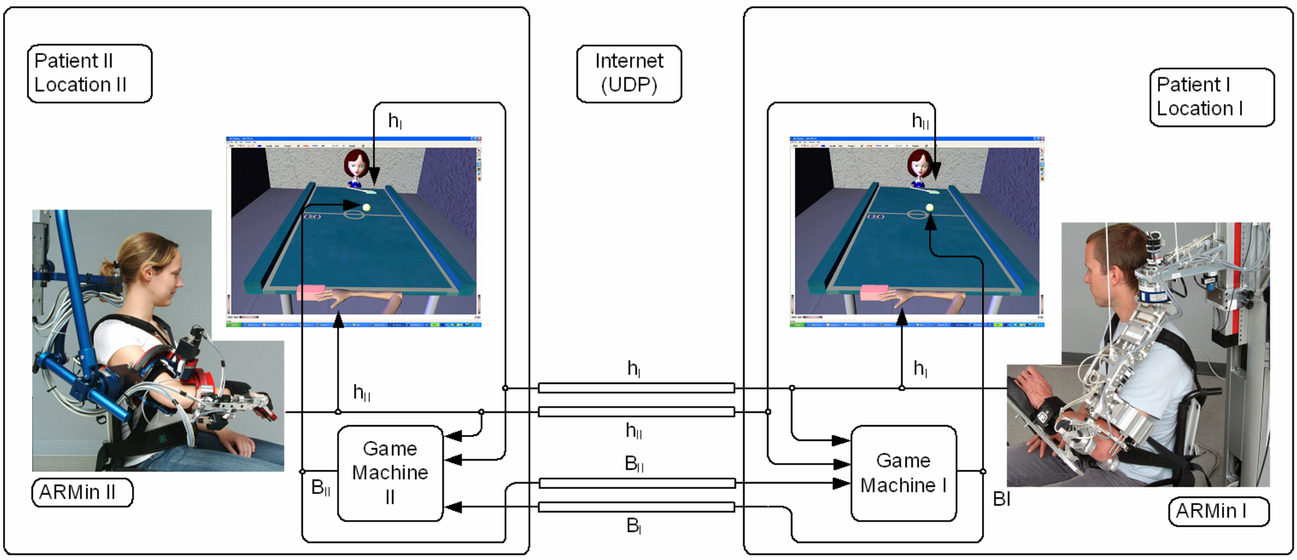

Figure 1: Overall setup. Patient A is working with ARMin II and patient B is working with ARMin I.

The transmission line is specified by the time delay *d*, by the sampling rate *r*, and by the percentage of lost samples *l*. Minimal requirements for the line are $d < 200\ ms$, $r < 60\ ms$, and $l < 5\ \%$ and have been selected based on measurements of the UDP connection. The handle position h_I and h_{II} are continuously transferred and without any correction directly displayed. As the handle movement is unpredictable, no delay correction is possible. Therefore, the movement of the opponent handle is delayed by *d* and sampled with the rate *r*. Nevertheless, because the handle movement is not a continuous movement and because the patient pays mainly attention to the ball, it is expected, that the ripple of the handle movement, that is due to the limited sampling rate, does not affect the user.

The ball position, collisions with the wall and collisions with the handles, are locally calculated by both game machines I and II. At game start, game machine I sends the initial ball position and velocity to the game machine II. When a collision with handle I occurs, the new velocity vector is calculated by both game machines by

$$\vec{v}_B(t+\Delta t) = \begin{pmatrix} v_{hIx}(t) + v_{Bx}(t) \\ v_{hIy}(t) - v_{By}(t) \end{pmatrix},$$

with the y-coordinate axis parallel to the longitudinal axis of the table. The results, calculated by game engine I and II, can differ, as the actual velocity and position of handle I is not known by game machine II. Therefore, game machine I sends the new ball position/velocity vector to II and II then adapts the actual ball position (and vice-versa) (figure 2).

RESULTS

The game machine was implemented on an xPC-target (The Mathwork inc.) real time engine with 1 ms sampling rate.

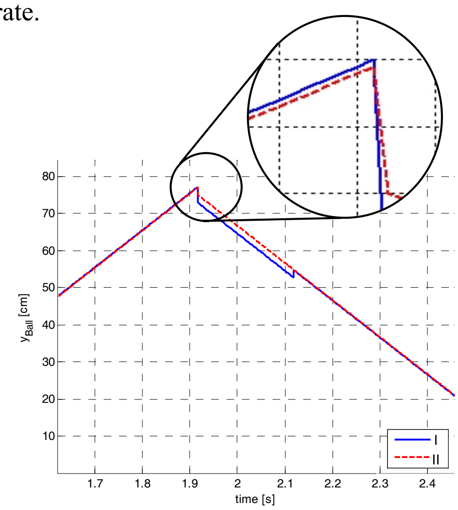

Figure 2: Simulation results showing the y coordinate of the ball before and after a collision (t =1.92s) with handle II. The trajectory of the handle I is synchronized 200ms after the collision.

The audiovisual display runs on a Windows (Microsoft Corp.) based personal computer and is programmed using the open inventor based Coin3D libraries (www.coin3d.org). The tele-game was tested with several healthy subjects and two stroke patients. The UDP-connection that was used for the test is characterized by ($d = 137ms,\ r = 50ms$ and $l = 2.9\%$). First tests indicate that the fact that the patients plays against another patient seems to motivate the patients to increase the participation.

CONCLUSION AND OUTLOOK

Tele-rehabilitation is generally defined as the provision of rehabilitation services (evaluation and intervention) at a distance by a therapist at a remote location [6], and it is characterized by the interaction of the patient and a therapist [7,8]. The hereby described idea of a tele-game to provide interaction between two patients for rehabilitation purposes is new.

Future work is dedicated to perform a clinical study with stroke patients comparing the motivation between normal game therapy and tele-game therapy.

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