RehaInteract:
3D Kinesitherapy for Domestic Environments

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INTRODUCTION

Besides well known application domains like monitoring of vital signs or disease prevention, telemedicine solutions can allow increasing the efficiency and sustainability of health care service delivery. Especially rehabilitation processes, required after severe injuries or diseases, are a promising application domain (Russel, 2007). These processes are subject to a high degree of individuality and monitoring effort, because both patients as well as disease pattern and course of disease differ in their particular characteristics. The patient's motivity and need of care have high impact on the required set of training scenarios and therefore on the set of medical sensors needed. Hence, a dynamic ICT infrastructure that allows physicians to rapidly adapt the training configuration based on the needs of each individual patient, is required. Considering immobile or geriatric patients and the depopulation of rural areas, the ability to deploy the rehabilitation system in domestic environments becomes important. Both caregivers and caretakers can benefit from remote enabled rehabilitation, because costs are reduced and the quality of life is increased. Allowing patients to stay in their domestic environments is one of the building blocks towards a more patient centered health care system. Moreover, it is often mentioned as one of the major advantages gained from using telemedicine solutions (Perednia, & Allen, 1995). However, besides monitoring of the patient's condition, rehabilitation at home requires to supervise the individual trainings in order to prevent the patient from additional injuries due to accidental execution of the exercises. Therefore, telemedicine solutions for rehabilitation that are applicable for both clinical and domestic environments need to combine monitoring and feedback techniques. Therapists need to be able to monitor the patient's condition using motion and vital signs sensors and simultaneously supervise the training remotely in order to give feedback.

The chapter will present the RehaInteract project, which aims at providing a telemedicine solution that fits the aforementioned requirements. Individualized rehabilitation activities shall be supported based on an easy-to-use interaction design. The interactions allow patients to carry out the exercises most ap-

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propriate for healing of their physiological dysfunctionalities (e.g. train to walk after stroke injuries or strengthening of shoulder muscles after a surgery). Additionally, motivational and emotional aspects will be included by providing an intuitive and attractive user interface. The visualization of individual goals and real-time feedback during the performed exercises will enhance the sustainability of the long-term therapy process at home. Using serious games design principles, the sometimes tiring exercises will be designed as much as variantly (Deterding et al., 2011).

The project provides an interaction- and communication platform based on sensors that are integrated into therapeutic devices. A self-configurable middleware allows rapidly adapting the training environment to the patient's needs and transmitting the results to clinical staff. From the patient's point of view, the system establishes a 3D therapy room at home providing individual exercises, which are tuned over time. The individual tuning is based on motion analysis and processing of the signals of the employed sensors. The results support the therapist in adapting the exercises remotely. Additionally, the platform integrates a virtual reality solution, that provides real-time feedback to the patient and increases his motivation. The chapter is organized as follows: section two will discuss the state of the art in terms of related tele-rehabilitation approaches. Additionally, the social dimension as well as the importance of interoperability will be discussed. Section three presents the training scenarios defined by the health carriers participating in the project. Section four will describe the system architecture, which includes the utilized sensors, the middleware platform and the movement analysis. Finally, section five and six will give and outlook towards future work and conclude the chapter.

BACKGROUND

This section will discuss related work by giving an overview of available sensing technologies and related research initiatives. Furthermore, the medical benefit will be highlighted from a caregivers point of view and the importance of interoperability for e-Health solutions will be discussed.

State of the Art

Recently, there has been increasing demand for telemedical applications for activity monitoring and interactive rehabilitation technologies. To measure daily and motion activities, a series of technologies exists that are already available on the market today. Some standard ones include the new pedometers and activity meters from such companies as Omron Medical Engineering or Aipermon (Aipermon GmbH & Co KG, 2014). While tracking the smallest movements, these sensors allow the calculation of the nature and intensity of motion and compare this with stored motion samples.

Sensors to detect motion, however, can also be installed in a stationary manner in an environment (e.g. cameras, sensory mats). Motion Capturing Methods, which have been in use since the 1970s, are used extensively in the movie and computer game industries. However, they are also utilized for motion analysis in the field of Life Sciences (Vicon Motion Systems Ltd. UK, 2014). Other body-near Motion Capturing or Tracking Systems are based on magnetic, mechanical or acoustic methods. For example the body-near worn MTx-System of the company XSens can be placed on each limb. The system tracks the angles of different limbs with high accuracy (XSens Technologies B. V., 2014). Nevertheless, stationary sensor systems frequently require that the subject wears additional sensory components close to his body (e.g. reflectors or tags) in order to yield greater precision.

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