Architecture of an Automated Coaching System for Elderly Population

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Abstract. We present an automated coaching system for elderly population living in assisted homes. The system guides its users through a sequence of exercises and tests. Each exercise is demonstrated by a pre-recorded video of a coach, checked for correct execution and qualitatively evaluated. Automatic coaching advices are generated in order to improve the execution. Performance measurements are shown as an immediate feedback to the user, and stored and evaluated over time. The system is designed to allow for a remote interaction with a coach, and, to bolster social aspect of the exercise, for concurrent exercise of two (or eventually multiple) remote users.

Keywords. Computer assisted coaching, marker-less motion capture, Kinect, automatic exercise evaluation

Introduction

One of the major goals in rehabilitation is to make improvements in daily activities in order to improve quality of independent living [1]. Rehabilitation process often includes task-oriented training and repetition of different motor activities involving impaired neuromuscular or musculoskeletal system [2]. In traditional rehabilitation approach, patient is guided by a trained physical therapist, which observes and assists the patient to perform the tasks correctly. This process, however, is labour intensive, time consuming and often very subjective. Patient often perceives the repetitive tasks as dull and non-engaging, which is consequently reducing patient's level of engagement.

Computer assisted coaching provides objective measurement of the performance, and has the potential to increase patient's motivation for home exercises, when not under direct coach's supervision. We are developing a system which guides patients through a series of exercises, based on [3], observes proper execution of the exercises and records the performance achieved.

Microsoft Kinect camera [4] is used to measure movements of patients. In [5] it has been shown that the accuracy of Kinect pose estimation is comparable to more complex and expensive marker-based motion capture (if that is run in a fully automatic mode without manual corrections) and several assumptions are fulfilled: the user is within the 2-4 meter range of the Kinect, facing the camera approximately frontally, and there are no significant occlusions.

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1. System Overview

The control flow of the user interface is schematically illustrated in Fig. 1. Each session consists of a sequence of exercises. Each exercise proceeds through three stages: teaching - demonstration of the routine, execution - computer assisted exercise by the

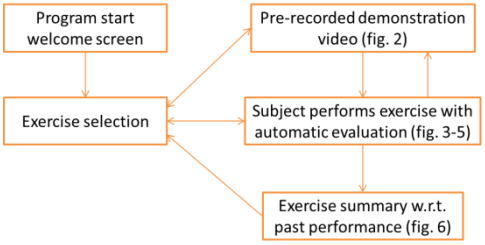

Figure 1: Automated coaching system architecture: Control flow overview

Figure 2: Pre-recorded video of a coach demonstrating the exercise

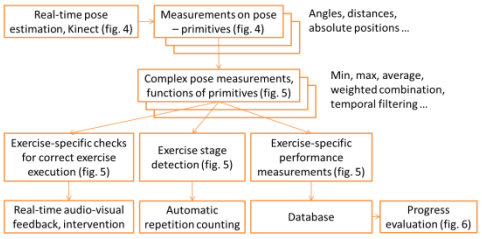

Figure 3: Automated evaluation of performed exercises: Data flow overview

Figure 4: Examples of pose measurement primitives. These are internal, not shown to the user

user, and final evaluation of the performance. The demonstration has the form of a pre-recorded video of a coach that explains the routine (Fig. 2). It is optional and can be ended at any time, accommodating for users with different levels of experience. As soon as the user is ready to perform the exercise on its own, the computer starts capturing his/her pose in real time using the Kinect camera. The pose is analysed end exercise-specific measurements are taken. See Fig. 3 for an illustration of the process. The measurements are evaluated for (i) improper execution of the routine, (ii) performance (ability) measurements, and (iii) progression through the exercise, counting repetitions. The exercise is ended after reaching a predefined number of repetitions, or it can be ended prematurely, if the user is unable to complete them all. Upon completion a database record is made that stores the number of repetitions completed along with the highest score achieved in each of the observed performance measurements. The records are displayed on the screen (Fig. 6) and are available to the coach.

As we have users with different impairments, the interface is navigated through mouse, keyboard, and speech commands using voice recognition. We are also

Figure 5: Using pose measurements to infer progress through exercise repetitions (first line), to evaluate performance (second and third line) and to give coaching advices (fourth line of text)

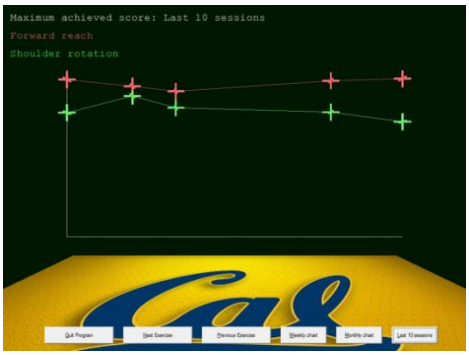

Figure 6: Achieved exercise-specific performance measurements are stored in a database, temporal progress charts are shown after each exercise

considering adding gesture control, though the gestures will have to be designed carefully as not to interfere with the exercises. The coaching feedback asking to improve the exercise execution is both shown on the screen and spoken using text-to-speech synthesis. In future the synthesized voice will be replaced with recorded human voice, preferred by the users. Positive feedback is currently given only after each exercise repetition.

2. Conclusions

We are presenting a system for computer assisted coaching of elderly people, capable of providing automatic coaching intervention, performance evaluation and remote interaction with a coach or other users. The system will be used as a platform for future research, exploring effects different forms of the audio-visual feedback on the performance and performance improvement, effect of added cognitive load, and social effect of concurrent exercising of multiple users in a shared virtual environment.

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