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Audio-Visual Feedback System for Reward-Based Training Sessions of Elderly People in a Home Environment

Abstract

Physical activity is one of the most important factors in the daily live of elderly people, e.g. to improve mobility or to prevent falls through improved physical fitness. Together with mental health, the physical condition is crucial for a self-determined life in the familiar home environment.

Within the research project FitForAge, which is funded by the Bavarian Research Foundation (BFS), we present an interface, which is especially designed to provide an easy and intuitive access to supervised physical activity for elderly people and which is easy to integrate in a home environment.

During an arbitrary exercise, which is specified by a physician and personalized according to the needs of the user, the electrocardiogram (ECG) is measured. Out of the ECG, the heart beats per minute are calculated to provide a measure for the current state of the physical strain. With the additional information of the optimal training range of the user, an intuitive audio-visual feedback system is set up, which recompenses the user while training in the optimal training range and otherwise intuitively suggests the user to correct the training.

More precisely, the user can choose between different audio-visual materials, e.g. music or video files, which are only rendered in correct speed if the heart rate of the user is in the optimal training range. Otherwise, the speed is continuously adapted to the current physical strain to indicate the direction in which the user has left the optimal range.

To avoid additional equipment in the home environment of elderly people, the complete audio-visual feedback is displayed on a conventional television, which is available in nearly every home nowadays.

In an evaluation, the interface is compared to unsupervised training with respect to the measured time, the user trained in the optimal training range.

Introduction

People at an age of more than 80 years form the fastest growing segment of population in Germany today. It is expected that this segment will more than double its population, from currently four million people to approximately ten million people in 2050 [1]. To cope with this situation, we need to develop sustainable solutions, which address the needs that come up with aging. Two main factors for a healthy aging are the mental and the physical fitness. These factors determine, if an elderly person is still able to live a self-determined life or not. Solutions, which are available for the physical training, are often too complicated in their application for elderly people or not feasible for a home installation. These modern training tools often provide a wealth of information and possible settings, which have a deterrence effect on most of the elderly people.

Within the research project FitForAge, we focus on the development of intuitive interfaces, which are adapted to the needs for elderly people. Necessary information about the physiological state is visualized in an intuitive way, which does not overload the user. The exercises themselves, with or without additional equipment, are specified by a physician and adapted to the individual needs of the user. Our interface is able to deal with nearly any exercise, which can be carried out in a home environment [2]. As an example to show the functionality of our interface, we chose a standard bicycle ergometer.

System setup

Figure 1 shows the equipment used to build up our system. It consists of three parts. The bicycle ergometer as a training tool, the nexus-10 from Mind Media [3] as a recording tool to acquire the electrocardiogram (ECG) and a Philips display for the visualization.

Fig. 1: Equipment for the Ergofeeder: Left: bicycle; Middle: nexus-10 [3]; Right: Philips display.

As mentioned, the bicycle ergometer was chosen to show an example training session. It can be replaced by nearly every exercise, which is defined by the physician. During the exercise, the ECG is continuously acquired with the nexus-10. From this signal, the current heart rate (HR) is derived. The heart rate is used to provide a measure for the current state of the physical strain to our system. Additionally, the information of the optimal training range of the user needs to be provided by the physician as reference for the interface.

Before the user can start the training session, the user needs to define the media, which should accompany the session. This is the only direct input from the user. Of course, it is also possible to store a predefined selection for the user. As media, nearly all commonly used video and audio file formats are supported. During the exercise, this media will be displayed on the TV as shown in Figure 2

Fig. 2: Running system in a home environment.

On the upper part of the TV screen, also the current HR, the optimal training range and an indicator for the current state of the user are displayed. The media, chosen by the user, fulfills two important functions at the same time. First, it serves as intuitive visualization of the current training state, as the rendering speed is adapted to the physical strain of the user. As soon as the user leaves the optimal training range, the rendering speed is increased if the user overexerts himself, or decreased if the user is below his optimal training range.
Secondly, it motivates the user to stay between the boarders of the optimal training range, as he is interested in watching the media. This is an important factor, as a system that does not motivate the user will not be used for a longer period of time. The combination of fun and workout in our system increases the chance for a longer use and additionally helps the user to train effectively.

Evaluation

The evaluation of our system consists of two parts. The first part shows that training with our system is more effective than unsupervised training. Therefore, twelve persons completed three training sessions à 5 minutes. One session without any feedback, one session, where only the heart rate without additional visualization was displayed, and one session, where our interface was visible to the user. The order of the different training sessions was changed during the evaluation. To gain an objective measure for the effectiveness of the different sessions, the time each user was training within the optimal training range was recorded.

Training Session	In Range
Unsupervised Training	61,96 %
Supervised Training (without visualization)	87,68 %
Supervised Training (with visualization)	88,28 %

Table 1: Percentage the user was within the optimal training range for each session.

The results in Table 1 show that the two training sessions, including the information of the current heart rate, are comparable concerning the goal to support the user to train in the optimal training range. Both sessions clearly outperform the unsupervised session in terms of effectiveness. If only the effectiveness would be the criteria to choose between the supervised training with or without our visualization, both applications would be satisfactory.
The second part of the evaluation focuses on the motivation of the user during the training sessions, as the aim of our system is not only to provide an effective training, but also to motivate the user. Thus, after the last session, the users had to rank the three sessions according to the motivation during the exercise. All of the participants chose the training session that included our visualization of a media file to be the one where they were motivated most.

Conclusion and future Work

The evaluation showed that our system is able to increase both the effectiveness of the absolved training session and the fun, which increases the motivation to finish the exercise and to repeat the sessions over time compared to an unsupervised training. With our tool, we provide a system that is easy to use and also usable with existing equipment, available in a standard home environment, e.g. a TV screen or existing sports equipment. Due to the intuitive feedback and the possibility to choose the visualized media according to the individual preferences of the user, our system also provides an access to a supervised training for the focus group of elderly persons.
To confirm this statement, a more intensive evaluation with test users of the focus group of elderly people is planned in the near future.

Literature

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