REHABILITATION OF PATIENTS WITH MOTOR DISABILITIES USING COMPUTER VISION BASED TECHNIQUES

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Abstract: In this paper we present details about the implementation of computer vision based applications for the rehabilitation of patients with motor disabilities. The applications are conceived as serious games, where the computer-patient interaction during playing contributes to the development of different motor skills. The use of computer vision methods allows the automatic guidance of the patient's movements making constant specialized supervision unnecessary. The hardware requirements are limited to low-cost devices like usual webcams and Netbooks.

Keywords: computer vision, rehabilitation, skin detection, OpenCV, QT.

Introduction

Physical rehabilitation is often necessary after a person suffers an injury or illness. Via physical therapy patients are able to restore movement and strength through range-of-motion exercises. In standard medical practice physical therapists work with the patient until he or she is able to regain an appropriate functioning. However, a number of patient's remains with disabling chronic disorders that sometimes persist for the rest of his life and require continuous specialized treatment. Therefore, in physical rehabilitation the attention cannot only focus on finding a cure for the patient. Physical therapy should aim to maximize the potential physical, psychological and social abilities of the patients. The attention to persons with chronic motor disabilities is consequently a complex process that needs an approach from different points of view.

Physical therapy involves direct manipulation of muscles, joints and other parts of the body affected by an injury or chronic illness. Strength training, massage and supervised exercises, each one may be elements of physical therapy. Individual therapy regimens often depend on the type of injury or condition, the patient's age and specialized treatments prescribed by a physician. It is therefore a costly process in terms of resources and specialized personnel.

We propose the development of computer applications with low cost hardware where, through serious games, the patient is encouraged to perform rehabilitation exercises while at the same time its evolution is recorded. It is intended that these games, in addition to the therapeutic function, increase the patient's motivation to engage in their rehabilitation permitting a pleasant experience. The continuous need of supervision through therapist should also be avoided. Recent studies have shown that serious games help to motivate patient's rehabilitation (Rego, Moreira, & Reis, 2010). Serious games are video games that allow users to achieve a specific objective through entertainment. The current developments of computer vision, in either software or hardware, allow the acquisition and

processing of large volume of data in real time using low-cost systems. Consequently the basic requirements for our applications are fulfilled.

The general idea is to capture the patient's movements through a web camera while at the same time he or she is displayed on screen in a modified environment. In this environment the patient will be faced with a representation of the rehabilitation goals in form of certain game tasks. These rehabilitation goals are defined by specialists and designed for the treatment and recovery of different motor skills.

The capture of the patient movement must be precise enough to allow an assessment of the development of their motor functions. It should be accurate enough to locate the joints of the patient's body and the movement or changes of their relative positions. This requires the use of diverse tools and methods of computer vision together with other computational techniques such as those presented in (Jaume-i-Capó, Varona, & Perales, 2009) and (Jaume-i-Capó, Varona, González-Hidalgo, & Perales, 2010).

Tools for vision based game implementation

Considering the requirements related above, the combination of OpenCV (Bradsky & Haheler, 2008) and Qt (Blanchette & Summerfield, 2008) has been identified as the base libraries and platforms for the development of the applications. The first of these tools, OpenCV, is a cross-platform and open source library designed to achieve the efficiency required in real time applications with optimal use of hardware resources on Intel architectures. It contains hundreds of functions that implement various computer vision algorithms. Thus, it provides an easy-to-use infrastructure for deploying vision-based applications with certain level of complexity in short time.

Meanwhile, Qt, is a framework intended to create desktop applications whose code can be compiled on a wide range of platforms, from Windows 98 to Windows 7, Solaris, Mac Os, Linux and other less known. As a platform, it offers to developers design patterns implementations, visual controls and tools for quick user interface creation.

Game overview

The games have been designed as simple applications with several abstraction layers. Several OpenCV tools are used to capture, transform and analyse images. The user interface is developed with QT. This design allows, in addition to an agile development, the adaptation of the functionality to different environment conditions under which the applications could be used. Depending on these conditions, different algorithms for human motion tracking can be used and the results properly analysed.

Games for patients with advanced mobility

Patients that are in an advanced state of recovery, can move superior joints more easily and require games with a more complex interaction that represent a challenge for them. Cognitive elements should be added to these exercises in order to improve the motivation and influence the integral rehabilitation.

In applications implemented as part of this research, physical exercises and simple activities such as link object images with their names, order the letters of a word or touch a target on the screen in a period of time should be combined (see Figure. 1).

Figure 1. Exercises for patients with advanced mobility. Source: University of Havana.
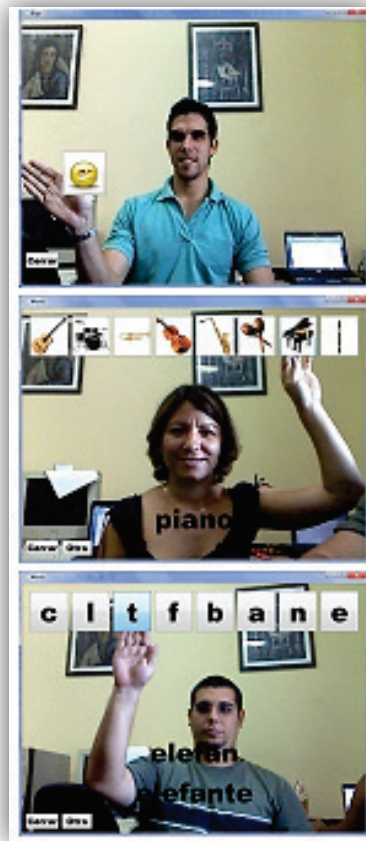
All the interaction in these games is managed through skin detection. Possible skin zones are detected in the images taken by the web camera. Skin detection is performed using simple algorithms that classify points regarding their chromatic properties (Vezhnevets, Sazonov, & Andreeyea, 2003). In most cases, these algorithms are efficient enough to be used in real time processing, but they need controlled lighting conditions in the environment and a background color that does not interfere with the analysis (see Figure. 2).

Figure 2. Skin Detection under different conditions.Source: University of Havana.

Games for motion instauration

In the first stages of rehabilitation, motion of affected joints is null or almost null. The main challenge for specialists at this point is to encourage a patient to make a movement, even a tiny one. Exercises used for this porpoises are called *ideomotors*. The patient receives an order that can be verbal or any other type and is recompensed if they achieve the goal. Some of the applications developed are aimed to improve this stage of the treatment, specially the shoulder motion instauration (see Figure 3).

Figure 3. Example of excersises for shoulder motion instauration. Source:University of Havana

In these games, the patient sees themselves on the screen and receives instructions to make a movement. Once the order is given, the application records information about movement appearance, amplitude and repetitions. Flexion and abduction are some of the types of movements this therapy works on.

All the interaction is implemented through markers made of colored papers that can be done by the family of the patient with a low cost, in contrast with the price of infrared markers traditionally used in this kind of treatment (Huiyu & Huosheng, 2008).

One of the remarkable aspects to take account during the development is the inertial or involuntary motion due to patient's handicaps, for example, in patients with Parkinson.

Game validation

Various factors such as efficiency, effectiveness, and satisfaction with the use of the applications by patients and therapist have been taken into account in the validation of the games.

For this validation control measures appearing in Manresa (Manresa, 2009) and others, in terms of usability, of the international standard ISO 9241-11 were considered.

Starting from requirements analysis we designed a database system to include all the information necessary for the final evaluation of the applications.

The validation phase is carried out with different groups of patients with movement disorders to them surveys are applied to measure the level of satisfaction before and after recovery. This phase also takes into account the comments of patients and therapist to improve the functionality of the games. The preliminary results allow to affirm the feasibility of the procedure.

Conclusions

Vision-based applications with interactive games for the rehabilitation of patients with motor disabilities promise to be an effective way to contribute to their social reintegration. The games that are already implemented are in long-term validation phase, but the preliminary results allow us to assure the feasibility of the procedure. High-cost hardware is not required to develop the games; this fact facilitates the spread of this technology over distribution of the software.

The use of more advanced techniques of computer vision, such as optical flow, allows us to improve and adapt the games to more general environments, which is a field of active research.

Acknowledgments

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