[DEMO] On the Use of Augmented Reality Techniques in a Telerehabilitation Environment for Wheelchair Users' Training

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ABSTRACT

This work's purpose is to investigate the use of Augmented Reality techniques on telerehabilitation, applied to wheelchair users training. In this scenario, using a computer with unconventional devices, the user will be connected to a remote training space and will be able to issue commands, in order to accomplish the execution of training exercises. The telerehabilitation environment should reproduce the main challenges faced by wheelchair users in their daily activities.

Index Terms: Augmented Reality;Telerehabilitation;Wheelchair Training

1 INTRODUCTION

One of the most relevant concepts nowadays, wheather in major events promotion, equipment design or public building construction is accessibility [6]. Thanks to advances on accessibility technologies, this is no longer seen as a differentiator, but a prerequisite in many different fields including those related to work, education and leisure. Thus, in many cases, movement limitations no longer prevent wheelchair users to perform their daily activities effectively. In recent years, one can easily notice changes in the urban environment, with the objective to provide accessibility to wheelchair users. Among these changes are more accessible sidewalks, ramps replacing stairs, electric elevators used for public transportation as well as adapted restrooms.

The wheelchair, in turn, played a major role in accessibility evolution. Worldwide, one can realize the benefits wheelchairs brought to the quality of life of its users. In Brazil, in particular, more than 24 million people have some form of disability, many of them using wheelchairs for mobility on a daily basis [8]. Despite its high cost, electronic wheelchairs definitely came out of research labs to gain a growing space in urban environments. Among with each new generation of electronic components, new control approaches are developed and tested. Moreover, miniaturization makes it possible to couple the electronic components to an embedded computer, weighing less than 500 grams.

On the other hand, rapid technology evolution brings new challenges: with robust control strategies and a wide range of features available, the adaptation of users to electronic chairs' control is not trivial. Thus, a training phase becomes an essential part of the overall rehabilitation process. For this training to be effective, it is necessary to expose the user to the same difficulties faced in the real world.

However, a formal approach to wheelchair users' training is still not usual [4, 5]. Among the main difficulties encountered in wheelchair training are restrictions in the time available for training, limitations on financial resources, limitations on the physical space available and lack of a standardized training process [7].

Therefore, the aim of this work is to perform an investigation of some computational techniques that could be used to overcome the problems stated above. These techniques will be better described on Section 2.

2 PROJECT MOTIVATION

Based on the informations presented on Section 1, the first challenge is to build a training environment that accurately reproduces the difficulties encountered by wheelchair users in their day-to-day activities, without exposing the patient to the real world risks. It is also desirable that this training environment should allow a degree of customization and adaptation to each patient's needs. Finally, another desirable feature is that the training environment should be remotely accessed, since access to the physical training environment can be, in its turn, a difficulty to be overcomed.

In order to overcome such limitations, the application of Virtual Reality techniques in human rehabilitation has been investigated in recent years by several researchers such as Holden *et al.* [2], Sugita *et al.* [10] D. Huang *et al.* [3] and Harrison *et al.* [1]. Among the main features of these environments, one can highlight the preservation of patient's physical integrity. However, many patients reported difficulties in using this kind of system, given the limitations on the degree of immersion virtual environments can provide [1].

From these observations, the importance of a real-time response by the training system can be noticed. Through the use of Augmented Reality techniques, it becomes possible to optimize the user experience, when compared to the immersion provided by purely virtual environments. Moreover, considering the application requirements and availability features inherent to Augmented Reality, it can be noticed that the same remote training environment can be shared by multiple users in different locations, at different times, maximizing this environment's utilization [9].

3 PROJECT DETAILS

3.1 Objective

The main objective of this project is to investigate the application of Augmented Reality techniques on wheelchair users' telerehabilitation process. To achieve this purpose, a prototype that will enable communication between three different environments will be developed: 1) a training environment, in which the wheelchair and the real/virtual barriers will be positioned; 2) a control environment, in which the training environment is presented for the user, who remotely controls the chair; 3) a supervision environment, in which the health professional can follow the execution of tasks by the user and access performance reports.

An outline of the main components of the proposed solution is shown in Figure 1.

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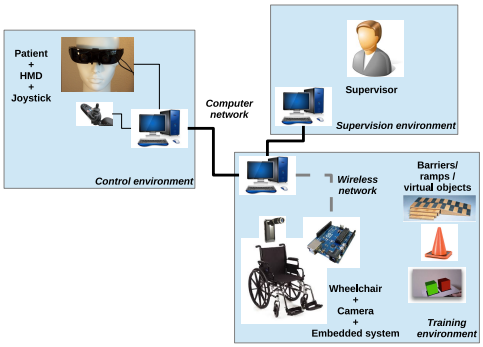

Figure 1: Solution's outline.

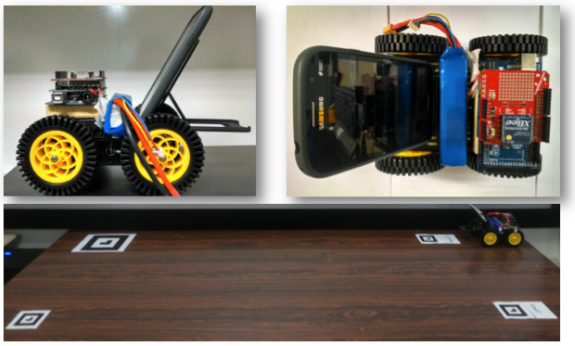

Figure 2: Test scenario.

3.2 System requirements

3.2.1 Training environment

Some elements such as an electronic wheelchair, a 3 DOF Camera, markers for Augmented Reality and physical barriers will be available in this environment. The electronic chair will respond to remote commands, issued by the patient. The 3 DOF Camera will be used to capture videos from this environment. These videos will be streamed to the control and supervision environments.

3.2.2 Control environment

Some unconventional devices (HMD and joystick) will be attached to the user's computer. The HMD will be used to view the training environment and also to track the patient point-of-view. The joystick, will be used to move the chair on the training environment.

3.2.3 Supervision environment

In this environment, the health professional will be able to follow the activities executed by the patient, in real-time. Also, he will be able to access performance reports, containing historical data from his patient's training sessions.

4 First tests

In order to validate the proposed architecture, a prototype scenario was assembled. On this scenario, a small electronic vehicle was used, to simulate the wheelchair, and to validate the command interface. A smartphone was attached to the vehicle, to simulate the camera and provide the video streaming of the training environment. A remote desktop is used to capture the stream and to issue the movement commands to the electronic vehicle.

Two approaches are being tested: on the first approach, the smartphone streams the raw video. The remote desktop then processes the video, detects the markers and augments the video with virtual objects in real time. The commands to move the vehicle are also issued on this desktop. On the other approach, the smartphone captures and processes the video, streaming the augmented video to the desktop. The desktop is used only for controlling the vehicle and presenting the augmented video to the user.

Figure 2 presents the test scenario, with its main components.

5 Conclusion

The use of computer systems in human rehabilitation has brought to health professionals the possibility of proposing standardized training processes, defining metrics and collecting large amounts of data that can be used to improve the training process itself. When it comes to telerehabilitation, computer systems play a major role on the global rehabilitation process, since they provide the basic infrastructure nedded to deliver rehabilitation services to remote patients.

Due to its inherent immersion and availability features, Augmented Reality presents itself as a valuable tool for use on telerehabilitation. By augmenting a standard training environment, health professionals will be able to customize this environment, according to each patient's limitations and needs. Patient's interactions with virtual objects can be used, for example, as metrics for evaluation and follow-up by the health professional.

Based on these conclusions, this work's preliminary investigation suggests that a telerehabilitation system providing Augmented Reality capabilities is an interesting and promising subject in the field of human rehabilitation.

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