Haptic-audio-visual platform for upper and lower limb telerehabilitation

Home based hybrid haptic telerhabilitation platfom

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***Abstract*— The combination of rehabilitation, haptic interfaces, and virtual reality technics provides a powerful platform for reproducing the visual and motor sensations that a physiotherapist experiences during physical therapy procedures. With the wide availability of information technologies and new, robust telecommunication technologies, remote tele-guidance for telerehabilitation has become feasible for more effectively employing expertise through remote instruction. The current study proposes a telerehabilitation platform based on virtual physical therapy environment and commercial low cost haptic interfaces.**

Keywords- telerhabilitation ; telehaptics; haptic motor skill transfer.

I. INTRODUCTION

The combination of rehabilitation (physical therapy), haptic interfaces, and virtual reality technics provides a powerful platform for reproducing the visual and motor sensations that a physiotherapist experiences during physical therapy procedures. This combination with the advent of new computer technologies has enabled revolution in telerehabilitation as well as in planning and executing physical therapy treatments. Many manual activities and manipulations may benefit from the use of haptic devices to assist and to replay fine movement and specific manipulation. This provides great utility in such domains as Physical therapy and rehabilitation, since the planning and execution of a patient movements can be analyzed, recorded, and replayed. Traditionally, physical therapy and rehabilitation sessions have been guided by the therapist throughout sessions, which consist of guiding movements, manipulations, and making the choice for type of physical therapy.

Telerehabilitation has been attacked by several prior studies and projects [1],[2],[3],[4], Some of them partially satisfy these requirements but none addresses all needs. Research on meeting these requirements is already underway.

Our idea is to propose a complete, low cost and portable telerehabilitation framework that supports both the patient and the therapist along the rehabilitation treatment. More precisely, the system supports the therapist in the definition of the exercises specified in terms of postures and trajectories for the specific patient. During rehabilitation, the patient is guided by the therapist through our platform in several online or offline guidance protocols to correctly execute the exercises, and this guidance is done with multi-modal feedback (haptic audio-visual teleguidance) to enhance the performance of the exercise and treatment. All the data (haptic and audio visual data) produced during the session can be collected for storage and further analysis. The result of the analysis is provided to the therapist in order to follow the evolution of the patient and tune the therapy and telerehabilitation, if needed. An overview of the proposed scenario is illustrated in Figure 1

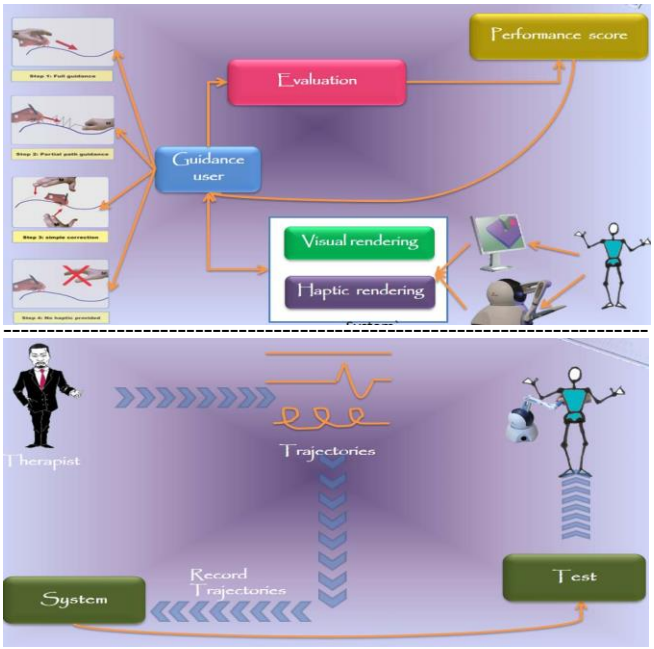

Figure 1. The proposed telerehabilitation/teleguidance platform.

II. TELEREHABILITATION PLATFORM DESCRIPTION

Our platform includes the following principal components:

1- Augmented reality telerehabilitation environment:

This environment is the multimodal immersive interface between patients and the therapist which provide virtual reality techniques for physical objects simulation and force

feedback rendering in addition to augmented reality techniques for more robust telepresence rehabilitation treatment.
This environment integrates some real time "treatment proficiency score" evaluation modules, which helps the therapist to evaluate the patient rehabilitation advancement and tune the therapy.

2- haptic patient-therapist tele-guidance support module:
This module consists of two general shape:
- *one-point force feedback platform* (figure 2): A haptic interface with stylus like Geomagic® Haptic Devices installed in two sides, the patient and the therapist context, and generally it is used for hand rehabilitation.

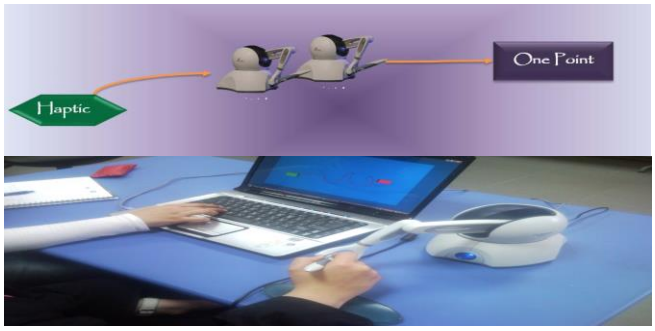

Figure 2. tele-guidance one-point force feedback platform.

- *multi-point force feedback platform* (figure 3): which configured by multi-connected haptic interfaces of the first shape providing a hybrid form, which provide multi-point force feedback rendering for upper and lower limbs. and these interfaces installed in two sides patient and therapist context.
And through these two platform shapes the therapist can tele-guide the patient upper limb or lower limb during the rehabilitation session.

Figure 3. tele-guidance multi-point force feedback platform

3- haptic tele-guidance protocol (motor skill transfer) module:
This module allows the therapist to guide the patient movements and gestures through the use of haptic tele-guidance support module and the augmented reality telerehabilitation environment. We have developed a master-slave system employing the haptic
interfaces that allow the therapist to tele-link a patient's haptic interface to the therapist's device, allowing the patient to feel the therapist's touch during the rehabilitation activities.
We apply in this module four guidance protocols for physical telerehabilitation as in figure 1
Full haptic guidance, partial path haptic guidance, simple correction haptic guidance, no haptic guidance.

4- Communication infrastructure:

We apply the same communication infrastructure that we developed in our last research project [6] which adopted a robust Networking-Communication Management Component (NCMC) and hybrid transport protocol, in order to ensure a real time and high efficient tele-guidance and effective telerehabilitation.

III. CONCLUSION

The project's main purpose was to develop and propose a new telerehabilitation platform through applying haptic and force feedback and using immersive augmented reality environment.
Experimental phase 1 is already reached and the iterative process has started. It will enable us to validate the system usability and real telerehabilitation feasibility.

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