Chapter 48
A PhysX–Based Framework to Develop Rehabilitation Systems Using Haptics and Virtual Reality

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ABSTRACT

The use of Virtual Reality (VR), in combination with haptic devices (i.e. robotic manipulators capable of generating forces that stimulate the tactile and/or proprioceptive system of the users) is becoming very popular in the field of rehabilitation. As matter of fact, different rehabilitation requirements, related to various pathologies, are usually addressed by developing specialized haptic devices, together with specific VR worlds and exercises to be performed within. This, in turn, usually brings a tremendous effort when new exercises must be designed and/or new haptic devices, with their mechanical model and hardware (HW) interfaces, must be embedded into an existing environment. To cope with the required flexibility and adaptability, while reducing the development cost, we propose in this chapter a software framework that aims at reducing the development time and cost of new VR+haptics systems, through the use of well-known software design patterns (Model/View/Controller, Strategy, Observer) and freely available technologies (XML, PhysX).

INTRODUCTION

The use of Virtual Reality (VR), in combination with haptic devices (i.e. robotic manipulators capable of generating forces that stimulate the tactile and/or proprioceptive system of the users) is becoming very popular in the field of rehabilitation. The use of such technologies helps both patients, who interact with a virtual world that encourages movements, and rehabilitation therapists, who can focus on the patients, leaving to the device the duty of collecting quantitative data about the rehabilitation sessions. In a rehabilitation system of this type, a common task for the patient consists in moving an object within the VR environment, by properly moving the end-effector of a haptic device (see Figure 1).

The target movements to be implemented by the patients depend on the pathology and the rehabilitation target, and they may be simple (like reaching different fixed object in the VR world or contouring fixed obstacles) or rather complex (as tracking a moving object in the VR world).

Systems based on VR and haptics have usually a common architecture, composed of three main components:

1. A simulation engine that dynamically model the environment to be reproduced in the virtual reality;
2. Visual, auditory, and haptic rendering algorithms which take care of interfacing with the user by generating forces, audio and video feedback;
3. A transducers that provides the haptic sensations to the patient, based on the data provided by simulation engine.

While it is possible to devise such a common architecture, the final rehabilitation system must then be customized on patient's characteristics and clinicians' needs, to support the execution of rehabilitation exercises, suitable for the particular disability. Therefore, current research has proposed different haptic devices, tailored to the specific pathology with different hardware and visual interfaces based on preferences of rehabilitation therapists. Nevertheless, this often requires a huge implementation effort, as the software for the control of each device is usually implemented from the scratch, with a time and cost efforts that could be largely reduced relying on previous experiences.

To cope with the required flexibility and adaptability while reducing the development cost, we proposed a software framework that aims at taking advantage of available knowledge, through the use of well-known software design patterns (Model/View/Controller, Strategy, Observer) and freely available technologies (XML, PhysX).

Figure 1. Schematic representation of a typical VR+haptics rehabilitation system
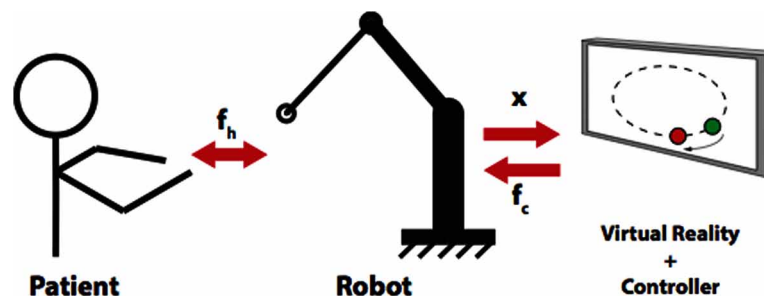
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