Chapter 58
Robot Modeling for Physical Rehabilitation

Rogério Sales Gonçalves
Federal University of Uberlândia, Brazil

João Carlos Mendes Carvalho
Federal University of Uberlândia, Brazil

ABSTRACT

The science of rehabilitation shows that repeated movements of human limbs can help the patient regain function in the injured limb. There are three types of mechanical systems used for movement rehabilitation: robots, cable-based manipulators, and exoskeletons. Industrial robots can be used because they provide a three-dimensional workspace with a wide range of flexibility to execute different trajectories, which are useful for motion rehabilitation. The cable-based manipulators consist of a movable platform and a base, which are connected by multiple cables that can extend or retract. The exoskeleton is fixed around the patient's limb to provide the physiotherapy movements. This chapter presents a summary of the principal human limb movements, a review of several mechanical systems used for rehabilitation, as well as common mathematical models of such systems.

INTRODUCTION

There exist two common techniques for movement rehabilitation: the first technique involves the patient staying passive throughout the therapy while the therapist (or the rehabilitation system) manipulates the injured limb to promote its movement. Motion and load limits must be well controlled in this technique to avoid new injuries of the still injured region/limb. In the second technique, the patient performs active movements. The big difference between patients and injury means different and/or multiple devices should be at the disposal of therapists.

One can identify two important areas for the application of robots to human health: the robotic surgery and the rehabilitation robots. Both areas have advanced considerably due to the development of control systems, video cameras, micro and nano technologies, new materials, and so on.

DOI: 10.4018/978-1-4666-4607-0.ch058

Physical medicine and rehabilitation is intended to treat, recuperate, or alleviate the disabilities caused by chronic diseases, neurological damage, or injuries resulting from pregnancy and childbirth, car accidents, cardiovascular diseases, and work. Rehabilitation is a comprehensive and dynamic process-oriented physical and psychological recovery of the disabled person, in order to achieve social reintegration.

Rehabilitation had been advanced and developed greatly in the twentieth century, especially in the periods after major disasters such as wars, in order to treat lesions.

The rehabilitation process involves several activities, from diagnosis to prescription of treatment, where the prescribed treatment must facilitate and stimulate the recovery processes and natural regeneration. In general, the process involves stimulus and repetitive movements that must be performed several times at various speeds.

The science of rehabilitation has shown that repeated movements of human limbs can to help the patient regain function of the injured limb. Robotic systems can be more efficient in performing these exercises than humans, and they the recording of information like position, trajectory, force, and velocity, maximizing motor performance during active movements. All data can be archived and then compared to check the progress of patients in therapy.

Different robotic architectures have been developed and applied in the rehabilitation of human limbs. In general, robotic structures used in rehabilitation are industrial robots or a new structure specifically designed for and/or adapted to the reproduction of human movements.

This paper focuses on mechanical systems, which are used in medicine to rehabilitate patients with loss of movement. These systems should reproduce the correspondent human limb motion, which will be recovered. The development of such mechanical systems is not a simple task due to the complexity of human limb motion. In order to understand the complexity of designing the mechanical structure for movement rehabilitation, initially only the principal human limb movements are introduced. In the following, a review of several systems used for rehabilitation is presented. They are based on industrial robots, specific structures (serial and parallel robotic structures), structures based on articulated closed loop mechanisms, and cable-based parallel manipulators. The usual mathematical modeling of such systems is presented both for kinematics and dynamics. An example of a cable-base parallel manipulator is also presented.

JOINTS AND MOVEMENTS OF THE HUMAN BODY

In the present section, the principal joints and human limb movements are presented. One must keep in mind that the upper limbs serve for manipulation, and therefore their joints must allow for great mobility, while the lower limbs serve for locomotion.

For a specific rehabilitation system to be developed, one should use appropriate characteristics of motions and loads for each application. In published papers there is a lot of information about movement limits, forces and torques at joints, but in general they do not explain how and in such conditions these data were obtained. Therefore, these data must be used with prudence. On the internet, one can obtain several videos and examples of human joint motions, which help us understand joint behavior, for example in http://www.infovisual.info/03/026_en.html, http://www.scribd.com/doc/9303667/The-Joint-of-Human-Body, and http://www.bbc.co.uk/science/humanbody/body/factfiles/joints/ball_and_socket_joint.shtml.

Anatomy, the study of the structure of the body, informs us about human joints and their movements.

Medical encyclopedias and textbooks on human anatomy usually list joints in different categories. Also, the total number of joints varies

Related Content