Chapter 13
A Human–Machine Interface Design to Control an Intelligent Rehabilitation Robot System

Erhan Akdoğan  
Marmara University, Turkey

M. Arif Adlı  
Marmara University, Turkey

Ertuğrul Taçgün  
Marmara University, Turkey

Nureddin Bennett  
Technical University of Kaiserslautern, Germany

ABSTRACT
The demand for rehabilitation increases daily as a result of diseases, occupational and traffic accidents and population growth. In the present time, some important problems occur regarding the rehabilitation period: the transportation of patients, the acquisition and storage of treatment data and the need to support the physiotherapists with intelligent devices. In order to overcome these challenges, the authors hereby propose a human machine interface to control an intelligent rehabilitation robot system designed for the lower limbs. The human machine interface has a structure that is created with a rule-based intelligent controlling structure, combined with conventional controller and an easy-to-use graphical user interface. By means of this interface, the rehabilitation sessions can be stored and members of the rehabilitation team can reach to this stored data via internet. Additionally, the patient can receive treatment in his house. One physiotherapist is able to treat several patients at a time by utilizing this system. The system’s capacity has been elaborated through the test results.

INTRODUCTION
The growing world population and the increasing number of problems people have with their limbs have intensified the need for rehabilitation particularly for lower limbs. Reestablishing and improving the limb functionality and strength are major issues. Furthermore, it is most important to help patients to return to society, to reintegrate them into social life and thus to improve the patients’
quality of life. Injuries in extremities like arms and legs are caused mainly due to old age, work and traffic accidents. The role of the rehabilitation process is to restore functionality of previously damaged limbs. Throughout the therapy, physical exercises for extremities like arms and legs have a key role in the recovery of the patient. Therapeutic exercises consist of active or passive physical movements of the patient, carried out through the physiotherapist (PT), or of movements carried out by the patient with the assistance of the physiotherapist, depending on the condition of the patient. Among them, the performing of resistive exercises is particularly difficult and exhausting for physiotherapists. For rehabilitation either the patient has to go to a healthcare center, or the physiotherapist has to come to the patient. Considering the often time-consuming process of rehabilitation, this is difficult and cost-intensive for both patient and physiotherapist, and demands a high amount of patience of all parties involved. Furthermore, a physiotherapist can only fully attend one patient at a time. Another important issue is to record the treatment period of the patient and to provide the members of the rehabilitation team—physiotherapist, occupational therapist etc— with fast and easy access to these records. By means of this access, the rehabilitation period can proceed well and a database can be formed for patients with similar conditions. The progress of a patient can be therefore monitored and compared to other patients. To achieve this aim and therefore to increase the efficiency of the rehabilitation process, the following issues have to be solved:

- The patient’s condition should be monitored and recorded throughout the treatment period. The monitoring information should be saved on the database of the medical center and must be easily accessible.
- Computerized mechanisms, capable of performing therapeutic exercises, are needed to support physiotherapists
- Intelligent human-machine and human-computer interfaces are needed to enable the physiotherapists to control these mechanisms.
- To overcome the problem of transporting patients to the medical center, internet-based rehabilitation methods should be developed for remote operation and treatment.

BACKGROUND

Over the last decade, the number of studies about robots in rehabilitation has increased. Studies carried out in recent past have proved that rehabilitation robots have many advantages compared to classic therapy methods (Lum et al., 2002). In addition, robotic therapy provides better possibilities to acquire and store information such as the therapy response of the patient (Richardson, Brown, & Plummer, 2000). A number of studies—an as part of the general studies made about rehabilitation robots—in which particularly conventional control techniques stand out, have hitherto been carried out. Lum and others (1995 & 1997) introduced an assisted rehabilitation system for arms. Krebs and others (1998 & 2003) have developed and have clinically evaluated a robot-aided neurorehabilitation system called MIT-MANUS. This device provides multiple-degree of freedom exercises of upper extremities for stroke patients. Rao, Agrawal and Scholz (1999) introduced another system using a Puma 240 robot for active and passive rehabilitation of upper extremities. Richardson and others developed a 3 DOF (degree of freedom) pneumatic device for rehabilitation of upper extremities using PD control and impedance control methodologies (Richardson et al., 1999, 2000, & 2003). Reinkensmeyer and others (2000) developed a 3 DOF system called ARM Guide (Assisted Rehabilitation and Measurement Guide) for rehabilitation of upper extremities. Another system with 3 DOF, called GENTLE/s,
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