Guest Editorial
Special Theme on Virtual Rehabilitation

OVER the past 15 years, the real-time performance of computing platforms has improved tremendously, while at the same time graphics hardware prices have fallen by orders of magnitude. While the driving force for change was the gaming industry, an interesting byproduct is the emergence of a new field of medical care of interest to the readership of the IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING. *Virtual rehabilitation* represents the combination of computers, special interfaces, and simulation exercises used to train patients in an engaging and motivating way. For the past five years, we have organized the International Workshop on Virtual Rehabilitation (IWVR), a venue where researchers from many continents present their latest discoveries, as well as clinical outcomes. A number of IWVR06 presenters were invited to contribute to this Special Theme and the seven papers included here were selected from among their submissions.

Training hand function in virtual environments involves special interfaces such as 3-D trackers (for wrist movement), or sensing gloves which measure finger joint positions in real time. A less developed interface at this time is the haptic glove which can apply computer-controlled resisting and/or assisting forces at the finger level. The first paper in this special issue "Use of Magnetorheological Fluid in a Force Feedback Glove" by Winter and Bouzit, describes a novel magnetorheologic force feedback glove they developed. The authors present their glove design as well as its initial usability evaluation which showed the glove to be light weight and portable.

Another type of interface, this time aimed at amputees is a mechatronic prosthesis. In the paper "A Virtual Reality Environment for Designing and Fitting Neural Prosthetic Limbs" by Hauschild *et al.*, the authors describe how virtual environments can be used to help patients operate a simulated limb to interact with virtual objects. The same virtual environments are then used in the development of the entire prosthetic system before introducing it to the patient.

A networked textual virtual environment is another type of interface which can serve as an aid for patients with vision loss. "AudioMUD: A Multiuser Virtual Environment for Blind People" by Sánchez and Hassler, presents the design and usability evaluation of AudioMUD. Their approach is based on MUD style games which let users perform a set of actions in a virtual environment where a navigable space is provided, with restrictions, orientation, and direction. The authors now adapted spoken text to describe the environment, navigation, and interaction, embedding some collaborative aspects between blind users. Blind learners were motivated when interacting with AudioMUD and helped to improve the interaction through audio and interface design elements.

Joint range-of-motion (ROM), manual muscle test (MMT), Berg sit-to-stand, Berg forward reach and timed up and go (TUG) are patient evaluation methods which require a visit to the clinic. The paper "Technical Feasibility of Teleassessments for Rehabilitation" by Durfee *et al.* studies the possibility of doing such assessments at a distance (thus, saving patient travel time and expenses). No differences were found between colocated and remote assessments for a group of 10 subjects.

Remote assessments are a component of telerehabilitation, or the provision of rehabilitation interventions at a distance. The paper "Technical and Patient Performance Using a Virtual Reality-Integrated Telerehabilitation System: Preliminary Findings" by Deutsch *et al.* describes a system used for poststroke remote training. Subjects used a prototype Rutgers Ankle robot to interact with two virtual reality simulations, while the therapist was in the same room during the first three weeks or in another room during the fourth week. Patient performance (in terms of accuracy of ankle movement, exercise duration and training efficiency, mechanical power of the ankle, and number of repetitions) did not decrease during telerehabilitation.

The last two papers of this special issue are "Telerehabilitation Using a Virtual Environment Improves Upper Extremity Function in Patients With Stroke" by Holden *et al.* and "Telerehabilitation Using the Rutgers Master II Glove Following Carpal Tunnel Release Surgery: Proof-of-Concept," by Heuser *et al.* Both describe systems where virtual environments mediate training at a distance. Results in both studies show significant improvements in upper extremity function (in the first case) or clinical measures of grasp force (for the second case).

By necessity, the number and scope of papers included in this special issue are limited. It is hoped that the reader will see the numerous possibilities virtual rehabilitation offers to clinicians and researchers alike.

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