Preface

Most disabilities are from neuro-diseases (such as stroke, brain trauma, etc.) or other non-natural reasons (such as arthritis). Using United States as an example, since 1994 disability-related costs for medical care and lost productivity have exceeded an estimated $300 billion annually. Other countries also put significant effort in the treatment of stroke patients and disability recovery. Efficient rehabilitation training (i.e., rehab-training) could greatly help to recover normal body coordination and flexibility (C&F) capabilities.

Other than conventional rehabilitation from physical therapists, the virtual reality (VR) based robot systems have emerged as one of the most effective auto-training methods in the recent several years. With the help of these systems, effective training interventions can greatly help people to shorten the training time and reduce the risk of trips and falls during the training. The most important components in VR based rehab-training system include: (1) VR game design: The VR rehabilitation games should focus on functional recovery, such as reaching out and grasping things, placing foot to a certain height. VR games should provide different scenarios in order to achieve different goals of training during rehab. (2) Sensor-based interaction: Several sensors can be used as the inputs of subject movement to interact with the virtual games. Medical sensors may also be used to present body signal for further feedbacks from healthcare professionals. (3) Robot-assist system: The highest concern of post-stroke patients is falling while doing rehab training. The robotic assistant machine can help to hold patients to prevent to fall. With such a system, we can

- Increase post-stroke patient motivation;
- Automate and personalize rehabilitation sessions;
- Collect and compare performance data;
- And give accurate performance feedbacks.

The VR rehabilitation training can be briefly separated into two parts: the rehabilitation of motor deficits of the upper extremities and the lower extremities after a brain lesion due to stroke. For the upper extremities training, arm, hand and finger movements need to be recorded. For the lower extremities training, leg and foot movements should be captured. VR rehabilitation system has been developed to be applied in both clinical and home environments. Session data is shared with healthcare professionals and therapy can be given remotely. In the future, VR rehabilitation training system will be an effective extension to existing physical therapies and also enables rehabilitation within patient’s home environment.
In this book, we have invited some experts in the world to write computing-assisted rehabilitation systems based on their research outcomes. Those chapters are organized into the following 6 sections:

**Section 1: Big Picture.** This section has one chapter that introduces the rehabilitation requirements for disabled patients. It also briefly discusses different rehabilitation methods.

**Section 2: Virtual Reality + Robot.** The integration of VR system and robot can provide an effective training through video games and robot-assisted action corrections. We have described a few interesting integrated systems here. A system with haptics and VR is introduced. We also introduced a system with VR and mobile robots for the treatment of the children with intellectual disability.

**Section 3: Virtual Reality Only.** This section introduces a lower cost system that uses only VR video games for rehabilitation. A chapter describes the VR tools for the assessment of executive functions and unilateral spatial neglect. Another chapter discusses the significance of VR-based rehabilitation for patients with acquired brain injury. Augmented reality is an enhancement of VR by adding real scene objects. A chapter talks about the use of augmented reality for upper limb rehabilitation.

**Section 4: Robot Only.** This section contributes to the mechanical and electrical design of robots in the rehabilitation systems. We have introduced a lower extremity rehabilitation robot, as well as a hand training robot with multiple degrees of freedom. Another chapter discusses the wearable power assisted robot with artificial muscles.

**Section 5: Sensors Only.** The most inexpensive way for virtual rehabilitation is perhaps to use sensors only to monitor the patient behaviors and generate warning messages if the gaits/gestures do not meet expectations. Here we described a Kinect-only biomechanical assessment of neurological patients’ motor performance for domestic rehabilitation. We also provided a multi-sensor fusion architecture to monitor neuro-disorder caused motor deficiency.

**Section 6: Other Approaches.** Here we described some of other approaches to achieve computing-based rehabilitation systems. For example, the patient can just touch a specially designed computer screen for upper extremity rehabilitation.

**Targeted Audiences:** This book targets both academia and industry world. The following types of readers can especially benefit from this book:

1. **Graduate Students:** For students who are working towards PhD or Master Degrees, they could find an interesting direction from the chapters and then think of how to extend the research topics there.
2. **College Educators:** Faculty could use this book for the reference materials when they teach advanced rehabilitation systems based on computer hardware and software.
3. **Researchers:** Each chapter provides unsolved research issues in the systems, thus researchers could easily select a promising topic for future development.
4. **Engineers:** The chapters include many graphic illustrations and math models. Thus engineers could study the design details and use them for their own design.
5. **Technicians:** They can easily digest the chapter content and understand the state-of-the-art development in this exciting field.
6. **Company Administrators:** They could use the provided data in different chapters for market analysis, and thus determine which product they should target.
Virtual rehabilitation is a hot area and many R&D issues have not been solved yet. We wish the readers could learn both basic principles and profound theories by reading this book. Although we have tried our best to provide complete references and enough credits for each cited source, there may be some missing points in this book. If that is the case, please contact the chapter authors or the publishers for our future corrections. Thank you and enjoy the reading of this book!