Robotic Exoskeleton For Rehabilitation Of The Upper Limb


Advances in the material sciences, 3D printing technology, functional electrical stimulation, smart devices and apps, FES technology, sensors and microprocessor technologies, and more have lately transformed the field of orthotics, making the prescription of these devices more complex than ever before. Atlas of Orthoses and Assistive Devices, 5th Edition, brings you completely up to date with these changes, helping physiatrists, orthopaedic surgeons, prosthetists, orthotists, and other rehabilitative specialists work together to select the appropriate orthotic device for optimal results in every patient.

Rehabilitation Robotics gives an introduction and overview of all areas of rehabilitation robotics, perfect for anyone new to the field. It also summarizes available robot technologies and their application to different pathologies for skilled researchers and clinicians. The editors have been involved in the development and application of robotic devices for neurorehabilitation for more than 15 years. This experience using several commercial devices for robotic rehabilitation has enabled them to develop the know-how and expertise necessary to guide those seeking comprehensive understanding of this topic. Each chapter is written by an expert in the respective field, pulling in perspectives from both engineers and clinicians to present a multi-disciplinary view. The book targets the implementation of efficient robot strategies to facilitate the re-acquisition of motor skills. This technology incorporates the outcomes of behavioral studies on motor learning and its neural correlates into the design, implementation and
validation of robot agents that behave as ‘optimal’ trainers, efficiently exploiting the structure
and plasticity of the human sensorimotor systems. In this context, human-robot interaction
plays a paramount role, at both the physical and cognitive level, toward achieving a symbiotic
interaction where the human body and the robot can benefit from each other’s dynamics.
Provides a comprehensive review of recent developments in the area of rehabilitation robotics
Includes information on both therapeutic and assistive robots Focuses on the state-of-the-art
and representative advancements in the design, control, analysis, implementation and
validation of rehabilitation robotic systems

This book contains the proceedings of the 1st Latin American Congress on Automation and
Robotics held at Panama City, Panama in February 2017. It gathers research work from
researchers, scientists, and engineers from academia and private industry, and presents
current and exciting research applications and future challenges in Latin American. The scope
of this book covers a wide range of themes associated with advances in automation and
robotics research encountered in engineering and scientific research and practice. These
topics are related to control algorithms, systems automation, perception, mobile robotics,
computer vision, educational robotics, robotics modeling and simulation, and robotics and
mechanism design. LACAR 2017 has been sponsored by SENACYT (Secretaria Nacional de
Ciencia, Tecnologia e Inovacion of Panama).

Balance, Gait, and Falls, Volume 159 presents the latest information on sensorimotor anatomy,
sensory integration, gravity and verticality, standing balance, balance perturbations, voluntary
stepping and gait initiation, gait and gait adaptability, disorders of balance and gait that result
from aging and neurological diseases. The book provides a brief overview of age-related
changes in the structure and function of sensorimotor and central processes, with sections
specifically devoted to Parkinson’s disease, parkinsonism, cerebellar ataxia, stroke,
corticobasal degeneration, multiple sclerosis, Huntington’s disease, dystonia, tremor,
Alzheimer’s disease, frontotemporal dementia, cerebral palsy, polio, motor neuron disease,
brainstem lesions, spinal lesions, peripheral nerve disease, and psychogenic conditions.
Diseases covered have a common structure comprising background and epidemiology,
pathology, balance disorders, gait disorders, falls, therapies (including fall prevention), and
future directions. Covers all aspects of basic and clinical research on disorders of balance and
gait in neurological disease Presents a multidisciplinary review of balance and gait physiology,
the epidemiology and natural history of balance and gait impairments in aging, and a broad
range of neurological diseases Addresses impairments of balance and gait for basic and
clinical researchers in neuroscience, human movement science, physiotherapy and exercise
physiology

This book presents the synthesis of a Hand Exoskeleton (HE) for the rehabilitation of post-
stroke patients. Through the analysis of the state-of-the-art, a topological classification was
proposed. Based on the proposed classification principles, the rehabilitation HEs were
systematically analyzed and classified accordingly, that is effective to both perceive the
demand for proposing application-specific solutions and provide some useful guidelines for the
design of a new HE. Further, a novel rehabilitation HE was designed to support patients in
cylindrical shape grasping tasks with the aim of recovering the basic functions of manipulation.
Numerous multi-objective optimizations followed by building a final prototype. The experimental
results of the preliminary tests are promising and demonstrate the potential for clinical
applications of the proposed device in robot-assisted training of the human hand for grasping
functions.

Wearable Robotics: Systems and Applications provides a comprehensive overview of the
entire field of wearable robotics, including active orthotics (exoskeleton) and active prosthetics for the upper and lower limb and full body. In its two major sections, wearable robotics systems are described from both engineering perspectives and their application in medicine and industry. Systems and applications at various levels of the development cycle are presented, including those that are still under active research and development, systems that are under preliminary or full clinical trials, and those in commercialized products. This book is a great resource for anyone working in this field, including researchers, industry professionals and those who want to use it as a teaching mechanism. Provides a comprehensive overview of the entire field, with both engineering and medical perspectives Helps readers quickly and efficiently design and develop wearable robotics for healthcare applications.

This book gathers the joint proceedings of the VIII Latin American Conference on Biomedical Engineering (CLAIB 2019) and the XLII National Conference on Biomedical Engineering (CNIB 2019). It reports on the latest findings and technological outcomes in the biomedical engineering field. Topics include: biomedical signal and image processing; biosensors, bioinstrumentation and micro-nanotechnologies; biomaterials and tissue engineering. Advances in biomechanics, biorobotics, neurorehabilitation, medical physics and clinical engineering are also discussed. A special emphasis is given to practice-oriented research and to the implementation of new technologies in clinical settings. The book provides academics and professionals with extensive knowledge on and a timely snapshot of cutting-edge research and developments in the field of biomedical engineering.

This book can serve as a reference resource for those very same design and control engineers who help connect their everyday experience in design with the control field of mechatronics. This book also consists of basic and main mechatronic system's laboratory applications for use in research and development departments in academia, government, and industry, and it can be used as a reference source in university libraries. It can also be used as a resource for scholars interested in understanding and explaining the engineering design and control process and for engineering students studying within the traditional structure of most engineering departments and colleges. It is evident that there is an expansion of mechatronics laboratories and classes in the university environment worldwide.

Human Modelling for Bio-inspired Robotics: Mechanical Engineering in Assistive Technologies presents the most cutting-edge research outcomes in the area of mechanical and control aspects of human functions for macro-scale (human size) applications. Intended to provide researchers both in academia and industry with key content on which to base their developments, this book is organized and written by senior experts in their fields. Human Modeling for Bio-Inspired Robotics: Mechanical Engineering in Assistive Technologies offers a system-level investigation into human mechanisms that inspire the development of assistive technologies and humanoid robotics, including topics in modelling of anatomical, musculoskeletal, neural and cognitive systems, as well as motor skills, adaptation and integration. Each chapter is written by a subject expert and discusses its background, research challenges, key outcomes, application, and future trends. This book will be especially useful for academic and industry researchers in this exciting field, as well as graduate-level students to bring them up to speed with the latest technology in mechanical design and control aspects of the area. Previous knowledge of the fundamentals of kinematics, dynamics, control, and signal processing is assumed. Presents the most recent research outcomes in the area of mechanical and control aspects of human functions for macro-scale (human size) applications Covers background information and fundamental concepts of human modelling Includes modelling of anatomical, musculoskeletal, neural and cognitive systems, as well as motor skills, adaptation, integration, and safety issues Assumes previous knowledge of the fundamentals of kinematics,
Rehabilitation Robotics summarizes the rationale for robot-assisted therapy and presents the technological steps in the evolution of the design and development of lower and upper extremity rehabilitation robots. After presenting the basic mechanisms of natural and artificial movement restoration, and the rationale for robot-aided movement therapy, it shows several design criteria that are relevant for the development of effective and safe rehabilitation robots.

Practical and authoritative, this new edition delivers easy access to the latest advances in the diagnosis and management of musculoskeletal disorders and other common conditions requiring rehabilitation. Each topic is presented in a concise, focused, and well-illustrated two-color format featuring a description of the condition, discussion of symptoms, examination findings, functional limitations, and diagnostic testing. The treatment section is extensive and covers initial therapies, rehabilitation interventions, procedures, and surgery. From sore shoulders in cancer patients to spinal cord injuries, Essentials of Physical Medicine and Rehabilitation, 2nd Edition provides you with the knowledge you need to face every challenge you confront. Offers practical, clinically relevant material for the diagnosis and treatment of musculoskeletal conditions. Discusses physical agents and therapeutic exercise in the prevention, diagnosis, treatment and rehabilitation of disorders that produce pain, impairment, and disability. Presents a consistent chapter organization that delivers all the content you need in a logical, practical manner. Presents a new co-editor, Thomas D. Rizzo, Jr., MD, and a pool of talented contributors who bring you fresh approaches to physical medicine and rehabilitation. Offers current evidence and expert guidance to help you make more accurate diagnoses and chose the best treatment option for each patient. Features an entirely new section on pain management so you can help your patients reach their full recovery potential. Incorporates redrawn artwork that makes every concept and technique easier to grasp. Includes updated ICD-9 codes giving you complete information for each disorder.

The potential of robotic systems to aid in the rehabilitation of populations with cerebral palsy is a burgeoning area of research. It is able to provide more repeatable and enjoyable physiotherapy regimes, in addition to lessening the burden on physiotherapists, shifting their work to a supervisory role. In this research, a control architecture for a wearable elbow exoskeleton device is presented. The exoskeleton contains a novel actuation joint, presented as the Bio-Sensor & Joint (BJS) and this is used to apply torques to the elbow joint. A torque controller based on sliding mode control (SMC) was derived from a model of the system and compared to a feedback-linearised proportional derivative (PD) controller for pure trajectory tracking. It was found that the SMC controller was more robust to disturbances and modelling uncertainties. The SMC controller was then tested for efficacy in applying torques to the elbows of human participants, while they conducted Activities of Daily Living (ADLs), where it was found that constant torques could be applied regardless of the presence of variable human motion. Tests were also conducted by integrating the SMC torque controller into an impedance-based control scheme and it was shown to reduce trajectory tracking error for both healthy participants and a participant diagnosed with cerebral palsy. Finally, a high-level gravity augmentation controller was developed that uses Denavit- Hartenberg parameters to estimate the component of gravity perpendicular to the forearm. With this information, the SMC torque controller can be commanded to exert a torque on the elbow that varies in response to orientation relative to the gravity vector, thus simulating the lifting of a weight. Experiments were conducted where participants were asked to lift a combination of physical and simulated weights, with surface-electromyography (sEMG) signals recorded as a measure of exertion. While the controller was able to accurately vary the torque on the elbow as the orientation relative to the gravity vector changed, it was not possible to draw statistically significant
conclusions regarding the effect of the augmented gravity conditions on the participants’ physical exertion.

This book addresses cutting-edge topics in robotics and related technologies for rehabilitation, covering basic concepts and providing the reader with the information they need to solve various practical problems. Intended as a reference guide to the application of robotics in rehabilitation, it covers e.g. musculoskeletal modelling, gait analysis, biomechanics, robotics modelling and simulation, sensors, wearable devices, and the Internet of Medical Things.

This book provides state-of-the-art scientific and engineering research findings and developments in the area of service robotics and associated support technologies around the theme of human-centric robotics. The book contains peer reviewed articles presented at the CLAWAR 2017 conference. The book contains a strong stream of papers on robotic locomotion strategies and wearable robotics for assistance and rehabilitation. There is also a strong collection of papers on non-destructive inspection, underwater and UAV robotics to meet the growing emerging needs in various sectors of the society. Robot designs based on biological inspirations are also strongly featured.

Americans praise medical technology for saving lives and improving health. Yet, new technology is often cited as a key factor in skyrocketing medical costs. This volume, second in the Medical Innovation at the Crossroads series, examines how economic incentives for innovation are changing and what that means for the future of health care. Up-to-date with a wide variety of examples and case studies, this book explores how payment, patent, and regulatory policies—as well as the involvement of numerous government agencies—affect the introduction and use of new pharmaceuticals, medical devices, and surgical procedures. The volume also includes detailed comparisons of policies and patterns of technological innovation in Western Europe and Japan. This fact-filled and practical book will be of interest to economists, policymakers, health administrators, health care practitioners, and the concerned public.

Offering a comprehensive look at physical therapy science and practice, Guccione’s Geriatric Physical Therapy, 4th Edition is a perfect resource for both students and practitioners alike. Year after year, this text is recommended as the primary preparatory resource for the Geriatric Physical Therapy Specialization exam. And this new fourth edition only gets better. Content is thoroughly revised to keep you up to date on the latest geriatric physical therapy protocols and conditions. Five new chapters are added to this edition to help you learn how to better manage common orthopedic, cardiopulmonary, and neurologic conditions; become familiar with functional outcomes and assessments; and better understand the psychosocial aspects of aging. In all, you can rely on Guccione’s Geriatric Physical Therapy to help you effectively care for today’s aging patient population. Comprehensive coverage of geriatric physical therapy prepares students and clinicians to provide thoughtful, evidence-based care for aging patients. Combination of foundational knowledge and clinically relevant information provides a meaningful background in how to effectively manage geriatric disorders Updated information reflects the most recent and relevant information on the Geriatric Clinical Specialty Exam. Standard APTA terminology prepares students for terms they will hear in practice. Expert authorship ensures all information is authoritative, current, and clinically accurate. NEW! Thoroughly revised and updated content across all chapters keeps students up to date with the latest geriatric physical therapy protocols and conditions. NEW! References located at the end of each chapter point students toward credible external sources for further information. NEW! Treatment chapters guide students in managing common conditions in orthopedics, cardiopulmonary, and neurology. NEW! Chapter on functional outcomes and assessment lists
relevant scores for the most frequently used tests. NEW! Chapter on psychosocial aspects of aging provides a well-rounded view of the social and mental conditions commonly affecting geriatric patients. NEW! Chapter on frailty covers a wide variety of interventions to optimize treatment. NEW! Enhanced eBook version is included with print purchase, allowing students to access all of the text, figures, and references from the book on a variety of devices.

Wearable exoskeletons are electro-mechanical systems designed to assist, augment, or enhance motion and mobility in a variety of human motion applications and scenarios. The applications, ranging from providing power supplementation to assist the wearers to situations where human motion is resisted for exercising applications, cover a wide range of domains such as medical devices for patient rehabilitation training recovering from trauma, movement aids for disabled persons, personal care robots for providing daily living assistance, and reduction of physical burden in industrial and military applications. The development of effective and affordable wearable exoskeletons poses several design, control and modelling challenges to researchers and manufacturers. Novel technologies are therefore being developed in adaptive motion controllers, human-robot interaction control, biological sensors and actuators, materials and structures, etc. In this book, the editors and authors report recent advances and technology breakthroughs in exoskeleton developments. It will be of interest to engineers and researchers in academia and industry as well as manufacturing companies interested in developing new markets in wearable exoskeleton robotics.

Every year there are about 800,000 new stroke patients in the US, and many of them suffer from upper limb neuromuscular disabilities including but not limited to: weakness, spasticity and abnormal synergy. Patients usually have the potential to rehabilitate (to some extent) based on neuroplasticity, and physical therapy intervention helps accelerate the recovery. However, many patients could not afford the expensive physical therapy after the onset of stroke, and miss the opportunity to get recovered. Robot-assisted rehabilitation thus might be the solution, with the following unparalleled advantages: (1) 24/7 capability of human arm gravity compensation; (2) multi-joint movement coordination/correction, which could not be easily done by human physical therapists; (3) dual-arm training, either coupled in joint space or task space; (4) quantitative platform for giving instructions, providing assistance, exerting resistance, and collecting real-time data in kinematics, dynamics and biomechanics; (5) potential training protocol personalization; etc. However, in the rehabilitation robotics field, there are still many open problems. I am especially interested in: (1) compliant control, in high-dimensional multi-joint coordination condition; (2) assist-as-needed (AAN) control, in quantitative model-based approach and model-free approach; (3) dual-arm training, in both symmetric and asymmetric modes; (4) system integration, e.g., virtual reality (VR) serious games and graphical user interfaces (GUIs) design and development. Our dual-arm/hand robotic exoskeleton system, EXO-UL8, is in its 4th generation, with seven (7) arm degrees-of-freedom (DOFs) and one (1) DOF hand gripper enabling hand opening and closing on each side. While developing features on this research platform, I contributed to the robotics research field in the following aspects: (1) I designed and developed a series of eighteen (18) serious VR games and GUIs that could be used for interactive post-stroke rehabilitation training. The VR environment, together with the exoskeleton robot, provides patients and physical therapists a quantitative rehabilitation training platform with capability in real-time human performance data collection and analysis. (2) To provide better compliant control, my colleagues and I proposed and implemented two new admittance controllers, based on the work done by previous research group alumni. Both the hyper parameter-based and Kalman Filter-based admittance controllers have satisfactory heuristic performance, and the latter is more promising in future adaptation. Unlike many other upper-limb exoskeletons, our current system utilizes force and torque (F/T) sensors and position encoders only, no surface electromyography (sEMG) signals...
are used. It brings convenience to practical use, as well as technical challenges. (3) To provide better AAN control, which is still not well understood in the academia, I worked out a redundant version of modified dynamic manipulability ellipsoid (DME) model to propose an Arm Postural Stability Index (APSI) to quantify the difficulty heterogeneity of the 3D Cartesian workspace. The theoretical framework could be used to teach the exoskeleton where and when to provide assistance, and to guide the virtual reality where to add new minimal challenges to stroke patients. To the best of my knowledge, it is also for the first time that human arm redundancy resolution was investigated when arm gravity is considered. (4) For the first time, my colleagues and I have done a pilot study on asymmetric dual-arm training using the exoskeleton system on one (1) post-stroke patient. The exoskeleton on the healthy side could trigger assistance for that on the affected side, and validates that the current mechanism/control is eligible for asymmetric dual-arm training. (5) Other works of mine include: activities of daily living (ADLs) data visualization for VR game difficulty design; human arm synergy modeling; dual-arm manipulation taxonomy classification (on-going work).

Living with Robots recounts a foundational shift in robotics, from artificial intelligence to artificial empathy, and foreshadows an inflection point in human evolution. As robots engage with people in socially meaningful ways, social robotics probes the nature of the human emotions that social robots are designed to emulate.

The book reports on advanced topics in the areas of wearable robotics research and practice. It focuses on new technologies, including neural interfaces, soft wearable robots, sensors and actuators technologies, and discusses important regulatory challenges, as well as clinical and ethical issues. Based on the 4th International Symposium on Wearable Robotics, WeRob2018, held October 16-20, 2018, in Pisa, Italy, the book addresses a large audience of academics and professionals working in government, industry, and medical centers, and end-users alike. It provides them with specialized information and with a source of inspiration for new ideas and collaborations. It discusses exemplary case studies highlighting practical challenges related to the implementation of wearable robots in a number of fields. One of the focus is on clinical applications, which was encouraged by the colocation of WeRob2018 with the International Conference on Neurorehabilitation, INCR2018. Additional topics include space applications and assistive technologies in the industry. The book merges together the engineering, medical, ethical and political perspectives, thus offering a multidisciplinary, timely snapshot of the field of wearable technologies.

A wearable robot is a mechatronic system that is designed around the shape and function of the human body, with segments and joints corresponding to those of the person it is externally coupled with. Teleoperation and power amplification were the first applications, but after recent technological advances the range of application fields has widened. Increasing recognition from the scientific community means that this technology is now employed in telemanipulation, man-amplification, neuromotor control research and rehabilitation, and to assist with impaired human motor control. Logical in structure and original in its global orientation, this volume gives a full overview of wearable robotics, providing the reader with a complete understanding of the key applications and technologies suitable for its development. The main topics are demonstrated through two detailed case studies; one on a lower limb active orthosis for a human leg, and one on a wearable robot that suppresses upper limb tremor. These examples highlight the difficulties and potentialities in this area of technology, illustrating how design decisions should be made based on these. As well as discussing the cognitive interaction between human and robot, this comprehensive text also covers: the mechanics of the wearable robot and it’s biomechanical interaction with the user, including state-of-the-art technologies that enable sensory and motor interaction between human (biological) and wearable artificial
(mechatronic) systems; the basis for bioinspiration and biomimetism, general rules for the
development of biologically-inspired designs, and how these could serve recursively as
biological models to explain biological systems; the study on the development of networks for
wearable robotics. Wearable Robotics: Biomechatronic Exoskeletons will appeal to lecturers,
senior undergraduate students, postgraduates and other researchers of medical, electrical and
bio engineering who are interested in the area of assistive robotics. Active system developers in
this sector of the engineering industry will also find it an informative and welcome resource.

This book gathers the proceedings of the 15th IFToMM World Congress, which was held in
Krakow, Poland, from June 30 to July 4, 2019. Having been organized every four years since
1965, the Congress represents the world’s largest scientific event on mechanism and machine
science (MMS). The contributions cover an extremely diverse range of topics, including
biomechanical engineering, computational kinematics, design methodologies, dynamics of
machinery, multibody dynamics, gearing and transmissions, history of MMS, linkage and
mechanical controls, robotics and mechatronics, micro-mechanisms, reliability of machines and
mechanisms, rotor dynamics, standardization of terminology, sustainable energy systems,
transportation machinery, tribology and vibration. Selected by means of a rigorous international
peer-review process, they highlight numerous exciting advances and ideas that will spur novel
research directions and foster new multidisciplinary collaborations.

This 2nd edition remains the only comprehensive evidence-based text on the Occupational
Therapy management of the stroke patient. The book is based on the most up-to-date research
on stroke rehabilitation and presents its content in a holistic fashion, combining aspects of
background medical information, samples of functionally based evaluations, and treatment
techniques and interventions. There are chapters on specific functional aspects of living after
stroke, such as driving, sexuality, mobility and gait, and self-care. Instructor resources are
available; please contact your Elsevier sales representative for details. Case studies are
featured in every chapter to help the reader understand how concepts apply to the real world. 2
chapters that feature the true stories of stroke victims, presenting occupational therapy
situations from the point of view of the patient. Key terms, chapter objectives, and review
questions help students better understand and remember important information. 7 new
chapters make this text more comprehensive than ever! Psychological Aspects of Stroke
Rehabilitation Improving Participation and Quality of Life Through Occupation The Task-
Oriented Approach to Stroke Rehabilitation Approaches to Motor Control Dysfunction: An
Evidence-Based Review Vestibular Rehabilitation and Stroke How Therapists Think: Exploring
Clinician’s Reasoning When Working With Clients Who Have Cognitive and Perceptual
Problems Following Stroke A Survivor's Perspective II: Stroke Reflects the current terminology
and categorization used by the WHO and the new AOTA Practice Framework so students will
be equipped with the latest standards when they enter the workforce. Updated medication
chart presents the latest drugs used in stroke rehabilitation.

In the last decade, diverse research areas have developed novel approaches to overcome
dysfunctions after a spinal cord injury (SCI). Even though motor restoration attracts the most
clinical attention, sensory, autonomic, and mental health are also aspects fundamental to
improving the quality of life of SCI patients. Over four sections of therapeutic, rehabilitation, and
technological approaches, this book examines preclinical and clinical studies using
mesenchymal stem cells and pharmacological or electrical stimulation strategies. Chapters also
address the impact of paraplegia and associated loss of autonomic functions, including bowel
and sexual dysfunction, as well as the convergence of new technologies aimed at providing
postural support and enhancing mobility.
The new technological advances opened widely the application field of robots. Robots are moving from the classical application scenario with structured industrial environments and tedious repetitive tasks to new application environments that require more interaction with the humans. It is in this context that the concept of Wearable Robots (WRs) has emerged. One of the most exciting and challenging aspects in the design of biomechatronics wearable robots is that the human takes a place in the design, this fact imposes several restrictions and requirements in the design of this sort of devices. The key distinctive aspect in wearable robots is their intrinsic dual cognitive and physical interaction with humans. The key role of a robot in a physical human–robot interaction (pHRI) is the generation of supplementary forces to empower and overcome human physical limits. The crucial role of a cognitive human–robot interaction (cHRI) is to make the human aware of the possibilities of the robot while allowing them to maintain control of the robot at all times. This book gives a general overview of the robotics exoskeletons and introduces the reader to this robotic field. Moreover, it describes the development of an upper limb exoskeleton for tremor suppression in order to illustrate the influence of a specific application in the designs decisions.

The book reports on advanced topics in the areas of wearable robotics research and practice. It focuses on new technologies, including neural interfaces, soft wearable robots, sensors and actuators technologies, and discusses important regulatory challenges, as well as clinical and ethical issues. Based on the 2nd International Symposium on Wearable Robotics, WeRob2016, held October 18-21, 2016, in Segovia, Spain, the book addresses a large audience of academics and professionals working in government, industry, and medical centers, and end-users alike. It provides them with specialized information and with a source of inspiration for new ideas and collaborations. It discusses exemplary case studies highlighting practical challenges related to the implementation of wearable robots in a number of fields. One of the focus is on clinical applications, which was encouraged by the colocation of WeRob2016 with the International Conference on Neurorehabilitation, INCR2016. Additional topics include space applications and assistive technologies in the industry. The book merges together the engineering, medical, ethical and political perspectives, thus offering a multidisciplinary, timely snapshot of the field of wearable technologies.

Gait disorder is a commonly lasting side-effect for stroke and spinal cord injury survivors. Conventional gait rehabilitation trainings provided by therapists are largely dependent on their experience. Such trainings are often challenging for the therapists due to their physically intensive nature. Hence, consistent optimal results cannot always be achieved. Robotic technologies were thus introduced to automate the gait rehabilitation trainings, in order to emancipate therapists from physically intensive work as well as making rehabilitation training more accessible to patients. Research have shown that task specific repetitive training and patients’ active participation can lead to more effective gait rehabilitation. However, conventional trajectory tracking controlled robotic gait rehabilitation could change the dynamics of the walking task, reduce inputs from patients’ motor systems, lower their physical effort and thus result less effective outcomes. Therefore, it is important to ensure that the robotic gait rehabilitation training is more analogous to actual human walking and maximize the training subject’s active participation. The goal of this thesis is the development of a new robotic GAit Rehabilitation EXoskeleton (GAREX) that is compliant with the current neurorehabilitation theories in order to achieve optimised robotic gait rehabilitation. Such goal is tackled systematically in terms of both robotic design and control algorithm research. GAREX was designed to provide safe, task specific gait rehabilitation to stroke patients. Pneumatic muscles (PM) actuators were used to drive GAREX, due to their high power/force to weight ratio and intrinsic compliance. Specially, the intrinsic compliance can create a wide range of dynamic environment for control strategy development. However, the negative correlation between PM’s
force output and contracting length means a trade-off between torque and range of motion specifications of the actuation system. The design of GAREX comprehensively addressed torque and joint range of motion requirements imposed by task-specific gait rehabilitation training. Control strategies are the key to implement the training theories into robotic operations. In order to encourage patients’ active participation, the robot should be controlled to supply just enough guidance/assistance a patient needs to complete treadmill based gait training. To implement assist-as-needed (AAN) concept, the robot should also be able to assess the extent of active participation and change the assistance provided accordingly. The intrinsic compliance of GAREX’s PM actuation system could be utilized to change the level of guidance. A new multi-input-multi-output (MIMO) sliding model (SM) controller was developed to adjust assistance while guiding training subjects to walk in predefined gait trajectories. Technical experimental validation indicated that controller was able to track reference gait trajectories and the desired joint space average antagonistic PM pressures. A study with 12 healthy subjects revealed strong statistical evidence that the proposed MIMO SM controller is able to vary the compliance of the exoskeleton To online assess the training patient’s active participation, a fuzzy logic compliance adaptation (FLCA) controller is proposed. The FLCA algorithm utilizes the robotic kinematics and human-exoskeleton interaction torque of the knee joint, to estimate the extent of the patient’s active participation. Based on the estimation, the desired compliance level can be automatically adjusted with higher compliance for more active participation and vice versa. Nevertheless, the FLCA algorithm does not require models of the exoskeleton and biomechanics of the training subject, which means less preparation work and easier implementation. Performance of the FLCA control system was validated with three healthy subjects who simulated different extents of participation. The FLCA control system could successfully adapt the joint actuation compliance accordingly in all the scenarios.

Rehabilitation of the hands is critical for restoring independence in activities of daily living for individuals with upper extremity disabilities. Conventional therapies for hand rehabilitation have not shown significant improvement in hand function. Robotic exoskeletons have been developed to assist in therapy and there is initial evidence that such devices with force-control based strategies can help in effective rehabilitation of human limbs. However, to the best of our knowledge, none of the existing hand exoskeletons allow for accurate force or torque control. In this dissertation, we design and prototype a novel hand exoskeleton that has the following unique features: (i) Bowden-cable-based series elastic actuation allowing for bidirectional torque control of each joint individually, (ii) an underlying kinematic mechanism that is optimized to achieve large range of motion and (iii) a thumb module that allows for independent actuation of the four thumb joints. To control the developed hand exoskeleton for efficacious rehabilitation after a neuromuscular impairment such as stroke, we present two types of subject-specific assist-as-needed controllers. Learned force-field control is a novel control technique in which a neural-network-based model of the required torques given the joint angles for a specific subject is learned and then used to build a force-field to assist the joint motion of the subject to follow a trajectory designed in the joint-angle space. Adaptive assist-as-needed control, on the other hand, estimates the coupled digit-exoskeleton system torque requirement of a subject using radial basis function (RBF) and on-the-fly adapts the RBF magnitudes to provide a feed-forward assistance for improved trajectory tracking. Experiments with healthy human subjects showed that each controller has its own trade-offs and is suitable for a specific type of impairment. Finally, to promote and optimize motor (re)-learning, we present a framework for robot-assisted motor (re)-learning that provides subject-specific training by allowing for simultaneous adaptation of task, assistance and feedback based on the performance of the subject on the task. To train the subjects for dexterous manipulation, we present a torque-based task that requires subjects to dynamically regulate their joint torques. A pilot study carried out with healthy human subjects using the developed hand exoskeleton
suggests that training under simultaneous adaptation of task, assistance and feedback can
module challenge and affect their motor learning.

Restoring human motor and cognitive function has been a fascinating research area during the
last century. Interfacing the human nervous system with electro-mechanical rehabilitation
machines is facing its crucial passage from research to clinical practice, enhancing the
potentiality of therapists, clinicians and researchers to rehabilitate, diagnose and generate
knowledge. The 2012 International Conference on Neurorehabilitation (ICNR2012) brings
together researchers and students from the fields of Clinical Rehabilitation, Applied
Neurophysiology and Biomedical Engineering, covering a wide range of research topics:
- Clinical Impact of Technology
- Brain-Computer Interface in Rehabilitation
- Neuromotor & Neurosensory modeling and processing
- Biomechanics in Rehabilitation
- Neural Prostheses in Rehabilitation
- Neuro-Robotics in Rehabilitation
- Neuromodulation

This Proceedings book includes general contributions (2-page extended abstracts) from oral and poster sessions, as
well as from special sessions. A section is also dedicated to pre-post conference workshops,
including invited contributions from internationally recognized researchers. A selection of most
relevant papers have been considered for publication in international journals (e.g. JNER,
JACCES, ), therefore they will appear soon in their extended versions in Special Issues. These
Proceedings also contain brief descriptions of keynote lectures from invited world-class
professors, and a number of thematic round tables covering technological and institutional
issues.

Soft Robotics in Rehabilitation explores the specific branch of robotics dealing with developing
robots from compliant and flexible materials. Unlike robots built from rigid materials, soft robots
behave the way in which living organs move and adapt to their surroundings and allow for
increased flexibility and adaptability for the user. This book is a comprehensive reference
discussing the application of soft robotics for rehabilitation of upper and lower extremities
separated by various limbs. The book examines various techniques applied in soft robotics,
including the development of soft actuators, rigid actuators with soft behavior, intrinsically soft
actuators, and soft sensors. This book is perfect for graduate students, researchers, and
professional engineers in robotics, control, mechanical, and electrical engineering who are
interested in soft robotics, artificial intelligence, rehabilitation therapy, and medical and
rehabilitation device design and manufacturing. Outlines the application of soft robotic
techniques to design platforms that provide rehabilitation therapy for disabled persons to help
improve their motor functions Discusses the application of soft robotics for rehabilitation of
upper and lower extremities separated by various limbs Offers readers the ability to find soft
robotics devices, methods, and results for any limb, and then compare the results with other
options provided in the book

Spinal cord injury (SCI) is one of the main pathologies causing significant loss of neurological
function. Therefore, a variety of pharmacological and non-pharmacological therapies are the
aims of several studies. To provide the best care, it is important to know and understand the
therapeutic approaches that have shown important progress in this topic. This book contains
eight chapters that are divided into three sections: Introduction, Pharmacological Therapies,
and Non-Pharmacological Therapies. The authors of the chapters deal with the
pathophysiology of SCI, the effect of antioxidant and immunosuppressive agents, stem cell-
based therapies, the use of cultured cells for transference or transplantation, and the
application of non-invasive modalities (transcutaneous electrical spinal cord stimulation, etc.)
for SCI rehabilitation.
The new technological advances opened widely the application field of robots. Robots are moving from the classical application scenario with structured industrial environments and tedious repetitive tasks to new application environments that require more interaction with the humans. It is in this context that the concept of Wearable Robots (WRs) has emerged. One of the most exciting and challenging aspects in the design of biomechatronics wearable robots is that the human takes a place in the design, this fact imposes several restrictions and requirements in the design of this sort of devices. The key distinctive aspect in wearable robots is their intrinsic dual cognitive and physical interaction with humans. The key role of a robot in a physical human–robot interaction (pHRI) is the generation of supplementary forces to empower and overcome human physical limits. The crucial role of a cognitive human–robot interaction (cHRI) is to make the human aware of the possibilities of the robot while allowing them to maintain control of the robot at all times. This book gives a general overview of the robotics exoskeletons and introduces the reader to this robotic field. Moreover, it describes the development of an upper limb exoskeleton for tremor suppression in order to illustrate the influence of a specific application in the designs decisions.

PID Control with Intelligent Compensation for Exoskeleton Robots explains how to use neural PD and PID controls to reduce integration gain, and provides explicit conditions on how to select linear PID gains using proof of semi-global asymptotic stability and local asymptotic stability with a velocity observer. These conditions are applied in both task and joint spaces, with PID controllers compensated by neural networks. This is a great resource on how to combine traditional PD/PID control techniques with intelligent control. Dr. Wen Yu presents several leading-edge methods for designing neural and fuzzy compensators with high-gain velocity observers for PD control using Lyapunov stability. Proportional-integral-derivative (PID) control is widely used in biomedical and industrial robot manipulators. An integrator in a PID controller reduces the bandwidth of the closed-loop system, leads to less-effective transient performance and may even destroy stability. Many robotic manipulators use proportional-derivative (PD) control with gravity and friction compensations, but improved gravity and friction models are needed. The introdution of intelligent control in these systems has dramatically changed the face of biomedical and industrial control engineering. Discusses novel PD and PID controllers for biomedical and industrial robotic applications, demonstrating how PD and PID with intelligent compensation is more effective than other model-based compensations. Presents a stability analysis of the book for industrial linear PID. Includes practical applications of robotic PD/PID control, such as serial sliding mode, explicit conditions for linear PID and high gain observers for neural PD control. Includes applied exoskeleton applications and MATLAB code for simulations and applications.

Volume 2 of the Textbook of Neural Repair and Rehabilitation stands alone as a clinical handbook for neurorehabilitation.

Present Your Research to the World! The World Congress 2009 on Medical Physics and Biomedical Engineering – the triennial scientific meeting of the IUPESM - is the world’s leading forum for presenting the results of current scientific work in health-related physics and technologies to an international audience. With more than 2,800 presentations it will be the biggest conference in the fields of Medical Physics and Biomedical Engineering in 2009! Medical physics, biomedical engineering and bioengineering have been driving forces of innovation and progress in medicine and healthcare over the past two decades. As new key technologies arise with significant potential to open new options in diagnostics and therapeutics, it is a multidisciplinary task to evaluate their benefit for medicine and healthcare with respect to the quality of performance and therapeutic output. Covering key aspects such as information and communication technologies, micro- and nanosystems, optics and
biotechnology, the congress will serve as an inter- and multidisciplinary platform that brings together people from basic research, R&D, industry and medical application to discuss these issues. As a major event for science, medicine and technology the congress provides a comprehensive overview and in-depth, first-hand information on new developments, advanced technologies and current and future applications. With this Final Program we would like to give you an overview of the dimension of the congress and invite you to join us in Munich! Olaf Dössel Congress President Wolfgang C.

This useful resource is designed to offer healthcare professionals specific information about the diverse area of assistive technology. It covers the variety of technology available and explains the adaptations of the technology, as well as how different devices work together. The first section provides the fundamentals of assistive technology, discussing issues such as life span considerations, environmental context, and funding and public policy. The next section delves into topics especially relevant for patient care, including computer access and alternative communication. Sections on manipulation, ambulation, and locomotion technologies are discussed next, concentrating on devices that assist with upper and lower body function. This text ends with a discussion of technologies for environments in the real world. Diversity of technology areas - covers all major areas and facets of assistive technology, including how the varied technologies can be used in conjunction to improve the ease of activities of daily living for the user Organization of text - by grouping assistive technology into four major areas, the book is able to easily lead the reader to both the general area and the specific information they are looking for Level of presentation - makes the text useful for both allied health professionals, their support personnel, and even the consumer looking for guidance in the area of assistive technology Outstanding group of authors, section editors and contributors representing the country’s major programs and each area of assistive technology - provides accurate, up-to-date information for the reader.

The concepts represented in this textbook are explored for the first time in assistive and rehabilitation robotics, which is the combination of physical, cognitive, and social human-robot interaction to empower gait rehabilitation and assist human mobility. The aim is to consolidate the methodologies, modules, and technologies implemented in lower-limb exoskeletons, smart walkers, and social robots when human gait assistance and rehabilitation are the primary targets. This book presents the combination of emergent technologies in healthcare applications and robotics science, such as soft robotics, force control, novel sensing methods, brain-computer interfaces, serious games, automatic learning, and motion planning. From the clinical perspective, case studies are presented for testing and evaluating how those robots interact with humans, analyzing acceptance, perception, biomechanics factors, and physiological mechanisms of recovery during the robotic assistance or therapy. Interfacing Humans and Robots for Gait Assistance and Rehabilitation will enable undergraduate and graduate students of biomedical engineering, rehabilitation engineering, robotics, and health sciences to understand the clinical needs, technology, and science of human-robot interaction behind robotic devices for rehabilitation, and the evidence and implications related to the implementation of those devices in actual therapy and daily life applications.

Stroke is one of the leading causes of physical disability in New Zealand and many suffer paralysis to their limbs. Unfortunately, fewer than 50% of survivors regaining their independence after 6 months particularly due to the inability to walk properly. One of the reason for the slow recovery of the gait function is that the current rehabilitation technique used is labour intensive and time consuming for the therapists and difficult to perform it effectively. In order to improve the gait rehabilitation process, robot assisted gait rehabilitation has gained much interest over the past years. There have been many prototypes and commercial products
for the robot assisted rehabilitation, but many had limitations. One of which is being bulky and had uncomfortable attachment for the patients. Improper attachment not only create uncomfortable feeling and pain for the patient but also causes human-robot axis misalignment which could lead to an injury with long term use. Another limitation is the lack of mechanical compliance which is the key to improve the safety of the operation and comfort for the patient. In order to address the limitations identified, a new robot orthosis, Human-inspired Robotic Exoskeleton (HuREx) was developed. HuREx consists of a compact exoskeleton parts custom fit for each individual patient manufactured using a rapid prototyping technique. Pneumatic Muscle Actuators (PMA) were used as they exhibit natural compliance and configured antagonistically. The design of the orthosis and the actuation mechanism made the system highly nonlinear. Therefore, an advanced model-based feedforward (FF) controller was designed and implemented to achieve the speed and accuracy of the response required. Many experiments were carried out to observe the performance and verify the proof of concept. The contributions of this research are the development of new robotic exoskeleton device designed to be light weight, comfortable and safe to use for gait rehabilitation for stroke patients, which were lacking in the existing devices. Another contribution is the establishment of new manufacturing technique that allow custom exoskeleton component for each individual patient. Finally the development of advanced model-based FF controller that achieves fast and accurate tracking performance.

This book provides state-of-the-art scientific and engineering research findings and developments in the area of service robotics and associated support technologies around the theme of human-centric robotics. The book contains peer reviewed articles presented at the CLAWAR 2017 conference. The book contains a strong stream of papers on robotic locomotion strategies and wearable robotics for assistance and rehabilitation. There is also a strong collection of papers on non-destructive inspection, underwater and UAV robotics to meet the growing emerging needs in various sectors of the society. Robot designs based on biological inspirations are also strongly featured.

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