Robotics For Stroke Rehabilitation

Locomotor training is aiming to promote recovery after spinal cord injury via activation of the neuromuscular system below the level of the lesion

The definitive core text in its field, Stroke Recovery and Rehabilitation is a comprehensive reference covering all aspects of stroke rehabilitation ó from neurophysiology of stroke through the latest treatments and interventions for functional recovery and restoration of mobility. This second edition is completely updated to reflect recent advances in scientific understanding of neural recovery and growing evidence for new clinical therapies. The second edition ó which includes free e-book access with every print purchase ó continues to provide in-depth information on the assessment and management of all acute and long-term stroke-related impairments and complications including cognitive dysfunctions, musculoskeletal pain, and psychological issues. It examines risk factors, epidemiology, prevention, and neurophysiology as well as complementary and alternative therapies, functional assessments, care systems, ethical issues, and community and psychosocial reintegration. With contributions from over 100 acknowledged leaders from every branch of the stroke recovery field, this edition features expanded coverage of key issues such as the role of robotics and virtual reality in rehabilitation. New chapters have been incorporated to cover fields of recent exploration including transcranial magnetic stimulation, biomarkers, and genetics of recovery as well as essentials like the use of medication and the survivoris perspective. The up-to-date presentation of scientific underpinnings and multi-specialty clinical perspectives from physical medicine and rehabilitation, neurology, physical therapy, occupational therapy, speech and language pathology, and nursing ensures that Stroke Recovery and Rehabilitation will continue to serve as an invaluable reference for every health care professional working to restore function and help stroke survivors achieve their maximum potential. New to Stroke Recovery and Rehabilitation, Second Edition All chapters are thoroughly revised and updated to reflect advances in scientific understanding of neural recovery and clinical progress Five completely new chapters and expanded coverage of key issues that drive the field forward New contributions from leading stroke specialists from all involved disciplines Includes access to the fully-searchable downloadable ebook

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The coupling of several areas of the medical field with recent advances in robotic systems has seen a paradigm shift in our approach to selected sectors of medical care, especially over the last decade. Rehabilitation medicine is one such area. The development of advanced robotic systems has ushered with it an exponential number of trials and experiments aimed at optimising restoration of quality of life to those who are physically debilitated. Despite these developments, there remains a paucity in the presentation of these advances in the form of a comprehensive tool. This book was written to present the most recent advances in rehabilitation robotics known to date from the perspective of some of the leading experts in the field and presents an interesting array of developments put into 33 comprehensive chapters. The chapters are presented in a way that the reader will get a seamless impression of the current concepts of optimal modes of both experimental and ap- plicable roles of robotic devices.

Stroke Recovery and Rehabilitation

Locomotor Training

Development of Assistive Robotic Arm for Stroke Rehabilitation

Proceedings of the 15th IFToMM World Congress on Mechanism and Machine Science

Stroke Rehabilitation

Stroke Recovery and Rehabilitation, 2nd Edition

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.

The aim of this book is to provide new ideas, original results and practical experiences regarding service robotics. This book provides only a small example of this research activity, but it covers a great deal of what has been done in the field recently. Furthermore, it works as a valuable resource for researchers interested in this field.

Rehabilitation Robots for Neurorehabilitation in High, Low, and Middle Income Countries: Current Practice, Barriers, and Future Directions describes the state-of-art research of stroke rehabilitation using robot systems in selected High Income Countries (HICs) and Low and Middle Income Countries (LMICs) as well as highlights potential solutions which enable these technologies to be available to clinicians worldwide, regardless of country and economic status. This book brings together engineers and clinicians, offers insights into healthcare disparities, and highlights potential solutions to facilitate the availability and accessibility of more robot systems to stroke survivors and their clinicians worldwide, regardless of country and economic status. The book provides examples of how robotic technology is used to bridge rehabilitation gaps in LMICs and describes potential strategies for increasing the expansion of robot-assisted stroke rehabilitation across more LMICs.

This chapter focuses on rehabilitation robotics which can be used to augment the clinician's toolbox in order to deliver meaningful restorative therapy for an aging population, as well as on advances in orthotics to augment an individual's functional abilities beyond neurorestoration potential. The interest in rehabilitation robotics and orthotics is increasing steadily with marked growth in the last 10 years. This growth is understandable in view of the increased demand for caregivers and rehabilitation services escalating apace with the graying of the population. We provide an overview on improving function in people with a weak limb due to a neurological disorder who cannot properly control it to interact with the environment (orthotics); we then focus on tools to assist the clinician in promoting rehabilitation of an individual so that s/he can interact with the environment unassisted (rehabilitation robotics). We present a few clinical results occurring immediately poststroke as well as during the chronic phase that demonstrate superior gains for the upper extremity when employing rehabilitation robotics instead of usual care. These include the landmark VA-ROBOTICS multisite, randomized clinical study which demonstrates clinical gains for chronic stroke that go beyond usual care at no additional cost.

Advances in Rehabilitation Robotics

Rehabilitation Robots for Neurorehabilitation in High, Low, and Middle Income Countries

Service Robot Applications

Wearable Rehabilitation Robotics for Upper Limb Stroke Recovery and Examining Electrophysiological Response

Human–friendly Technologies on Movement Assistance and Restoration for People with Disabilities

Service Robotics

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.

Biomimetic research is an emerging field that aims to draw inspiration and substances from natural sources and create biological systems in structure, mechanism, and function through robotics. The products have a wide array of application including surgical robots, prosthetics, neurosurgery, and biomedical image analysis. The Handbook of Research on Biomimetics and Biomedical Robotics provides emerging research on robotics, mechatronics, and the application of biomimetic design. While highlighting mechatronical challenges in today¶s society, readers will find new opportunities and innovations in design capabilities in intelligent robotics and interdisciplinary biomedical products. This publication is a vital resource for senior and graduate students, researchers, and scientists in engineering seeking current research on best ways to globally expand online higher education.

This open access book focuses on practical clinical problems that are frequently encountered in stroke rehabilitation. Consequences of diseases, e.g. impairments and activity limitations, are addressed in rehabilitation with the overall goal to reduce disability and promote participation. Based on the available best external evidence, clinical pathways are described for stroke rehabilitation bridging the gap between clinical evidence and clinical decision-making. The clinical pathways answer the questions which rehabilitation treatment options are beneficial to overcome specific impairment constellations and activity limitations and are well acceptable to stroke survivors, as well as when and in which settings to provide rehabilitation over the course of recovery post stroke. Each chapter starts with a description of the clinical problem encountered. This is followed by a systematic, but concise review of the evidence (RCTs, systematic reviews and meta-analyses) that is relevant for clinical decision-making, and comments on assessment, therapy (training, technology, medication), and the use of technical aids as appropriate. Based on these summaries, clinical algorithms / pathways are provided and the main clinical-decision situations are portrayed. The book is invaluable for all neurorehabilitation team members, clinicians, nurses, and therapists in neurology, physical medicine and rehabilitation, and related fields. It is a World Federation for NeuroRehabilitation (WFNR) educational initiative, bridging the gap between the rapidly expanding clinical research in stroke rehabilitation and clinical practice across societies and continents. It can be used for both clinical decision-making for individuals and as well as clinical background knowledge for stroke rehabilitation service development initiatives.

With the increasing applications of intelligent robotic systems in various ?elds, the - sign and control of these systems have increasingly attracted interest from researchers. This edited book entitled "Design and Control of Intelligent Robotic Systems" in the book series of "Studies in Computational Intelligence" is a collection of some advanced research on design and control of intelligent robots. The works presented range in scope from design methodologies to robot development. Various design approaches and al- rithms, such as evolutionary computation, neural networks, fuzzy logic, learning, etc. are included. We also would like to mention that most studies reported in this book have been implemented in physical systems. An overview on the applications of computational intelligence in bio-inspired robotics is given in Chapter 1 by M. Begum and F. Karray, with highlights of the recent progress in bio-inspired robotics research and a focus on the usage of computational intelligence tools to design human-like cognitive abilities in the robotic systems. In Chapter 2, Lisa L. Grant and Ganesh K. Venayagamoorthy present greedy search, particle swarm optimization and fuzzy logic based strategies for navigating a swarm of robots for target search in a hazardous environment, with potential applications in high-risk tasks such as disaster recovery and hazardous material detection.

Technology and Global Public Health

Clinical Pathways in Stroke Rehabilitation

Chapter 23. Rehabilitation Robotics

Experimental Robotics

Exoskeleton Robots for Rehabilitation and Healthcare Devices

Soft Robotics in Rehabilitation

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.

Practical and concise, Stroke Rehabilitation provides everyday clinical guidance on current methods, techniques, evidence, and controversies in this important area. This focused resource by Drs. Richard Wilson and Preeti Raghavan consolidates today's available information in an easy-to-navigate format for today's practicing and trainee physiatrists, as well as other members of the rehabilitation team.

A Doody's Core Title 2012 Stroke Recovery and Rehabilitation is the new gold standard comprehensive guide to the management of stroke patients. Beginning with detailed information on risk factors, epidemiology, prevention, and neurophysiology, the book details the acute and long-term treatment of all stroke-related impairments and complications. Additional sections discuss psychological issues, outcomes, community reintegration, and new research. Written by dozens of acknowledged leaders in the field, and containing hundreds of tables, graphs, and photographic images, Stroke Recovery and Rehabilitation features: The first full-length discussion of the most commonly-encountered component of neurorehabilitation Multi-specialty coverage of issues in rehabilitation, neurology, PT, OT, speech therapy, and nursing Focus on therapeutic management of stroke related impairments and complications An international perspective from dozens of foremost authorities on stroke Cutting edge, practical information on new developments and research trends Stroke Recovery and Rehabilitation is a valuable reference for clinicians and academics in rehabilitation and neurology, and professionals in all disciplines who serve the needs of stroke survivors.

The availability of practical applications, techniques, and case studies by international therapists is limited despite expansions to the fields of clinical psychology, rehabilitation, and counseling. As dialogues surrounding mental health grow, it is important to maintain therapeutic modalities that ensure the highest level of patient-centered rehabilitation and care are met across global networks. Research Anthology on Rehabilitation Practices and Therapy is a vital reference source that examines the latest scholarly material on trends and techniques in counseling and therapy and provides innovative insights into contemporary and future issues within the field. Highlighting a range of topics such as psychotherapy, anger management, and psychodynamics, this multi-volume book is ideally designed for mental health professionals, counselors, therapists, clinical psychologists, sociologists, social workers, researchers, students, and social science academicians seeking coverage on significant advances in rehabilitation and therapy.

Proceedings of the 4th International Symposium on Wearable Robotics, WeRob2018, October 16-20, 2018, Pisa, Italy

Neuromechanics and Motor Control

An Integrated Robotic and Virtual Mirror Therapy System for Stroke Rehabilitation

Advances in Mechanism and Machine Science

Insights from Neuroscience and Imaging

Empowering Cognitive, Physical, Social and Communicative Skills Through Virtual Reality, Robots, Wearable Systems and Brain-computer Interfaces

The book reports on advanced topics in the areas of neurorehabilitation research and practice. It focuses on new methods for interfacing the human nervous system with electronic and mechatronic systems to restore or compensate impaired neural functions. Importantly, the book merges different perspectives, such as the clinical, neurophysiological, and bioengineering ones, to promote, feed and encourage collaborations between clinicians, neuroscientists and engineers. Based on the 2016 International Conference on Neurorehabilitation (ICNR 2016) held on October 18-21, 2016, in Segovia, Spain, this book covers various aspects of neurorehabilitation research and practice, including new insights into biomechanics, brain physiology, neuroplasticity, and brain damages and diseases, as well as innovative methods and technologies for studying and/or recovering brain function, from data mining to interface technologies and neuroprosthetics. In this way, it offers a concise, yet comprehensive reference guide to neurosurgeons, rehabilitation physicians, neurologists, and bioengineers. Moreover, by highlighting current challenges in understanding brain diseases as well as in the available technologies and their implementation, the book is also expected to foster new collaborations between the different groups, thus stimulating new ideas and research directions.

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

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.

A synthesis of biomechanics and neural control that draws on recent advances in robotics to address control problems solved by the human sensorimotor system. This book proposes a transdisciplinary approach to investigating human motor control that synthesizes musculoskeletal biomechanics and neural control. The authors argue that this integrated approach—which uses the framework of robotics to understand sensorimotor control problems—offers a more complete and accurate description than either a purely neural computational approach or a purely biomechanical one. The authors offer an account of motor control in which explanatory models are based on experimental evidence using mathematical approaches reminiscent of physics. These computational models yield algorithms for motor control that may be used as tools to investigate or treat diseases of the sensorimotor system and to guide the development of algorithms and hardware that can be incorporated into products designed to assist with the tasks of daily living. The authors focus on the insights their approach offers in understanding how movement of the arm is controlled and how the control adapts to changing environments. The book begins with muscle mechanics and control, progresses in a logical manner to planning and behavior, and describes applications in neurorehabilitation and robotics. The material is self-contained, and accessible to researchers and professionals in a range of fields, including psychology, kinesiology, neurology, computer science, and robotics.

Occupational Outlook Handbook

Recovery After Stroke

Stroke Rehabilitation - E-Book

Evidence-based Clinical Practice Recommendations

Converging Clinical and Engineering Research on Neurorehabilitation II

Sex-Specific Analysis of Cardiovascular Function

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).

The goal of this book is to bring together ideas from several different disciplines in order to examine the focus and aims that drive rehabilitation intervention and technology development. Specifically, the chapters in this book address the questions of what research is currently taking place to further develop rehabilitation, applied technology and how we have been able to modify and measure responses in both healthy and clinical populations using these technologies.

This book explores the pivotal role played by technology over the past decade in advancing global public health and health care. At present, the global community faces unprecedented healthcare challenges fueled by an aging population, rising rates of chronic disease, and persistent health disparities. New technologies and advancements have the potential to extend the reach of health professionals while improving quality and efficiency of service delivery and reducing costs within the public and the private health systems. The chapters highlight the barriers faced by the global healthcare workforce in using technology to promote health and human rights of communities: Role of Digital Health, mHealth, and Low-Cost Technologies in Advancing Universal Health Coverage in Emerging Economies Telehealth and Homecare Agencies Technology and the Practice of Health Education in Conflict Zones The Worldwide Digital Divide and Access to Healthcare Technology Technology for Creating Better Professional Teams to Strengthen Healthcare Systems Global Public Health Disaster Management and Technology As a resource on the evolution of technology as a valuable and integral component in the promotion and practice of public health and health care, with a focus on SDG 3 targets, Technology and Global Public Health should engage students, instructors, practitioners, and other professionals interested in public health, universal health care, health technology, digital health, and health equity. Dr. Murthy has been a respected leader and mentor on scientific health-related matters within the UN system for many years. Her book develops a theoretical system connecting concepts that have coined global public health with the rapid development of technology, all with the focus to achieve Sustainable Development Goal number three, within the time frame set by World Leaders. - Henry L. Mac-Donald, Former Permanent Representative of Suriname to the United Nations

One of the major application targets of service robots is to use them as assistive devices for rehabilitation. This book introduces some latest achievements in the field of rehabilitation robotics and assistive technology for people with disabilities and aged people. The book contains results from both theoretical and experimental works and reviews on some new advanced rehabilitation devices which has been recently transferred to the industry. Significant parts of the book are devoted to the assessment of new rehabilitation technologies, the evaluation of prototype devices with end-users, the safety of rehabilitation robots, and robot-assisted neurorehabilitation. The book is a representative selection of the latest trends in rehabilitation robotics and can be used as a reference for teaching on mechatronic devices for rehabilitation.

Control and Dynamic Manipulability of a Dual-Arm/Hand Robotic Exoskeleton System (EXO-UL8) for Rehabilitation Training in Virtual Reality

A Function-Based Approach

Robot-assisted Training for Stroke Rehabilitation

Design and Control of Intelligent Robotic Systems

Iterative Learning Control for Electrical Stimulation and Stroke Rehabilitation

Current Practice, Barriers, and Future Directions

Gillen's Stroke Rehabilitation: A Function-Based Approach, 3rd Edition is the only comprehensive, evidence-based stroke rehabilitation resource for occupational therapists. Extensively updated with the latest research in assessment and intervention, this essential text presents a holistic, application-based approach that integrates background medical information, samples of functionally based evaluations, and current treatment techniques and intervention strategies to help you confidently manage the growing number of stroke rehabilitation clients. UNIQUE! Case studies challenge you to apply rehabilitation concepts to realistic scenarios. Evidence-based clinical trials and outcome studies clearly outline the basis for stroke interventions. UNIQUE! Survivor's Perspectives help you understand the stroke rehabilitation process from the client's point-of-view. UNIQUE! A multidisciplinary approach highlights discipline-specific distinctions in stroke rehabilitation among occupation and physical therapists, physicians, and speech-language pathologists. Review questions in each chapter help you assess your understanding of rehabilitation concepts. Key terms and chapter objectives at the beginning of each chapter help you study more efficiently. Three new chapters broaden your understanding of stroke intervention in the areas of Using Technology to Improve Limb Function, Managing Speech and Language Deficits after Stroke, and Parenting after Stroke. Learning activities and interactive references on a companion Evolve Resources website help you review textbook content and locate additional information.

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

Iterative learning control (ILC) has its origins in the control of processes that perform a task repetitively with a view to improving accuracy from trial to trial by using information from previous executions of the task. This brief shows how a classic application of this technique – trajectory following in robots – can be extended to neurological rehabilitation after stroke. Regaining upper limb movement is an important step in a return to independence after stroke, but the prognosis for such recovery has remained poor. Rehabilitation robotics provides the opportunity for repetitive task-oriented movement practice reflecting the importance of such intense practice demonstrated by conventional therapeutic research and motor learning theory. Until now this technique has not allowed feedback from one practice repetition to influence the next, also implicated as an important factor in therapy. The authors demonstrate how ILC can be used to adjust external functional electrical stimulation of patients' muscles while they are repeatedly performing a task in response to the known effects of stimulation in previous repetitions. As the motor nerves and muscles of the arm reaquire the ability to convert an intention to move into a motion of accurate trajectory, force and rapidity, initially intense external stimulation can now be scaled back progressively until the fullest possible independence of movement is achieved.

Stroke is the leading cause of severe long-term disability worldwide. A commonly reported disability is hemiparesis. Impairments of the upper limb inhibit the individual's ability to perform activities of daily living; High-dose repetitive practice of functional tasks is important for recovery after stroke. This type of training is labor-intensive.Additionally, many stroke patients cannot complete traditional physical therapy due to the severity of their motor impairments. Robotics offers an alternative approach whereby assistance is provided via forces applied to the limb, allowing high dose and repetitive completion of movements that would otherwise be impossible to complete unassisted. However, even with the standardized rehabilitation programs that stakeholders implemented with robotic therapy, patients demonstrate variance in response to treatment due to the heterogeneous damage to the brain during the stroke. Subsequently, three studies investigated wearable robotics for stroke upper limb rehabilitation and the neural mechanisms of upper limb control and recovery. For the first study, 12 chronic stroke patients completed 8 weeks of at-home rehabilitation using a novel exoskeleton wearable robotic hand device that assisted with the opening of the hand-this enabled performance of therapeutic functional exercises. I examined the neural response to recovery using the neuroimaging technique electroencephalography. The study identified patients with the greatest operational hand improvements had the largest increase in interhemispheric sensorimotor communication. Additionally, neural biomarkers that could predict a patient's response to robotic therapy were identified. I performed biomechanic analysis using 3d motion capture and clinical evaluations without the device pre, post, and 3 months after completion of the study, which showed the novel device restored hand function. The second study saw the development of a new wearable robotic hand device that assists users with opening and closing motions. Additionally, an integrated Android app was developed, which could be used with the automated machine. The app has therapeutic video games and exercises to complement robotic therapy. The study gives a detailed evaluation of the mechanical and control system of the automated device and the responses of persons with the stroke that used the device. To better understand the neural process of upper limb recovery, the final study explored the neural pathways involved in grip force modulation and how robotics that offers upper limb gravity compensation alters the corticospinal path and neural activation. The studies show home-based robotic devices that can induce improvements in hand function after stroke and are well received by persons with stroke. Electroencephalography can be used to track the brain's plasticity during rehabilitation, identify biomarkers that predict response to therapy, and determine the influence of gravity compensation robotic devices on the corticospinal pathway. These findings may be of relevance for optimizing the design of rehabilitation robotics and neurorehabilitation programs.

From Brain Machine Interfaces to Rehabilitation Robotics

Human Robotics

Handbook of Research on Biomimetics and Biomedical Robotics

Research Anthology on Rehabilitation Practices and Therapy

The 10th International Symposium on Experimental Robotics

Neuro-Robotics

Stroke Rehabilitation: Insights from Neuroscience and Imaging informs and challenges neurologists, rehabilitation therapists, imagers, and stroke specialists to adopt more restorative and scientific approaches to stroke rehabilitation based on new evidence from neuroscience and neuroimaging literatures. The fields of cognitive neuroscience and neuroimaging are advancing rapidly and providing new insights into human behavior and learning. Similarly, improved knowledge of how the brain processes information after injury and recovers over time is providing new perspectives on what can be achieved through rehabilitation. Stroke Rehabilitation explores the potential to shape and maximize neural plastic changes in the brain after stroke from a multimodal perspective. Active skill based learning is identified as a central element of a restorative approach to rehabilitation. The evidence behind core learning principles as well as specific learning strategies that have been applied to retrain lost functions of movement, sensation, cognition and language are also discussed. Current interventions are evaluated relative to this knowledge base and examples are given of how active learning principles have been successfully applied in specific interventions. The benefits and evidence behind enriched environments is reviewed with examples of potential application in stroke rehabilitation. The capacity of adjunctive therapies, such as transcranial magnetic stimulation, to modulate receptivity of the damaged brain to benefit from behavioral interventions is also discussed in the context of this multimodal approach. Focusing on new insights from neuroscience and imaging, the book explores the potential to tailor interventions to the individual based on viable brain networks. This book is intended for clinicians, rehabilitation specialists and neurologists who are interested in using these new discoveries to achieve more optimal outcomes. Equally as important, it is intended for neuroscientists, clinical researchers, and imaging specialists to help frame important clinical questions and to better understand the context in which their discoveries may be used.

Under the context of using robot to perform rehabilitation on stroke patient, the robot must be able to understand the patient so to be able to interact with the patient more effectively. Current practise to rehabilitate stroke patient depends on the resource available that mostly involve trained human therapists. Progresses basically are monitored continuously in qualitative manner and the therapy session needs to be done in regular basis repetitively. However, the practice is costly and does not provide a quantitative way to measure the progress of the affected person. A robot on the other hand can work precisely and continuously and able to record the progresses of a patient quantitatively. The therapy using a robotic system can be made more efficient when the physiological state of the affected muscle of the patient complemented with the affective state (psychological state) of the patient is known. For this research, the focus of the affective state is the engagement level of the patient when subjected to rehabilitation procedure of his upper limb (i.e. moving his arm to follow specific trajectory). For evaluating engagement level, the lectrooculogram (EOG) signal is captured when the patient is doing the therapy. The signals are fed into fuzzy classifier to deduce the engagement level of the patient. In developing the fuzzy classifier, the related data is required to deduce the engagement level. A series of experiments are designed where the patients are asked to track a set of prescribed paths on the computer screen which has different level of difficulties within the allocated times and have to obey different speed constraints. The position error from the trajectory tracking is measured together with

the electrooculogram (EOG) signal which is recorded by using a G-tec data acquisition system simultaneously. The information on the endogenous type of eye blinking is extracted from the electrooculogram (EOG) and it plays an important role to study the engagement level. Following the experiment, a series of questionnaires that has been carefully designed are given to the subjects to verify the engagement level deduced from the experiment done earlier by the subjects. A robotic platform is then used to verify the engagement level in real-time. The engagement model in the form of fuzzy classifier is used to adapt the speed of the robotic platform which is useful for the human-robot interaction. In particular, if the level of engagement is high, the subject is subjected to more challenging trajectory to be tracked. This is useful especially for the robot assisted type of stroke rehabilitation. The analysis on the questionnaire and the deduction of the level of engagement from the experimental results shows an accuracy of 95%. The robotic system is also able to adapt its speed whenever the level of engagement level changes. The research is only limited to one physiological signal namely the electrooculogram (EOG). Besides that, this research only consider onto one affective state which is the engagement.

Stroke rehabilitation technologies have focused on reducing treatment cost while improving effectiveness. Rehabilitation robots are generally developed for home and clinical usage to: 1) deliver repetitive and stimulating practice to post-stroke patients, 2) minimize therapist interventions, and 3) increase the number of patients per therapist, thereby decreasing the associated cost. The control of rehabilitation robots is often limited to black- or gray-box approaches; thus, safety issues regarding the human-robot interaction are not easily considered. Furthermore, despite numerous studies of control strategies for rehabilitation, there are very few rehabilitation robots in which the tasks are implemented using optimal control theory. Optimal controllers using physics-based models have the potential to overcome these issues. This thesis presents advanced impedance- and model-based controllers for an end-effector-based upper extremity stroke rehabilitation robot. The final goal is to implement a biomechanically-plausible real-time nonlinear model predictive control for the studied rehabilitation system. The real-time term indicates that the controller computations finish within the sampling frequency time. This control structure, along with advanced impedance-based controllers, can be applied to any human-environment interactions. This makes them promising tools for different types of assistive devices, exoskeletons, active prostheses and orthoses, and exercise equipment. In this thesis, a high-fidelity biomechatronic model of the human-robot interaction is developed. The rehabilitation robot is a 2 degree-of-freedom parallelogram linkage with joint friction and backlash, and nonlinear dynamics. The mechatronic model of the robot with relatively accurate identified dynamic parameters is used in the human-robot interaction plant. Different musculoskeletal upper extremity, biomechanic, models are used to model human body motions while interacting with the rehabilitation robot model. Human-robot interaction models are recruited for model-in-loop simulations, thereby tuning the developed controllers in a structured resolution. The interaction models are optimized for real-time simulations. Thus, they are also used within the model-based control structures to provide biofeedback during a rehabilitation therapy. In robotic rehabilitation, because of physical interaction of the patient with a mechanical device, safety is a fundamental element in the design of a controller. Thus, impedance-based assistance is commonly used for robotic rehabilitation. One of our objectives is to achieve a reliable and real-time implementable controller. In our definition, a reliable controller is capable of handling variable exercises and admittance interactions. The controller should reduce therapist intervention and improve the quality of the rehabilitation. Hence, we develop advanced impedance-based assistance controllers for the rehabilitation robot. Overall, two types of impedance-based (i.e., hybrid force-impedance and optimal impedance) controllers are developed and tuned using model-in-loop simulations. Their performances are assessed using simulations and/or experiments. Furthermore, their drawbacks are discussed and possible methods for their improvements are proposed. In contrast to black/gray-box controllers, a physics-based model can leverage the inherent dynamics of the system and facilitate implementation of special control techniques, which can optimize a specific performance criterion while meeting stringent system constraints. Thus, we present model-based controllers for the upper extremity rehabilitation robot using our developed musculoskeletal models. Two types of model-based controllers (i.e., nonlinear model predictive control using external 3-dimensional musculoskeletal model or internal 2-dimensional musculoskeletal model) are proposed. Their performances are evaluated in simulations and/or experiments. The biomechanically-plausible nonlinear model predictive control using internal 2-dimensional musculoskeletal model predicts muscular activities of the human subject and provides optimal assistance in real-time experiments, thereby conforming to our final goal for this project.

This revised, updated second edition provides an accessible, practical overview of major areas of technical development and clinical application in the field of neurorehabilitation movement therapy. The initial section provides a rationale for technology application in movement therapy by summarizing recent findings in neuroplasticity and motor learning. The following section then explains the state of the art in human-machine interaction requirements for clinical rehabilitation practice. Subsequent sections describe the ongoing revolution in robotic therapy for upper extremity movement and for walking, and then describe other emerging technologies including electrical stimulation, virtual reality, wearable sensors, and brain-computer interfaces. The promises and limitations of these technologies in neurorehabilitation are discussed. Throughout the book the chapters provide detailed practical information on state-of-the-art clinical applications of these devices following stroke, spinal cord injury, and other neurologic disorders. The text is illustrated throughout with photographs and schematic diagrams which serve to clarify the information for the reader. Neurorehabilitation Technology, Second Edition is a valuable resource for neurologists, biomedical engineers, roboticists, rehabilitation specialists, physiotherapists, occupational therapists and those training in these fields.

Rehabilitation Robotics

Real-time Affective States Identification for Human-robot Interaction

A Thesis Presented in Partial Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Engineering at Massey University, Albany, New Zealand

Advanced Technologies in Rehabilitation

Wearable Robotics: Challenges and Trends

Neurological Rehabilitation

Neurorehabilitation Technology provides an accessible, practical overview of the all the major areas of development and application in the field. The initial chapters provide a clear, concise explanation of the rationale for robot use and the science behind the technology before proceeding to outline a theoretical framework for robotics in neurorehabilitative therapy. Subsequent chapters provide detailed practical information on state-of-the-art clinical applications of robotic devices, including robotics for locomotion; posture and balance an upper extremity recovery in stroke and spinal cord injury. Schematic diagrams, photographs and tables will be included to clarify the information for the reader. The book also discusses standard and safety issues and future perspectives.

The International Symposium on Experimental Robotics (ISER) is a series of bi-annual meetings which are organized in a rotating fashion around North America, Europe and Asia/Oceania. The goal of ISER is to provide a forum for research in robotics that focuses on the novelty of theoretical contributions validated by experimental results. This unique reference presents the latest advances in robotics, with ideas that are conceived conceptually and have been explored experimentally.

This book gathers together contributions from internationally renowned authors in the field of cardiovascular systems and provides crucial insight into the importance of sex- and gender-concepts during the analysis of patient data. This innovative title is the first to offer the elements necessary to consider sex-related properties in both clinical and basic studies regarding the heart and circulation on multiscale levels (i.e. molecular, cellular, electrophysiologically, neuroendocrine, immunoregulatory, organ, allometric, and modeling). Observ differences at (ultra)cellular and organ level are quantified, with focus on clinical relevance and implications for diagnosis and patient management. Since the cardiovascular system is of vital importance for all tissues, Sex-Specific Analysis of Cardiovascular Function is an essential source of information for clinicians, biologists, and biomedical investigators. The wide spectrum of differences described in this book will also act as an eye-opener and serve as a handbook for students, teachers, scientists and practitioners.

Covering neuroscience and rehabilitation strategies, an essential handbook and reference for multidisciplinary stroke rehabilitation teams.

Principles and Practice

Technology and Application

Proceedings of the 3rd International Conference on NeuroRehabilitation (ICNR2016), October 18-21, 2016, Segovia, Spain

Neurorehabilitation Technology

Model-based Control of Upper Extremity Human-robot Rehabilitation Systems

Neuro-robotics is one of the most multidisciplinary fields of the last decades, fusing information and knowledge from neuroscience, engineering and computer science. This book focuses on the results from the strategic alliance between Neuroscience and Robotics that help the scientific community to better understand the brain as well as design robotic devices and algorithms for interfacing humans and robots. The first part of the book introduces the idea of neuro-robotics, by presenting state-of-the-art bio-inspired devices. The second part of the book focuses on human-machine interfaces for performance augmentation, w abilities of healthy subjects or assistance in case of the mobility impaired. The third part of the book focuses on the inverse problem, i.e. how we can use robotic devices that physically interact with the human body, in order (a) to understand human motor control and (b) to provide therapy to neurologically impaired people or people with disabilities.