June 07, 2022

Notes from SIG-Robotics June 2022

The start of 2022 was busy for WFNR Robotics Special Interest Group (SIG). We assisted with the organization of two events in the USA and India. Highlights from these events are listed below.

Rehabilitation Robotics Symposium at MossRehab, Philadelphia, PA, USA, April 29 and 30, 2022

The goal of the two-day international Symposium that takes place at MossRehab in collaboration with Moss Rehabilitation Research Institute in alternate years was best expressed by its organizers, Dr. Dylan Edwards and Dr. Alberto Esquenazi, as an opportunity to learn from different stakeholders as well as to discuss progress in the previous two years and expectations for the following two-year period. The hybrid symposium had 50 onsite attendees coming from 14 states as well as international attendees form Switzerland, Italy, Venezuela, Spain, Australia, and Israel. The Symposium included discussions of why robotics should be used in neurorehabilitation, their basic design features, and guidelines for operation. Examples were given of how these devices can be used to assess human functions along with their limitations such as movement recognition, cognition studies, and their use in detecting language and speech patterns.

The Speakers:

“Rehabilitation Robotics, From Development to Marketing” by Dr. Hermano Igo Krebs of Massachusetts Institute of Technology (MIT) covered the state of robot-assisted therapy for upper limb impairment reduction, then the need to control “usual care” for patients. Following this initial overview, he dispensed advice on how to start a robotics company. He discussed how to avoid the “valley of death” funding gap that kills most start-ups and the importance of a strong financial backing, a well-skilled team, relevant technology, and most importantly, good timing, to build a successful business. Finally, he discussed a spinoff case study of the MIT Skywalker: BrainE Labs, the company that manufactures the Cadense Shoes developed by Dr. Tyler Susko of the University of California, Santa Barbara.

“Propulsion-augmenting Soft Robotic Exosuits for Gait Assistance and Rehabilitation After Stroke” by Dr. Louis Awad of Boston University demonstrated how bodies propel themselves forward through motion and how exoskeletons overcome deficiencies in physical functions. This was based on a breakdown of motions needed to walk and included explanations of how recent studies targeting the propulsion phase have backed these assertions, showing a 10% metabolic reduction in stroke patients and 30% reduction in healthy individuals though use of a soft exosuit.

“Back To the Future – The Use Of Advanced Virtual Reality Technology In Rehabilitation” by Dr. Moshe Bondi of the Sheba Medical Center clarified the distinctions between Virtual Reality (VR) and Augmented Reality (AR) before explaining how VR, in particular, can be applied in a clinical setting during rehabilitation treatment. Type I & IIa/b muscle fibers are vital for balance recovery, and Dr. Bondi demonstrated that vision affects gait speed and how, through eye tracking and locomotion, VR can provide a setting for patients to relearn balance recovery in a controlled setting.

Hermano Igo Krebs, Ph.D.
MIT, The 77 Lab, Cambridge, MA, USA

We invite you to participate in the upcoming IEEE-BioRob 2022 Conference in Seoul, South Korea. This engineering conference will take place on August 21-14, 2022.

http://biorob2022.org/

We invite you to participate in 12th World Congress for NeuroRehabilitation. This conference will take place on 14 to 17 December 2022 in Vienna, Austria.

WCNR2022 (wfnr-congress.org)

https://www.wfnr-congress.org/pages/wcnr/

Dylan J. Edwards, Ph.D.
Moss Rehabilitation Research Institute, Philadelphia, PA, USA

NEW MEMBER:

Vibeke Wagner Vibeke.Wagner@regionh.dk

Member of WFNR and a developmental physical therapist at Rigshospitalet, Copenhagen, Denmark.

Vibeke has 15 years of experience with early rehabilitation after severe acquired brain injury (ABI), and his clinical area specialty is robotics in rehabilitation. He is starting his PhD studying Robotic gait training (Lokomat) early after ABI.

“Integrating Technology In Neurorehabilitation Clinical Trials” by Dr. Gerard Francisco of TIRR Memorial Hermann broke down the three major impairment categories to conclude that, while motor impairment has many assistive and rehabilitative technologies, comparatively, the cognitive and sensory fields are lacking. Factors that are considered when incorporating technology include potential benefits of the system, relevance to findings of technologically-driven research, acceptance into the target population, and clinical translatability to specific patient needs. The practicality of technology was addressed, and the two main issues raised were whether robot-assisted rehabilitation is cost-effective relative to conventional therapy, and how the technology can promote personalized interventions.

“Robots for Fall Prevention In the Orthopedic Patient” by Dr. Jess Lonner, an orthopedic surgeon specializing in the lower limb, described how 50-75% of nursing home residents fall every year, and 41% of falls occur while using a walker. These falls can have domino effect, leading to further health issues. The current state of gait training was discussed, along with the current exoskeleton categories and the use of robotic canes and walkers that assist with standing. He then introduced the Robofall machine that he has been helping develop. Robofall provides an automatic robotic mobile support system (ARMSS) that detects potentials falls for people in walkers and assists when necessary.

“Clinical Application of Lower Extremity Devices” by Dr. Ning Cao and Andrew Packel, both of MossRehab, outlined repetitive approaches for lower limb recovery and how to facility recovering of walking during stroke rehabilitation. A hierarchical locomotor training program was introduced, quantifying training intensity through accelerometers attached to a step watch on the leg and an oxygen saturation monitor. Clinical examples of walking training were given, with assessments split into scores of knee stance stability, upright trunk, limb advancement, and dynamic balance. By understanding the current deficits in these four areas of a patient’s walking, rehabilitation therapy can be customized, and the appropriate type of robo-therapy can be selected if necessary.

“Clinical Application of Upper Extremity Devices” by Juan May and Casey McKee of MossRehab discussed the importance of practice (massed, distributed, constant, and variable) and the intrinsic and extrinsic feedback loops that are optimal to facilitate motor learning. This was conveyed through examples of studies with robotic therapy, which showed that intensive delivery of large quantities of goal-directed, specific movements is important for training of the upper limb. Clinicians can then manipulate therapy parameters and evaluate the results, adjusting them until patient-centered goals are achieved and the rehabilitation is successful.

“Gait Training In Motor Incomplete Spinal Cord Injury Using Exoskeleton Robotics” by Dr. Dylan Edwards, Director of Moss Rehabilitation Research Institute (MRRI), discussed his recent findings demonstrating clinically meaningful improvements in non-assisted walking speeds achieved through use of overground robotic exoskeletons following a 12-week gait training regimen. 36 sessions of 45 minutes each with at least 300 steps produced improvements in home and community ambulation speeds in a significant proportion of individuals. However, the intervention did not show statistical significance when compared to usual care or intensive therapy. He speculated that the results should be interpreted with care as the number of participants was half of the target, and perhaps a larger study might show advantages of the robotic group over usual care.

PAPERS:

We recommend reading the following papers:

Edwards DJ, Forrest G, Cortes M, *et al.* “Walking improvement in chronic incomplete spinal cord injury with exoskeleton robotic training (WISE): a randomized controlled trial.” Spinal Cord (2022).

Agrafiotis DK, Yang E, Littman GS, Byttebier G, Dipietro L, DiBernardo A, Chavez JC, Rykman A, McArthur K, Hajjar K, Lees KR, Volpe BT, Krams M, Krebs HI, “Accurate prediction of clinical stroke scales and improved biomarkers of motor impairment from robotic measurements.” PLoS ONE 16(1): e0245874 (2021).

Fernandez-Garcia C, Ternent L, Homer TM, Rodgers H, Bosomworth H, Shaw L, Aird L, Andole S, Cohen DL, Dawson J, Finch, T, Ford GA, Francis R, Hogg S, Hughes N, Krebs HI, Price CI, Turner DL, van Wijck F, Wilkes S, Wilson N, Vale L, "Economic evaluation of robot-assisted training versus an enhanced upper limb therapy programme or usual care for patients with moderate or severe upper limb functional limitation due to stroke: results from the RATULS randomised controlled trial," BMJ Open, 11(5) p. e042081 (2021).

Moretti CB, Edwards DJ, Hamilton T, Cortes M, Rykman Peltz A, Chang JL, Delbem ACB, Volpe BT, Krebs HI, “Robotic Kinematic measures of the arm in chronic Stroke: part 1 – Motor Recovery patterns from tDCS preceding intensive training,” Bioelectronic Medicine **7,** 20 (2021).

Moretti CB, Hamilton T, Edwards DJ, Cortes M, Rykman Peltz A, Chang JL, Delbem ACB, Volpe BT, Krebs HI, “Robotic Kinematic measures of the arm in chronic Stroke: part 2 – strong correlation with clinical outcome measures,” Bioelectronic Medicine **7,** 21 (2021).

Lu L *et al*., "Evaluating Rehabilitation Progress Using Motion Features Identified by Machine Learning," IEEE Transactions on Biomedical Engineering. 68(4):1417-1428 (2021).

Awad LN, Esquenazi A, Francisco GE, et al. “The ReWalk ReStore™ soft robotic exosuit: a multi-site clinical trial of the safety, reliability, and feasibility of exosuit-augmented post-stroke gait rehabilitation,” J NeuroEngineering Rehabil 17, 80 (2020).

“From Assessing Impairment To Tailored Intervention: How Technology Can Benefit Rehabilitation Research” by Dr. Amanda Therrien of MRRI discussed the utility of robotic and virtual reality technology in patient assessment. A detailed understanding of impairment can optimize the use of this technology in rehabilitation interventions. This perspective was grounded in her research on the effects of reinforcement learning to improve motor training in cerebellar ataxia. Virtual Reality and a closed loop schedule allowed for repeated tests where the patient reached for a target, with visual feedback enabled or disabled. When visual feedback was disabled during reaching, improvements in baseline function were observed in the patients, demonstrating changes to high dimensional movement parameters which were directly related to the severity of the patient’s ataxia.

“Tele-Rehabilitation For Stroke” by Dr. Steven C. Cramer of the University of California, Los Angeles (UCLA) delved into the low-intensity doses of rehabilitation therapy used in humans compared to animal studies, citing financial constraints, poor patient compliance, and access to proper providers, and how tele-rehabilitation has the potential to counter these limitations. The core principles for better rehabilitation were defined as user-friendly, high-intensity movement practice that engages numerous brain circuits and is supervised by OT’s and PT’s. Gamification raised user compliance and improved arm movement, regardless of computer skills. Future directions for telerehabilitation include connections to electronic health records and long-term treatment to prevent functional decline.

“Robot-aided Recovery after Stroke: Role Of Sensation, Synergies And Success” by Prof. David Reinkensmeyer from the University of California, Irvine described sensation, synergies, and success as the three important motor learning factors underlying patient-specific variability in responses to robotic movement training. Based on his research, finger proprioception, measured via hand therapy and bolstered with a ‘Manumeter’ activity counter for finger and wrist movement (along with brain activity), was correlated to probability of effectively responding to therapy. His research showed that greater proprioception was correlated with greater improvement during therapy. Relevant technologies were further targeted on a patient-specific basis, moving towards precision rehabilitation. He also presented a novel and promising wheelchair adapter which allows stroke patients to move the wheelchair using elbow extension.

The Symposium concluded with live demonstrations of the equipment at the exhibition hall (ReWalk, Heaxel Icone, Hocoma, THERA-Trainer), and demonstrations of the more than 25 robots in clinical use at MossRehab including: Hocoma Armeo Spring, C-Mill, Andago, Heaxel Icone, Tyromotion Amadeo, Diego, Myro, THERA-Trainer Lyra, Ekso Bionics EksoNR.

Advances in Rehab Robotics Symposium at the 10th Annual Conference of the Indian Federation of NeuroRehabilitation, Mumbai, India, April 22 to 24, 2022

1. “Strategy for upper extremity rehabilitation among patients with stroke” by Dr. Joon-Ho Shin from National Rehabilitation Center (Seoul, South Korea).

Abstract: Robotic rehabilitation of the upper limb among patients with stroke has become popular. The present talk will discuss clinical strategies for robotic rehabilitation. It includes selection of proper rehabilitation technique and optimal population to maximize the effects of rehabilitation.

2. “Propulsion-augmenting soft robotic exosuits for gait assistance and rehabilitation after stroke” by Dr. Louis Awad of Boston University (Boston, USA)

Abstract: Human bipedal locomotion is characteristically fast, stable, and economical and requires coordination of the three subtasks: propulsion, bodyweight support, and ground clearance. Impaired propulsion is a hallmark deficit after stroke that is associated with slow walking speeds, reduced 6-minute walk test distance, and a higher energy cost of walking---key predictors of real-world community walking activity. Our team is developing new technologies and interventions for propulsion re-training after stroke. In this presentation, I will review our development and study of soft robotic exosuits that provide coordinated paretic plantarflexor assistance during post-stroke walking, as well as an individualized and progressive gait training program designed to leverage unique attributes of the exosuit technology to improve walking after stroke.

3. Robotic Kinematic measures of the arm in chronic Stroke: part 1 - Motor Recovery patterns from tDCS preceding intensive training and part 2 – strong correlation with clinical outcome measures” by Hermano Igo Krebs of MIT (Cambridge, USA)

Abstract: Effectiveness of robotic therapy and transcranial direct current stimulation is conventionally assessed with clinical measures. Robotic metrics may be more objective and sensitive for measuring the efficacy of interventions on stroke survivor’s motor recovery. Here we will discuss the advantage of robotic metrics to detect any difference in outcomes in a study of transcranial direct current stimulation (tDCS) preceding robotic therapy. Impact of impairment severity on intervention response was also analyzed to explore optimization of outcomes by targeting patient sub-groups as well as the added value of distal wrist measurement to a proximal robotic kinematic assay to improve its correlation with clinical upper extremity measures in chronic stroke.

For more information on WFNR SIG on Robotics, visit:

https://mrri.org/world-federation-for-neurorehabilitation/

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Co-Chair: Hermano Igo Krebs, PhD. (hikrebs@mit.edu)

Clinical Advisor: Alberto Esquenazi, MD.