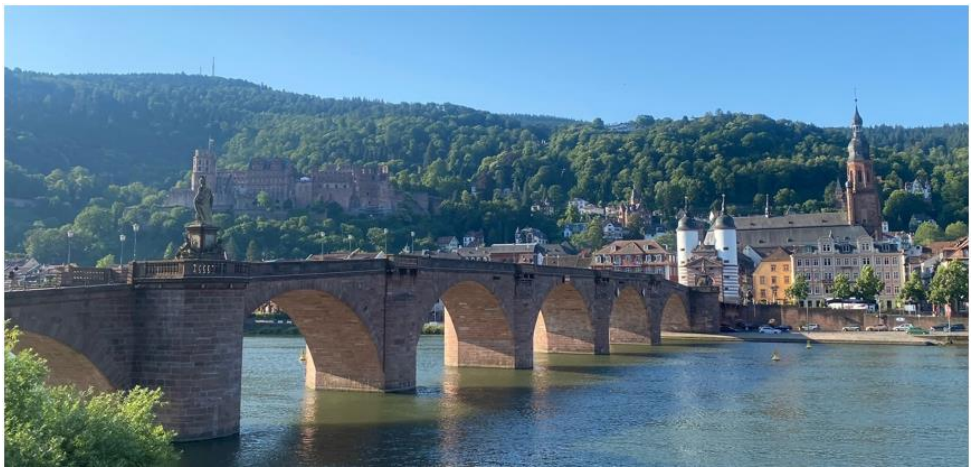
September 8th 2025

The WFNR WFNR Robotics Special Interest Group (SIG) was highly active over the past year with multiple successful events including a four-day conference in Heidelberg, Germany, and a two-day symposium in Elkins Park, PA, USA.

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

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

13th IEEE RAS EMBS 10th International Conference on Biomedical Robotics and Biomechatronics (BioRob 2024)
1-4 September, 2024: Heidelberg, Germany



General Chair: Lorenzo Masia, PhD
General Co-Chairs: Hermano Igo Krebs, PhD, and Franziska Mathis Ullrich, PhD

Held at Universität Heidelberg's Neue Universität, this conference represented a collaborative endeavor between IEEE's Robotics and Automation Society (RAS) and Engineering in Medicine and Biology Society (EMBS). The conference program included invited talks, paper sessions for contributed works, workshops and tutorials, contributed posters, poster sessions for late-breaking results, continuing medical credits (CME), and exhibitions focused on the latest advances in rehabilitation robotics and prosthetics.

Highlights:
Oral Session on Rehabilitation robotics
Chair: Hermano Igo Krebs, Co-Chair: Juan C Moreno

Authors: Julius Rominger; Lucia Buatier de Mongeot; Jacob Boehm; Anne Lieb; David Baur; Ulf Ziemann; Lorenzo Masia; Daniel Florian Benedict Haeufle
Title: ***Supporting functional tasks in bi-manual robotic mirror therapy by coupling upper limb movements based on virtual reality***

Authors: Agnese Cherubini; Clara Sánchez del Valle; Clara Beatriz Sanz-Morère; Eloisa Herranz-Calero; Elena De Eusebio Rubio; Sara Gonzalez; Diana Sofia Herrera Valenzuela; Antonio J. del-Ama; Susana Borromeo; Vanesa Soto León; Antonio Oliviero; Angel Gil-Agudo; Natacha León; Diego Torricelli; Jesús Tornero; Juan C.Moreno
Title: ***Multi-level characterization of the recovery process of a stroke survivor after 2 months of robotic therapy with the Walkbot robot***

Authors: Peijun Zhao; Hermano Igo Krebs
Title: ***Enabling Home Rehabilitation with Smartphone-Powered Upper Limb Training***

Authors: Erica Waters, Rochelle Mendonca; Pamela Cacchione; Michelle J. Johnson
Title: ***Towards Multi-User Robot-Based Stroke Rehabilitation: The Influence of Relative Partner Skill on Motor Learning***

Authors: Seong-Hoon Lee; Won-Kyung Song
Title: ***Bilateral Arm Movement Enhancement: Robotic Error Augmentation Insights from Stroke and Able-Bodied Participants***

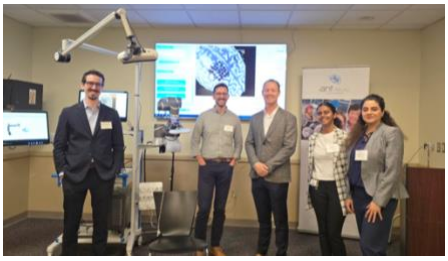
PAPERS:

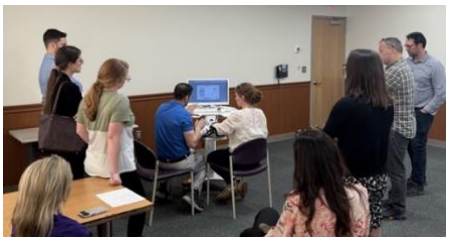
The assessment of movement abilities in individuals with neurological disorders is a critical task in clinical practice. Currently, clinical assessments are time-consuming and rely on qualitative scales typically conducted by trained clinicians at the clinic. Moreover, these assessments offer only coarse snapshots of a person's abilities, failing to track the minutiae of recovery over time. To overcome these limitations, this paper describes an AI-based computer vision to extract movement features from pose data obtained from monocular videos collected with mobile devices (e.g., smartphones, tablets). The method can be efficiently implemented on a wide range of mobile devices in real-time or near real-time.

We recommend reading the following recent paper:

Zhao P, Alencastre-Miranda M, Shen Z, O'Neill C, Whiteman D, Gervas-Arruga J, Krebs HI, "Computer Vision for Gait Assessment in Cerebral Palsy: Metric Learning and Confidence Estimation," IEEE Transactions on Neural Systems and Rehabilitation Engineering, 2024.

3rd Robotics and Technology in Rehabilitation: Bridging Science and Clinical Care Symposium
2-3 May, 2025: Elkins Park, PA, USA





This conference, hosted by Jefferson Moss-Magee Rehabilitation and Jefferson Moss Rehabilitation Research Institute, highlighted work being in the development, research, and clinical implementation of various technologies and robotics. The conference was organized by Dylan Edwards, PhD, and Alberto Esquenazi, MD. It included a broad range of expert presentations and hands-on practical sessions using the latest clinical devices, and various sponsors showcased their latest products. Each day the conference included a highly interactive panel discussion with guest speakers engaging with attendees. The topic for the panel discussion on the first day was "Neurophysiological Assessment and Intervention Individualization", and on the second day, the discussion focused on "Community-Based Rehabilitation Systems - similarities and differences". Thank you to all of the clinicians who helped with the sessions and to Paria Arfa Fatollahkhani, Benjamin Ayzenberg, Andrew Packel, and Tejaswini Sudhakar, and Jacqueline Zuccarelli for preparing summaries for this newsletter.

Presentations:

Speaker: Steven C. Cramer, MD, MMSc, FAAN, FAHA, - UCLA, California Rehabilitation Institute

Title: ***TeleRehabilitation After Stroke Care***

Various therapies can promote recovery in people after stroke, including drugs, biological agents, brain stimulation, lesion bypass methods, and activity- and cognitive-based therapies. Activity-based therapies are important for improving outcomes and facilitating neural plasticity after stroke; however, there is an unmet need for delivering high doses of rehabilitation therapy due to factors like cost and access. Telerehabilitation may be an option to address this unmet need due to its ability to promote high-intensity practice, ease of access, brain circuit engagement, and gamification for compliance. Dr. Cramer and colleagues have published—and continue to study—findings that demonstrate how home-based telerehabilitation achieved comparable gains in arm function to in-clinic therapy, and that it is feasible and safe for early initiation after stroke, significantly increasing therapy time and enabling remote monitoring.

Speaker: M. Reid Gooch, MD, FAANS - Jefferson Health

Title: ***Improving Stroke Care from the Cath Lab to Rehab***

Neuronal plasticity is at the core of motor function recovery following stroke, and there is evidence that vagus nerve stimulation (VNS) can help induce neuronal plasticity to improve rehabilitation outcomes. VNS combined with rehabilitation has been shown to help forelimb recovery in animal models after neurological injury. Dr. Gooch, a neurosurgeon, has been implanting a vagus nerve stimulator device, Vivistim, in order to promote recovery in upper extremity motor function following stroke. He has found that VNS paired with activity-based rehabilitation can result in significant improvements in upper extremity motor functional as measured by the Fugl-Meyer Assessment for Upper Extremity. These findings suggest that more research should be done on the applicability and timing of VNS in order to improve post-stroke care.

Speaker: Dylan Edwards, PhD - Jefferson Moss Rehabilitation Research Institute
Speaker: Nathaniel H Mayer, MD - Jefferson Moss-Magee Rehabilitation

Title: ***Transcranial Magnetic Brain Stimulation for Stroke Assessment***

This talk examines the relationship between corticospinal tract (CST) integrity and voluntary movement in individuals with hemiparetic stroke, particularly those with severe motor impairment (Fugl-Meyer scores <30/66). Transcranial Magnetic Stimulation (TMS) over the primary motor cortex (M1) is commonly used to assess CST function by eliciting motor evoked potentials (MEPs). While the presence of MEPs has traditionally been linked to better recovery outcomes, studies conducted by Dr. Mayer and Dr. Edwards have shown that some patients can still voluntarily contract muscles—even when MEPs are absent, especially in proximal muscles like the biceps. This suggests alternative motor pathways may support recovery when CST integrity is compromised. The presentation emphasizes the importance of assessing CST integrity during active movement not just at rest, as voluntary movement involves broader brain and spinal inputs. Research using bilateral tasks showed that even severely impaired individuals could perform coordinated arm movements, including symmetrical and asymmetrical tasks. These findings suggest new rehabilitation strategies focused on identifying muscles with preserved voluntary activation. EMG pattern recognition could be used to control assistive technologies such as orthoses, electrical stimulators, or vibratory devices, enhancing functional movement in stroke survivors with limited CST integrity.

Speaker: Franco Molteni, MD, PhD - Villa Beretta Rehabilitation Research Institute, Master RehabTech Politecnico

Title: ***Neurophysiologic Assessment During Robotic-Mediated Training***

Research showed that robots could thus open up a wider choice of options for delivering movement rehabilitation grounded on the principles underpinning neuroplasticity in human CNS. Dr. Molteni and his colleagues work focused on how the EEG and EMG signals are integrated into the robotic rehabilitation systems to enhance several parameters including the control precision, adaptability, patient engagement and maintenance of their engagement. Their work revealed enhancing effects of the synchronization of EEG and EMG signals for mobile brain/body imaging in clinical settings, which found that muscle synergy activation can be decoded from EEG signals and be utilized for the prediction models. Moreover, Dr. Molteni' recent work on the robotic exoskeleton gait training, which is an EMG-based evaluation, for stroke population, suggested that robotic-assisted training can promote supraspinal plasticity in the motor centers involved in the locomotion.

Speaker: Andrew Packel, PT - Jefferson Moss-Magee Rehabilitation
Speaker : Mukul Talaty, PhD - Jefferson Moss-Magee Rehabilitation

Title: ***Personalized Robotic Assistance via a Hip Exoskeleton for Individuals with Chronic Stroke***

Personalized Robotic Assistance via a Hip Exoskeleton for Individuals after a Chronic Stroke Research on rehabilitation practices following stroke has shown that the in order to improve walking ability, one must practice walking. Robotics can be utilized in rehabilitation to promote walking practice and address impairments in gait. The Active Pelvis Orthosis (APO) is an investigational exoskeleton device that may assist clinicians in identifying and addressing gait impairments post-stroke, as well as improving overall walking ability through walking practice with augmented hip flexion. Preliminary findings suggest that gait training with the APO can improve joint mechanics during gait in the hip, knee, and ankle, and temporospatial mechanics, such as step length and gait speed. These findings suggest that these improvements are retained without the APO and 2 months after training.

Speaker: Asgeir Alexandersson, MD - Neuromuscular Technology

Title: ***Advances in Prosthetic Control***

This talk highlights recent advances in prosthetic control, emphasizing the need to align device function more closely with user intent. Current lower-limb prostheses rely on internal sensors and reactive control, lacking direct access to neuromuscular signals or meaningful sensory feedback. Upper-limb systems typically use surface EMG, but signal instability, poor intuitiveness, and high abandonment rates remain challenges. Artificial intelligence (AI) offers promising improvements in intent recognition through multimodal sensor integration, though its effectiveness depends on the quality and reliability of input signals. Implantable Myoelectric Sensors (IMES), developed by the Alfred Mann Foundation, represent a significant breakthrough, offering stable, intuitive control via wireless EMG signals from implanted electrodes. Clinical trials have demonstrated safe, long-term use and proportional control of multiple joints. Participants report natural feeling movements and low cognitive load. The talk also addresses cortical

reorganization after limb loss and how prosthesis use may mitigate phantom pain. Despite technological progress, clinical adoption is hindered by user concerns about surgery, clinician training gaps, and regulatory barriers. Current outcome measures often fail to capture real-world benefits like embodiment or improved daily function. The presentation concludes by stressing the importance of patient-centered design, improved clinical communication, and early regulatory planning to ensure these technologies transition effectively from lab to life.

Speaker: Thomas Watanabe, MD - Jefferson Moss-Magee Rehabilitation

Title: ***Implementation of Robotics: The Clinicians' Perspective***

This talk explores the integration of robotics into clinical rehabilitation through the lens of implementation science, which studies how to systematically translate evidence based interventions into routine practice. Robotic technologies offer benefits such as increased therapy intensity, enhanced patient motivation, and potential for expanded access through home-based systems. However, adoption in clinical settings remains limited due to factors like clinician hesitancy, inadequate training, logistical constraints, cost, and lack of adaptability to individual patient needs. Uptake varies across inpatient, outpatient, and home settings, each with distinct challenges. A study by Klaic (2022) assessed the adoption of an upper extremity robot in both public and private practices using pre-post Technology Acceptance Model (TAM2) surveys and focus groups, revealing concerns related to usability, storage, portability, and patient fit. Home based systems, such as soft robotic gloves paired with telerehabilitation, may extend care to underserved populations and reduce reliance on in person sessions. Among 100 clinicians surveyed, only 37% had prior experience with robotic rehab, with key adoption themes including therapy goals, cost, and staffing needs. Demonstrating efficacy alone is insufficient; successful implementation requires a multi-level, patient-centered strategy that addresses real-world constraints, equity, and stakeholder engagement to ensure meaningful clinical impact and public health benefit.

Speaker: Amanda Rabinowitz, PhD - Jefferson Moss Rehabilitation Research Institute

Title: ***Mobile Rehabilitation: Future Directions for mRehab for People with Disabilities***

The lecture on Mobile Rehabilitation, given by Amanda Rabinowitz, PhD, focuses on the future of mobile rehabilitation for individuals with disabilities. It highlights the increasing demand for rehabilitation services due to an aging population, issues of insurance coverage, and a shortage of professionals, creating a significant gap between patient needs and available care. The lecture emphasizes the issue of low adherence to home exercise programs, which is crucial for recovery. It suggests that mobile technology offers a promising solution that could eventually lead to a hybrid clinician delivered, mobile healthcare model. Rabinowitz acknowledges some challenges to mobile rehabilitation such as tech adoption, clinician buy-in, and reimbursement. However, this lecture discusses that mobile rehab tools have the potential to improve access, engagement, and outcomes through features like real-time feedback, reminders, and personalization. Ultimately, the success of mobile rehabilitation depends on a client-centered design and seamless clinical integration.

Speaker: Jakko Brouwers, MSc , MCSP - Morello Clinic, Nelson House

Title: ***Assessment and Rehabilitation: Using FES and AI for the Rehabilitation of Gait in Neurological Conditions***

Morrello company has developed a clinical model for the use of FES and AI in the community Rehabilitation of Gait in Neurological conditions. NeuroSkin is an AI-powered Multichannel Electrical Stimulation device allowing for multimodal FES-based therapies. The NeuroSkin system has multiple components such as a stimulator, which attaches to the lower back of the patient and FES garment with dry electrodes which are located on the different regions of the lower limbs. This system also includes two different motion and pressure sensors which help with the AI-powered stimulation timings. Additionally, the upper body is also equipped with a controller and router which is useful for the medical follow ups and AI models update. Their pilot study of using NeuroSkin AI-powered FES-walking for gait rehabilitation on 30 post-stroke patients suggested promising improvements on different assessments including the 10MWT, 6MWT and TUG tests.

Speaker: Natalee Takasumi, PT, DPT, DVM - US Tyromotion

Title: ***Sensor-based Rehabilitation for Use in the Community***

This lecture, given by Natalee Takasumi, focuses on sensor-based rehabilitation devices for use outside of traditional clinical settings. Takasumi defines a sensor as "a device that detects and responds to a physical stimulus." Her lecture aims to educate the audience on the history, benefits, available technologies, and research surrounding these wearable health systems that help patients monitor activity and vital signs. The lecture reviews multiple systematic reviews evaluating various sensor-based rehabilitation devices including smartwatches, LE and UE wearable devices, an interactive wearable device. Some challenges reviewed in these studies include needing to charge devices, utilization of multiple devices, and connectivity issues. Studies found that factors such as ease of use, individualization of exercises, adjustability, high repetition, visualization of progress, and feedback were effective for clients to continue use of the technology. Takasumi highlights how these devices can improve motivation, support remote rehabilitation, and potentially enhance cognitive function for individuals recovering from conditions like stroke.

Speaker: Hermano I Krebs, PhD - MIT, University of Maryland School of Medicine

Title: ***Continuum of Care: Robotics at the Clinic and at Home***

This talk presents the transformative role of rehabilitation robotics in post-stroke recovery, challenging the long-held belief that the brain is "hardwired" and incapable of repair. Advances in neuroscience now recognize the brain's plasticity, supporting new therapeutic paradigms that promote recovery through intensive, targeted intervention. Evidence from major randomized controlled trials, including the VA multisite study and RATULS (the world's largest robotics RCT with over 770 participants), demonstrates that robot-assisted therapy (RT) produces superior upper-limb motor recovery outcomes compared to both usual care and intensive conventional therapy. These robotic systems deliver high-dosage, task-specific training and adapt to individual performance using assist-as-needed and performance-based algorithms. The presentation outlines distinct robotic training modalities such as discrete (submovements), rhythmic (oscillations), and impedance based (strength), each targeting unique aspects of motor recovery. Robotics also enables collection of biomarkers that improve trial efficiency and inform personalized care. Additionally, there is growing emphasis on expanding access through low-cost, smartphone-based home systems and AI-driven motion analysis. Despite proven efficacy, challenges remain in clinical adoption due to economic and logistical barriers across healthcare systems in the U.S., U.K., and Italy. The talk advocates for a continuum of care, from inpatient to home, to address stroke as a lifelong condition. Robotics, paired with implementation science, holds promise to transform rehabilitation into a scalable, evidence-based, and patient-centered practice.

Practical Sessions: Clinical Application of Devices and Technologies :

1) Demonstrators: Dylan Edwards, PhD, and Tejaswini Sudhakar, BE - Jefferson Moss Rehabilitation Research Institute

Title: ***Robotic Guided Transcranial Magnetic Stimulation (TMS)***

Robotic Guided Transcranial Magnetic Stimulation (TMS) offers enhanced precision and consistency in targeting specific brain regions, making it a promising tool in neurorehabilitation for stroke and spinal cord injury. By delivering repetitive, focused stimulation to promote neuroplasticity, robotic-guided TMS can help improve motor function, reduce spasticity, and support recovery. The integration of robotics ensures optimal coil positioning and reproducibility across sessions, leading to more reliable outcomes and individualized treatment planning.

2) Demonstrators: Casey Finley, MOT, OTR/L, and Alexey Nastaskin, MSOT - Jefferson Moss-Magee Rehabilitation

Title: ***Amadeo for Upper Limb Rehabilitation***

Participants saw the Amadeo robotic device for finger and hand rehabilitation. This device incorporates sensors as well as actuated movements in a gamified environment to allow for high engagement during repetitive practice. It also allows practice of more gross movements such as grasping, versus individual finger movements.

3) Demonstrator: Janine Brodovsky, PT, DPT - MossRehab Institute for Brain Health

Title: ***Virtualis MotionVR computerized dynamic posturography with VR***

The Virtualis Virtual Reality system demonstration featured a 360 degree balance platform and virtual reality headset that can be used for testing balance abilities and for training in an immersive virtual reality environment. Balance strategies were demonstrated, as well as visual motion habituation and motion habituation training techniques. Participants were invited to experience virtual reality training on the floor and on the balance platform for weight shifting, training balance reactions, motion desensitization in a supermarket and upper and lower extremity training for stepping and reacting. Participant discussion focused on application of the different virtual environments and how to translate virtual reality treatments into real world environments.

4) Demonstrators: Andrew Packel, PT, and Mukul Talaty, PhD - Jefferson Moss-Magee Rehabilitation

Title: ***Active Pelvic Orthosis (APO) for Post-Stroke Gait Rehabilitation***

The Active Pelvis Orthosis (APO) demonstration featured a hip exoskeleton that allows customization of motoric assistance from the device for both hip flexion and extension that is tuned to the particular walking pattern and characteristics of the individual user. Several participants were able to trial the device while others observed and were able to see the immediate effects on gait of use of the device. Discussion centered around the potential longer-term effects of repeated training with the device for individuals with stroke or other neurologic conditions affecting their gait.

Upcoming Events in 2026:

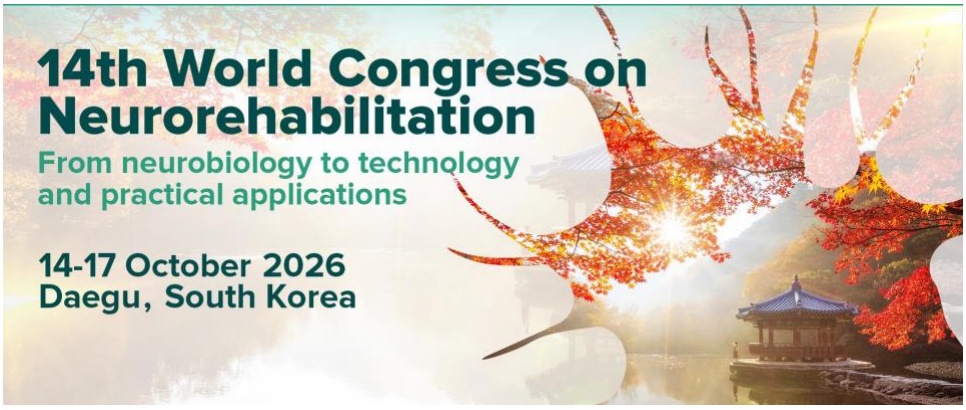
2026 11th IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob)

Aug 1, 2026 - Aug 4, 2026: Edmonton, Alberta, Canada

Mark your calendars for the BioRob 2026 in Edmonton! The BioRob conference covers both theoretical and experimental challenges posed by the application of robotics and mechatronics in medicine and biology, and it will bring together diverse experts from across the world for 4 days of engaging programming and discussions.

WFNR 14th World Congress for Neurorehabilitation,

14-17 October, 2026: Daegu, South Korea



We hope you can join us in Korea for our next WFNR World Congress for Neurorehabilitation, and we encourage you to mark your calendar for 14-17 October, 2026. We are excited to announce that we are planning to submit a proposal for a symposium that will be titled “From the Bedside to Home, Robotics and Technology for Rehabilitation” and will build on the discussion we started at the 2024 meeting. Stay tuned for more updates as the meeting approaches.

Chair: Dylan J. Edwards, PhD. (dylan.edwards@jefferson.edu)

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

Clinical Advisor: Alberto Esquenazi, MD.

For more information on WFNR SIG on Robotics, visit:

https://rehabilitationresearch.jefferson.edu/innovations/wfnr-robotics-sig.html

If you’re interested in joining the Robotics Special Interest Group (SIG), please contact mary.czerniak@jefferson.edu.