РОБОТИКА, НЕУРОНАУКА И ХИРУРГИЈА

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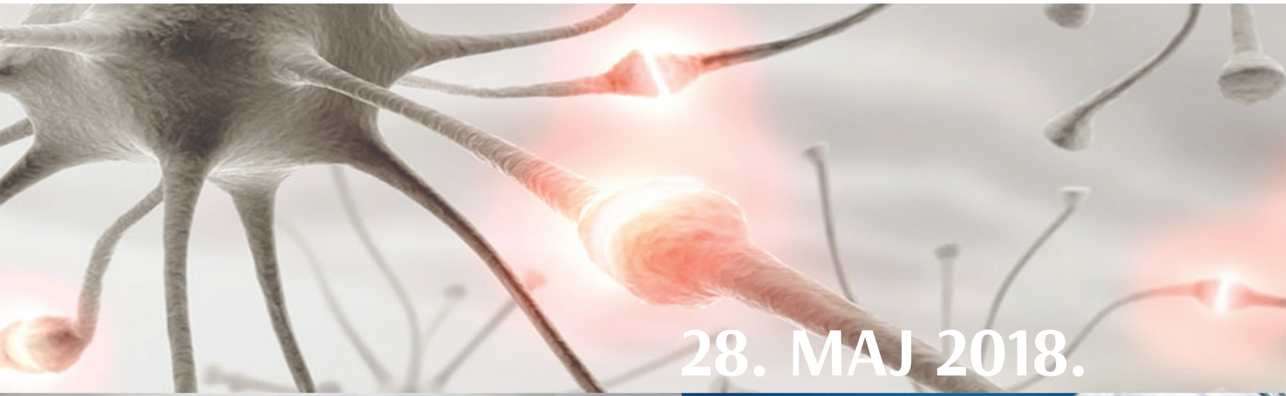

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ROBOTICS, NEUROSCIENCE, AND SURGERY *for* NEUROREHABILITATION

MAY 28, 2018

SASA Main Hall, Serbian academy of sciences and arts,
Belgrade, Knez Mihailova 35/II

PROGRAM

10:00 **Workshop opening**,
Zoran Lj. Petrović, Secretary of the Department of technical sciences of SASA, Belgrade

10:15 **Freezing of gait in Parkinson's disease: internal drivers vs. external cues,**
Vladimir S. Kostić, Belgrade, Serbia

10:45 **Role of synergies in motor control,**
Jozsef Laczko, Budapest, Hungary

11:15 **Advanced technology and neurorehabilitation: a doctors' perspective,**
Marco Molinari, Rome, Italy

11:45 Coffee break

12:15 **Neural Interfaces for stroke rehabilitation,**
Ander Ramos Murguialday, San Sebastian, Spain

12:45 **Non-invasive spinal cord stimulation for modification of spasticity and restoration of movement after spinal cord injury,**
Winfried Mayr, Vienna, Austria

13:30 Lunch at the SASA club

14:30 **New Methods in Microsurgery,**
Marko Bumbaširević, Belgrade, Serbia

15:00 **New methods and devices for external and internal skeletal fixation,**
Milorad Mitković & Milan Mitković, Niš, Serbia

15:30 **Exoskeletons for motor rehabilitation**,
Dejan B. Popović, Belgrade, Serbia and Aalborg, Denmark

16:00 **Novel approaches in rehabilitation robotics for gait training,**
Zlatko Matjačič, Ljubljana, Slovenia

16:30 **Stimulation and evaluation of recovery of denervated muscles,**
Dietmar Rafolt, Graz and Vienna, Austria

FREEZING OF GAIT IN PARKINSON´S DISEASE: INTERNAL DRIVERS VS. EXTERNAL CUES

Vladimir S. Kostić, M.D, Ph.D.

Institute of Neurology, School of Medicine University of Belgrade, Serbia
President of the Serbian Academy of Sciences and Arts

Summary: Freezing of gait (FOG; "a brief, episodic absence or marked reduction of forward progression of the feet despite the intention to walk"), is a unique and disturbing gait disorder usually observed in patients with Parkinson's disease (PD). PD patients suffering from FOG (PD-FOG) are more likely to experience falls, loss of independence, and decrease in quality of life compared with those without. Besides environmental stimuli, considerable evidence suggested that additional cognitive demands while walking might be an important trigger of FOG. Attentional set-shifting in both treated and particularly drug-naive PD patients were impaired in their ability to perform an extra-dimensional, but not an intra-dimensional shift. In situations in which competitive stimuli were present, PD patients have impaired attentional set-shifting abilities, but preserved task-set switching abilities. Recently, we found that gray matter frontal and parietal atrophy occur in PD-FOG patients and concluded that FOG in PD seemed to share with executive dysfunction and perception deficits a common pattern of structural damage to the frontal and parietal cortices. Resting-state functional MRI analysis showed that PD-FOG was associated with a decreased functional connectivity of the primary motor cortex and supplementary motor area bilaterally in the sensorimotor network, frontoparietal regions in the default mode network, and occipital cortex in the visual associative network. Therefore, we suggested that FOG in PD can be the result of a poor structural and functional integration between motor and extramotor (cognitive) neural systems.

Automaticity is impaired in PD, putting more stress on voluntary mechanisms. Internal drivers of movement are impaired, likely because of deficient basal ganglia function. This deficiency gives a greater influence to external or sensory factors. Indeed, FOG occurs more often during the performance of a dual-task. In contrast,

external cues help to overcome FOG (cues generally led to a statistically significant improvement in the step and stride length, speed of gait, and cadence). A recent model hypothesized that during FOG, increased firing rate within the subthalamic nucleus (STN) induced an increase in activity within the globus pallidus internus (GPi), leading to decreased activity within the pedunculopontine nucleus (PPN). The inhibited PPN was unable to inform the motor spinal cord (SCm) properly, which in turn caused FOG. External cues or attention might help to trigger the striatum to inhibit the GPi, effectively releasing the STN-mediated "brake" on the PPN and SCm.

Vladimir S. Kostić is professor of neurology at the School of Medicine University of Belgrade (SMUB), visiting professor at the Universities of Novi Sad and Skopje. In addition to SMUB over several years he worked and studied in London (1987) and at the Institute of Neurology Columbia University in New York (1989/1990 and 1995/1996). He was the head of the Institute of Neurology of the CCS for 15 years, was a dean of SMUB, chaired the Committee for Biomedical Sciences of the Ministry of Science and Technology of the Republic of Serbia, was a member of the National Science Council, etc. Currently is the Honorary President of the Serbian Neurological Society. Scientifically, he is focused neuro-degenerative diseases of the central nervous system. He is an author and co-author in >280 papers cited at the JCR list.

ROLE OF SYNERGIES IN MOTOR CONTROL

Jozsef Laczko, Ph.D.

Wigner Research Centre for Physics of the Hungarian Academy of Sciences, Budapest, Hungary & University of Pécs, Faculty of Science, Institute of Informatics and Mathematics, Pécs, Hungary

Summary: There is an infinite number of solutions to accomplish a motor task by a human limb. The question is, how to control redundant degrees of freedom of the motor system. How may the controlled variables be reduced to perform a motor task successfully? Joints and muscles work together, and these types of co-operation are referred as joint- and muscle synergies. Limb movements may be controlled by combining a small number of joint and muscle synergies. To reveal such synergies the reduction of dimensions is applied. Here the application of classical principal component analysis, nonnegative matrix factorization, and the uncontrolled manifold approaches are presented. Variances of repetitively executed limb movements may depend on environmental conditions, external forces, neuro-motor diseases. The number and strength of synergies accounted for the majority of the variances may depend on such factors and reflect motor control principles. As examples, bimanual and unimanual arm movements are investigated. For reaching movements, joint synergies, and for arm cycling on a cycle-ergometer, muscle synergies show that bimanual synergy is not an execution of two unimanual synergies. This may quantitatively reflect that there are different levels of control for unimanual and bimanual arm movements. Muscle co-activations are also investigated, as they vary with altered external conditions. Examples of lower limb cycling show the dependence of muscle activity patterns on cycling speed and crank resistance. Muscle synergies and co-activations discerned in movements of non-disabled people are applied in defining stimulation patterns for functional neuro-muscular stimulation of spinal cord injured individuals. Another application of dimension reduction is artificial control of movements when people with motor impairments use their residual motor abilities to control other body parts or external devices.

Professor Jozsef Laczko is head of Department of Information Technology and Biorobotics at University of Pecs in Hungary. He also holds positions in the Wigner Research Centre for Physics in Budapest and an adjunct assignment at the Northwestern University in Chicago. Dr. Laczko earned his Ph.D. in mathematics at the Eotvos Lorand University in Budapest, Hungary. He is experienced in computational approaches for motor control. He has published over 40 papers in refereed journals and proceedings, four book chapters and has presented over 50 professional talks. He was the chair of the “Progress in Motor Control X” conference of the Society for Motor Control. His chief research interest is on the area of biomechanics, and in the last decade, he became engaged in the control of Functional Electrical Stimulation driven limb movements for spinal cord injured individuals.

ADVANCED TECHNOLOGY AND NEUROREHABILITATION: A DOCTORS' PERSPECTIVE

Marco Molinari, MD Ph.D.

Director Neurorehabilitation and Spinal Center, Director Clinical Translational Research, Head Neuro-Robot Rehabilitation Lab, IRCCS Fondazione S. Lucia, Rome, Italy

Summary: At the end of last century, growing data on brain plasticity forced critical changes in the Neurological Rehabilitation approaches to patients. Traditionally, rehabilitation possibilities after brain damage were considered minimal and thus all efforts are directed to provide ways to substitute for a lost function. Nowadays, brain plasticity is a fact. No matter the severity of a lesion, some recovery is always expected. Today's challenge is to acquire the knowledge and skills to guide neurological recovery. Both experimental and clinical approaches are providing ample demonstration of this changing world and the potentialities of technological and neuroscience research for neurological rehabilitation advancements.

The introduction of several different technology-based devices into clinical rehabilitation represents one of the leading novelties in the field. Different robotic commercial devices for ambulation or arm training in are nowadays on the market. Nevertheless, still little evidence on the efficacy of such approaches is available a no consensus exists on technology-based treatment protocols. In spite of these limitations, media coverage is boosting patient expectations. Experimental data are promising, and patient expectations are legitimate and require answers. The gap between expectation and clinically meaningful results might be related to the lack of specificity in protocols and control algorithms. In particular, control systems that are more flexible or adjustable to patients' needs appear to provide better results. This tailoring of rehabilitation paradigms, although considered, it is often quite vaguely defined. Most approaches tend to develop control algorithms to minimize support and guidance according to the concept of "assistance as needed." In spite of the plausibility of the approach, it is a typical experience that rehab protocols cannot be only based on predetermined support and guidance. Patient attention and

mental states, differences in motor learning paradigms, resistance vs. assistance, control of abnormal postures and synergies are among the factors to be considered. By customizing the information provide to patient and therapist during technology assisted therapy, it is possible to improve treatment efficacy.

Neurological rehabilitation is a clinical field witnessing exponential growth. Increasing demand because population aging and better first care together with better understanding of neural mechanisms of recovery and technological advancements are the factors supporting this growth. In the last decade interactions among clinicians, neuroscientist and engineers have proven fruitful in developing different devices potentially of high clinical impact. The challenge now is to merge technology-based and traditional rehabilitation approaches to create clinical friendly technologies easy to implement in the framework of multidisciplinary personalized rehabilitation programs.

Dr. Marco Molinari (Neurologist, Physical medicine and rehabilitation specialist, PhD in Neuroscience) is the Director of Neurorehabilitation Translational Researchand Clinic at IRCCS Fondazione Santa Lucia, Rome. The Department integrates Neuroscience research and clinical neurological rehabilitation units. The clinical ward is devoted to rehabilitation of patients with brain or spinal cord lesions in a multidisciplinary environment. Research activity span from basic science approaches in animal models to development and testing of new rehab approaches in humans. Dr. Molinari is author of over 150 articles published on indexed journals. SCOPUS H-index 45. He is Review Editor of The Cerebellum. Research activity has been always focused on brain plasticity mechanisms and functional recovery both at basic science and clinical levels.

NEURAL INTERFACES FOR STROKE REHABILITATION

Ander Ramos Murguialday, Ph.D.

Director of Tecnalia's Neurotechnology Research Laboratory, Spain

Summary: Neural Interfaces have been proposed as a revolutionary mean to control robots and assistive devices. Recently we have proven the efficacy of a Brain-Machine-Interface in rehabilitation of severely paralyzed chronic stroke patients. During this talk, I will present a summary of the first clinical trial results (behavioral, clinical and neurophysiological data) and an overview of the all the clinical trials conducted until today using Neural Interfaces for stroke rehabilitation. New and future developments to understand the induction of functional neuroplasticity in motor recovery after stroke will be discussed.

Dr. Ander Ramos Murguialday got his mechanical engineering bachelor's degree from the University of Navarre in San Sebastian Spain and a Master of Science in Industrial Engineering from the same institution finishing it at the Technical University of Graz, Austria in 2004. He received a Master of Science degree in Biomedical Engineering at the Technical University of Munich, Germany, finishing the degree at the Johns Hopkins University, Baltimore, USA in 2007. In 2004 he got the Iñaki Goenaga Fellowship starting his work as a researcher in the Fatronik-Tecnalia Technological Foundation, San Sebastian Spain, becoming the director of Tecnalia Germany in 2010. He obtained his PhD in Neuroscience at the Max Planck Graduate School University of Tübingen in 2011. In 2016 he became the Director of Tecnalia's newly founded Neurotechnology Research Laboratory, in 2017 he became a member of TECNALIA's executive board and attained Junior Group leader at the University of Tübingen. His current research topics include robotics and mechatronics, neurophysiology, neuroplasticity, neuroprosthetics and neurorehabilitation using BMI techniques (EEG, MEG, ECoG) coupled with robotics.

NON-INVASIVE SPINAL CORD STIMULATION FOR MODIFICATION OF SPASTICITY AND RESTORATION OF MOVEMENT AFTER SPINAL CORD INJURY

Winfried Mayr, Ph.D.

Center for Medical Physics and Biomedical Engineering,
Medical University of Vienna Austria

Summary: Spinal cord stimulation (SCS) after spinal cord injury is a complementary method to neuromuscular or direct muscle stimulation and targets providing afferent neural inputs to spinal interneuron networks. It opens new methodological options for detailed assessment of post-injury neurophysiological function profiles, which is useful for intervention planning and monitoring, and for follow-up validation of temporal developments with or without therapeutic influences. As well it provides means for interventions to modify spasticity and augment residual movement functions.

Stimuli can be administered non-invasively by transcutaneous electrical stimulation (tSCS) or via epidural electrodes in temporary or permanent setups. To some extend tSCS can be useful for preparation and decision support for later implantation of an implantable solution.

There are similarities between tSCS and epidural SCS in their ability to activate afferent nerve fibers in the posterior roots. Selectivity is limited in both cases, specific challenges in the tSCS concern electrode configuration and handling, and interference with co-activation of nerve structures that are situated closer to the electrodes, than the spinal roots and can act as additional afferent inputs. Nevertheless effective methods are already available and actually under further development, for use in clinical diagnostic and therapeutic application.

Current setups rely on bipolar arrangements of hydrogel electrodes placed over the lumbar dorsal spine, 8-channel EMG recording from the 4 main muscle groups of both legs and goniometers for tracing knee joint movements. Assessment protocols

include recruitment curves of reflex responses, dependence of responses from frequency and intensity of stimulation and variation of electrode locations. Interventions build on assessed optimums and rely on home-based application of suitable mobile stimulators.

Prof. Winfried Mayr received his Diploma in "Electronics and Control Engineering" from Vienna University of Technology in 1983, his work is focused on Functional Electrical Stimulation (FES) and rehabilitation engineering, mainly at Vienna Medical University, since. His Ph.D. in Biomedical Engineering was on "Reactivation of Paralyzed Muscles by FES via Implants" (1992) and included experimental and applied research on phrenic pacing, lower extremity, pelvic floor and denervated muscles. Work in the subsequent years was dedicated mainly on non-invasive FES of lower extremity in paraplegia, in microgravity and clinical bed-rest, and upper extremity. Outcome of the European Project RISE on FES of denervated muscles, an initiative with 20 partner groups under his coordination, was development of a novel clinical method and associated equipment for rehabilitation after flaccid paraplegia. His special current focus is spinal cord stimulation for modification of spasticity and restoration of movement after SCI. Between 2009 and 2017 he chaired the Austrian Society for Biomedical Engineering (OeGBMT), and is current vice-president and IFMBE delegate of OeGBMT, and councillor in EAMBES, the roof organisation of European Biomedical Engineering Societies. He is foundation member and board member of the International FES Society IFESS. He serves as reviewer in various journals and funding agencies and Co-Editor for FES in the Journal "Artificial Organs".

NEW METHODS IN MICROSURGERY

Marko Bumbaširević, M.D, Ph.D.

Chair professor and chief of Department of reconstructive surgery and microsurgery at Clinical Center of Serbia, Belgrade; corresponding member of the Serbian Academy of Sciences and Arts

Summary: Microsurgical techniques have become an integral part of the armamentarium for surgeons, allowing for tissue revascularization and reattachment of completely amputated parts of human body as well as soft-tissue coverage and function after trauma or oncologic resections. Technological advance and progress has not bypassed microsurgery. Latest achievements are considering new, sophisticated microscopes, instruments and suture materials for supermicrosurgery, better understanding of the anatomy and blood supply facilitating anastomosis of vessels of 0.3 mm and lesser. Two aspects of progress we have to consider: advances in surgical techniques and the influence of technological progress on microsurgical practice.

Super microsurgery is recently pushing the boundaries allowing reconstructive surgeon an important tool for achieving complex reconstruction by proceeding with free tissue transfer from distant sites. It allows anastomosis of very small vessels of perforator flaps from different donor sites to perforator recipient vessels. Complex digital replantations and even fingertip injuries are more successful. Super microsurgical procedures such as lymphatic venous anastomosis and vascularized lymph node transfer can treat the excess fluid component of lymphedema.

Boundaries are pushed further in composite tissue transfers, functioning free muscle transfers, vascularized bone grafts, toe transplantation, neural grafts or vein grafts. By dissecting the blood vessels to the flap and sparing the surrounding tissue, large flaps can be harvested with minimal functional loss to the patient.

New developments are also noticed in allotransplantation. Many centers are capable of doing the surgical part, but we still have immunosuppression part and rehabilitation that are disputable. Making them simpler and affordable will popularize procedure and will open up tremendous possibilities.

Technical issue applies to the appearance of mechanical devices like couplers for anastomosis of vessels. Couplers are faster, safer and when we compare it even better than suturing. Robots for microsurgical work are available but we can't completely rely on mechanical devices due to possibility of malfunction.

Marko Bumbasirevic M.D. PhD is professor of Orthopaedic Surgery and Traumatology at Faculty of Medicine University of Belgrade. He is also corresponding member of Serbian Academy of Sciences and Arts (SANU), chair professor and chief of department of reconstructive surgery and microsurgery at Clinical Center of Serbia, President of European Federation of Societies for Microsurgery (EFSM), founding President of Serbian Orthopaedic and Traumatology Association (SOTA), founding President of Serbian Hand Society (SSHS), founding President of Serbian Society for Reconstructive Microsurgery (SSRM), President of SICOT World Orthopaedic Congress 2021, national delegate in SICOT, national delegate in EFFORT and national delegate in FESSH. He has published 178 articles in international peer-reviewed journals mostly related to microsurgery, hand surgery, Ilizarov method and trauma.

NEW METHODS AND DEVICES FOR EXTERNAL AND INTERNAL SKELETAL FIXATION

Milorad Mitković, M.D., Ph.D., Milan Mitković, M.D.

Corresponding member of the Serbian Academy of Sciences and Arts, Belgrade and Professor at the Medical Faculty, University of Niš, Serbia

Summary: Skeletal trauma continues to recruit hundreds of thousands of people with special needs, every year, worldwide. In other hand, there are many people with different skeletal and neuromuscular disorders with motor dysfunction. New achievements coming from multidisciplinary scientific fields make obvious contributions to increase quality of life of disabled people and to decrease costs of societies. We present here our results of biomechanical investigations of parts of human skeleton, our results on experimental animals and our clinical results. In the field of external skeletal fixation, we have developed original system with balanced 3D biomechanical stability, imitating biomechanical features of natural human bones and designing it to be as simple as possible from surgical and from routine practical point of view. This external skeletal fixation system has been accepted on international level and has been applied to more than 26 thousands patients so far, mainly for surgical long bones fractures treatment. Results have showed important advantages in relation to other existing devices. However, it can further be improved, especially in regard of use in deformities correction and limbs lengthening. Using the same philosophy we have also developed new fully implantable extramedulary internal device. After biomechanical investigations and experimental results, it has been accepted and already applied to more than six thousands patients, mainly for fractures surgical treatment. This device provides preserving of two main blood sources of long bones: intramedular and periosteal. The main feature of the device is spontaneous axial dynamisation which is activated in case of delay union or non union only. Because of that feature this implant functions as „Inteligent implant“. Results showed decreasing of percent of complications in regard to bone healing success and complications. Further research using this implant as carrier, can be

very helpful in defining how much axial dynamisation is important. It can further help in development of new ideas, new methods and devices.

Milorad Mitkovic, M.D., Ph.D. is Consultant Orthopaedic Surgeon, Professor of Surgery at the School of Medicine, University of Nis, member of the Serbian Academy of Sciences and Arts (SASA), president of the Serbian Trauma Association. He completed his education in Nis, Belgrade, London, Oxford, Cambridge, Ulm, Bruxelles, Davos, Moscow, Hannover, Tubingen, etc. He is an active surgeon (joint replacement, arthroscopy, correction of deformities, limb lengthening, etc.) as well as inventor (48 inventions) and scientific researcher (he has been a coordinator of 12 scientific projects). More than 30 thousand of patients have been treated using methods and devices he developed. He is a founder of school and courses, based on new approach in bone fixation. He published 507 scientific publications (articles and books). He was founder and president of the Serbian Trauma association - STA, as well as of the Association for Investigation and Research in External and Internal Fixation known as “Mitkovic School” that organizes courses on regular bases. He is a Board member of the European Society for Trauma and Emergency Surgery - ESTES, and active member of other distinguished international societies such as SICOT, AAOS, EFFORT, ASAMI B&R, AO/ASIF etc. He was the founder and head of one Orthopaedic clinic in Kuwait.

EXOSKELETONS FOR MOTOR REHABILITATION

Dejan B. Popović, Ph.D., Dr. Tech.

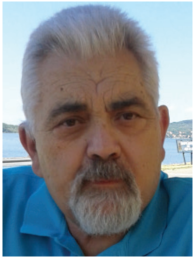
Member of Serbian Academy of Sciences and Arts, Belgrade, Serbia
and Professor Emeritus, Aalborg University, Denmark

Summary: Wearable robots are exoskeleton which support and augment the diminished motor function of a person with disability. The interaction of a wearable robot and the body is essential for the eventual adequate recovery of the function.

A wearable robot is a parallel frame to the human skeleton and the control operates in parallel to the preserved neural systems. Externally generated torques act to compensate compromised motor systems. Wearable robots need, in some cases, to provide balance for a person who lost the ability to stand and walk, and in some cases need to be assistants to extremely complex task to allow the reaching, grasping and using the objects.

Wearable robots need to be used either to supplement motor functions; or to replicate them completely. Wearable robots interact with humans in multiple situations; hence, ergonomics, ethics and societal interaction (EES) must be considered at all times. Wearable robot designers must understand the users when designing an innovation.

The presentation will discuss bottlenecks in the application of wearable robots today and suggest the possible paths for implementing soft wearable robots and hybrid system that combine skeletons with neuromuscular stimulation.



Dejan B. Popović was Professor, Faculty of Electrical Engineering, University of Belgrade up to 2015, and is Professor Emeritus, Aalborg University, Aalborg, Denmark, member of the Serbian Academy of Sciences and Arts (SASA) and member of the Academy of Engineering Sciences, Belgrade, Serbia. He published close to 500 papers. He is Editor of the Journal of Automatic Control, Belgrade and associated Editor of the IEEE Transactions on Neural Systems and Rehabilitation Engineering and Medical & Biological Engineering & Computing. He is the member of the editorial board of Medical Engineering and Physics and Neurorehabilitation journals. He is fellow and the founding member of the EAMBES and IFESS. He is president of the Serbian Society for ETRAN. Memberships: IEEE; IFESS – Founding and Life Member; EMBS; AEMBES - Fellow and Founding member, President of the Society for Electronics, Telecommunication, Computing, Automation and Nuclear Engineering (ETRAN), Serbia.

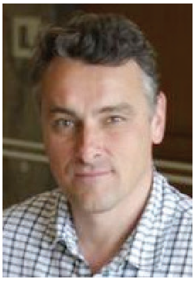
NOVEL APPROACHES IN REHABILITATION ROBOTICS FOR GAIT TRAINING

Zlatko Matjačič, Ph.D,

Head of Research and Development Unit, University Rehabilitation Institute, Republic of Slovenia and Professor of Biomechanics, University of Ljubljana, Slovenia

Summary: In the recent two decades many rehabilitation robots intended for training of walking has been deployed to a clinical environment. Locomat (Hocoma AG), G-EO (Reha Technologies AG) and Lyra (medica Medizintechnik GmbH) are devices that are used to restore stepping following pre-determined trajectories in lower limbs in the early phase while devices like Andago (Hocoma AG) and E-go (medica Medizintechnik GmbH) are used to practice overground walking in later period of rehabilitation. After completing rehabilitation program majority of stroke survivors are left with specific gait deficiencies like pronounced stepping asymmetry, incomplete weight bearing ability and reduced push-off on the impaired leg as well as reduced balancing abilities that would need to be further addressed.

We have developed an innovative admittance-controlled Balance Assessment Robot (BAR) that enables movement of a pelvis in all six degrees-of-freedom while a subject is walking on an instrumented treadmill. Further, we have developed several training approaches that are targeted to diminish specific deficiencies like gait asymmetry, insufficient weight-bearing, reduced push-off and poor dynamic balancing capabilities. A novel approach of precisely-timed push-like exertion of forces to the pelvis, performed similarly to physiotherapists that physically manipulate pelvis to indirectly modify trajectories of pelvis and legs of trainees, was developed. The developed approach was implemented in a series of case studies involving high-functioning stroke subjects in the early chronic stage. The results of prolonged training with high volume, specificity and intensity brought about remarkable changes in the balancing capabilities as well as in overall walking performance.



Dr. Zlatko Matjačić is an electrical engineer, specialized in biomedical and rehabilitation engineering. He obtained his MSc and PhD in biomedical engineering from University of Ljubljana, Slovenia. Dr. Matjačić is currently the Head of Research and Development Unit at University Rehabilitation Institute, Republic of Slovenia and Full Professor of Biomechanics at University of Ljubljana, Slovenia. From 1st April 1998 to 31st October 2001 he held a position of Assistant Professor in world renowned Center for Sensory-Motor Interaction at Aalborg University, Denmark. Dr. Matjačić has been active and made significant contributions in the fields of human motion analysis and synthesis, biomechanics, control of human movement, functional electrical stimulation (FES) of extremities, rehabilitation robotics and telerehabilitation of movement. Dr. Matjačić has co-authored more than 60 SCI journal articles and leaded several national and international research projects. He holds 9 international patents, two of them were commercialized as standing balance training device and walking balance training device (www.thera-trainer.de). Dr. Matjačić received "The Jožef Stefan Golden Emblem Award" for outstanding contributions made to science in doctoral thesis (2000) as well as prestigious Slovenian national "Puh Award" for excellence in transferring new scientific findings into innovative products (2012). Dr. Matjačić serves as a member of Editorial Board of international journal "Technology and Health Care".

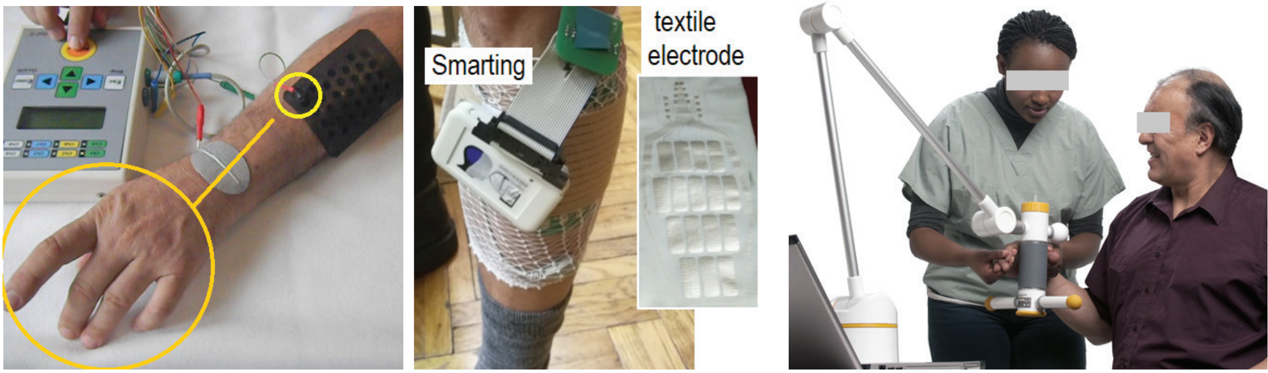
STIMULATION AND EVALUATION OF RECOVERY OF DENERVATED MUSCLES

Dietmar Rafolt, Ph.D.

The University of Graz and Technical University of Vienna, Austria

Summary: Electrical muscle stimulation (EMS) of denervated muscles needs particular stimulation protocols and devices regarding higher amplitudes and much longer pulse widths resulting in newly developed stimulation devices. Also for the evaluation of the force output alternatives to traditional knee dynamometers must be applied since the conventional methods are not sensitive sufficiently. Especially after long-term denervation at the beginning of the therapy, there is no force output detectable during EMS. The other reason is that the high stimulation amplitudes lead to crosstalk of the electric field producing considerable co-contraction of the antagonistic muscles. The knee dynamometers return wrong data if we focus on the force output of the quadriceps musculature. The automated palpation of the muscle belly with a haptic device is used to indicate an increase of muscle transversal stiffness during contraction. Another approach is the pendulum method that turns out very sensitive and reliable as there is no spastic input from the sensor/motor nerves. The presentation will include details on the stimulation and test devices used in more than 20 patients with denervated muscles. The methods were developed in the earlier EU-project headed by Prof. Winfried Mayr. The presentation was prepared jointly with Drs. Winfried Mayr and Eugen Gallasch.

Dietmar Rafolt is a professor for Biomedical Engineering at the Center for Medical Physics and Biomedical Engineering at the Medical University of Vienna. He was born in 1959 in Lustenau/Austria and has graduated from the Technical University of Graz, Department of Communications Engineering and Electronics where he received his Ph.D degree in 1996. His thesis and subsequent work concerned sensor systems and intelligent clothing for lifescience (cardiovascular and neuromuscular) experiments in the MIR space station. In 2005 he received the Venia Docendi (Habilitation) for the entire field of Biomedical Engineering. His research interest includes sensor technologies and analog design, FES and haptic interfaces, electrophysiology, TMS, biomechanics and biotelemetry. He is with the Center for Biomedical Engineering and Physics at the Vienna Medical University since 1992. At the MUV he is also working in a multidisciplinary team that interacts with many clinics in the Vienna General Hospital. In 2017 he was one of the co-founders of Edera-Safety Gmbh&CoKG and is CTO for personal safety devices in sports and rehabilitation. Edera-Safety currently is developing an new generation of spine protectors.


Smarting
textile electrode


3F-Fit Fabricando Faber

ROBOTICS, NEUROSCIENCE, AND SURGERY *for* NEUROREHABILITATION