Tecnalia Serbia ltd.

Technology acceleration office of Tecnalia Research and Innovation Foundation

For 11 years *Tecnalia Serbia* has been the technology acceleration office for the Health Division of *Tecnalia Research and Innovation Foundation,* the largest Spanish private research organization. With focus on rapid development with “day 0” user involvement, *Tecnalia Serbia* has spearheaded the early development of most of the assets in Tecnalia Health division portfolio, resulting in high generation of IP and scientific publications.

The ability to perform early “patient in the middle” development of medical devices, together with a highly excellent research and development team, enable a streamlined process of concept testing, creation of functional prototypes, technical validation and clinical piloting. This directly translates in major reduction of RnD costs and duration, and simplifies feasibility testing of new ideas, thus decreasing the technological risks and improving the cost benefit ratio of innovation.

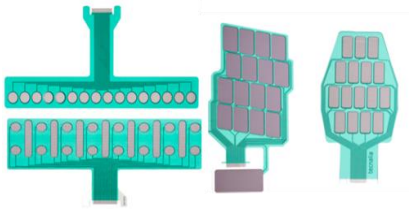
Currently Tecnalia Serbia employs 11 researchers, including 4 senior researchers with PhDs in Health engineering and Biotechnologies and 7 junior researchers with highly specific expertise and skillset in electrical engineering and data processing that ensures the team can cover all the steps required for early stage and short cycle development that ensures the role of Tecnalia Serbia as technology acceleration office.

One of the major assets of Tecnalia Serbia is the lasting collaborations of our team with multiple research groups from the clinics affiliated with the Medical faculty. The group is actively performing research in collaboration with 8 different clinics from the public and private sector, among which are:

- Specialized hospital for orthopaedic prosthetics
- Clinic for physical rehabilitation Dr Miroslav Zotovic – the national centre of reference for neurorehabilitation
- Clinic for sports medicine and rehabilitation - Sport Medical Alliance

Here are some of the assets that Tecnalia Serbia has proudly developed **from concept to clinically piloted prototype**:

Multi-pad – Neuro-prosthesis based on multiplexed matrix electrodes



This cutting-edge technology has the potential to revolutionise the use of neuro-prosthesis for restauration of motor control in neurological patients. The ten-year research lead development of two distinct lines, *Walk* – for patients with foot drop, and *Grasp* – for patients with upper extremity impairment. These were commercialised by a spinoff company Fesia®. The horizontal potential of the technology made it the basis of all project listed below.

Results: From concept to preindustrial prototype; one spinoff company; 20+ SCI publications; 2 patents and 1 H2020 grant

Video: http://tiny.cc/Grasp; http://tiny.cc/DropFoot

Maxsens - intuitive electro-tactile biofeedback.

Advanced feedback of multi-DoF myoelectric prosthesis. It sends messages containing hand orientation, aperture and grip force for continual feedback with a very steep learning curve (>95% in under 30min). The strong potential of this technology as haptic feedback in VR/AR applications resulted in launch of H2020 project TACTILITY.

Results: From concept to prototype tested in clinic; 8 SCI publications; 1 patent and 1 H2020 grant

Video: http://tiny.cc/MaxSens

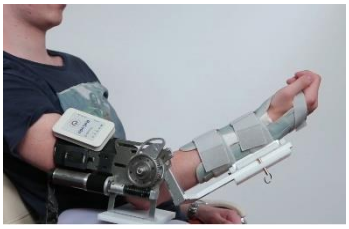
Elcode – controlled iontophoretic substance exchange

Connected microstimulator for safe and controlled iontophoretic drug delivery or analytes extraction. Based on Tecnalia electrical stimulation technology, the project success resulted in new IP and successful technology transfer.

Results: Progress from concept to prototype tested with patients; 1 patent; technology transferred to industry; and 1 startup created.

Video: http://tiny.cc/Elcode

ReCodo –active orthosis for multimodal at home elbow rehabilitation



Posttraumatic elbow injury rehabilitation, leveraging synergic application of kinesitherapy and electrostimulation. Patented solution for dynamic exercises with humeroulnar distraction synchronized with targeted electrical stimulation for optimal results.

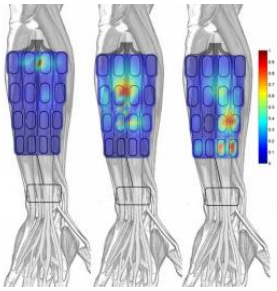
Results: Progress from concept to prototype tested with patients; 1 patent.

Video: http://tiny.cc/ReCodo

Considering the underlined technologies previously developed, expertise and competence of Tecnalia Serbia researchers and the company aims for diversification, following research lines can be marked out as being in focus for **further developments of emerging technologies and future opportunities pursued by Tecnalia Serbia**:

o Augmented intelligence

Specifically designed decision support systems which ensure that human operators controlling the complex system based on novel technology receive optimal level of information through underlined algorithm that provides guidance. This type of augmented intelligence is critical to ensure usability of all the previously developed multi-pad systems, especially as a part of neurorehabilitation systems for grasping or drop-foot where involvement of clinicians is a critical factor.

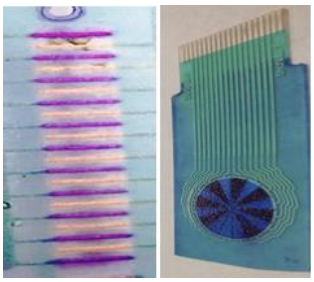


o Brain-Computer Interface

Previous developments in which Tecnalia Serbia worked on the design of the closed-loop electrostimulation system with incorporated EEG amplifier, EEG processing of evoked potentials, mapping information into intuitive feedback or muscle control ensure the technological expertise in this domain. Some of the developed BCI systems also lead to clinical trials of this technology which resulted with improved data processing algorithms and better closed-loop control.

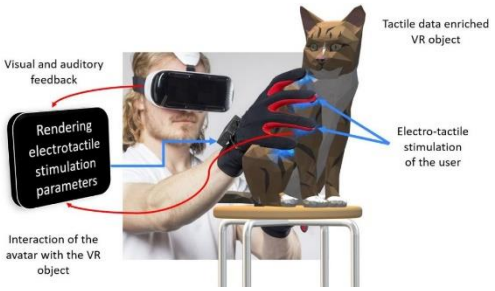
o Emotion AI

In ongoing H2020 project SIXTHSENSE Tecnalia Serbia is in charge of production of basis for multi-sensor platform that includes stress and fatigue bioanalytical and electrophysiological sensors. Along with production of the basis for sensing, integration with hardware that will ensure a wearable device, Tecnalia Serbia is working on the design of the algorithms for assessment of the overall health status and real time communication to the user through tactile feedback interface.



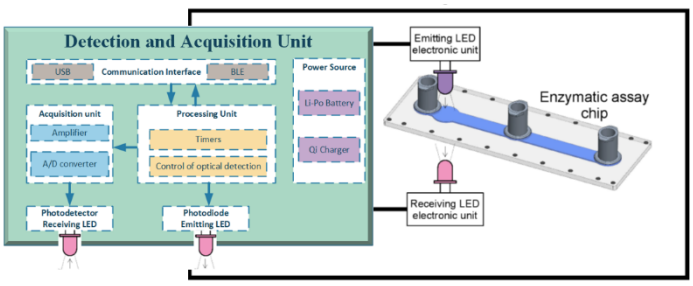
o Mixed Reality Devices

Tecnalia Serbia is a core partner in development of new generation of mixed reality devices that will integrate additional sense in a form of virtual touch in H2020 project TACTILITY. Foundation for virtual touch is the electrostimulation technology based on which Tecnalia Serbia already developed several relevant systems like MaxSens and can be considered a leading center of excellence.



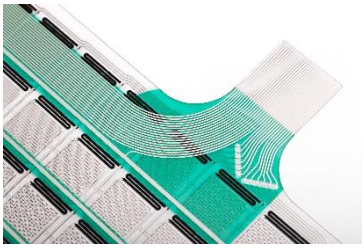
o Biochips

Development of biochips and biosensors is one of the key research lines for Tecnalia Serbia. In parallel to development of the basis for sensing and methods for lamination of microfluidic LOC devices, Tecnalia Serbia is actively involved in the development of electronics and readout devices. Example of this is active involvement of Tecnalia Serbia in H2020 project NEXTGENMICROFLUIDICS.



o Nanotube Electronics

Years of work in electrode design and mastering of multilayer printing of electrodes sensors is a strong foundation for Tecnalia Serbia future work on nanotube electronics. Ongoing work in several projects considers development of sensors and actuators based on reduced graphene oxide, PEDOT:PSS and polymeric piezo materials, which forms a good starting point for emerging field of printed nanoelectronics.



o Smart Fabrics

Tecnalia Serbia has strong expertise in screen printing of conductive and biofunctional materials on textiles, number of functional prototypes of biomedical electrodes have been developed and tested. Underlining technologies include printing directly to textile, printing a primer layer for better printability and to prevent stretching issues, but also integration of devices in a form of strip circuits. Additional expertise in integration, usability and validation of wearable systems is of also of specific relevance. Ongoing work in H2020 project WEARPLEX in which Tecnalia Serbia is a partner is tackling all this with the specific core aim of production of smart fabrics biomedical electrodes.

List of selected scientific publications:

MULTI-PAD:

1. **Malešević, J., Štrbac, M., Isaković, M., Kojić, V.,** Konstantinović, L., Vidaković, A., ... & Keller, T. (2017). Temporal and Spatial Variability of Surface Motor Activation Zones in Hemiplegic Patients During Functional Electrical Stimulation Therapy Sessions. *Artificial organs*, *41*(11).
2. Dujović, S. D., **Malešević, J., Malešević, N.,** Vidaković, A. S., **Bijelić, G.,** Keller, T., & Konstantinović, L. (2017). Novel multi-pad functional electrical stimulation in stroke patients: A single-blind randomized study. *NeuroRehabilitation*, *41*(4), 791-800.
3. **Malešević, J.,** Dujović, S. D., **Savić, A. M.,** Konstantinović, L., Vidaković, A., **Bijelić, G.,** ... & Keller, T. (2017). A decision support system for electrode shaping in multi-pad FES foot drop correction. *Journal of neuroengineering and rehabilitation*, *14*(1), 66.
4. **Malešević, J., Štrbac, M., Isaković, M., Kojić, V.,** Konstantinović, L., Vidaković, A., ... & Keller, T. (2016). Evolution of surface motor activation zones in hemiplegic patients during 20 sessions of FES therapy with multi-pad electrodes. *European journal of translational myology*, *26*(2).
5. **Savić, A. M., Malešević, N. M.,** & Popović, M. B. (2014). Feasibility of a hybrid brain-computer interface for advanced functional electrical therapy. *The Scientific World Journal*, *2014*.
6. **Miljković, N., Malešević, N., Kojić, V., Bijelić, G.,** Keller, T., & Popović, D. B. (2015). Recording and assessment of evoked potentials with electrode arrays. *Medical & biological engineering & computing*, *53*(9), 857-867.
7. **Popović-Maneski, L., Kostić, M.,** Bijelić, G., Keller, T., Mitrović, S., Konstantinović, L., & Popović, D. B. (2013). Multi-pad electrode for effective grasping: design. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *21*(4), 648-654
8. **Malešević, N. M., Popović, L. Z.,** Schwirtlich, L., & Popović, D. B. (2010). Distributed low-frequency functional electrical stimulation delays muscle fatigue compared to conventional stimulation. *Muscle & nerve*, *42*(4), 556-562.
9. **Malešević, N. M., Maneski, L. Z. P**., Ilić, V., Jorgovanović, N., **Bijelić, G.,** Keller, T., & Popović, D. B. (2012). A multi-pad electrode based functional electrical stimulation system for restoration of grasp. *Journal of neuroengineering and rehabilitation*, *9*(1), 66.
10. **Maneski, L. Z. P., Malešević, N. M., Savić, A. M.,** Keller, T., & Popović, D. B. (2013). Surface-distributed low-frequency asynchronous stimulation delays fatigue of stimulated muscles. *Muscle & nerve*, *48*(6), 930-937.

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MAXSENS

1. **Isaković, M., Malešević, J.,** Keller, T., **Kostić, M. and Štrbac, M.,** 2019. Optimization of Semiautomated Calibration Algorithm of Multichannel Electrotactile Feedback for Myoelectric Hand Prosthesis. *Applied Bionics and Biomechanics*, *2019*.
2. Došen, S., Marković, M., **Štrbac, M., Kojić, V., Bijelić, G.,** Keller, T., & Farina, D. (2017). Multichannel electrotactile feedback with spatial and mixed coding for closed-loop control of grasping force in hand prostheses. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *25*(3), 183-195.
3. Franceschi, M., Seminara, L., Došen, S., **Štrbac, M.,** Valle, M., & Farina, D. (2017). A system for electrotactile feedback using electronic skin and flexible matrix electrodes: Experimental evaluation. *IEEE transactions on haptics*, *10*(2), 162-172.
4. **Štrbac, M., Isaković, M., Belić, G.,** Popović, I., Simanić, I., Farina, D., ... & Došen, S. (2017). Short-and Long-Term Learning of Feedforward Control of a Myoelectric Prosthesis with Sensory Feedback by Amputees. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *25*(11), 2133-2145.
5. **Isaković, M., Belić, M., Štrbac, M.,** Popović, I., Došen, S., Farina, D., & Keller, T. (2016). Electrotactile feedback improves performance and facilitates learning in the routine grasping task. *European journal of translational myology*, *26*(3).
6. **Štrbac, M., Belić, M., Isaković, M., Kojić, V., Bijelić, G.,** Popović, I., ... & Keller, T. (2016). Integrated and flexible multichannel interface for electrotactile stimulation. *Journal of neural engineering*, *13*(4), 046014.
7. **Perović, M.,** Stevanović, M., **Jevtić, T., Štrbac, M., Bijelić, G.,** Vučetić, Č., ... & Popović, D. B. (2013). Electrical stimulation of the forearm: a method for transmitting sensory signals from the artificial hand to the brain. *Journal of Automatic Control*, *21*(1), 13-18.
8. Došen, S., Cipriani, C., **Kostić, M.,** Controzzi, M., Carrozza, M. C., & Popović, D. B. (2010). Cognitive vision system for control of dexterous prosthetic hands: experimental evaluation. *Journal of neuroengineering and rehabilitation*, *7*(1), 42.

Elcode

1. Filipović, N., Živanović, M., **Savić, A., & Bijelić, G.** (2016). Numerical simulation of iontophoresis in the drug delivery system. *Computer methods in biomechanics and biomedical engineering*, *19*(11), 1154-1159