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News Bulletin

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Amputees merge with their bionic leg

In an international collaboration led by Swiss scientists, three amputees merge with their bionic prosthetic legs as they climb over various obstacles without having to look. The sensory feedback from the prosthetic leg is based on technology developed by a NCCR Robotics spin-off.

Djurica Resanovic lost his leg in a motorbike accident several years ago which resulted in amputation above the knee. Thanks to novel neuroprosthetic leg technology, Resanovic was successfully merged with his bionic leg during clinical trials in Belgrade, Serbia.

“After all of these years, I could feel my leg and my foot again, as if it were my own leg,” reports Resanovic about the bionic leg prototype. “It was very interesting. You don’t need to concentrate to walk, you can just look forward and step. You don’t need to look at where your leg is to avoid falling.”

Walking with instinct again

Scientists from a European consortium led by Swiss Institutions, ETH Zurich and EPFL spin-off SensArs Neuroprosthetics, with clinical trials in collaboration with institutions in Belgrade, Serbia, successfully characterized and implemented bionic leg technology with three amputees. The results appear in today’s issue of Science Translational Medicine.

“We showed that less mental effort is needed to control the bionic leg because the amputee feels as though their prosthetic limb belongs to their own body,” explains Stanisa Raspopovic, ETH Zurich professor and co-founder of EPFL spin-off SensArs Neuroprosthetics, who led the study.

He continues, “This is the first prosthesis in the world for above-knee leg amputees equipped with sensory feedback. We show that the feedback is crucial for relieving the mental burden of wearing a prosthetic limb which, in turn, leads to improved performance and ease of use.”

Wearing a blindfold and earplugs, Resanovic could feel his bionic leg prototype thanks to sensory information that was delivered wirelessly via electrodes surgically placed into the stump’s intact nervous system. These electrodes pierce through the intact tibial nerve instead of wrapping around it. This approach has already proven to be efficient for studies of the bionic hand led by Silvestro Micera, co-author of the publication, EPFL’s Bertarelli Foundation Chair in Translational Neuroengineering, professor of Bioelectronics at Scuola Superiore Sant’Anna, and co-founder of SensArs Neuroprosthetics.

Resanovic continues, “I could tell when they touched the [big toe], the heel, or anywhere else on the foot. I could even tell how much the knee was flexed.”

Resanovic is one of three leg amputees, all with transfemoral amputation, who participated in a three-month clinical study to test new bionic leg technology which literally takes neuroengineering a step forward, providing a promising new solution for this highly disabling condition that affects more than 4 million people in Europe and in the United States.

Thanks to detailed sensations from the sole of the artificial foot and from the artificial knee, all three patients could maneuver through obstacles without the burden of looking at their artificial limb as they walked. They could stumble over objects yet mitigate falling. Most importantly, brain imaging and psychophysical tests confirmed that the brain is less solicited with the bionic leg, leaving more mental capacity available to successfully complete the various tasks.

How the bionic leg works: connection between body and machine

The fundamental neuroengineering principle is about merging body and machine. It involves imitating the electrical signals that the nervous system would have normally received from the person’s own, real leg. Specifically, the bionic leg prototype is equipped with seven sensors all along the sole of the foot and one encoder at the knee that detects the angle of flexion. These sensors generate information about touch and movement from the prosthesis. Next, the raw signals are engineered via a smart algorithm into biosignals which are delivered into the stump’s nervous system, into the tibial nerve via intraneural electrodes, and these signals reach the brain for interpretation.

From the lab to the clinic

SensArs, a NCCR Robotics spin-off, developed the sensorized sole that, coupled to the prosthetic leg, was tested for this paper.

SensArs received the NCCR Robotics spin-fund in 2016, allowing Petrini and Raspopovic, who were previously post-doc in Silvestro Micera’s lab, to concentrate on building the company and its business plan. “We had initially focused our technology on the upper limbs, but during that phase we decided to refocus on lower limbs” explains Petrini (pictured below). “There are more leg than arm amputees in the world, and the benefits of adding sensory feedback to the prosthesis for them can be more clearly demonstrated”.

“We now have a four-year plan to take this technology to the market” Petrini continues. “Two more years of industrial development to make the system less dependant on the skill of the individual surgeon, and two more years for clinical tests and regulatory approval”.

Literature

F. M. Petrini et al., Enhancing functional abilities and cognitive integration of the lower limb prosthesis, Science Translational Medicine, 2019.

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NCCR Robotics

The Swiss National Center of Competence in Robotics (NCCR Robotics) is a federally funded programme bringing together robotics laboratories from EPFL, ETH Zurich, University of Zurich, IDSIA, EMPA and UNIBE to work on wearable, rescue and educational robots.

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