robotics Swiss National Centre of Competence in Research
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Improving motor control after spinal cord injury

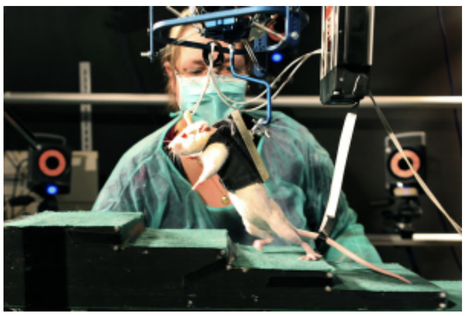
Professors Grégoire Courtine, Stéphanie Lacour and Silvestro Micera, all from NCCR Robotics and EPFL, have published their latest groundbreaking research. Inspired by the technology behind cochlear implants, the paper published in Nature Medicine presents a new approach for epidural electrical stimulation to restore movement in patients with paralysis.



Electrochemical neuromodulation of the spinal cord, whereby specific neurones are artificially made to function using electrical and chemical stimulants via an implant placed on the spine, has previously been shown to improve motor control and restore movement after spinal cord injury (SCI). However, while this work has produced very promising trials in animals, so far no team has found a method that provides long term results in keeping with natural body movements. Where previous tests have fallen down is that electrical or chemical impulses have been provided continuously at one given spot, which, although resulting in movement, does not replicate the way that the motor system functions in mammals or give the level of speed and precision required for every day life.

Lower limb movements in healthy subjects are created by sets of neurones (the cells of the nervous system) which are triggered in a specific order to produce the required result, much like a wave travelling through water and hitting different points consecutively. Through observing healthy subjects it was discovered that walking involves alternating activation of bundles of neurones in “hot spots” in extensor (i.e. leg straightening) and flexor (i.e. leg bending) muscles. These hot spots then trigger local circuits to initiate the movement, thus locating and activating the correct hot spots is absolutely essential for controlled, precise movements. In fact, activating the proprioceptive feedback loop (the process by which your brain knows where a certain part of your body is at any given time) was found to be enough to send the impulses back to the hot spots and activate movement as these feedback systems create patterns of motor signals, much like repeating an exercise such as lifting weights or using a rowing machine creates muscle memory, making the same exercise easier and more natural with every repetition.

What is presented in this paper is a regimen to take recent advances in electrical neuromodulation hardware and focus them on “hot spots” in order to refine the movement produced by replicating how the motor system creates that movement in able bodied subjects. The team behind the publication used computer simulations of movement in mammals to identify exact locations on the spine to place the electrodes to provide stimulation by looking at proprioception feedback loops. By using the provided information, and observing patterns of movements in the subjects, engineers could design implants that would deliver electrical stimulation to multiple precise desired points with the right timing on the spine which allow control over movements.



With specially tailored spinal implants, rats were able to control how much their left or right hind limb was bent or extended, a level of control that has not existed in previous trials. Continued monitoring also confirmed that eight weeks after implantation, host rejection had not occurred and the implant was still stable and functioning.

While this work is still far from common clinical usage, the spatiotemporal neuromodulation therapies is suitable for human with respect of anatomical modifications. Ensuring that the host does not reject the implant and longevity of hardware involved, the potential impact on those with SCI is enormous.

References

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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 and IDSIA to work on wearable, rescue and educational robots.

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