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Teaching prosthetics – when robots learn from mistakes

Brain-Machine Interfaces (BMIs) are a promising and expanding branch of robotics that has life-changing capabilities for those with reduced motor controls. A BMI can be used to bridge a gap in the nervous system that may have been caused by injury or illness by using electrodes on the skin (EEG) to record brain waves and then using these brain waves to operate an external robot (e.g. prosthetic arm) to perform actions in exactly the way the user requires. In a paper published in Nature Scientific Reports, a group from CNBI, EPFL and NCCR Robotics have developed a method of using decoded error-related EEG potentials to teach a robot what its user may want and thus speed up the training process of the BMI system.

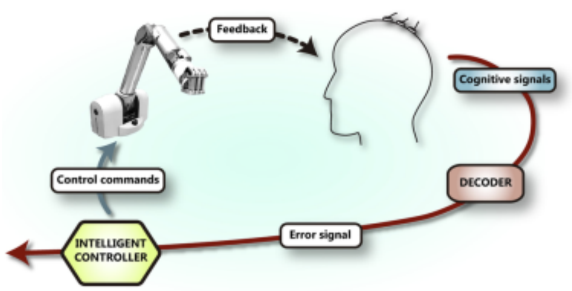
VIDEO

One important issue that bars the use of BMIs in everyday life for those with disabilities is the amount of time required to train the user and the system to understand each other. Users must learn to modulate their thought processes before their signals are clear enough to control a robot, so for example, to move an arm, the person must think that they will move their arm, a thought process that uses significantly more brainpower than the subconscious instructions that someone with a natural arm uses. For people without this type of disability, movements are naturally controlled by the brainstem and spinal cord, with the cerebral cortex only becoming involved to modulate those movements. In fact, correct and incorrect actions result in very different brain-waves in the cerebral cortex which can be picked up using a cap with electrodes placed on the skin.

It is with this in mind that the NCCR Robotics research team developed a new feedback system for controlling robots using BMIs. By recording errors through error-related potentials (ErrPs) in the cerebral cortex a robot can quickly understand whether it has made the correct movement or not, and can repeat alterations of a movement until it finds the correct one. Moreover, the robot also learns its control policy through experiments with the user – thus the system continues to become more accurate the longer it is in use – a valuable skill when designing controllers for active prostheses that are made to be used for long periods of time.

Under experimental conditions, twelve subjects were asked to watch a machine performing 350 separate movements, where the machine was programmed to make the wrong movement in 20% of cases in order to set the ErrP. This step took an average of 25 minutes. After this first training stage, each subject performed three experiments where they were to try to locate a specific target using the robotic arm.

In these experiments, the arm was able to find 12-13 targets with 71-78% accuracy in 100 movements, whereas randomly-behaving robots found only two targets each. As expected, the time taken to locate a target reduced as the experiment continued.



This new approach finds obviously applicability in the field of neuroprosthesis, particularly for those with degenerative neurological conditions, who find that their requirements change over time, but that this new technology has the potential to automatically adapt itself to their requirements without the need for retraining or reprogramming.

References

I. Iturrate, R. Chavarriaga, L. Montesano, J. Minguez and J. del R. Millán, "Teaching brain-machine interfaces as an alternative paradigm to neuroprosthetics control," Nature Scientific Reports, vol. 5, Article number: 13893, 2015. doi:10.1038/srep13893

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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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