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BRAIN MACHINE INTERFACES: a ray of hope

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Neuroscientists have long relished the possibility of using brain signals to control artificial devices. Already, in literature there are several devices such as brain-actuated technology, neuroprosthes or neurorobots collectively refer as hybrid brain machine interfaces (HBMI) [1]. The word hybrid means a continuous interaction between living brain and artificial electronic devices. HBMI uses mainly in two types of applications-

Type One HBMI-

In type one HBMI, devices use artificially generated electrical signals to stimulate brain tissue in order to transmit some particular neurological function. The classic example of type one HBMI application is an auditory prosthesis.

Type Two HBMI-

Type two HBMI rely on the real time sampling and processing of large- scale brain activity to control artificial devices. Type two HBMI applications is use of neural signals derived from the motor cortex to control the movements of a prosthetic robotic arm in real time.

Clinical applications that require reciprocal interaction between the brain and artificial devices will combine both type one and type two HBMIs. The design and implementation of HBMI will involve the combined efforts of many area of research, such as neuroscience, computer science, biomedical engineering, very large integration design and robotics.

Brain machine interfaces arises from the need to provide to communication and a means of acting on the environment to patients that have lost control of their body. The processes of development, adaptation in the normal nervous system, and repair in the damaged nervous system are fundamental to a successful clinical brain machine interfaces. So Brain machine interfaces offer a unique family of tools for challenging some of the most fundamental ideas of modern neuro-science.

Brain machines interfaces research has to address a number of issue related to improving the quality of neuronal recording, achieving stable long-term performance and extending the brain-machine interface approach to a broad range of motor and sensory function [3].

Today the rapidly emerging field of brain-machine interfaces is bringing the same vision to the pursuit of other goals as creating more powerful computers and giving new hope to a broad segment of the disabled population [2].

The research and development costs of functional BMI neuroprosthetic are enormous. Only time will tell whether there is sufficient commercial interest to successfully overcome the multifactorial challenges in the path of clinical BMI development [4].

Brain machine interfaces use neuronal activity recorded from the brain to establish direct communication with external actuators, such as prosthetic arms and hoped that this interfaces can be used to restore the normal sensorimotor functions of the limbs, but so far they have locked tactile sensation [5].

Motor prostheses aim to restore function to disabled patients. This is difficult to develop a low-power, fully implantable system that dissipates only minimal power so as not to damage tissue. Spiking neural network implementation runs in real-time and its closed-loop performance is quite comparable to that of the standard Kalman filter [12]. The success of this closed loop decoder holds promise for hardware spiking neural network implementations of statistical signal processing algorithms on neuromorphic chips, which may offer power savings necessary to overcome a major obstacle to the successful clinical translation of neural motor prosthess.

Today, BMIs designed for both experimental and clinical studies can translate raw neuronal signals into motor commands that reproduce arm reaching and hand grasping movements in artificial actuators [9]. BMI would utilize a combination of high-order motor commands, derived from cortical and subcortical neuronal activity, and peripheral low-level control signals, derived from artificial reflex-like control loops. Closed-loop, hybrid BMIs would get one step closer to the dream of restoring a large repertoire of motor functions to a multitude of patients who currently have very few options for regaining their mobility.

APPLICATIONS

HBMIs for Epilepsy control

Estimates indicate that about 0 ·5 - 2·00% of the population has epilepsy. About 10-50% of these patients do not respond well to current antiepileptic medication and may not be candidates for surgery. So neuroscientists have used multi-channel recording from scalp, brain surface and even chronically implanted intracranial electrodes of investigate the electrophysiological activity that characterizes different types of seizure in humans. By doing so, scientists have not only identified different types of epilepsy, but they have also learned that there are distinct patterns of neurophysiological activity associated with the initiation and establishment of seizure attack. A few laboratories have introduced automatic seizure-prediction algorithms that can be applied to intracranial and scalp recording to forecast the occurrence of seizure [1]. Studies in both animals and human subjects have revealed that electrical stimulation of peripheral cranial nerves, such as the vagus and trigeminal nerves, can substantially reduce cortical epileptic activity. Brain pacemaker would rely on arrays of chronically implanted electrodes to search continuously for spatiotemporal patterns of cortical activity indicating an imminent epileptic attack. Once pre-seizure activity patterns were detected, the analytical neuro-chip could trigger electrical stimulation of one or multiple cranial nerves. In patients who respond to pharmacological therapy, the same simulator could be used to activate a mini-pump to deliver one or more anti-epileptic drugs directly into the blood steam.

BMI for paralyzed patient

BMI is a motor neuroprosthetic device for paralyzed individuals, who are unable to deliver movement intentions to the muscles. Spinal cord injuries that damage descending corticospinal pathways or neuromuscular disorders such as amyotropic lateral scleroasi (Lou Gehrigs disease) are among the most common causer of severe paralysis afflicting millions [6]. BMI technology offers a revolutionary treatment for paralysis. Recent study suggests that BMI have the potential to restore mobility to both upper and lower extremities and to enable a range of motor tasks, from arm reaching and graping to the bipeadal locomotion and balance. Multidisciplinary BMI research will lead to the creation of whole body neural prosthetic devices aimed at restoring full, essential mobility function to paralyzed patient. A series of principles of neural ensemble physiology that have been derived from BMI studies and these principles may be used in the development of new neuroprosthetic devices.

BMIs aimed at restoring speech communication via real time speech synthesis. The use of formant synthesizer in the current studies limits the speech output to continuously voiced speech segments, namely vowels, diphthongs, semi- vowels and glides. Most consonants can not be produced without very precise manipulations of many parameters in a format synthesizer. BMI which allow locked-in patients to produce synthetic speech at near-conversational rates are possible in future [7].

Brain machine interface based on EEG reduce the complexity that is gradually prevailing upon the very potential field of rehabilitation. This technique is used to control assistive robotic devices such as robotic wheelchair for the disabled [8].

Kianoush Nazarpour [13] compared the classic biomimetic and biofeedback approaches to BMI. In biomimetic designs, the decoded trajectories are connected only via visual feedback, leading to jerky movements. BMI control may seem more like concatenation of several feed-forward movement segments rather than the smooth operation of a closed-loop feedback controller. The mechanism by which the brain deals with variability in neural firing patterns during natural movements are only now beginning to be understood, but these insights have yet to be developed within a BMI setting. The mechanism of neural adaption from biofeedback experiments may be incorporated into new adaptive biomimetic decoders and these strategies will lead to a new generation of machines that interface with the brain on computational, algorithmic and implementational levels to restore sophisticated function for injury.

Michael J. Black [14] has demonstrated the viability of controlling devices with signals obtained from neural implants in animal models. In addition to computers-based interfaces, decoding of smooth 2D trajectories suggests the possibility of using neural signals for telerobotics though many problems remain to solved. Effective neural robot control will require a semi-autonomous platform with obstacle avoidance capabilities.

4 SUMMARY

The brain controls the entire body and all functions, so medical researchers and practitioners have a strong interest in modeling the brain. The rapidly emerging field of brain-machine interface is bringing the vision to the pursuit of goals with creating more powerful computers and giving new hope to a broad segment of the disabled population. The main advantages of using BMIs are a) BMIs can enable humans to effectively control external devices with neural signals and b) A BMI system may be able to provide similar or greater benefit with a less invasive surgical procedure.

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