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Brain Computer Interface

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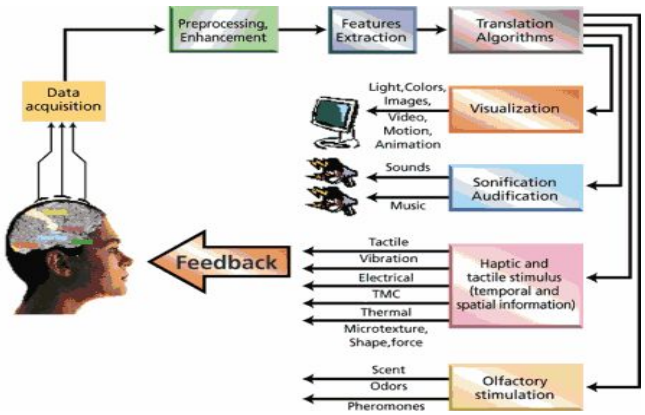
Abstract—*Brain Computer Interface (BCI) is an environment which provides communication path between human brain and the computer system. In the areas of information technology and neurosciences, Actually there has been a surge of interest in turning fiction into reality. The one of the major goal of BCI research is to be develop a system that allow disabled people to communicate with other persons and helps to interact with the external environments. Additionally, This area includes components like comparison of invasive and noninvasive technologies to measure brain activity.*
This Paper provides an insight into the aspects of BCI, its applications and recent developments and open problems in this area of research. In this paper, the classification of mental tasks based on electroencephalographic (EEG) data for Brain Computer Interfaces (BCI) in two scenarios, off line and on-line. In the off-line scenario we evaluate the performance of a number of classifiers using a benchmark dataset, same pre-processing and feature selection and show that classifiers that haven't been used before are good choices.
In the on-line scenario that we have designed, we study the performances of system to play a computer game from which the signals are processed in real time and the subject receives visual feedback of the resulting control within the game environment. This ability is made possible through the use of sensors that can monitor some of the physical processes that occur within the brain which corresponds with certain forms of thought. The extracted features were input into machine learning algorithms to generate the decision rules required for our application.

1. INTRODUCTION

Brain–computer interface (BCI) started with the Hans Berger's inventing of electrical activity of the human brain and development of the electroencephalography (EEG). The importance of computers in our lives makes human-computer interaction to most critical factor in systems design EEGs permitted completely new possibilities for the research of human brain activities. One of fundamental issue in human-computer interaction is that the limitations exist on the communication between human and computer. It's a human-system interaction is still fundamentally bounded by the inherent capabilities of humans to absorb, analyze, store. The interpret information to create behavior and by the limitations in the ability of computers to predict human intentions, action, and communications. Additionally, The tremendous growth of research in the field of neuroscience over the past several decades offers an approach to address these limitations.

2. BRAIN COMPUTER INTERFACE (BCI)

A Brain–Computer Interface (BCI) is called a Mind-Machine Interface (MMI) or sometimes it's called a direct neural interface or a Brain–Machine Interface (BMI) which is a direct communication channel between the brain and an external device. However, Brain-computer interface (BCI) is an upcoming technology which aims to convey people's intentions to the outside world directly from their thoughts and enhancing cognitive capabilities. BCIs are directed at augmenting, assisting, or repairing human cognitive or sensory-motor functions. The BCI is used for those people who are unable to express through speech. Normally these people are "locked in" means that they can't move their face or any of their appendages. The field of BCI research and development has been focused on neuroprosthetics applications. Actually, This aims at restoring damaged hearing, sight and movement. Whether, Neuroprosthetics is an area of neuroscience concerned with neural prostheses. We can use the artificial devices to replace where the function of nervous system which is not proper and brain related problems as well as sensory organs. The difference between BCI and neuroprosthetics is that neuroprosthetics connected nervous system to a device where as BCI connects the brain to a computer system. Actually, neuroprosthetics and BCIs are mainly focusing on to achieve the same goal such as cognitive function, restoring sight, hearing, movement and ability to communicate. Whether, Both use similar experimental methods and surgical techniques.



Data acquisition is derive Each subject, sitting in front of a computer was asked to perform imaginary movements of the left hand, right hand, tongue and foot during a pre-specified time interval. when a person imagine such movements, there are associated changes in the EEG data called event-related synchronization or de- synchronization.

Pre-processing applied on the Common Spatial Patterns (CSP) method to the raw EEG data. The standard CSP is applicable to two class problems so it transforms the original signal into a new space where variance of one of the classes is maximised while the variance of the other is minimized.

Feature extraction is the term through machine learning, pattern recognition, feature extraction starts from an intial set of measured data and builds derived values intended to be informative, non redundant, generalization steps which leading to better human interpretations.

Translation algorithm is the sub-field of computational logistics that investigates the use of software to translate textor speech from one language to other Visualization is the technique used for creating images, diagrams, animations to communicate a message

Sonification Audification is used for non-speech audio to convey information or perceptualize data. Auditory perception has advantages in temporal, spatial, amplitude and frequency resolution that derive open possibilities as an alternative or complement to visualization technique.

Olfactory simulation is automated simulation of sense of smell. Its an emerging application of modern engineering where robots or other automated systems are needed to measure the existence of a particular chemical concentration in a air. Such an electronic know as electronic nose or e-nose.

Feedback is that last stage of BCI which depend upon the data which generate.

3. TYPES OF BRAIN COMPUTER INTERFACE

There are several types of brain-computer interfaces which are reported. The basic purpose of these devices or types is to intercept the electrical signals that pass between neurons in the brain and translate them to a signal that is sensed by external devices.

4. INVASIVE BRAIN COMPUTER INTERFACES

Invasive Brain Computer Interface devices which implanted directly into the brain and have the highest quality signals. Actually, These devices are used to provide functionality to paralyzed people. Invasive BCIs are used to restore vision by connecting the brain with external cameras and restore the use of limbs by using brain controlled robotic arms and legs. As they rest in the grey matter, invasive devices produce the highest quality signals of BCI devices but they are prone to scar-tissue build-up, causing the signal to become weaker or even lost as the body reacts to a foreign object in the brain. In vision science, there are direct brain implants have been used to treat non-congenital i.e. acquired blindness. Whether, One of the first scientists to come up with working brain interface to restore sight as private researcher, William Dobell. He implanted the first prototype into Jerry, A man blinded in adulthood in 1978. Actually, He inserted single array BCI containing 68 electrodes into Jerry's visual cortex and succeeded in producing the sensation of seeing light. In 2002, experiment was conducted on Jens Neumann where Dobell used more sophisticated implant enable better mapping of phosphenes into coherent vision and after the experiment Neumann was interviewed on CBS's. BCIs focusing on motor Neuroprosthetics whichaim to either restore movement in paralyzed individuals or provide devices to assist them such as interfaces with computers or robot arms. Researchers at Emory University in Atlanta led by Philip Kennedy and Roy Bakay were the first who install a brain implant in a human that produced signals of high enough quality to stimulate movement.

5. PARTIALLY INVASIVE BRAIN COMPUTER INTERFACES

Partially invasive BCI devices are implanted inside the skull but rest is outside of the brain rather than within grey matter. Actually, Signal strength using this type of BCI is bit weaker when it compares to Invasive BCI. They produce better resolution signals rather than non-invasive BCIs. Partially invasive BCIs have less risk of scar tissues formation when compared to Invasive BCI. Electrocorticography used the same technology as non-invasive electroencephalography, but the electrodes are embedded in a thin plastic pad that is placed above the cortex, beneath the dura mater. ECoG technologies were the first trade-in humans in 2004 by Eric Leuthardt and Daniel Moran from Washington University in St Louis. Even the researchers enabled a teenage boy to play Space Invaders using his ECoG implant. This research indicates that it is really difficult to produce kinematics BCI devices with more than one dimension of control using ECoG. By the way, Light Reactive Imaging BCI devices are still in the realm of theory and these would involve implanting laser inside the skull. The laser would be trained on a single neuron and neuron's reflectance, which measured by a separate sensor. When neuron fires, the laser light patterns and wavelengths reflects it which would change slightly. This would allow researchers to monitored single neurons, but require less contact with tissue and reduce the risk of scar-tissue build up.

6. NON INVASIVE BRAIN COMPUTER INTERFACES

Non invasive brain computer interface has the least signal clarity when it comes to communicating with the brain (skull distorts signal) but it's considered to be safest when compared to other types. This type of devices has been found to be successful in giving a patient the ability to move muscle

implants and restore partial movement. Non-Invasive technique is profound the medical scanning devices or sensors are mounted on caps or headbands read brain signals. However, This approach is less intrusive but also read signals less effectively because electrodes cannot be placed directly on the desired part of the brain. One of most popular devices under this category is the EEG or electroencephalography capable of providing a fine temporal resolution and also It's easy to use, cheap and portable.

7. APPLICATIONS OF BRAIN COMPUTER INTERFACE

7.1 Direct Control

Some of the earliest concepts for Brain-computer interface (BCI) applications focused on conscious direct control, i.e. using the brain signals to directly manipulate the state of an object. Examples come from clinical applications (like wheelchairs, prosthetic devices, communication applications) and from the first brain-control games. In the future, consumer demand is likely to continue to push BCIs, particularly in entertainment and quality-of-life applications, to pursue direct control.

7.2 Indirect Control

One of the fundamental concepts that will directly influence future BCIs used for brain indices that provide information that is not as readily or robustly available through other channels. A human can perceive early in the process whether the robot's hand position is appropriate for manipulating the specific door/handle combination [100], while the algorithms that control the robotic arm and then select from multiple alternative handle manipulations, selecting a new manipulation style based on the error signals received from the human user. This example indirect control application accesses the neural correlates associated with the user's perceived "error" to influences of the robotic controller's choice to manipulation strategy, but does not engage the operator directly in the control task.

7.3 Communications

BCI applications for communication to deal with severe communication disabilities resulting from neurological diseases. This kind of application represents the most pressing research in the field of BCI, because communication activity is essential for humans. Applications for communication purposes, outline an operation which typically displays a virtual keyboard on screen, where the user selects a letter from the alphabet by means of a BCI. The distinguishing element where each approach is usually the BCI and the type of control signal.

7.4 Brain-Process Modification

BCI technologies can also provide potential for users to actively modify their own brain processes or states. Methods such as neuro-feedback can already allow for individuals to adjust their own brain function in an attempt to attain a more desirable state. As sensor technologies and analytical approaches improve, so do the potential benefits of neuro-feedback. There are multiple potential applications of these methods and the most promising would be for training and rehabilitation.

7.5 Mental state Detection

One of the recent common themes in BCIs is the detection and the use of mental states as opposed to specific instances of neural processing such as an event-related potential to modify a system .As alluded to in the above sections, the ability to reliably and accurately detect fatigue, attentional, arousal, and affective levels could allow systems or environments to adapt to the state of the user, increasing joint user-system performance across a wide range of tasks or helping the user achieve a desired mental or emotional state.

7.6 Opportunistic State-Based Detection

Once technology reaches the point where useful opportunistic BCIs can be realized, a wide range of state-based applications can be envisioned. Neural state monitoring used in combination with pervasive intelligence to opportunistically change the environment. For example, affective state have numerous home, entertainment, and medical applications, including providing entertainment, exercise, or food suggestions, or directly adjusting music selections.

7.7 Mental Strategies and Brain Patterns

Measuring brain activity effectively, its a critical first step for brain–computer communication. The measuring activity is not enough, because a BCI cannot read the mind or decipher thoughts in general. A BCI can only detect and classify specific patterns of activity in the on going brain signals that are associated with specific tasks or events. BCI user has to do to produce these patterns which is determined by the mental strategy the BCI system employs. Whether, the mental strategy is the foundation of any brain–computer communication. The mental strategy determines what the user has to do to volition- ally produce brain patterns that the BCI can interpret

7.8 Motor Restoration

Motor restoration may alleviate the psychological and social suffering. Spinal cord injury (SCI) or other neurological diseases with associate loss of sensory and motor functions which dramatically decrease the patient's quality of life and create life-long dependency on home care services. Additionally, Restoring movement such as grasping is feasible in quadriplegic patients through neuroprostheses guided by functional electrical stimulation (FES). FES compensates for loss of voluntary functions by eliciting artificial muscle contractions. Electrical currents generate the artificial action

potential by depolarizing intact peripheral motor nerves that innervate the targeted muscle and cause a muscle contraction.

7.9 Environmental Control

One of the main goals of BCIs based applications is to achieve maximum independence for the patient, despite any motor disability. People who suffer severe motor disabilities are often homebound and for this reason, environmental control applications focused on the control of domestic devices such as TV, lights or ambient temperatures. Apart from improving the quality of life of severely disabled people, assistive devices mean that the tasks of the caregiver are less intensive, costs reduced and the life of relatives is less onerous.

7.10 Locomotion

BCI applications that allow disabled people to control a means of transportation represent an important field in their use. By these applications, people suffering from paraplegia or with other physical impairments can autonomously drive a wheelchair, making them more autonomous and improving their life quality.

7.11 Entertainment

Entertainment-orientated BCIs applications have typically had a lower priority in this field. Until now, the research into BCI technology has usually focused on assistive applications, such as spelling devices, wheelchair control or neuroprostheses rather than applications with entertainment purposes.

8. CONCLUSION

The current explosion of neuroscience research and neurotechnologies provides the opportunity to provide computers predictive capabilities for emotional and cognitive states which processes of the people using them, potentially revolutionizing not only interfaces, but the basic interactions people have with these systems. However, to reach their full potential the development of the BCI technologies over the coming decades will have to overcome a number of obstacles. For example, the amazing abilities of people to adapt the dynamic, complex tasks and environments present difficulties in interpreting an individual's neural processes and behavior at any given time. These difficulties may arise due to the signal noise caused by environmental effects, overlapping neural processes arising from the performances of multiple concurrent tasks and changes in neural signatures over the short and long term, the wide variation in neural signals across individuals.

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