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Instinctive wheel chair by brain to computer interface

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ABSTRACT- This paper presents a brain computer interface (BCI) to control a robotic arm by brain signals from visual stimuli. The following signal processing steps were established; acquisition of brain signals by electroencephalography (EEG) electrodes; noise reduction; extraction of signal characteristics and signal classification. Reliable brain signals were obtained by the use of the commercial hardware. The commercial software was used to program the signal processing algorithms. By using Matlab together with an Arduino electronic board, two servo motors were controlled to drive two joints of a 5 degrees-of-freedom robot commanded by P300-type evoked potential brain signals from visual stimulation when a subject concentrates on particular images from an image matrix displayed in the computer screen. The experiments were conducted with and without hearing and visual noise (artifacts) to find out the noise influence in the signal classification outcome. The obtained experimental results presented an efficiency in the identification stage up to 100% with and without hearing noise conditions. However, under visual noise conditions a maximum efficiency of 50% was reached. The experiments for the servomotors control were carried out without noise, reaching an efficiency of 100% in the identification stage.

Keywords: Electroencephalography Signals, Brain Computer Interface, Visual Stimuli, Brain Signals Processing, P300 Evoked Potential, Servomotors Control, Robotic Arm.

I .INTRODUCTION

Brain–computer interfaces are a new technology that could help to restore useful function to people severely disabled by a wide variety of devastating neuromuscular disorders and to enhance functions in healthy individuals. The first demonstrations of brain–computer interface (BCI) technology occurred in the 1960s when Grey Walter used the scalp-recorded electroencephalogram (EEG) to control a slide projector in 1964 and when Eberhard Fetz taught monkeys to control a meter needle (and thereby earn food rewards) by changing the firing rate of a single cortical neuron . In the 1970s, Jacques Vidal developed a system that used the scalp-recorded visual evoked potential (VEP) over the visual cortex to determine the eye-gaze direction (i.e., the visual fixation point) in humans, and thus to determine the direction in which a person wanted to move a computer cursor . At that time, Vidal coined the term “brain–computer interface.” Since then and into the early 1990s, BCI research studies continued to
appear only every few years. In 1980, Elbert et al. showed that people could learn to control slow cortical potentials (SCPs) in scalp-recorded EEG activity and could use that control to adjust theThe pace and breadth of BCI research began to increase rapidly in the mid-1990s and this growth has continued almost exponentially into the present. The work over the past 20 years has included a broad range of studies in all the areas relevant to BCI research and development, including basic and applied neuroscience, biomedical engineering, materials engineering, electrical engineering, signal processing, computer science, assistive technology, clinical rehabilitation, and human factors engineering

BCI Definition and Structure:

According to present understanding, the role of the central nervous system (CNS) is to respond to occurrences in the environment or in the body by producing appropriate outputs. The natural outputs of the CNS are either neuromuscular or hormonal. A brain–computer interface (BCI) gives the CNS new output that is not neuromuscular or hormonal. A BCI is a system that measures CNS activity and converts it into artificial output that replaces, restores, enhances, supplements, or improves natural CNS output and thereby changes the ongoing interactions between the CNS and its external or internalenvironment.

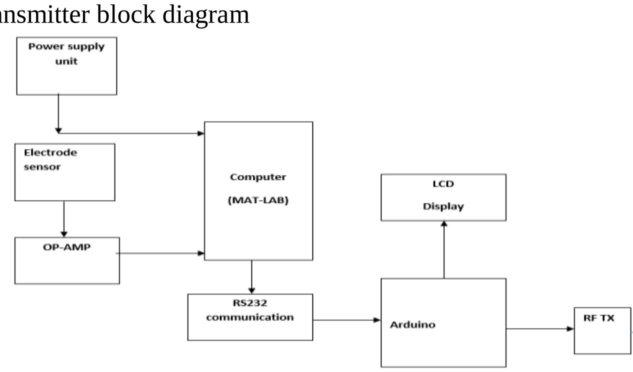
Fig(1)Design and operation of a brain–computer interface (BCI) system.

Signals produced by brain activity are recorded from the scalp, from the cortical surface, or from within the brain. These signals are analyzed to measure signal features (e.g., amplitudes of EEG rhythms or firing rates of individual neurons) that correlate with the user's intent. These features are then translated into commands that control application devices that replace, restore, enhance, supplement, or improve natural CNS outputs

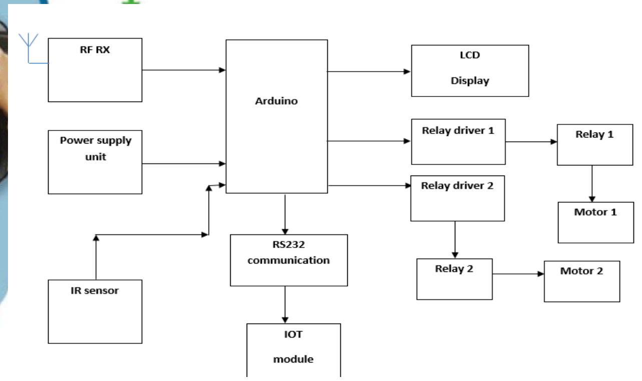
To understand this definition, one needs to understand each of its key terms, starting with CNS. The CNS is composed of the brain and the spinal cord and is differentiated from the peripheral nervous system (PNS), which is composed of the peripheral nerves and ganglia and the sensory receptors. The unique features of CNS structures are their location within the meningeal coverings (i.e., meninges), their distinctive cell types and histology, and their role in integrating the numerous different sensory inputs to produce effective motor outputs. In contrast, the PNS is not inside the meninges, does not have the unique CNS histology, and serves primarily to bring sensory inputs to the CNS and to carry motor outputs from it.

II.SYSTEM ARCHITECTURE

Transmitter block diagram



Receiver block diagram



user's possible range of feature values covers the full range of device control and also to make control as effective and efficient A BCI detects and measures features of brain signals that reveal the user's intentions and translates these features in real time into commands that achieve the user's intent. In order to do this, a BCI system has four components: 1) signal acquisition; 2) feature extraction; 3) feature translation; and 4) device output commands. A BCI also has an operating protocol that specifies how the onset and timing of operation is controlled, how the feature translation process is parameterized, the nature of the commands that the BCI produces, and how errors in translation are handled. A successful operating protocol enables the BCI system to be flexible and to serve the particular needs of each of its users.

ARDUINO:

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board

RF Transmitter-receiver:

These wireless transmitters work with our 434MHz receivers. They can easily fit into a breadboard and work well with microcontrollers to create a very simple wireless data link. Since these are only transmitters, they will only work communicating data one-way, you would need two pairs (of different frequencies) to act as a transmitter/receiver pair.

IoT Module: This module is attached to the microcontroller and the output obtained from every sensor is taken in account and are updated to the website using this IoT module. This provides a fast response towards the process and it updates the website every second with the obtained information.

RELAY: A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit.

RS-232: In telecommunications, RS232, Recommended Standard is a standard introduced in for serial communication transmission of data. It formally defines the signals connecting between a *DTE* (*data terminal equipment*) such as a computer terminal, and a *DCE* (*data circuit-terminating equipment* or *data communication equipment*), such as a modem. The RS-232 standard had been commonly used in computer serial ports. The standard defines the electrical characteristics and timing of signals, the meaning of signals, and the physical size and pin out of connectors

Signal Processing

The goal of BCI signal processing is to extract features from the acquired signals and translate them into logical control commands for BCI applications. A feature in a signal can be viewed as a reflection of a specific aspect of the physiology and anatomy of the nervous system. Based on this definition, the goal of feature extraction for BCI applications is to obtain features that accurately and reliably reflect the intent of the BCI user.

III.RESULT

Current EEG devices measure potential differences on several electrodes placed on the head of the subject and digitize it for further analysis. In other words the EEG can be seen as a multivariate time series. Figure 2 shows the placement and naming conventions of the electrodes together with the corresponding regions of the brain.
BCI systems using these EEG signals, are subdivided in categories based on the signal features they use. Some of these features like the P300 and SSVEP (steady-state visual evoked potential) are elicited naturally by external stimuli while others like the SMR (sensorimotor rhythm) and SCP (slow cortical potential) need to be learned by the user through self-regulation and feedback.

P300:

The P300 reflects the cognitive processing of events and is defined as a positive potential about 300ms after presentation of an infrequent stimulus amongst frequent ones. The oddball paradigm is a well-known task used to evoke this potential. The subject is instructed to listen to auditory stimuli. Most of these

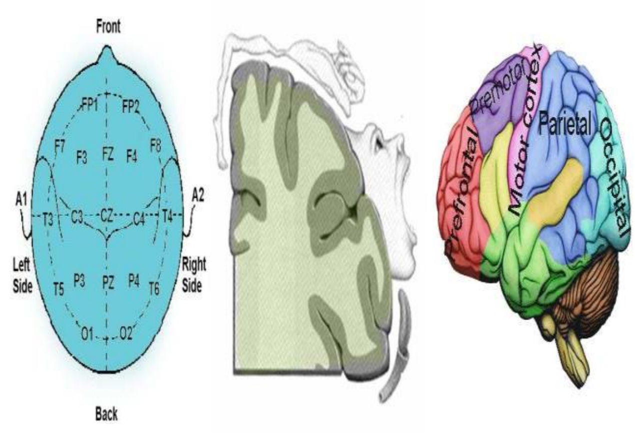
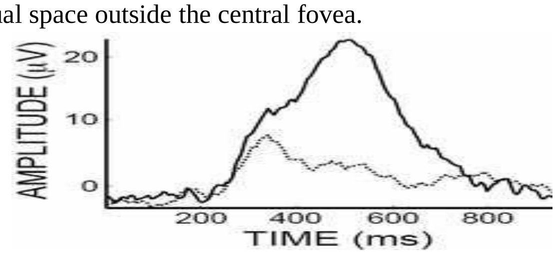


Fig. 2: Left The placement (and names) of the electrodes on the head according to the 10-20 international system.

Middle The homunculus shows the mapping of the different body parts to the motor cortex. Notice that the hands occupy a large region. Right The different lobes of the brain. The motor cortex corresponds to the picture in the center.

Steady-State Visual Evoked Potential:

SSVEPs receive increasingly more attention for use in BCI because of its high accuracy, very low training time and high transfer rates. It was employed by the Air Force Research Laboratory [12] for selection of two virtual buttons, both flickering at different frequencies. The SSVEP is a visual evoked potential that is characterized by increased amplitude at the frequency of the button the user is looking at. In [13] the authors show the same task can be performed through covert attention (selection of regions of visual space outside the central fovea.

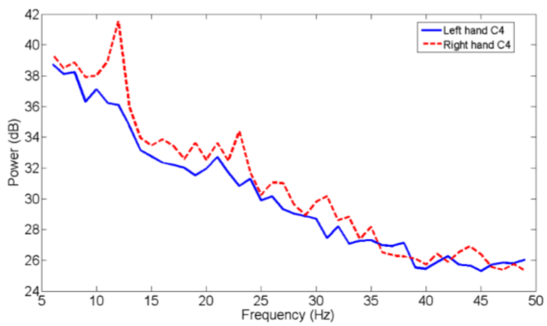


(a) (b)

The solid line represents the P300 potential associated with an infrequent stimulus. (b) The BCI2000 spelling interface shows the illumination of one row. The rows and columns flash repeatedly in a randomized order .region. This leads to a setup completely independent of peripheral muscles and nerves because the user does not really need to direct his gaze to the target. In [14] researchers elaborate on this concept and apply it to robot control in a virtual environment.

Sensorimotor Rhythm

The cortical areas involved in motor function show a strong 8-12 Hz (or even 18-26 Hz) activity when the person is not performing any motor (imagery) task. However, when the person is engaged in a motor task the neural networks in the corresponding cortical areas are activated. This blocks the idle synchronized firing of the neurons and thus causes a measurable attenuation in the frequency range of 8-12Hz. Analysis (IDA) group using this approach quite exhaustively in their Berlin BCI. They extended CSP with temporal filtering , made it more robust for non and reduced calibration time by transferring knowledge learned during previous sessions [20]. After almost a decade this method still proves it superiority based on the results of the fourth BCI competition[1]. Still, this BCI setup is less accurate than the P300-based BCI and initially



The solid (blue) line represents the spectrum on channel C4 averaged across all left hand trials. The dashed (red) line corresponds to the right hand trials. The trials display the biggest correlation with the labels around 12 Hz. It's also clear that the power is strongly attenuated in this frequency range for the left hand trials.

Slow Cortical Potential:

Slow cortical potentials are slow positive or negative DC shifts that can last up to several seconds. SCP's are global signals and represent the mobilization of neural resources for cognitive tasks if the shift is negative. Positive SCP's are measured during task execution and hence represent consumption of resources. People are able to modulate the amplitude of this slow wave through extensive feedback training and thus able to control a spelling device . It's also an important feature for neuron feedback applications in treatment of several disorders Patients.

IV.CONCLUSION

Numerous researchers throughout the world are realizing BCI systems that only a few years ago might have been considered science fiction. illustrates the publication years of essentially all peer-reviewed BCI articles that have appeared to date and shows that a majority of all the articles ever published have appeared just in the past few years. These BCIs use a variety of different brain signals, recording techniques, and signal-processing methods. They can operate a wide variety of different applications, including communication programs, cursors on computer screens, wheelchairs, and robotic arms. A small number of people with severe disabilities are already employing BCIs for simple communication and control functions in their everyday lives. With improved signal-acquisition hardware, definitive clinical validation, effective dissemination models, and, most importantly, better reliability, BCIs could become a major new technology for people with disabilities - and perhaps for the general population as well. The future of BCI will strongly depend on two things. Firstly, from the effector point of view improvements need to be made in accuracy, speed, reliability, convenience and functionality. Functionality like a high number of controllable degrees of freedom for use in a prosthetic device might lead to a breakthrough. Secondly, successful implementation of BCI systems in the field of rehabilitation and treatment of disorders could also be beneficial for the future of BCI.

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