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Smart Home Automation for Paralyzed People using Non-Invasive Brain Computer Interfaces

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Abstract: *In the area of home security, control and protection, vision based home automation systems (HAS) plays a significant role. Increasingly, as they are applied in real world applications, vision recognition systems can't operate in most of the acoustic environment. In this paper, we present the design and implementation of a smart home automation with incorporated EEG signal detection to minimize the false rate caused by signal interferences. Generally, EEG signals were decomposed into frequency sub bands using discrete wavelet transform (DWT). Then these sub-band frequencies were used as an input to a HAS network with several discrete inputs based on statistical measures and threshold bound abnormal signals were asserted which can drive output voltage regulation unit. This system comprised of a simple architecture and requires no human intervention to help paralyzed and physically disabled peoples. It allows for prompt accessibility, efficient usage of EEG signal characteristics and provides user convenience. The aim of the work presented in this thesis is to make automatic EEG recognition, clinical context and its derivative systems robust to any environmental differences.*

I. Introduction

Background And Objectives:

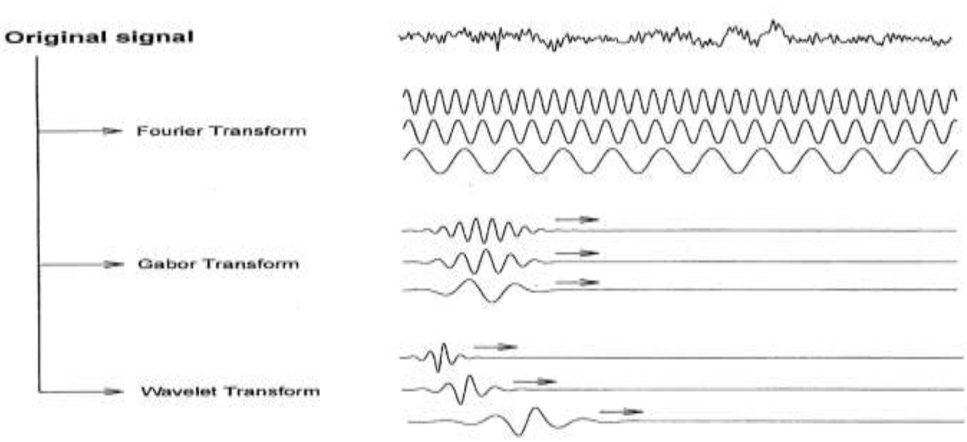
Human brain comprises of three major parts; forebrain, midbrain and hindbrain. Forebrain consists of cerebrum and the limbic system. Midbrain comprises of tectum and tegmentum while the hindbrain composed of cerebellum, pons and medulla. Cerebrum performs thinking and problem solving actions. Midbrain relates to the auditory and visual activities. Cerebrum being the cortex is the most important part of the brain. It controls all the muscular activities from limbs movement to the eye blinking of a person. Whenever there is a muscular activity or some sort of thoughts provoked by a person, the neurons in the cerebrum gets activated.

Special people who are unable to move anywhere or to perform any muscular activity due to non-functioning of their nerve cells that carry information to the muscles. In this regard, to facilitate those people, the concept of Brain Computer Interfaced (BCI) based system was developed by the srilankan scientist professor Asiri Nanayakkara. BCI is a communication link between human brain and computer in order to control the external devices. The system measures and analyses brain signals and then translate them into commands to control external devices such as wheelchair, TV, and light system. Invasive and Non-Invasive are two major types of BCI systems. In invasive BCI based systems, a chip is installed inside the brain which records the brain activity. This is not often practical because this requires a brain surgery. While in non-invasive type, a device (headset) is attached to the scalp (externally) which measures the brain signals.

Eeg Signal

Electroencephalography (EEG) is the recording of electrical activity along the scalp produced by the firing of neurons within the brain.[2] In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp. In neurology, the main diagnostic application of EEG is in the case of epilepsy, as epileptic activity can create clear abnormalities on a standard EEG study. A secondary clinical use of EEG is in the diagnosis of coma, encephalopathies, and brain death. EEG used to be a first-line method for the diagnosis of tumors, stroke and other focal brain disorders, but this use has decreased with the advent of anatomical imaging techniques such as MRI and CT.

The EEG is the electrical field potential that results from the spike train of many neurons. Thus, there is a relationship between the spike train and the EEG and the latter also encodes information processes of the neural-network amusement and analysis of the EEG can be traced back to Berger's experiments in 1929. Since then it has had wide medical applications, from studying sleep stages to diagnosing neurological irregularities and disorders. It was not until the 1970's that researchers considered using the EEG for communication.



Electroencephalography (EEG) sensors are used to capture the electrical signals generated in the human brain. BCI based system consists of several steps. Typical BCI based systems comprise of Electrode headset connected to a computer via wired or wireless connection. The headset records and transmits the brain signals to the computer. The brain signals are processed in computer and respective algorithms are applied to get the desired results. The aim of this step is to acquire the EEG signals. This is achieved by using Electrodes that are placed on the user's scalp (head) at respective positions. It consists of two electrodes, one being attached at the forehead right above the left eye and other one is attached to the left ear lobe that works as a ground. It records the brain waves and transmits it to the computer via Bluetooth which is built in feature of Mind wave.

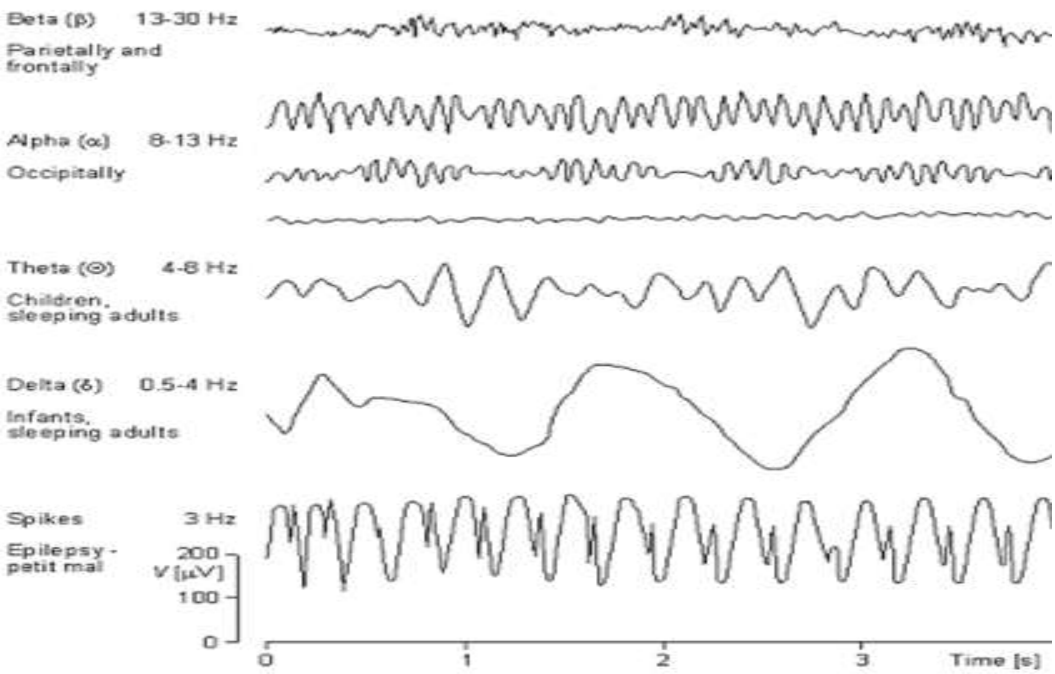


Fig 1.2 EEG Signals

Automation is one such application. Automation refers to the use of automatic equipment for carrying out a task. In other words, it is the technology that enables a process or procedure to be performed without human assistance. The last century of neuroscience research has greatly increased our knowledge about the brain and particularly, the electrical signals emitted by neurons firing in the brain. The knowledge that we have now had people wondering if it were possible to integrate automation with brain's activity. The result of this integration is termed Thought Driven Automation (TDA), or more popularly, Brain Controlled Automation (BCA).EEG signals are shown in fig 1.2. Brainwaves are recorded by EEG sensors which are characterized by amplitude and frequency. Amplitude ranges from 0 up to 100 microvolt's, while frequencies range from 1Hz up to 100 Hz. Brainwaves are in general divided into five categories: Delta, Theta, Alpha, Beta, and Gamma.

Single Channel Amplifier:
The amplification may be fine-adjusted to the appropriate voltage level for the data capture microcontroller's analog-to-digital converters (ADC).

Data Processing And Storage:
Two primary goals of this ambulatory BCI system is data collection using nonvolatile storage, and on-line real time processing and control. A single processing unit could be used; however, employing a parallel processing configuration enabled the system to be more flexible in design and programming with less computationally powerful microcontrollers.

Electrical Isolation And Shielding Requirements:
For this type of application, electronic devices standards require the isolation of the subject from the supply mains. Electrical isolation may be achieved by incorporating electro-optical isolation components. In addition to the safety considerations, there are significant shielding and grounding considerations for a device that must Measure signals in the mV range with respect to an external reference. Amplify and shift the signal with respect to an internal floating reference. Output an isolated signal that is referenced to ground.

Capturing Brainwaves
In this work, brain waves are captured using non-invasive BCI technique. The user wears the Brain Sense headset. It employs a medical probe to capture patterns and transmit them to Micro controller for further use. This device consists of a headband and an ear clip. The ground and reference electrodes are located on the ear clip whereas the EEG electrode is on the forehead. It uses a single AAA battery with 6 hours of battery life. Inside the Brain Sense headset, is a TGAM (Think Gear ASIC Module) which has a TGAT (Task Group on Assessment and Testing) chip. Brain waves are then captured, processed and interpreted by this chip. The Block Diagram of Brain Computer Interface using Non-Invasive Techniques is shown in the figure 3.2.

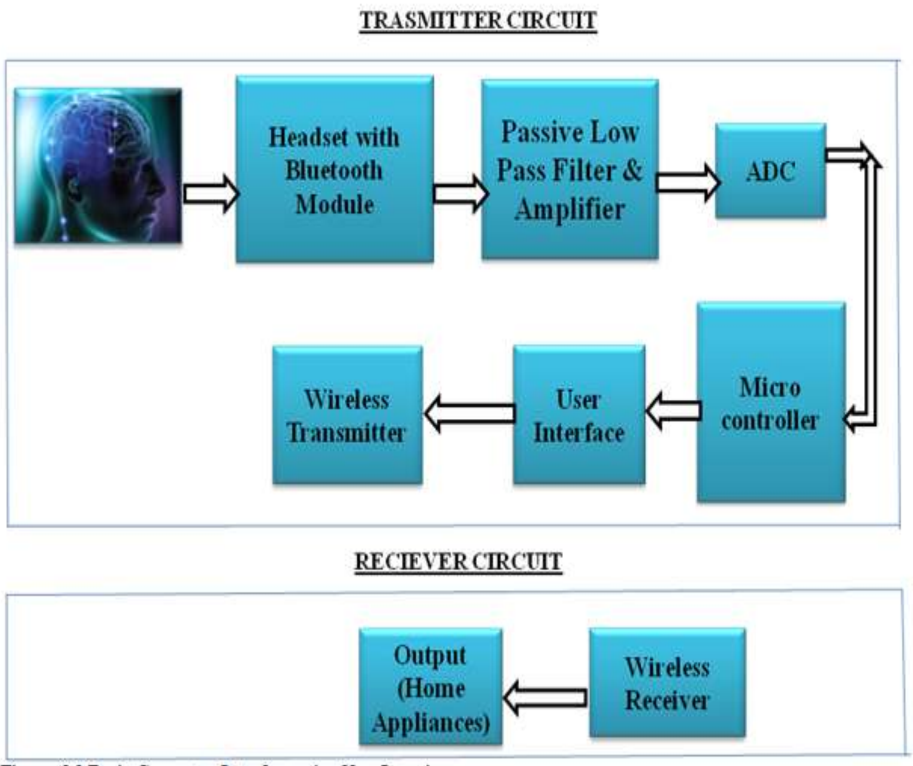


Figure: 3.2 Brain Computer Interface using Non-Invasi

II. Conclusion

Consumer-level units based EEG device methodology was presented for analysis of EEGs and delta, theta, alpha, beta, and gamma sub bands of EEGs for detection of seizure and epilepsy. Since the EEG is an overall representation of brain dynamics, it opens up the possibility that the observed changes in the parameters quantifying chaos in the band-limited EEG are actually the result of the superimposition of multiple processes underlying the EEG. Here one method of studying the underlying processes of the sub-band component which are represents the processes at a finer level. The decomposition of the original EEG into its five constituent sub-bands alters the original phase space and leads to new phase spaces that do not necessarily correspond directly to that of the original EEG. Finally with the statistical analysis is carried out based on the entire band-limited EEG and availability of multiple potential discriminating parameters results with the increased accuracy of real-time EEG epilepsy and automation systems that is explored.