Realizing Signals from Human Cognitive for Computing Devices

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Abstract: - The human nervous system makes use of electrical signals to control the whole human body. This fact has been well known nearly for past century. It is also known that the activities happening within the nerves are reflected by variation in the surface potential distribution of the brain surface. We are going to make use of Steady State Visual Evoked Potential (SSVEP) based Brain Computer Interface (BCI) system to control the computing devices like smart phones. We are aiming to create computer controlled system that will be using signals generated by the human brain cells, to control a hand held computing device. The hands free technology we are proposing will be especially useful for the handicapped people.

Keywords - *SSVEP (Steady State Visual Evoked Potential), BCI (Brain Computer Interface), EEG (Electro Encephalograph), SNR (Signal to Noise ratio)*

I. Introduction

Severe disabilities occurring in humans due to diseases such as Amyotrophic Lateral Sclerosis, quadriplegia, or due to massive brain strokes, severe spinal cord injury can leave the human body parts disconnected from the brain. This often results in major motor disabilities among humans, for the whole life making them dependent on other humans. There are a few existing technology devices that help such disabled people to stay independent. But most of them function on some or the other motor activities coming from human body parts such as touch or voice. But with these severe disabilities, there is no alternative left for these humans but to utilize their neural processes in brain. These electrical fields generate electrical signals with indirect modulation; hence they can be used to generate signals of different frequencies. This helps in creating control signals for a simple interface between the person using the device and the computing device. This interface is the Brain Computer Interface. A commonly used model for BCI is controlling the curser movements and its positions on the screen of computing device being used. The model requires the person to be trained to modulate his own electro encephalograph signals by using different thought patterns for different tasks.

The variation in the surface potential distribution on the human body surface indicates the functional activities or responses occurring in the nerve cells underneath the body surface. In order to record this surface potential difference, arrays of electrodes are mounted on the scalp of the person. The voltage between pairs of these electrodes is measured and then filtered, amplified and recorded.
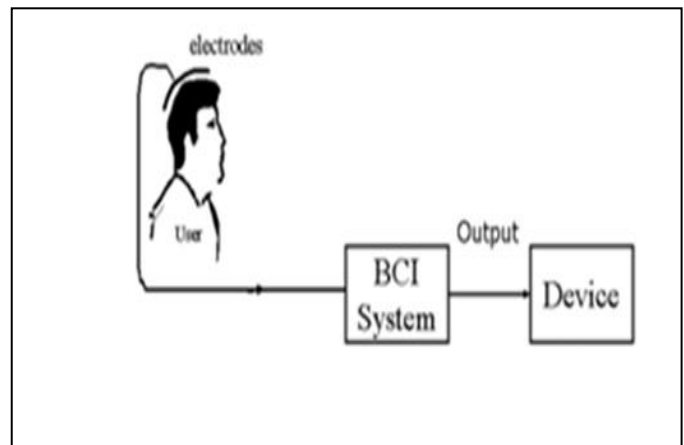

Fig.1: Overview of BCI system

II. How it works

Steady State Visual Evoked Potentials (SSVEP) are the periodically evoked potentials induced by repetitive visual stimulation generated very rapidly. Typical frequency for these periodically evoked potentials is greater than 6 Hz. The person will be displayed with a number of visual spots, each flickering at different frequencies. The person stares at one of those visual spots and generates an SSVEP with specific frequency components.

Figure 1(c) shows the amplitude spectrum of the SSVEP evoked by the visual spot flickering at 7 Hz. Hence, the spectrum peaks appear at 7 Hz, 14 Hz (in second harmonic), and 21 Hz (in third harmonic). When the peaks are detected, the flickering spot the subject is staring at can be identified.
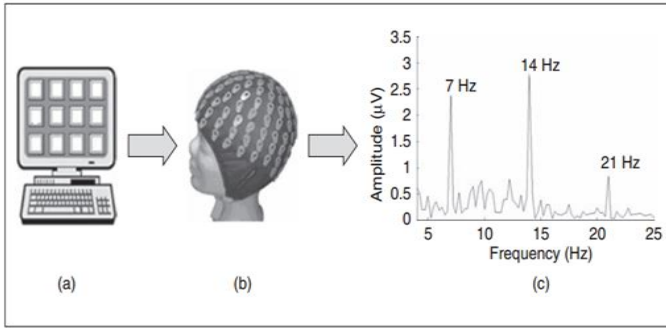
Fig 2: SSVEP BCI based on frequency coding. (a) The visual stimulator consists of targets flickering at different frequencies. (c) The SSVEP elicited by the 7-Hz stimulation shows characteristic frequency components with peaks at the fundamental and harmonic frequencies at the O2 electrode.

III. Implementation

The above technique based on frequency coding seems to be rather simple in principle. However, a number of issues (such as which electrodes to be used, stimulating frequencies ranges, algorithm for feature extraction and threshold setting) have to be looked after during its implementation. Among them, lead position selection and frequency feature extraction are the most important aspects. In order to get SSVEPs with a high SNR using the least number of electrodes is the goal of lead selection. Only one bipolar lead is chosen as the input to the system. VEP can be recorded with maximum amplitude around the occipital region of the brain. So, the electrode giving the strongest SSVEP, generally located in the occipital region, is selected as the signal channel. The location of the reference channel is searched under the following considerations: the amplitude of the SSVEP in it should be lower, and its position should lie in the vicinity of the signal channel so that the noise component is similar to that in the signal channel. High SNR can then be achieved when the potentials of the two electrodes are subtracted. Most spontaneous background activities are eliminated after the subtraction, whereas the SSVEP component is retained.
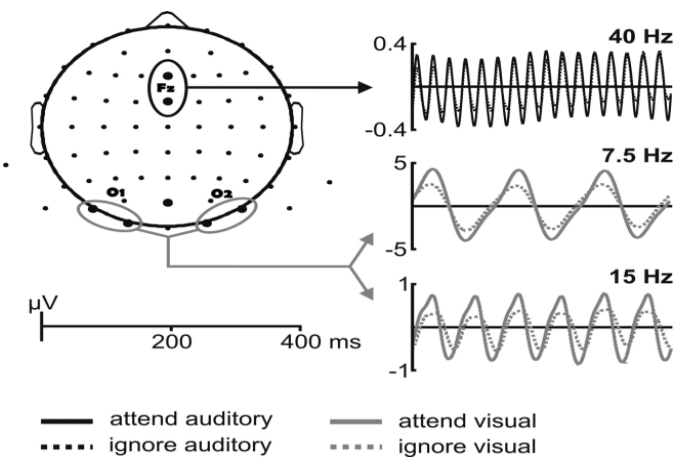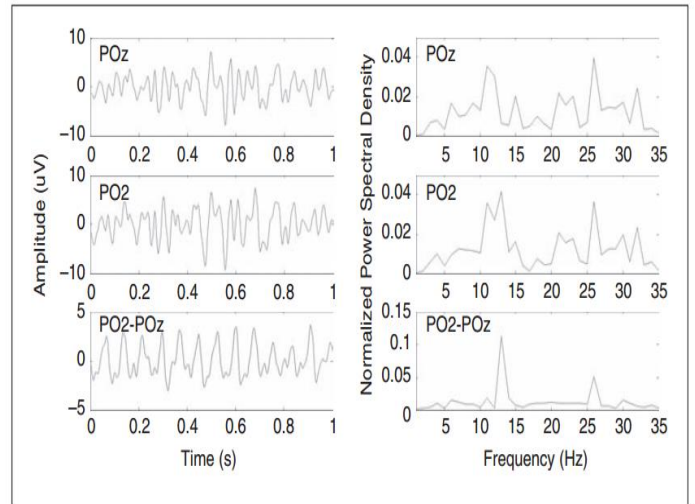

Fig.3: Electrode Placement Position

Fig 4: Monopolar and bipolar waveforms and normalized PSDs (sum of the spectrum is normalized to one) of EEG signals on two optimal electrodes (PO2 as the signal electrode and POz as the reference electrode) for one subject. The stimulation frequency is 13 Hz.

There is some nonlinearity during information transfer in visual system. Due to this, strong harmonics are often be found in the SSVEPs. The accuracy obtained with combined harmonics (up to the third harmonic) was significantly higher than with only the first harmonic. For some subjects, the intensity of the second harmonic may sometimes be even stronger than that of the fundamental component. Thus analysis of the frequency band should cover the second harmonic and the frequency feature has to be taken as the weighted sum of their Amplitude:

$$A_i = xA1_i + (1-x)A2_i$$
$$\text{Where } i = 1, 2...N$$

Where, N is the number of targets, and $A1_i$ and $A2_i$ are, respectively, the spectrum peak values of fundamental and second harmonics of the ith frequency (i.e., i^{th} target), and 'x' is the optimized weighting factor that varies between subjects. Its empirical value may be taken as

$$x = 1/N \sum_{i=0}^{N} A1_i / (A1_i + A2_i)$$

Our system is being designed in following aspects:
1) The software application shows special flickering patterns on the computing device's screen. Each pattern has a unique frequency. Each frequency is meant for a specific task. The application will be programmed accordingly. The subject is expected to gaze at specific pattern if he wants to carry out the task associated with that pattern. The flickering frequency can be controlled by the application. The frequencies cover bandwidth from 6 to 15 Hz.

2) AG/AgCl electrodes are attached to the scalp of the subject at O1, Fz, O2 position of occipital lobe.
3) The basic principle of operation may be described as follows: Multiple targets are placed on the screen and each target is flickering with different frequency. When the subject gazes at a certain target, SSVEP is induced in visual area of the brain, i.e. occipital lobe. The fundamental frequency of the evoked SSVEP is equal to the flickering frequency of the target. Thus, the target that the subject is gazing at can be identified by frequency analysis. This is called "frequency-coded selection by SSVEP".
4) The minimum difference between frequencies of the neighbouring flickering targets, the subject is able to discriminate is determined empirically to be 0.2Hz.

Data are recorded for 3 s. This yields 18 periods for the lowest frequency of 6 Hz and 48 periods for the highest frequency of 16 Hz. The 3-s time is long enough for accurate frequency estimation. With a sampling frequency of 200 Hz, only 600 points are sampled. These data should be zero-padded to 1024 points to satisfy the frequency resolution required.

Fig.5: Different stages of the system

5) The signals obtained from these are in the form of potential difference. These signals are too weak to be processed. Hence these signals are passed through amplifiers and filters to remove noise associated with it and to make signals strong enough to be processed. Electrodes are directly connected to amplifiers and filters.
6) Amplifier is then connected to microcontroller for signal processing. It converts signals from analog to digital form. It then transmits processed and converted signals to Bluetooth module.

7) Bluetooth module receives digital processed signals from microcontroller. Its basic function is to transmit those signals to the application device i.e. back to smartphone over Bluetooth. Bluetooth module is basically used to connect microcontroller and end divide wirelessly over Bluetooth. This increases the range of operation for BCI system.
8) Finally the android smartphone receives the signals. Depending on the frequency of the signals, a particular task is carried out in the smartphone.
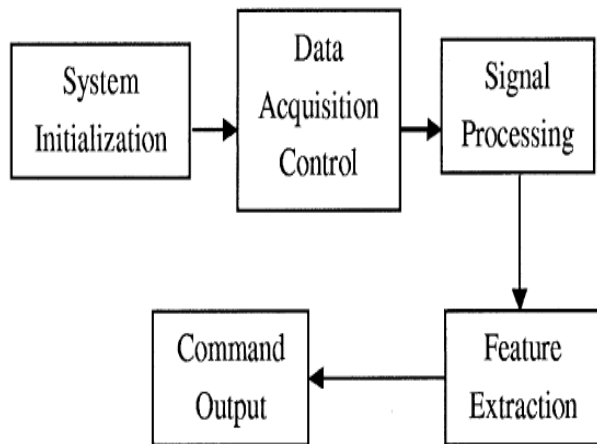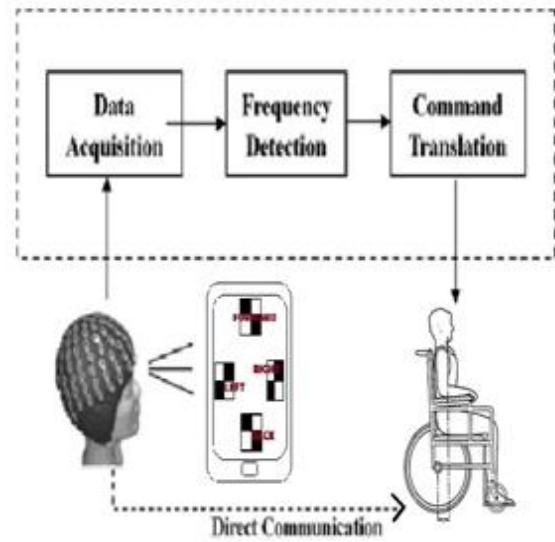

Fig 6: A BCI system allows users to control a device using their brain signals only.

IV. Conclusion

To conclude, we can say that the system showcases an improved usability, efficiency, improved feature selection algorithm and efficient smoothing and filtering of SSVEP. With these added benefits, the system can strive to make life better for the people with severe disabilities.

The system can be easily showcased as a better solution than the traditional FFT-based methods. Paradigms based on steady-state visual and other evoked potentials are one of the most reliable modes of communication for implementation of a fast non-invasive EEG-BCI system that can discriminate in near real time a very high number of unique commands or symbols. The system has the ability to process large amounts of commands at a given time. This will give a better control of semiautonomous remote sensing devices or in navigating a cursor on a computing device's screen. Thus, successful

implementation will allow people to operate in their surroundings only through their brain.

V. References

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