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Hands Free Instruction Passing Through SSVEP

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Abstract: **A communication device that does not depend upon the peripheral nerves and muscles i.e. totally independent from the traditional output pathways of nerves or muscles is known as BCI (Brain Computer Interface) or BMI (Brain Machine Interface). Without hand movement the BCI user is able to communicate with the external device e.g. computer. The people suffering from the severe palsy e.g. amyotrophic lateral sclerosis or brain stem stroke. For them BCI is way to communicate with the external environment. People by himself can accomplish requirements without need of a nurse who is actually revolving all around the patient's bed all the time. The productions of signals help the users to manipulate the brain activity instead of using motor movements so that the user can use the signals to control the computer or any communicational device. So here a BCI device is launched where subject can able to open any browser without using any hand movement. The BCI measures the brain activity and translate into the control signal which acts as the input for the BCI applications. As the research in BCI has grown rapidly, it is showing renewed interest. A BCI is an artificial intelligence that recognizes a set of brain signals in the following stages: - Signal acquisition, pre-processing or signal enhancement, feature extraction, classification and control interface.**

Index Terms— **BCI, SSVEP, EEG**

I. INTRODUCTION

The goal of BCI research is to provide the communicational abilities to those who are totally paralyzed or 'locked in' by neurological, neuromuscular disorders. Like other communication and control systems, a BCI establishes a real-time interaction between the user and the outside world. The user encodes his or her intent in brain signals that the BCI detects, analyzes, and translates into a command to be executed. The result of the BCI's operation is immediately available to the user, so that it can influence subsequent intent and the brain signals that encode that intent. For example, if a person uses a BCI to control the movements of a robotic arm, the arm's position after each movement affects the person's intent for the succeeding movement and the brain signals that convey that intent. BCIs are not "mind-reading" or "wire-tapping" devices that listen in on the brain, detect its intent, and then accomplish that intent directly rather than through neuromuscular channels. The BCI measures the brain activity and translate into the control signal which is the input for the BCI applications. As the research in BCI has grown rapidly, it is showing renewed interest. Human body have billions of neurons who maintained the brain's electrical charge. Neurons are electrically charged (or "polarized") by membrane transport proteins that pump ions across their membranes. Neurons are constantly exchanging ions with the extracellular environment, which helps to maintain resting potential and to propagate action potentials. We know that Ions having similar charge repel each other, and in situation when many ions are pushed out of many neurons at the same time, they can also push their neighbours, and further they push their neighbours, and so on, as they form a wave. This process is known as volume conduction. When the wave of ions reaches the electrodes on the scalp, they can push or pull electrons on the metal on the electrodes. Since metal conducts the push and pull of electrons easily, the difference in push or pull voltages between any two electrodes can be measured by a voltmeter. Recording these voltages over time gives us the EEG.

EEG signals are easily recorded in a non-invasive manner through electrodes placed on the scalp, for that reason it is found or distributed over a large area or number of people recording the quality of the modal. However, the quality of signals may be poor as the signals have to cross the scalp, skull, and many other layers. This means that EEG signals recorded through the electrodes are weak, hard to acquire and of poor quality. This technique is can badly affected by background noise generated either inside the brain or externally over the scalp. A set of signals of EEG can be classified according to their frequencies. The well known frequency ranges have been defined according to distribution over the scalp or biological significance. These frequency bands that are mentioned as delta (δ), theta (θ), alpha (α), beta (β), and gamma (γ) from low to high, respectively. The criteria of the electrodes placement over the scalp are commonly based on the International 10–20 system, which has been standardized by the American Electroencephalographic Society.

Unconscious		Conscious		
Delta	Theta	Alpha	Beta	Gamma
0,5 – 4 Hz	4 – 8 Hz	8 – 13 Hz	13 – 30 Hz	30-42 Hz
Instinct	Emotion	Consciousness	Thought	Will
Survival Deep sleep Coma	Drives Feelings Trance Dreams	Awareness of the body Integration of feelings	Perception Concentration Mental activity	Extreme focus Energy Ecstasy

Figure 1.1 Brainwaves and Frequencies

Visual Evoked Potentials (VEPs)

After receiving a visual stimulus VEPs are that brain activity modulations which occur in the visual cortex. These modulations are relatively easy to detect since the amplitude of VEPs increases enormously as the stimulus is moved closer to the central visual field.

VEPs can be classified according to different criteria.

i. By the morphology of the optical stimuli
ii. By the frequency of visual stimulation
iii. By field stimulation.

VEPs can be classified according to the frequency as transient VEPs (TVEPs) and as steady-state VEPs (SSVEPs). TVEPs occur when the frequency of visual stimulation is below 6 Hz, while SSVEPs occur in reaction to stimuli of a higher frequency. SSVEPs are elicited by the same visual stimulus. In this case, the stimulus changes at a frequency higher than 6 Hz. If the stimulus is a flash, SSVEP shows a sinusoidal-like waveform, the fundamental frequency of which is the same as the blinking frequency of the stimulus. If the stimulus is a pattern, the SSVEP occurs at the reversal rate and at their harmonics. SSVEP-based BCIs allow users to select a target by means of an eye-gaze. The user visually fixes attention on a target.

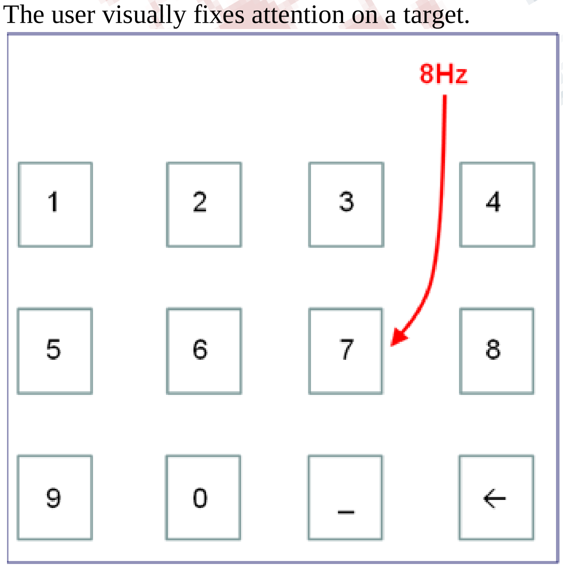

Figure 1.2 target selected by user gaze[14]

The BCI identifies the target through SSVEP features analysis.

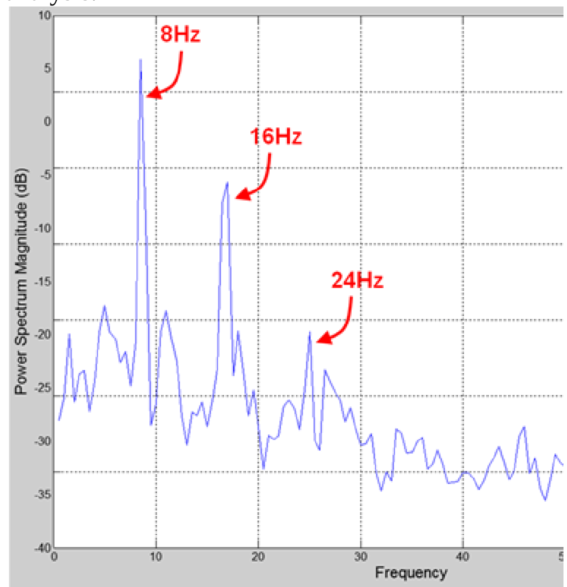

Figure 1.3 Highest peak detection of selected target[14]

II. LITERATURE REVIEW

In the experiment, the researcher's traditional approach was based on extraction of frequency features of an SSVEP. They concluded that results were higher than those using a widely used Fast Fourier Transform based spectrum estimation method. After recognition they gave the fact that signals from multiple channels that were used, may have contributed to much improved results associated with CCA approach. Canonical Correlation Analysis may improve signal to noise ratio. The fact about Canonical Correlation Analysis is that, it is used to analyse the frequency component in EEG[1]. **Xiaorong Gao** *et al.* presented an environmental controller which was based on Steady State Visual Evoked Potential using a BCI technique. The system was composed of stimulator, a digital signal processor and trainable infrared remote controller. Remote controller had an infrared receiver, a memory, an infrared emitter, and RS232 port. In the system the commands that issued by user to the trainable controller through the RS232 port of the digital signal processing (DSP) were translated by fetching the information from stored memory and then sent through device to the infrared emitter on the trainable controller[2]. A hybrid brain computer interface that is composed of an imagery based brain switch and a steady state visual evoked potential (SSVEP) was introduced by **Gert Pfurtscheller** *et al.* where the brain switch (Event Related Synchronization (ERS)-based BCI was used to activate the four step SSVEP- based orthosis. In the patients suffering from spinal cord injury (SCI) or brain stem stroke, BCI can be used to control neuro prothesis e.g. functional electrical stimulation for grasp restoration with surface electrodes or implanted devices. The SCI patients lose control over the grasping function, ability to control the external devices, also the elbow function. The Researchers reported a communication device 'Hand Prosthesis' having LEDs. [3] In the technique **Po-Lei Lee** *et al*. used the six LEDs in clockwise direction around the monitor screen. These LEDs were controlling the six cursor functions(cursor up, cursor down, cursor left, cursor right, left click, right click). The flickering sequences were lies at 13.16 Hz with duty cycle of 10.5% to 89.5%. The proposed design driven by flickering sequences consisting of repetitive stimulus cycles and that had the time duration of 76ms. The phase delays for LEDs were set at 60°(0°,60°,120°,180°,240°,300° respectively) ±30° phase margin and corresponded to these phase delay, the time delays were 0,12.67,25.33,38,50.67 and 63.33ms. The gazing target was detected every 1s, subjects were asked to keep gazing at the same LED for three successive times and sequentially input a sequence of cursor commands with the 25.08-bits/min ITR. When a valid input was achieved, a voice feedback informed the subject whose command was just executed. 89.5% duty cycle flicker was noticed as a comfortable flicker [6]

III. OBJECTIVE

For generations, humans have invented the ability to communicate and interact with machines that may be through thought or to create such the devices that can peer into person's mind and thoughts. These ideas have captured the imagination of human kind in the form of ancient myths, now the time has been changed the advances in cognitive neuroscience and brain imaging technologies have started to provide us the ability to interface directly with the human brain. Through the use of sensors this ability is made possible that can monitor some of the physical processes that occur within the brain which correspond to certain forms of thought. After recognition of the growing of needs of people with physical disabilities, then the researchers use these technologies such as brain computer interfaces (BCIs). The physically disabled person may face problem to operate and control the devices.

So here the proposed work is to make such a hands free system that can help the paralyzed person for the instruction passing. That person can operate the electrical or electronic device without use of their hands. In the work, there is an interface, which will flicker at different frequencies that corresponds to two different actions displayed on the monitor screen. When the subject fixes his/her eyes on one of the screen the SSVEP will analyze and convert to corresponding control command.

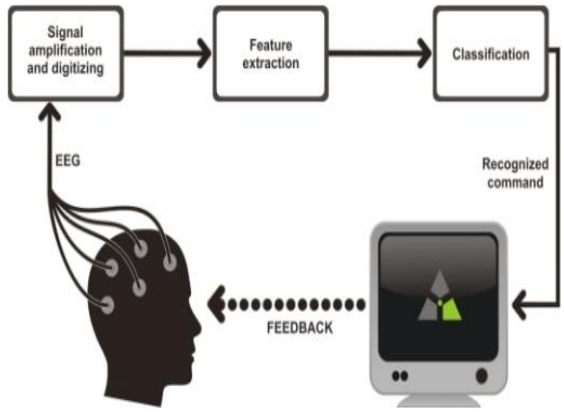

Figure1.2 Basic BCI operation [13]

To convert the demonstration systems into practical devices, the problems to be solved are:-

1. The system should provide a sufficiently high transfer rate to make the system practical.
2. The system should be compact and portable, so it can be used conveniently.
3. There should be easy electrode placement and with little user training.

IV. Facilities Required

Software Requirements: -

- Windows XP or above
- Mat lab R2013a(8.1.0.604)
- Microsoft excel

Hardware Requirements: -

- EEG acquisition Kit
- 1 GB RAM
- 3 GB hard disk drive space

V. Proposed Methodology

1. **Conduct the Literature Study:** Conduct the Literature Survey so as to analyze the present study of SSVEP and the work that has been done in this field.
2. **Setting up the scenario:** Create experimental set up to gather EEG signals. In the following study the EEG signals are collected from the source of internet. After Gathering the signals in csv format and analyzed the data for filtering out the frequencies of the flickering display in MATLAB.
3. **Acquire signals:** - The volunteer was shown a flickering image with frequency 10 Hz for 10 seconds and he told to close the eyes for 10 more seconds. In the process of EEG acquisition, noise was produced due to the volunteers certain actions apart from continuously looking at the interface.

4. Fast Fourier Transformation: - So to remove the unwanted noise FFT was applied to the noisy signals to obtain the high amplitude peak that showing the particular task that the volunteer may want. Otherwise the acquired EEG signals before FFT can be show the various peaks from which the actual signal identification become more difficult. Convert the result of data analysis into workable actions.

```
NFFT = 2^nextpow2(L); % Next power of 2 from length of
y
Y = fft(x,NFFT)/L;
f = Fs/2*linspace(0,1,NFFT/2+1);
% Plot single-sided amplitude spectrum.
plot(f,2*abs(Y(1:NFFT/2+1)))
M = length (Y);
N= 2*abs(Y(1:NFFT/2+1));
index = find(N == max(N(:)));
fans= f(index);
```

5. BCI Application Study: The signal-processing procedure given above is followed. The EEG signals were collected from source that was filtered with 10–20Hz to obtain SSVEP responses.

a.csv

	A	B	C	D	E
	VarName1	VarName2	VarName3	VarName4	VarName!
	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER
1	-9.80E-07	-3.35E-06	5.56E-06	2.26E-06	9.86E-06
2	-2.92E-06	-1.24E-06	5.73E-06	8.50E-07	9.61E-06
3	-4.51E-06	3.13E-07	5.55E-06	-4.83E-07	9.12E-06
4	-5.73E-06	1.23E-06	5.12E-06	-1.63E-06	8.29E-06
5	-6.60E-06	1.57E-06	4.56E-06	-2.51E-06	7.05E-06
6	-7.20E-06	1.40E-06	3.98E-06	-3.09E-06	5.33E-06

Figure 1.3 Collected data for experiment

Exact frequency had been taken was 10 Hz and 17 Hz .The latency of the maximum amplitude peak in SSVEP was denoted.

The sampling rate was 250 Hz. In the process of EEG acquisition, noise will be produced due to the volunteers certain actions apart from continuously looking at the interface. So to remove the unwanted noise FFT was applied to the noisy signals to obtain the high amplitude peak that showing the particular task that the volunteer may want.

```
if ( fans == f1)
   {

web('http://google.com','-browser')
      }
elseif ( fans == f2)
   {

web('http://yahoo.com','-browser')
      }
else
   {
     fprintf('error');
   }
end
```

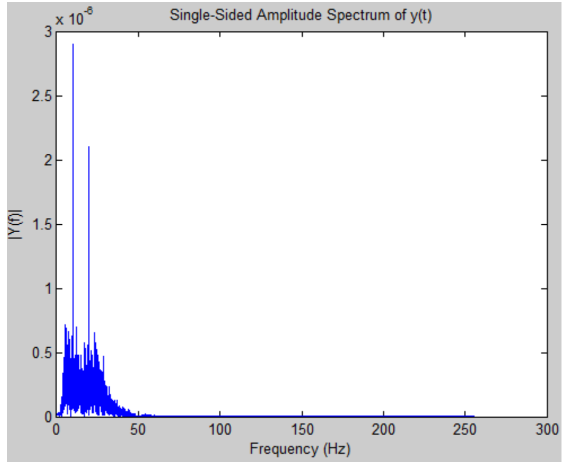

Figure1.4 high amplitude peak detected

Otherwise the acquired EEG signals before FFT can be show the various peaks from which the actual signal identification become more difficult. FFT is easy to implement and it is more robust than other frequency estimation methods. The feature extraction module detects the frequencies of stimuli by locating the peaks in the spectrum in order to determine the fixation target according to predefined criteria. Response intensity is defined as the sum of the amplitude of the fundamental frequency and its second harmonic. The threshold is set at approximately twice the average amplitude over the frequency band 4 to approximately 35 Hz and has to be adjusted for each user. When the maximum intensity is greater than the threshold, the corresponding stimulation is selected as the target. The last step is to open the browser.

VI. EXPERIMENTAL RESULTS

For the conducted experiments the readings are based on a noninvasive BCI that uses sensors with contact on the surface of the scalp via standard EEG electrodes. The EEG data were acquired with an amplifier , the sampling frequency was 250 Hz. During the EEG ac- quisition, an analog bandpass filter between 2 and 30 Hz.For the software, an LCD screen with the resolution of 1366 X 768 pixels was used. The code was developed in MATLAB R2013a. As the above disscused createria we were able to open the browser say at 10 Hz http://www.google.co.in/ and at 17 Hz http://www.yahoo.in . The feature extraction module detects the frequencies of stimuli by locating the peaks in the spectrum in order to determine the fixation target according to explained criteria of opening the web browser.

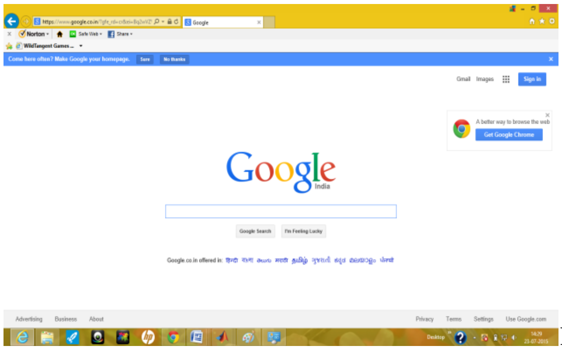

Figure 1.5 Opening browser at frequency of 10 Hz

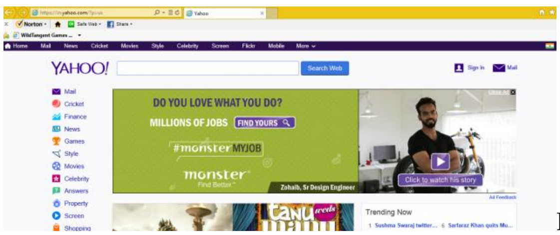

Figure1. 6 Opening browser at the frequency of 17 Hz

CONCLUSION AND FUTURE WORK

SSVEP-based BCIs allow users to communicate with the external world by selectively paying attention to one out of a set of repetitive visual stimuli. In this paper, we have highlighted important facts of the stimuli in BCIs. The productions of signals help the users to manipulate the brain activity instead of using motor movements so that the user can use the signals to control the computer or any communicational device.

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