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Research article

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Android Based EEG Speller for the Disabled

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Abstract
Steady State Visually Evoked Potential (SSVEP) is the electro encephalograph (EEG) response observed at the occipital region of the brain to a visual stimulation having a periodic intensity variation. When the retina is excited by a visual stimulus ranging from 3.5 Hz to 75 Hz, the brain generates electrical activity at the same or multiples of frequency of the visual stimulus. SSVEP response can be used to determine the light source the subject is viewing and can form an useful part of a brain machine interface (BMI). Here we present an Android Application that produces visual stimuli, receives EEG signals and performs real time signal processing that enables the classification of the signal spectrum. This is aimed at providing a speller technology for the disabled.

Keywords EEG, SSVEP, Emotiv, Speller

1. Introduction

Electroencephalography (EEG) is the recording of electrical activity along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain. In order to study these wave patterns, the electrodes need to be placed at specific locations on the scalp. When the subject views a periodically flickering light source flickering at frequency f, the occipital region of the brain puts out an EEG signal that contains this frequency f and its harmonics. This is termed as the steady state visual evoked potential (SSVEP) [1], [2]. If there were multiple sources flickering at different frequencies, the Fourier spectrum of the SSVEP recording would indicate the light source the subject was viewing. Each frequency could now be used to trigger an algorithm or indicate a message and this can be used for brain machine interfaces (BMI) and brain computer interface (BCI) (Fig. 1). This technology has great value for the disabled.

In this paper we present an Android Application that uses SSVEP recordings to provide a speller for the disabled [3]-[8].

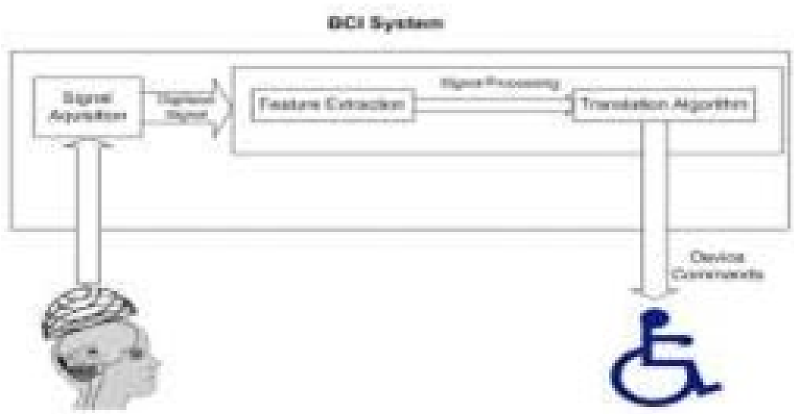


Figure1: Typical BCI pathway.

2. Overview of Application

The Application has three parts. The first part presents different light sources on a LCD screen that can be viewed by the subject. Each light source has a different flicker frequency riding on top of the 50Hz screen refresh rate. The light source could be the message to be transmitted itself. The hardware to pick EEG signals was the commercially available Emotiv headset. The second part of the algorithm picks the EEG signals and analyzes it in real time. This analysis involves the real time spectrum extraction and classification. The third part of the Application uses the result of this classification to send out the message.

3. Hardware

Emotiv EPOC research edition headset was used to pick signals. Emotiv EPOC features 14 EEG channels plus 2 references offering optimal positioning for accurate spatial resolution. Channel names based on the international 10-20 electrode location system are: AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4, with CMS/DRL references in the P3/P4 locations. It uses sequential sampling method, single ADC, at a rate of 128 SPS or 256 SPS (2048 Hz internal). Emotiv EPOC operates at a resolution of 14 bit or 16 bit per channel with frequency response between 0.16 - 43 Hz.

4. Software - Stimulus Generation

Since it is a complete software based Application, hence the flickering LED display as seen in Fig. 2 was made using Microsoft Visual C++. Six different square grids of LEDs were made such that they were flickering at frequencies of 5Hz, 7Hz, 9Hz, 11Hz, 13Hz and 23Hz respectively. To calibrate the flicker frequency, a photodiode was placed close to the display screen near each stimulus grid. The photodiode was used in a resistor divider configuration with a known resistor and the output voltage signal was measured on the oscilloscope. The setup is shown in Fig. 3a and the results are shown in Fig. 3b. The actual flicker frequency matches the input via software with a maximum 5% error. Each frequency reproduces a corresponding unique emergency message which the disabled person wishes to speak (Table I).

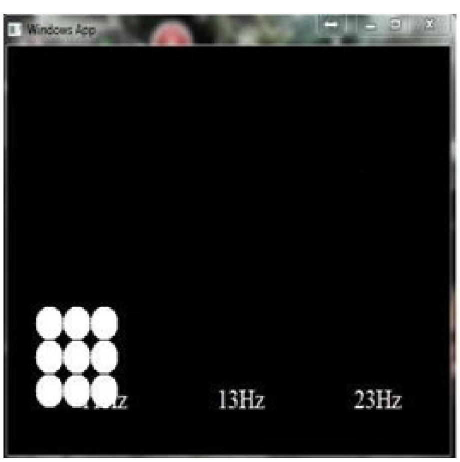
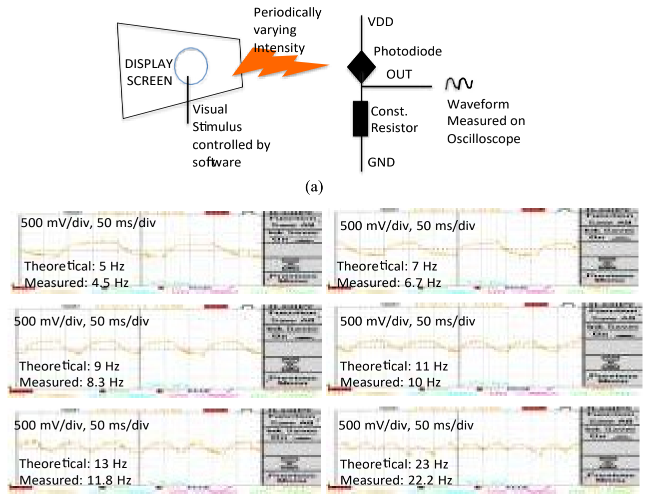


Figure 2: Screen grab of software driven stimulus.



(b)

Figure 3: Calibration of frequency of projected stimuli (a) experimental setup, (b) experimental measurements

5. Software – Fourier Spectrum Extraction

The Application as seen in Fig. 4 is developed in such a way that the EEG signals (seen on the window on the left bottom) received are processed. A serial port interface program has been coded to receive the signal via the COM port in the form of buffer of 10 s using dynamic memory allocation. The data in the buffer is emptied and is taken in for processing and the buffer is refilled in with new data and the process continues. The data from the buffer is processed through a Bandpass Bessel filter of eighth order eliminating any frequency beyond 3-30Hz to remove unwanted noise due to electrode artifact or the power supply interference. Conversion of data from time-domain to frequency-domain is required for SSVEP analysis. The fast Fourier transform (FFT) algorithm is run in real time on this data string. The complete time to process a data string is less than 1s to get a plot of the power spectra, i.e., power vs frequency plot. Subsequent EEG data strings are processed batch by batch. Fast Fourier Transform (the six windows on the upper part) is computed for each frequency band corresponding to the six LEDs. The bands chosen for FFT calculation are in the range 4-6 Hz, 6-8 Hz, 8-10 Hz, 10-12 Hz, 12-14 Hz and 22-24 Hz.

LED Frequency	Emergency Message
5	I am hungry.
7	I need my book to read.
9	Can I get some water please?
11	I need to go to bed.
13	I wish to go out for a while.
23	Can you please switch on the AC.

TABLE 1: FREQUENCY-MESSAGE

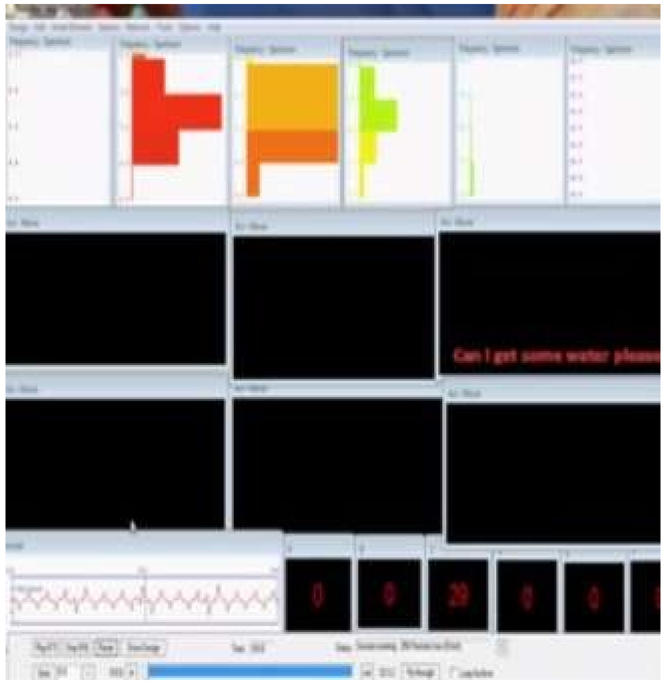


Figure 4: Screenshot of FFT processing and message display window

The band that gives the maximum power contains the frequency of the LED at which the user is staring at. The power windows (bottom right) compute the power of the frequency spectrum; all other powers are zero, only the maximum power is displayed and a corresponding message is shown.

6. Android Implementation

TeamViewer 10 was made use of to transfer and interface the Applications developed in Windows to make them to function successfully on an Android system (Sony Xperia Smartphone) as shown in Fig. 5. Hence the EEG based speller developed is portable and could easily be accessed by a physically challenged person in a Windows or Android Smartphone anywhere and at anytime

Conclusion

Electroencephalography (EEG) equipments are becoming more available on the public market, which enables more diverse research in a currently narrow field. The Brain-

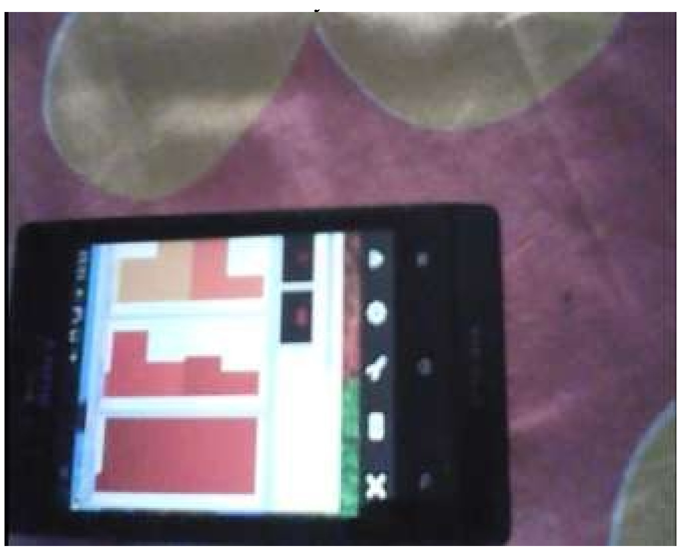


Figure 5: Working on Android

Computer Interface (BCI) community recognize the need for systems that makes BCI more user-friendly. The work presented shows the development of a SSVEP recognition toolkit on an Android platform achieving this goal. Future work involves the control of machines using this toolbox.

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References

1. Beverina, F., Palmas, G., Silvoni, S., Piccione, F., & Giove, S. (2003). User adaptive BCIs: SSVEP and P300 based interfaces. PsychNology J., 1(4), 331-354.
2. Regan, D. (1989). Human Brain Electrophysiology: Evoked Potentials and Evoked Magnetic Fields in Science and Medicine, Elsevier, New York, NY, USA.
3. Wolpaw, J. R., McFarland, D. J., Neat, G. W., & Forneris, C. A. (1991). An EEG-based brain-computer interface for cursor control. Electroencephalography and clinical neurophysiology, 78(3), 252-259.
4. Gerwin Schalk, Dennis J. McFarland, Thilo Hinterberger, Niels Birbaumer,Jonathan R.Wolpaw: BCI2000: A General-Purpose Brain- Computer Interface (BCI) System, IEEE Trans. Biomedical Eng., vol. 51, no. 6, June 2004.
5. Veigl, C. (2006). An open-source system for biosignal-and camera-mouse applications. studying Medical Computer Science, Technical University Vienna.
6. Birbaumer, N., Ghanayim, N., Hinterberger, T., Iversen, I., Kotchoubey, B., Kübler, A., ... & Flor, H. (1999). A spelling device for the paralysed. Nature, 398(6725), 297-298.
7. Brodsky, B. E., Darkhovsky, B. S., Kaplan, A. Y., & Shishkin, S. L. (2000). Application of the change-point analysis to the investigation of the brain's electrical activity. Non-Parametric Statistical Diagnosis: Problems and Methods, 333-388.
8. Guger, C., Harkam, W., Hertnaes, C., & Pfurtscheller, G. (1999, November). Prosthetic control by an EEG-based brain-computer interface (BCI). In Proc. aaate 5th european conference for the advancement of assistive technology (pp. 3-6).