International Journal of Medical, Medicine and Health Sciences
ISSN: 2517-9969
Vol:10, No:9, 2016

Artificial Generation of Visual Evoked Potential to Enhance Visual Ability

A. Vani, M. N. Mamatha

***Abstract*—**Visual signal processing in human beings occurs in the occipital lobe of the brain. The signals that are generated in the brain are universal for all the human beings and they are called Visual Evoked Potential (VEP). Generally, the visually impaired people lose sight because of severe damage to only the eyes natural photo sensors, but the occipital lobe will still be functioning. In this paper, a technique of artificially generating VEP is proposed to enhance the visual ability of the subject. The system uses the electrical photoreceptors to capture image, process the image, to detect and recognize the subject or object. This voltage is further processed and can transmit wirelessly to a BIOMEMS implanted into occipital lobe of the patient's brain. The proposed BIOMEMS consists of array of electrodes that generate the neuron potential which is similar to VEP of normal people. Thus, the neurons get the visual data from the BioMEMS which helps in generating partial vision or sight for the visually challenged patient.

***Keywords*—**Visual evoked potential, OpenViBe, BioMEMS, Neuro prosthesis.

I. Introduction

THE brain is the most complex part of the body. The function of the human body is frequently associated with the signals of electrical, chemical, or acoustic origin. Such signals convey information which may not be immediately perceived but which is hidden in the signal's structure. This information has to be "decoded" or extracted in some way before the signals can give meaningful interpretations. The neural signals reflect the properties of their associated organs, and decoding this signal is found to be very helpful in various diagnoses.

VEP is one such signal that indicates the eye's electrical activity; it is widely used in eye-related research studies. The generation of VEP by applying various signal processing algorithms and simulation helps to develop a system which aims to provide a functional central vision to assist with tasks such as face recognition and object detection.

Since visually impaired people have damaged eyes, the reason of their loss of sight is that their natural photoreceptors (eye) are unable to generate signals that excite the neurons in the occipital lobe of the brain. The temporal lobe in the brain is responsible for the visual sensation. It is proved that the neurons of the occipital lobe of the blind are healthy and have a potential to create visual sensation, if the required signals are fired to the neurons in that region. Hence, we discuss a technique of transmitting visual data digitally into the occipital lobe of the brain by wireless means. In the brain, a BIOMEMS can be implanted to receive this wireless digital data by using patch antenna present on it. Digital data tapped by patch antenna are converted into analog signal by using a resistor controlled Wein bridge oscillator. Obtained analog signal is equivalent to the signals that are required by the occipital lobe neurons to create visual sensation in human beings.

The visual sensation occurs in temporal lobe, but the image processing in the human beings is done in the occipital lobe of the brain. Our main objective is to generate the same image processing signals in blind people's mind. The brain signals also referred as VEP are obtained from EEG tests of normal people. These signals serve as a means of reference for us to design our system [1].

Vani A (Student) is with the Dept. of Electronics, BMS College of Engineering, Bangalore, India (e-mail: vaninagesh44@gmail.com).
Mamatha M. N (Associate Professor) is with the Dept. of Electronics and instrumentation, BMS College of Engineering, Bangalore, India (e-mail: mamathamnbms.intn@bmsce.ac.in).

II. Literature Survey

The development of several neuro-prosthetic aid or devices such as developing a bionic eye to restore vision to people with retinitis pigmentosa and age related macular degeneration and many other visual problems, is very essential for the human society. Several government and private agencies have taken a research projects related to development of visual aided devices.

The BioMEMS that can be implanted on the human brain are described in [2]. It uses heterogeneous integration of 100-element micro-electro-mechanical system (MEMS) electrode array, front-end CMOS integrated circuit for neural signal pre-amplification, filtering, multiplexing and analog-to-digital conversion, and a second CMOS integrated circuit for the transmission of neural data wirelessly and conditioning of the neural signal. The Prosthesis is the process of generating the electrical signal to simulate any paralyzed limbs and control the operation of any part of subject. Flip-chip technology can be chosen for the integration of the electronics and MEMS electrode array to accommodate the high density of interconnections [3], [4].

An overview on the use of micro-electro-mechanical systems (MEMS) technologies for timing and frequency control is presented. The vibrating RF MEMS are seen frequently as circuit building hinders than as stand-alone device. The analysis of EEG signal and extraction of VEP signal with the help of case studies and examples are described by Rangayanan [5].

III. Image Acquisition and Processing

A digital camera is used to capture the image. The obtained images are then subjected to pre-processing. Viola Jones algorithm is applied on pre-processed image for face detection. The face recognition is done by using Principal Component Analysis (PCA); the key idea of the PCA method is to transform the face images into a small set of characteristics feature images, called eigenfaces, which are the principal components of the initial training set of the face images.

An Evoked Potential or Evoked response is an electrical recorded from the nervous system of a human or other animal on presentation of a stimulus, and can be detected and recorded by Electroencephalography (EEG), Electromyography (EMG), or other Electrophysiological recording method.

A. VEP Stimuli

The checkerboard is commonly used pattern for VEP and Electroretinography (ERG) tests. This pattern uses light and dark squares. These squares of black and white which are equal in size are presented through the computer screen.

B. VEP Electrode Placement

Electrode placement is very important to get good VEP response which is free of artifact. One electrode is placed 2.5 cm above the ***inion*** and a reference electrode is placed at Frontal midline Fz. For a more detailed response, two additional electrodes can be placed 2.5 cm to the right and left of Oz. VEP recorded from EEG tests of normal people for basic edges say Circular, Square, Triangular, etc. serves as a means of reference to design our system.

C. Software for Simulation:

There are several proprietary software packages, several open source software tools are available in the field of biomedical signal processing.

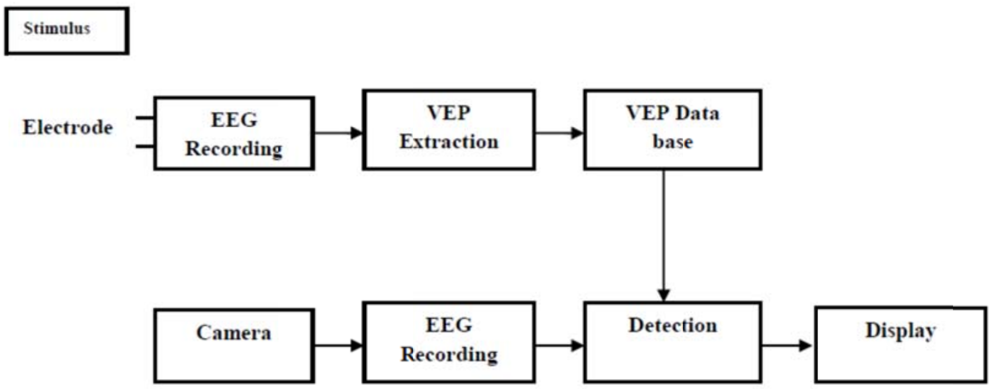

Fig. 1 Block Diagram of the System

IV. Implementation

Fig. 1 shows the block diagram of designed system. Initially, the subject is made to focus on given stimulus. Then, the EEG signals are acquired by using the electrodes placed according to 10-20 International standards. The acquired EEG signals are processed to extract VEP signals; these VEPs are stored as database. Further, this database will serve as reference in the detection process. Following sections briefs out the detection process.

A. Face Detection

Face detection is done by using the Viola Jones algorithm which involves three stages

1. Haar Features selection: First, we will define a rectangle of required number of rows and columns. The value of given feature is then computed as sum of pixels within clear rectangles subtracted from the sum of the pixels within shaded rectangles.
2. Integrated image at location (x, y) is sum of pixels above and to the left of (x, y).

For example, consider an image of 24X24 pixels, the possible features are 162336. The processing of this becomes more expensive. Hence, variant of the learning algorithm AdaBoost is selected for these features and to train the classifiers.

3. In AdaBoost algorithm, we take a set of ‘N’ positive and negative training images with labels (x^i, y^i). If image ‘i’ is face then y^i=1 else y^i=-1.

Training steps involve following steps,

1) Initialization, assign a weight wi=1/N

For each feature f_j with j=1, 2….N

2) Renormalize the weights

Apply the feature to each image in training set, and then find the optimal threshold and polarity that minimizes weighted classification error.

$$\theta j, sj = \arg(\min(\theta, s)) \sum_{i=1}^{N} w_j^i e_j^i$$

$$e_{j=}^i \begin{cases} 0, & if\ y^i = hj(x^i, \theta j, sj) \\ 1, & otherwise \end{cases}$$

3) Weights of next iteration is reduced for the imaged ‘i’ that are correctly classified.

B. Face Recognition

PCA for face recognition is based on the Information theory approach [6]. We apply PCA on the created image database and get the unique feature vectors using following method. The following sequence is computed, if there are training images of mxn configuration then,

1. Each column represents an image; the database is arranged in the form of matrix.
2. Covariance matrix is computed with the help of eigenvalues and eigenvectors
3. The Feature vector for every picture is processed. The feature vector represents signature of image. The Signature matrix is computed for the complete database.
4. Euclidean distance is processed for the image.
5. Image is distinguished as the one which gives slightest separation with the mark of picture to perceive.

C. Object Detection

Object Detection is done by using Background subtraction algorithm, which is fast and reliable for moving objects to avoid complexity. This algorithm proposes a new method to detect moving object based on background subtraction. Background subtraction method is to use the difference method of current image and background image to detect moving objects. After background image B(X, Y) is obtained, subtract the background image B(X, Y) from current frame $F_k(X, Y)$. If pixel difference is greater than set threshold value T, then determines that the pixel appears in the moving object, otherwise as a background pixel. Expression used

$$D_k(X, Y) = 1 \text{ if } (|F_k(X, Y) - B(X, Y)| > T)$$

$$D_k(X, Y) = 0 \text{ for others}$$

D. Software Used

Open Vibe is a software platform dedicated to designing, testing and using brain-computer interfaces. Open Vibe is software for real-time neurosciences. It can be used to acquire, filter, process, classify and visualize brain signals in real time. It works on Windows and Linux operating systems. OpenViBe can use a vast selection of hardware EEG devices. OpenViBe is multi-platform software. OpenViBe has many capabilities such as signal processing algorithms, machine learning functions, and scripting support. Fig. 2 shows the Flow diagram of VEP Extraction.

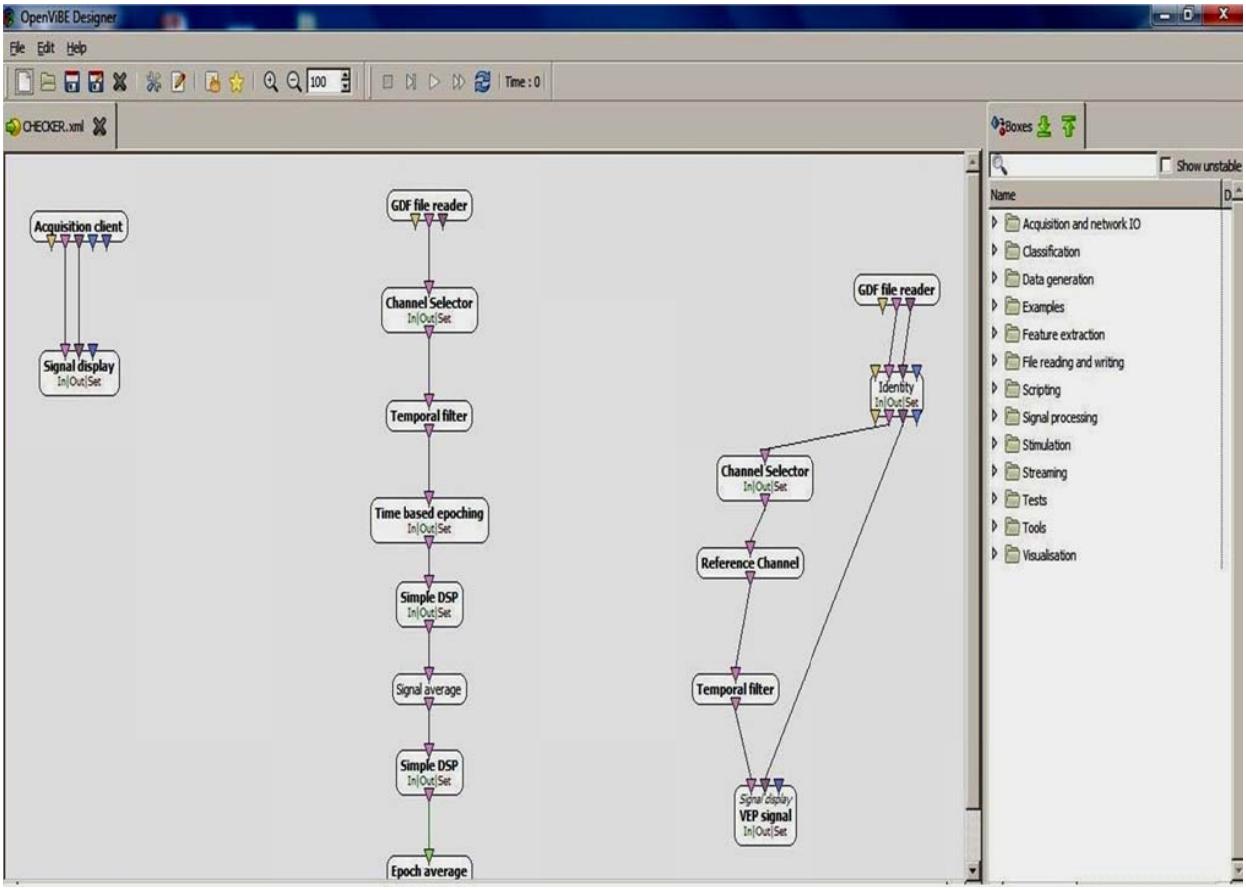

Fig. 2 Flow Diagram for VEP Extraction

The averaged digital VEP obtained can be transmitted to the BioMEMS that can be implanted inside the patient's brain [5]. To establish this communication link, we need to use wireless technology. VEP signal is transmitter using a wireless patch antenna operated at 300 MHz frequency. Also, there will be one more patch antenna, meant only for receiving data, is embedded on the surface of the BioMEMS device. This patch antenna is tuned to operate in the band or around 300 MHz.

The digital data have to be encoded, because the resistance values must have different resonant frequencies so that the particular resistance is selected. This is achieved by having a Voltage Controlled Oscillator.

V. Results

The common objects like staircase and faces of some people forms the database of objects and faces. When the subject visualizes the object or face of the person, corresponding EEG signal and VEP signals are computed and displayed in the screen. Fig. 3 shows the simulated result of Extracted VEP signal for face detection and Fig. 4. shows the simulated result of extracted VEP signal for Checker board image.

The VEP collected from the normal vision EEG signal forms the reference signal database. The database of this VEP for important objects like staircase humps and important people of their life is formed. As the VEP signal is universal for all human being, we can generate VEP and transmit to BioMEMs which can be implanted on the brain of visually challenged subject. The generated VEP signal which enables partial vision simulates the required neurons in the occipital lobes [1].

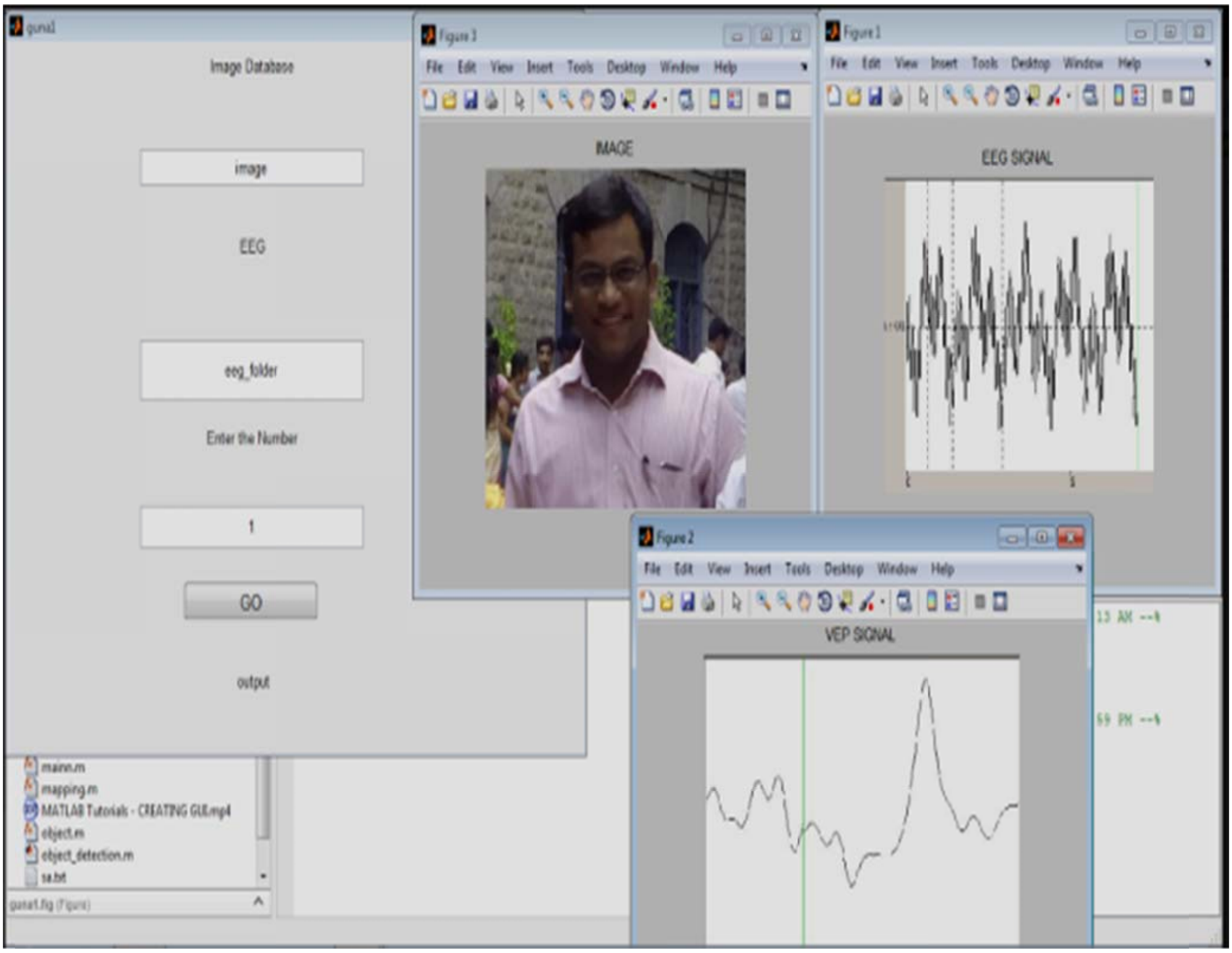

Fig. 3 Simulated result of Extracted VEP signal for Face detection

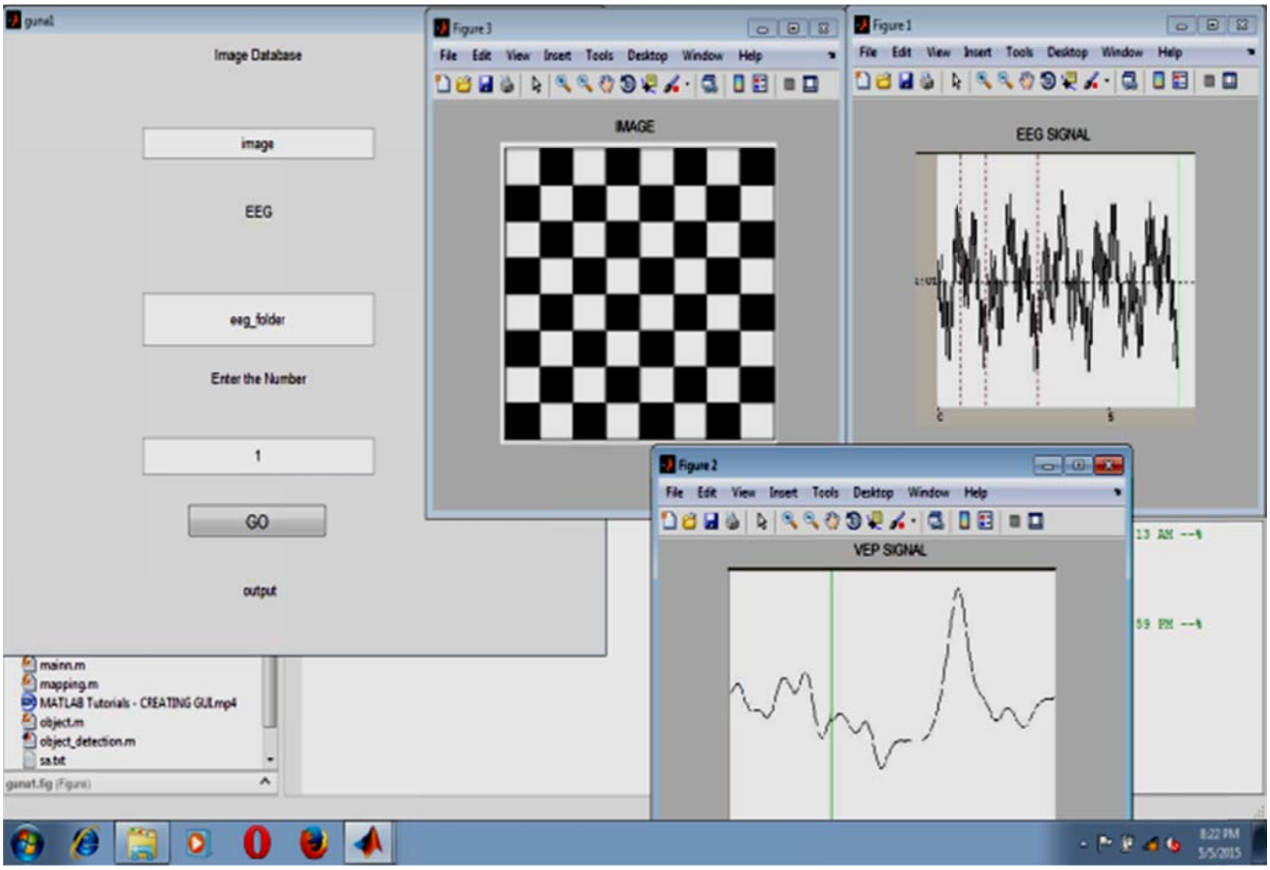

Fig. 4 Simulated result of Extracted VEP signal for Checker board

VI. Conclusion and Future Scope

A technology to enable the partial vision in visual impaired people is discussed here. Since majority of the blind people have healthy occipital lobe, we are artificially generating VEP that can be sent to the BioMEMS electrodes arrays. The BioMEMS can be implanted on human brain that precisely fires the neurons with required brain signals. The brain signals are generated by using OpenViBe software where image is captured by using photoreceptors for this purpose.

References

[1] Suraj H, Bhavyabhushan Yadav. A. V, "The use of VLSI to Generate Vision in Blind People using suitable Neuroprosthesis Implant of BIOMEMS in Brain" *IEEE Transaction on Biomedical Engineering 2011.*
[2] Mohammed Mojarradi, "Miniaturized Neuroprosthesis Suitable for Implantation into Brain*" IEEE transaction on neuro system and rehabilitation engineering, March 2009.*
[3] Mehrdad Fatourechi, Ali Bashashati, Rabab K. Ward and G. E. Birch, "EMG and EOG Artifacts in Brain Computer Interface Systems: A survey", *Clinical Neurophysiology, Vol. 118, No. 3, pp. 480-484, Mar. 2007.*
[4] Clark T.-C Nguyen, "MEMS Technology for Timing and Frequency Control", *IEEE transactions on ultrasonics, ferroelectrics, and frequency control, vol. 54, no. 2, february 2007.*
[5] Rangaraja. M. Rangayanan, "Biomedical Signal Processing Analysis. A case study Approach" *.IEEE Press.*
[6] T. Singh, "Face Recognition Based on PCA Algorithm", *Special Issue of International Journal of Computer Science & Informatics, ISSN (PRINT): 2231–5292, Vol.- II, Issue-1, pp. 221-225.*