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Eye Blink Controlled Virtual Keyboard Using Brain Signals for Autism Persons

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***Abstract* - Waste and their management become a big challenge in front of the developed. In our society there are more people suffered by paralytic diseases causes them several disabilities like they are unable to talk and unable to move physically and unable to express their everyday basic needs, but they can still use their eyes and sometimes move their heads. This Paper is working under the principle of Brain-Computer Interface (BCI)Our model helps them to type the letters using the virtual keyboard, which is displayed in the monitor, designed using python programming. This system is having core system as Raspberry Pi. The virtual keyboard contains alphabets, numbers, and some punctuations. Mouse pointer gets automatically shifted through every key; characters can be chosen by making an eye blink at a particular position of mouse pointer at a certain character. In this paper the brain wave signals are analyzed and on the basis of Eye-Blink counts, the direction of the keyboard is controlled. The basic idea of BCI is to translate user produced patterns of brain activity into corresponding commands. A typical BCI is composed of signal acquisition and signal processing (including pre-processing, feature extraction and classification).**

***Index Terms* - Brain Computer Interface (BCI), EEG, Eye blinks, Data Acquisition.**

INTRODUCTION

Motor neuron diseases like ALS (Amyotrophic lateral sclerosis) are a form of progressive, fatal, neurodegenerative disease caused by the degeneration of motor neurons, the nerve cells in the central nervous system that control voluntary muscle movement. The disorder causes muscle weakness and atrophy throughout the body as both the upper and lower motor neurons degenerate, ceasing to send messages to muscles. The patient may ultimately lose the ability to initiate and control all voluntary movement. Electroencephalograph (EEG) was first recorded by Berger In 1929 by externally attaching several electrodes on the human skull. Such signals generally deliver in indirect way information about physiological functions, which are related to the brain. Possible applications using such signals are very numerous. They are for example integrated in the design of new technological devices with embedded intelligence and allow for Brain-Computer-Interfaces. BCI is composed of signal collection and processing, pattern identification and control systems. In healthy adults, the amplitudes and frequencies of such signals change from one state of a human to another, such as wakefulness and sleep. The EEG signal of ALS patients will have the least EMG (Electromyography) artifact content (EMG is a technique for evaluating and recording the electrical activity produced by skeletal muscles). The eye event signals can be easily detected and can be effectively used as controls in BCI applications.

The main artifacts in EEG can be divided into patient-related (physiological) and system artifacts. The patient-related or internal artifacts are body movement-related, EMG, ECG (and pulsation), Sweating etc. The system artifacts are 50/60 Hz power supply interference, impedance fluctuations, cable defects, electrical noise from the electronic components and unbalanced impedances of the electrodes. There are five major brain waves called delta (δ), theta (θ), alpha (α), beta (β), and gamma (γ) distinguished by their different frequencies ranging from low to high that are listed as follows:

Table 1: Brainwave Types

Brainwave Type	Frequency range	Mental states and conditions
Delta (δ)	0.1Hz to 3Hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta (θ)	4Hz to 7Hz	Intuitive, creative, recall, fantasy imaginary, dream
Alpha (α)	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness ,agitation
Gamma (γ)	30Hz to 100Hz	Motor Functions, higher mental activity

Eye blinks are normally considered as physiological artifacts in the EEG. But if we consider in a BCI point of view, these signals, although artifacts, can be used as good control signals. Eye blink signals can be used in BCI applications like virtual keyboard while the eye close and eyes open signals can be used for folding and opening electric foldable hospital beds.

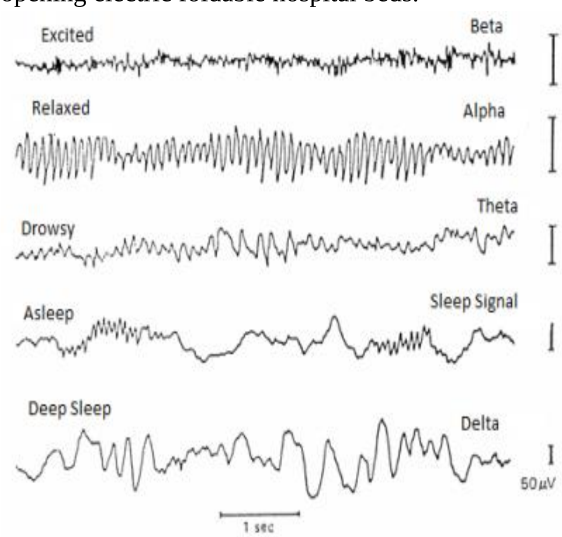

Fig 1: EEG waves [7]

II.LITERATURE REVIEW

In the paper "Emotional state classification from EEG using machine learning "[1], a very sophisticated headset was used to obtain the EEG signal from the subjects. This headset has 27 electrodes namely FP1–FP2, AF3–AF4, F1–F2, F3–F4, F5–F6, F7–F8, FC1–FC2, FC3–FC4, FC5–FC6, FT7–FT8, C1–C2, C3–C4, C5–C6, T7–T8, CP1–CP2, CP3–CP4, CP5–CP6, TP7–TP8, P1–P2, P3–P4, P5–P6, P7–P8, PO3–PO4, PO5–PO6, PO7–PO8, CB1–CB2, O1–O2. Six subjects participate in this experiment, and movie clips are used to arouse the emotions. The Russel emotional model which has two dimension of emotional use classifies the emotions as shown in Figure (2.20). The best result was with a 1s time window among four different time window periods applied which are 0.5s, 1s, 1.5s, and 2s. Three different kinds of features are extracted which are power spectrum, wavelet, and nonlinear features. However, in order to reduce the number of features, three different techniques are used to reduce the features' dimensions; these techniques are Principle Component Analysis (PCA), Linear Discernment Analysis (LDA), and Correlation-based Features Selector (CFS). Different classification algorithms are used such as Support Vector Machine with different types of kernel, Linear, polynomial, and radial basis function (RBF) kernels. The best average accuracy of classification was 91.77% obtained using an LDA classifier with 30 different features.

In the paper "Comparison of SVM and ANN for classification of eye events in EEG "[2], Biospac MP36R system is used to record the EEG signal from the participant. This headset has 4 electrodes, FP1 and F3, one electrode placed on the earlobe, and lead set SS2L connects the electrode to Channel 1 of the MP36 system. Two hardware filters are used for this configuration: one is 0.5 Hz high-pass filter, and one 1 kHz low-pass filter. A temporal window of 5 seconds is used in this paper. Three different features extracted are the Kurtosis coefficient, maximum amplitude, and minimum amplitude. Two different classifiers are used in this paper to classify three different eye events which are eyes blink, eyes close, and eyes open. The first classifier is the Support Vector Machine with different kernels which are Linear, quadratic, polynomial order three, polynomial order four and radial basis function. The second classifier is the artificial neural network with two different architectures in which the both of architectures has 4 layers which first layer refer to the input, second and third layer refer to hidden layers and the fourth layers refer to output layer. The first architecture has 3 inputs,20 nodes in first hidden layer, 10 nodes in the second hidden layer, and 3 outputs. The second architecture has 3 inputs,30 nodes in first hidden layer, 14 nodes in the second hidden layer, and 3 outputs. The best accuracy for eyes blink was obtained using SVM with a quadratic kernel which has an accuracy of 91.9%; the best accuracy for eyes close was obtained using ANN with first architecture which has an accuracy of 88.4%; and the best accuracy for eyes open event was obtained using SVM with a linear kernel.

In the paper "Real Time EEG based Happiness Detection system" [3], Emotive EPOC+ EEG headset which has 14 electrodes namely AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF42 is used to record EEG signals [8]. Ten subjects participate in these 35 experiments: 1 male and 9 females, with an average age of 34.60. The Russel emotional model which has two dimension of emotional use classifies the emotions as shown in Figure (2.20) [8]. Five trials are used in this experiment in which every trial contains happy and unhappy stimuli, and every trial has 60s of happy stimuli and 60s of unhappy stimuli. The stimuli were 10 pictures with one piece of classical music played along for 60 seconds. The pictures were obtained using the Geneva Affective Picture Database (GAPED) [29], and classical music was obtained using the Vampala and Russo method for happy and unhappy stimuli [69]. Pre-processing used a 5th order sinc filter to remove the noise power at 50Hz and 60Hz. The temporal window used in this paper was one second. Five frequency band features which are Delta, Theta, Alpha, Beta, and Gamma are only extracted using Wavelet Transform. Since Emotive Epoc has 14 channel, 70 features were obtained. Normalization was used before classification which scaled the features between 0 and 1. 600 samples were used per participant; 10 participants were involve in this experiment which has a total of 6000. Gaussian Support Vector Machine was used in this paper with average accuracy of 75.62% for subject dependent and 65.12% for subject independent respectively [3].

III.METHODOLOGY

Since the system uses Raspberry Pi, it does not require Matlab for processing the signal. Raspberry Pi which has in built Bluetooth, so that there is no need for external Bluetooth. In this proposed system virtual keyboard is designed using python programming by having Tkinter library for virtual keyboard design and Pyautogui library for mouse pointer movement.

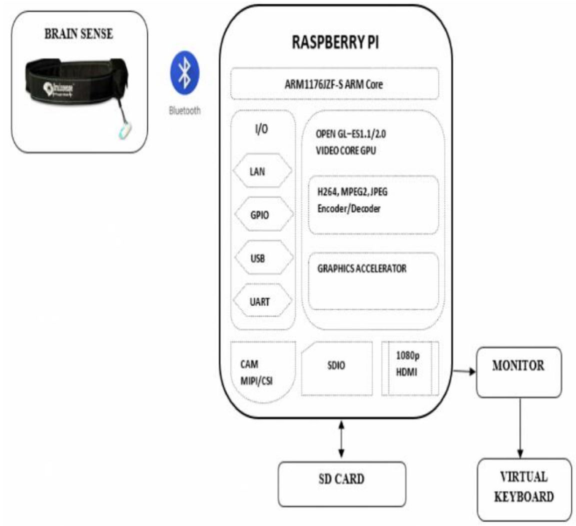

Fig 2: Block Diagram of Proposed System

A. HARDWARE REQUIRED

- Raspberry Pi
- Mind wave mobile or Brain sense

B. SOFTWARE REQUIRED

- Raspbian OS
- SD card Formatter
- Win32 disk imager

IV.HARDWARE IMPLEMENTATION

Hardware components used for this system are Raspberry pi, EEG Headset, and a power adapter. The EEG headset on head captures the brain waves from brain. The captured waves are sent to Raspberry Pi through Bluetooth. The eyeblink output is available on the virtual keypad. It can be monitored by desktop. The power for system is given using 16000mAh adapter. A rectifier circuit is used to charge the power source.

A. Raspberry Pi 3 B+:

The Raspberry Pi 3 Model B+ is the latest product, an updated 64-bit quad core processor running at 1.4GHz with built-in metal heatsink, dual-band 2.4GHz and 5GHz wireless LAN. Raspberry pi can also be used for processing the images captured by camera.

Fig. 3. Raspberry Pi 3b+

B. Power unit

The universal micro USB power supply used for Raspberry Pi. it will keep feeding your Pi the steady 2.5A it needs for proper performance. Input Voltage AC 100-240V 50/60Hz Output DC 5.0V 2500mA (2.5A).

C. Mind wave Reader

The Electronics and embedded subsystem comprise of the Neurosky's Mind wave Headset which is a portable EEG mobile headset used to pick up EEG signals from the brain of the user and transmit them to the microcontroller unit via Bluetooth. The Bluetooth module used for receiving the signals transmitted by headset is BlueSMiRF (RN-42) that is interfaced with the microcontroller used over USART. Figure 3 shows the algorithm for data acquisition by RN-42 (BlueSMiRF) from the mind wave.

The data transmitted by the Mind wave Headset will be received by the raspberry pi Computer's Bluetooth receiver. And all the data will be analyzed by the Level Analysis Platform. The Level Analysis Platform will extract the raw data using Python Program. The data will be received from the port pin which they are giving the same port number for the Bluetooth receiver.

The raspberry pi used is ARM Cortex which is a Freescale Freedom development platform microcontroller board assembly. It features a Kinetis L series microcontroller built on ARM Cortex M0+ core [11]. H-Bridge MOSFET drivers are used to drive motors. The microcontroller forms an essential part of the processing system. The microcontroller in response to the signals picked up by EEG sensors compute the direction of motion. The microcontroller outputs the processed data to the user interface and motion control systems

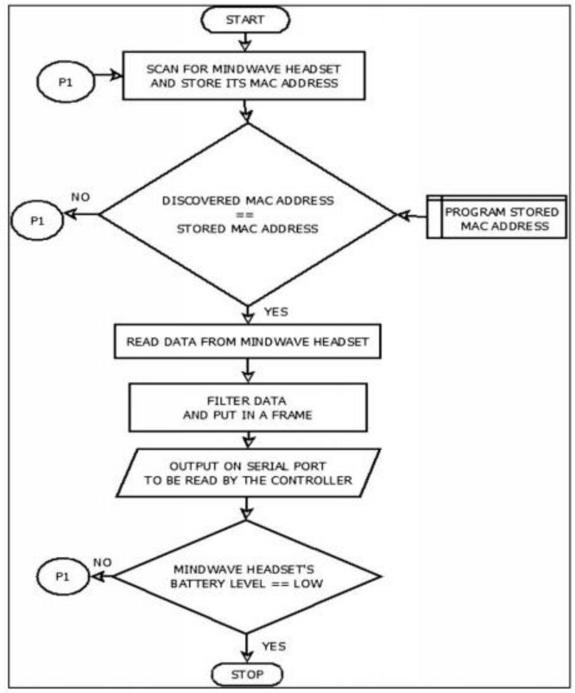

Figure 4: Data acquisition

V.SOFTWARE AND DATA PROCESSING

The EEG sensor distinguishes and increases the little electrical voltages that are created by mind cells (neurons). The frequencies most ordinarily for EEG are between 1 to 40 Hz. The EEG sensor records a "crude" EEG flag, which is the continually changing contrast of potential between the positive and negative anode, and the product forms that flag by applying an assortment of computerized channels to the recorded flag, keeping in mind the end goal to concentrate recurrence space data. The EEG flag has different recurrence groups, including the "delta" band (0.5-4Hz), which compares to rest action, the "theta" band (4-8Hz), which is identified with laziness, the "alpha" band (8-13 Hz), which speaks to unwinding and inventiveness, and the "beta" band (13-25Hz),which relates to readiness. A reduction in the power changes in the "alpha" recurrence band and an expansion in the theta/delta recurrence band demonstrates languor.

The whole idea is as described below:

1. Mind wave mobile headset is paired with raspberry pi using Bluetooth.
2. The virtual keyboard is interfaced with raspberry pi (raspberry pi is connected to HDMI Monitor)
3. The levels of attention are detected. If the attention level is below threshold, buzzer is

activated, and the Robot is stable. If the attention level exceeds the threshold value, eye blink detection is considered.

4. Based on the number of eye blinks, Virtual keyboard is controlled.

For example,

1. If eye blink count =1, Cursor is moved forward.
2. If eye blink count =2, Cursor is programmed to move left 3. If count=3, then it moves right.
3. Else if count =4, it moves backward.

Electroencephalography (EEG) equipment is becoming more available on the public market, which enables more diverse research in a currently narrow field. The Brain-Computer Interface (BCI) community recognizes the need for systems that makes BCI more user-friendly, real-time, manageable and suited for people that are not forced to use them, like clinical patients, and those who are disabled. The principle center have been building a framework which empowers utilization of the accessible EEG gadget and making a model that joins all parts of a working BCI framework. These parts are 1) getting the EEG flag 2) handle and order the EEG flag and 3) utilize the flag characterization to control a component in a framework. The arrangement technique in the venture utilizes the NEUROSKY mentality for section 1, the signs are prepared through the Python Programming and a fake neural system for ordering mind wave designs to some extent 2, and framework utilizes the characterization results to control the framework developments to some extent 3.

The objective of this paper is to pick up information in the two areas, i.e. Cerebrum Computer Interfaces, particularly techniques for examining mind waves, and the NEUROSKY EEG hardware. From this examination, a model programming application ought to be actualized that can read mind wave contribution from an EEG gadget, arrange them, and make them be a piece of the or the main, client contribution to a diversion. A basic illustration situation is as per the following: A client is wearing the NEUROSKY mentality that advances cerebrum wave signs to the product application. Keeping in mind the end goal to get general data about the client's cerebrum wave design, a progression of mental assignment situations must be executed by the client. This data will then be utilized to prepare a characterization framework so it can figure out how to perceive and, in this way, delineate mind examples to activities. The client can then begin a framework, and the arrangement framework will consistently dissect the approaching mind waves and guide them to the proper activities and in this manner control some feature(s) of the running framework.

VI.RESULTS AND DISCUSSION

The Virtual Keyboard developed is a Virtual Instrument (VI). A character selection rate of 1 character/min is obtained with the current settings. A single selection of the block is obtained in 20s, the column in the block is selected in the next 20s and the character is selected in the next 20s. Every selection by the user is accompanied by giving a visual feedback to the user by glowing the corresponding block/column/character in the Virtual Keyboard. Every selection of a character will show the corresponding character in the screen in the Virtual Keyboard.

Eye blinks are used as inputs or control signals in this BCI. The user of the BCI has to produce an eye blink in the specified time interval, i.e. 5s interval. The input is of binary nature. The BCI detects in this 5s interval whether an eye blink is present or not. A single selection can be done in 20s. In every 5s interval the user should make an eyeblink. So, in effect at the end of 20s interval the BCI will detect one of the following events.

- Single eye blink occurred
- Two eye blinks occurred
- Three eye blinks occurred

The entire alphabets (A - Z) and the space character (--) are the characters available in the Virtual Keyboard. The total 29 characters are divided into three blocks having 9 characters each.

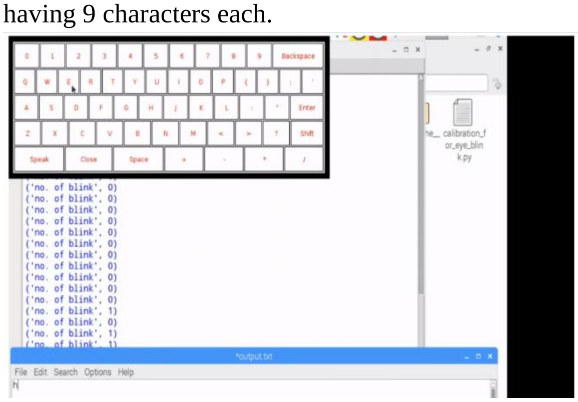

Fig 5. Selection scheme in the Virtual Keyboard

The Block 1 contains the characters A – I, the Block 2 contains the characters J – R and the Block 3 contains the characters S – Z and space (--) character. The user can select the Block 1 by producing a single eye blink. The selection of a block is accompanied by glowing the characters in the block for a small-time interval. This is considered as a visual feedback to the user. Similarly, the user can select the Block 2 and Block 3 by producing two eye blinks and three eye blinks, respectively. The corresponding block selected is glowed for a small-time interval. After the first selection the user can select one of the three columns in each block by producing the next set of eye blinks. The first, second and third column can be selected by one, two and three eye blinks, respectively. After the selection of a particular column, a particular character in that column can be selected using the next set of eye blinks. Every column has three characters. The first, second and third character can be selected using one, two and three eye blinks, respectively. After selecting a character, the entire process continues again to select the next character and so on.

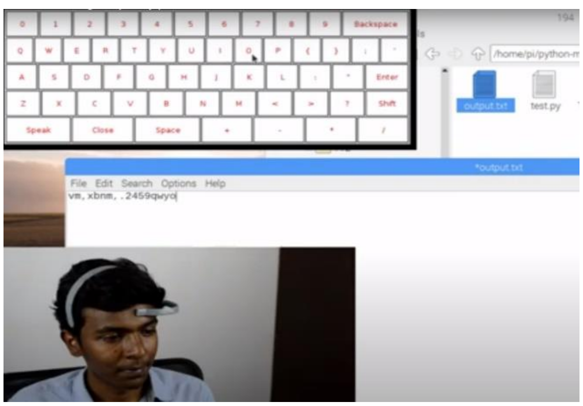

Fig 6: Experimental Setup

VII.CONCLUSION

This contribution presented a development of a BCI system, the Virtual Keyboard. Eye blinks are used as control signals in this BCI and kurtosis coefficient, maximum amplitude and minimum amplitude in a sample window are successfully used to detect the eye blinks from non-eye blink signal. The BCI developed can be used for communication purposes, which use eye blinks as control signals, especially for locked-in patients like those suffering from Amyotrophic lateral sclerosis (ALS). The innovative work of Mind-controlled framework has gotten a lot of consideration since they can take portability back to individuals with crushing neuromuscular issue and in this way enhance their personal satisfaction. In this paper, we displayed an extensive of the Mind-controlled System. This paper utilizes a cerebrum wave sensor which can gather EEG based mind signs of various recurrence and adequacy and it will change over these signs into bundles and transmit through Bluetooth medium into the level splitter segment to check the consideration level and give sound sign to driver. Further work and achievement of this exploration would prompt the advancement of mechanical frameworks that can be utilized by debilitated clients, and accordingly enhance their versatility, freedom, and personal satisfaction

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