SMART BRAIN-CONTROLLED WHEELCHAIR AND DEVICES BASED ON EEG IN LOW COST FOR DISABLED PERSON

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ABSTRACT - The proposed work is to develop a wheelchair that can assist by the disabled people in their daily life to do some work independent on others and to bring this technique into the equipments which are used by the elders at homes. The proposed system analyze the brain wave signals, and uses only single electrode headset based on EEG sensors which will monitor the EYE BLINKS, ATTENTION MODE, and MEDITATION MODE, and not going to monitor all the rays coming from the scalp, by analysing the frequencies ranges of the certain level, every human being will have different thoughts and emotions so it's enough monitor waves from forehead frontal point (FP1)alone, this mind wave headset sensor uses the Electromyography (EMG) Technique which will detect the muscle contractions that occurs while blinking the eye(i.e. rising the eyebrows or blinking)and this contraction will generate a unique electrical signal. These electrical waves will be sensed by the brain wave sensor and it will convert the raw data into packets and transmit through wireless medium. Level analyzer unit (LAU) will receive the brain wave raw data and it will extract and process the signal using MATLAB platform. With this it's possible move a wheelchair in all directions (right, left, forward, backward) and can control devices, according to the human thoughts both at attention and meditation modes, by only keeping single electrode on the forehead it is possible to do, since it's a portable headset device it can be easily operated by the elders.

Key Words: Electroencephalogram (EEG) sensor, Eye blinks, Attention, Meditation mode, BCI.

I.INTRODUCTION

Electroencephalogram (EEG) Based systems are the advanced techniques which are yet to bring into the common man life. The present system is so costly due to the no of electrodes in the electrode cap and the equipments are huge components, only hospitalized persons are provided with this for their comfortable environment, yet patients must depend on others to operate it. . Consistent with previous studies, power spectral analysis results confirm that the EEG activities correlate well with the variables in vigilance this study developed a system with a wireless and wearable EEG device, an efficient prediction model, and a real-time mobile App to remedy for disable elders. A link was established between the fluctuation in the behavioural index in brain waves and the changes in the brain activity. In this, the proposed system is going to monitor the pattern of interaction between these neurons is represented as thoughts and emotional states through EEG sensors related to BCI (Brain Computer Interface). Basically human brain will let different waves in different frequencies; this is due to neurons firing at the timing of any thought arising, i.e. if a person wants to focus on any work, or in resting mentality. BCIs are systems that can bypass conventional channels of communication (i.e., muscles and thoughts) to provide direct communication and control between the human brain and physical devices by translating different patterns of brain activity into commands in real time.

The output signal from a BCI is limited and may not facilitate direct interfacing to technologies that are controlled using conventional means, it seems that it is available up to 2 classes to eight classes BCI, and accuracy reduces as the number of classes increase [1]. Many designs based on the BCI are designed with the EEG (Electroencephalogram) systems, such as brain controlled wheelchair are present in the literature [2]-[3]. However these papers are mentions about the movements of the systems and not about the control methods applied on it to control them in particular direction or to stop them when it required. This problem is solved in the literature [4] where in this, they have mentioned about the adaptive user interface (iAUI) within the framework of adaptive shared control BCI system. BCI assistive technologies, communication and control related applications are detailed discussed in the literature [8], Brain–computer interface (BCI) technology provides a means of communication that allows individuals with severely impaired movement to communicate with assistive devices using the electroencephalogram (EEG) or other brain signals. Where future challenges are mentions as a survey by referred up to 100 papers. From the literature [5]-[6]-[7] the designed wheelchair is seems to be connected with the huge components and wired connections, with in the limited range only it is possible to move alone with the wheelchair, where the patients are with the complete electrode cap on their head, having interconnections with the entire system.

The proposed work is to develop a wheelchair which is controlled by human thoughts that can assist by the disabled people in their daily life to do some work independent on others; this will be in less cost and comfortable for the society to in take these technologies at their homes. Furthermore, the proposed system demonstrated the feasibility of predicting the disabled people's vigilance in real time. In this paper it is a detailed explanations given about the comparison of proposed system with the existing systems, event detection by mapping user's brain patterns, EEG signal extraction, simple execution of program codes simulation outputs, and conclusion of this paper.

II. METHODOLOGY

A. *EEG Signal Obtainment and Event Detection in Existing techniques*

The existing technologies use EEG based systems which consist of many no of electrodes[9]-[10] which is so costly modals used in the hospitals which is so difficult process, a huge component maintains and connections are required. The monitoring system and maintenance are also difficult and mostly this EEG technique is used in hospitals only and also is used to trace the patient's brain wave conditions. Monitoring there brain waves and detecting there concentrating towards self thoughts. The existing system is used to operate many devices, but with huge no of combinations of components and connections. Complex for a patient or a disable person to operate any devices in the home or hospital along with these many components. And also it is not necessary to monitor the waves overall the head like in existing system, with an electrode cap.

Figure (a)

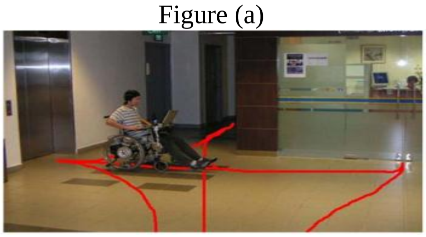

Figure (b)

Typical examples of the brain- controlled mobile robots Fig (a) From [6], Fig (b) From [7]

Drawbacks in the Existing System

No of electrodes used in a single system connection. Varieties are more in the existing systems, like operating all devices with may interfacing and electrodes. But not cost effective, more costly to develop even a single system. Mostly it has been used only in the hospitals and in richer environment. Common people can't use this technique in their home for their elderly people. Detects cortical dysfunction but rarely discloses it's etiologic. Relatively low sensitivity and specificity. Related with both electrical and physiologic artifacts. Influenced by state of alertness, focus of the person, drugs intaken. Small or deep actions might not produce an EEG abnormality. Limited time sampling (for routine EEG) and spatial sampling.

B. *Brain controlled Wheelchair and devices Setup*

The aim of this proposed system is to acquire and identify the EEG signal that is related with the user intention to operate a device in home itself, in less cost. This proposed works uses a single electrode headset (Mind wave Headset), which reduce the cost of the equipment as the society required, and to do the four operations in wheelchair such as (forward, right side, left side) without any GUI, unless the systems requires any other high level devices yet to control. Getting signal from the headset and processing and transmitting it through the wireless medium to the Laptop. The laptop gives its processed signal to the Zigbee, which is connected to it. The receiver Zigbee will receive it and gives to the ARM Processor. Which will then process and control the devices which all interfaced with it. Mostly in our homes, a disabled elders will be in need of only lights and fans to be ON and OFF frequently and sometimes TV to be ON and OFF.

Advantage of the Proposed System

Single electrode is used in this system. No complex algorithms are used. It will look like a headset which can be taken one place to another. No need of many interfaces like GUI, MUI etc. Headset and with simple Mat lab code can make execute the device through the brain waves which is monitored only from forehead where its possible to get both attention and meditation mode wave which will be in required frequencies. Only eye blink, attention mode and meditation mode are detected and programmed accordingly.

c. *Location of the sensor at FP1*

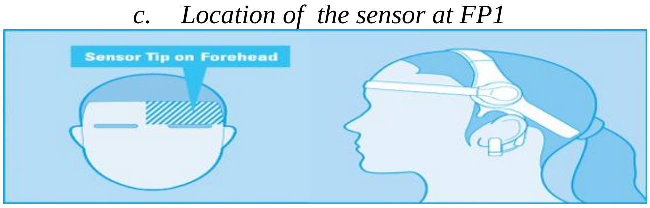

Figure 2. Brain wave sensor headset in the forehead

Our sensor placement targets FP1 (Fig.2). As this is a forehead area with reduced hairs, it offers clear EEG signals to enable the accurate delivery of raw and power band. Moreover, this location is ideal to measure higher cognitive processes including Attention and meditation algorithms. And the proximity is given to the eye, FP1 placement enables Blink detection. Instead of keeping electrode cap over entire head it's enough monitor waves coming out from forehead, since to operate any simple devices such as fan, TV, light which is readily used by elders at their homes.

D. Basic Design of the Setup

This proposed system explains the concept that how to operate devices according to our thoughts, that is using a single brain wave sensor electrode can monitor the waveform of those electrical signals which comes from the scalp of the human being. This proposed system uses the headset called think gear which have a single mind wave sensor which will senses the waves, those signals will be in very low frequencies which can be sensed only using such devices (electrodes). The signal is raw data, which is sent through the signal conditioner later, that converted signal is then passed as data packets sent through wireless medium to the laptop will get that data, and using the mind wave software which is already installed in the laptop, matlab programming will sense the no of 'EYE BLINK' produced by the person, and monitor the attention level and meditation level.

III. SPECIFICATIONS OF ELECTRODE(Sensor)

Surface electrodes such as the ones used in EEG must create an interface between an ionic solution (the subject) and a metallic conductor (the electrode). Thus it leads to a half-cell potential which can be large relative to the signal being recorded. To minimize this problem of polarization of the electrode, electrodes are coated with silver chloride, but they are conserved away from the skin through an intermediate layer of conductive paste. An electrode which is not contacting the skin very well acts like an antenna with resulting 60-cycle interference

A. Electrode Specifications

1. Maximum surface area of ~150mm2 (but less surface area is optimal)
2. Ag/AgCl, Stainless Steel, Gold, or/and Silver (both solid and plated material works)
3. EEG electrode located above the left or right eye on the forehead, Ground and reference electrodes located behind the ear or at the earlobe
4. Have enough pressure to prevent movement, with a minimum of 0.8 PSI
5. Length of less than 12 inches, the longer the higher the susceptibility to noise
6. Shielding (not necessary for the ground)
7. Thinner than AWG2

The electrode will look like a chip which have no of pins to be connected to reference voltage, ground, and raw data point.

B. TGAM: Think gear Asic Module(Electrode Module)

1. Directly connects to dry electrode (as opposed to conventional medical wet sensors)
2. EEG channel with three contacts: EEG; REF; and GND
3. Improper fit detected through "Poor Signal Quality" warning from ASIC to reset if off the head for four consecutive seconds, or if it is receiving a poor signal for seven consecutive seconds
4. Advanced filtering technology with high noise immunity
5. Low power consumption suitable for portable battery-driven applications
6. Max power consumption 15mA @ 3.3 V, Raw EEG data output at 512 bits per second

C. *Brain waves frequency that detected in EEG sensor*

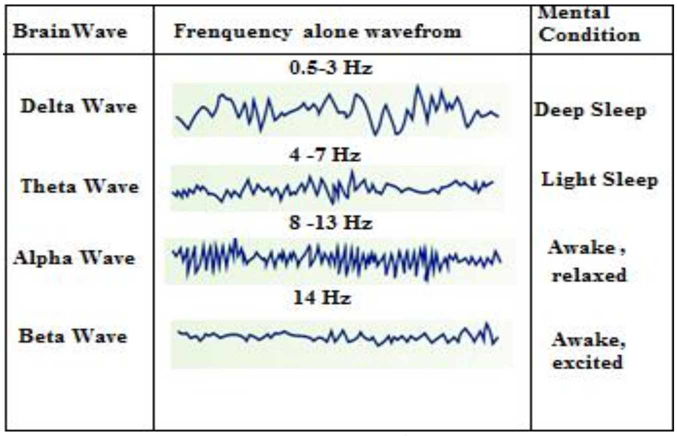

Figure 3. Brain waveforms

A rundown of the frequencies involved follows, along with a grossly oversimplified summary of the associated mental states. In addition to these power-band values, the chip provides a pair of proprietary, black-box data values dubbed "attention" and "mediation". Attention: Indicates the intensity of a user's level of mental "focus" or "attention", such as that which occurs during intense concentration shown with Beta waves in (Fig. 3). Distractions or anxiety may lower the Attention meter levels. Meditation: Indicates the level of a user's mental "calmness" or "relaxation". Meditation is related to reduce activity by the active mental processes in the brain, and it has long been an observed effect that closing one's eyes turns off the mental activities which process images from the eyes, so closing the eyes is often an effective method for increasing the Meditation meter level. Distractions, wandering thoughts, anxiety, agitation, and sensory stimuli may lower the Meditation meter levels.

IV SIGNAL ACQUISITION AND PROCESSING

Block diagram of the proposed system is shown in (Fig.4) in this electrode (Brain wave Sensor) will follow the below conversion techniques to convert the raw data to voltage

A. Conversion of Raw Values to Voltage and waveforms spike extraction

For TGAT-based hardware devices (such as TGAT, TGAM, MindSet, MindWave, and Mind Wave Mobile), the formula for converting raw values to voltage is:

[raw Value * (1.8/4096)] / 2000 (1)

This is due to a 2000x gain, 4096 value range, and 1.8V input voltage. The EEG raw values from Cardio Chip based devices must use following conversion:

(raw Value * 18.3) / 128.0 (2)

Please note the gain on actual hardware may be slightly off from 2000x (maybe +/- 5%?), but unless you need to make ultra-sensitive measurements.

Since the scalp EEG signal is very weak, typically with an amplitude range of 10~100uV, thereby requiring conditioning prior to any signal processing. Furthermore, the human skin typically provides source impedance on the order of 1~5Mohm. To acquire the signal effectively, the amplifier must match or have greater input impedance than the source impedance. In order to reject 60Hz (or 50Hz) power line interference from the signal, a relatively high Common Mode Rejection Ratio (CMRR) is desired consequence. In our design, a low power instrumentation amplifier is selected which has high CMRR of 120dB and a differential input impedance of 10Gohm || 2pF. To get the whole efficient EEG signals (frequency band about 0.1Hz ~ 100Hz), have to implement some filters to service signal filtering well. From the instrumentation amplifier, a Low Pass Filter (LPF) is employed to attenuate frequencies up 100Hz, where the cut-off frequency is 100Hz at -3dB and gives 0dB gain. Then, the signal is filtered by a High Pass Filter (HPF) to attenuate frequencies below 0.1Hz, where the cut-off frequency is 0.1Hz at -3dB and gives 40dB gain. After that, the signal goes to a 60Hz notch filter to reject 60Hz interference. Finally, the signal is gained by the 2nd non-inverting amplifier with 12dB. The operation amplifier chip used here is also a low power Operation Amplifier (Op Amp) with Rail-to-Rail input and output. The total gains of our designed signal conditioning part are about 85dB and the frequency pass band is between 0.1Hz and 100Hz, and the amplified signal voltage level can serve the Analog-to-Digital converter (ADC) well To develop a multi-channel EEG device to be used in our proposed information system, an analog multiplexer is employed for channel selection.

B. Equations for electrodes

In mathematics, EEG records at the i^{th} electrode of the m^{th} trail can be modelled as

$$y_t^q(t) = \sum_{j-1}^{r} a_{ij}^q s_j^q(t) + n_t^q(t), \tag{3}$$

where, a_{ij}^q is the transfer coefficient between a source and an electrode, q=1,… Q. t=1,…,T, and if $s_k^q(t)(k \in [1, r])$ is the desired source signal, $s_j^q(t)(j \in [1, r], j \neq k)$ is denoted as the artefact, and $r_i^q(t)$ Represents the random background Gaussian noise. Hence the average trace based is

$$\overline{y}_i(t) = \frac{1}{Q}\sum_{q-1}^{Q}\left[z_i^q(t)\right] =$$

$$\frac{1}{Q}\sum_{r-1}^{Q}\left[\sum_{j-1}^{r} a_{ij}^q s_j^q(t)\right] + \frac{1}{Q}\sum_{r-1}^{Q} r_i^q(t) \tag{4}$$

The above equations are identified for single electrode by analysing the multi channel electrodes.

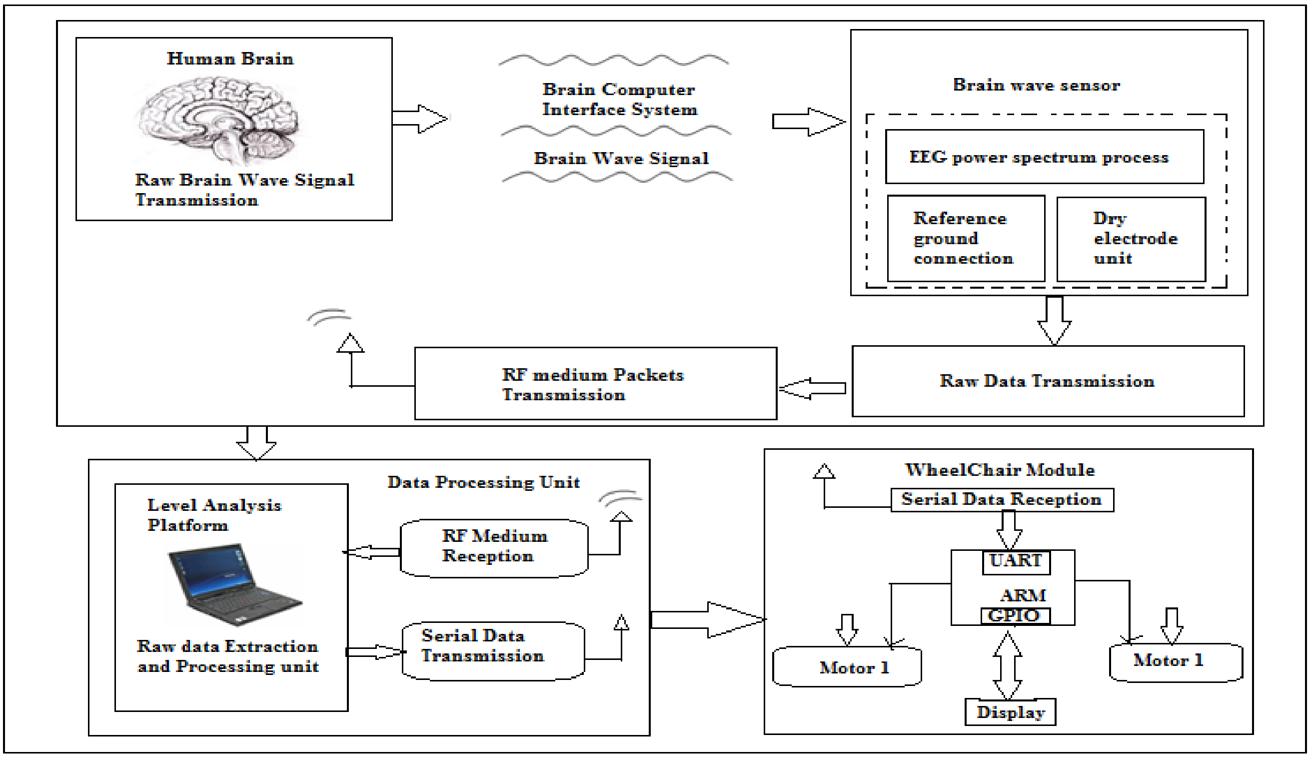

Figure 4. Block diagram

C. *Algorithm Flow for the Mat lab code execution*

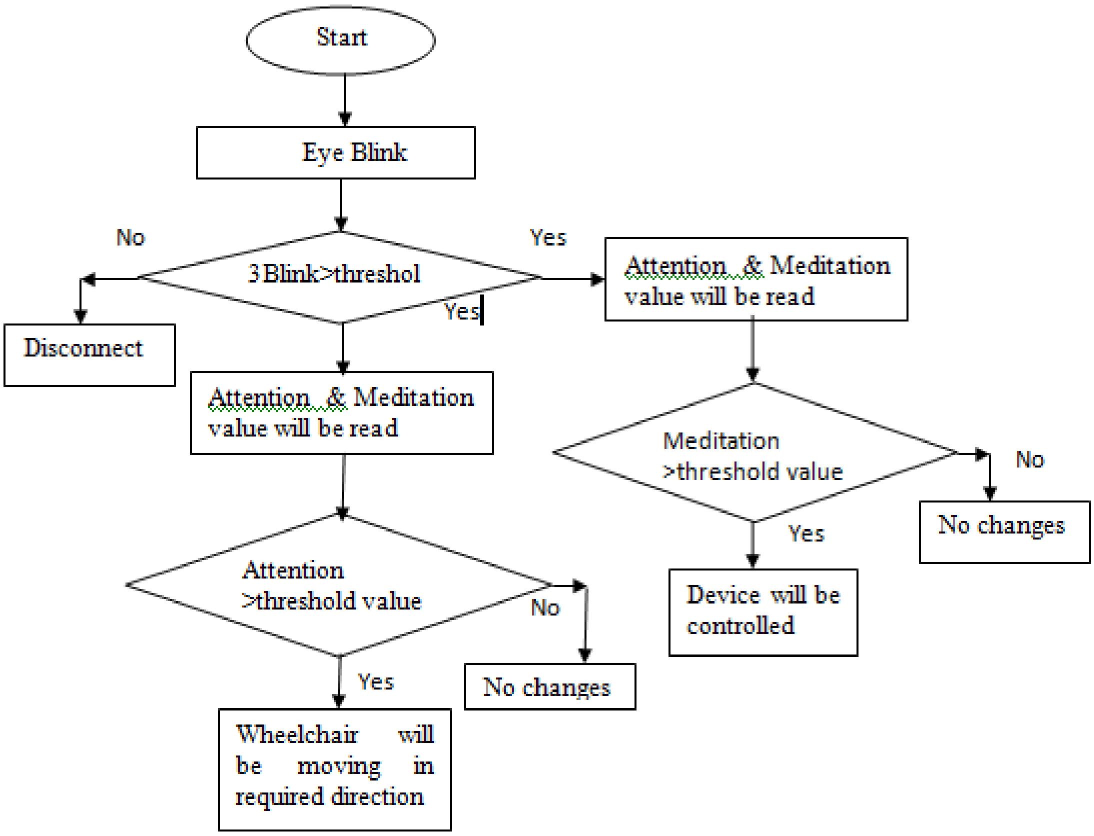

Figure 5. A Simple flow chart of the event flow and control condition

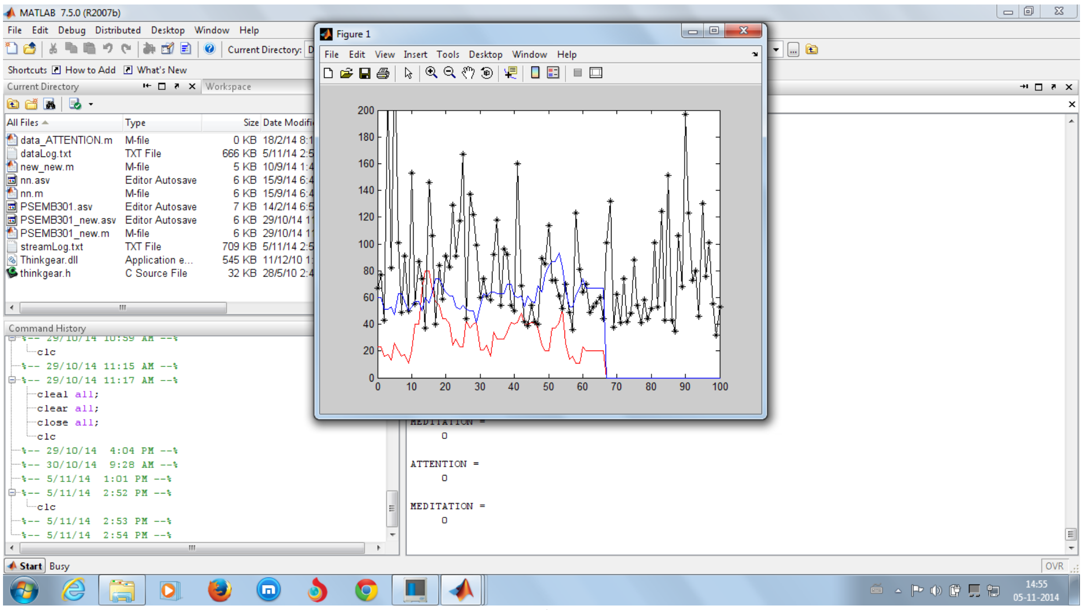

Figure 6 Detection of Eye Blink Enabled

The Black points are the eye blinks which is monitored by the sensor and plotted as graph it's shown in the figure 6

D. *Simulation Output Waveform*

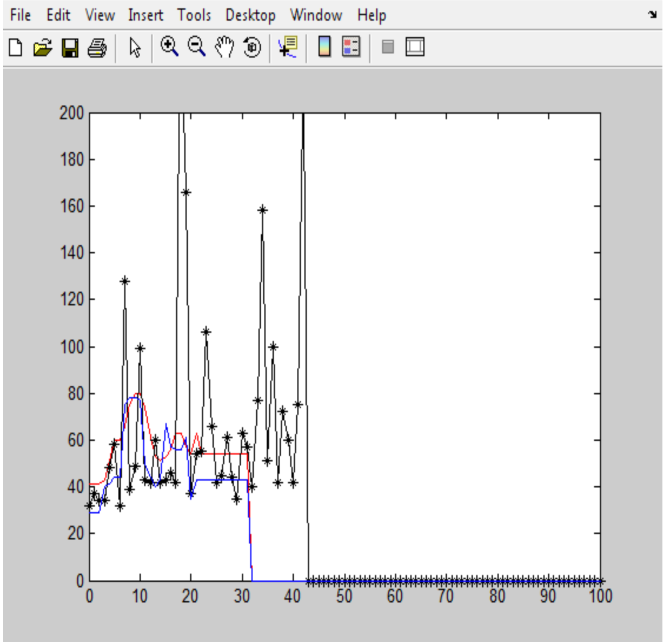

Figure 7. Eye blink detection graph

After detecting the first 3 eye blinks it will start monitoring other waves that comes out from the forehead.

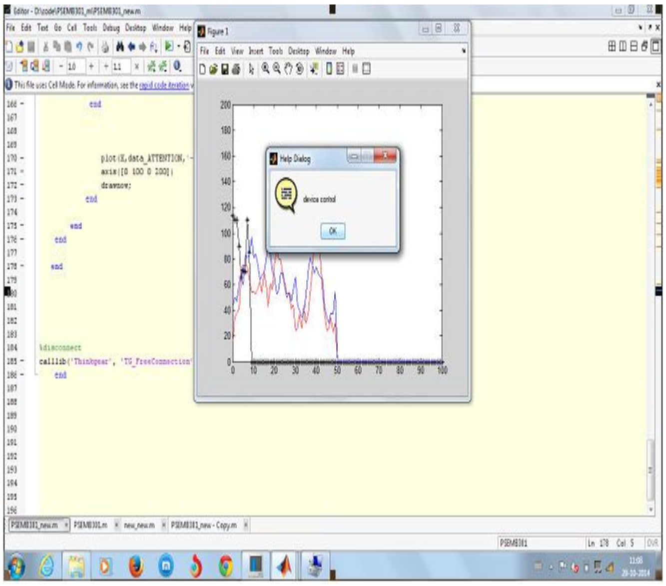

Figure 8. Attention and meditation mode waveform graph

After certain eye blinks detect enabled, other waves are detected(red waves are attention mode, black waves are meditation mode) For every 3 blink wheelchair will go forward, and for 1 blink turns to left, and for 2 blinks turns rights as programmed in matlab.

V CONCLUSION

Thus the single electrode mind wave headset can be used to monitor the eye blink (Show in Fig.,6) attention mode, and meditation mode through FP1 (Frontal point) which is placed in front of the forehead. (Fig.7) and (Fig.8) are waves. Simple flow of both the modes and control condition are shown in (Fig.5). It's more than enough to monitor the forehead signals alone where it's possible to get important waves using single electrode instead of using multi channel electrode cap for just to operate simple applications like fan, light or TV. Accordingly it can be controlled by the ARM processor. This system will be very useful to the common people and also as how society requires in low cost.

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