Brain-Computer Interface Systems for Home Automation

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Abstract- **Brain-Computer Interface is used to communicate based on human brains neural activity and its very much independent of output generated by peripheral nerves and muscles. It is avoids the use of normal muscular (hand or eye) body parts to make contact and operate the devices. The system is useful for the handicapped people which are unable to move physically. In this paper system aims to control home appliances (like bulb, fan etc.) with the help of Human Attention Level which comes under non-invasive method of brains signal measurement. This attention is being measured by Neuro Sky Headset. Attention level values are ranges from 1 to 100. Attention means user's level of mental focus which occurs during intense concentration and directed (but stable) mental activity. So, to get attention values user should observe the object (or focus onto the object). For demonstration, we are going to use one fan and one bulb.**

Index Terms- BCI, HCI, exogenous, endogenous, ECoG, VEP

I. INTRODUCTION

Human-Computer Interaction (HCI) and its advance application are very much useful in society. Another growing development in HCI is the concept of a direct Brain Computer Interface (BCI). [1] The aim of BCI is to improve the quality of one's life, and its full potential has been improved definitely. The BCI system have many other utilities in different areas like video gaming, robotics, communication etc. unlike the other researches which are mainly focus on only disabled people. Also, many challenges arise in the development of such systems[2]. The type of brain signals used as data, data acquisition methods, the algorithms which are used to translate the collected data, the hardware which facilitates user control, the type of feedback the user receives when executing commands, and the characteristics of the users themselves these are very much important factors which affects the BCI system.[3],[4]. Hence, future improvements in BCI systems require structured, well-controlled studies which give us the comparative signals combined signals and different methods of signal acquisition, for various kinds of users.

II. OVERVIEW & COMPARISON OF DIFFERENT BCI SYSTEMS

BCI divided into several categories: independent or dependent, invasive or noninvasive, and exogenous or endogenous. Classification on BCI development, presenting the various types of current BCI that fit into their respective categories.

A. Independent VS Dependent

Independent and dependent BCI systems are distinguished by how reliant the system is on additional types of activity while in working state. This type BCI systems are not dependent on any physical body parts; its does not required any other signals to get EEG signals from brain to run certain commands[18].The example is, the word or letter from the text have to choose by user and thinking deeply.

When the letters flash, the user produces a P300 potential, allowing for the user to select the currently lit letter. Because of the system, the user was able to select a specific letter by looking at it. Furthermore, the users selected letter is determined by the highest recorded potential which is hi/her VEP and its recorded by visual cortex of each flashing letter. The signals are generated by users thinking but for doing the task the EEG signals are used.

B. Invasive Vs Non Invasive

The two systems, Invasive and noninvasive BCI systems are differs from each other's by the method of extraction. The first Invasive BCI requires implanting foreign materials into the subject's body. This type of things may include large electrode setups or chemical molecules. The BCI systems are improvised by different types of freedoms and used different signals to control the system, for large time of recording the BCI system faces difficulties in sustaining because of they use the electrodes in cortex. The signals are degraded in the process because of the electrodes used in cortex of the system [23]. Also, the small changes in the locations of the electrodes can move the recording sites away from the areas which are recorded very easily. Because of the low signal-to-noise ratio of EEG signals. Also, ECoG is expected to be safer and have a greater stability in the long-term, compared to the mentioned approach above.

Furthermore the BCI systems Classify, non-invasive BCIs can be classified as “evoked” or “spontaneous”. This BCI depends heavily on evoked potentials, which reflects the immediate automatic responses of the brain to some external stimuli. Using the scalp electrodes it is easy to detect the evoked potentials. Also, Slow Cortical Potentials (SCP) are also sometimes used in evoked BCI systems. The need of external stimulation does, not allowed the evoked potentials are applied for some tasks.

Unlike the other types, the cognitive process is used by spontaneous BCI systems freely because it eliminates the need for external stimulation. This type of a method is especially beneficial when controlling robotic devices. From all signals some are spontaneous BCI may depend on are event related de/synchronization (ERD/ERS) and Steady State Evoked Potentials (SSEP).

C. Exogenous Vs Endogenous

The exogenous or endogenous are types of BCI systems, depending on the nature of the recorded signal. In this type of systems the neuron activity evoked is done by external stimuli. VEPs or auditory evoked potentials BCI systems are used in this system i.e. Exogenous do not require intensive training since it is easy to setup their control signals (SSVEPs and P300). It’s shown with a single EEG channel, capable of an information rate of up to 60 bits/min.

At the other side, endogenous systems do not rely on an external stimulus; it is based mainly on brain rhythms and other potentials. Training the users using neuron feedback usually does this. A period of the training varies by subject as well as the experimental strategy and training environment. Technique chosen for the experiment determines how the user learns and what they must do to produce the required brain activity patterns. Grumman et al describes two approaches for endogenous systems: Operant conditioning and performance of specific mental tasks.

The strategy used in calibration- free robotics, the same strategy used in this type of system [22]. IN different, motor imagery is the most common mental work used to produce brain patterns that can be trustily generated and distinguished. The image of motor is activated through the imagination of changes of limbs. The users have to perform such mental tasks without physically executing the corresponding movement. Doing so produces de-synchronization (ERD) and event-related synchronization (ERS) [24].

III. SYSTEM DESIGN

A. Objective of system

1. To capture EEG waves using sensor.

Here, to capture the EEG signals coming from the brain the sensor is used. This sensor called as EEG sensor and it coming with the headset.

2. To store waves in temporary file & pre-process it

The EEG signal recording of the EEG sensor is done with the software coming with sensor .There are different kind of software’s available in the market for it. The software shows the amplitude and meditation variation while recording the signal.

3. To extract features of EEG for Typical Activity.

The feature extraction of EEG signal for different activities is done by the MATLAB. We have to generate MATLAB codes for every feature

4. To analysis activity base variation on number of subjects. For this purpose we need to consider as many signals as possible. To analysis activity base variation for different subject need to analyze features of the signal

5. To classify features for home automation.

For this purpose we need to consider the different activity useful for home automation. Next we have to record EEG signals for it and record the different activity signals as possible as times. Then have to extract the features for each signal and analyze it properly.

B. Methodology

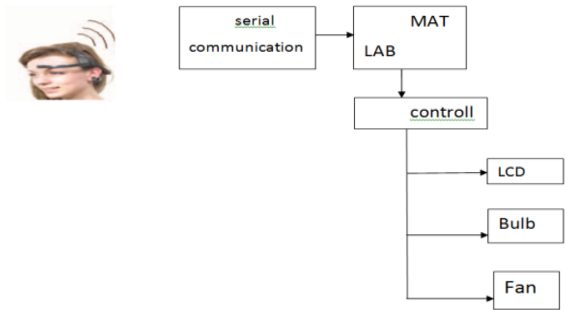


Figure1. Block Diagram

The block diagram for proposed system is shown in Fig. 1.

1)Signal Acquisition: The Neuro Sky Mind wave sensor is brainwave sensing headset which uses a medical probe to capture patterns and translate them to PC for further use with computer development platforms. Neuro Sky Mind wave contains single sensor to make the contact on users forehead. This Mind wave device consists of a headband, an ear clip and sensor arm. The headsets reference and ground electrodes are on the ear clip and the EEG electrode is on the sensor arm, resting on the forehead above the eye. It uses a single AAA battery with 8-10 hours of battery life[7]. The headset image is shown in Fig.2.

2) Bluetooth: The acquired signal from headset is transferred through Bluetooth to personal computer.

3) MATLAB: Here the MATLAB is used to process the EEG signals which sensor detects. The MATLAB based application we are going to developed . Here the SVN/ANN is used for deciding respective thought.

3.3. Structural Block Diagram:

1. Input waves: These waves are captured by the sensor and send it to the MATLAB for further processing.
2. Feature Extraction: Here we use the MATLAB tool for features extraction of the Brain waves like kurtosis, frequency, skewness, deviation frequency etc.

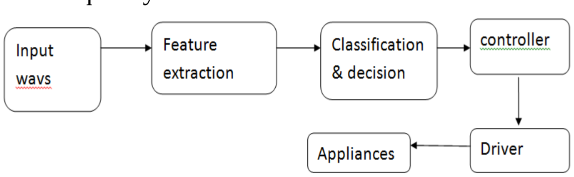


Figure 2: Structural block diagram of system

3. Classification & Decision: The SVM or ANN techniques are used for deciding respective thought.

4. Controller: It is used to control the appliances which we are going to used for home automation using the BCI

THETA - 3.5 - 7.5 Hz (creativity, falling asleep)

ALPHA-8-13Hz (relaxation, closed eyes)

BETA - 14 - 30 Hz and more (concentration, logical and analytical thinking, fidget)

GAMMA - greater than 30 Hz (simultaneous processes)

IV. SYSTEM IMPLIMENTATION

A. EEG Sensor

Here we use the EEG sensor of Brain sense the figure shows the view of it

Technical specifications:

- Uses the TGAM1 module, Dry Electrode and Ear clip electrode
- Automatic wireless pairing
- 6-hours battery run time
- Bluetooth v2.1 Class 2 (10 meters range).
- iOS and Android suppor

Figure 3: EEG sensor

V. RESULTS ANALYSIS

At this stage the working of the project is nearly half done. The sensor is from Brainsense for recording of EEG signals is purchased. The neuroview software for recording of the EEG waves is installed and studded well. This software also gives the amplitude and meditation variation results also. For pre-processing of the EEG signals also this software is used.

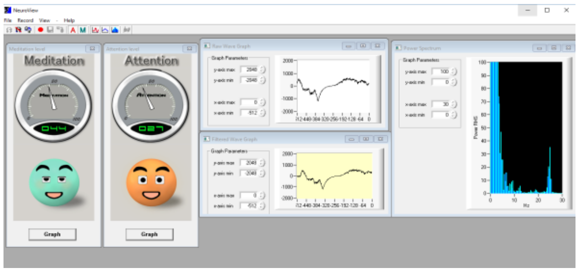
A. Recorded Signal Analysis:

The neuroview software records different EEG signals for different activity of the brain. These signal are further processed by the MATLAB for feature extraction and get the different features like frequency, skewness, kurtosis, mean frequency etc.

The results of !0 different thought from the brain are processed by MATLAB coed and gives the following resulted features,

a. First signal recording with different parameters&

b. Second signal while blinking the eyes:



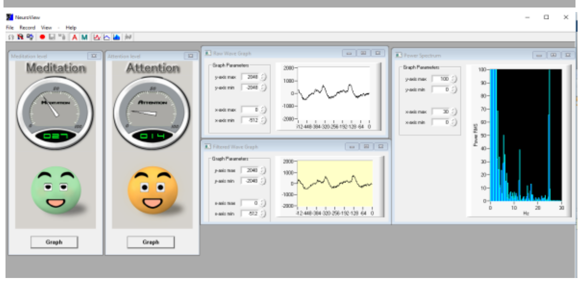


Figure4: EEG raw signal recording

Figure 5: Recording of signal while blinking the eyes

B. Features Extraction of different signals:

We extracted the features of different signals in the form of frequency, mea frequency, kurtosis and skewness.

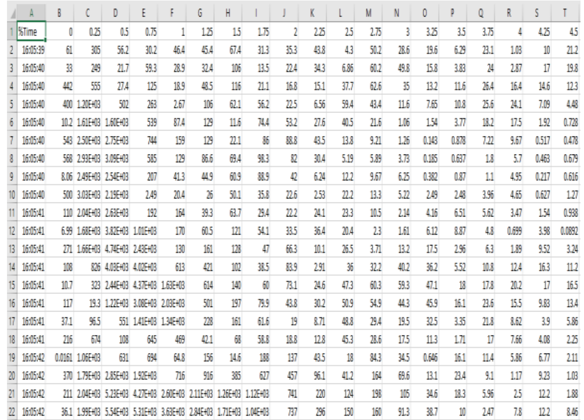
The mat lab results for these features are:

Thought	Kurtosis	Skewness	Frequency
To drive scooter	4.625196	-0.132637	128.000000
To turn on Lamp	3.825380	0.151134	128.000000
To drive car	4.490902	0.168848	128.000000
General Thought	6.013063	0.076580	128.000000
To turn on Lamp	3.317827	0.161856	128.000000
To turn on Fan	1.669615	0.138617	128.000000
To turn off Fan	1.672952	0.134423	128.000000

*C. EEG recorded signals***:**

Figure 6: EEG recorded signals

D. Attention levels of raw signal with respect to time:



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	%Time	0	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5	2.75	3	3.25	3.5	3.75	4	4.25	4.5
2	16:05:39	61	305	56.2	30.2	46.4	45.4	67.4	31.3	35.3	43.8	4.3	50.2	28.6	19.6	6.29	23.1	1.03	10	21.2
3	16:05:40	33	249	21.7	59.3	28.9	32.4	106	13.5	22.4	34.3	6.86	60.2	49.8	15.8	3.83	24	2.87	17	19.8
4	16:05:40	442	555	27.4	125	18.9	48.5	116	21.1	16.8	15.1	37.7	62.6	35	13.2	11.6	26.4	16.4	14.6	12.3
5	16:05:40	400	1.20E+03	502	263	2.67	106	62.1	56.2	22.5	6.56	59.4	43.4	11.6	7.65	10.8	25.6	24.1	7.09	4.48
6	16:05:40	10.2	1.61E+03	1.60E+03	539	87.4	129	11.6	74.4	53.2	27.6	40.5	21.6	1.06	1.54	3.77	18.2	17.5	1.92	0.728
7	16:05:40	543	2.50E+03	2.75E+03	744	159	129	22.1	86	88.8	43.5	13.8	9.21	1.26	0.143	0.878	7.22	9.67	0.517	0.478
8	16:05:40	568	2.93E+03	3.09E+03	585	129	86.6	69.4	98.3	82	30.4	5.19	5.89	3.73	0.185	0.637	1.8	5.7	0.463	0.679
9	16:05:40	8.06	2.49E+03	2.54E+03	207	41.3	44.9	60.9	88.9	42	6.24	12.2	9.67	6.25	0.382	0.87	1.1	4.95	0.217	0.616
10	16:05:40	500	3.03E+03	2.19E+03	2.49	20.4	26	50.1	35.8	22.6	2.53	22.2	13.3	5.22	2.49	2.48	3.96	4.65	0.627	1.27
11	16:05:41	110	2.04E+03	2.63E+03	192	164	39.3	63.7	29.4	22.2	24.1	23.3	10.5	2.14	4.16	6.51	5.62	3.47	1.54	0.938
12	16:05:41	6.99	1.68E+03	3.82E+03	1.01E+03	170	60.5	121	54.1	33.5	36.4	20.4	2.3	1.61	6.12	8.87	4.8	0.699	3.98	0.0892
13	16:05:41	271	1.66E+03	4.74E+03	2.43E+03	130	161	128	47	66.3	10.1	26.5	3.71	13.2	17.5	2.96	6.3	1.89	9.52	3.24
14	16:05:41	108	826	4.03E+03	4.02E+03	613	421	102	38.5	83.9	2.91	36	32.2	40.2	36.2	5.52	10.8	12.4	16.3	11.2
15	16:05:41	10.7	323	2.44E+03	4.37E+03	1.63E+03	614	140	60	73.1	24.6	47.3	60.3	59.3	47.1	18	17.8	20.2	17	16.5
16	16:05:41	117	19.3	1.22E+03	3.08E+03	2.03E+03	501	197	79.9	43.8	30.2	50.9	54.9	44.3	45.9	16.1	23.6	15.5	9.83	13.4
17	16:05:41	37.1	96.5	551	1.41E+03	1.34E+03	228	161	61.6	19	8.71	48.8	29.4	19.5	32.5	3.35	21.8	8.62	3.9	5.86
18	16:05:41	216	674	108	645	469	42.1	68	58.8	18.8	12.8	45.3	28.6	17.5	11.3	1.71	17	7.66	4.08	2.25
19	16:05:42	0.0161	1.06E+03	631	694	64.8	156	14.6	188	137	43.5	18	84.3	34.5	0.646	16.1	11.4	5.86	6.77	2.11
20	16:05:42	370	1.79E+03	2.85E+03	1.92E+03	716	916	385	627	457	96.1	41.2	164	69.6	13.1	23.4	9.1	1.17	9.23	1.03
21	16:05:42	211	2.04E+03	5.23E+03	4.27E+03	2.60E+03	2.11E+03	1.26E+03	1.12E+03	741	220	124	198	105	34.6	18.3	5.96	2.5	12.2	1.88
22	16:05:42	36.1	1.99E+03	5.54E+03	5.31E+03	3.63E+03	2.84E+03	1.71E+03	1.04E+03	737	296	150	160	91.3	38.7	10	2.47	7.8	12.2	8.46

Figure 7: Attention levels

VI. CONCLUSION

The Brain computer interface for home automation system is working on the brain signals coming from the users mind while thinking of something. The brain waves are recorded in the form of Attention Levels from the Brainsense EEG sensor. We check different signals coming from brain for different thoughts, and conclude the difference in the features for different activity thoughts. The Brainsenses sensor is very easy to use and also the Neuroview software also very easy to operate and record the signals.

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