

The Home Automation System Using Brain Computer Interface

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Abstract

There are a few people endured by Home Automation, a lack infection which causes them immobilization of their body parts, they are not ready to move, talk, and a few people can't move even their head. Commonly, various electronic appliances in our home can be operated with the help of a remote or an on/off switch. But, this is not possible for the disabled people as they cannot move their body. So, for these individuals mind sensor is a boon. The Mind wave sensor takes a shot at the guideline of BCI (Brain Computer Interface) which screens EEG waves from Brain. It secures mind flags and makes an interpretation of them into directions that are handed-off to yield gadgets that complete the ideal activity. It depends on EEG. EEG – Electroencephalography which screens the Electrical property of the Brain along the Scalp (Non-intrusive). An EEG records cerebrum wave designs. Little plate (Electrodes) are set on the scalp, and afterward impart signs to a PC to record the signs. Electrical movement in the mind makes a conspicuous example. Our work helps them to operate various home appliances with the aid of eye blink. Our work is having a core system as Arduino. In this system, priority is set in order of light and fan. We can add more appliances by giving furthermore order of priorities.

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1. Introduction

These days, humans have fantasized to connect and communicate with devices through their actions or thoughts. Humans also wish to have gadgets that work with the human brain. Human Brain imagination is transformed into modern science fiction stories and ancient myths. Although, the technique of Brain Computer Interface and Neuro Imaging have now begun to supply individuals with capacity to interface with the human mind. With the use of sensors, the physical activities that happen inside the mind and the type of actions can be observed. For the requirements of individuals in developing society, analysts have utilized this innovation to build Brain Computer Interface(a connection between the brain and the computer), communication systems, i.e., a system that doesn't rely upon the nervous system of the brain and peripheral muscles. BCI is utilized to produce a straightforward

communication channel between the human mind, i.e., user's thoughts and a computer system. This communication channel can help two kinds of people, firstly the people with disabilities who cannot move their body. These people can utilize the BCI technology to operate various appliances with the help of their brain waves. Secondly, for healthy people, it can be an additional advantage that can help in improving the quality of life and increasing the efficiency of tasks. Among various techniques involved in the non-invasive acquiring of the large scale electrical signals from the brain, electroencephalography is utilized and has magnificent outcomes, which empowers real time connection between the human mind and the PC through Brain Computer Interface. Electroencephalography alludes to a mind wave observing technique which will record the activity happening at the outside of the cerebrum by utilizing electrodes or sensors placed on the

scalp of the mind. EEG acquires electrical waves from the brain in voltage vacillations. This activity will be displayed on the screen of the computer which is connected to electrodes embedded in the brain as waveforms of frequency and the varying amplitude. BCI is a technology that detects the electrical activity in the human brain in the form of EEG signals; and interprets these particular features of the signal that shows the purpose of the operator in the form of computer understandable commands. These commands can be utilized to manage any electronic gear. This technology is growing quickly, as it has countless uses, the most significant of which is improving the lifestyle of individuals in general and old and handicapped people

particularly. The Brain Computer Interface can be separated into three different kinds-Non-invasive BCI, Semi-invasive BCI and invasive BCI. In invasive BCI technique, an Integrated Circuit is embedded in the human brain with the help of surgery. So, individuals commonly prefer non-invasive BCI because it includes just wearing of a headset(EEG sensor) which consists of a single electrode system. In our work, the main motive is to make a human brain managed - The Home Automation System. We use the Neurosky brainwave sensor to acquire signals from the brain. These signals are then transferred through a Bluetooth medium to the PC. The Discussion of various type of brainwaves on the tabulation 1.1

Tabulation 1.1: Types of Brainwaves

Mindwave Type	Range of frequency	Mental state of humans
Delta (δ)	0.5Hz to 2Hz	Deep, Dreamless sleep, Transcendental meditation, unconscious.
Theta (θ)	4Hz to 7.5Hz	Deep meditation, light sleep, Intuitive, creative, Twilight state ,fantasy, imaginary, dreams.
Alpha (α)	7.5Hz to 12Hz	Deep relaxation, non drowsy state, calm,free from disturbance.
Low Beta	12.5Hz to 16Hz	Active concentration, relaxed state, fast idle, anxious thought process.
Beta	16.5Hz to 20Hz	Thinking state, awareness of ourselves and the environment, High engagement
High Beta	20.5Hz to 30Hz	Alert state, Agitated, Highly complex, High anxiety.
Gamma (γ)	31Hz to 100Hz	Information is passed rapidly, high mental activity, cognitive functioning, learning, memory.

2. Literature Survey

[1] In this paper, “a Zigbee-based Home Automation system is presented”. This system is combined with the internet network with the help of a residential gateway. This gateway provides a basic and easy to understand interface, with network compatibility. A remote access to the system is additionally provided.

Disadvantages of the system are: Small range, less efficient, low data transfer rate, high upkeep cost and also lack of a complete solution.

[2] This research work highlights the capability of “Full Home Control, which is the objective of Home Automation Systems in the future”. This work includes analyzing and implementing of the home automation technology with the help of “Global System for Mobile Communication (GSM) modem” to operate the household devices like bulb, fan, TV, etc. through the messaging service. The proposed work depends on “functionality of GSM protocol”, which will enable the user to operate home appliances by using the frequency bandwidths.

Disadvantages of the system are: Qualcomm has protected most of the GSM technologies. So, if the user

wants to access these technologies, licenses must be obtained from Qualcomm. In order to increase the coverage, repeaters need to be installed. GSM provides restricted rate capacity, for higher rate, advanced version devices are used. GSM generally utilizes FTDMA access scheme. In this process, different clients share the same bandwidth. So, this will cause an obstruction when more users will use the GSM service. To avoid this problem, robust frequency correction algorithms are used in cell phones and base stations.

[3] In this work, the clients in their home can control diverse home machines using PDA. The inherent program available in the android market is used to control the gadgets inside the home. Now, this will make utilization of different gadgets like light, fan, etc. and the controlling hardware for preparing different remote association between the cell phone and home devices utilizes Bluetooth module. All the client needs is an Android cell phone, which is easily available these days and a control circuit.

Disadvantages of this system are: Restricted range because of bluetooth. The range can be increased by using the web in place of Bluetooth. But, this technique won't

be financially savvy. This system is also less effective in a noisy environment.

[4] Smart home innovation can boost the quality of life for individuals living in their homes. This innovation permits the people to control any electric gadget in their home locally or remotely through a computer supported centralized control. Regardless of the advances in smart home innovations, individuals with disabilities - especially those individuals with tetraplegia, - will not be able to use currently available techniques. So, Brain Computer Interface based Home Automation Systems are powerful control instruments for people with disorders; as it permits them to adapt and adjust with the already existing technologies. In this system, Emotiv EPOC+ is used in acquiring brain signals.

Disadvantages of the system are: Emotiv EPOC+ is very costly. EPOC+ electrodes must be placed delicately on the scalp for proper functioning.

[5] In this paper, the major motive is to develop a “smart home system”(and the thinking mechanism behind it). The smart home is designed in order to boost the living experience of the people with disabilities, based on logic, Brain Computer interface and portable sensors. There exists a large number of individuals who, because of either their age or conditions, for example, immobility/lack of motion lose their capacity to deal with their own lives. So, for those individuals this system can be very helpful. In this paper, ideas such as “epistemic logic and logic of trust” are utilized. It is to enable communication by means of a brain wave sensor between individuals and heterogeneous agents.

3. Proposed System

The proposed approach helps the people with physical disability to control home appliances using Electroencephalogram signals (EEG). The proposed approach has mainly three steps and is given below.

- Capturing and identifying the EEG signal
- Filtering of input signals and Feature Extraction
- Device control

In this system, signals are acquired from the brain using EEG sensor in the form of waves. These signals are converted in the form of packets and are sent to the MATLAB through the Bluetooth module. EEG signals are then filtered to remove the unwanted noises and the feature extraction takes place. With the help of communication protocols, the signal will be sent to Arduino. Arduino is the micro controller that distributes the power to bulb and fan using relay switches based on the signal received from MATLAB. Relay is connected with the Arduino and also it is connected with input and output pins of the Arduino. These relay pins are connected with bulb, fans and other home appliances. By using MATLAB software more numbers of output can be connected.

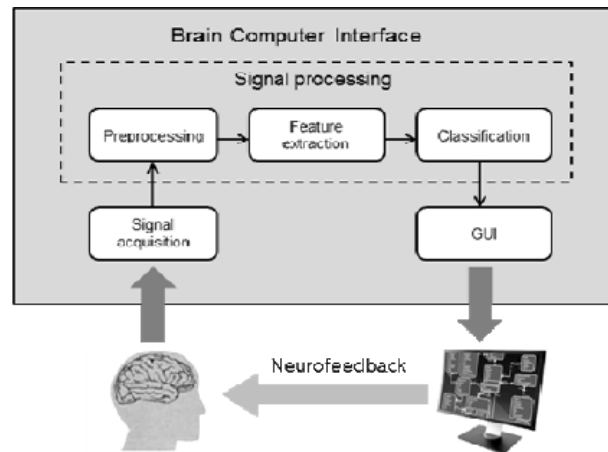


Figure 3.1: Architecture Diagram of Home Automation System

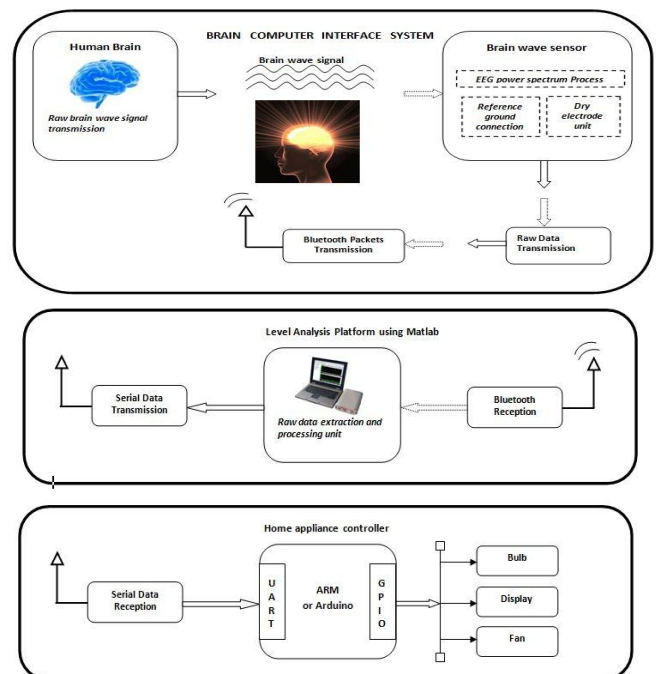


Figure 3.2: Block Diagram of Home Automation System

4. Methodology

4.1 Brain Computer Interface

Brain Computer Interface is defined as a means of transmission between the mind and the PC. The mental state of any individual changes according to the situation he is facing, which causes in change of signals acquired from the brain. The BCI framework distinguishes the signals acquired from the brain and then converts them to a control signal which can be utilized to govern the movement of a wheel seat, operating a computer game, Folding and opening electric emergency clinic beds, etc. The major goal of BCI is to enable a totally stifled patient to speak with their condition.



Figure 4.1: NeuroSky Brain Sensor

4.1.1 Signal Acquisition

Process of acquiring EEG Signals from the brain is called Signal Acquisition. The NeuroSky sensor (the brain wave sensor) is a mind wave detecting headset. It is used to capture patterns from the brain and transfer them to the computer for additional utilization with PC development applications. The brainwave sensor includes a single electrode that is mounted on the operator's forehead. The brainwave detecting gadget comprises of a headband, an ear clasp and sensor arm. The headband is placed on the user's forehead. Ground electrodes are placed on the ear clasp so that the ear acts as "ground" for the system to work and the brain wave detecting EEG electrode is present on the sensor arm, placed on the head above the left eye. It utilizes one triple-A battery that can work for 7 to 9 hours. The brainwave sensor provides raw data in addition to two values such as attention values and meditation values that can be seen in Neuroview software. Attention level values demonstrate the client's psychological concentration and meditation level values shows the client's psychological smoothness.

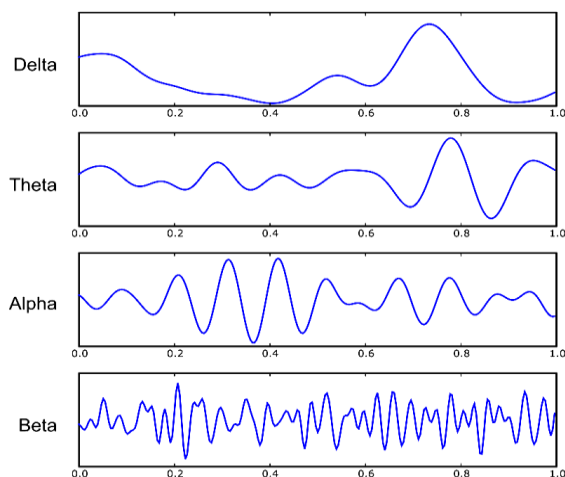


Figure 4.2: Types of Mind Waves

4.1.2 Filtering of EEG Signals and Feature Extraction

Feature extraction is a method for reducing the amplitude in which a primary group of raw data is decreased to a much smaller possible category for processing. An attribute of these large data groups is that it retains substantial measures of factors that require plenty of

computing resources to process. Feature extraction is used to choose and join factors into features. Hence, it lessens the measure of information that is required to processed, while still precisely and entirely describing the initial data.

The signals acquired from the brain along with the user's state of mind and various factors involved in acquiring signals, make the linear classification of brain wave data almost impossible. To get notable discrimination, the proposed technique extricates an enormous number of independent features by enlarging the feature space to acquire a wide margin of inter-class segregation and to reduce the intra-class variation.

Fourier Transform is used in Feature Extraction. The advantage of Fourier Transform is that it can calculate the frequency for a particular time period. Within a time period the amplitude of the signal waves varies constantly, Hence, the normal frequency formula cannot be used.

$$\int_{-\infty}^{\infty} f(x) e^{-2\pi i k x} dx.$$

4.1.3 Device Control

In this project a person's consolidation level and blinking level are used to switch on/off any appliance. Initially, we have to perform a check to determine whether the sensor is connected or not. Once the information has been obtained about the sensor's connection we need to enter into the MATLAB for checking the blinking levels of a person. Then, the brain wave sensor must be placed on the forehead of the operator. The signals from the brain will be acquired by this sensor. The signals are then further transferred by the use of Bluetooth. The data regarding the blinking levels can be used to operate any of the electrical appliances. Now if the user wants to operate any electronic appliance he needs to concentrate his mind. If the user concentrates his mind and the Beta waves (16-31Hz) are being generated, the brain emits signals whose frequency is more than 18 Hz, then this frequency will get locked and the particular device can be switched on/off.

5. Hardware Required

5.1 Mind Wave

The Mindset, Mindwave, and Mindwave Mobile are largely remote gadgets used to record EEG. Each of three gadgets use indistinguishable chips. Likewise, the gadgets utilize a similar dry sensor technology. The Mindset utilizes Bluetooth to transmit information, and incorporates a Bluetooth dongle for PCs without an implicit Bluetooth collector. The Mindset is perfect with PC, Mac, and Android. The Mindset additionally incorporates Bluetooth stereo sound information, has an amplifier, and can be utilized as a hand's free gadget. Mindwave and Mindwave Mobile do exclude these

highlights, yet as an exchange off, require a littler impression.

5.2 Arduino UNO

The Arduino Uno is a micro controller board based on ATmega328P. It is an open source micro controller in nature and has 14 automated bits, 6 direct data sources, 16 MHz resonator, a USB support alongside an In Circuit Serial Programming title and a reset button. The Arduino power supply can be done in two ways: with USB chord or an external power supply.

Arduino has an operating voltage of 5 volts and is used in basic circuit designing.



Figure 5.1: ARDUINO UNO Board

5.3 Laptops and Pc

Laptops and Pc which commonly have a dainty LCD screen plays a major part in the Home Automation System. The MATLAB software and Arduino IDE are installed in the laptops. By running the MATLAB code, GUI is displayed on the screen. There are virtual buttons in the GUI , with the help of these buttons the user can switch on or off any electronic gadget with the help of an eye blink.

5.4 Bluetooth Module

Like everything else in your PC, Bluetooth requires both equipment and programming. A Bluetooth connector supplies Bluetooth equipment. On the off chance that your PC didn't accompany the Bluetooth equipment introduced, you can undoubtedly include it by acquiring a Bluetooth USB dongle. Pick Hardware and Sound, and afterwards pick Device Manager.

A USB-based gadget that transmits and gets Bluetooth remote signs. It connects to the USB port to assist the Bluetooth mice, consoles and other Bluetooth gadgets. Additionally, called a "Bluetooth Module." See dongle. Bluetooth connectors are small and scarcely jut in excess of a half inch from the USB attachment. In the figure 4.2 HC-05 Bluetooth module is used to transfer signals from one end to another.

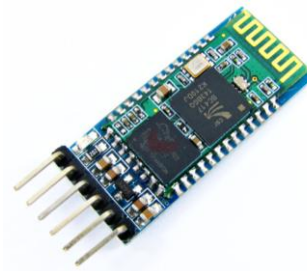


Figure 5.2: HC-05 Bluetooth Module

5.5 Relay Module

Relay module is a hardware equipment which is utilized for the switching operations of remote devices. It is majorly used for controlling gadgets over a system or the Internet. Gadgets can be remotely turned on and off with the help of commands conveyed over a network. The network can be LAN or WAN. A Relay is a device which is electrically operated with the assistance of an electromagnet. The electromagnet is implemented with small voltage, from a micro controller, and it pulls a contact to make or break a high voltage circuit.

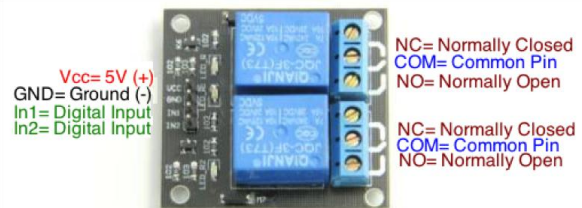


Figure 5.3: Relay Module

6. Software System

6.1 MATLAB

MATLAB is a predominant language for specific figuring. It facilitates recognition, calculation, perception, and programming in an easy to use condition, where problems and arrangements are imparted in commonplace scientific documents. Some common uses include:

- Mathematics and calculations.
- Algorithm headway.
- Modeling, amusement, and prototyping.
- Data assessment, examination, and creating observations.
- Scientifical uses and structuring illustrations.
- Application progression, including graphical UI building.

6.2 Arduino IDE

Arduino IDE is an open source software which is generally used to create and orchestrate the program in the Arduino Module. In case of Arduino programming, the code assembling is very simple, and even an average person with no prior technical knowledge may consider going forward with the learning method. The advantage of Arduino IDE is that it is successfully available for

working on systems like MAC, Windows, Linux and runs on the Java Platform that goes along with built-in limits and expect a critical activity for researching, changing and aggregating the code. An extent of Arduino modules include Arduino Uno, Arduino Mega, Arduino Micro, etc.

Arduino has a micro controller on the board which is truly customized to recognize the information as a code. The standard code, in any case known as the IDE Sketch, will finally deliver a Hex File. This file is then transferred and uploaded to the micro controller. The IDE is basically comprised of two fundamental parts: Editor and Compiler. The editor is used to create the vital program and the compiler is used to organise and move the program to the Arduino Module. This IDE bolsters both C and C++ languages.

7. Results and Discussion

In our designed system, A MATLAB GUI is designed which contains the virtual buttons of home appliances. When the user wears the EEG sensor and the system goes live by clicking on the start button in the MATLAB GUI, the real time application of the Home Automation System can be seen when the user blinks his/her eyes while looking at the virtual buttons in the GUI. By blinking the eyes on the bulb button, it will be switched ON. After that the control will be passed to the fan button. User may choose to blink or not on any button, in this case the control will be passed on to the next button in the span of 4 seconds. By clicking on the Stop button, the system will stop working.



Figure 7.1: Attention and Meditation levels as seen in Neuroview Software.

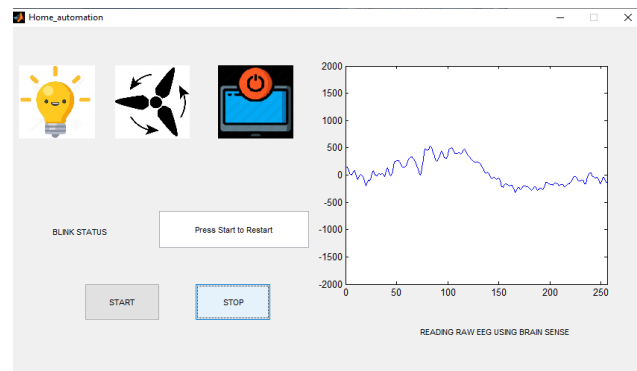
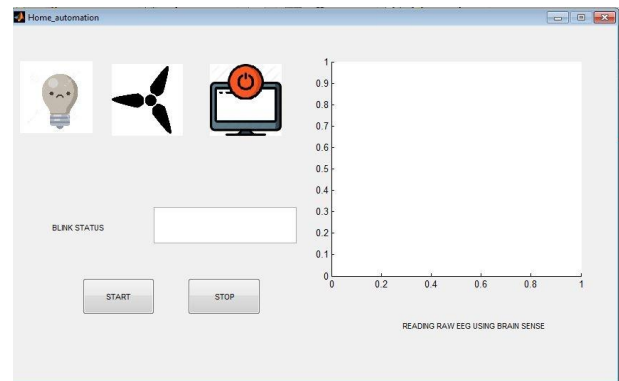


Figure 7.2: GUI Window for Home Automation

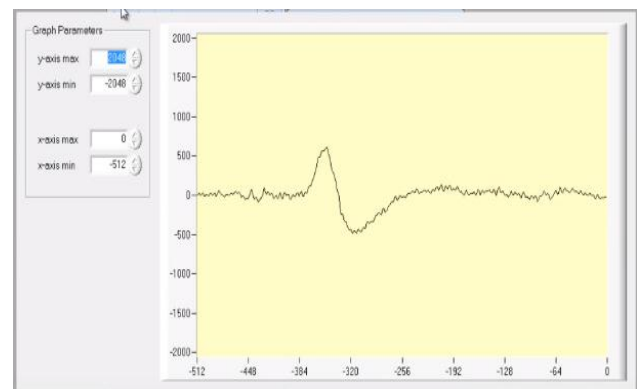


Figure 7.3: Graph for Amplitude levels of EEG waves of the user. The peak in amplitude levels denotes an eye blink.

8. Conclusion and Future Work

Brain Computer Interface utilizes brain waves in the form of raw EEG signals, acquired with the help of the brain wave sensor to control various electronic appliances like fan and bulb. We check for threshold value to operate the appliances. We are using the brain wave sensor because it is easy to use and will be very beneficial for the disabled people. The headset and the sensors are completely harmless and safe for the user. We just have to place the headset properly on the forehead check for the connection status using Neuroview software. If the sensor is connected properly then we can proceed further.

Further this system may be used to control

movements of a prosthetic limb. It can also be used in medical, neuro ergonomics, neuro marketing, educational and self-regulation, and also in security and authentication fields. This system can be operated easily and the BCI technology is very beneficial for the people as most of the work is done by the brain. BCI investigate expects to re-establish upgrade neural highlights of the focal sensory system by connecting it to a PC framework.

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