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RESEARCH ARTICLE

EEG BASED SMART HOME AUTOMATION USING NON-INVASIVE BRAIN-COMPUTER INTERFACE APPROACH.

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Abstract

The main aim of this paper is to control the physical devices like home appliances using Electroencephalogram (EEG) signals. The objective of this paper is to help the paralyzed and physically disabled people to control the home appliances, so they become independent in their daily life. The BCI is abbreviated as Brain-Computer Interface, is considered as a recent and a unique transmission medium between the human brain and a computer. EEG signals are associated with the virtual and reality system to control the home appliances. This approach offers an alternative communication and the control system and is referred as an artificial system that circumvents the human body's normal adequate pathways, which are the neuromuscular output channels. Here, non-invasive Brain-Computer Interface approach is used. The NeuroSky brainwave sensor is used to sense the brain signals and the eye blink. The ARM7 processor is used as a main interfacing device. According to the eye blink values and the brain attention values the devices will be selected and through relays the switching on and off of the home appliances are done accordingly.

Introduction:-

A concept on smart home application and development includes various implementation techniques and is ever growing. Smart home systems are created based on analysis on client needs and budget to cater for the system. With technologies available today, efficient integration of this system could be achieved. Home automation is a new concept that encompasses the ability to control electrical and electronic devices at home remotely thus providing ease of access to the users. This concept may be applied in various manners to fit the requirement of a smart home. Originally, smart home technology was used to control environmental systems. The Brain-Computer Interface technique is treated as a communication system that serves the person to operate the devices by using his or her own thoughts. The data flows from brain to the outside machinery or from outside machinery to the brain. Different research groups have examined and used different methods to achieve this. All these method uses electroencephalography (EEG) signals which are taken from the scalp. The different brain states are the outcome of the various arrangements of neural interaction. These pattern leads to the waves that are characterized by various amplitude and frequency values.

EEG is the most studied non-invasive interface, which provides temporal resolution, ease of use, portability and low set-up cost. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain. Neurons or nerve cells are the building blocks of the brain. Nerve cells interact and communicate information through electrical signals. This creates a neural pathway for information flow or a neural network. The way in which these pathways are arranged can account for our thoughts and emotions. Every thought or emotion, thus have their own unique pattern. Therefore these patterns can also be caused by muscle contraction of the eye blink and can be detected by brain wave sensor. A brain wave sensor then transmits the data buy using the Bluetooth medium. Then the Level Analyzer Unit (LAU) receives the data packets and processes them. MATLAB is used for this process.

Using this process we can control physical devices from thoughts and muscle contractions of an eye i.e., eye blink muscle contraction values.

Brainwave Types:-

Brainwaves are detected using the brainwave sensor and is placed on the scalp. The brainwaves are divided into different types according to their bandwidths to describe their functions and the different states of the human mind. EEG measures voltage fluctuations which are resulting from ionic current within the neurons of the human brain. The Table I describes the different types of brainwaves and their frequency ranges.

Table I:- Summary of the Different Types of Brainwave

Brainwave Type	Frequency Range	Mental States and Conditions
Delta	0.1Hz to 3Hz	Dreamless sleep, unconscious
Theta	4Hz to 7Hz	Creative, recall, imaginary
Alpha	8Hz to 12Hz	Relaxed but not drowsy, conscious
Low Beta	12Hz to 15Hz	Relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self and surroundings
High Beta	21Hz to 30Hz	Alertness, agitation
Gamma	30Hz to 100Hz	Higher mental activity

Brain-Computer Interface Types

The brain-computer interface (BCI) in its scientific interpretation is a combination of several hardware and software components trying to enable its user to communicate with a computer by intentionally altering his or her brain waves. There are three types of Brain-Computer Interface approaches. They are:

- Invasive BCI
- Partially invasive BCI
- Non-invasive BCI

In invasive BCI approach, the brainwave sensor chip is implanted directly onto the grey matter of the human brain during neurosurgery. Invasive devices produce the highest quality signals of BCI devices but this method is prone to scar-tissue. In the partially invasive BCI approach, the brainwave sensor chip is placed inside the skull but rests outside the grey matter of the human brain. This method produces a better resolution signals. In the non-invasive BCI approach, the brainwave sensor chip will be placed outside the skull i.e., on the scalp. Here, dry electrode will be used to sense the brain signals and a reference electrode ear clip is used for the reference point. The non-invasive technique is used for a much variety of the applications, since the brainwave sensors for the non-invasive BCI method are easy to wear and do not require any surgery as it is in the invasive and partially invasive methods.

Material and Methods:-

The brain signals are used for different applications. A Human-Machine Interfaces (HMIs) based on EMG signal and EEG signal was proposed in [1]. In [5], the brain waves are used to detect the driver drowsiness. When the driver starts driving the car, the brainwave sensor unit calculates the eye blinking level and also compares the driver's present attention value with the recorded minimum attention value. When the eye blinking value crosses the set point, the driver gets an alert. In this paper brain signals with their attention values and the eye blinking values are used to control the home appliances such as lights and fans. There are various techniques implemented and used for the home automations. In the proposed system, a NeuroSky brainwave sensor [7] is used to analyze the EEG signals. The BCI is a direct communication pathway between the human brain and an external device. According to the human thoughts i.e., the brain attention values the physical devices are operated. Brain wave sensors are still not used in hospitals, but used in the interface of brain and computer (BCI) and neural-feedback. The way in which these pathways are arranged can account for our thoughts and emotions. Every thought or emotion, thus have their own unique pattern. These patterns can also be caused by muscle contraction of the eye blink and can be detected by brain wave sensor. A brain wave sensor then transmits the data by using the Bluetooth medium. The BCI technique is a straight path for communication between the brain and the home appliances to provide control between human brain and home appliances by converting patterns of brain action into directions in real time. Also it provides to analyze the stress. The BCI section is as shown in the Fig. 1.

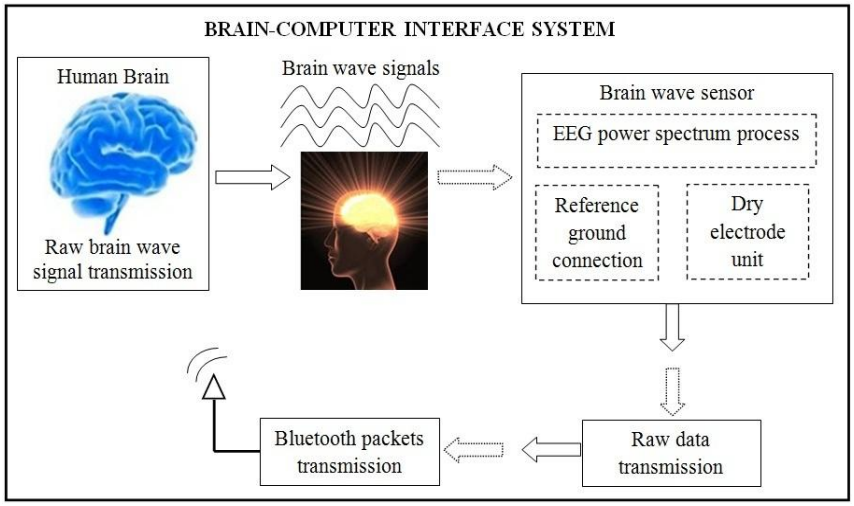

Fig. 1:- Brain-Computer Interface section

The level analyzer unit (LAU) will receive the brain wave raw data and it will process the signal using MATLAB platform which is shown in data processing unit in the Fig. 2.

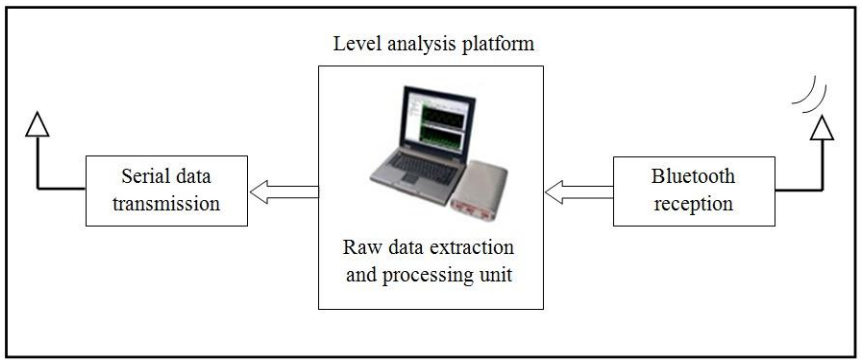

Fig. 2:- Data processing unit

In the data processing unit, for processing the data we use DSP processing i.e., MATLAB. Here the Visual Basic software is used along with the MATLAB because, 179 bytes of huge data will be receiving from the brain sensor and sending these data to the MATLAB and meanwhile these data i.e., the attention and the eye blink values should be sent to the hardware part. So the data transmission rate in visual basic is comparatively greater than that of the MATLAB. The form is created in the visual basic with two captions Device 1 and Device 2. The processed data is transmitted to the controller section serially using UART. The control commands will be transmitted to the home appliance controller as shown in the block diagram for further processing.

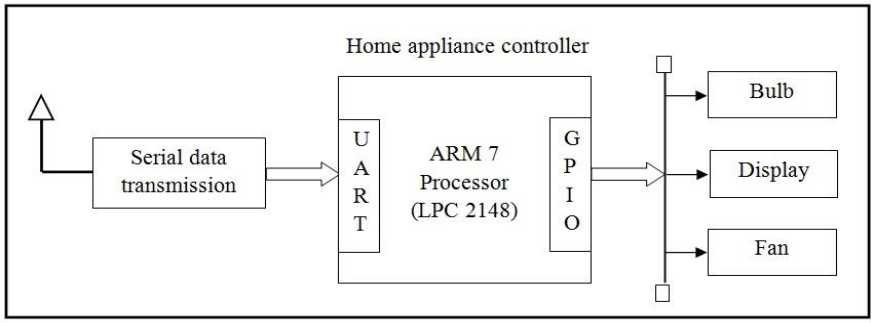

Fig. 3:- Controller section.

Result and Discussion:-

The proposed system is implemented and the desired results are obtained in controlling the physical devices using brain signals. The experimental set up of the proposed system is shown in Fig.4 and the EEG signals that are sensed

by the brainwave sensor are checked using the Brainwave Visualizer application. Initial steps are done and after giving the Run command in the MATLAB, the Form of the Visual Basic is displayed when the eye blink value detected is 60. According to the number of eye blinks i.e., either one eye blink or two eye blinks the particular device is selected. Depending on the attention value device is switched on and switched off.

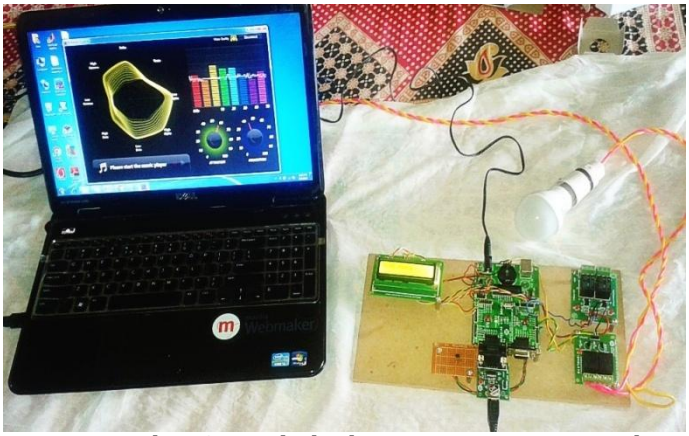

Fig. 4:- Project set up and EEG signals displaying in Brainwave Visualizer application.

The approximate values of attention level of the brain and the values of eye blinking are obtained in the command window of the MATLAB for the purpose of better understanding. The snap shot of the values obtained is as shown in the Fig. 5.

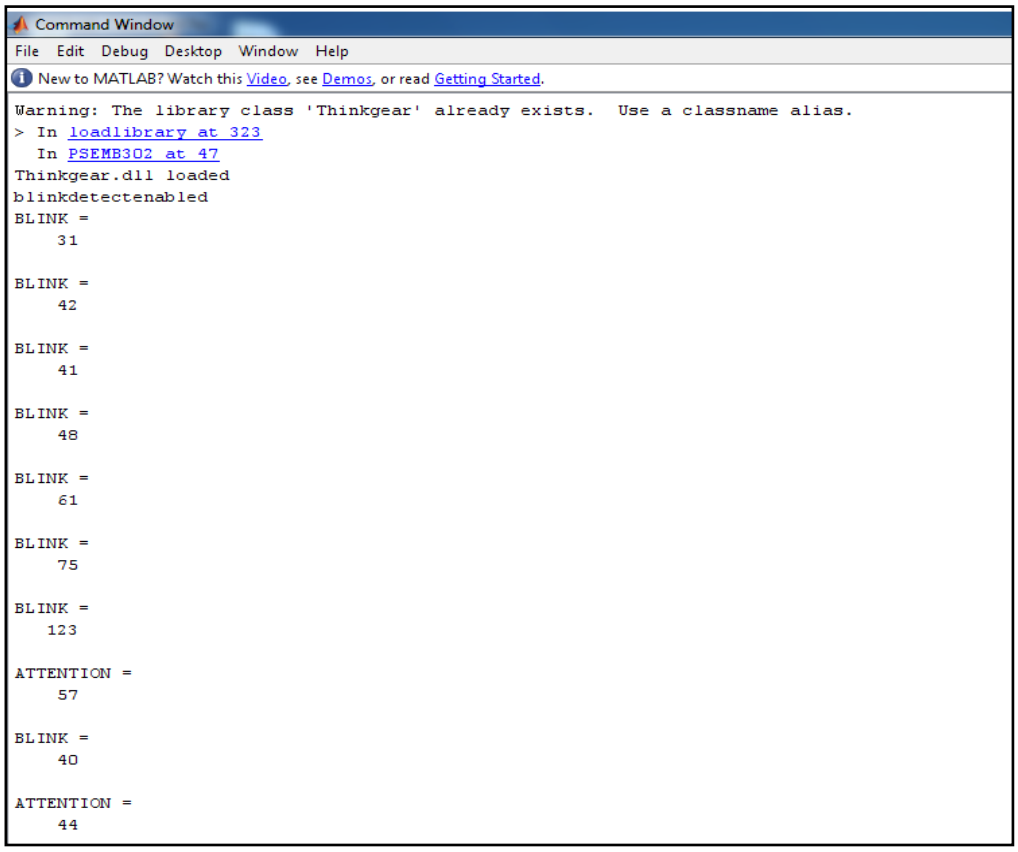

Fig. 5:- Eye blinks and brain attention values.

The non-invasive BCI is an emerging technique which is still under research. This paper presents the design and implementation of non-invasive type of Brain-Computer Interface technique to control the home appliances using EEG based brain signals. It includes NeuroSky Brainwave Sensor with a dry electrode and a reference ear clip so

that usage of gel is not necessary as it is used in wet electrode for connecting the sensor electrode to the scalp. This paper works on the brain signals for controlling the physical devices, so the paralyzed and the physically disabled people can independently do their work like switching on and off the lights and fans by their own .Whereas, in existing techniques remotes are used for controlling purpose. In the future, this technique can be used to replace the whole manual control system in industries and in risk environments with the human mind control.

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