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A Review on Brain Wave Signal Appliance Control

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Abstract: ***Brain Computer Interface systems are the tools that have been put forward to help the disabled people who are inadequate of retorting to a computer using brain signal. The development in home automation is moving forward towards the future in creating the ideal smart homes environment. Optionally, home automation system design also been develop for certain situation which for those who need a special attention such as old age person, sick patients, and handicapped person. A brain–computer interface (BCI), often called a mind-machine interface (MMI), or sometimes called a brain–machine interface (BMI), it is a direct communication pathway between the brain and an external device. Most research investigating BCI in humans has used scalp-recorded electroencephalography or intracranial electrocorticography. The use of brain signals obtained directly from stereotactic depth electrodes to control a BCI has not previously been explored. In this paper, we present a smart home automation system using brain–computer interface. BCI is becoming progressively studied as the way users interact with computers because recent technological developments have led to low priced, high exactness BCI devices. These systems that can detour conventional channels of communication (i.e., muscles and thoughts) between human brain and corporeal devices, to provide undeviating communication and sway, by recasting different patterns of brain activity into commands in real time. The device tested in this paper is called Neurosky Necomimmi Brainwave Cat Ears, which is an electroencephalograph (EEG) measuring device and enables the measuring of brain bustle. With the help of this, we are analyzing the brain wave signals. Human brain has millions of interconnected neurons. The interaction pattern between these neurons is represented as emotional states and thoughts. This pattern will be changing as the human thoughts change, which in turn produces different electrical waves. These electrical waves will be sensed by the brain wave sensor and it will convert the data into packets and transmit via Bluetooth medium.***

Keywords: Brain Computer Interface (BCI), Neurons, Brainwave sensor, Electroencephalogram (EEG), Neurosky, and Arduino.

I. INTRODUCTION

BCI is used to communicate based on human brains neural activity and it is very much independent of output generated by peripheral nerves and muscles. Typical BCI equipment that utilizes EEG to measure brain activity is expensive and requires expert knowledge to setup and use. The signals generated by brain are received by the brain sensor and are divided into packets and the packet data is transmitted to wireless medium (Bluetooth). The wave measuring unit will receive the brain wave in raw data format and it will convert it into signal. Brain-computer interface is nothing but the interaction between the human brain system and machines. It is a control system which enables the people to communicate and control a device by mere thinking. BCI collects the information from the brain and give commands to computer interface at the same time and operate different appliances. This is an electrical activity that records brain waves from scalp of the brain. For decades, humans have been dreaming to communicate and interact with machines via thoughts itself and moreover expectation was always that the devices will be able to reveal human brains, feelings, meditation as well as attention. Neurosky Mind wave logs the wearers mental state in the form of NeuroSky's embedded properties like Attention and Meditation. People with cerebral palsy, which have their cognitive function preserved, but are unable to communicate, or move or both require technological learning aids.

II. LITERATURE REVIEW

The literature of review of the topic was done in order to find the past work done in this field of study and hence a number of such works are briefed .The Brain-Computer Interface (BCIs) system serves the disabled people. The various brain computer system and applications that have been developed with different time span and a brief description of the work is discussed in this section.

A. The common spatial patterns (CSPs) are the most widely used algorithm for the EEG Classification by Stationary Matrix Logistic Regression in Brain– Computer Interface [4]. The CSP aim is to present the discriminative spatial projection with the belt power characterization of signals. There are two significant drawbacks for the CSP-based method. Initially, the

classification algorithm LDA and the feature extraction algorithm CSP modify different detached functions. Second, the intrinsic non stationarity of the EEG signals recording in a single session tends to worsen the classification performance with the primary CSP-based method. The divergence-based framework for common spatial patterns algorithms [5].

B. The divergence-based framework just allows catching different unchangeability and employing details from other substances. Hence, it combines the currently suggested many of CSP alternatives in a principled manner. As well as, it permits scheming novel spatial filtering algorithms by including usual schemes into the accumulation process or appealing different severances.

C. A Kullback–Leibler (KL) CSP is favored, in which the linear spatial filtering algorithm is used to withdraw characteristics that are robust and inflexible. In opposite, the recommended KLCSP algorithm simultaneously maximizes the variances between the class means and it also minimizes the within-class differences which are unhurried by a loss function [6].

D. Bayesian learning for spatial filtering in Brain–Computer Interface based electroencephalography (EEG). However, there is no established hypothesis for spatial filtering that directly links to Bayes classification error. In order to report this problem for spatial filtering, a Bayesian analysis theory in correlation to Bayes error is proposed [7].

E. The stationary standard spatial patters for brain-computer interfacing. This method is not only appropriate to Brain signals using EEG but also to the censorious modeling of the innovative standard beyond BCI [8].

F. In iterative spatiospectral patterns learning (ISSPL), to achieve efficient performance the spectral filters and classifier are simultaneously parameterized for an extension. In ISSPL, a rigorous derivation and theoretical analysis are complicated [9].

G. The 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 [10]

H. The signal generated by brain was received by the brain sensor and it will divide into packets and the packet data transmitted to wireless medium (blue tooth).the wave measuring unit will receive the brain wave raw data and it will convert into signal using MATLAB GUI platform. Then the instructions will be sending to the home section to operate the modules (bulb, fan). The project operated with human brain assumption and the on off condition of home appliance is based on changing the muscle movement with blinking. The Brain Computer Interface has proved to be boon to the disabled persons by providing them independent environment not by manual control but by mere “thinking”.[11]

I. This project dealing with the signals from brain. Different brain states are the result of different patterns of neural interaction. These patterns lead to waves characterized by different amplitudes and frequencies. The signal generated by brain was received by the brain sensor and it will divide into packets and the packet data transmitted to wireless medium (blue tooth).the wave measuring unit will receive the brain wave raw data and it will convert into signal using MATLAB GUI platform[12]

J. The signals generated by brain were received by the brainwave sensing device and it will divide into packets and the packet data transmitted to wireless medium (Bluetooth). The wave measuring unit will receive the brain wave raw data and it will convert into signal using MATLAB/Python Programming Platform. Then the instructions will be sending to the home section to operate the appliances (bulb, fan).[13]

K. Brain Computer System uses brain signals in form of Attention Level through Mind wave Headset to control the Bulb and Fan. We check for some threshold value to operate the peripherals. It’s very easy to use the headset over the head scalp whereas there is no harm in using this. You just need to place over the scalp and check for connection status to Fitting shown in Mind Wave Mobile core UI. If headset is connected correctly then it’s good to go further. Attention values get measured between 1 to 100 number values.[14]

L. An EEG-based Brain-controlled robotic and home appliance was proposed for disabled people and senior’s people to lead their daily life without any arduousness. Two applications were developed. The electrical signals of attention were used for making a robot to move in forwarding direction for ten feet’s and coming back to a starting point, and meditation signals were used for controlling the home appliances. Based on various metrics the performance was analyzed. The prototype model of EEG-based controlling robotic and home appliances has been developed with the help of Neurosky technology. The eSense technique was implemented in signal processing; the robo and home appliances were controlled by Arduino Microcontroller. This system can help the people do their work without any human interrelation and also enrich their life standard. Though the BCI system field is in its early development, but it requires improvement on the robotic to be more user-friendly. The robotic shall be further upgraded by removing noise level and duplicates precisely in signal processing and thus focus on additional improvement of the

detection of irregular attention and meditation so that, the robotic and home appliances can be controlled accurately without any contradiction. [15]

M. Smart home technology facilitates in-home everyday activities by providing central computerized control over the home environment. This technology can be adapted to be effective for people who suffer from severe movement impairments caused by spinal cord injury, by combining this technology with BCI systems. In general, BCI-based systems provide instant communication between the user and the computer as an alternative for the normal output pathway of peripheral nerves and muscles. This paper has presented a BCI-based smart home (BSH) system for controlling home doors using two different suites for the Emotive headset: The Expressive Suite and Cognitive Suite. Furthermore, the developed system was tested, and the two suites used were tested to determine which one is easier for daily use.[16]

N. We have successfully implemented a robust BCI for home automation with coarse bluetooth-based indoor user localization. This system detects SSVEP response to identify the device to be controlled and uses the eye-blink artifact to confirm device selection. The system is GUI-independent and uses LEDs which flicker at distinct frequencies for each device. These LEDs provide the stimuli for SSVEP detection. This system has been tested with toggling the state of table lamp and table fan and has exhibited detection accuracy on par with and transfer rate better than the current state-of-the art.[17]

O. Benefits of the EEG classification in BCI systems are mentioned below: Economical, Portable, low maintenance cost. Enable broken people to control prosthetic limbs with their mind. Allowing the deaf person to hear, by transmitting sensory data to their mind. Permit gamers (especially broken people) to control video games with their minds. Enable injured people to control a wheelchair, robotic and so on. Allows a person to monitor the home appliances using IOT. Allows a dumb person to have their line of thinking displayed and spoken by a computer. Enables motion less automation at faster control when used effectively.

III. DESIGN & IMPLEMENTATION

This project work consists of an Arduino Uno, Necomimmi brainwave cat ears to process data and transmit it wirelessly, Bluetooth modules and a relay module to control the AC/DC appliances. Initially the person's attention or meditation level is found out by using a brainwave sensor.

Figure 1: Necomimmi brainwave headset.

The signals from our brain are taken by using the brain sensor as shown in fig. 1 and those signals are transferred via Bluetooth module. The cat shaped ears are programmed to turn up or down based on the wearer's electroencephalogram influenced by "thoughts and emotions". The cat shaped ears turn up when the wearer concentrates and turn down when he/she relaxes. The headset runs for 4 hours on 4 AAA batteries and has interchangeable Cat, Dog and Devil horn ears.

In this project the Necomimmi headset has been completely hacked by following steps:

A. The cat ears, AAA batteries have been removed and MCU has been soldered out.
B. All the connections to the base IC have also been removed.
C. Now a wire has been connected to TGAM T pin, VCC and GND also.
D. A 5V and 3.3V voltage regulator has been designed using IC 7805 and a voltage divider. The TGAM has been fed with 3.3V from the divider.
E. Also the AAA batteries have been replaced by a 9V battery connected outside along with an ON/OFF switch and an LED.

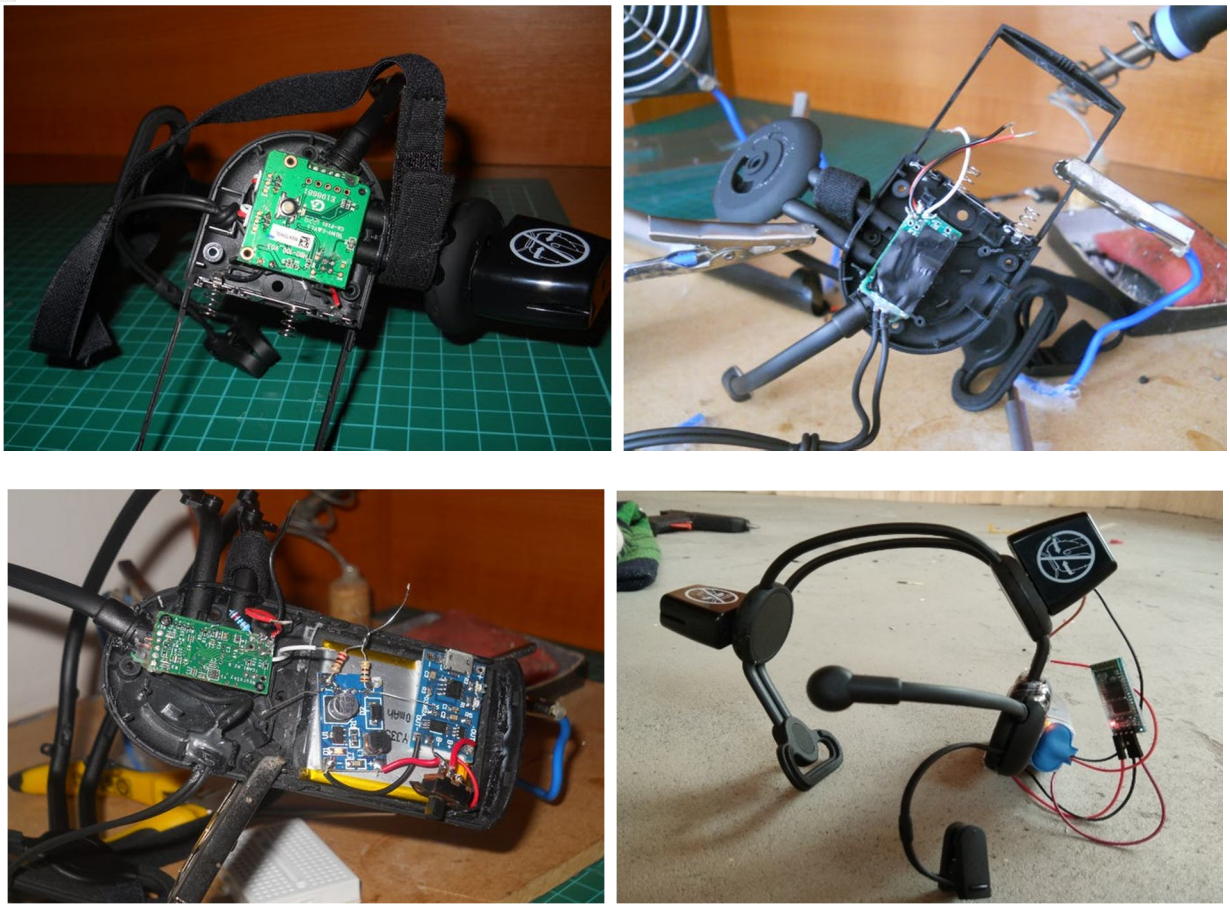

Figure 2: Figures showing the headset hacking

IV. ANDROID CAPABILITY

The hardware of all the NeuroSky app compatible headsets is the Neurosky TGAM IC with a baud rate of 57600. The Necomimmi headset will be compatible only when the Bluetooth module transmits at this rate. The default rate of HC-06 is 9600. We can change the baud rate of our Bluetooth module using AT commands.AT is the basic communication test command that allows us to check the HC-06 is connected and communicating. To set the baud rate to 57600 we give the command “AT+BAUD7” (no quotes). If HC-06 is properly connected it will reply with ‘OK 57600’ and hence baud rate is set to 57600.

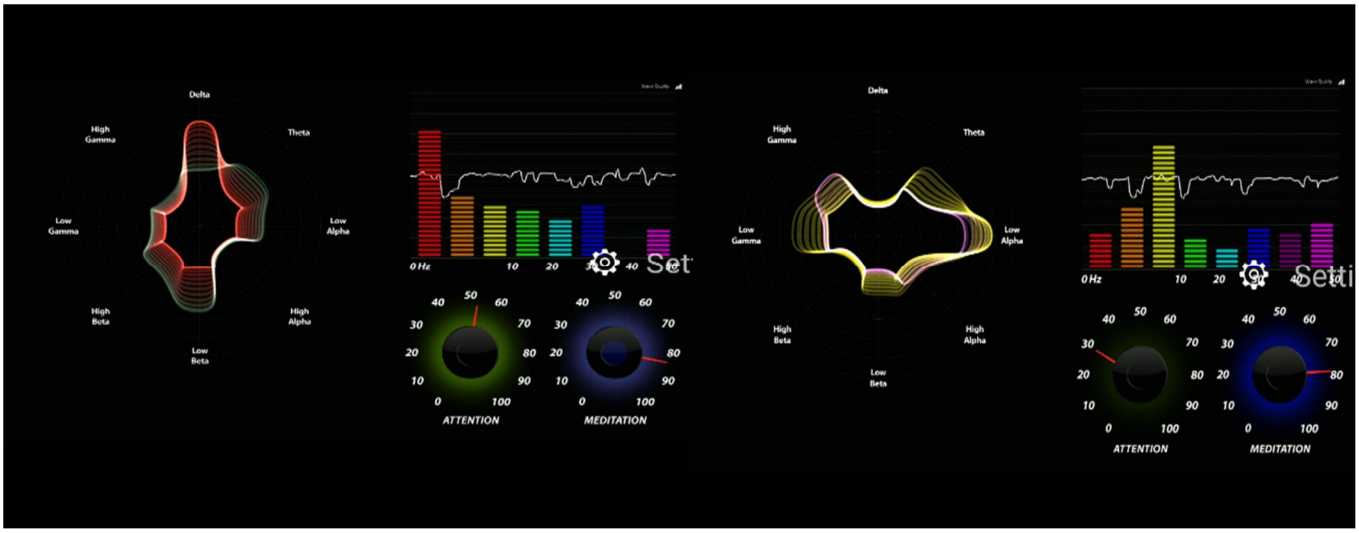

Figure 3: Screenshots of t he Brain Visualiser App with brain data from Necomimmi headset.

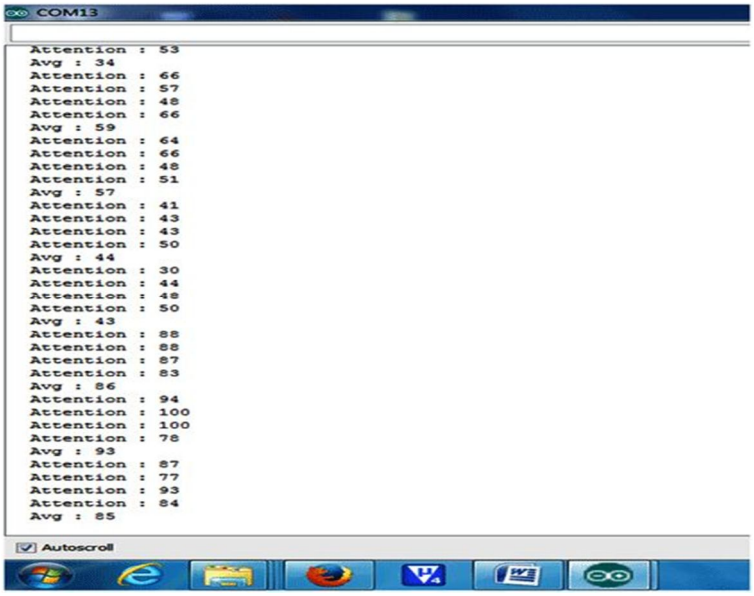

Figure 4: Serial monitor with brain data

V. THE BRAIN SIGNALS

Electrodes play the key role to collect EEG signals from the surface of the scalp. The most widely used electrodes are the silver/silver chloride (Ag/AgCl) due to low cost, low contact impedance and relatively good stability. In this project, dry electrodes have been used hence no gel and skin cleaning is required.The main disadvantage of dry electrodes is that the acquired EEG signals are worse than those acquired with conventional electrodes due to the increase of contact impedance.

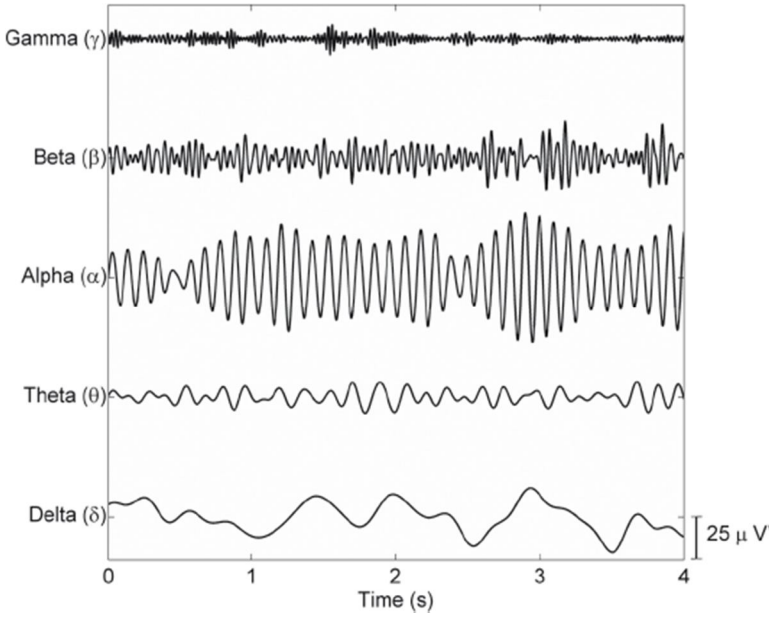

Figure 5: EEG for Automatic Person Recognition.

The human brain consists of millions of interconnected neurons. The pattern of interaction between these neurons are represented as thoughts and emotional states. The pattern keeps on changing according to the human thoughts which in turn produces different electrical waves. The patterns and frequencies of these electrical signals can be measured by placing a sensor on the scalp. The mind tools line of headset products contain NeuroSky Think Gear technology, which quantify the analog electrical signals and converts them into the digital signals.**eSense** is a NeuroSky's proprietary algorithm for representing mental states. To calculate eSense, the

Neurosky Think Gear technology intensifies the raw brainwave signal and removes the ambient noise and muscle movement. The eSense algorithm is then applied to the remaining signal, resulting in explicated eSense meter values. The eSense meter values do not interpret an exact value but instead describe the ranges of an activity. The eSense meters are a way to show how effectively the user is captivating, i.e. ATTENTION or MEDITATION. Attention eSense meter shows the intensity of a user's level of mental "focus" or "attention", such as that which occurs during intense concentration and directed mental activity. Its value ranges from 0 to 100. Distractions, wandering thoughts, lack of focus, or anxiety may lower the attention meter. Meditation eSense: The eSense Meditation meter shows the level of a user's mental "calmness" or "relaxation". Its value ranges from 0 to 100. Meditation is a measure of a person's mental states, not physical levels, so simply relaxing all the muscles of the body may not instantly result in an intensified meditation level. Meditation is related to reduce activity by the active mental processes in the brain. It has been observed 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.

VI. SETUP

The brain wave signal wireless control of appliances is designed a modular system using the following modules: Arduino Uno,4-Relay module, Bluetooth HC-05/06, IC 7805 voltage regulator, Necomimmi brain wave cat ears,9V batteries,5V Adapters., Indicator LED's. Brain Wave Visualizer Android App, DC Fan, AC Bulb/socket, Sockets/Plugs, Connecting male/female pins. The design can be divided into the following steps:

A. Engineering of the Necomimmi brain wave cat ears to process brain data and transmit it wirelessly.
B. Making the Bluetooth modules compatible with the Necomimmi headset and Neurosky apps.
C. Hard pairing of the two Bluetooth modules.
D. Retrieving the brain data in Arduino to control the GPIO pins.
E. Setting up the relay module for control of the AC/DC appliances.

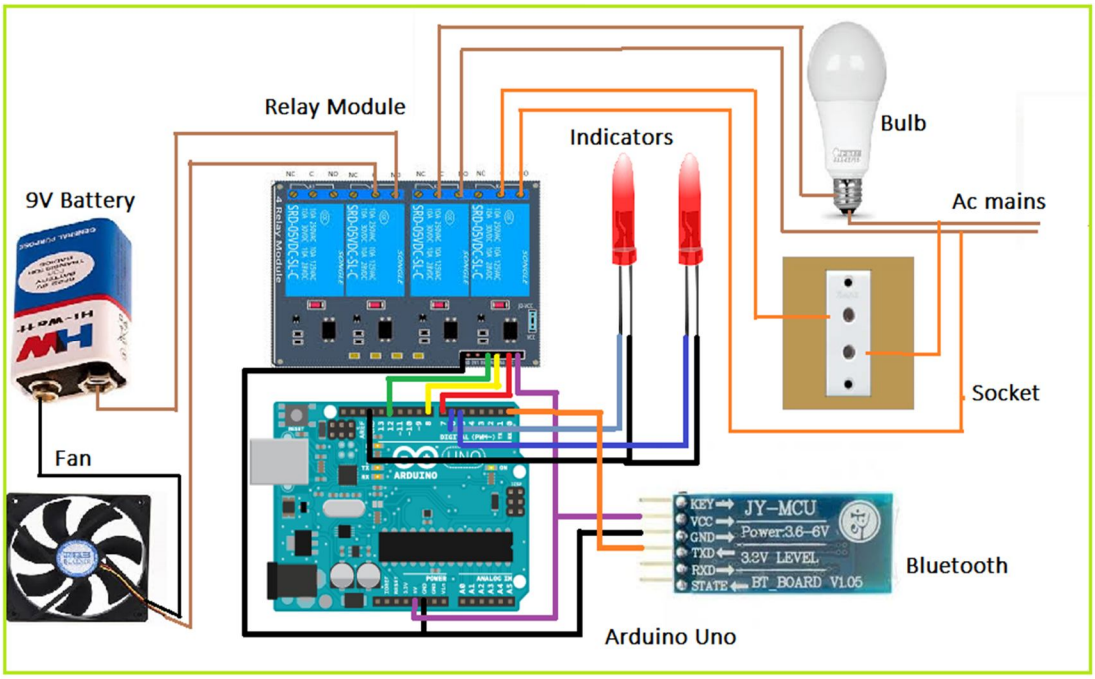

Figure 6: Overall receiver Setup

VII. CONCLUSION

The results are checked with NeuroSky headset. The headset does not give the 100% accuracy of brainwaves but it is too good for its price and it can give upto 80% accuracy of brainwaves by installing all the NeuroSky software in Android. In this project we have presented the design and implementation of automation and control system for appliances and other electronic devices using

the power of human brain. This system is designed using the Necomimmi brainwave cat ear headset enabled with wireless transmission, an Arduino Uno controller, Bluetooth receiver and a 4 relay module that controls the AC/DC appliances. The system has an overall range of 15 meters and the headset has a battery time of 32 hours without charging. This system utilizes the attention and meditation levels of human brain to control the appliances. The variation of these values resulted in turning the relays ON/OFF. The user can practice to stabilize his/her meditation/attention levels using brainwave visualizer app added in our system as an additional feature. Hence higher rate of success can be achieved. This project is a result of extensive engineering of a toy into a usable product thereby making it cost effective and accurate as compared to the products available in the market.

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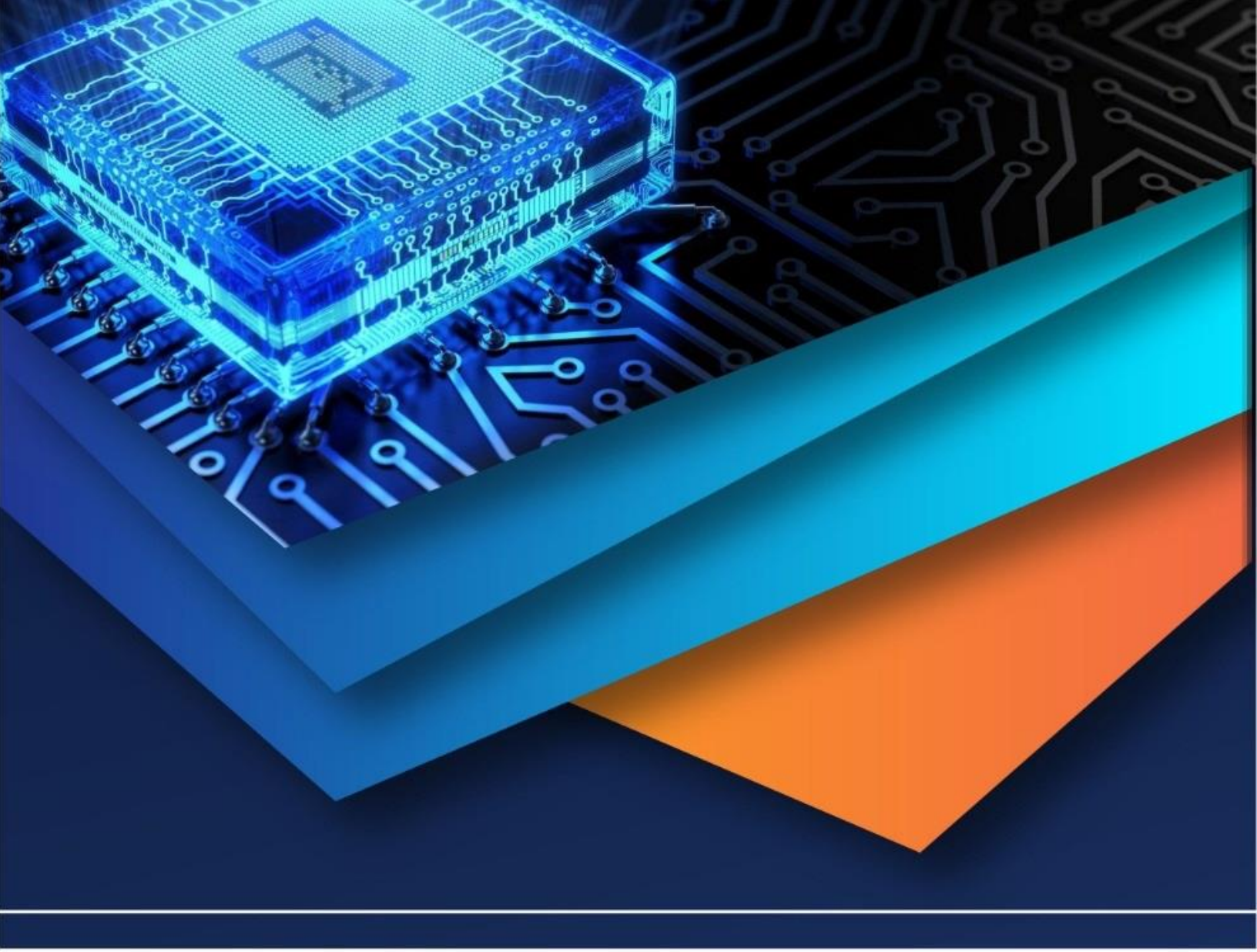

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