Faculty of Electronics and Computer Technology and Engineering

Development of EEG-based IoT Smart Home Controller using ESP8266

MOHAMAD SYAKIR AIMAN BIN ARIFFIN

Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

2024

DECLARATION

I declare that this project report entitled "Development of EEG-based IoT Smart Home Controller using ESP8266" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I approve that this Bachelor Degree Project 2 (PSM2) report entitled Development of EEG-based IoT Smart Home Controller using ESP8266 is sufficient for submission.

Signature	:	
Supervisor Name	:	Ts KHAIRUL AZHA B A AZIZ
Date	:	14/1/2024

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APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours.

Signature : ________________________________

Supervisor Name : KHAIRUL AZHA BIN A AZIZ______

Date : 14/1/2024

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ABSTRACT

This research proposes the development of an EEG-based IoT smart home controller using ESP8266. The system captures and analyzes brainwave signals, a non-invasive brain-computer interface technology. The system is designed to be scalable, interoperable, and compatible with existing IoT protocols. It aims to provide a natural and intuitive way of controlling smart homes, benefiting users with physical disabilities and elderly individuals. In this project the microcontroller that be use is NodeMCU that be the center of connection between EEG sensor that connect using Bluetooth and Blynk that connect using wifi. The feasibility and performance of the proposed system be evaluated through experiments and user studies, with the goal of achieving a reliable and user-friendly EEG-based IoT smart home controller using ESP8266. EEG sensor collect data and be evaluate in two state that is attention and meditation to turn on and off the fan and lamp. This project also use Blynk as another controller system.

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ABSTRAK

Penyelidikan ini mencadangkan pembangunan pengawal rumah pintar IoT berasaskan EEG menggunakan ESP8266. Sistem ini menangkap dan menganalisis isyarat gelombang otak, teknologi antara muka otak-komputer yang tidak invasif. Sistem ini direka untuk berskala, Boleh dioperasikan, dan serasi dengan protokol IoT yang sedia ada. Ia bertujuan untuk menyediakan cara semula jadi dan intuitif untuk mengawal rumah pintar, memberi manfaat kepada pengguna dengan kecacatan fizikal dan individu tua. Dalam projek ini pengawalmikro yang digunakan adalah NodeMCU yang menjadi pusat sambungan antara sensor EEG yang disambungkan dengan Bluetooth dan Blynk yang disambungkan dengan wifi. Kebolehlaksanaan dan prestasi sistem yang dicadangkan dinilai melalui eksperimen dan kajian pengguna, dengan matlamat untuk mencapai pengawal rumah pintar IoT berasaskan EEG yang boleh dipercayai dan mesra pengguna menggunakan ESP8266. Sensor EEG mengumpul data dan menilai dalam dua keadaan iaitu perhatian dan meditasi untuk menghidupkan dan mematikan kipas dan lampu. Projek ini juga menggunakan Blynk sebagai sistem pengawal lain.

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ACKNOWLEDGEMENT

First and foremost, I would like to express my gratitude to my supervisor, Khairul Azha Bin A Aziz for their precious guidance, words of wisdom and patient throughout this project.

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CHAPTER 1

INTRODUCTION

1.1 Background

This research proposes the development of an Electroencephalogram (EEG)-based IoT smart home controller using ESP8266. EEG is a non-invasive brain-computer interface technology that measures electrical activity in the brain and can be used to capture and analyze brainwave signals.

The development of the proposed EEG-based IoT smart home controller involves multiple stages, including data acquisition, signal processing, feature extraction, command recognition, and system integration. The system is designed to be scalable, interoperable, and compatible with existing IoT protocols and standards, ensuring seamless integration with various smart home devices.The potential benefits of the proposed system are numerous. It can provide a more natural and intuitive way of controlling smart homes, without the need for physical or voice interactions, which can be particularly beneficial for users with physical disabilities, elderly individuals, or in situations where traditional control methods may not be convenient.

Smart homes have become increasingly popular with the advent of the Internet of Things (IoT), where various household devices can be interconnected to create an intelligent ecosystem that enhances convenience, comfort, and energy efficiency. However, traditional smart home controllers typically rely on manual input or voice commands, which may not be convenient for all users, especially those with physical limitations or in certain situations where voice commands may not be feasible, such as during sleep or in a noisy environment.

This research aims to contribute to the advancement of IoT and their application in smart homes, by providing a novel and innovative solution for enhancing the accessibility and usability of smart home systems. The feasibility and performance of the proposed system is evaluated through extensive experiments and user studies, with the goal of achieving a reliable and user-friendly EEG-based IoT smart home controller using ESP8266.

1.2 Problem Statement

This research proposes the development of an EEG-based IoT smart home controller using ESP 8266, aiming to help an individual with physical disabilities and elderly individuals. The aim is to provide a solution that allows them to control their home appliances and devices easily, using brain signal. The existing limitations in accessibility, complex interfaces, and the need for personalized control necessitate the development of a system that promotes independence and autonomy. By leveraging EEG signals, the system interprets user intent and adapt over time, enhancing the accuracy and intuitiveness of control. The solution should be scalable and compatible with existing smart home devices, ultimately empowering individuals with disabilities and the elderly to interact with their environment effortlessly and independently.

Beyond these considerations, the proposed EEG-based IoT smart home controller emphasizes crucial additional features. These include the integration of emergency protocols for swift communication during critical situations, ensuring the safety and well-being of users. Furthermore, the system prioritizes cross-platform compatibility, allowing users to control their smart home devices not only through the

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dedicated controller but also through other devices such as smartphones or tablets. This flexibility acknowledges the diverse ways individuals interact with technology in their daily lives, enhancing the overall accessibility and usability of the proposed solution. In tandem, these features collectively contribute to the creation of a comprehensive, adaptable, and user-centric smart home controller that aims to significantly improve the quality of life for individuals with physical disabilities and the elderly.

1.3 Project Objective

The objectives of developing an EEG-based IoT smart home controller using ESP8266 could be stated as follows:

- To monitor the present state and control home appliances with a smartphone.
- To analyze EEG attention and meditation patterns for smart home control.
- To develop an EEG-based smart home controller with IoT using ESP8266.

1.4 Scope of Project

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The scope of this project are as follows:

a) The scope of the project is limited to controlling two devices: a fan and a lamp.

b) An ESP 8266 microcontroller is used as the main microcontroller for receiving commands controlling the fan and lamp.

c) MindLink be used solely as a data collector for collecting EEG signals related to meditation and attention.

d) The collected EEG data is used to train for accurate classification of user commands or intention

e) Aiming to help an individual with physical disabilities and elderly individuals

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The whole smart home development idea and theory are discussed and summarized in this section. The major goal of this chapter is to discuss previous research and current projects. The philosophy and concept utilized to tackle the project's challenge are discussed in this project. The major sources of material are journals, papers, and case studies, which were chosen for their resemblance to the project aim.

2.2 CURRENT SMART HOME TECHNOLOGY

2.2.1 CONCEPT OF SMART HOME

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The Smart Home concept is the integration of different services within a home by using a common communication system. It assures an economic, secure and comfortable operation of the home and includes a high degree of intelligent functionality and flexibility. With arising activities all around the world, several synonyms are used to describe this novel concept. The Japanese generally talk about 'Home Automation', whereas in United States or Europe 'Smart Home' or 'Smart House' are often used. In France the new word 'Domotique' has been created

The greatest beneficiaries of an Internet of Things-based home automation system are the elderly and disabled. By using these technologies, people in fragile health or with limited mobility can maintain their independence instead of moving into an assisted living facility. Creating a Smart Home's design is also essential. Creating a house design that not only suits your needs and budget, but also shows your taste may be challenging and requires careful preparation. [1] [2] [3] [4] [5]

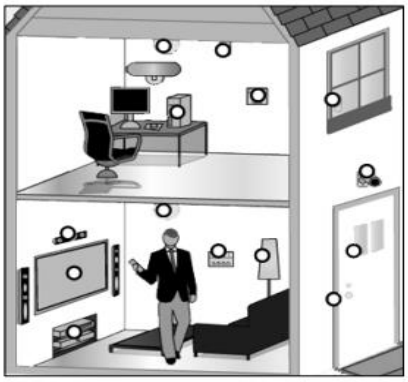

Figure 2.1 Smart home point

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2.3 Electroencephalography (EEG)

Electroencephalography (EEG) is a technique used to measure the electrical fields generated by the brain through electrodes placed on the scalp. These electrical fields are produced by the electrochemical signals transmitted between neurons. When numerous signals are generated simultaneously by large groups of neurons, the resulting electrical fields can be detected from outside the head. EEG was first explored by Hans Berger, who sought to understand the basis of extrasensory phenomena. It was already known in the late 19th century that the brain produces electrical fields with oscillatory patterns. Berger's significant contributions included demonstrating that these fields could be measured in humans non-invasively and linking neural oscillations to cognitive processes such as sensory perception and problem-solving. [6] [7] [8]

2.3.1 BRAINWAVE

Overall, EEG signals provide valuable information about the electrical activity of the brain, and the different brain wave patterns can give insights into an individual's state of mind and level of alertness. The alpha rhythm is the most well-known and studied brain wave, and is associated with relaxation and closed eyes. Beta waves are dominant during wakefulness and alertness, while lower frequency bands increase during relaxation, drowsiness, and sleep. The different stages of sleep are characterized by specific brain wave patterns, with delta waves being more prominent during deeper stages of NREM sleep. EEG signals are unique to individuals, and can potentially be used to distinguish between different types of individuals based on their brain activity patterns. [9] [10]

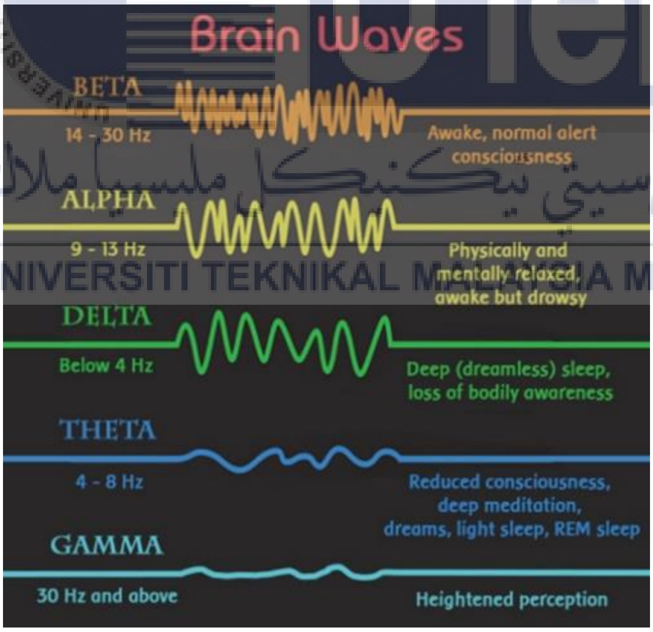

Figure 2.2 Brainwave signal

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2.3.1.1 ALPHA SIGNAL

This article reviews EEG alpha activity and the various indices that are commonly used to characterize it. It suggests that there is a lack of consensus on the definition of alpha activity and offers three indices for its measurement: individual alpha peak frequency, activation magnitude, and alpha auto-rhythmicity indices. The article also examines the mechanisms underlying alpha activity and its variability, as well as its importance for optimal functioning and behavior. Overall, the review provides insights into the nature of alpha activity and its potential applications in research and clinical settings.

2.3.1.2 THETA SIGNAL

Theta is a type of brain wave that occurs between 4 and 8 Hz in frequency. When someone is under emotional stress, especially disappointment or tension, they exhibit theta.

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2.3.1.3 BETA SIGNAL

The frequency range of the beta brain wave is 13–30 Hz. When a person is actively thinking, actively concentrating, or focused on addressing an issue, they typically experience a beta brain wave. Based on frequency range, beta is further separated into two groups: Low Beta (13–20 Hz) and High Beta (20–30 Hz).

2.3.1.4 DELTA SIGNAL

The brain wave known as delta has a frequency range of 0.5 to 4 Hz. When someone is in a deep slumber, they seem like delta. Delta signals may also point to structural abnormalities in the brain.

2.3.1.5 GAMMA SIGNAL

Gamma is a brain wave with a frequency range between 35 - 45 Hz This brain wave occurs when a person experiences very high mental activity, a state of extreme panic or fear in a fully conscious state

2.3.1.6 MEDITATION

Meditation is a catch-all term for a variety of contemplative practices that involve mental relaxation and conscious regulation of attention, thought, and emotion. Western researchers define meditation broadly, but all agree that it brings both short- and long-term benefits to practitioners, including feelings of peace and happiness, reduced anxiety, and improvements in heart condition and immune function. EEG studies have identified two main types of meditation, concentrative and open, which correspond to meditation on an object and objectless meditation in traditional Buddhist categories. The most consistent EEG correlate of meditation is an increase in the power of lower frequencies, especially in the theta and alpha bands. Alpha blocking, or the maintenance of consistent alpha rhythms even in response to external stimuli, is a key component of meditation and indicates the ability to control attention and internal state in the face of sensory input. While alpha oscillations are important, recent research is discovering other phenomena in other frequency bands, neural synchrony, and

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hemispheric symmetry that may shed further light on the neural correlates of meditation. [11]

2.3.1.7 ATTENTATION

The author suggests that alpha brain waves do indeed play a direct role in regulating attention. The study involved giving participants real-time feedback on their alpha waves and rewarding them for manipulating their brain waves to increase the contrast of a grating pattern. As the participants became more skilled at controlling the asymmetry of their alpha waves, they were able to enhance their attention and respond more strongly to visual stimuli on the opposite side of the screen. This suggests that alpha waves play a role in filtering out distracting sensory information and enhancing attention to important stimuli. [12]

2.4 INTERNET OF THING

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The Internet of Things (IoT) is a concept that enables smart devices to sense and communicate with each other, transforming decision-making processes regarding our physical world. Initially, IoT was implemented in consumer products such as refrigerators and washing machines, allowing them to connect to the internet. Over time, the concept expanded to include various types of products, and now many companies aim to incorporate IoT into modern manufacturing systems. Using an IoT platform to collect usage data from production equipment is crucial for developing a cloud-based predictive maintenance system, which streamlines factory upkeep.

However, a challenge lies in connecting standard industrial devices with web platforms. To address this issue, the author suggests a new method that uses microcontrollers like Arduino or Raspberry Pi to translate the language of industrial equipment to IoT-compatible devices.

In 1999, Kevin Ashton introduced the notion of the Internet of Things (IoT), defining it as a network of uniquely identified, connected items that utilize radio-frequency identification (RFID) technology. Nevertheless, the precise definition of the Internet of Things is still being developed and is dependent on several viewpoints. "Dynamic global network infrastructure with self-configuring capabilities based on standards and communication protocols" was the general definition of the Internet of things. [13]

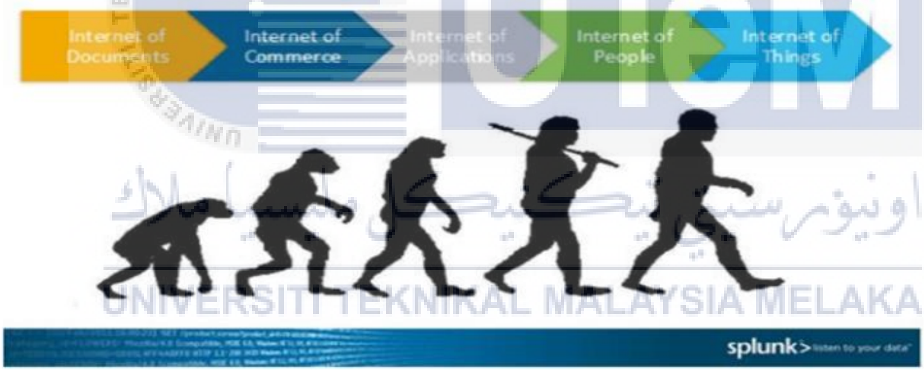

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Figure 2.3 Revolution of smart home

2.4.1.1 PLATFORM

In the early 2000s, Condition-Based Maintenance (CBM) was a popular method for machinery diagnostics and prognostics. It involved data acquisition, processing, and maintenance decision-making based on condition monitoring. However, the market environment changed, leading to the integration of products and services. The shift towards predictive manufacturing highlighted the need for refined maintenance techniques. IoT-based fault prediction systems were developed to ensure sustainable operations. IoT platforms served as interfaces for connecting devices and processing data. Simple IoT applications had ready-to-use platforms, while complex industrial applications required specialized platforms. Interoperability, facilitated by communication protocols, was crucial for successful IoT solutions. Arduino could be used as a translator between industrial machines and IoT platforms. [14]

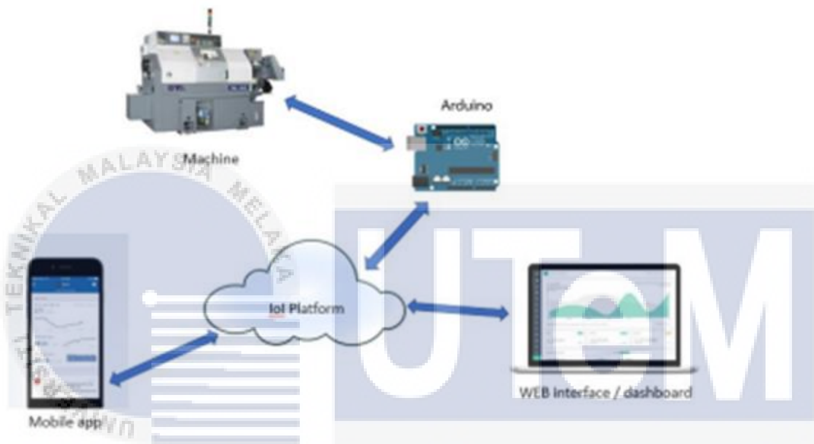

Figure 2.4 IoT platform

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2.5 BRAIN SENSOR

2.5.1.1 Toolbox for Emotional Feature Extraction From Physiological Signals (TEAP)

An open-source MATLAB toolkit called toolkit for Emotional Feature Extraction from Physiological Signals (TEAP) is available. It is made to process and compute physiological signals, including electromyogram (EMG), skin temperature, breathing pattern, blood volume pulse information, and electroencephalogram (EEG), in order to extract aspects associated to emotion.

TEAP provides a convenient framework for extracting emotional features from these signals, allowing researchers and practitioners to analyze and understand the emotional states of individuals. The toolbox has undergone testing on the MAHNOB-HCI and DEAP databases, demonstrating promising performance in capturing emotional information.

By utilizing TEAP, users can leverage the functionality and algorithms provided to extract relevant features from multiple physiological signals, facilitating further analysis and interpretation of emotional states. Its open-source nature allows for customization and adaptation to different research or application requirements.

Overall, TEAP serves as a valuable resource for researchers and practitioners interested in exploring emotions through physiological signals, providing a reliable and tested toolbox for feature extraction and analysis. [15]

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2.5.1.2 MINDLINK-EUMPY

An open-source software toolkit for emotion identification is called MindLink-Eumpy. In order to decrease subject dependence and increase accuracy in emotion recognition, the toolbox incorporates facial expression data and electroencephalogram (EEG) data. MindLink-Eumpy uses a number of techniques to automatically gather physiological data from participants, analyzing the EEG and facial expression data independently. A multitask transfer learning-based convolutional neural network (CNN) is used for face expression identification. Two techniques are offered for EEG detection: a subject-independent model based on long short-term memory network (LSTM) and a subject-dependent model based on support vector machine (SVM). The predictions from SVM and CNN are combined using weight enumerator and AdaBoost techniques at the decision level. The authors conducted offline experiments on the DEAP and MAHNOB-HCI datasets, as well as an online experiment with 15 healthy subjects. The results demonstrate that the multimodal methods outperform single-modal methods in both offline and online experiments. In the subject-dependent condition, the multimodal method achieves high accuracies in the valence and arousal dimensions. In the subject-independent condition, the LSTM-based method achieves even higher accuracies. The feasibility and efficiency of MindLink-Eumpy for emotion recognition are confirmed. [16]

2.5.1.3 Computer Expression Recognition Toolbox (CERT)

An open-source software program for real-time facial expression recognition is called the Computer Expression Recognition Toolbox (CERT). Based on the FACS method, it can recognize six standard face emotions and automatically code the strength of 19 other facial gestures. In addition, CERT gives 3D head orientation and assesses the placements of ten face features. Experiments using datasets of spontaneous facial expressions have shown an accuracy of about 80%. Because CERT is open-source, it can be customized and adjusted for use in human-computer interface, psychological research, and emotion identification applications.. [17]

2.5.1.4 MixedEmotions

The MixedEmotions toolbox is a versatile software package that includes text, audio, and video processing functions for emotion recognition. It offers ready-to-use modules and plug-and-play capabilities. The toolbox is applied in real-world cases such as emotion-driven smart TV use, brand reputation analysis, and call center monitoring. It enables emotion-based recommendation systems, monitors brand reputation from social media data, and tracks customer emotions in call center interactions. The toolbox provides valuable insights for personalized recommendations, assessing public sentiment, and improving customer service. [18]

2.5.1.5 Electrical Appliance Switching Controller By Brain Wave Spectrum Evalation Using a Wireless EEG

The paper includes the development of an electrical appliance switching controller using a wireless EEG headset to assist elderly and disabled individuals in independently managing household appliances wirelessly and without using their hands. The system permits the user to separately switch on and off the 4 electrical devices connected to the power socket. The use of attention and meditation as triggers for relay switching based on brain wave signals, with the recognition that users require practice or passive training to control their brain wave signals efficiently.

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The methodology used in the study involved capturing EEG signals using a MindLink EEG headset connected to an Arduino microcontroller board, analyzing brain wave signals to trigger relay switching, considering various strategies for extracting information from raw EEG signals, and configuring preset combinations of attention and meditation levels. It was found that using the EEG headset to regulate a user's attention and meditation signal levels required some practice before it could be done effortlessly. [19]

2.6 PREVIOUS PROJECT RELATED

The previous research or articles are revised before further development in drunk detector in a car. The main purpose of readings previous research work is to discuss the theory and concept that used to solve the problems that be faced during the development in this project. These sources that have been chosen is related to the objective for this project.

2.6.1 A Smart IoT Security System for Smart-Home Using Motion Detection and Facial Recognition

The concept of technology adding value to our everyday life is combined with the Internet of Things (IoT) like a project diagram in Figure 2.7. The idea of security and privacy is one important area where technology helps us. Since smartphones are the most popular smart device, they can serve as security alert systems.

Using the component shown in Figure 2.8, the author of this research created a smart IoT security system for a smart house. wherein a NoIR Pi Camera Module is used to record videos and take pictures, and a Raspberry Pi serves as a security system. Motion is also detected using a Passive Infrared (PIR) Motion Sensor. The author suggests utilizing the pictures acquired from the motion sensor data and the. Author propose to use motion sensor data and the images acquired from the NoIR Pi Camera Module to anticipate a security threat using a facial recognition classification technique together with our built algorithm. In the event of an emergency, the user can receive notifications from the system. With precision of 91% and accuracy of 95.5%, the suggested system is capable of identifying any security danger. [20].

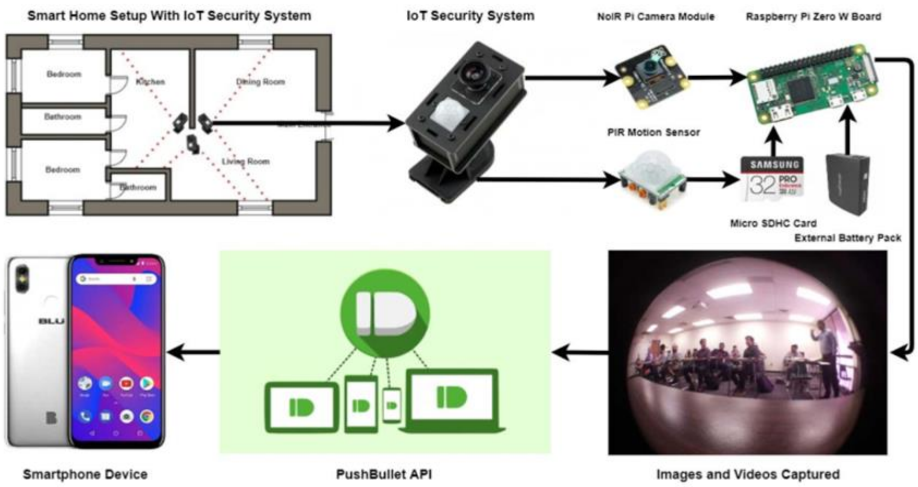

Figure 2.5 Project Diagram

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Figure 2.6 List of component

2.6.2 EYE BLINKS FROM EEG SIGNALS FOR HOME LIGHTING SYSTEM ACTIVATION

Three electrodes were positioned on the frontal, occipital, and earlobe regions of 20 participants in order to record their EEG data. The KL-72001 main unit and KL-75004 EEG module were used to record the signals, and they were connected to a computer via an RS-232 cable, just like in Figure 2.10. A calm patient's normal EEG signal included spontaneous eye blinks below 5 Hz and beta waves between 13 and 22 Hz. The electrode implantation on the subject is shown in Figure 2.9. The EEG signal for intentional eye blinking, which was longer in duration and had a greater amplitude than spontaneous eye blinks, is shown in Figure 2.12. It was found that the lighting system could be turned on with three consecutive eye blinks that had a predetermined interval between eye closure and opening.

The study took into account a variety of situations, including eye motions (left, right, upward, and downward), eye closure, intentional blinking, and single-eye blinking. Voluntary eye blinking generated high-amplitude EEG signals among these circumstances, hence it was selected for additional examination. The short-time Fourier transform was used to evaluate the signals after they were sampled at 50 Hz and passed through a low-pass filter with a 5 Hz cutoff frequency..

The EEG waves were processed using a MATLAB technique to extract information about eye blinking. The program distinguished between eyelid movements brought on by eye movements and spontaneous eye blinks by identifying three nearby local maxima and minima within a predetermined amplitude range. The zero state denoted that the switch was off, while the extracted pulses represented the switch being activated.

In 85% of the records from the 20 EEG signal samples that were examined, eye blinks were successfully identified. Nevertheless, noise from incorrect electrode placement and low EEG signal amplitude when the subject's eyes were not fully blinked caused poor detection results in some recordings. [21]

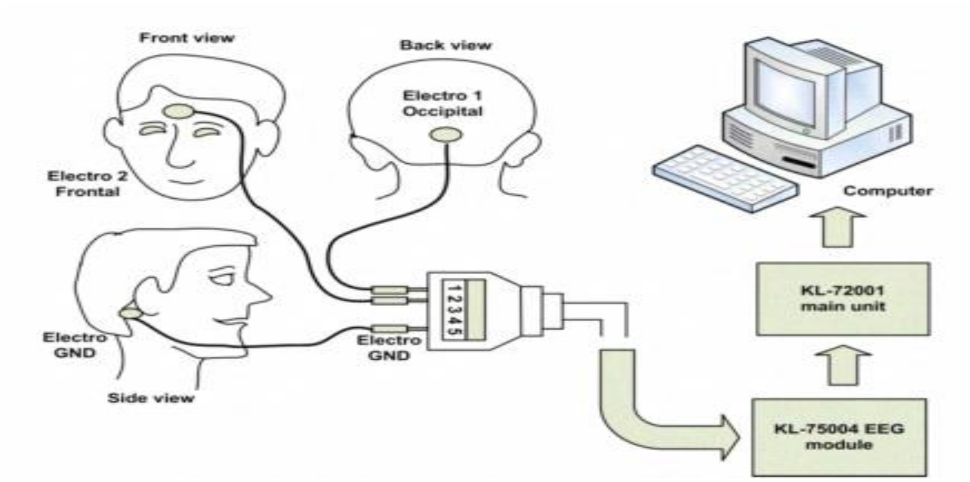

Figure 2.7 Connection of electrodes on subject

Figure 2.8 Basic block diagram of eeg signal processing

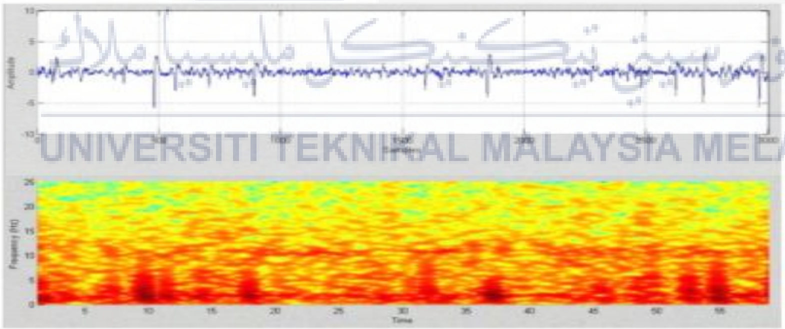

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Figure 2.9 normal EEG signal (relax condition) and its spectrogram

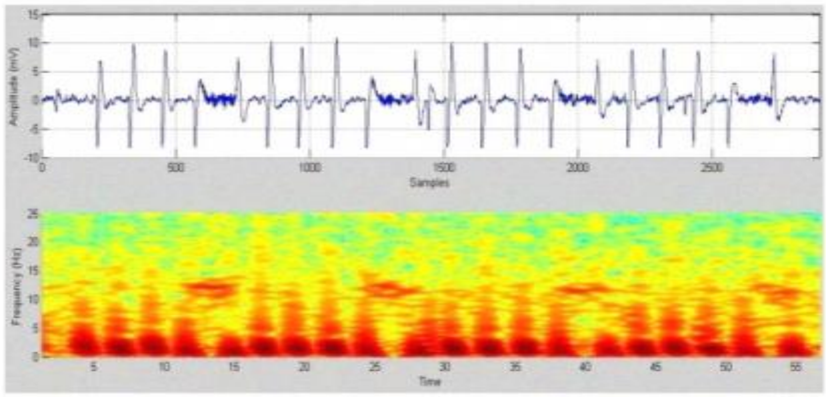

Figure 2.10 EEG signal and its spectrogram for voluntary eye blinking condition

2.6.3 Pengembangan *Passive Infrared Sensor* (PIR) HC-SR501 dengan Microcontrollers ESP32-CAM Berbasiskan *Internet of Things* (IoT) dan *Smart Home* sebagai Deteksi Gerak untuk Keamanan Perumahan

This study focuses on utilizing the HC-SR501 passive infrared sensor (PIR) and the ESP32-CAM microcontroller for housing security. The HC-SR501 PIR sensor detects object motion, while the ESP32-CAM captures and sends images or videos based on programmed instructions. When an intruder is detected within a specified range, the ESP32-CAM sends images or videos to the householder's smartphone. The study found an effective detection distance of 0 to 5 meters for the HC-SR501 PIR sensor, indicating potential security breaches within this range. Beyond 5 meters, the system considers the environment safe. [22]

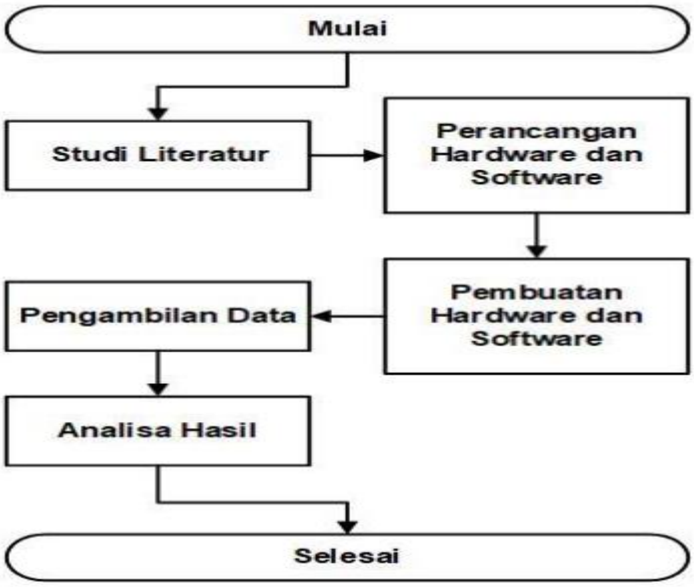

Figure 2.11 Flowchart project

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Figure 2.12 Hardware diagram

2.6.4 Point-n-Press: An Intelligent Universal Remote Control System for Home Appliances

The PPRC's G sensor allows the system to recognize when the device has been shaken, indicating that it is getting ready to carry out some control actions. This sensor can be utilized to operate appliances. The PPCB in the area receives a "Be Ready" signal from the PPRC over Bluetooth or Wi-Fi. The "Be Ready" signal causes a PPCB to activate and initialize its inbuilt infrared receiver. The PPCB's IR receiver then uses the directionality of the IR characteristic to receive the signal that was emitted from the PPRC's IR transmitter once the PPRC has been fixed on and pointed at a particular PPCB. Throughout this period, the DCP is concurrently transmitted from the PPCB's Target Control component to the PPRC's URC Control component over a Bluetooth or Wi-Fi wireless network. The URC Control component uses the Interface Generator component to create a control user interface (UI) based on the received DCP and the state dependencies of the FSM after registering it with the Device Profile Registry component. At this point, the UPnP Control Point component allows the PPRC to issue control commands via the associated control UI. In order to operate the particular target device, the PPRC then sends control commands to the PPCB's UPnP Device component. Lastly, via an IR transmitter, the PPCB sends the appliance the control commands it got from the PPRC in order to produce the necessary control operations. The household appliance carries out the related tasks mandated by the PPRC [23].

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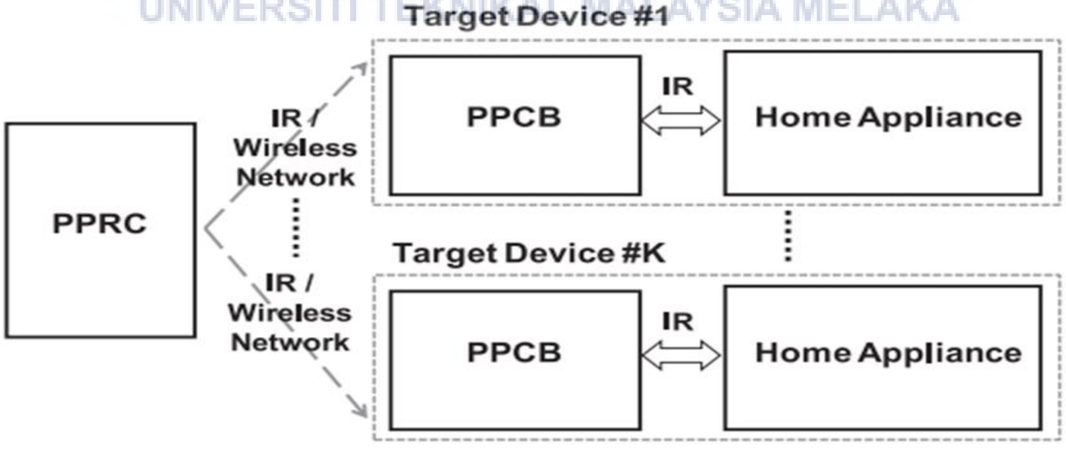

Figure 2.13 System architecture of the proposed control system

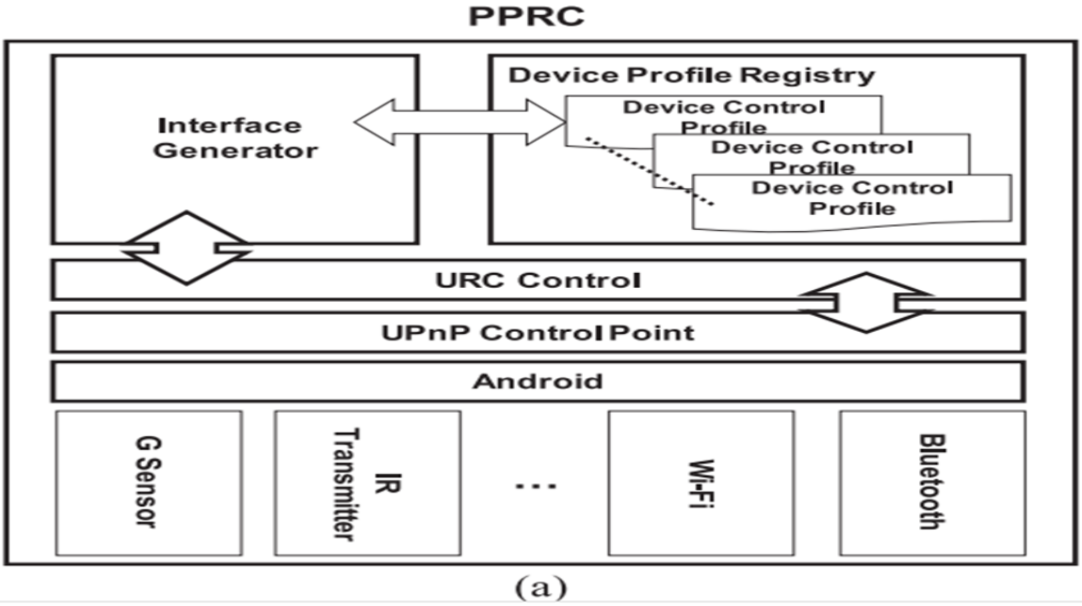

Figure 2.14 How PPRC work

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2.7 PREVIOUS RESEARCHER WORK COMPARISON

Table 2.1 List of Previous Research Work

Title	Author	Method
A Smart IoT Security System for Smart-Home Using Motion Detection and Facial Recognition	AKM Jahangir Alam Majumder and Joshua Aaron Izaguirre	Raspberry PI, GPIO (PIR Motion Sensor), camera (NoIR Pi Camera Module).
Detection of Eye Blinks From EEG Signals For Home	Mohd Shaifulrizal b Abd Rani, Wahidah bt. Mansor	KL-72001 main unit and KL-75004 EEG module which was connected to a computer via a RS-232
Pengembangan Passive Infrared Sensor (PIR) HC SR501 dengan Microcontrollers ESP32-CAM Berbasiskan Internet of Things (IoT) dan	Andi Setiawan, Ade Irma Purnamasari	HC-SR501, ESP32-CAM

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Smart Home sebagai Deteksi Gerak untuk keamanan Perumahan		
Point-n-Press: An Intelligent Universal Remote Control System for Home Appliances	Kuen-Min Lee, Wei-Guang Teng, Ting-Wei Hou,	Point-n-Press remote controller (PPRC),Point-n-Press control box

2.8 CHAPTER SUMMARY

In conclusion, the concept of a smart home revolves around integrating various services within a home through a common communication system, offering economic, secure, and comfortable operations. Smart home technology has gained momentum worldwide, with different terms like home automation, smart home, smart house, and demotics being used to describe the concept in different regions. So, the project that is build is be based from this concept to ease the people in their life.

Within the realm of smart homes, several technologies have emerged. These include Brain-Computer Interface (BCI) systems which is EEG sensor that able thought-controlled interactions with home appliances, Smart Switch Control Systems (SSCS) for remote control of electrical outlets and energy management, and motion detection and facial recognition systems for enhanced security. This is related to the our project that is used EEG sensor as a controlled interaction with home appliance.

Electroencephalography (EEG) plays a crucial role in capturing and analyzing brain activity. Different brain wave patterns, such as alpha, beta, theta, delta, and gamma signals, provide valuable insights into an individual's state of mind and level of alertness. EEG signals can be used to improve brain-computer interactions, monitor emotional states, and enhance attention.

The Internet of Things (IoT) is a fundamental component of smart homes, allowing devices to sense and communicate with each other, facilitating decision-making processes in the physical world. IoT platforms serve as interfaces for connecting devices and processing data, and technologies like Arduino and Raspberry Pi can bridge the gap between standard industrial equipment and IoT-compatible devices.

In summary, in our project that is development of EEG-based IoT Smart Home Controller using ESP8266 we build a project that use microcontroller that is ESP8266, with some other future like EEG sensor which is mindlink.

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CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter went over the project flow in great depth. The ways on how this project be carried out throughout the time were explained in part of this chapter. This chapter's purpose is to provide details and confirmation about how the project wil be carried out. Both hardware and software that be use in the design development of EEG-based IoT smart home controller using ESP8266 is shown in this chapter. These methods were well-executed, resulting in a suitable mechanism and component for EEG-based IoT smart home controller using ESP8266 for the installation of fence posts.

3.2 PROJECT FLOW

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Project milestones play a crucial role in project management as they mark significant points or achievements throughout the project's lifecycle. These milestones serve as essential markers, providing a clear indication of progress, key deliverables, and important events within a project. Understanding project milestones is vital for effective project planning, execution, and control. They serve as strategic checkpoints that help break down the project into manageable phases and provide an overview of the project's timeline.

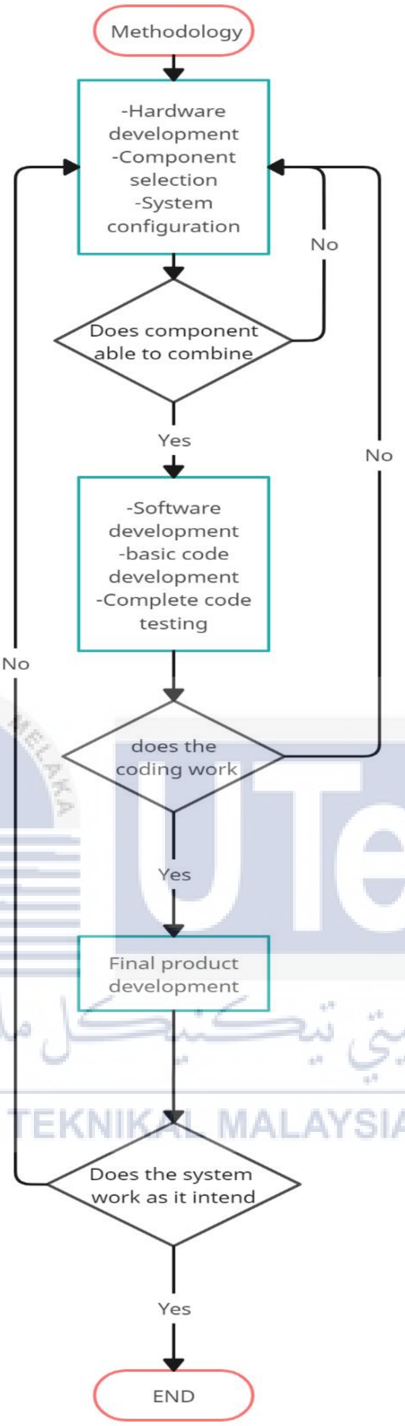

Figure 3.1 Milestone project

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3.3 DESIGN

This project presents a new and integrated analytical approach Development of EEG-based IoT Smart Home Controller using ESP8266. The essence of the approach that be use in this project is centered on the concept of EEG and IoT.

3.3.1 SYSTEM DESIGN

The system consists of several small component parts like in the block diagram in Figure 3.2, each of which requires specific connection for it to properly function. The component includes a ESP8266, smartphone, relay, lamp, fan and mindlink as a data collector. Firstly, connection between smartphone and the ESP8266 must be establish via Hc-05 Bluetooth device. Once the connection is done there are two methods to control the lamp and fan that is by using Blynk application which is like in Figure 3.3 and EEG sensor that is mindlink refer to Figure 3.4.

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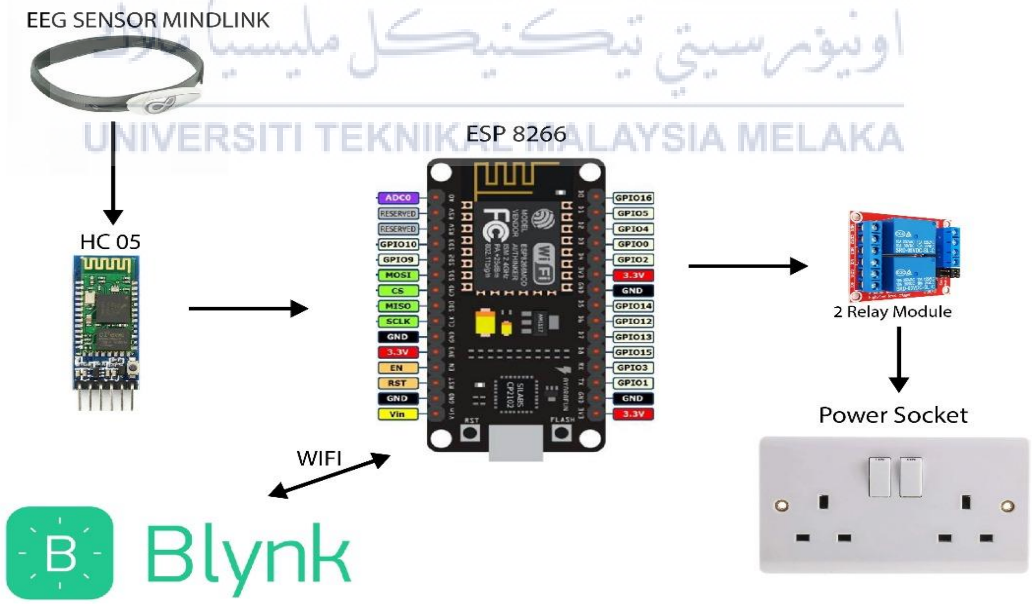

Figure 3.2 Block diagram

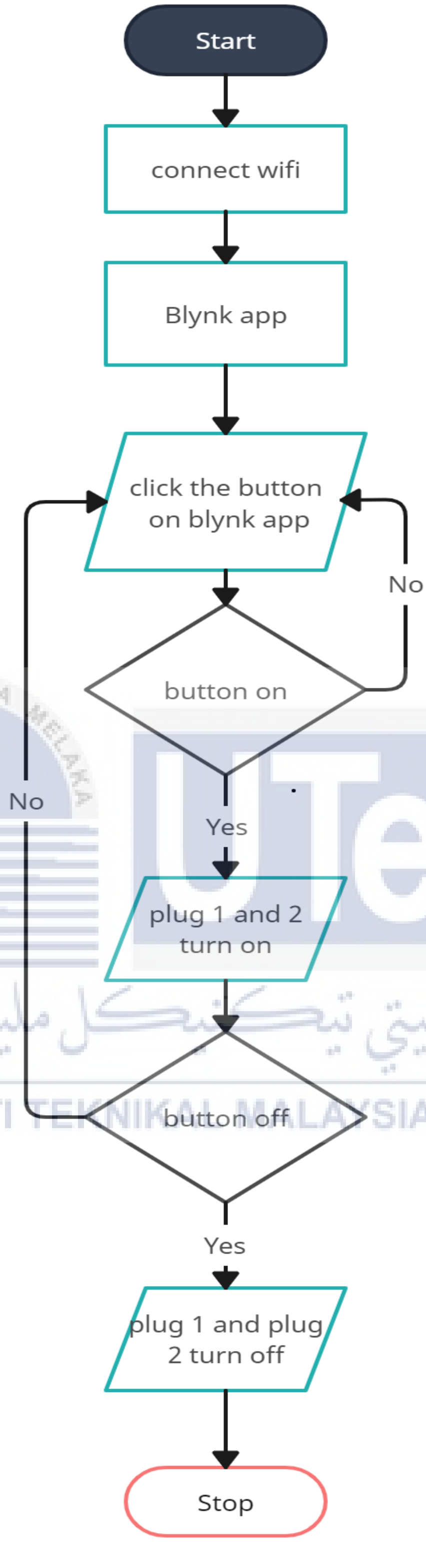

Figure 3.3 Flowchart control using Blynk application

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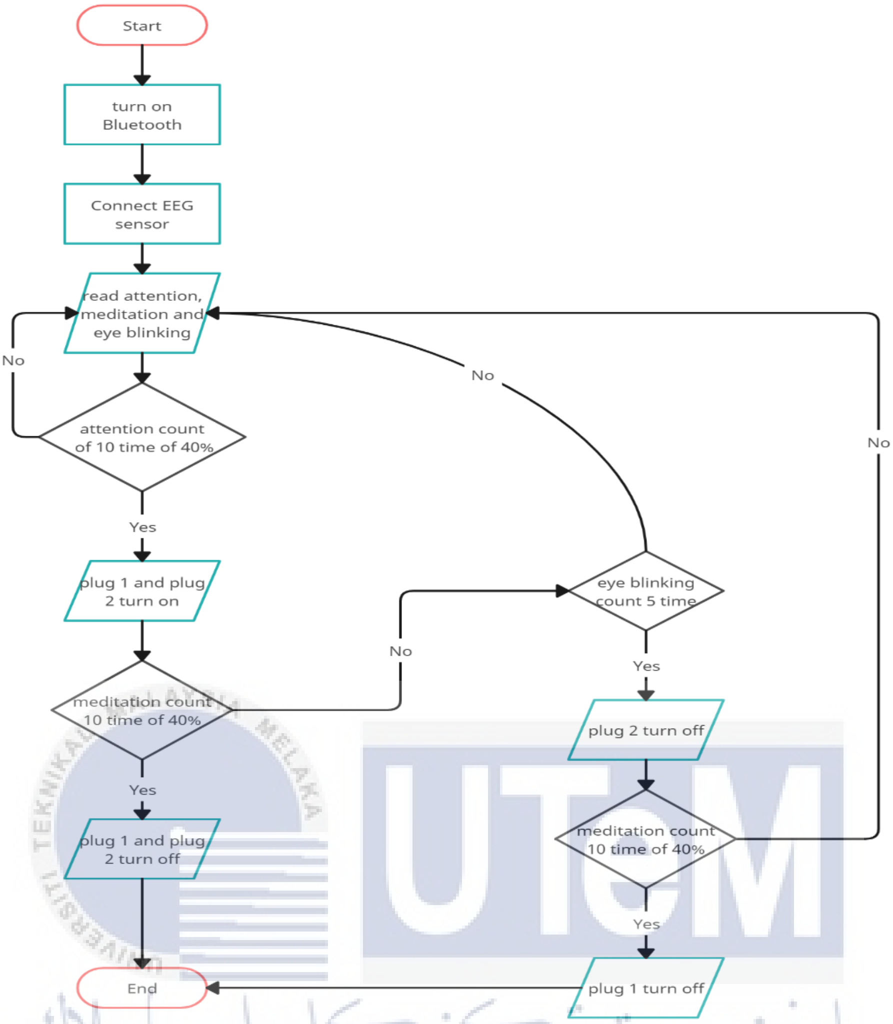

Figure 3.4 flowchart using EEG sensor

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3.3.2 COMPONENT SELECTION

The project is comprised of a small number of component parts which is show in Figure 3.2, each of which requires a specific connection in order to function properly. These include a NodeMCU, relay module, mindlink sensor and Hc 05 for Bluetooth connection. After the process of studying the related literature, a decision regarding the selection of components is made. According to the findings of the literature analysis conducted on Chapter 2, the components that were chosen are as follows: a microcontroller NodeMCU as the main processing unit and for the wifi , HC 05 as the communication between smartphone and the mindlink sensor. For the purpose of developing the prototype, these components are practical, suited for the task at hand, and simple to implement.

3.3.2.1 HC 05

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH(Adaptive Frequency Hopping Feature). [24]

Specification of HC-05 Bluetooth Module:

- Bluetooth version: 2.0 + EDR (Enhanced Data Rate)
- Frequency: 2.4 GHz ISM band
- Modulation: GFSK (Gaussian Frequency Shift Keying)
- Transmit power: Class 2 (up to 4 dBm)
- Sensitivity: -80 dBm typical
- Range: approximately 10 meters (or 33 feet) in open air
- Profiles supported: SPP (Serial Port Profile), HID (Human Interface Device) and others
- Operating voltage: 3.3V to 5V DC
- Operating current: less than 50mA
- Standby current: less than 2.5mA

• Sleep current: less than 1mA

• Interface: UART (Universal Asynchronous Receiver/Transmitter)

• Baud rates: 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, and 460800

• Operating temperature: -20°C to 75°C (-4°F to 167°F)

Figure 3.5 Hc-05

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3.3.2.2 NodeMCU

The module discussed in the paragraph is primarily based on the ESP8266 microchip, which is a cost-effective Wi-Fi module that integrates a full TCP/IP stack and microcontroller capabilities. It was developed by Expressive Systems. The ESP8266 NodeMCU is a versatile device that combines certain features of the Arduino board with the ability to connect to the internet.

While Arduino modules and microcontrollers have been popular choices for automation projects, they lack built-in Wi-Fi capabilities. To overcome this limitation and enable internet connectivity, an external Wi-Fi protocol needs to be added to these devices.

The NodeMCU is a well-known development board that utilizes the ESP8266 Wi-Fi System-on-Chip (SoC). The version mentioned in the paragraph is version 3, based on the ESP-12E module. NodeMCU is an open-source firmware and development kit that facilitates prototyping of IoT (Internet of Things) products using LUA scripting. It can also be programmed using the Arduino IDE, providing flexibility for different programming approaches. [25]

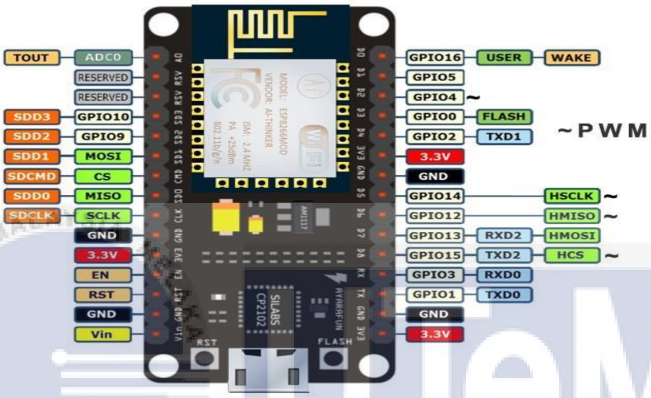

Figure 3.6 ESP8266

3.3.2.3 BLYNK

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Blynk is an Internet of Things (IoT) platform that enables remote control of electronic devices through its iOS and Android apps. It offers a dashboard where users can create graphical interfaces using various widgets. Blynk also provides the capability to store and display sensor data. It offers libraries for a wide range of popular hardware platforms including Arduino, ESP8266, Raspberry Pi, SparkFun, and more. By leveraging Blynk's platform and libraries, users can easily integrate their hardware devices and create custom applications for controlling and monitoring them remotely. [26]

3.3.2.4 EEG SENSOR

When a person moves a body part, the electrode sensor's job is to detect changes in the electric field caused by neuronal activity in the various brain lobes. These field shifts can also be felt when a person imagines moving their body parts in a soft way without really moving them. The range of brainwaves is most likely between 0.5 and 40 Hz. The 512 Hz sample rate was used to record the EEG data. Three electrodes make up this EEG sensor: ground, reference, and EEG. In essence, this is how the EEG signals are extracted and sent to the Arduino.. [27]

Figure 3.7 MindLink

3.3.2.5 RELAY

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A 2-channel relay module is an electronic component that allows you to control two separate circuits using a single module. It consists of two relays, each capable of switching high voltage or high current loads on and off.

The relay module typically has input pins that can be connected to a microcontroller, Arduino board, or any other digital output device. These input pins control the activation and deactivation of the relays. When the input signal is received, the relay switches its contacts, either connecting or disconnecting the load circuit.

Each channel of the relay module usually has three output pins: a normally open (NO) pin, a normally closed (NC) pin, and a common (COM) pin. The NO and COM pins are connected when the relay is activated, while the NC and COM pins are connected when the relay is inactive. [28]

Figure 3.8 Relay

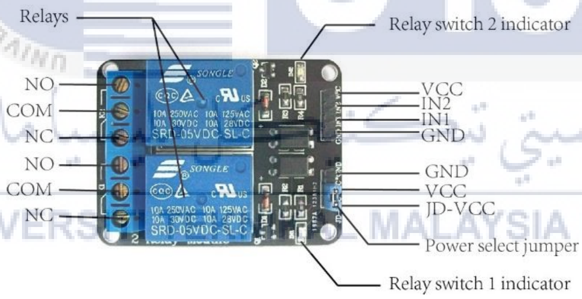

Figure 3.9 Relay pin connection

3.4 SOFTWARE IMPLEMENTATION

3.4.1 Integrated Development Environment (IDE)

Integrated Development Environment is referred to as IDE. It is a piece of software that offers many capabilities and tools to help with software development. To

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speed up the development process, an IDE often comes with a source code editor, a compiler or interpreter, debugging tools, and other utilities.

3.4.1.1 CODING FOR BLYNK

```
#define BLYNK_PRINT Serial
#define BLYNK_TEMPLATE_ID "TMPL6XksQsT_s"
#define BLYNK_TEMPLATE_NAME "development of eeg for smart home using ai"
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

char auth[] = "lnmFJ9__gedC2o5F-3DgbvLGa3-JvnSz";
char ssid[] = "Kir Kir";
char pass[] = "syakirpunye";

void setup() {
pinMode (D1, OUTPUT);
pinMode (D2, OUTPUT);
Blynk.begin(auth, ssid, pass);
}

void loop() {
 Blynk.run();
}
```

Figure 3.10 Blynk coding

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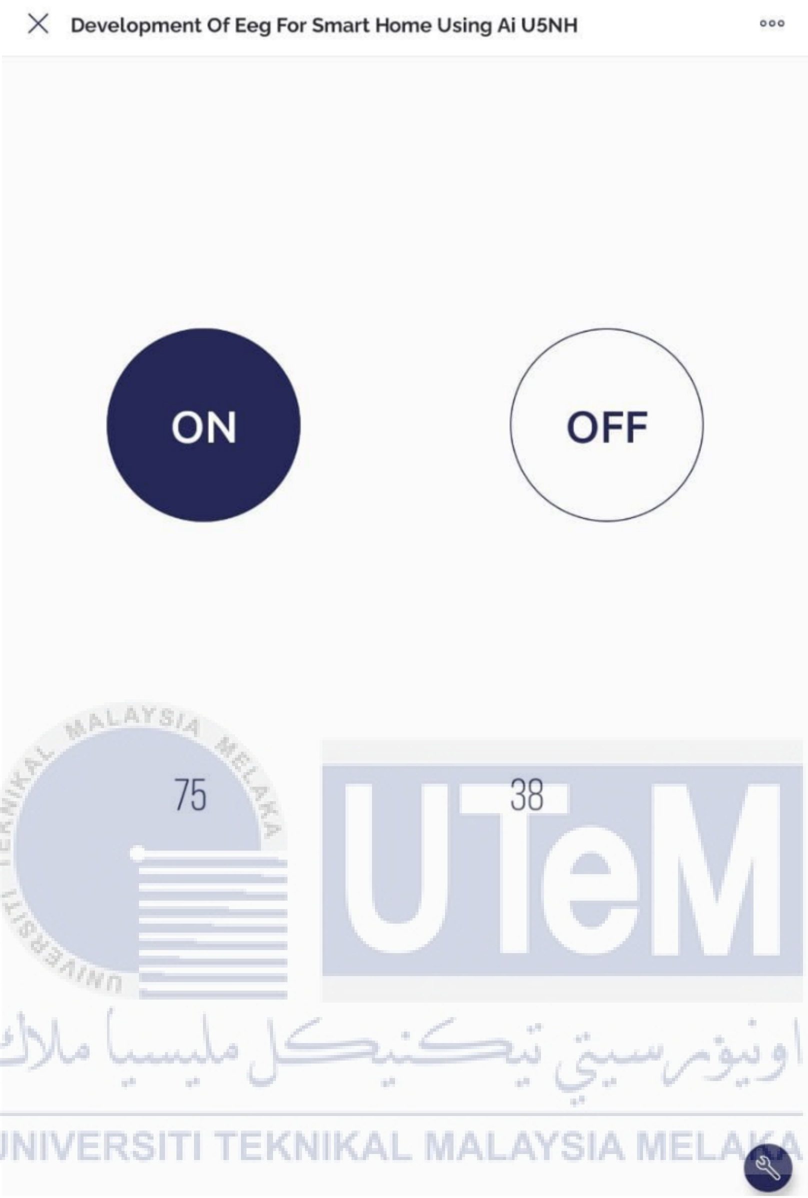

Figure 3.11 Blynk interface

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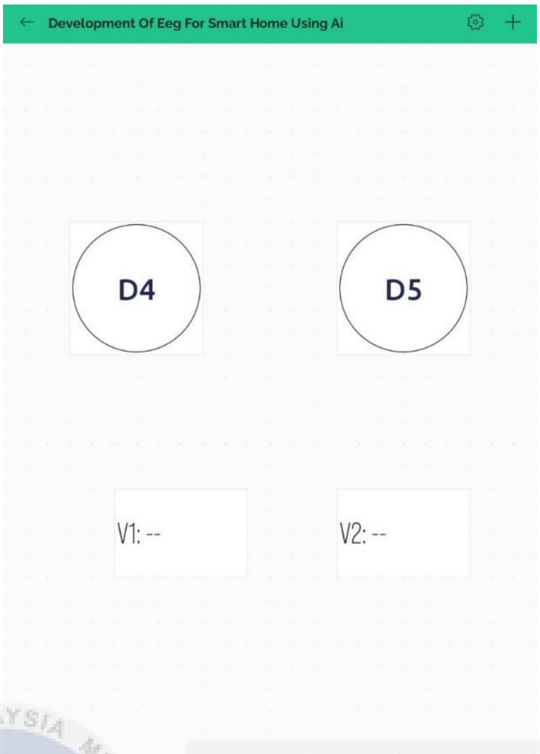

Figure 3.12 Blynk setup

Based on Figure 3.13, the D4 in the blink setup is refer to pin input/output 4 in the ESP8266. For D5 this refer to input/output 5 pin in the ESP8266. Then V1 and V2 is virtual pin for indicator for attention and meditation.

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3.5 HARDWARE

3.5.1 Project Circuit

The third milestone is established so that after the hardware and software testing completely before transfer to real project. By doing this method it can save time and resource before assembling the component to a real project. For controlling tool like EEG sensor and Blynk app is test through real project. Lastly is the design of the housing prototype for all the component. Repeated work on this particular aspect of the project is required in order to guarantee the highest quality end result possible for the design.

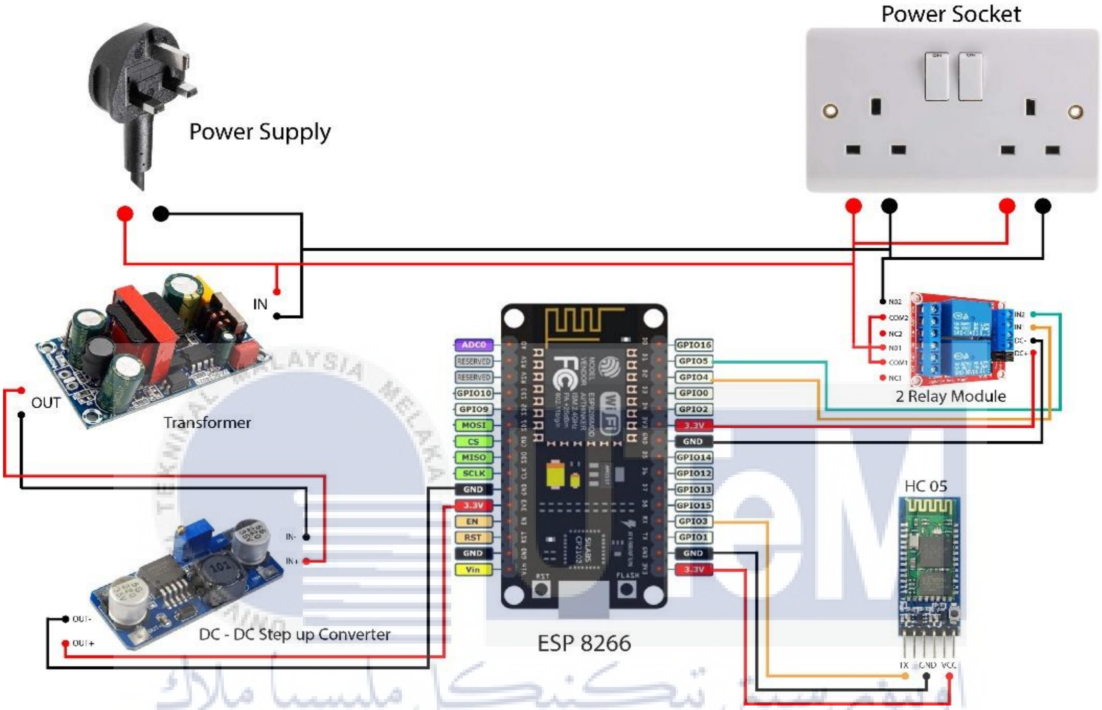

Figure 3.13 Circuit diagram

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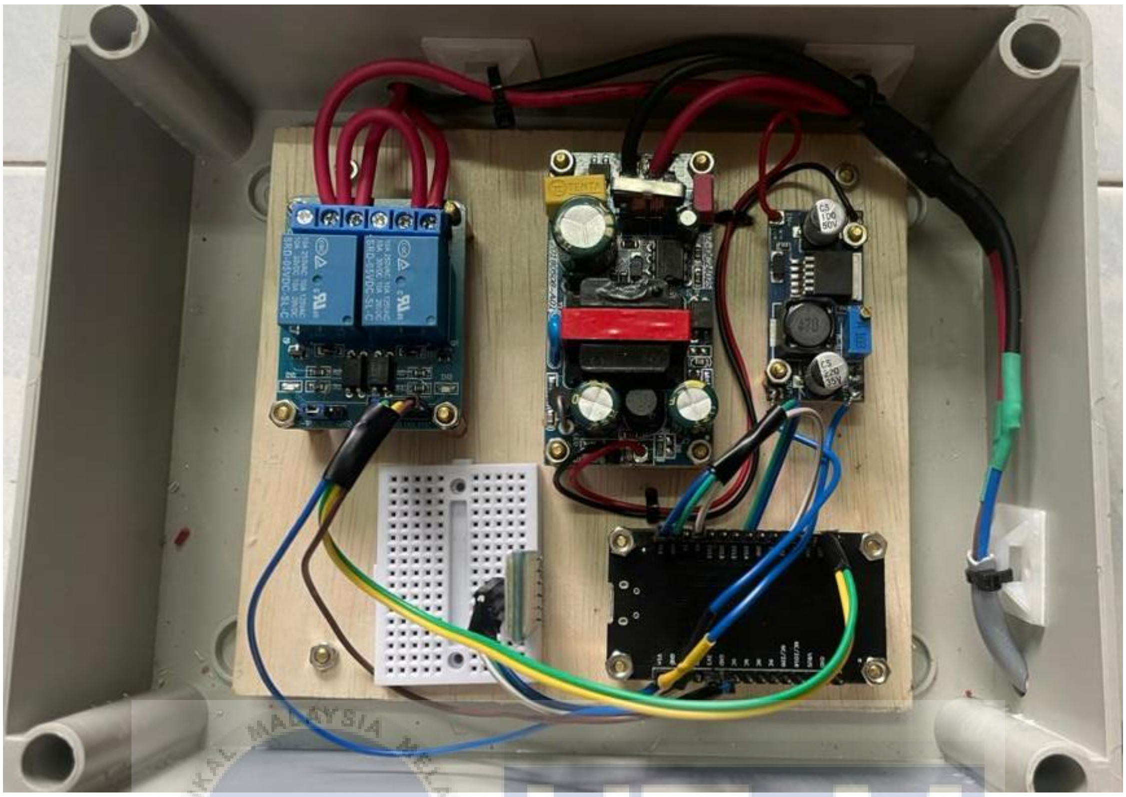

Figure 3.14 Project circuit

Based on the Figure 3.13 , the NodeMCU ESP8266 which was powered using 12 volts serial power port, is the brain of this project according to the figure above. The GND and VCC pins of this microcontroller were linked to the VCC and GND pins of the HC-05 Bluetooth module, while the Bluetooth’s TXD pins were connected to the ESP’s RXD. This Bluetooth module is already set up as a slave with a 57600 baud rate.

3.6 SUMMARY

This microcontroller system for smart home is completed at the end of the project. The results described the likely outcomes after completing this project,

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indicating that it be a successful project at its conclusion. The project's success is determined by how well the hardware and software development are done. Following the planning session, the result outcomes are predicted.

The hardware results are likely to operate well as expected. The NodeMCU ESP8266 microcontroller is performing well since it is the most appropriate and acceptable microcontroller board for controlling the smart home. However, there are some errors that arise when setting up the Arduino because the codes and clarifications of the devices are written incorrectly.

Furthermore, the performance and operation of the EEG sensor equipment (Mind Link) are both excellent, with no major issues. Troubleshooting even overcomes a little problem that happened during the headset's assembly and detection. The electrodes were placed incorrectly on the head, and the headgear was not properly positioned. There is also a serious issue with power performance when the battery runs out, which may be solved by recharge the battery.

This project meet all of its objectives, and the problem that exists now can be triumphantly solved. In addition, this project is planned to provide smart control of home appliances, which assist house residents who lack the ability to turn on or off appliances. Last but not least, one of the most significant issues that has led to the development of this smart house project is the inefficient use of electricity and the inability to control home equipment without physical movement.

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CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, the outcomes and analysis of the development of an EEG-based IoT smart home controller using ESP8266, and the chapter also examines all of the data that is necessary to establish the effectiveness of the project. Whether or whether the aim and scope are met, the data be collected in accordance with those criteria. There be some analysis done and observations made, both of which be reported in this chapter for the preliminary results.

4.1.1 Control using Blynk application

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Figure 4.1 Control using Blynk

Figure 4.2 shows the scenario in which the light will turn on anytime when the ON/OFF button is pressed. There is a notification feature for this application that alerts the user of the home when the smart home is connected or disconnected. This notification serves as an alert system to let the home owner know how their residence is doing

4.1.2 CONTROL USING MEDITATION AND ATTENTION


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Figure 4.2 Turn on using attention

In Figure 4.2, this figure show the result when the attention is reach 40% for 10 count in continuously. The plug 1 and plug 2 be function accordingly like its intend to do. This figure is taking after the project finish before collecting data

Figure 4.3 Turn off using meditation

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In Figure 4.2, this figure show the result when the meditation is reach 40% for 10 count in continuously. The plug 1 and plug 2 be turn off accordingly like its intend to do. This figure is taking after the project finish before collecting data.

4.2 DATA AND ANALYSIS

4.2.1 TIME TAKEN TO GET ATTENTION

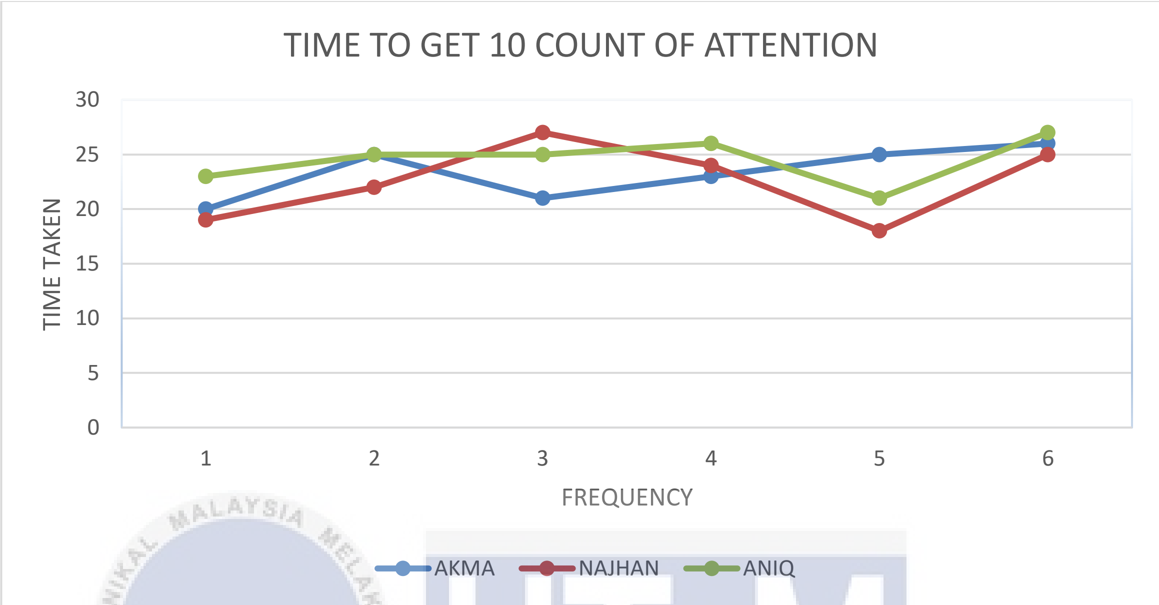

Figure 4.4 Attention counter

Table 4.1 Time to get 10 count of attention

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STUDENT NAME	TIME TO GET 10 COUNT OF ATTENTION(s)					
AKMA	20	25	21	23	25	26
NAJHAN	19	22	27	24	18	25
ANIQ	23	25	25	26	21	27

The data above reveals variations in the time it takes for students to garner a 10-count attention, with AKMA exhibiting a range from 20 to 26 seconds, NAJHAN fluctuating between 18 and 27 seconds, and ANIQ showcasing a span from 21 to 27 seconds. Comparing students' attention times suggests potential patterns or consistencies within their performance. Calculating average attention times could offer a generalized understanding of each student's ability, while pinpointing outliers may unveil instances of significant deviation from their typical patterns. This data provides a foundation for exploring factors influencing students' attention-capturing skills and understanding the dynamics of attention span in the given context.

4.2.2 TIME TAKEN TAKEN TO GET MEDITATION

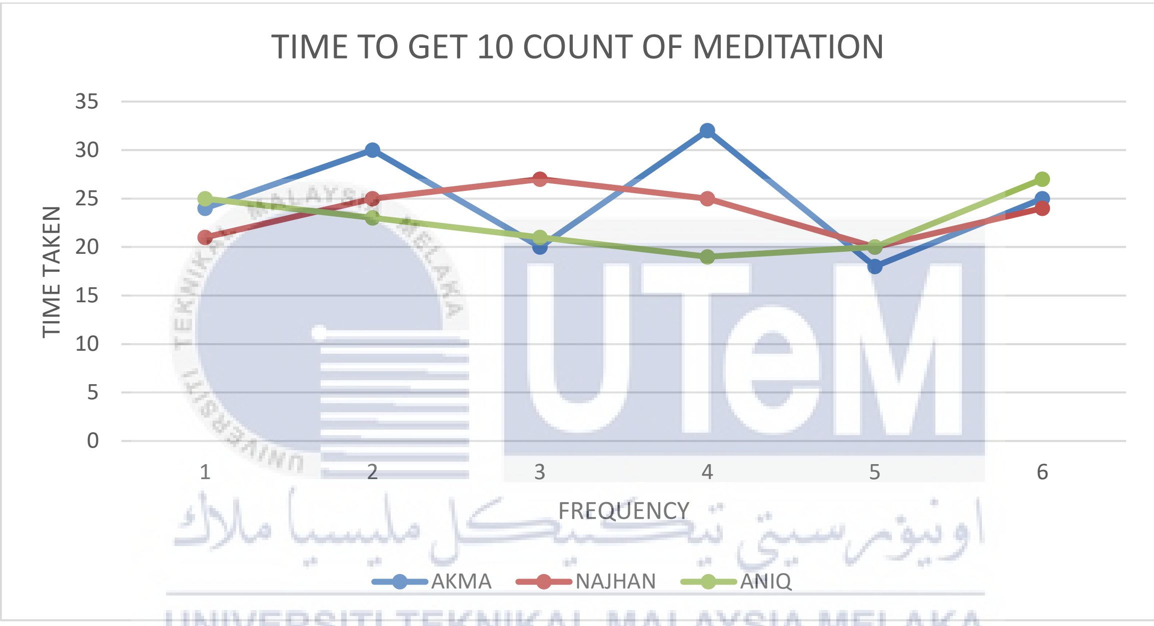

Figure 4.5 Meditation count

Table 4.2 Time to get 10 count of meditation

STUDENT NAME	TIME TO GET 10 COUNT OF MEDITATION(s)					
AKMA	24	30	20	32	18	25
NAJHAN	21	25	27	25	20	24
ANIQ	25	23	21	19	20	27

The presented data illustrates the time each student requires to achieve a 10-count meditation, showcasing individual variations in meditation duration. AKMA's meditation times range from 18 to 32 seconds, indicating notable variability in their ability to reach the desired count. NAJHAN's meditation spans between 20 and 27 seconds, with consistent performance across measurements. ANIQ, on the other hand, demonstrates a range from 19 to 27 seconds. Comparing students, it appears that ANIQ generally has a shorter meditation duration compared to AKMA, while NAJHAN falls in between. Calculating average meditation times for each student could provide a comprehensive understanding of their typical performance. Additionally, identifying any outliers or instances of significant deviation may offer insights into factors influencing meditation duration. This data offers a starting point for exploring individual meditation practices and understanding the dynamics of concentration among the students.

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CHAPTER 5

CONCLUSION

5.1 Conclusion

The development of an EEG-based IoT Smart Home Controller using ESP8266 yielded promising results. based on the results obtained, it shows that this project has been carried out successfully. it has also successfully achieved the set objectives such as monitoring and controlling home appliances, analyzing EEG and turning it into something to control home appliances. By integrating EEG technology, IoT devices, the system allows users to control their smart homes using their brainwave signals. Through extensive signal processing, the system accurately interprets user intentions, enabling seamless interaction with a variety of IoT devices. The project showcases the potential of using brainwave signals as a convenient and intuitive input method for smart home control, offering a novel and inclusive user experience. Further research and development in this field is hoping to hold significant promise for advancing the capabilities and accessibility of smart home technology.

5.1.1 Project Potential

The EEG-based IoT Smart Home Controller using ESP8266 is a cool gadget that can control your smart home devices using your brainwaves. It's great for people with disabilities or anyone who wants a hands-free and intuitive way to manage their smart home. The device is accurate, secure, and works with popular smart home systems. It's easy to use, reasonably priced, and follows all the rules. With a good marketing plan, helpful customer support, and potential partnerships, it has the potential to be a hit in the market.

5.2 FUTURE RECOMMENDATION

For future recommendation, the function of artificial intelligence which is fuzzy logic can be explore and be add to the project to enhance the system's capabilities. This could involve implementing machine learning algorithms for more intelligent control of home appliances based on user behavior and preferences. Furthermore, the improvement on the user interface of the Blynk application to make it more intuitive and user-friendly. Consider incorporating additional features that enhance user experience and control.

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Appendix

Appendix A

```
#define BLYNK_TEMPLATE_ID "TMPL6XksQsT_s"
#define BLYNK_TEMPLATE_NAME "development of eeg for smart home using ai"
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

int BAUDRATE = 57600;

char auth[] = "lnmFJ9__gedC2o5F-3DgbvLGa3-JvnSz";
char ssid[] = "Kir Kir";
char pass[] = "syakirpunye";

int ledPin = D1;
int ledPin2 = D2;



byte payloadChecksum = 0;
byte CalculatedChecksum;
byte checksum = 0;
int payloadLength = 0;
byte payloadData[64] = {0};
byte poorQuality = 0;
byte attention = 0;
byte meditation = 0;
byte quality_C = 0;
byte kira_attention = 0;
byte blinks = 0;

long lastReceivedPacket = 0;
boolean bigPacket = false;
boolean brainwave = false;
```

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```
boolean brainwave = false;

int attentionCounter = 0;
int meditationCounter = 0;
boolean ledOn = false;
boolean attentionCounting = true;

void setup() {
  pinMode(D1, OUTPUT);
  Blynk.begin(auth, ssid, pass);
  Serial.begin(57600);
  delay(500);
}

byte ReadOneByte() {
  int ByteRead;
  while (!Serial.available())
    ;
  ByteRead = Serial.read();
  return ByteRead;
}

unsigned int delta_wave = 0;
unsigned int theta_wave = 0;
unsigned int low_alpha_wave = 0;
unsigned int high_alpha_wave = 0;
unsigned int low_beta_wave = 0;
unsigned int high_beta_wave = 0;
unsigned int low_gamma_wave = 0;
unsigned int mid_gamma_wave = 0;

```

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```
void read_waves(int i) {
  delta_wave = read_3byte_int(i);
  i += 3;
  theta_wave = read_3byte_int(i);
  i += 3;
  low_alpha_wave = read_3byte_int(i);
  i += 3;
  high_alpha_wave = read_3byte_int(i);
  i += 3;
  low_beta_wave = read_3byte_int(i);
  i += 3;
  high_beta_wave = read_3byte_int(i);
  i += 3;
  low_gamma_wave = read_3byte_int(i);
  i += 3;
  mid_gamma_wave = read_3byte_int(i);
}

int read_3byte_int(int i) {
  return ((payloadData[i] << 16) + (payloadData[i + 1] << 8) + payloadData[i + 2]);
}

void loop() {
  Blynk.run();

  if (ReadOneByte() == 0xAA) {
    if (ReadOneByte() == 0xAA) {
      payloadLength = ReadOneByte();
      if (payloadLength > 169)
        return;
      payloadChecksum = 0;
```

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```
for (int i = 0; i < payloadLength; i++) {
  payloadData[i] = ReadOneByte();
  payloadChecksum += payloadData[i];
}
checksum = ReadOneByte();
payloadChecksum = 255 - payloadChecksum;
if (checksum == payloadChecksum) {
  poorQuality = 200;
  attention = 0;
  meditation = 0;
}
brainwave = false;
for (int i = 0; i < payloadLength; i++) {
  switch (payloadData[i]) {
    case 02:
      i++;
      poorQuality = payloadData[i];
      bigPacket = true;
      break;
    case 04:
      i++;
      attention = payloadData[i];
      break;
    case 05:
      i++;
      meditation = payloadData[i];
      break;
    case 0x80:
      i = i + 3;
      break;
    case 0x83:
      i++;
```

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```
          brainwave = true;
          byte vlen = payloadData[i];
          read_waves(i + 1);
          i += vlen;
          break;
      }
    }

    if (bigPacket) {
      if (poorQuality == 0) {
      } else {
      }
    }

    quality_C = (100 - (poorQuality / 2));

    if (brainwave && attention > 0 && attention < 100) {
      Serial.print(attention, DEC);
      Serial.print(",");
      Serial.print(meditation, DEC);
      Serial.print(",");
      Serial.print(attentionCounter, DEC);
      Serial.println(",");
      Serial.print(meditationCounter, DEC);
      Serial.println(",");
      Serial.print(blinks, DEC);
      Serial.println();

      if (attention > 40 && attentionCounting) {
        attentionCounter++;
        if (attentionCounter >= 10) {
```

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```
          digitalWrite(ledPin, LOW);
          digitalWrite(ledPin2, LOW);
          ledOn = false;
          attentionCounter = 0;
          attentionCounting = false;
        }
      } else {
        attentionCounter = 0;
      }

      if (meditation > 40 && !attentionCounting) {
        meditationCounter++;
        if (meditationCounter >= 10) {
          digitalWrite(ledPin, HIGH);
          digitalWrite(ledPin2, HIGH);
          ledOn = true;
          meditationCounter = 0;
          attentionCounting = true;
        }
      } else {
        meditationCounter = 0;
      }

      if (quality_C < 90) {
        blinks = blinks + 1;
      }

      if (blinks >= 5) {
        digitalWrite(ledPin2, LOW);
        blinks = 0;
      }
    }
```

```
          blinks = 0;
        }
      }
    }
  }
}
```

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