FUZZY CONTROL SYSTEM FOR SMART HOME APPLICATION

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2020
DECLARATION

I hereby declare that this report based on my original work except for quotations and citation, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at University Sultan Zainal Abidin or other institutions.

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CONFIRMATION

This is to confirm that:

The research conducted and the writing of this report was under my supervision.

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DEDICATION

All praise is due to Allah who has given me this opportunity to conduct this report for this final year project.

I would like to express my greatest appreciation to my family and friends who supported me and encourage me throughout the process of completing my project. I would like to express my sincere appreciation and gratitude to my supervisor Dr Aznida Hayati Binti Zakaria @ Mohamad for encourage, guidance, critics, advice, motivation and supports. This project would not have been completed without continue support from them.

I have learned more from this subject about the way to conduct a project research. Every single thing that I learned from my supervisor, I accepted as a valuable experience in my life. I will always remember all the knowledge and guidance that I have obtained. Also, sincere thanks to all my fellow friends for their help in completing my final project.
ABSTRACT

The ever-growing use of smart devices has already influenced all aspects of human life and has triggered the emergence of the smart home. Not to be mentioned, the different parts of a Smart Home are researched but there are still distances from an applicable system, using the modern technology. This paper presents the Smart Home system necessary for controlling the house based on mobile application and microcontroller. The system is able to monitor and control room temperature which is air conditioner and lights in the house using fuzzy logic. The main aim of the prototype development is to reduce electricity wastage by facilitating the home owner to optimize the usage of electricity through remote control using mobile application. This is because the usage of the electricity were increased drastically nowadays. Furthermore, this system also provide ease of control which support special needs of the elderly and people with disabilities. Mobile application was used for sending message from user’s mobile phone that automatically enable the controller to take any further action such as to switch ON and OFF the home appliances such as lights and air conditioner. The system is activated when user open and used the application in their mobile which then send the signal to controller at home. Upon receiving the signal from mobile application, the microcontroller unit then automatically controls the electrical home appliances by switching ON or OFF the device according to the user order. In other words, it read signal from the mobile phone and response to control the devices according to the received signal. This fuzzy control system for smart home application could provide an effective mechanism in utilizing the energy source efficiently.
ABSTRAK

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CHAPTER 1

INTRODUCTION

1.1 Background

The use of electricity is very important as one of the main source of energy that is crucial in this modern life. Some kinds of mechanism using available technology could be used to reduce wastage in electricity usage. Hence a prototype based on a microcontroller device using mobile application is developed. It can automatically control any electrical equipment at home remotely using mobile phone. So the electrical energy saving in daily life can be made more efficient and effective.

Mobile application technology has been widely accepted as a part of medium of communication. The purpose of using mobile application is to provide widest coverage at minimal cost. Then the use of mobile application would facilitate in controlling the electrical device at home from long distance and low in maintenance and independent from any physical geographical boundary. At the present time, people use electrical energy as one of the main source of power of energy to operate any electrical device or
appliance. Most of the people turn on the light and air conditioner for 24 hours per day even when they are away from home. Leaving the light and air conditioner turned on continuously, lead to energy waste.

Thus this project which is Fuzzy Control System for Smart Home Application is proposed to develop a system to facilitate the home owner to optimize usage of electricity remotely using mobile application.

1.2 Problem Statement

There are several problems that have been identify in this project. This problem statement will be the core statements in improving the existing system which are:

i. People with disabilities face the problem

Disable people might find it a problem as they need to move around to switch on or off their home appliances such as air conditioner and lighting.
ii. Waste time

If the appliances is on in the users house while they are on their way to work or maybe they already at the office, it might take some time to come back home just to switch it off. It is frustrated and nuisance if their workplace is far from home.

iii. Electricity wastage

People is too busy with their daily life, working from morning and back at home at night. Sometimes they forgot to check whether the appliances in their home is switch off or not as they leave the home.

1.3 Objective

i. To design the Fuzzy Control System for Smart Home Application anywhere at any time

ii. To implement the design of the model into Smart Home System

iii. To test and evaluate whether the Smart Home System developed is fully functioned.
1.4 Scope

This project focuses on two scope:

1. Scope of client which is to all people that has house
2. Scope of technology which is this technology will use Raspberry pi kit

1.5 Limitation

This project is only work in a wireless network connection to send the signal to the microcontroller and sensor at home. Next, this project only use the battery for power supply.

1.6 Expected Result

At the end of this project, the expected outcome from this project will be:

i. Able to help users to control the appliances in order to control appliances usage
ii. The Smart Home System: Air Conditioner Control is fully developed, installed and functioned for user to use
CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Literature review is a text of scholarly paper, which includes the current knowledge including substantive findings, as well as a theoretical and methodological contribution to a related works. There are a few devices related to Electrical Control System for Smart Home Application (Air Conditioner). However, most of the devices did meet the requirement that needed by the users.

2.2 Related Works
2.2.1 Smart Home Automation System

According to this article [1], Smart home automation system is a web based application that allows user to monitor home appliances using mobile devices. This system is established for the entire home user after gaining access from administrator. This system includes remote control and monitoring domestic appliances, security and energy management. Once all the appliances in home are automated and connected it important to consider issue of security authentication and access control.

The implementation and design of this project done by using three methods, motion sensor technology, RF remote control and Wi-Fi Router hand held to control of the selective home devices. The software consists of assembly language for programming microcontroller and visual basic language that use to communicate between transmitter and receiver model. The system is created for energy efficient housing that was optimized for low cost.

2.2.2 Home Automation System using Android

In this article [2], target of this venture is to build up with Android application controlled Bluetooth which is the input is taken in the Android. The framework executes Bluetooth innovation to give remote access from the cell phone. Bluetooth operation is accomplished by any PDA/Tablet and so forth with Android OS, upon a GUI (Graphical User Interface) based touch Screen operation.

This article states that the switches status is synchronized in all the control framework while each one of the UI demonstrates the constant existing switches status. Android application goes about as the transmitter, which sends ON/OFF orders to the collector where
loads are associated. This invention has secure connection channels amongst application and Raspberry pi. It has the utilization of secure conventions over Bluetooth with the goal that different gadgets can't control the appliances. The framework expected to control electrical machines and gadgets in-house with generally minimal effort outline, easy to use interface, and simplicity of establishment.

2.2.3 Android Based Automation System for the next Generation of Technology using Wi-Fi

This article [3] is a project focused on a design of monitoring and controlling home automation system from an android application based on Raspberry Pi. This system uses Wi-Fi technology as a communication protocol to connect system components. This system focus on two main component which is the first one is android application that can give orders to units that one wishes to control by locally or remotely and the second one is Raspberry pi that has an appropriate interface to sensors and appliances of a home automation system and finally able to communicates with android application through wireless technology.

Android is used as the operating system in this project as it is the most suitable OS to run the system. The Andoid code is installed as an executable on the phone, which then communicate with the java server on the computer system. Java language is used as the communication for the system to run and complete. The designed system not only monitors the sensor data, like temperature, gas, light, motion sensors, but also actuates a process according to the requirement, for example switching on the light when it gets dark. It also stores the sensor parameters in the cloud (Gmail) in a timely manner.
This will help the user to analyze the condition of various parameters in the home anytime anywhere.

### 2.2.4 SHAS-IoT: Smart Home Automation System (SHAS) using Internet of Things (IoT) to Improve Safety and Security

In this article [4], this project tells us how SHAS-IoT provides high degree of security and safety also energy saving. This project includes a description of SHAS-IoT that enable of monitoring sensors and remotely controlling actuators to flexibly construct security and safety services. Basically, this project which contains SHAS-IoT refers to automation of home appliances which can be viewed from security, automatic monitoring and controlling view. The major element of this project are sensors network, Arduino and mobile application.

From a home security perspective, this project includes alarm system, smoke detectors and all of the doors lighting, cameras and other sensors. This system is built by combining many communication protocols such as ZigBee, GSM, WiFi into wireless network through a standard home gateway. This home gateway actually works as a central control unit that manages the overall communication.

There are two scenarios in building SHAS-IoT. The first scenario is smart home remote system. For this scenario, the Bluetooth module is turned on and begin to send and receive from the mobile. User need to sign up in the mobile application by personal data then user can start sign in at that exact time. For example, if user choose room one, user can control every device in the room by clicking turn in or off.
Then, the second scenario is full control automatic within the home. In this scenario, all sensors work in case there are a person in the home. For example, if user enter the home or any room, user can see the action happened by sensor for every part in the home.

2.2.5 An Internet of Things Based Air Conditioning and Lighting Control System for Smart Home

This article [5] proposed an IoT based system which provides the controls the controls of air conditioning and lighting devices in a smart home. The system proposed provides both heat comfort and energy savings to the households. This system includes switches and sensors that communicate with a central axis which are sometimes called “gateways”. These “gateways” are control systems with a user interface that interact with a tablet, mobile phone or computer and the network connectivity of these systems is managed by IoT.

This system works when the residents leave their smart homes, the devices inside their homes automatically turn off. The residents use mobile devices for this system instead of a physical key. For this smart home application, the NodeMCU WiFi module with embedded system architecture and the Arduino Pro Mini 328P microcontroller are used. NodeMCU WiFi has a modular structure with built-in WiFi feature which its programmable feature makes it possible to implement internet applications of objects at low costs. Arduino Pro Mini acts as an RF receiver module DHT22 temperature humidity sensor is used to take the temperature and humidity information of the medium.
2.2.6 Smart Home Control by using Raspberry Pi & Arduino UNO

This paper [6] presents a flexible and an inexpensive home control and monitoring system by utilizing network based on Raspberry Pi and using Arduino Microcontroller. The interface between the Access Point and switches with IP connectivity for accessing devices and appliances and controlling it remotely will be made by using Android based Smartphone application or server computer. This switch node connected to electrical devices that can be controlled using sensor and remotely controlled through an access point, the Smart Switch system for Smart Home development consists of two major parts that are smart switch device and the access point. The main hardware for this system contain: Raspberry Pi, Arduino Microcontroller, nRF24L0+ Wireless Transceiver, Relay Modules, Gang Switches, Lamps, Plugs, Sensors and Wire Set. Expected outcomes from this system: programming by using Python that comes built-in with Raspbian, Wireless module adapter to make connections between the Arduino Microcontroller and nRF24L0+ Wireless Transceiver.

This paper has system development for monitoring and determining the confidence of fire in a building presented shows the Raspberry Pi’s power in home automation. Thus the developed Raspberry Pi prototype Sensor Web node is based on RESTful services and constructed in order to build the infrastructure that supports fast critical event signalling and remote access through the Internet to sensor data (the detection of critical events is performed by using fuzzy logic). Both shown client mean for data processing is just one possible way of application. Use Raspberry Pi as a Sensor Web node with the presented approach makes its applications endless.
2.2.7 Advanced Home Automation System Using Raspberry pi and Arduino

This article [7] proposed a cost effective system to achieve such automation system based on IoT concept. All the devices of this system are connected to Raspberry Pi. This system also provides a facility to control all home appliances locally without the internet via a local network. Raspberry Pi runs a web server to host a web-based control interface and a SQL database to maintain the current status of appliances. The interface can be accessed through the internet or locally without the internet. The automatic re-start mechanism makes the system more efficient. Raspberry Pi is used as it is a powerful computer and supports the latest web technologies and databases.

The proposed system controls home appliances remotely using Raspberry Pi. The Raspberry Pi receives commands from the user through a web interface and executes a shell command to generate a control signal for Arduino. Then, relay switches are controlled by the Arduino according to the control signal. The system requires the following components; A hotspot (wireless internet connectivity or pocket router) to provide internet connection to the Raspberry Pi; A Raspberry Pi which acts as a web server, SQL server and also a control unit; Dataplicity to remotely access Raspberry Pi from anywhere in the world via internet without DynDNS, VPN, static IP or Port forwarding("Dataplicity: Remotely Control your Raspberry Pi"); Web-based graphical user interface (GUI) to control the system("Web Interface,"); Arduino to control relay switch according to the control signal sent by the Pi.

For the restart mechanism All of the appliances are connected with the Arduino. So, if Arduino is reset, all appliances will be turned off automatically. When the power goes off, the Pi will be off. That means the server will go offline. The appliances will not get into their previous state after restarting the server. To prevent this problem a python script is used. When the server will reboot this script will run automatically and restore the previous state.
2.2.8 Smart GSM Based Home Automation System

The article [8] Smart GSM Based Home Automation System is focused on functionality of the GSM protocol, which allows the user to control the target system away from residential using the frequency bandwidths. It is the implementation of the home automation technology using Global System for Mobile Communication (GSM) modem to control home appliances such as light, conditional system, and security system via Short Message Service (SMS) text messages. This system applied the concept of serial communication and AT-commands towards development of the smart GSM-based home automation system.

The system works when the home owners will be able to receive feedback status of any home appliances under control whether switched on or off remotely from their mobile phones. PIC16F887 microcontroller with the integration of GSM provides the smart automated house system with the desired baud rate of 9600 bps. In this proposed system design, incoming SMS message is sent from the user phone to the GSM modem as a text message via cellular network. The GSM modem then sends the commands in text mode to the PIC microcontroller using an RS232 interface. The RS232 voltage levels are at ±12V whereas both the microcontroller input and output operates at 0V to +5V. Since RS232 is not compatible with microcontroller, MAX232 is utilized to enable the communication between both the GSM modem and PIC microcontroller by converting RS232 level signals to TTL level signal. Outgoing message from the system containing the home appliances status is delivered to the mobile phone through GSM modem.

Among the cellular technologies, GSM network is preferred for the communication between the home appliances and the user due to its wide spread coverage [8,9] which makes the whole system online for almost all the time.
2.2.9 Social Networks of Things for Smart Homes Using Fuzzy Logic

This article [9] presents an approach for Smart Homes using Fuzzy Logic. The proposed study provides solutions for development of smart homes and proposed a model for inter Smart home communication. This approach not only gets real time data from internal sensors rather it also includes input from local weather station for Fuzzification and Defuzzification process to produce results in real time. The aim of proposed system is to provide dynamic information and communication between nearby as well as remote smart homes.

The proposed model provide an economical solution for inter-smart home communication because in the proposed Smart Home network system it is not necessary to deploy or install sensors for input in every node (home) rather it only needs one home form a cluster to be equipped with sensors or smart objects in order to share the sensory information to its own as well as other clusters within smart home network using fuzzy cloud services.

This system receives sensory inputs within Fuzzy cloud and on the basis of knowledge base including Scaling Function, Fuzzy Rules and Membership functions fuzzy rule base system process it to produce output after fuzzification and defuzzification using inference engine. Any Logic based on multiple values regarding truth values or any real number between “0” and “1” of a variable is called fuzzy logic that is used to perform the concept of partial truth in which truth value may be between completely true and false.
CHAPTER III

METHODOLOGY

3.1 Introduction

Methodology is the outline of the way a process or task will be carried out. Thus, the development of this device is carried out by applying the methodology of Electrical Control System for Smart Home Application (Air Conditioner) development. The development of this project is carried out by applying the methodology of Agile Development. Figure below shows the iterative and incremental model that is chosen to develop the project. This model is chosen because the project can be developed through repeated cycle which is iterative. The project can be proceeds if there are any changes in the middle of the project.
3.2 Methodology Phases

This model consists of six phases which are planning, requirement, analysis and design, implementation, testing and deployment.

Figure 1: Agile Development Model Methodology
3.2.1 Planning

The first step of the Agile Development is planning where in this step included the development of Raspberry pi and implemented coding from the Raspberry pi. By referring from previous project, Raspberry pi is an important part in this project because Raspberry pi is the main part of this project and will be attached with others part and sensor. This step also include the development of selection the right sensor that 40 kHz ultrasonic sensor (HCSR04). This step is important to develop the Raspberry pi board to combined with the ultrasonic sensor to give signal to the sensor at home whether to switch on or off the air conditioner.

3.2.2 Data Model (Requirement)

3.2.2.1 Software

3.2.2.1.1 Android Studio IDE

Android Studio is the official integrated development environment (IDE) for Android application development. It is based on the IntelliJ IDEA, a Java integrated development environment for software, and incorporates its code editing and developer tools. It is easy to use and flexible.

3.2.2.1.2 Google Firebase

Google Firebase is a Google-backed application development software that enables developers to develop iOS, Android and Web apps. Firebase provides tools for tracking analytics,
reporting and fixing app crashes, creating marketing and product experiment.

3.2.2.1.3 Python

Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance.

3.2.2.1.4 PyCharm

PyCharm is an integrated development environment used in computer programming, specifically for the Python language. PyCharm makes it easier for programmers to write various web applications in Python.
3.2.2.2 Hardware

3.2.2.2.1 Raspberry Pi

A Raspberry Pi is a credit-card sized computer originally designed for education, inspired by the 1981 BBC Micro. The Raspberry Pi is open hardware, with the exception of the primary chip on the Raspberry Pi, the BroadcomSoC (System on a Chip), which runs many of the main components of the board—CPU, graphics, memory, the USB controller, etc.

3.2.2.2.2 PIR motion sensor

This PIR sensors signals produce are only high (motion detected) and low (no motion detected). With this signal feed into the controller, the controller will able to notice the present of the human and thus takes appropriate action on the lights

3.2.2.2.3 DHT11 Temperature and Humidity Sensor

Provides digital temperature and humidity readings. Really easy to set up, and only requires one wire for the data signal.

3.2.2.2.4 Relay Module

A relay is an electrically-operated switch. These switches can be extremely useful for a variety of Raspberry Pi projects (think turning on a light).
3.2.2.5 Mini Breadboard

The modern breadboard is a plug-and-play way to make connections between electronic components. It is easy to setup. To connect all the input and output of the circuit.

3.2.2.6 ESP8266 WiFi

A self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor.

3.2.2.7 Light Dependent Resistor (LDR)

An LDR is a component that has a (variable) resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits.
3.2.3 Design

This step is required so that the flow of project will be successful. In this step, a design of a circuit as shown as in figure below.
Figure 1: Flow chart for smart switch node sends status to Android app.
Figure 2: Flow chart for Android app sends status to smart switch node.

The flowchart of the Smart Home System shows that when the power is ON, all of the component will start working, the Raspberry pi will connect to the wireless network.

3.2.4 Implementation

After the design phase has been develop, the configuration and the coding of the Raspberry is implement. The circuit is installed and connected. The coding for the pulse of waves include the 1-minute looping time for generate the pulse. If else rule is used in the coding to determine whether there has obstacle or not.
3.2.5 Testing

In this step the complete circuit will be tested. If there is still an error occurred, it will be solve in this step. If there is any change need to implement, the project must start back at design step for revision flow.

3.2.6 Deployment

After the circuit has been completely installed without error, the complete circuit will be attached.

3.3 Summary

In this chapter, the methodology of the project is explained. The flow of this project followed the steps that need to develop the Smart Home System. The requirement of the hardware and software is listed properly for the development of the Smart Home System.
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