Smart Home Monitoring and Control System

by
Cristian Orna
Matthew Acosta

Senior Design Project
September 2019
Faculty Advisor: Prof. Dmitri Donetski

Abstract

Our goal is to design and build an automated smart home control system. This control system will be able to three other auxiliary systems: a light control system, a heating, ventilation and air conditioning(HVAC) control system, and a water sprinkler control system. The system will be able to be controlled by an application so it can be remotely controlled by a smartphone. The project will consist of seven phases. The first three phases consist of designing the light control system, the HVAC control system, and the sprinkler control system. The fourth phase consists of integrating the three systems together. The fifth phase consists of ordering the parts and assembling the circuit. The sixth phase involves developing the mobile app. The seventh phase consists of designing and testing the PCB boards for the three systems. The whole project will take approximately 160 days.

Table of Contents

Introduction

Project statement and goals

Our goal is to design and build an automated smart home control system. This control system will be able to three other auxiliary systems: a light control system, a heating, ventilation and air conditioning(HVAC) control system, and a water sprinkler control system. The lighting control system will detect motion in a room and turn it on, then turn it off after a set period. The HVAC control system will sense the temperature and determine whether the room needs to be heated or cooled depending on temperature range set by the user. Then, the system will open the vents and activate either the heating or cooling system accordingly. The sprinkler control will allow the user to schedule when the water sprinkler system activates. The system will be able to be controlled by an application so it can be remotely controlled by a smartphone.

Project Goals:

- Design a Sprinkler Control System
- Design a Lighting Control System
- Design an HVAC Control System
- Design a Central Control System
- Design a mobile app to control the system remotely

Background

Internet Of things (IoT)

As time progresses the Internet of Things or commonly known as (IoT) has become one of the main topics for development and implementation of new technology. Internet of Things can be define defined as the interconnections of many devices in one whole place that is the internet. The internet is a universal system that connects many networks via communication protocols like the internet protocol address (IP address). In other words, devices that have the right kind of hardware and software that are available to connect and communicate in the internet are consider smart devices and run in this environment of IoT. Some examples, are cars, cellphones, smart surveillance, etc. Take for instance, smart hubs like the Amazon Echo which is considered part of this interface in which a person through voice command can get information like the news, hear music from different applications, access the weather, get notifications from social media, and much more. In fact, there are even cities now that are connected in IoT and are considered smart cities. This consist of installing different devices all over the city ,that contain many electronic pieces like sensors that are available to exchange, gather, and interpret different kinds of data in the internet. This helps the city gather information like traffic, weather, GPS and more. The information is store in the cloud and the users , and other devices can access it thought their phones, computers, tablets, and electronic systems as long as they have a internet connection

Smart Home Automated Systems

The idea of an automated home has been around for a very long time. Think about the different home function that appeared in back to the future or the show rosie from the persons. In fact, many scientist scientists like created devices that can think for themselves for purpose creating a home that can maintain itself. This was before the first automated home system was invented, which was the ECHO IV develop in 19666 by Jeff Bezos. After that in 1979 X10 was invented. Since then home automatization has increased popularity dramatically due to the improvement in technology like the creation and development of IoT. Now, a smart home automated system can be defined as the integration of technology within a home to help improve the living environment in which people can benefit in many different ways, such as bringing safety to the home by controlling camarares and other electronic equipment. In other words, is a system that integrates and controls entertainment systems, lighting, temperature, and other appliances in a house, and that it can effortless maintain itself little with little to non human interaction. For example, a system can control which lights are turn on or off, or gather the temperature in the house and store it to give you accurate details on how the temperature change and when.

Existing Smart Home systems

In today's modern world there are different types of smart home systems available to the public. Each of this systems perform different kinds of functions and are available to help improve people's live. Some of the systems include:

Control4

Control4 is a one of the most popular smart home automated systems in the market. This system can perform many more function than other systems.This is because the system is compatible with other devices, that share the same connectivity like wifi or bluetooth. Also, is user friendly. Meaning that it has the user can control and access the system through different devices. According to their website the system can perform the following: control the lighting in the home, entertainment systems, climate system, and blinds and shades system. One problem with this system is that for every system that a user wants to control they would have to buy different products that add to the Control4. Which means that people need to have different technologies to operate the different controls. For example, in their website the company mentions that for climate control the system can be only use if there is existing HVAC, radiant flooring, forced air, dual fuel and geothermal system in the house. Control4 is quite expensive and depending on what the user wants to control it can increase to thousands of dollars. Meaning that the company mainly targets the upper class. Other problems are mentioned by Lobaccaro, Carlucii, and Lofstrom which state that "The system must be installed professionally by an authorized dealer, It offers limited mobile access functionality with its base system setup, The Help & Support section of the system is poorly performed."

Crestron

Creston is another automated system that is very popular. This system has the same functionality as Control4, but it's more compatible with other devices. Also, it can control different systems at the same time allowing the user to keep adding new appliances without having to upgrade every time. This company also makes this products very user friendly. Some

drawbacks to this system are that it can only be installed by professionals and that it doesn't monitor its energy use. This product is also quite expensive and, like the previous home system, if you want to add more functions you have to pay more, which makes it difficult for lower class people to afford this.

British Gas Smarter Living & Energy saving

This is another system but unlike the other it can only control british Gas controlling systems with the objective of saving energy. This is also popular because outside of saving money people are able to help the environment. This system consist of smart meters and smart sensors which tell the user the amount of energy consume and lets the user decide what to do. According to Lobaccaro, Carlucii, and Lofstrom the only weakness in this system is that is bounded to a British Gas company making it hard for people to use this in other products that are not from the company.

Social, environmental and social Impact

Narrative

This project consist of automating a home to perform the following functions. Controlling the lights. Determining the temperature, so that it can either turn on ventilation, AC, or heater to a specific environment set by user. The last thing is a sprinkler system which is going to turn on or off in a specific schedule set by the user. This project can be better understood if we divide it into different sections thats is.

Hardware

The hardware of our system will be composed of different electronic components, such as, sensors, capacitors, resistors and so on. It will be incharge of obtaining the different information need to fulfill the different commands the user is going to input. The following parts are some of the part that we need or might use in our system:

Temperature Sensors

This is a device that gathers the temperature the room and measure it. Temperature sensors are used in various applications like medical devices, food, and more. There are two types of sensors contact sensor and noncontact sensors. We would need a non contact sensor. This type of sensor gathers the thermal energy in a area and stores it. We need this because in our project will to take into account the temperature in the home, so that it can turn off or on the ventilation, heating, and AC system. A possible sensor that we could use is the Resistance Temperature Detectors (RTDs) sensor. According to Carolyn Mathas this sensors "are temperature sensors with a resistor that changes resistive value simultaneously with temperature changes. Accurate and known for repeatability and stability"(((()))).Also, we would need a sensor that operates in our desire voltage and current so other electronic parts are safe and not damage.

Moisture Sensor

Our project consists of a sprinkler system which will automatically turn on or turn on by the user. Some possible electrical components are water level sensor and a moisture sensor. The water level sensor is basically a liquid level sensor. This sensor is going to measure the water

that is going to go into the sprinklers. The Moisture sensor is going to measure the moisture to determine if the plants need watering. If the water and the moisture sensor have the adequate data they are either going to turn on or off the system.

Light sensors & Motion Sensor

Light sensors are sensors that are going to detect if it's day or night. Motion sensors are going to detect if there is any movement in the area. This two sensors are going to be the base for our lighting system. We plan to unified them to allow the user to input when to turn on or off the light and for how long the lights should be on or off. The Light sensor we could built it using LDRs, resistance, and transistors. The motion sensor will be purches. This will help reduce the amount of power consume consumed by the lights in the house.

Others

The system is going to need extra part like wire, resistors,capacitors and other. This electronic devices are going to help combine all the sensors and systems together so we can safely operate our circuit. For example, the resistors are going to help regulate the current so the circuit don't overheat and burn.

Data

The electronic components need to be controlled to be able to perform the function the the user wants. Thus, we need a electronic device that gathers the data from the components and also commands this devices. We can use a embedded microcontroller. Which use their technology to gather information and control different systems. Basically, The hardware is going to gather the different physical data that we need, now the data needs to be process and control. Thus, by incorporating a microcontroller the data is store and saved. For our project we will need a microcontroller that is able of storing all we are going to have. Additionally, it has to have enough capability of operating this systems. This microcontroller can be programmed by using ATMEL.

Connectivity

Now, that we have hardware. Now we need to figure out how this systems will communicate, how they are going to be controlled, and how they'll function. Since we are going to use an app to control the hold system we decided to use a Wifi module. This modules are going to be place in every system to help communicate and exchange data. A wifi module is a electronic device that that uses the internet to communicate between the microcontroller and the other devices. This device connects to the IP and making it easy for us to produce our goal.

Software

The software will Interpret the data and sends determine instructions to perform different commands. We would possibly use two types of software. Atmel Studio to program the microcontroller, and android studio. Android studio is a software that we would use to help us create an app that is going to use the IP address to communicate between the microcontroller. This app is going to have different function that the user is going to able to use. Meaning that it will send a signal to the microcontroller via wifi to perform the different instructions. For example, it is going to have a calendar so that the user can set the when. What time, and for how long the lights are going to be on. Also, it would allow the user to change this as many times they want. Also this app will be program for multiple user. In other words, several people can control the system. This is something important because is a weakness in every automated home. For example, the Control4 system can only manage and alter by 1 user only.

Project task & Road-map to deliverables

The first phase of the project involves designing the sprinkler system. First we will determine what parts and materials we will need for the the system. This will take one week and will be completed on 9/28/18. The next step is to determine what standards are applicable to our design. The will take two days and be completed on 10/2/18. The final step is to draw and simulate the circuits. This will take eight days and will be completed on 10/12/18. This phase of the project will take a total of 15 days, or three weeks.

The second phase of the project involves designing the lighting system. This phase will follow the same work structure and scheduling as the first phase. This phase will take 15 days and be completed on 11/2/18.

The third phase of the project involves designing the ventilation system. This phase will also follow the same work structure and scheduling as the first phase. This phase will take 15 days and be completed on 11/28/18.

The fourth phase of the project involves integrating the three systems together. The first task is to decide what parts and materials we need. This will take 5 days and will be completed by 11/30/18. The second task is to research the part characteristics. This will take six days and will be completed on 12/4/18. The next task is to draw and simulate the circuits. This will take 6 days and will be completed by 12/12/18. The final task is to ensure that the systems are compatible with each other. This will take two days and will be completed on 12/14/18. This phase will take a total of 15 days.

The fifth phase involves building the necessary circuits. The first task is to order the parts. This will take 30 days and will completed on 1/15/19. The second task is to begin building the circuit. This will take 15 days and will be completed on 2/15/19. The next task is to test the circuit to ensure it works properly. This will take 5 days and will be completed on 2/22/19. The

final task to perform final verifications on the circuit. This will take 5 days and will be completed on 3/1/19. This phase will take a total of 55 days.

The sixth phase involves developing the app that will be used to control the system. The first task is to decide what software we need to use for app development. This will take 2 days and will be completed on 3/5/19. The next task is to design and code the app. This will take 12 days and will be completed on 3/12/19. The final task is test the app with the system make sure it works properly. This will take 11 days and will be completed on 4/5/19. This phase will take a total of 25 days.

The seventh phase involves designing and manufacturing the PCB boards for the three systems. The first task is to design the PCB boards. This will take 8 days and will be completed on 4/17/19. The next task is to simulate the PCB boards and test them with the system. This will take 2 days and will be completed on 4/19/19. The final task is to order the PCB boards. This will take 10 days and will be completed on 5/3/19. This phase will take a total of 20 days.

The entire project will take a total of 160 work days and will be completed on 5/3/19.

Potential risks

Team Members

- Matthew Acosta:
    - Fourth Year Electrical Engineering Student
    - Expertise:
        - Digital Design/Embedded Systems
        - Cadence OrCAD/PSPICE

Project timeline

Budget

Considering the parts need that were mentioned above we could find some parts to use and their price. This part are not the definitive and may need additional and parts as the project progresses. The amount of part we need are yet to be determine so we only did price per unit. The parts we found are based on Digikey Electronics and Mouser Electronics.
This are as follow:

Part	Part Name	Units	Cost
Microcontroller	Atmega344A	1	$4.38
Temperature Sensor	480-2017-ND	1	$3.05

Soil Moisture Sensor	1568-1360-ND	1	$4.95
Motion Sensor	490-11915-ND	1	$3.12
Wifi Module	ESP826	1	$6.95
Transistor	2N700	1	$0.39
LDR	485-161	1	$0.95

Table 1.

References

Appendix A