Initial Project and Group Identification Document

Divide and Conquer 2.0

Home Safety and Automation System

Group 14

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Project Motivation

Popularity of smart home systems are on the rise, but many are extremely expensive. We realized that the idea of a smart home already has many subsystems for monitoring activity, so we decided to combine an automated home system with a security system for an all-in-one interface. It will be comparatively low-cost to other automated home systems and include security functionality such as fire detection, front-door identification, and light management.

Project Description

Motion Detectors and Infrared Photodiodes

Two of the key features of our Home Automation System are safety and security. Infrared motion detectors will be able to detect when someone enters or leaves a room. This is essential for allowing users to know if someone is in their house and can provide a speedy reaction to burglary or other crimes. These sensors will be embedded into the doorbell to detect when someone is at the front door to allow recording of any visitors. They also act simply to communicate to the other portions of our system that someone is home to turn on lights or switch the air conditioning setting.

A fire detection system will be set in place by utilizing NIR photodiodes to detect high temperatures within a room. These photodiodes will operate at the peak blackbody emission of house fires, around 1.1 micrometers, and communicate to the central system when something in the room is emitting at this spectrum. This system has a much faster response time than smoke detectors, so the user will be able to react in a timelier manner.

The proximity of the motion sensors will be conical and limited to about ten to twenty feet, so several will be spaced in the same room. The photodiodes have a shorter proximity limited to around 2.5 feet for small flames and a much further range as the flame increase, so many more of them will be connected in a circuit for each room. This will ensure that all points of interest including heated appliances and electrical sockets are carefully monitored.

A single lens system will be implemented to increase both field of view and range of the infrared photodiodes. This will increase the input signal from any household fire and increase the reliability of the photodiode. The lens will also focus noise from incident outside sources onto the photodiode so an anti-reflection coating will be utilized to create a better signal to noise ratio in the system. The photodiodes will be housed in an aluminum box to reflect any of the signal which wasn't completely incident on the photodiode back onto it.

Display

The display will be a touch screen display compatible with the chosen system controller. The interface will be no more than seven inches measured diagonally. There will be a sleep function on the display to conserve power when it is not in use. All configurable buttons, sliders, and

text boxes of the web application will be compatible with the available touch screen and on-screen keyboard.

AC Control

The system will need to be able to turn AC units on/off with the use of a relay installed at the AC controller. If possible, the system will also be able to act as an AC controller with the addition of a temperature sensor. User will be able to set up an AC schedule and (if applicable) Automatic AC through the use of the System Web Application.

Outlets

This System should be able to incorporate Smart Outlets through either direct GPIO manipulation to a modified outlet or by using the IP accessible wireless outlets already available in the market. The user should be able to label and turn these outlets on and off through the central hub or by the use of the LAN web interface.

User Interface

Included with the system, a central hub and a web interface will allow users to manage and control the system. This central hub will be a local server connected to the various other components discussed before. It will act as a receiver for the data sent by them and a processing unit of such data. The web interface will be the main link between the users and the system. It will allow the user will be able to program the system to their requirements, see the data logs, and manage access to the system.

Central Hub

Sensors and control interfaces will be connected to a microcontroller platform such as an Arduino or MSP430, which will simplify the process of making a direct connection between the hardware of the sensors and the central hub of the system. The microcontroller will in turn be connected to a more powerful microcomputing platform such as a raspberry pi upon which a control system and user-interface can be built in software. This component will be directly connected to the user's LAN, either via WIFI or via ethernet, and will host a lightweight web server which can be connected to by any computer on the network and implements password verification for access to the settings for the various connected devices. This solution offers a great deal of flexibility in regards to the number of devices which can be used to access and control the central hub of the system and also reduces the implicit workload of creating a user-interface, as an HTTP-Based solution will allow a wide range of devices to access the interface without the need to design a client-application for each.

The system should also allow utilization of the display mentioned above for in-person configuration, presenting the same interface and allowing for the same range of customization as is available to users in either computers on the network or via a connected mobile device.

Project Specifications

Product Specification Number	Specification Name	Specification Description	Specification Justification	Specification Priority
Smart Outlets and Lights				
1	SMART Outlet Power Switch	A standard outlet modified with either a 5V or 3.3V relay switch	This will allow for system control of the outlet and allow for a core feature	Core
2	Lighting Control Unit	A wireless module with a 3.3V or 5V output that will control a relay switch that will allow for the control of any standard Lightbulb Fixture	This will allow for the control of room lighting, a core feature	Core
3	AC Unit Wireless Power Switch	A wireless module with a 5V output that will control a relay switch for an AC unit	This will allow for system control of the AC unit, a core feature	Core
4	SMART Outlet Wireless Control	A standard outlet modified with either a 5V or 3.3V relay switch and a wireless module that has a 3.3V or 5V output and can communicate with the system controller	This will allow for wireless control of a core feature	Advanced
5	Wireless Module	A wireless module with either 3.3V or 5V output that can communicate with the system controller. This device should be compatible with most of the standalone components to allow for easier system installation	This will help make the system easier to use/install and reduce the need to physically wire components	Advanced

6	AC Unit Temperature Control	A temperature sensor attached to the AC Control Component that will allow the system to support automatic cooling settings	This is a desired feature for obtaining more quality home automation services	Wish List
7	Door Lock Control System	A wireless door lock that can communicate and receive command from the system controller	This door lock will be part of the safety components of the system	Wish List
Sensors and Optics				
8	Fire Detection	Infrared photodiodes will alert any user of fire or exceedingly high temperatures	Alerts any user of potential danger	Core
9	Extended Range and Field of View	A single lens system will focus incident rays onto the photodiode extending sensor proximity and FOV	Less photodiodes are necessary, and the monitored area will be larger	Advanced
10	Optical Noise Reduction	An anti-reflection coating will be applied to the lens to increase signal quality in the infrared spectrum. A band pass filter may be applied for optimal SNR.	The system will be more reliable because outside sources such as the sun will not trigger false positives as easily	Wish List
11	Motion Detection	Passive infrared photodiodes will be utilized to sense the presence of any user or guest	Provides the system with the initial input signal for user presence	Core

Table 1 Hardware Engineering Design Specifications

Web Server				
Product Specification Number	**Specification Name**	**Specification Description**	**Specification Justification**	**Specification Priority**
1	System Management	Users can manage system through a web page	This will allow the user to manage the system in a fast way	Core
2	Security	Unauthorized access should be prevented	This will allow the system to be secure	Core
3	Hosting	Web server will be hosted within a third-party service	This will prevent the user of the need to manage a server	Core
4	Capacity	The system should be able to support a minimum of 5 users and have space for growth	This will allow the system to be scalable	Core
5	Log	The web interface should provide a log of who/what triggered the sensors	This will allow the user to have greater control of the system	Advanced Feature
6	Camera	Facial recognition will be used as an extra security feature	For faster access to the system, a camera will be implemented	Advanced Feature
7	Mobile App	Users will also have the option to use a mobile app to control the system	Will serve as an extra option to manage the system	Wish List
Embedded Programming/System Controller				
Product Specification Number	**Specification Name**	**Specification Description**	**Specification Justification**	**Specification Priority**
1	Micro Controller	Raspberry Pi 3 Model B+	Low power consumption and light form factor make a micro-computer like the pi an ideal candidate for a system controller	Core
2	CPU	Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz	ARM processors are typically ideal for efficient low-power computing and should be more than adequate for all tasks required by the system.	Core

3	Memory	1GB LPDDR2 SDRAM	Most non-wish list features require negligible onboard memory. Most memory-demanding wish list/advanced features consist of basic web-browsing for physical UI and image-processing tasks for camera, for which 1GB memory should be adequate.	Core
4	Video Output	Full-Size HDMI port	HDMI output is included in the board to be used but will primarily only be used if the wish list goal of a physical user interface is pursued.	Wish List
5	USB	4 USB 2.0 Ports	Can be used to connect to peripherals and other close-range devices.	Core
6	Extended GPIO Header	General-purpose 40-pin input/output header	Useful for direct interface with hardware components and sensors.	Core
7	Storage	32GB MicroSD	Will store operating system and programs required for operation of the system.	Core
8	Wireless Networking	2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE	Provides a wide range of wireless networking capabilities, Wi-Fi is necessary for project as described and Bluetooth has potential use as well.	Core

Table 2 Software Engineering Design Specifications

House of Quality

Power Efficiency			-	
Modular Components				
User Application			+	
Safety Measures				- -

Technical Specifications / Customer Requirements	Safety Measures	User Application	Modular Components	Power Efficiency
Modular Control of Household Appliances	-	-	+/P	*
Reliable System	+/P	-	-	*
Intuitive Interface	-	+/P	-	-
Easy of Installation	-	*	+/P	-
Cost Efficient	+/N	-	*	+/P

Legend	Description
+	Positive Correlation
+ +	Strong Positive Correlation
-	Negative Correlation
- -	Strong Negative Correlation

Legend	Description
+	Strong Relationship
*	Moderate Relationship
-	Weak Relationship
P	Increasing Relationship
N	Decreasing Relationship

Constraints

Constraint	Type
Security functions will be implemented to the best of our ability to protect the system against outside attacks. While it is nearly impossible to account for all threats, we will try to have at least a basic security system in place.	Security
Perhaps the main constraint for this project is time. It is imperative for us as a group to be on top of our tasks, in order to complete all the milestones defined at Table 4.	Time
The marketability of this product is contingent on the amount of money it costs to manufacture. A low-cost system will allow more potential profits and make this product appealing to produce.	Financial
The system must have low power consumption for both financial and environmental concerns.	Power Efficiency
Modular components allow for variable cost, which in turn makes it possible for users to select which sensors and devices best met their needs and budgets.	Financial
The system automatically turns off when appliances when no user is present and allows the customer to save money on power consumption.	Reliability
Sensors need to be able to distinguish input signals from noise.	Reliability

Table 3 Project Constraints

Milestones

Task	Start Date	End Date	Status
Week 1			
Formation of Group	5/13/2019	5/17/2019	Completed
Week 2			
Brainstorming	5/19/2019	5/24/2019	Completed
Initial Project Document	5/21/2019	5/27/2019	Completed
Weeks 3, 4, and 5			
Meeting with Professor	5/28/2019	5/31/2019	In Progress
Divide and Conquer 2.0	5/28/2019	6/7/2019	In Progress
Table of Contents	5/30/2019	6/14/2019	In Progress
Week 8			
50% Documentation Draft	5/30/2019	7/7/2019	In Progress
Week 9			
Group Meetings for 50% Review	TBA	TBA	Not Started
Week 10			
75% Documentation Draft	7/7/2019	7/21/2019	Not Started
Week 11			
Optional Group Meetings for 75% Review	TBA	TBA	Not Started
Week 12			
Final Draft	7/21/2019	8/2/2019	Not Started
PCB Design	TBA	TBA	Not Started
Acquire Components	5/27/2019	-	In Progress
Senior Design II			
Build Prototype	TBA	TBA	Not Started
Test Prototype	TBA	TBA	Not Started
Code Research Code Development	TBA	TBA	Not Started
Final Presentation	TBA	TBA	Not Started

Table 4 Project Milestones

Project Standards

Standards Related to Project				
Standard Number	**Standard Name**	**Standard Description**	**Reasoning**	**Minimum Specification Dependency**
1	IEEE 802.11	Standard for implementing wireless local-area network.	Allow communication between system controller without the need to run wires.	Core
2	USB 2.0	Describes buses which can be used to connect peripherals or computers together for the purpose of communication or power transfer.	All connection between system controller microcontroller or other peripherals which are not a long distance away.	Core
3	HTTP	Protocol for the transmission of HTML over a network, markup language used for the rendering of webpages.	Required for communication between user device and control server.	Core
4	HTML	Markup language designed for transmission over network and used in the process of rendering webpages.	Necessary for the use of the control server web interface.	Core

5	CSS	Cascading Style Sheets for improving the ease of producing visually impressive web pages.	Useful for improving the look and feel of the web interface and ensuring a consistent style across all pages therein.	Core

Table 5 Project Standards

Budget

The project will be sponsored by the team members themselves. The following table provides estimates of the prices of the main components for the project.

Parts	Expected Costs
Motion Sensor System	$10
Thermal Sensor System	$25
Micro Controller	$35
Security Camera	$10
PCB	$30
Door Lock System	$20
Outlet System	$35
Backup Battery System	$30
Web Server	$45
Domain	$15
Total	**$255**

Table 6 Project Budget

System Diagram

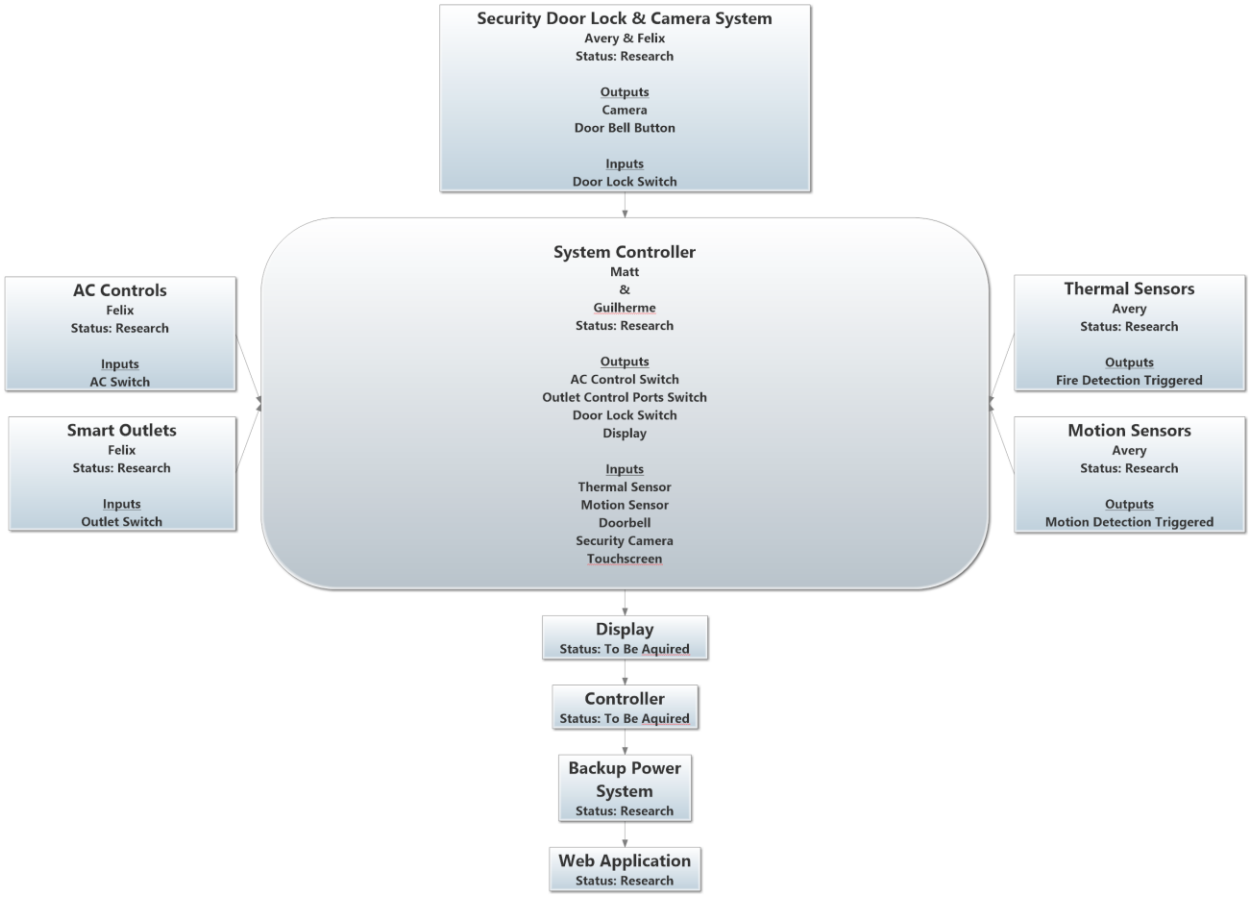

Figure 1 System Diagram

Theoretical Layout

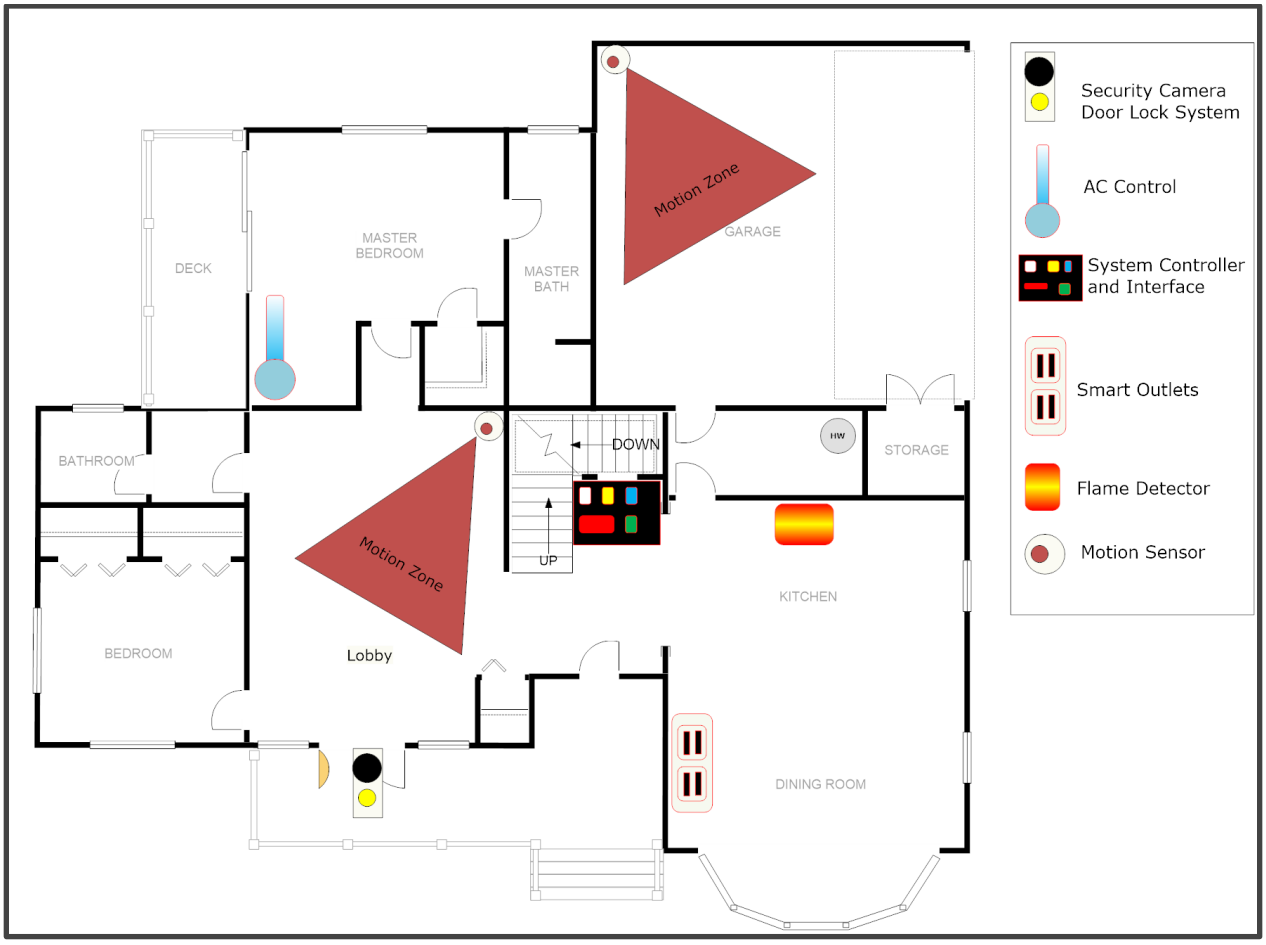

Figure 2 System Theoretical Layout