HA HOME ATTENDER

February 21, 2018
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V5A 1S6

HA HOME ATTENDER

Re: ENSC 405W/440 Requirements Specifications for **Home Security System** by **Home Attender**

Dear Dr. Rawicz,

Enclosed is the requirements specifications for Home Attender, part of the curriculum for ENSC 405W/440. Our group is aiming to design a cost effective home security system which uses a thermal and optical camera module along with accelerometers to detect intruders and fires.

This document will outline the high level design, showing which requirements our system will need to meet. It includes the overview, system requirements, sustainability and safety issues, as well as engineering standards for both the proof-of-concept and later stages of the Home Attender. The specifications outlined in this document will serve as a guide throughout the design for our project.

Our group consists of five dedicated and passionate Engineering students: Isaac Qiao, Benjamin Ji Fung Ng, Christopher Se Chern Chiu, Qing Yang Li, and Ruisi Wang. With two Systems Engineers and three Computer Engineers, we believe we have the skillset to create an excellent product while also gaining plenty of knowledge along the way.

Thank you for taking the time to review our requirement specification. Please feel free to contact our Chief Executive Officer, Isaac Qiao, by email or phone at bqiao@sfu.ca or (778) 927-4893 if you have any questions or concerns.

Sincerely,
Isaac Qiao
Chief Executive Officer
Home Attender

HA HOME ATTENDER

Requirements Specifications for Home Security System

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Abstract

The Home Attender home security system is a scalable, multi-purpose intruder and fire detection system designed to be compatible with a variety of markets. The product's overall specifications can be separated into general, hardware, and software functionalities. The high-level requirements for these functionalities will be analyzed for the proof-of-concept, prototype, and production stages of development. They will also be labeled with priority levels ranging from low to high. Additionally, development of the product must take into account engineering standards, environmental impact, and safety concerns. All of the aforementioned aspects must be taken into consideration for the upcoming development of the Home Attender.

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Glossary

iOS Operating system of the Apple phone lines

MatLab A scripting language and numerical analysis environment that can run mathematical algorithms

Field of View The angle in which an optical device can observe at a given time

Sensor Grid Sensors are arranged into rows and columns along the surface

Server A computer that does the processing of information gathered by the sensor grid and camera module. The computer also includes the storage of the recorded video and handles connections to and from the iOS application

Thermal Imaging Camera A camera that detects heat and converts it into a visible image

Arduino Board An open-source microcontroller that is used to build digital devices that can interact with the physical world

PoE (Power over ethernet) Technology that allows power to be transfer via the internet cable as well as data

Alert Flag A notification that represents that an intruder has been detected or a fire has been detected

Proof of Concept A model that shows that the main features work

Prototype The preliminary model of the product

Production Stage Product is out to market and being manufactured

1.Introduction

The core of the Home Attender home security system will have many different components dedicated to specific optimized tasks. Each component will be relatively simple and our goal is to combine them together to create an integrated system. The system is designed to be cheap and efficient in terms of the cost-to-performance ratio in order to appeal to a wider market. The Home Attender will be scalable, allowing deployment in varying home layouts with the eventual goal being expansion into other markets.

1.1 Background

A major area of concern to Canadian homeowners is the issue of home security. The Canadian Statistics Report shows that there is an increase breaking and entering [1], which requires more advanced security systems. The average home security consists only of an alarm system triggered by physical contact, and do not integrate other elements. However, there are many technologies available which can provide a safer environment for residents. The goal of Home Attender is to combine many of these elements into a more affordable, sophisticated, and user friendly security system for an average home user, with better diversity than those used in the industrial, commercial, or militarized industries.

1.2 Scope

The system will contain the following components: thermal imaging and optical camera, accelerometers, mobile application, wireless communication to home speakers, and networking and server.

As part of the integrated system, the Home Attender will include a fire detection feature. It will use a thermal camera to detect and alert the user of a possible fire. The system will also attempt to perform a localize fire suppression to minimize water damage.

The Home Attender will also have an app to allow a homeowner to flag a false alarm and be alerted of any intrusions. It will allow the user to quickly find out about possible dangers and give them the option to alert the authorities.

1.3 Classification/ Requirement Code

In order to make it easier to reference and prioritize the requirements, the following convention will be used through this document:

[Req <Section Number>.<Subsection>-<Priority Encoding>-<Development Stage>]
Example: Req 3.1.1-M-PROTO

Req stands for requirements. **Section Number** correspond to integer values that symbolize the hierarchical order of the requirement. **Subsection** represents the subsection of **Section Number**. Priority Encoding and Development Stage are defined in the tables below.

Section Number	Description
1.	General Design Requirement
2.	Hardware Design Requirement
3.	Software Design Requirement
4.	Sustainability and Safety Requirement

Table 1: Section Number Description

Priority Encoding	Description
H	High priority items that are definitive features
M	Medium priority items that are essential features
L	Low priority items are non-essential for the product

Table 2: Priority Encoding Description

Development Stage	Description
PoC	Proof of Concept stage and onward
PROTO	Prototype stage and onward
PROD	Production stage

Table 3: Development Stage Explanation

2.System Overview

The Home Attender's objective is to create a cost efficient and sophisticated home security system that has a level of technology which is scalable to the commercial, industrial, and military industries, but at the same time utilizing low cost consumer-grade equipment.

The current market of home monitoring is heavily divided between militarized grade homes with blast resistant doors and searchlights for those who are financially competent, and low quality surveillance cameras for the average consumer. Both systems are heavily user driven, requiring the customer to directly report intrusions to the appropriate authorities. Our company believes that this process can be completely automated. Another issue the Home Attender aims to combat relates to the increasing popularity of smart homes. The market is flooded with various electronic devices installed around your home to invoke convenience for the user. But what happens when a fire erupts inside your home? Current sprinkler systems, when initiated, results in a large discharge of water that is expected to cover every inch of your house with little regard for the exact location of the fire. This is extremely problematic as a small house fire can result in major water damage to the home due to the sprinkler system. Additionally, a common practice for firefighters after rescuing small fires in Canada is to open up sections of the home's walls to extinguish any hidden fires lurking inside walls. These are major questions that have facilitated the design of the Home Attender. The Home Attender system is fully automated and a one-stop-shop product that provides various security and smart utility features to protect your house.

The protection Home Attender system provides begins on the outside of the customer's house. Thermal and optical cameras are place at a high vantage point on your house and sit on top of a small controller capable of pivotal movement. The user's lawn is then instrumented with an array structure of vibration and force sensors underneath their lawn. The buried sensors prevent accidental clipping from surface activity, vandalism, theft, and provides better aesthetic. The overall layout can be observed in Figure 2-1.

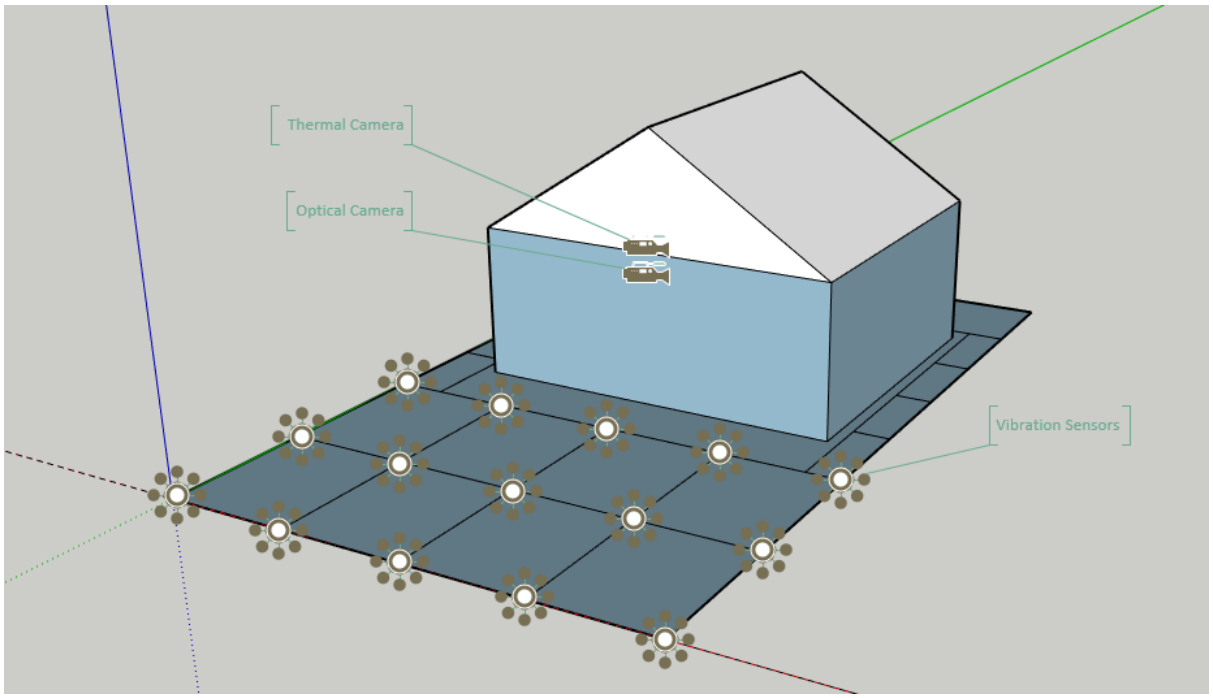

Figure 2-1: Home Attender Layout Diagram

The Home Attender system's intruder detection is first triggered by the thermal imaging camera, which picks up high heat signature readings that stand out from the static environment. Figure 2-2 displays the control diagram of the outdoor component of the Home Attender. This will be recalibrated between seasons or when there are major changes that happen to the house's exterior. A heat signature of 36 degrees Celsius or greater--coinciding with average human internal body temperature of 36 to 38 degree Celsius--is required to trigger the "alert flag" in the system. Afterwards, the sensors on the field will compute the approximate location of the intruder. Since the thermal imaging cameras contain a single lens system; accurate depth perception is a major hurdle. The sensor system is essential in answering the following questions:

- Is the intruder on or off the user's property?
- How many intruders are there?
- If there is more than one intruder, which one should the camera track and record?
- Does the intruder actually exist?

The design of the system's prototype design is to only track the intruder closest to the house. Although a small sized home property in the Greater Vancouver area has very little use for instrumenting the property with sensors; the scalability of this design is also applicable to owners with large plots of property such as private schools or farms. For the prototype design, the vibration and force sensors will only help determine where and which intruder to track. After both the heat signature and location of the intruder is determined, the optical camera is activated. As both the thermal and optical cameras sit on a small pivotal controller; this controller will be actuated by the thermal imaging camera to be able to continuously follow the heat signature of the intruder, while the optical camera will provide additional visual evidence. Data is recorded and stored in five-minute files for one week on a ring buffer within an integrated home server.

Simultaneously, the security system will notify the home owner through our proprietary smartphone application. The prototype app will be compatible with iOS only.

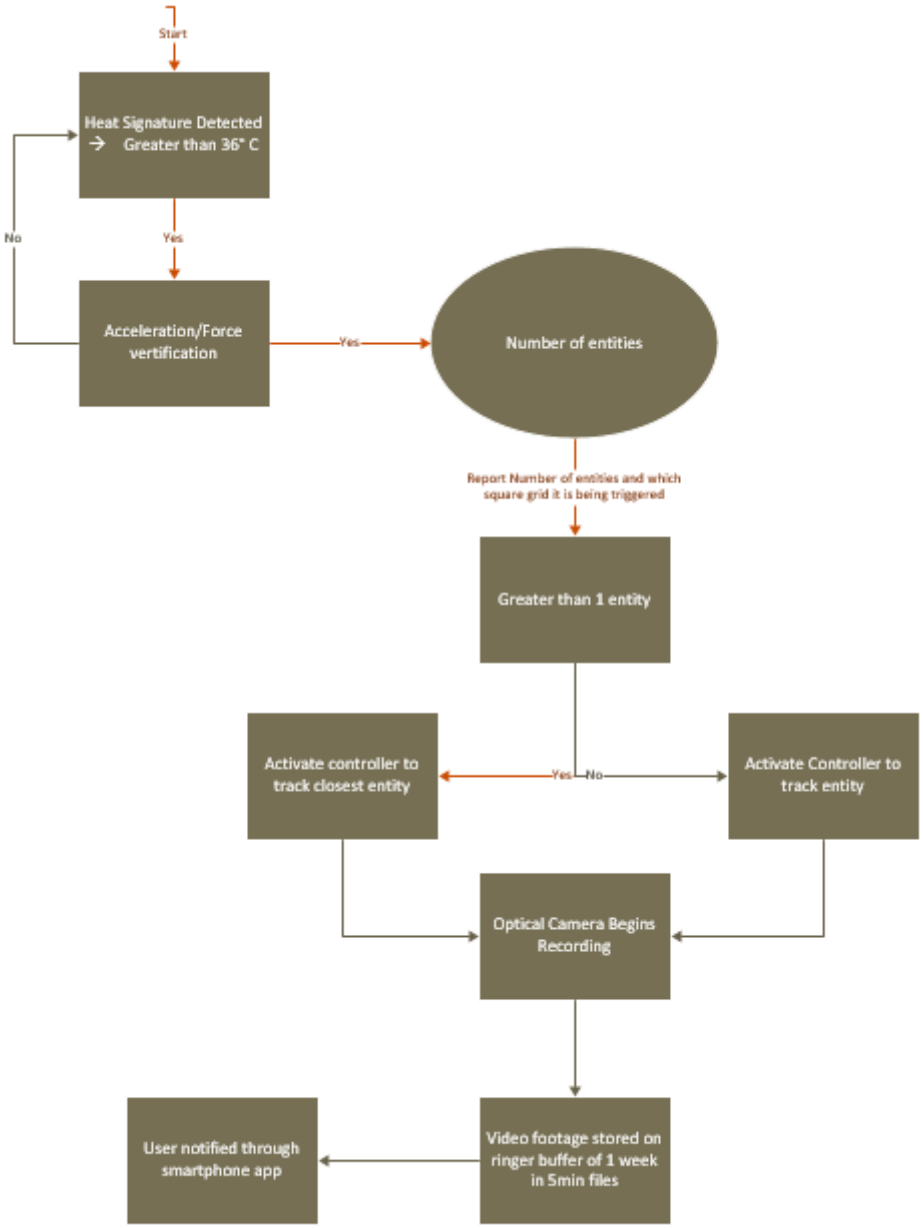

Figure 2-2: Home Attender Control Diagram (Outside)

While the outdoor component of the Home Attender focuses on intruder detection, the indoor component focuses on monitoring intrusion and fire suppression. The inside of your house will be instrumented with an identical camera set up as the outdoor component. The only difference is that the camera will be introduced with two different functionalities:

- Reading internal temperatures in humans (36 to 38 degrees Celsius)
- Temperature of a red coloured fire (lowest temperature of 600 degrees Celsius)

The thermal imaging camera will run continuously and monitor the heat signatures inside the users' house. In addition, the prototype design will incorporate an additional controller that will actuate the flow of water for fire suppression. The camera will first determine whether or not the heat signature is consistent to that of a human body. If this is the case:

- Optical camera will be activated and begin recording video
- Pivotal controller will use the data obtained by the thermal imaging camera to track the heat signatures
- Data is reported to the server
- Local authorities will be notified
- User will receive notification via the proprietary app

If this is not the case, the system will move to the next condition of heat signatures being consistent with typical red-flamed fires. In this case:

- Optical camera will still be activated, footage is valuable for evidence usable for insurance purposes
- Pivotal controller will use the data obtained by the thermal imaging camera to track the heat signatures
- Controller for the fire suppression will shoot water out of a hose to suppress the fire
- Data is reported to the server
- Local authorities will be notified
- User will receive notification via the proprietary app

Complete control diagram of the indoor component can be seen in figure 2-3.

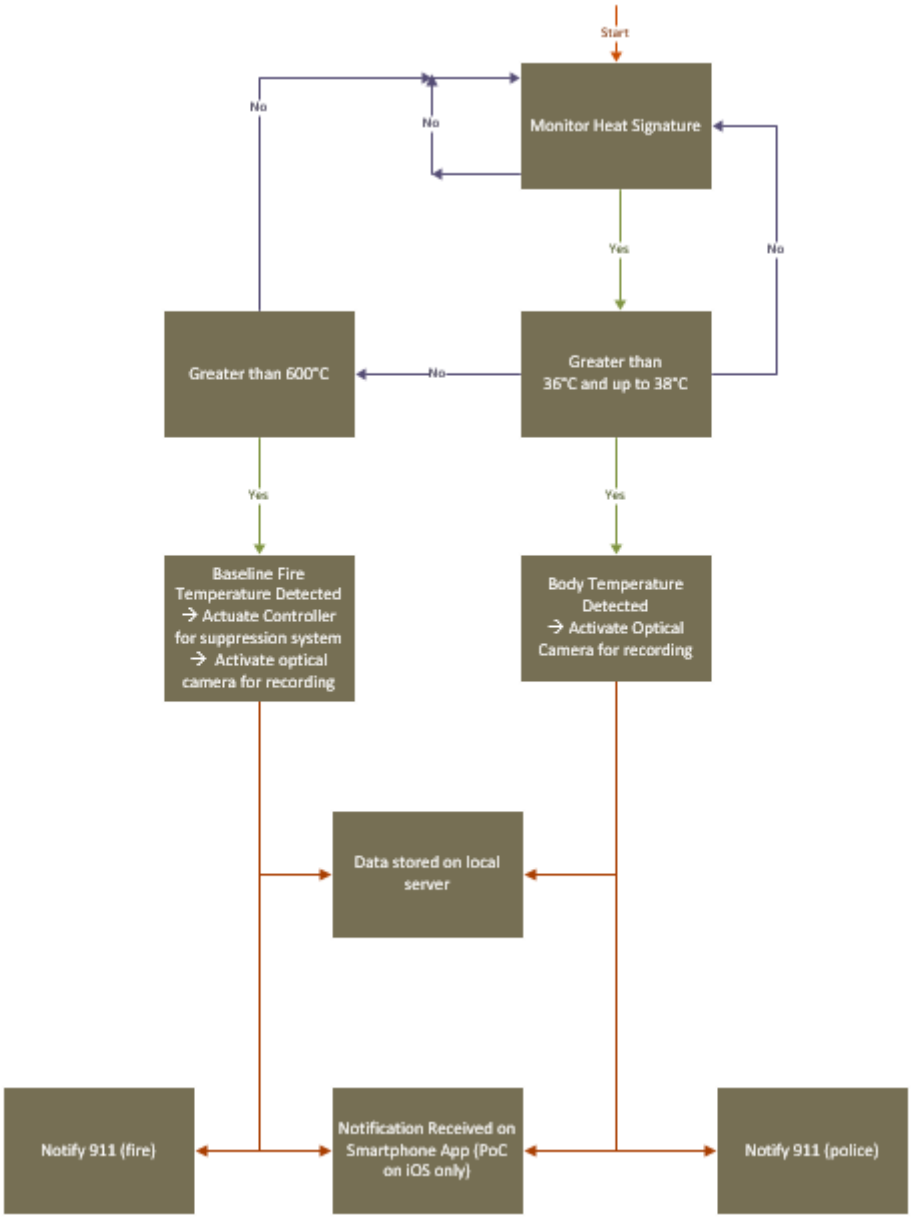

Figure 2-3: Home Attender Control Diagram (Inside)

A major defining aspect of the Home Attender is its relatively low data usage of the user's home internet. Our company understands that not everyone has unlimited internet data. A common issue with home security systems is that everything is hosted on the cloud. Video footage being uploaded in real time causes major strain on bandwidth and internet data consumption. This is why many home camera systems recommend users to either upgrade their internet package or purchase another dry line. Home Attender's solution to this is simple; make data storage from the cameras local. By introducing a small consumer grade server, we are able to cut down on having footage being continuously uploaded to the internet. Even if the user would like to access this footage remotely, they are only paying for internet during the time they are accessing the computer. Figure 2-4 shows the Home Attender's network diagram.

With the outdoor component, optical and thermal cameras are connected to a PoE (Power over Ethernet) switch and then into the local server. The Accelerometers and force-pads will have the data compiled and computed with a data recorder consisting of

either an Arduino or Raspberry Pi and then sent to the local server. This is to compensate for real time computation delays. As image processing requires the majority of threads in the CPU for a consumer grade server, a separate controller can help ease computation speeds.

For the indoor component of the Home Attender, thermal and optical footages follow the same network link to a PoE switch before entering into the local server.

Once data has made its way into the server; the server will begin computation and feed the information into the controllers. The controllers will actuate the pivotal platforms. With the outdoor component it will only pivot the platform, while with the inside component it will also activate the fire suppression water pump.

Next, the server will notify the user through the home Wi-Fi. The notification will make its way into our proprietary app on the user's smartphone. From there the user is able to review what the issues are and access footage and vibration data.

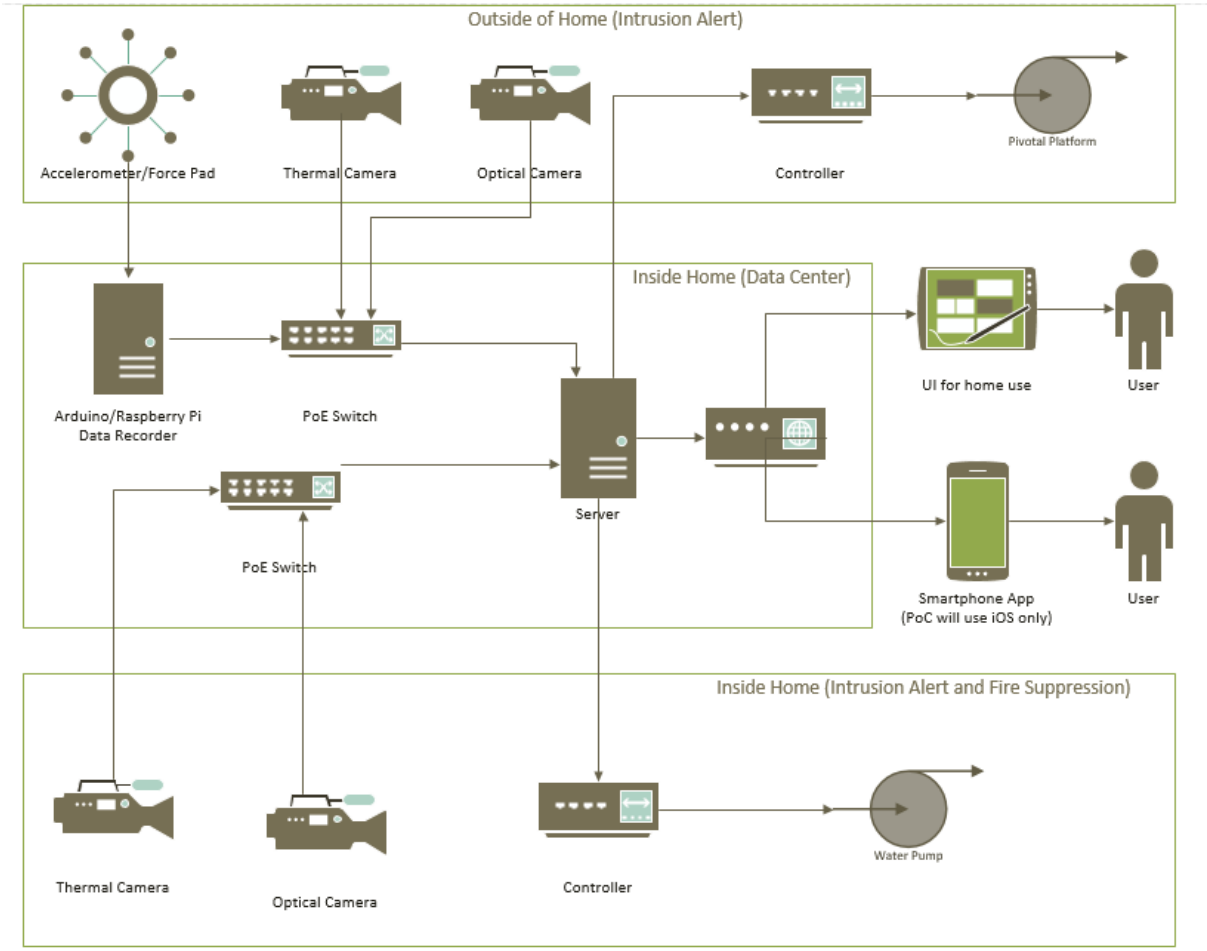

Figure 2-4: Home Attender System Network Diagram

3. System Requirements

The following section will summarize the overall functionality and design requirements for this system. The requirements will be split up into three sections: General Design Requirements, Hardware Design Specification, and Software Design Specification.

3.1 General Design Specification

Before going into detail regarding the hardware design specification and software design specifications, this section will outline the general requirements for this home security system.

3.1.1 General

Requirement Code	Requirement Description
Req 1.1.1-H-PoC	The operating temperature of the system should be from -20°C to 90°C
Req 1.1.2-H-PoC	The operating humidity of the system should be from 5% to 95%
Req 1.1.3-H-PoC	The product's proposed lifespan should be a minimum of ten years
Req 1.1.4-H-PROTO	The user manual should specify the system usage procedure
Req 1.1.5-M-PROD	The system should be installed into the user's building with help from our service department
Req 1.1.6-L-PROD	Technical support should be provided to assist customers having troubles with the system
Req 1.1.7-M-PROD	The system can be initialized and operated by a single person without the need for prior technical knowledge

Table 4: General Requirements

3.1.2 Physical and Operational

Requirement Code	Requirement Description
Req 1.2.1-H-PoC	The product's metallic components must be rust-resistant and non-corrosive
Req 1.2.2-H-PoC	The product must operate under most weather conditions, including heavy sun, rain and snow
Req 1.2.3-H-PoC	The system should be installable in buildings with 220V/110V power supplies
Req 1.2.4-M-PROTO	The system should be able to run without interruption
Req 1.2.5-H-PROTO	Each camera module will contain both thermal and optical components

Req 1.2.6-H-PROTO	The server should be connected to either WIFI or Ethernet from a secured network
Req 1.2.7-H-PROTO	The system should be able to track intruders
Req 1.2.8-H-PROTO	User should be able to control the system using both in-house controls and phone application
Req 1.2.9-M-PROD	System software and firmware updates should be automatic
Req 1.2.10-H-PROD	The system should be constructed using waterproof equipment
Req 1.2.11-H-PROD	The video recordings should be stored in the server for one week

Table 5: Requirements for general physical and operational aspects

3.2 Hardware Design Specification

This section describes the hardware requirements based on necessary minimum requirements to achieve our functionality.

3.2.1 Camera Module

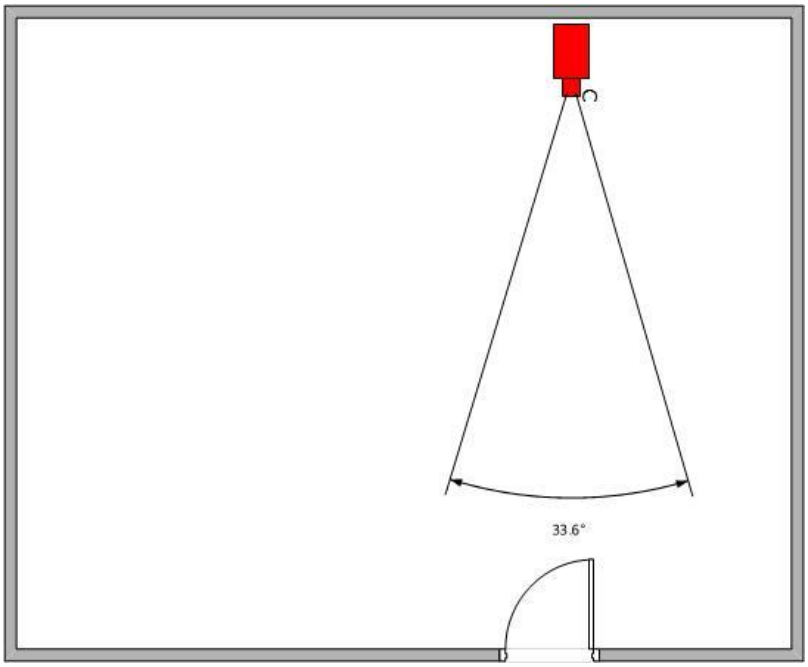

Figure 3-1: Camera requirements example

The camera module consists of both thermal and optical camera components for heat signature tracking and video recording. The cameras need a minimal resolution that provides enough information and clarity for image processing and user viewing, so a 720x480 resolution requirement was selected. The thermal camera itself must encompass the human body heat range and have a maximum temperature high enough to detect fire. A standard of 24 to 30 FPS [2] is chosen as a minimum for image recording. A servo that moves the camera according to a controller is necessary for human tracking algorithms to be implemented. The needs stated above are all necessary

during the proof-of-concept stage since the camera module is a fundamental component of the security system. At the production stage the product has a audio recording component to provide more information for the user and enhance its capabilities. It will also include a sensor to acquire distances.

Requirement Code	Requirement Description
Req 2.1.1-H-PoC	Camera module has at least 33° field of view
Req 2.1.2-H-PoC	Camera requires max input voltage of 5V
Req 2.1.3-H-PoC	Resolution of the camera is at least 720x480 pixels
Req 2.1.4-H-PoC	Thermal Camera can detect heat ranges of the range 0℃ - 80℃
Req 2.1.5-H-PoC	Camera captures in 24 or 30 FPS [2]
Req 2.1.6-H-PROTO	Servo moves the camera according to a controller
Req 2.1.7-L-PROD	Camera module can perform audio recording with a minimum range of three meters
Req 2.1.8-L-PROD	Camera module has an ultrasound sensor to acquire distances of at least three meters

Table 6: Requirements for camera module

3.2.2 Intruder Tracking

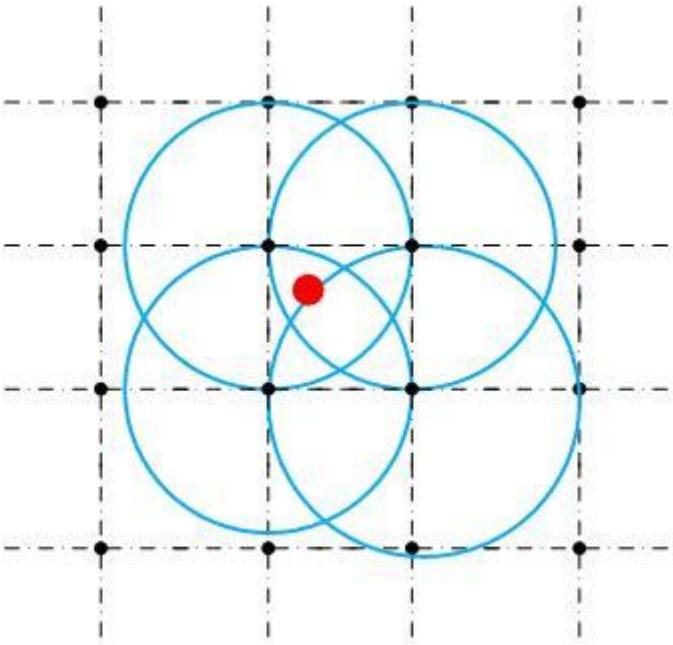

Figure 3-2: Example of sensor grid

The proof-of-concept stage will include the following features to demonstrate the functionality of cheap sensors in a grid, and the algorithms needed to provide accurate motion tracking. The approach requires the sensor to be able to measure vibrations or

forces in a grid pattern to determine the location of the intruder via interpolation. The sensitivity of the sensors and resistance to breakage is required for this component. At the production stage the Home Attender requires the sensor grid to cover the entire property to provide accurate and timely tracking of the intruder.

Requirement Code	Requirement Description
Req 2.2.1-H-PROD	The sensors do not break when stepped on
Req 2.2.2-L-PoC	Sensors have a voltage input 3-5 VDC
Req 2.2.3-H-PoC	The sensor grid is able to read varying levels of vibrations
Req 2.2.4-H-PoC	System can determine which sensor has been activated
Req 2.2.5-M-PoC	Sensor grid measures vibrations within a 40 cm x 40 cm square
Req 2.2.6-H-PROTO	Sensor grid is able to determine location of intruder
Req 2.2.7-H-PROD	Sensors are placed in a grid that covers entire property

Table 7: Requirements for sensor grid

3.2.3 Server

The server in the Smart Home Security system performs all the data processing and acts as an intermediary for transferring alerts to the owner. The image processing algorithms are done using MatLab scripts so the server must have enough processing power to run it. A minimum storage requirement of 2 TB is to allow for enough space for recent videos, with surplus. The server must also have 8 GB system memory to run the processing algorithms. The requirements below exist in the proof of concept stage as they are required to perform other features of the Smart Home Security System. At the prototype stage and beyond, the server connects with the user's mobile application and handles all the networking connections to create a seamless system.

Requirement Code	Requirement Description
Req 2.3.1-H-PoC	Server has x86-64 processor from Intel or AMD
Req 2.3.2-H-PoC	Server has 2 TB storage for media
Req 2.3.3-H-PoC	Server has a minimum of 8 GB RAM
Req 2.3.4-H-PoC	Server consumes a maximum of 600W
Req 2.3.5-H-PROTO	Server has networking equipment for mobile application connection

Table 8: Hardware requirements for server

3.2.4 Fire Suppression

The fire suppression system component of the Home Attender is developed during the prototype stage and beyond as it is having few connections to the intruder and fire detection aspect of the product. The requirements are chosen to ensure that the suppression system performs its duties and minimizes possible water damage compared to when water sprinklers are activated.

Requirement Code	Requirement Description
Req 2.4.1-M-PROTO	System activates water source to suppress fire
Req 2.4.2-M-PROTO	The water source does not leak
Req 2.4.3-M-PROD	System only activates when fire is detected
Req 2.4.4-M-PROD	System performs localized suppression only
Req 2.4.5-H-PROD	System is able to differentiate cooking heat to uncontrolled fire

Table 9: Requirements for fire suppression feature

3.3 Software Design Specification

3.3.1 Server software design

The server-side software of the Home Attender will be responsible for communicating between cameras, sensors and mobile application. It will also perform calculations and processing data. In the server it will have image processing and machine learning functionalities and will be present on the prototype and production products. The system's data storage capability for storing and archiving images, footage, and other collected data for use as evidence for police and insurance agencies or for personal use.

Requirement Code	Requirement Description
Req 3.1.1-H-PoC	Server should have a base OS system
Req 3.1.2-H-PoC	Server should be able to store video from camera source
Req 3.1.3-H-PROTO	Server software enables machine learning functionality
Req 3.1.4-H-PROTO	Machine learning functionality should recognize humans, most animals, and fires
Req 3.1.6-H-PROTO	Server is able to send out notification to alert mobile application
Req 3.1.7-H-PROTO	Server will be able to manage networking connection
Req 3.1.8-H-PROTO	Local server generates password for security purposes
Req 3.1.9-H-PROTO	User will be able to register on the mobile app
Req 3.1.10-M-PROTO	Media stored in the server will be automatically updated
Req 3.1.12-L-PROD	User can change the settings for the video storage feature
Req 3.1.13-H-PROD	Server must respond within required time frame
Req 3.1.15-L-PROD	Machine learning can recognize the owner
Req 3.1.16-H-PROD	Notification to mobile app will include footage which requires a password to access

Table 10: Software requirements of server

3.3.2 Mobile application design

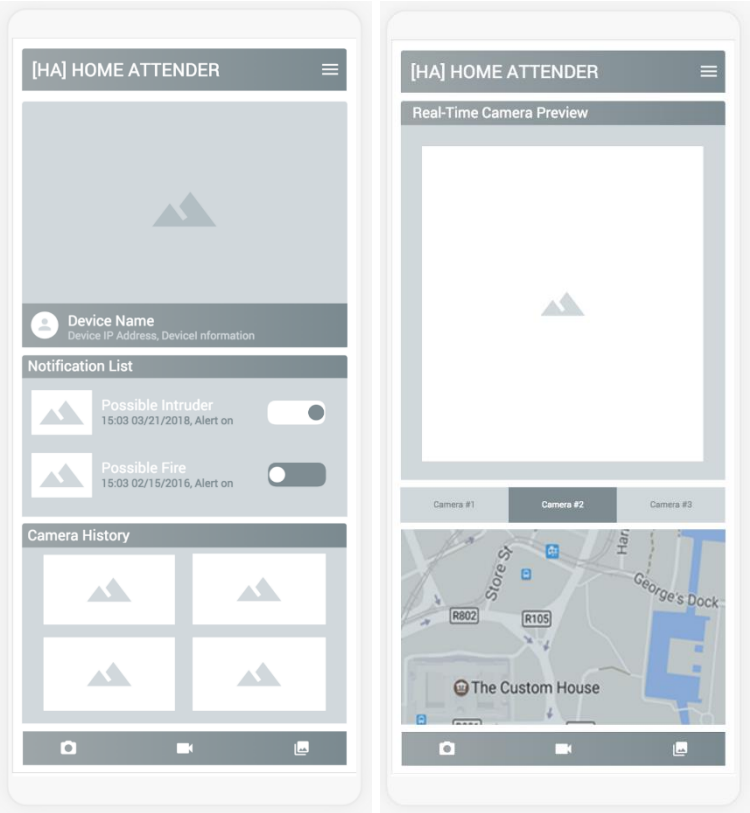

Figure 3-3: Example of mobile app UI

The mobile application for the Home Attender provides the user with a convenient control platform that allows them to access the camera in real time, modify security system settings, and alert them to potential safety risks.

Requirement Code	Requirement Description
Req 3.2.1-H-PROTO	Application runs on IOS platform
Req 3.2.2-H-PROTO	Application accepts notifications from the local server
Req 3.2.3-M-PROTO	User will be able to modify alert settings with the application
Req 3.2.4-H-PROTO	Application requires password when accessing media
Req 3.2.5-L-PROD	Application has real time access to the camera
Req 3.2.6-H-PROD	User will be able to register on the mobile app
Req 3.2.7-H-PROD	On-board processor can communicate with the application
Req 3.2.8-H-PROD	User will be able to modify camera settings with the application
Req 3.2.9-M-PROD	User will be able to manage data and video with the application

Table 11: Requirements for mobile application

4. Sustainability and Safety Requirements

4.1 Sustainability

In an attempt to circumvent and reduce the Home Attender's impact on the environment, our company has adopted the cradle-to-cradle design approach for our product. We have considered the life cycle of the Home Attender and how the materials used to build each component can be recycled or disposed of with the cradle-to-cradle approach in mind.

The reusable elements of our proof-of-concept include the thermal and optical cameras, Arduino kit, and server computer. If any of these components are damaged or unusable, they will be recycled at the appropriate location, along with outstanding parts such as accelerometers and wires.

For the production-level security system, removal at the end of its lifetime will be done by company personnel to ensure that the product is dealt with correctly.

Additional considerations regarding the Home Attenders environmental impact include the process of installing of accelerometers and gyroscopes, which will be carefully calculated based on the customer's property to ensure that a minimum amount is used to achieve the desired effect. Also, thanks to the products ability to localize fire suppression, the amount of water used to perform the task is reduced considerably.

4.2 Safety

The Home Attender is a security system, so the majority of the product's safety element depends on its ability to protect the user from potential threats. Every requirement in Section 3 of this report should be should be upheld as tightly as possible to maximize the user’s security. Additionally, the following requirements are set for further assurance.

Requirement Code	Requirement Description
Req 4.2.1-M-PROD	Intruder and fire detection work under extreme weather conditions
Req 4.2.2-M-PROD	Fire detection works when subject to intense heat
Req 4.2.3-L-PROD	Cameras will be installed securely in locations where accidents are less likely to occur
Req 4.2.4-L-PROD	Wiring and other connections will be installed correctly without risk of electric shock or tripping

Table 12: Safety requirements

5. Engineering Standard

Outlines specific engineering standards that apply to the device or system and lists them in the references.

Requirement Code	Requirement Description
IEEE 802.4h [3]	Standards for token bus network
IEEE 802.6 [4]	Standards for information exchange between systems
IEEE 802.15.1 [5]	Standards for WPAN/Bluetooth
IEEE 829 [6]	Standards for Software and System Test Documentation
IEEE 830 [7]	IEEE Recommended Practice for Software Requirements Specifications
IEEE 1016 [8]	Standard for Software Design Description
IEEE 1074.1[9]	IEEE Guide for Software Development Life Cycle
CAN/CSA-C22.2 NO. 60065:16 [10]	Audio, video and similar electronic apparatus - Safety requirements (Adopted IEC 60065:2014, eighth edition, 2014-06, with Canadian deviations)
CAN/CSA-C22.2 NO. 61508-1:17 [10]	Functional safety of electrical/electronic/programmable electronic safety-related systems
CAN/CSA-C22.2 NO. 0-10 [10]	General requirements - Canadian electrical code, part II
CAN/CSA-ISO 14040-06 [11]	Environmental Management - Life Cycle Assessment - Principles and Framework
CSA C22.1-15 PACKAGE - 2015 [12]	Canadian electrical code, part I

Table 13: Engineering standard requirements

6. Conclusion

The Home Attender home security system is a new generation alert system that can help Canadian homes to become some of the safest homes worldwide. It uses multi-camera detection to prevent false alerts, giving users a more accurate threat detection system so they can avoid false alert fees and benefit the city's emergency resources. The overall system will be connected to the network and server, which allows users to access the camera, past intrusions, and send commands to the system in real time.

In the aforementioned requirement specifications, the characteristics and design constraints of the Home Attender are clearly established to provide a detailed outline of the requirements for the hardware, software and normal operational aspects of the project. Our company will use this document as a guide throughout the design for this project. To allocate all the resources efficiently, the development team will design this project according to a prioritization system. At each stage of our development process, we will put high priority on the features that are necessary for the system to have the basic desired functionality. For the Home Attender team, the importance of cost efficiency is a major priority. We will also consider the reuse and recycling of parts after each stage of the project due to environmental concerns.

References

[1] M. Allen, "Statistics Canada," Canada, 20 June 2015. [Online]. Available: http://www.statcan.gc.ca/pub/85-002-x/2016001/article/14642-eng.htm. [Accessed 20 February 2018].

[2] Brown, Julie, "Audio-visual Palimpsests: Resynchronizing Silent Films with 'Special' Music". In David Neumeyer. The Oxford Handbook of Film Music Studies. Oxford University Press, 2014, p. 588. [Accessed: 21- Feb- 2018].

[3]"IEEE 802.4h-1997 - IEEE Standard Local and Metropolitan Area Networks--Alternative Use of BNC Connectors and Manchester-Encoded Signaling Methods for Single-Channel Bus Physical Layer Entities", Standards.ieee.org, 2018. [Online]. Available: http://standards.ieee.org/findstds/standard/802.4h-1997.html. [Accessed: 21- Feb- 2018].

[4]"IEEE 802.6-1990 - Local and Metropolitan Area Networks: Distributed Queue Dual Bus (DQDB) Subnetwork of a Metropolitan Area Network (MAN)", Standards.ieee.org, 2018. [Online]. Available: http://standards.ieee.org/findstds/standard/802.6-1990.html. [Accessed: 21- Feb- 2018].

[5]"IEEE 802.15.1-2005 - IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 15.1a: Wireless Medium Access Control (MAC) and Physical Layer (PHY) specifications for Wireless Personal Area Networks (WPAN)", Standards.ieee.org, 2018. [Online]. Available: http://standards.ieee.org/findstds/standard/802.15.1-2005.html. [Accessed: 21- Feb- 2018].

[6]"829-2008 - IEEE Standard for Software and System Test Documentation - IEEE Standard", Ieeexplore.ieee.org, 2018. [Online]. Available: http://ieeexplore.ieee.org/document/4578383/. [Accessed: 21- Feb- 2018].

[7]"830-1998 - IEEE Recommended Practice for Software Requirements Specifications - IEEE Standard", Ieeexplore.ieee.org, 2018. [Online]. Available: http://ieeexplore.ieee.org/document/720574/. [Accessed: 21- Feb- 2018].

[8]"IEEE 1016-2009 - IEEE Standard for Information Technology--Systems Design--Software Design Descriptions", Standards.ieee.org, 2018. [Online]. Available: https://standards.ieee.org/findstds/standard/1016-2009.html. [Accessed: 21- Feb- 2018].

[9]"IEEE 1074.1-1995 - IEEE Guide for Developing Software Life Cycle Processes", Standards.ieee.org, 2018. [Online]. Available: http://standards.ieee.org/findstds/standard/1074.1-1995.html. [Accessed: 21- Feb- 2018].

[10] CSA Group, "CAN/CSA-C22.2 NO. 0-10 (R2015) - General requirements - Canadian electrical code, part II," CSA, Mississauga, 2015. [Accessed: 21- Feb- 2018].

[11] CSA Group, "CAN/CSA-ISO 14040-06 (R2016) - Environmental Management - Life Cycle Assessment - Principles and Framework (Adopted ISO 14040:2006, second edition, 2006-07-01)," CSA, Mississauga, 2016. [Accessed: 21- Feb- 2018].

[12] CSA Group, "CAN/CSA-C22.1-15 (R2015) - Canadian electrical code, part I (23rd edition), safety standard for electrical installations [Accessed: 21- Feb- 2018].

APPENDIX A

Requirement Code	Requirement Description
Req 1.1.1-H-PoC	The operating temperature of the system should be from -20°C to 90°C
Req 1.1.2-H-PoC	The operating humidity of the system should be from 5% to 95%
Req 1.1.3-H-PoC	The product's proposed lifespan should be a minimum of ten years
Req 1.2.1-H-PoC	The product's metallic components must be rust-resistant and non-corrosive
Req 1.2.2-H-PoC	The product must operate under most weather conditions, including heavy sun, rain and snow
Req 1.2.3-H-PoC	The system should be installable in buildings with 220V/110V power supplies
Req 2.1.1-H-PoC	Camera module has at least 33° field of view
Req 2.1.2-H-PoC	Camera requires max input voltage of 5V
Req 2.1.3-H-PoC	Resolution of the camera is at least 720x480 pixels
Req 2.1.4-H-PoC	Thermal Camera can detect heat ranges of the range 0℃ - 80℃
Req 2.1.5-H-PoC	Camera captures in 24 or 30 FPS [2]
Req 2.2.2-L-PoC	Sensors have a voltage input 3-5 VDC
Req 2.2.3-H-PoC	The sensor grid is able to read varying levels of vibrations
Req 2.2.4-H-PoC	System can determine which sensor has been activated
Req 2.2.5-M-PoC	Sensor grid measures vibrations within a 40 cm x 40 cm square
Req 2.3.1-H-PoC	Server has x86-64 processor from Intel or AMD
Req 2.3.2-H-PoC	Server has 2 TB storage for media
Req 2.3.3-H-PoC	Server has a minimum of 8 GB RAM
Req 2.3.4-H-PoC	Server consumes a maximum of 600W
Req 3.1.1-H-PoC	Server should have a base OS system
Req 3.1.2-H-PoC	Server should be able to store video from camera source