ASHESI UNIVERSITY

THE EQUINE VISION MODEL:

Sensing & Data Acquisition

APPLIED PROJECT

B.Sc. Management Information Systems

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ASHESI UNIVERSITY COLLEGE

The Equine Model:

APPLIED PROJECT

Applied project submitted to the Department of Computer Science, Ashesi University in partial fulfilment to the requirements for the award of Bachelor of Science degree in Management Information Systems.

Eugene Nii Sackey Parker

May 2020

DECLARATION

I hereby declare that this applied project is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: 

…….

Candidate's Name:

Eugene Nii Sackey Parker

…….

Date: 31st May 2020

……

I hereby declare that preparation and presentation of this applied project were supervised in accordance with the guidelines on supervision of Applied project laid down by Ashesi University.

Supervisor's Signature:

…….

Supervisor's Name:

…….

Date: ……

Acknowledgment

First of all, I dedicate this applied project to God almighty for given me the strength and will to complete this project with my current health condition. I am forever grateful. I also dedicate this project to my mum, Gift Gifty Parker, and dad, Mark Parker, for all the support and love shown during the execution of this project.

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Abstract

Over the decades, crime rate has exponentially increased in major countries due to factors such as unemployment, economic hardship, greed and gang retaliation. Every year, 1 in 5 people are affected by crime, which is equivalent to 10 million people. Also, 1 in 10 children has been victims of crime in the last year which caused severe depression and Post-traumatic stress disorder in our youth today. Furthermore, the metrics used in measuring crime rate tend to be inaccurate due to the number of underreporting cases. This, therefore, places risk on countries who believe their security infrastructure to be mostly efficient and effective. In Africa today, the current rise in private security firms and security innovations have become commonly known and preferred by residents after a major backlash against the police services. However, the cost of most security services and systems put low-earned income residents at a disadvantage which increases their risk of experiencing burglary attacks. Though some systems may be affordable, the connecting link that helps these firms capture user experience is not formed or is ignored which results in poor feedback channels. In this applied project, I designed and implemented a cost-effective security model that broadens the ecosystem of security for residents living in an African country, as well as evaluate some underlying assumptions relating to security in Africa.

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Chapter 1: Introduction

1.1 Background & Significance

The term "crime" is so abstract to the extent that there is no universally agreed definition to determine what should be or not to be taken as a crime [15]. Therefore, the best approach to understanding crime is to consider it in terms of a legalistic perspective - from this approach, crime in the paper, is defined as a deliberative act that causes physical or psychological harm, damage, or loss of property to which is against the law [14]. Every year, **1 in 5 people** are affected by crime, which is equivalent to 10 million people. Also, **1 in 10 children** have been victims of crime in the last year which makes this quite an interesting issue to tackle [10]. Despite the complexity of laws governing individuals and properties, the crime rate over decades has exponentially increased in some countries due to a lack of claimed factors such as unemployment, economic hardship, greed, and gang retaliation. While other countries report a low turnout of criminal activities, the statistical analysis used in determining the global crime rate seems to be the problem. In general, the crime rate of a given country is measured by several factors such as victimization surveys, online reporting platforms, and the most common one being, the number of reported cases to the police. However, the metrics used in measuring crime could lead to some inaccuracy due to the number of underreported cases globally [6]. Therefore, if countries were to use these rates, in making policies to reduce illegal activities, they might understate the resources and infrastructure needed to keep individuals protected.

Furthermore, the long procedures of investigations, insurance filings, and police reports could sometimes be frustrating for victims, which causes them to ignore such services,[4] thus resulting in the increase of underreported cases. Based on this, some crimes known today are homicide, theft, rape, human trafficking, burglary, and robbery. With a strict focus on home attacks, the analysis of this project would be mainly based on home burglary activities especially in Africa. Burglary, on the other hand, refers to gaining unauthorized access to a part of a building or premise using force with the sole intention to steal goods or vital information [9]. Moreover, recent results by FBI Uniform Crime Reporting Statistics indicate

over 2.5 million burglaries happen a year, to which 66% of those being home break-ins in America. Also, an estimate of 1,495,790 burglaries is said to occur during the day, to which 6% of these break-ins happen between 6 am and 6 pm [10]. Thus, indicates the vulnerability of a home during the daytime. Although some burglary attacks may occur in the absence of a person, individuals present during most burglary operations tend to suffer from the **psychological effects it brings** [4]. However, it is impossible to fully predict the effects an individual victim will suffer. In some rare cases, these effects may last for a short while, as the shock of the attack hits the victim in weeks or months after the incident [4]. Moreover, some victims tend to develop anger, guilt, depression, anxiety, and fear to which they isolate themselves from the public. In the worst possible case, victims may have sleeplessness, flashbacks to the offense, or Post-Traumatic Stress Disorder which **may last for a long period**. Also, those who are more vulnerable (such as individuals who are poor, living in deprived areas) and those who have been previously victimized are more likely to have a greater impact. Moving forward, **the ripple effects** of burglary attacks can also affect the close friends and family of victims, forcing them to be more conscious about their surroundings too [4]. In a report published by Supreme Security, it was evidently seen that victims who experience burglary once or twice move away to different locations just to stay safe and free themselves from guilt. But how many individuals in the world would migrate to a different location every time there is a sudden occurrence. Furthermore, an article published by Psychology Today, reveal that majority of burglary victims would never have **the same feeling of security and inviolability** they had in the past [4][7]. Thus, the reason for the increase in home security today. Home security today, is an essential component of many households, used for protecting and prevent unauthorized entry and forceful intrusion [11]. In an article published by the Electronic Security Association, 90% of convicted burglars said **they would avoid homes** with alarm systems which shows the effectiveness of security today [11]. However, the high cost and interface of most security systems put several residents living in African countries at a disadvantage due to their low purchasing power and background. In some cases, individuals who have used some form of security were unsatisfied due to poor services and feedback from companies (as highlighted in the statistical analysis of this paper).

The Internet of things, however, provides a perspective solution to this problem. Internet of things commonly known as IoT is a system of interrelated mechanical, digital devices and humans connected to a network that uniquely identifies each endpoint and allows the transfer of data between them. With almost **4.5 million active users** of the internet today, the implementation of IoT systems becomes a reliable tool for many processes such as factory automation, security, farm irrigation systems, and many others. Also, the nature of its architecture makes it **cost-effective** as one can easily use a device for multiple applications without incurring extra cost. IoT, though, not a new field, has grown bigger over the years as enterprises utilize its structure to access data of their products and internal control systems. In an article published by ZDNet, a tech analyst company known as IDC estimates that there will be over 41.6 billion connected IoT devices by 2025 which shows the magnitude of its growth in the years to come [3]. Also, another tech analyst, named Gartner estimates that the enterprise and sectors will account for 5.1 billion devices in the latter quarter of 2019 which shows its influence in the technology industry [3]. IoT applications today, ranging from consumer IoT, enterprise IoT to manufacturing IoT has become extremely powerful due to the embeddings of artificial intelligence functions which enables these applications further process on data collected.

The application of **Artificial Intelligence** used in most systems has reduced the margin of errors, risks, daunting and repetitive tasks which has improved human life in general. Artificial intelligence, therefore, is classified under two main categories such as Narrow AI and Artificial General Intelligence. Narrow AI also known as Weak AI mainly focuses on performing a single task extremely well operating under a series of constraints and limitations. Moreover, Artificial General Intelligence mostly known as Strong AI are seen in several applications of robotics as its usage helps systems to reason like human beings. Moreover, AGI has become the most preferred by enterprises as it can apply an intelligence to solve any problem [5]. In a report published by UBS, the AI Industry is estimated to exponentially double revenue recording an amount of 12.5 billion by the end of 2020 which shows the worth of these applications today [5].This, however, has caused **the cost of most security systems** using such technology to be expensive,

making it quite difficult for residents living in African countries who want such systems to look to a **cheaper alternative** which might have vulnerabilities created.

Therefore, the objective of my project is to develop a **low-cost model** that seeks to broaden the ecosystem of security for residents living in Africa who are at a disadvantage of purchasing the state-of-the-art security systems. This model **captures user experience** throughout the lifespan of a security IoT technology, as well as provides security firms in Africa, an analysis of current burglary in some African countries to which they can gain insights.

1.2 Related work

1.2.1 **Building efficient IOT model**

The development of several IoT middleware and solutions have led to technologies such as medical surveillance systems, security surveillance application, and home automation applications. These systems aid in services in the health sector and the security sector. However, the outlook of the model proposed is to provide an enhancement of security services provided to users. Based on this, the model was designed using some key highlights drawn from Steve Hilton's article "What to expect from security and surveillance monitoring solutions in the IoT world". In this article, emphasis on four aspects of security and surveillance solutions would be highlighted, showing changes from an M2M to an IoT world. Some aspects used for the models are as follows: IP enhancement, Integration with other home and business automation systems, video, and mobile devices. In this chapter, these aspects described would be analyzed with the model proposed to show if it meets the requirements of a standard IoT model and if additional features are added.

IP Enhancement

In the article, the anticipation of increased reliance on IP as the transport medium for security and surveillance solutions show the introduction of new solutions such as home management solutions, video-

based surveillance, and facial recognition solutions [13]. With the same design applied, the model proposed does the same by sending a live feed channel over the network to a portal using a static IP address.

Integration with other home and businesses automation

In the article, security IoT technology anticipated to integrate the home security and surveillance solution with other systems such as a home management system and the security of uniquely untagged, valuable residential assets. This functionality indicated in the article reveals some improvements in customer experience through simplicity common interface used [13]. With the same outlook, the model proposed does the same by providing a shop to which users can access all IOT system and components as well as retrieve an access code via email to gain access to the portal where stored data are displayed. Moreover, the functionality that enable the platform's automation would be used in the model.

Video

In reference to the article, a security IOT technology is described as a tool for providing higher bandwidth speeds and standardized applications for things like facial recognition and sophisticated movement identification. This function represents what the video aspects of security system would. Based on this, the model proposed, provides facial recognition functions as event capturing functionality added to the stored relevant frames in a MySQL database.

Mobile device access

In reference to the article, mobile device access was described to be any smartphone or tablet that has a connection to security and surveillance data. This data is highly demanded by residential & commercial buyers of security solutions. In the model proposed, a mobile application and web portal would be used to display data of the IoT device for residents to view.

Feedback Control

In reference to the article, the expectations of service providers and vendors of security solutions to continue providing services are highly demanded. As part of the model proposed, shop & portal administrators are used to track users' performance as well as provide instant feedback without using a chatbot like most state-of-the-art of security technology.

Dell Technologies & Huawei

Dell Technologies & Huawei over the years have been the main contributors to IOT solutions for surveillance in Africa [17][18]. Compared to my model which focuses on home security specifically, their most popular solutions are in wide-coverage surveillance systems such as cities and campuses. Based on the concept on ensuring safe cities, the model proposed in relation to these systems connect a range of users with devices and provide instant data to a platform when a sudden event occurs.

Chapter 2: System Specifications & Functionality

2.1 Project Objective

This capstone project seeks to develop a security model, aimed at broadening the ecosystem of security for residents living in Africa. The model involves three major developments integrated, to ensure user safety, as well as capture the real-time experience of users and backend issues that may arise when using the system. Also, the core intuition of the model is to provide security firms and institutions in Africa insights into several security problems faced by residents. The model, however, is named "Equine Vision +" to emphasize the wide area at which security is analyzed.

2.2 Equine Model

The term "Equine Vision" was taken from the biological classification of mammals known as equine mammals. These mammals are known to have a wide view of their environment, which makes it easy for them to detect danger ahead. Based on this idea and further studies, the model proposed would be designed to function like these mammals in digital sense. The equine model is a multi-platform system that syncs three active system components together to enable system activation. Despite the complex structure used in the design of the system, the system functions encompass that of an already existing surveillance system with a new factor being added. These components included in the system are as follows: Home Hub, Monitoring Kit, Iris MQs & Management Platform.

Equine Home Hub

Equine Home Hub represents the entry point of the system. With Equine Home Hub, users can register and sign in to gain access to controls on the Equine Vision Portal. On accessing the portal, users can view tutorials on how the device works, to get started. In addition, users can gain extra help on system configuration from services such as the manual guide incorporated in the platform. Moreover, the core function of home hub is to activate hidden controls after a successful system synchronization.

Equine Monitoring Kit

The monitoring kit is a small polished black system using a camera module and ultra-sonic as the inputs to the system. The system is embedded with image processing algorithm to detect human motion at all times. Moreover, the monitoring kit can only be activated after a successful synchronization between the Home Hub and the surveillance system. This functionality was included as a way to encapsulate user data to prevent any form of data manipulation.

Iris MQ

Iris MQ is a mobile application that holds the software packages to run the surveillance system. After a successful activation with Equine Home Hub, users can download the application online to receive real-time updates and alerts from the surveillance system. This application is built using a cross-platform architecture which means it is compatible with all operation systems available. In addition, the application can be downloaded for free on Apple Store or Play Store.

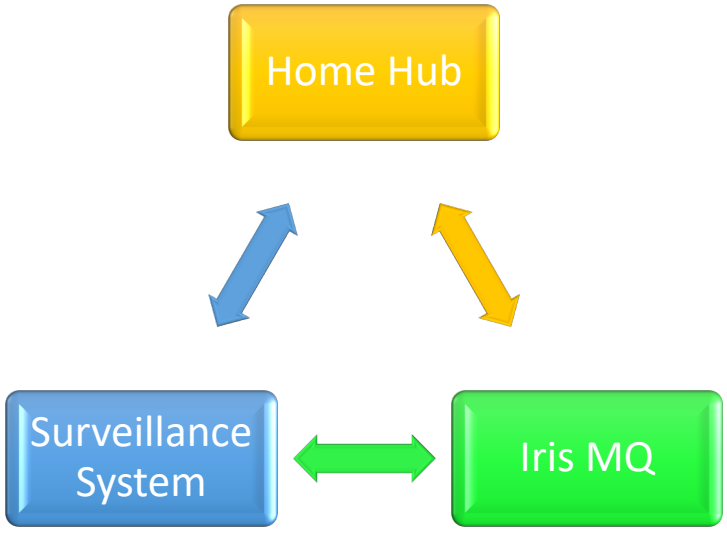


Figure 1: Diagram showing the closed loop system

The security layer of the model uses a closed loop system approach to update itself on current events occurring in the set perimeter. The ultrasonic sensor used, allows the camera module to receive real positioning based on the region of the interest. Moreover, frames of the region of interest are stored into the database upon detection and then compared with new frames entering the database using image processing algorithms. This, therefore, enables the user to create a collection of familiar faces.

2.3 Use Cases & User Classes

The equine Model was structured to influence two different groups of individuals. The first group of people this model seeks to influence are the users of the system. The model provides full protection to users in focus on improving their lifestyle. The second group of people, this model seeks to influence are the security firms in Africa. This model provides a statistical analysis part relating to security in African countries. Finally, fellow students looking to build a home automation application or implement higher image processing algorithms could benefit from this project.

2.4 Functional Requirements

- The robotic monitoring kit is responsible for effective surveillance of the perimeter zone and analysis of frames to create a tree of known faces.
- Ultrasonic Sensors are required to continuously monitor the perimeter after the detection of objects present in the region of interest (ROI). The ultrasonic sensors feed the camera module with a real-time position based on objects detected in the zone. The ultrasonic sensors must have two degrees of freedom to enable the two sensors to move in opposite directions to cover a wide area as the horse eye does.
- The system should be fully IP based and IP enabled. The system would have a unique IP address as well as a changed MAC address upon system activation. However, to avoid DNS spoofing and application hijacking, the system would host personal data and IoT signals on an IOT cloud to ensure full system security.
- The system should provide live feeds on the Home Hub platform.
- The system should support the interoperability of hardware, servers, networking, and communication protocols used.

- The surveillance component to Equine Vision should have an open standard based system with IP centric functionality to enable high-speed network connectivity for faster image capturing and real-time actions.
- The system shall have a night mode camera module with an individual IP address, two ultrasonic sensors for objects tracking within the set perimeter, database storage for video capturing and processing, MQTT server to post analog data to database, System Administration workstation and Admin module.

2.4.1 Web Portal

- The web portal should be able to prevent unauthorized users from gaining entry into the system
- The web portal should allow users to add friends, family to the platform.
- Friends and relatives of users should be able to join the platform of the user.
- The web portal should able to limit friends and members controls.
- User should be able to receive an email with access code.

2.4.2 Communication

- Users should be able to connect to the device after a successful sync.
- Users should be able to view live feeds from the robotic monitoring kit.

2.4.3 Locomotion

- The system should have actuators and effectors to enable the ultrasonic swing module to activate as well as camera rotation.
- The system should be able to move autonomously when activated by the user.

2.4.5 Processes

- The system should be able to save new frames in the database.
- The system should be able to compare new frames with already stored frames in the database.
- The system should be able to give real-time alert within a 5 seconds window after a security breach.

- The system should be able to add trained machine learning models to the platform for accurate prediction of objects.

2.4.6 Recording & Sensing

- The system should be able to know the state of its current properties such as the positioning of swing A and swing B for ultrasonic, camera rotational degree, network communication, and battery capacity.
- The system should be able to allow users to add two references from their contact lists as a backup helper.

2.4.7 Training Module

- The trainer should be able to train a number of faces and store the frames into a dataset
- The trainer should be able to recognize faces stored in the dataset file
- The trainer should be able to learn and identify new faces added

2.5 Non-functional Requirements

- The system should support the concepts of equine vision in some animals, especially that of a horse.
- The system should be able to apply behavior control functions to update ultrasonic sensors after an alert.

Chapter 3: System Architecture & Designs

3.1 System Overview

The Equine Vision model is an integration of various systems that enables users to broaden their ecosystem of security by connecting friends and family to their world of security. Equine Model platforms are aimed at providing researchers and students looking to develop home automation projects. The system design and architecture of the Equine model provides an overview of its complex structure and flow throughout the entire system.

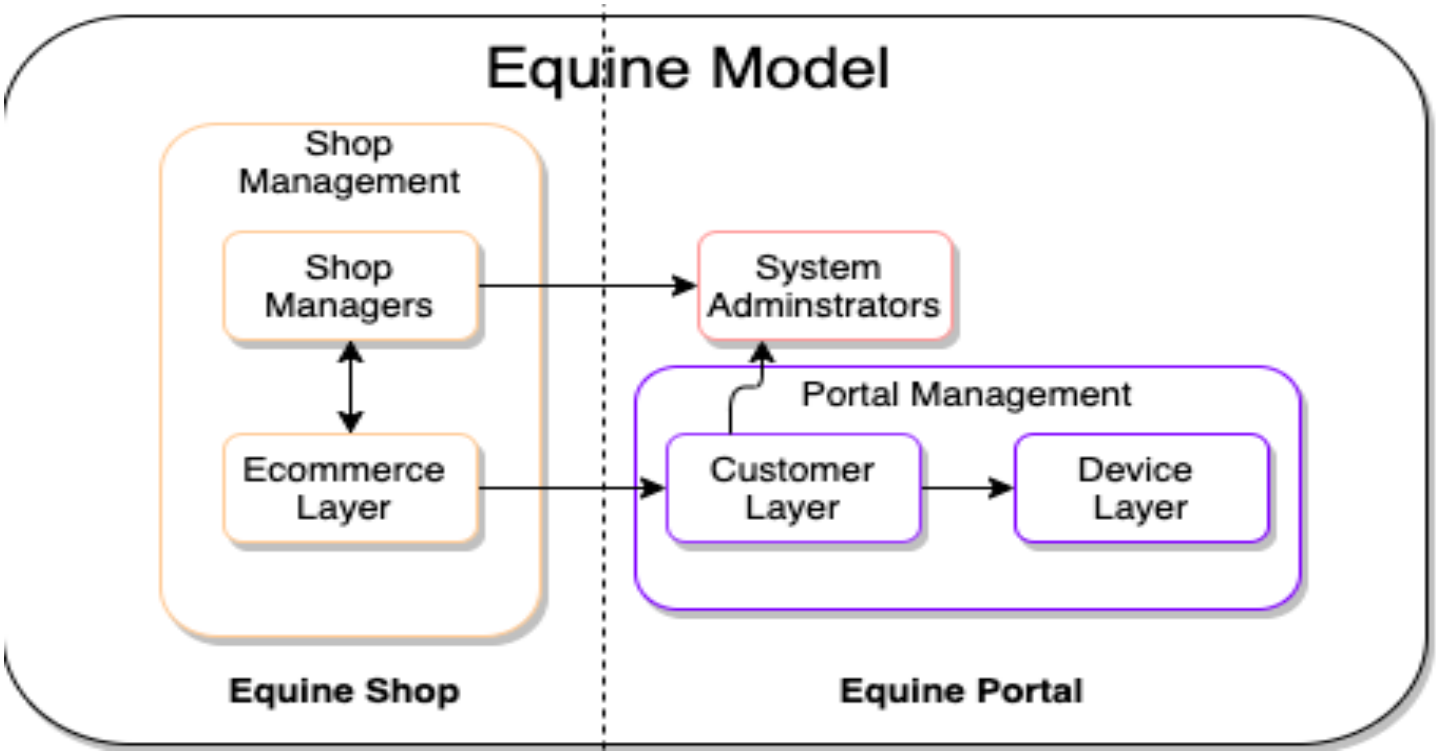


Figure 3.1 Layered architecture of Equine Model

The equine model is an integration of two sub-system namely equine shop, and equine portal that help track users experience throughout the use of the IoT technology. Under the equine shop, there is a shop management section where shop managers can directly connect to an ecommerce layer to allows them to identify the customer pool as well as integrate the ecommerce layer of the equine model with the equine portal. Furthermore, the equine portal allows for the integration of the system administrators layer and

customer layer through the provision of back end services to users found on the customer layer. Within the portal management, the customer layer is integrated with the device layer to ensure connectivity with the robotic monitoring kit.

3.2 Shop Blueprint

3.2.1 The shop management

The shop management as initially identified was created to track user activities as well as provide information on the most preferred models chosen by individuals. The core functionality of the shop management platform is to allow the shop managers to track new users and their status on the portal. This, part of the model ensures that processes used in tracking models and users are constantly active without back-end issues.

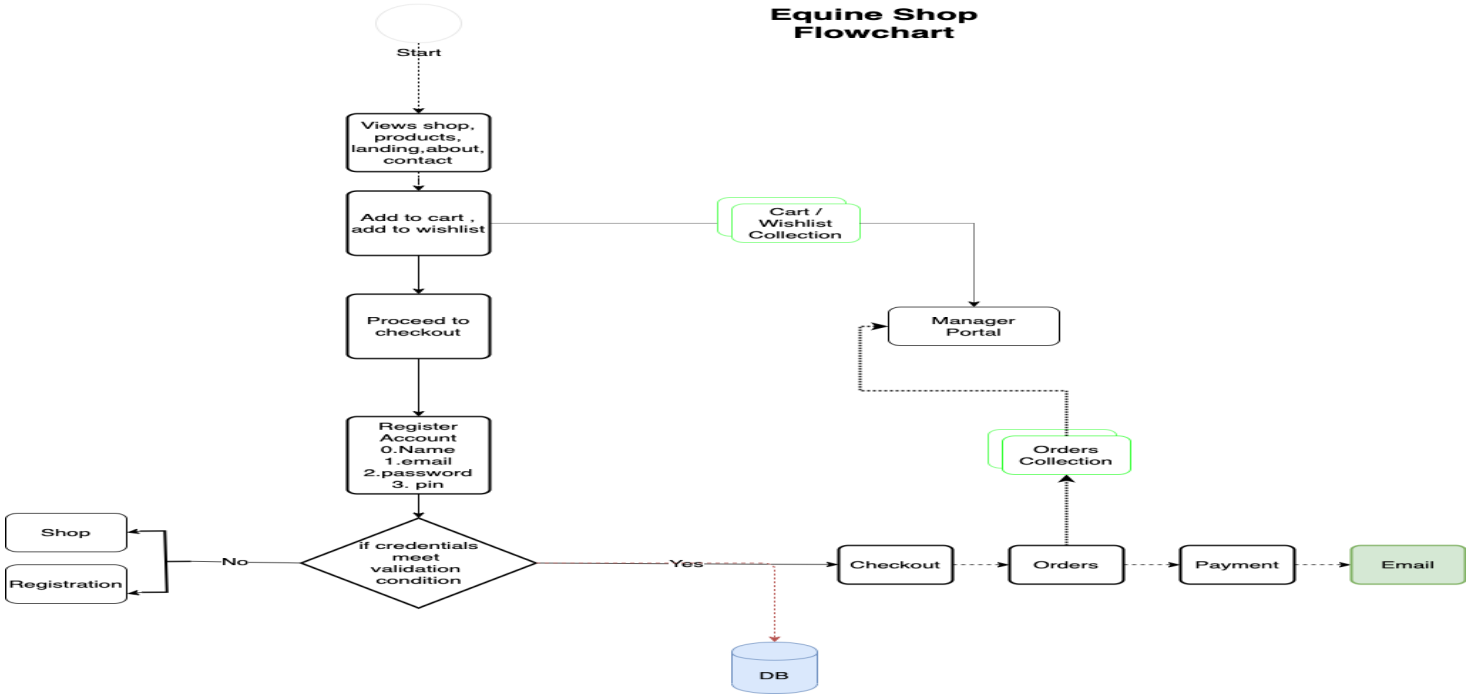


Figure 3.2. Flowchart of the Equine Shop

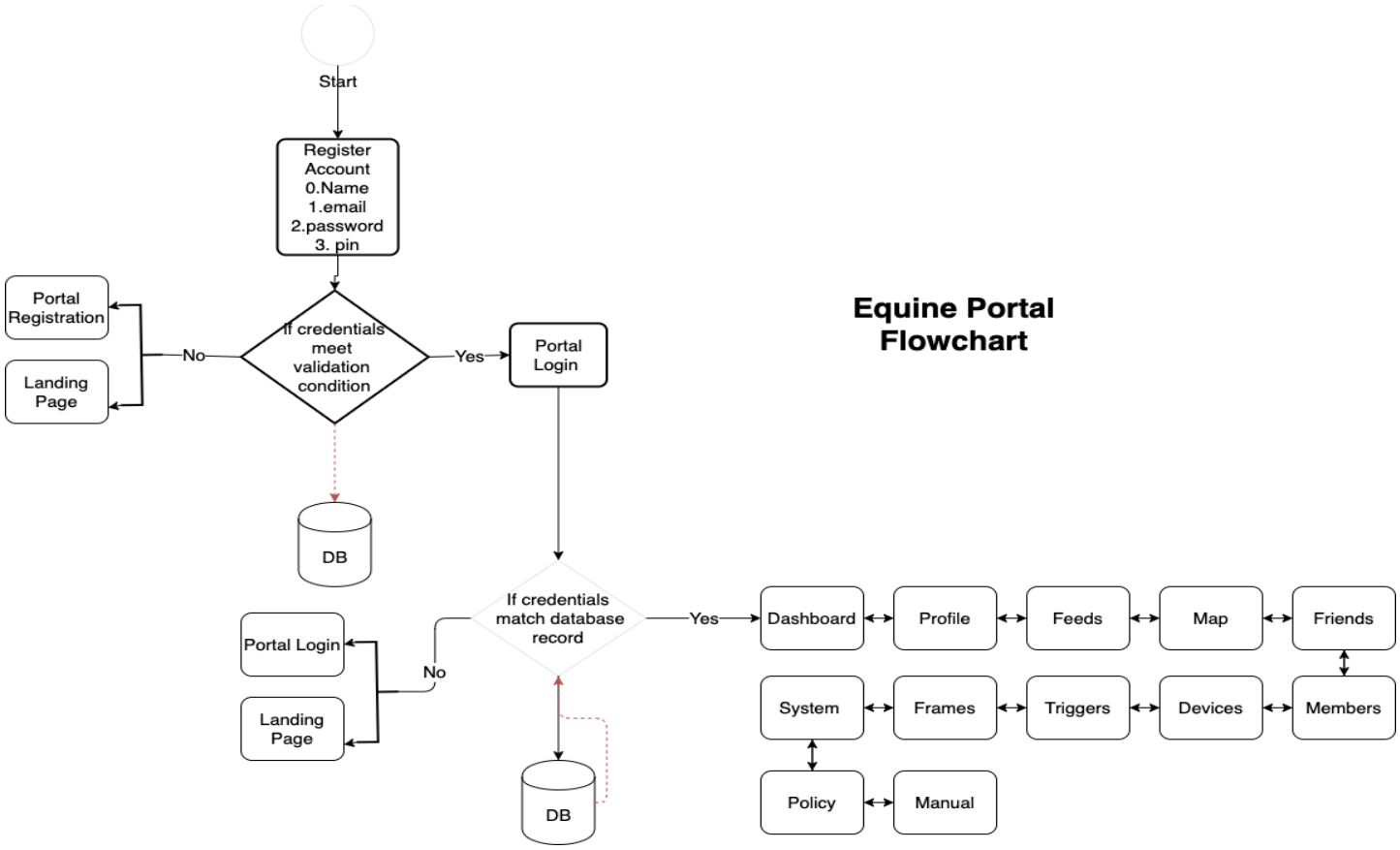
3.2.2 The Equine Shop (Ecommerce)

The design of the equine portal & shop was created using the dry principle approach to reduce the runtime of applications across the various platform in order to ensure higher system functionality. Based on this, the object-oriented way was applied to create various modules for scalability purpose. In designing, the Laravel web application framework was used to maintain this structure of modularity. This model utilizes security tools of Laravel through its use of guards and middleware which helps with user authentication and authorization. The equine shop being the only layer that deals with electronic money hold a high-level of security using the passport library to encrypt information pertaining to transactions on the site. The model divides the shop management into two parts, bringing in an administrator (mentioned in the above) to track collective carts and wish lists entries of users. (shown in figure 3.2). Furthermore, the connection between the shop and the equine Home Hub is made after a successful purchase of a device. An email indicating the access code to the device is later sent to the user to access the portal.

3.3 The Equine Home Hub

Equine Home Hub is a portal designed to encapsulate user data to prevent unauthorized users from accessing vital information from the server unit (which would be discussed later). Portal was designed using Laravel as the backend framework to ensure security on user information. Users' accounts are created with a token and referred to during login to gain approval into the system. Equine Portal consists of major divisions such as the device analysis, member & friends' analysis as well as frames & triggers analysis. On accessing the portal, users can view tutorials on how the device works, to get started. Also, users can get extra help on system & device configuration from a manual guide added to the platform (shown in diagram 5). Moreover, the core function of the home hub is to activate hidden controls after a successful device & portal synchronization. Users on Equine Home hub can add family and friends on their platform and share security access. Also, the home hub provides users with a map to track friends and family location using a search coordinates function. Users can also view live feeds from the robotic monitoring kit (described below) using a web socket protocol to connect to a live feed posted to an IP addresses. Equine Home Hub

also provides additional controls that enables users to terminate signals and retrieve feeds using a messaging queue system to allows the sending of private topic messages to the broker (shown in figure 1 in the



supporting diagram section). The flow of the Equine Home Hub can be seen in the diagram below.

Figure 3.3 Flowchart of Equine Home Hub

3.2.4 System Administrator Platform

The system administrator platform represents the most important part of the model through its ability to capture user experience as well as receive an instant report when a user system malfunctions. In addition to this, the system administrator platform allows for emergency services when users encounter problems during registration.

3.3 Iris MQ

Iris MQ is a mobile application designed to easily flash in real-time notifications and alerts when there is a break-in. The core idea behind Iris MQ was to keep the user always connected to their home at all times. This solves one of the problems concerning usability as mentioned earlier. Residents in Africa while using this system can now view their homes from their workplace or neighbor's house, etc through the use of the internet (Internet of Things). With the use of a lightweight protocol known as MQTT, the transmission of signals and alerts can be done using less bandwidth as compared to that HTTP 1.0 protocol. The design of Iris MQ also prevents unauthorized users from flooding the system as entries to this application is done through the Equine home hub which creates a sync between the two system components. The application is also designed using a cross-platform architecture to ensure the app works across all operating systems.

3.4 Robotic Monitoring Kit

The robotic monitoring kit represents the security tool of the equine model, which provides users, a system that captures real-time occurrences of sudden events in the restricted area monitored. This kit was designed using the principles of design thinking to choose and combine electronic and non-electronic parts in its development to reduce cost of the prototype. With the application of designing thinking, profit models developed, indicate a 5% rise in profit after a sale of 6 units with zero change in the manufacturing process (as shown in the Profit modeling in supporting diagrams). This, therefore, provides evidence of the low-cost of the model proposed.

The system architecture of the Equine MQ provides a general overview of its hardware, software, and external infrastructure. Equine MQ consists of five layers such as: the onboard sensors, the equine monitoring motion, the camera motion layer, the behavioral logic program, and training layer.

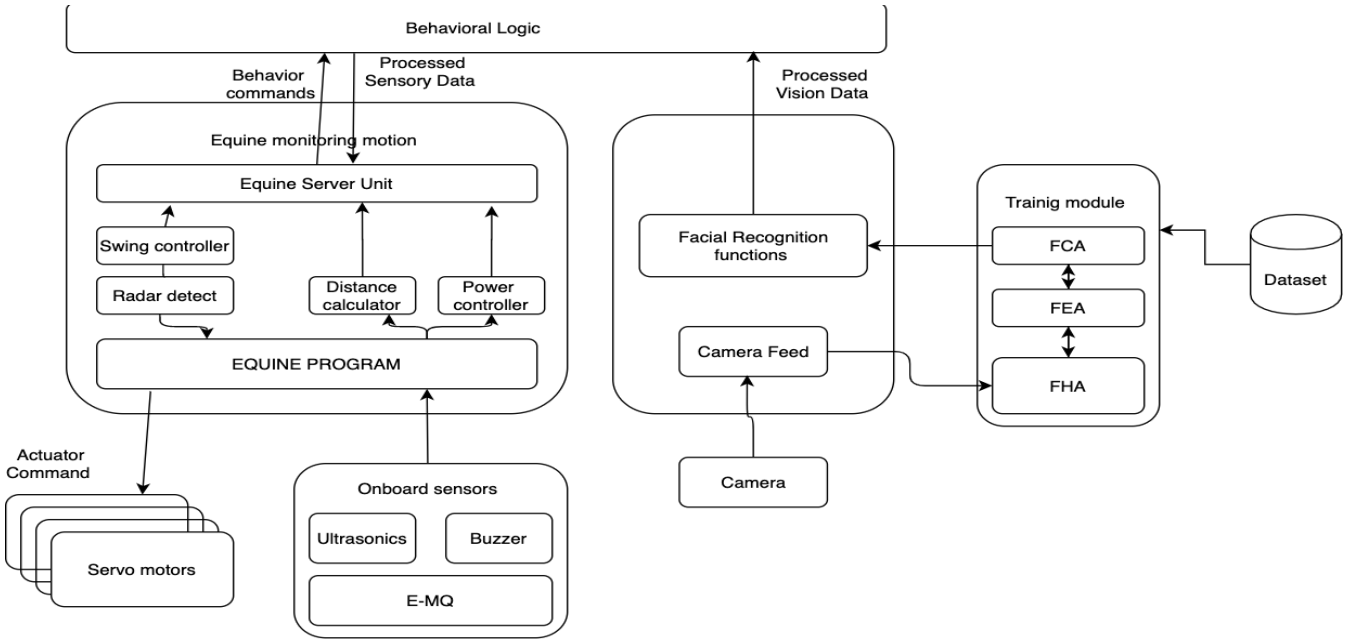


Figure 3.4a Layered architecture of Equine MQ

The structure of Equine MQ was initially developed by representing all components as instances of a class that perform some actions using methods of the inherited class. With this approach, sensors and other components used within the program, such as an ultrasonic, buzzer, servo motors can be doubled without affecting the core functions and tasks of the monitoring kit. As mentioned earlier, the modular approach to this helps equine developers to easily factor in new components for newer models.

3.4.1 On-board sensors

The on-board sensor layers represent all sensors and components to the system. As mentioned earlier, components are in the form of objects for easy tracking of connections errors. (shown in table 1) In addition, components and sensors are labeled using the names of classes they inherited as well as a random number for identification purposes. Sensors and components that inherit from the Radar Class, for example, would be labeled Radar-01 indicate a radar component at position 1(as shown in the table 1 & 2 in the appendix). By applying this approach, the system structure would be made easy for systems administrators to understand the entire equine system.

The sensors and components that make up the physical layer are as follows:

- Ultrasonic sensor: This is a measuring instrument that acts as the eye of the robotic monitoring kit. It functions involves the creation of a radar which allows users to identify objects located within their blind spots (restricted areas). Moreover, by combining the ultrasonic and camera functions of the system, partially observed states can also be analyzed for a while by the monitoring kit. Its inclusion in the model was to help imitate the movement of equine mammals, as well as monitor a large area of the user environment.
- Raspberry PiCamera: This is a single board module fitted with an MP Omni vision focus sensor placed in a dark lens. It is capable of capturing high-resolution images at a given rate of 24 -32 fps which provides Equine MQ a central eye to sense its external environment and current events (Exteroception). However, with the use of some python libraries (mentioned later on), frames per second can be doubled to improve the efficiency of the kit.

3.4.2 Equine Monitoring motion

The equine monitoring motion layers contains a collection of relatable software units and functions that work together to perform a given task. The structure of this layer allows various processes of the system to communicate with each other. The layer, therefore, consists of radar class, swing class, buzzer class, camera class, and power class to which the system controls its components and sensors. This layer, however, acts as the main controller to Equine MQ.

- Swing Controller: The swing controller calculates the stored angle of servo turns. With the application of modularity in this system, the swing controller passes angles calculated to other layers module for further usage, thus results in real-time positioning of camera swing.
- Radar Controller: The radar controller records the distance of objects identified in restricted areas set by the user and passes it to the equine program for further analysis.
- Power Controller: The power controller terminates and activates signals sent to all power modules of the three systems components. This controller receives signals from the behavior program to perform some power methods.

- Buzzer Controller: The buzzer controller activates and terminates signals to all buzzer components used in the buzzer unit. This controller receives signals from the behavior program when there is a break in to perform a variety of noises, thus result in the loud noise.
- Camera Controller: The camera motion layer was initially designed to capture frames located in restricted areas which are then passed onto the facial recognition layer for further processing. The facial recognition layer uses the training module functions: Facial Entity Algorithm, Facial content Algorithms, Facial Handling Algorithms.

3.4.2 Behavioral Logic: Relative Control System

The behavioral logic controller was designed to capture the fundamentals of a reactive based control system commonly used in most robotics systems. This controller follows the sense-think-act approach to which every equine model produced would be based on. This layer, therefore, acts as the logic that feeds the system with underlying rules to perform a given task. Also, the design of code to each module of the system allows the equine program to run different behaviors concurrently to prevent unit malfunctioning, shown in figure 2.3. Furthermore, the logic controller allows users to successfully connect Equine MQ and home hub using a publish/subscribe based communication system known as pub-sub. The usage of pub-sub creates a connection to a broker that allows users to subscribe to a specific topic of interest to broadcast messages published by Equine MQ.

Communication & Integration

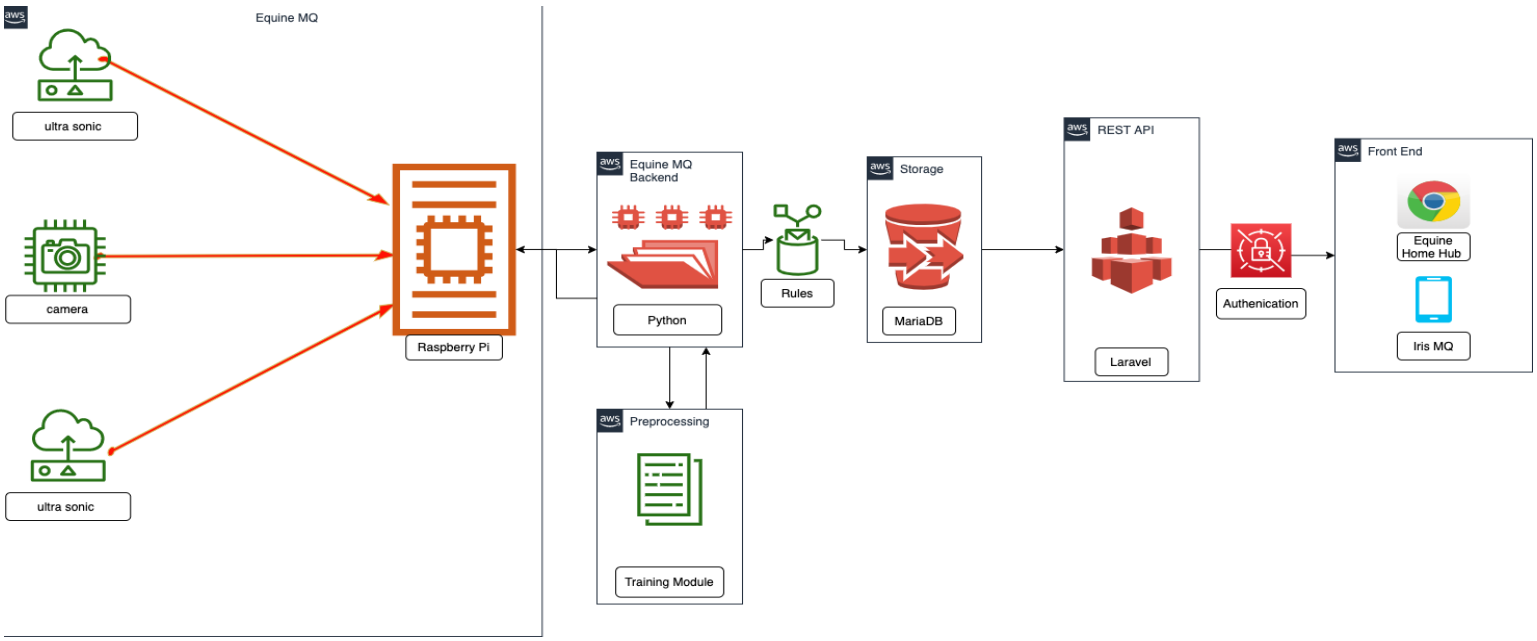


Figure 3.4b Diagram showing the flow of data on the Home monitoring kit

The diagram above shows the flow of the data from the server unit to the Equine Home Hub. The backend of the server unit was written in python object-oriented programing as identified earlier for scalability purposes. This modular way of data transfer between the modes of operations are validated against a set of rules before storage. After a successfully validation, behaviors of the system are activated by the behavioral logic controller after which data is stored and displayed on the equine home hub.

Chapter 4: Requirement & Analysis

Procedure for Requirement Gathering

Requirements of this project would be developed from findings of Quantitative as well as Qualitative research. These findings are to assist developers in making key decisions for data handling, data storage, and system ability to know the user. Having these, however, would be helpful to incorporate privacy laws when developing the IoT system. As a part of the primary goal of the project, target users and early adopters would be given questionnaires to fill over a specified period. The questionnaire would entail security and privacy questions, representing the first wave of questions sent (appendix). Also, other qualitative methods such as focus groups and phone calls would be used in collecting data to have a general overview of individuals' concerns about security and privacy. Expert knowledge from IT specialists at Ashesi University and other security companies would be taken into consideration to make the development of the system more authentic and valuable.

Target Users

The main users of Equine Vision + are families, or individuals looking for an affordable security system to secure their homes and other properties when they are out of sight.

Statistics

Statistics is one of the most important factors regarded during the equine model design process as these data contribute to major decisions being made. In collecting data, several waves of questionnaires would be sent to the public to help capture vital responses on security problems, security systems, and general privacy concerns as mentioned before. In addition to this, the questionnaire would be designed using google forms for the easy spread and quick responses due to the disruptions of activities caused by the pandemic. The designs to the questionnaire can be seen in this link provided: EQ_questions. Furthermore, data provided would quickly be formulated and organized using a codebook created (shown in table 5)

Population frame

The population frame measured in the project includes all residents living in Africa who have experienced home burglary and robbery over the past five years.

Sampling Method

The Cluster sampling method known to be less bias, would be used in this project to determine the general views on security across all nationalities, age groups, and countries in Africa. This statistical tool would divide the entire population frame described above into groups (clusters). After which a probability sample of 9 responses is drawn from each cluster to generally represent countries across the African continent.

Sample size

The sample size measured in this project was 45 respondents out of the total participant number (100).

Sample frame

The sampling frame measured includes residents in Africa who have currently experienced burglary attacks out of the given population size.

Hypothesis Testing

Hypothesis Testing in statistics is known to be one of the best approaches for identifying relationships and correlation across data variables. The creation of the hypothesis in the project was to gather enough information (evidence) to some underlying phenomenon and stereotypes about security. Based on this, the hypothesis section was divided into parts including Security & Privacy. The security part represents analysis on security data while the privacy part represents analysis on privacy data. In addition, variables used were mostly in a categorical form which makes the analysis even easier as C – C (categorical to categorical) forms in data analysis are the most common forms used throughout.

Statistical Analysis

Overview

This chapter provides an analysis of recorded responses from the first wave of questionnaires sent to the public. As described earlier, this section is to provide relevant information concerning assumptions of security and privacy in Africa. In this chapter, I provide some assumptions on security usage, hypotheses, and post hoc analysis to provide evidence to the underlying assumptions of security in Africa.

Assumptions

Assumptions are the generalization an individual makes which evolve into stereotypes over a prolonged period. This subsection presents some underlying assumptions of security usage most residents believe to be true.

Some **security assumptions** used for the study are as follows:

- The assumption that having a security system prevents one from being attacked.
- The assumption that individuals who have previously experienced burglary will opt for security systems after.
- The assumption that the time of security activation determines the frequency of burglary attacks.
- The assumption that victims of burglary report to the police station after an incident.

Some **marketing assumptions** used for the study are as follows:

- The assumption that the equine model would be most preferred since its price is lower than the state-of-the-art security systems.
- The assumption that individuals who prefer the equine model will want some administrator support.
- The assumption that individuals depend on price only when choosing a security system.

Research Question & Hypotheses

As briefly discussed in the above, research questions and hypotheses are used generally as an initial step to provide an answerable inquiry into a specific concern. Based on this, the research questions and

hypotheses presented here are formed based on the underlying assumptions presented in the above. As part of this study, the research questions would be used to form relationships between two variables (**explanatory** variable and **response** variable) to help with the hypotheses formulation.

In the **hypotheses formulation**, the hypotheses null would be used to support the claim while alternative hypotheses would be used to reject the claim based on the p-value calculated. Therefore, this would help in determining evidence to the study. To begin the analysis, some research questions & hypotheses used for the study are listed and results to that association is provided after:

Association 1

Is there a direct relationship between the time of security activation **(explanatory variable)** and the frequent burglary attacks **(response variable)**?

Hypotheses Null

No more than 60% of burglary victims living in Africa use security systems 24/7.

Hypotheses Alternative

More than 60% of burglary victims living in Africa use security systems 24/7.

Results

This study was formed to grasp the understanding backing the number of times burglary happens to a resident in Africa. Most people when spoken to say there are more burglary attacks during the night compared to the day. However, when processing this data, there was no record for day (only) which is why it was neglected in further analysis. Looking closely at the first Graph in the supporting diagram section, it seems as though, those who use or have security systems active both during the day and night have experienced burglary attacks. This information however still does not prove enough evidence to say these state-of-the-art systems are ineffective because other factors could influence such activities. Examples of some lurking variables linked to this study are the area, location, quality of the system and time. Furthermore, from the Chi-square analysis, the p-value shown was 28.54% which is between the range of

the hypotheses null of 60%. Therefore, we accept the hypothesis null that states “No more than 60% of burglary victims living in Africa use security systems 24/7”. To which I proposed the equine model.

In conclusion, the results of the study show that there is no direct relationship between security activation and burglary rate as, residents that use the security system 24/7 experience more attacks than those that use the security during the night.

Association 2

Is there a direct relationship between current usage of security **(explanatory variable)** and experience of burglary **(response variable)**?

Null Hypotheses

No more than 50% of burglary victims currently use a form of security

Hypotheses Alternative

More than 50% of burglary victims currently use a form of security

Results

This study was formed to gain insights on residents' decision in protecting their homes after an intrusion. Ideally, it is expected that an individual would have to find some form of protection after an intrusion or break in. Therefore, this study helps find answers to this. From the analysis, it is realized that 25% of residents who have experienced burglary still do not use security systems while 65% of residents in Africa who have experienced some form of burglary attack have current security installed or in place. With a p-value of 32.28%, we accept the hypothesis null which claims that “No more than 50% of burglary victims currently use a form of security.” This, however, proves the significance of this project as it focuses on the minor group of residents within the low-income bracket who cannot afford such expenses due to certain factors. Examples of some lurking variables identified are as follows: (1) Poverty – money issue; (2) Expensive security tool circulating the market; (3) Frequent Maintenance Fees. Graphs can be seen in supporting diagram section.

In conclusion, the results of the study show that there is no direct relationship between current usage of security system and burglary rate as, majority of residents that have experienced burglary before still do not have security systems in place.

Association 3

Is there a direct relationship between the previous usage of security **(explanatory variable)** and experience of burglary **(response variable)**?

Null Hypotheses

No more than 70% of burglary victims currently use a form of security

Hypotheses Alternative

More than 70% of burglary victims currently use a form of security

Results

This study was formed to gain insights to whether residents were using any form of security before an intrusion. From the analysis, it is realized that residents living in Africa who have used some form of security have experienced attacks more than those who have not. Could this be because of the type of security? However, there is not enough evidence on that yet. With a p-value of 39.8%, we accept the null hypothesis which claims that “No more than 70% of burglary victims previously used a form of security”. However, some lurking variables that could explain the turnout could be as a result of the location, time, place and environment cluster. This is not to say the usage of systems affects their one negatively, it just happens to be one of those rare cases. In addition, the sample size might be too small for this analysis.

In conclusion, the results of the study show that there is no direct relationship between previous usage of security system and burglary rate as, residents that use the security system 24/7 experience more attacks than those that use the security during the night.

Assumptions 4

Is there a direct relationship between the country one resides in **(explanatory variable)** and the experience of burglary attacked **(response variable)**?

Null Hypothesis

No More than 40% of residents living in Africa have experienced some form of burglary attack

Alternative Hypothesis

More than 40% of residents living in Africa have experienced some form of burglary attack

Results

This study was formed to gain insights to countries in Africa that have a high tendency of burglary activities. In addition, this study was formed for planning purposes, to help the equine management decide which market in Africa to target first. Also, this information could help travelers know countries that are riskier to migrate to. Surprisingly, with constant crime cases reported in South Africa and Kenya, one would expect the two countries to take the lead. However, it is realized from the study that Nigeria has frequent attacks compared to the two which makes it a bit odd. Moreover, the Chi-square analysis indicates a p-value of 22.8%, which makes us accept the hypotheses null which claims that "No more than 60% of residents living in Africa have experienced burglary attacks. In the case of Nigeria, some lurking variables that could influence this could be as a result of the current situation of lack of electricity and water in Nigeria. (shown in the supporting diagram section)

In conclusion, the results of the study show that there is a direct relationship between the country one resides in and burglary attacks as, data show more residents in Africa experiencing burglary attacks.

Other Findings

The results from the questionnaire shows that more females responded compared to males. From the sample size of 45, 34 were females and the remaining males. A randomizer from excel was used to select the sample which could have caused this bias. The age bracket that was highly represented was between 18-29, which represented 86.7% of the sample.

Types of system used in Africa (Previously used)

This part of the Questionnaire sought to find out the type of security systems which the respondents have used in the past. Home security, CCTV systems, Extra locks, Wired Burglar Alarm, Trapdoor, Burglar proof and Security Guards were the specific security systems used in the questionnaire. The results here showed that home security guards and extra locks were popular with the respondents, this means most of the respondents have previously used this. CCTV systems and Burglar proofs were unpopular amongst the respondents, an average of 67% of the respondents have not used CCTV systems and Burglar previously. Wired Burglar proof alarms, trap doors, and security guards had a fair share of respondents who had previously used them and respondents who had not used them. (shown in figure 30 in the supporting diagram section)

Types of system used in Africa (Currently used).

This section of the questionnaire was a follow up on the previous one. This section intended to find out the security systems currently being used by the respondents. The security systems in the previous section were the same ones used in this section, these include Home security, CCTV systems, Extra locks, Wired Burglar Alarm, Trapdoor, Burglar proof and Security Guards. The results showed that currently home security and extra locks are still a high hit with the respondents. CCTV systems and Burglar proofs are still unpopular security systems with security guards also becoming an unpopular security system currently used. From the sample respondents while Wired Burglar proof alarms and trap doors still had a fair share of respondents who currently use them and respondents who do not use them currently. There was not much of a change between what the respondents used previously and what they use currently, the only difference was that the number of people who currently used security guards had reduced significantly. (shown in the figure 29 in supporting diagram section)

Factors influencing a buyer's decision

This part of the questionnaire wanted to find out what the respondents took into consideration before purchasing a security system. The main variables here were; price, feature, performance and simplicity of the security system. Out of the 45 respondents, 31 considered the price, 28 considered the feature, 31 considered the performance and 24 considered the simplicity of the security system. This shows that people do not just buy a security system for "buying sake", they take into consideration some of these factors before buying. (shown in figure 20 in the supporting diagram section)

Expenses

The respondents were asked in the questionnaire how much they would be willing to pay for a security system. Three price ranges were given and these were all denominated in Ghana cedis. The first range of prices was below a 1,000 Ghana cedis, the second was between a 1,000 Ghana cedis and 4,999 Ghana cedis and the third option was for people who did not know how much they were willing to pay. Out of the 45 respondents, 13 were willing to pay below a 1,000 Ghana cedis, 11 were willing to pay between the price range of 1,000 Ghana cedis and 4,999 Ghana cedis. This information implies that most people were either willing to pay below 1,000 Ghana cedis or did not know exactly how much they would want to pay for the security system. Their willingness to pay would most likely depend on other factors like the features and the performance of the security system indicated above. (shown in figure 21 in supporting diagram section)

Security Activation

Out of all the respondents, 74.19% activated their security systems both day and night whilst 25.81% activated them only at night. This means most people keep their security systems on 24 hours a day. (shown in figure 22 in the supporting diagram section)

Burglary attacks

This section sought to find out the number of respondents who had experienced home invasion. 63% of the respondents had experienced home invasions whilst the remaining 36% had not experienced home invasions. (shown in figure 23 in the supporting diagram section)

Satisfaction

The questionnaire also intended to find out if customers were satisfied with their current security systems. 60% of the sample size was not satisfied with their current security systems and the remaining 40% were satisfied with their current security systems.

Security Alternative

This part of the questionnaire sought to find out the alternative ways people find security when they have been attacked. The respondents were asked if they would turn to their family members or friends, the police and self-protection. 64% considered their family and friends, 40% considered the police and 64% considered self-protection. These results imply that people would rather turn to family and friends or themselves for protection rather than go to the police.

In conclusion, the results presented show a positive impact of security system on the lifestyle of residents. However, the decision made by users in choosing security systems that caused the demand for some high technology to be used by residents. Also, the assumption that price influence the demand still hold but other factors such as performance and features are considered. Furthermore, the assumption that residents would the equine model and admin services was proven to be true.

Chapter 5: Implementation

This chapter gives an overview of the implementation of the Equine model. As described earlier, the equine model consists of five independent parts integrated to provide an effective security platform for residents living in Africa. In this chapter, I provide a detailed description of the core functions of the complete prototype, showing how each module is implemented while satisfying the functional requirements listed above. Also, details of software packages and libraries used would be further discussed in this chapter.

5.1 Pre-planning

Planning is the most essential step needed in any project as a form of guide and aid to the development of any product or service. Based on this, the start of this project involved a pre-planning stage that helped management identify the scope of the project before tackling tasks involved. As part of planning, the project charter, milestones, deliverables, UI/UX Designs, and Gantt charts were used to provide an overview of the model.

5.1.1 Project Charter

The Project charter is a project management tool that describes the project in its entirety. In planning, the project charter was used to understand and identify the core objectives, processes, and stakeholders involved. Based on this, the project scope was made clearer and involve several iterations throughout the period (shown in Table 5 in the appendix).

5.1.2 Milestones & Gantt Charts

The milestones sheet, also another powerful project management tool was used to mark specific activities along the project timeline which helped in meeting deadlines during the development of the system. In the pre-planning stage, Gantt charts were mostly used to divide tasks that needed to be completed by developers. Moreover, with the nature of the equine model being so complex and involving, the Gantt chart was used to create a sequence of processes with their corresponding relevance which helped in determining the important part of the equine model to implement first.

5.1.3 UI/UX Designs

Programming, in general, can be stressful depending on the functions of the application involved. Therefore, as part of the pre-planning stage, UI/UX designs of the platform were created to reduce the length of time spent on developing an application. Moreover, UI designs for the shop, admin portals, home hub, and mobile applications were designed in the early stages of the project.

5.1.4 Database Relation & Designs

Database Designing is quite essential in every project as it helps in determining storage cost and capacity. As part of the pre-planning stage, the designs of the database were created to outline the relationship between entities and rules that exist. (shown in Figure 15 & 16 in the supporting diagram section)

5.1.5 Prototyping

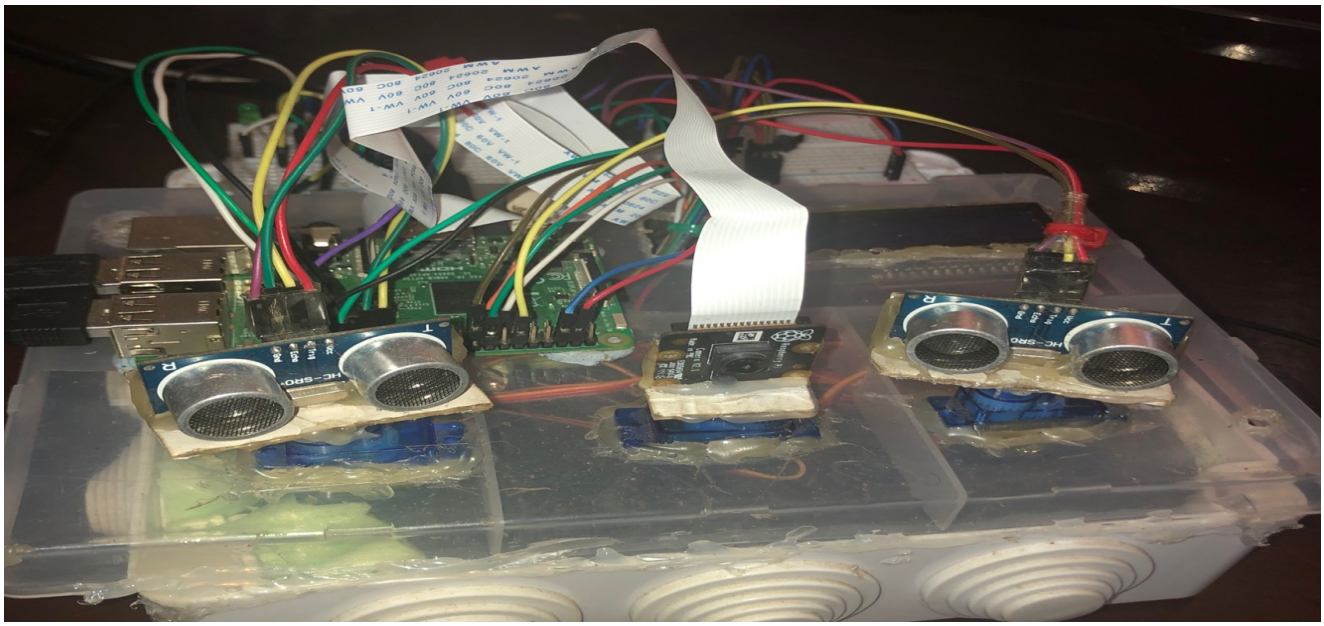


Figure 5.1 Image showing Prototype of the monitoring kit

Designing and building a system could very challenging as components used begin to fail in the actual model. Based on this, a prototype of the equine home monitoring kit was developed to test the core function of the equine program as well as know which components to use in the actual development.

5.2 Equine Shop Implementation

The Equine shop as described earlier was created with the sole intention to track device performance in the market. Based on this, its development considered different types of users (shoppers, buyers, browsers, etc.) on the internet to interact with the system. Primarily, all users identified above can add to wish list or carts without registration which makes it easier for management to know which models are preferred more. However, the design of the shop prevents user access to the checkout page if they are not authenticated by the system. This was done mainly to reduce the load on database storage as the possibility of having ghost users could cause runtime of the system to worsen. Currently, the development of the shop uses a stripe payment option to handle online payment processing of the devices and services provided. For a user to get to the payment stage, accounts need to be verified and a billing address would be required and stored into the database for future reference. Also, the addresses stored is done on runtime to enable users to change their billing addresses and add new ones as pleased. After a successful payment, an email is sent to the user to provide other information of the product, like the access code needed for the Home hub (shown in the appendix).

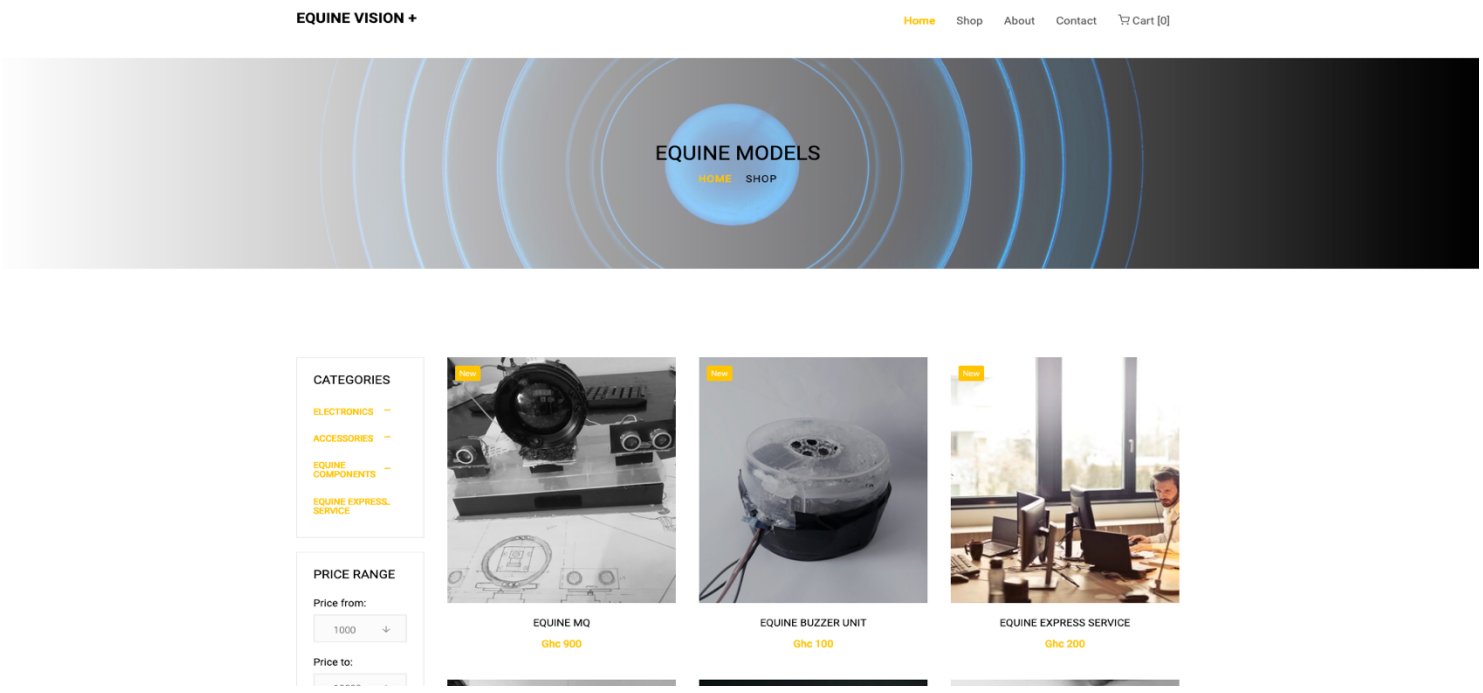


Figure 5.2 Image showing the shop part of the ecommerce platform

5.3 Equine Home Hub

The Equine Home hub as its name suggests represents the main portal of the security system. It was given the word "Home" to represent the feel of a homely environment and "hub" to represents its ability to connect with devices and other users similar to that of "a hub" in networking. Moreover, the home hub involved various sections such as user profile, friends and family activation, policy, and manual guide, camera feeds, alerts and frames analysis, device profile & connectivity, system reports and a map to track friends & member's location. Furthermore, the home hub requires user registration to be able to display all of the services provided on the platform to various users. Based on this, the user registration process is supported with Laravel guard authentication packages to enable multi-users registration for friends, family members, users, and administrators. With this approach, the portal for each identified user is created and limited to their roles.

5.3.1 Dashboard & User Profile

The dashboard represents the first screen shown, which provides a summary of information to the users after a successful login. Information presented here shows the number of friends& family members added as well as the device connected to. Also, alerts charts and members' activation can be viewed from here without that navigation to the main page. The User Profile, on the other hand, allows users to edit profile, view a collection of members & friends as well as add daily tasks shown in the image below.

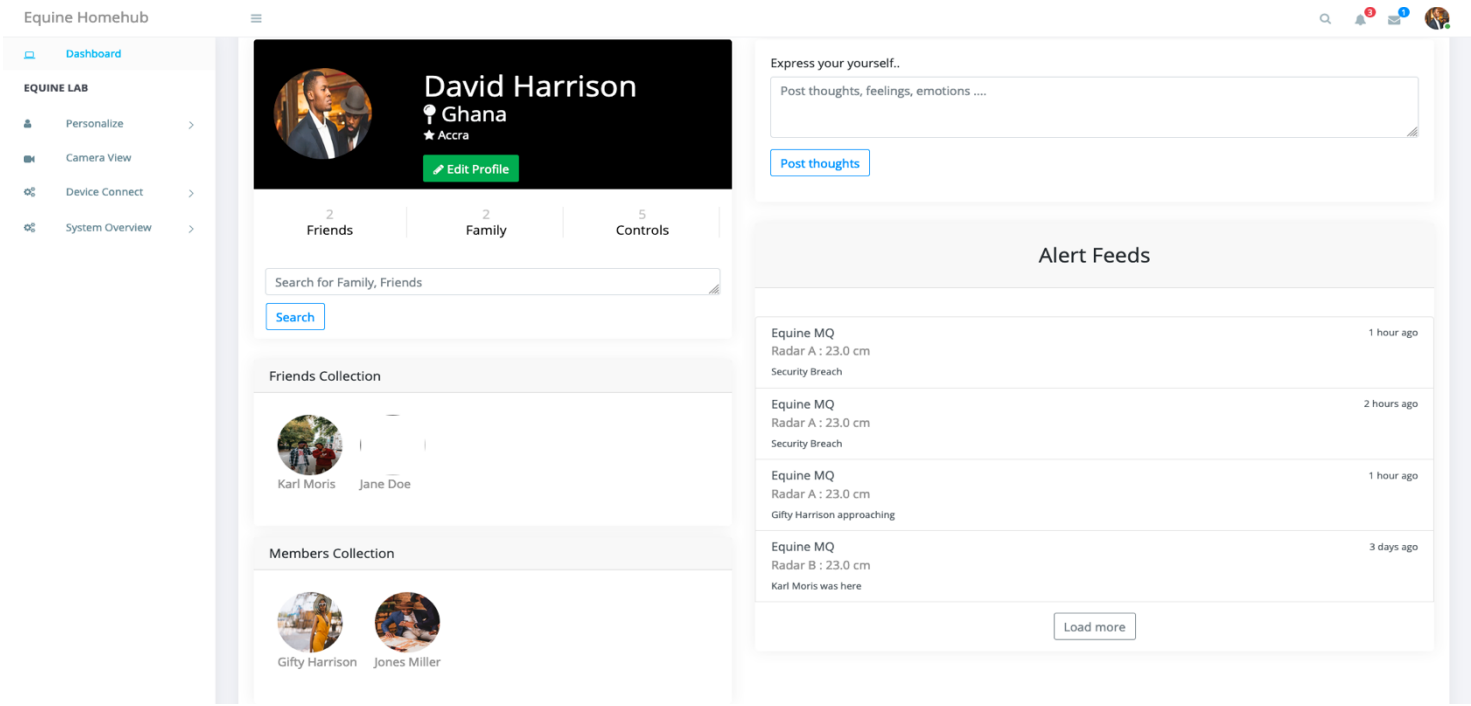


Figure 5.3.1 Image showing user profile on Home Hub

5.3.2 Camera Feeds

The Camera feed sections represent the eye to the home monitoring kit which would be discussed later in this section. The camera feeds show the environment of the user at the position in which the device is placed. The feed, however, is provided through a web socket protocol using a static IP address given to the robotic monitoring kit.

5.3.3 Friends & Family Activation

Friends & family activation, though implemented at various sections of the platform, consists of the same procedure which explains their combination in this report. Users through these sections can add family members and friends to the platform with ease. Users can also activate members & friends' accounts based on their availability to reduce the level of vulnerability created. This feature was added to block all dominant users from access to vital information. Also, the addition of this feature allows users to keep

member accounts for future purposes. This part of the platform acts as the registration section for all friends and members.

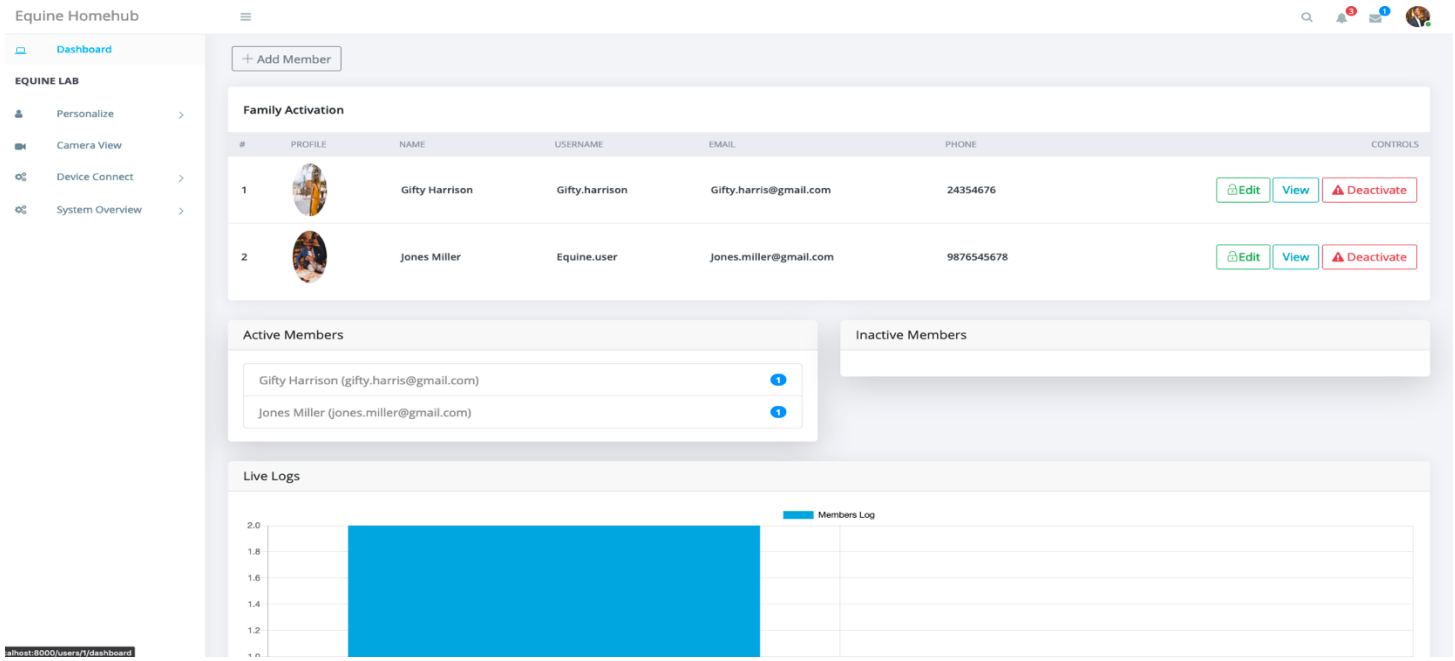


Figure 5.3.3 Image showing Family member on Home Hub

5.3.4 Device Profile & Connectivity

As mentioned earlier in the equine shop section, users receive an access code through an email. This access code creates a sync between the device and the Equine Home hub. After successful synchronization, the access code is blocked automatically to prevent others from connecting to that device. Also, the user can view the properties of the device in the Device section to the platform after synchronization.

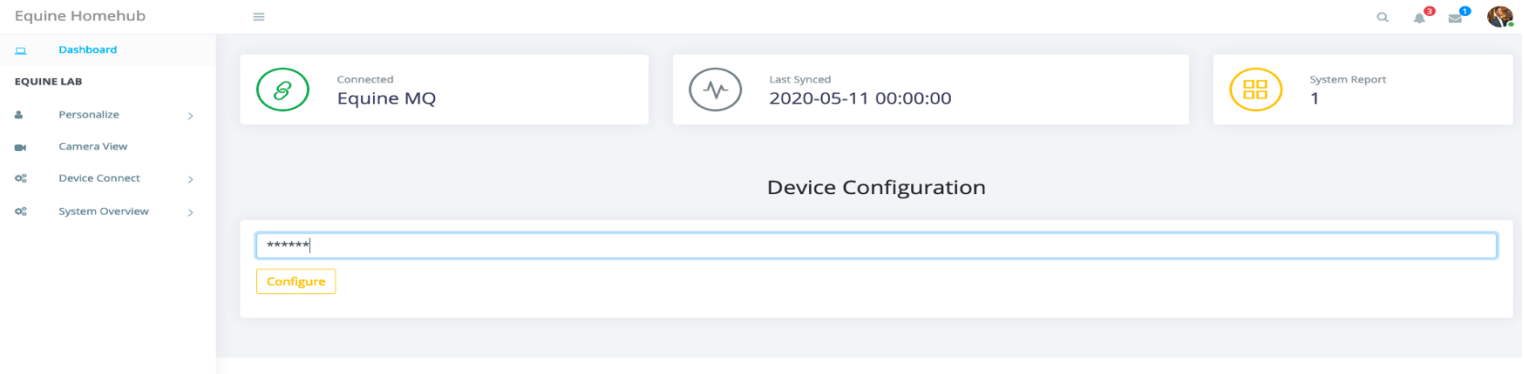


Figure 5.3.4 Image showing Device Configuration on Home Hub

5.3.5 Map View

Following the core intuition of this project which is to broaden the ecosystem of the users' security, the map view was created to allow the tracking of the users' location when an emergency arises. The functionality must be enabled by all users of the system. The map displays location of users, friends & members added to the platform with multiple markers depending on their labels.

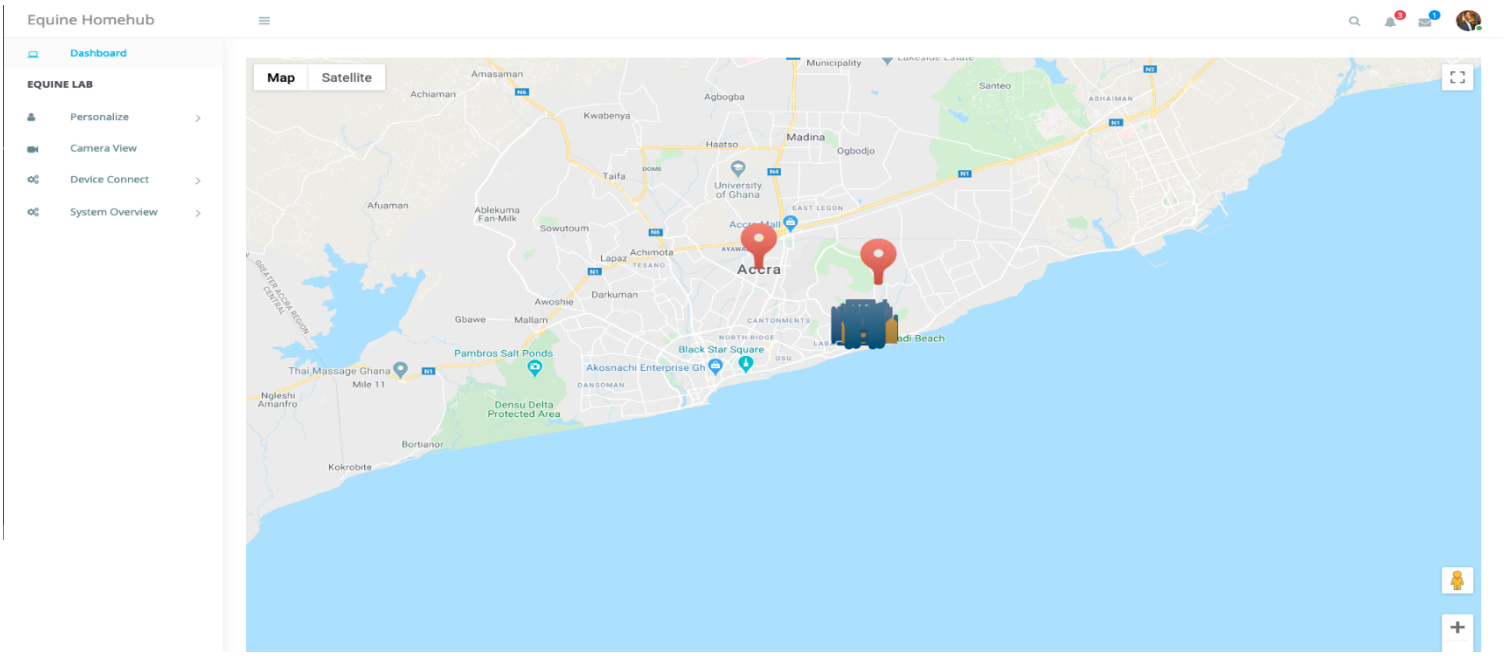


Figure 5.3.5 Image showing User map page on Home Hub

5.3.6 System Report

With concerns relating to usability and feedback collection of the state-of-the-art systems, the equine platform was designed to collect reports of system errors, bugs, or failures. The reporting section was added was to keep system administrator aware of user troubles to able to provide faster updates. Since

the platform is under the development phase, all reports are sent to a Php mailable email which is presented on the administrator platform.

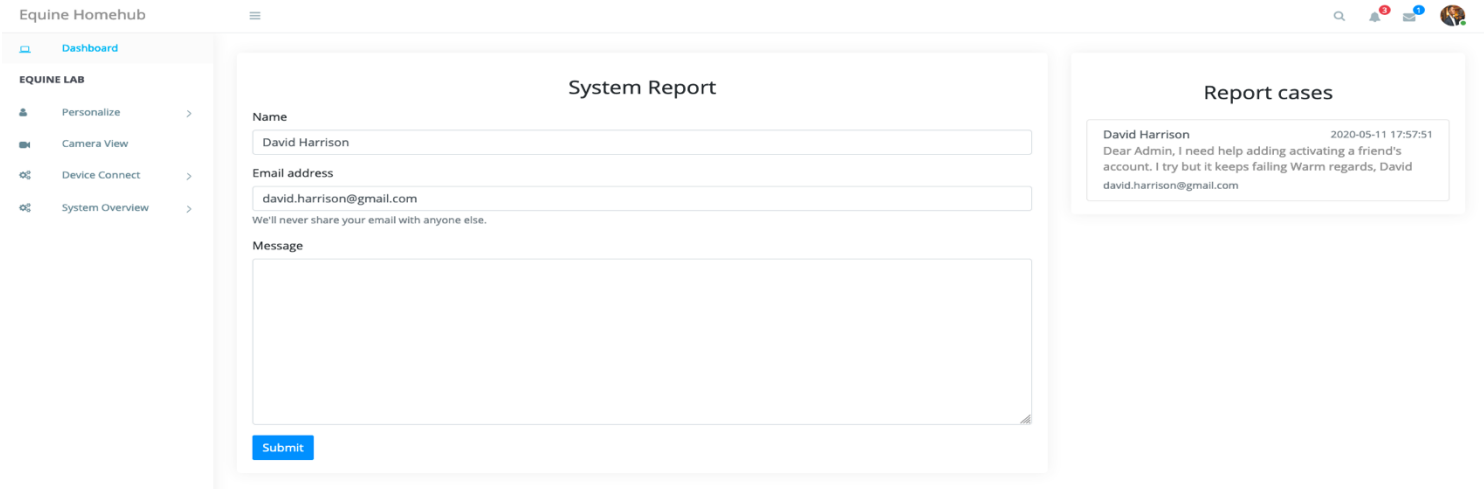


Figure 5.3.6 Image showing System Report on Home Hub

5.3.7 Friends & Members Login

As mentioned earlier, registration of friends and members is done on the user portal. Upon registration, users provide a unique pin that allows friends and members to login to their side of the platform. Upon login, friends and members are asked for their phone numbers as a means to verify the account. If the credentials provided are valid, a Twilio SMS would be sent to the user to sync the number with the portal.

5.4 Robotic monitoring

Overview

The robotic monitoring kit as described earlier was designed to imitate the movement of equine mammals to cover a wider area as known as the safe zone. In achieving this, the application of control theory and cybernetics was incorporated, to outline features of the monitoring kit as well as its programming, to enable it to work just like the biological systems of the mammal. The system as identified in the above, includes five modes of operations that share data across various nodes of the system. When a sudden event happens in the restricted zones, the radar modules pick up the distance and pass it to the

camera module which causes its real-time positioning. This, therefore, allows for further analysis of the area pinged, which would later be discussed in this section. With parts of the system designed in defragments, all connections are made to connect to the control board known as the "spine" which allows components to communicate with each other to evoke different behaviors stored in the behavioral logic controller (shown in figure 7 in supporting diagram section). The camera module captures a portion of the frame known to be the region of interest(face) which is sent to the behavioral logic controller for further processing. In this mode, the region of interest (frame) captured by the camera at a resolution of 2 x 2 with a rate of 32 fps is compared to the stored dataset for a match. If ROI is invalid, the label "unknown" is tagged to the object found and an immediate signal is sent to the buzzer module to sound the alarm. However, if the ROI matches frames stored in the dataset, the correct label would be assigned to the object and the program continues. Ideally, the system should stop when an event occurs, but the design of the system allows the radar module to run concurrently with the camera module to keep the zone safe at all times.

5.4.1 Software / Libraries Used

The designs and implementation of the robotic monitoring kit depended on some existing libraries and software packages listed below. Some libraries and software packages used are:

VideoStream / Imutils: Initially, the Raspberry Picamera reads frames at a rate of 24 - 32 frames per second which is quite the standard. However, for applications like this that involve more real-time processing for longer hours, the central processing unit (CPU) could become slower over the period, which is the reason for including VideoStream open source. The Video stream extends from an Open-source Imutils package that provides higher Frames per second used in the application. It achieves this by moving the I/O (i.e. the reading of the frames from the camera sensor to a completely separate thread. Therefore, the current frames can still be read in one thread while the root thread performs additional processing.

Proteus: Proteus is a proprietary software tool suite used for circuit designs. In this implementation, the proteus software was used to design the circuit layout of the kit (shown in Figure 14).

OpenCV: OpenCV is a powerful library of programming functions aimed at providing computer vision applications the packages needed to perform high-level analysis on images & videos. For this implementation, version 4.2 of this library was used for most facial detections and morphological operations.

Solidworks: Solidworks is also a powerful computer-aided design and engineering program that enables users to create 3-dimensional designs with animations just like that of Autodesk Eagle. however, due to its simplicity, it is used for designing the body of the robotic monitoring kit.

NumPy: NumPy, as its suffix shows, is a python programming language, used for computing of multidimensional array. Since an image is merely an array of pixels and pixels are numerical values of a scalar, NumPy was used in this implementation to support the OpenCV library when processing images.

Python MySQL package: MySQL commonly known as a database management system was used in this implementation to store triggers and frames into a hosted database**.**

getMac: getMac is a python library that allows programmers to retrieve their mac address using python. The getMac library was used in the application to retrieve the mac address of the device which is later stored in the database upon system activation.

Mosquito MQTT: MQTT commonly known for its swift transport of message through a sub pub network was used together with Node-Red to connect to components of the system.

5.4.2 Equine MQ

Equine MQ as identified earlier integrates three independent systems such as buzzer unit, server unit, and camera unit to achieve its goal of monitoring. Also, Equine MQ uses the control board discussed earlier to keep the unit connected. The design of the control board involves color codes and pin codes for easy identification of components connection. (shown in table 1 and 2 in the appendix)

Disclaimer:

The design of the buzzer unit, server unit and camera unit were changed due to inaccessibility of a 3D printer caused by the COVID-19 pandemic. Based on this, the application of design thinking was applied in gathering materials that could be of help to the application. However, the initial designs to the system is included in appendix to show the actual blueprint of the home monitoring kit.

Buzzer Unit

The design of the buzzer unit includes two piezo buzzers and a red led soldered on the perforated board in an enclosed case to echo loud sounds when activated by the radar module.

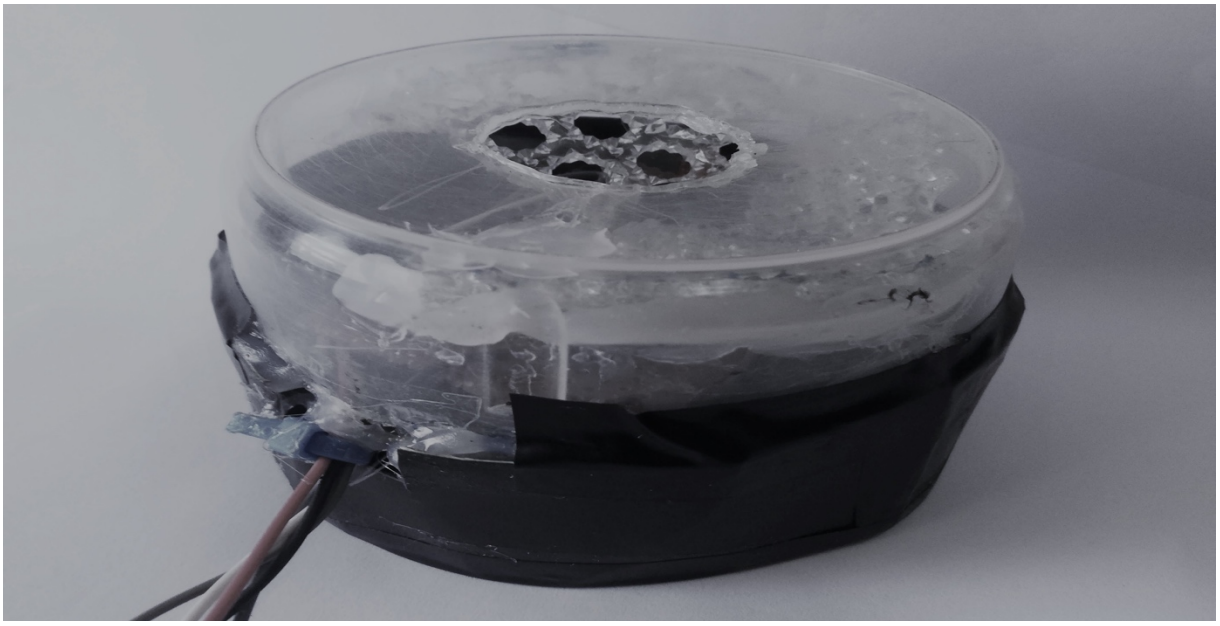


Figure 5.4.2a Image showing the buzzer unit

Server Unit

The design of the server unit, therefore, included a white box with two huge airspaces to prevent the system from overheating.

Camera Unit

The camera unit, on the other hand, included two ultrasonic for object detection at far proximity, three servos for swing movements (actuators), and a raspberry PiCamera for facial detection as described in Chapter 4. The swiftness and frequent updates of this unit would depend on the successful integration of the camera and ultrasonic (sensor fusion).

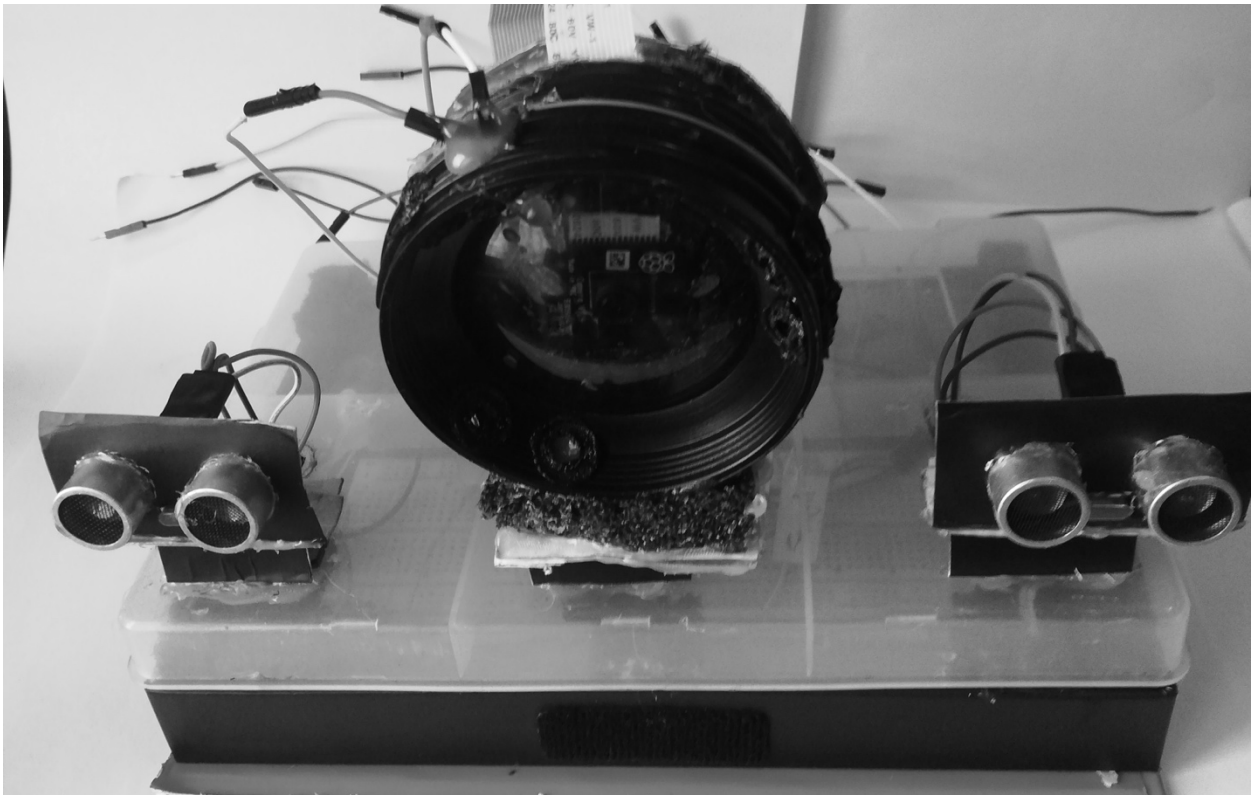


Figure 5.4.2 b Image showing Camera unit of the robotic monitoring kit

5.4.3 Radar Movement

The design of the radar movement was implemented to create a hidden trap, thus the reason for including ultrasonic. The ultra-sonic sensors being the main component of the radar module, moves in opposite direction (x-space) with the support of the swing module to create a radar-like system(locomotion). In this module, the distance it last pinged an object is measured and the angle of its corresponding swing module is sent to the camera module for its real-time movement (reactive based control).After a successful swing, the camera module performs further analysis on the area pinged using the pre-processed image

function. In addition, the state-space within its programming is made known to each radar component to prevent the camera from swinging to the wrong direction when an event occurs. In the rare cases where there are several objects in the restricted area, the camera would continuously check the zones and compare frames to the dataset using the sense-think-act approach before taken an action (reactive based control). Ideally, with most theft cases identified and analyzed, the movements of burglars are seen around backdoors in search of vulnerabilities. Therefore, with the use of ultrasonic in this implementation, placing the unit within that area would create a safe zone would ensure the users' safety at all times (shown in figure 5.4.3).

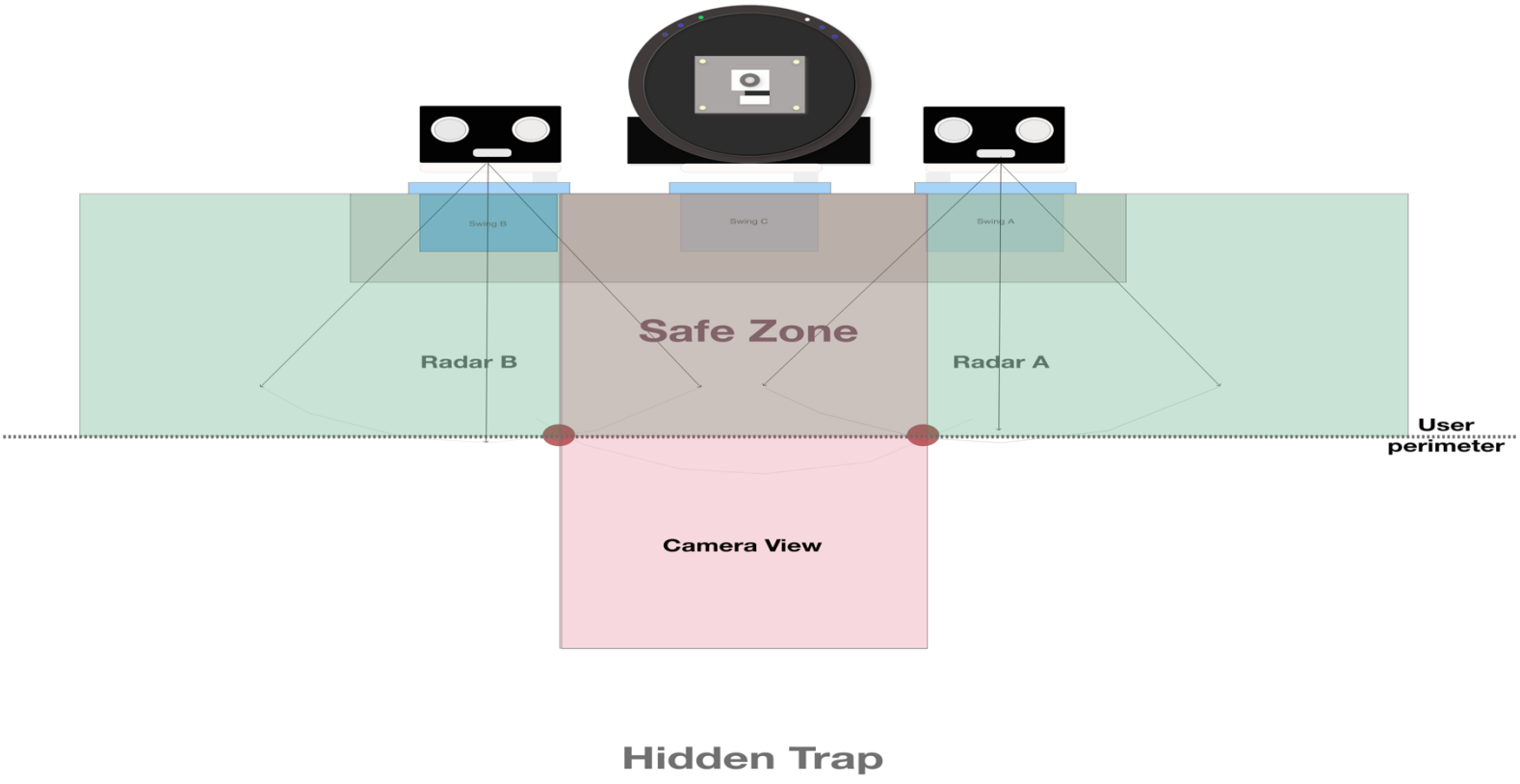


Figure 5.4.3 Diagram showing the safe zone and hidden trap.

5.4.4 Communication

Moreover, with the use of MQTT, these signals from the kit are published to a secured topic subscribed by the Home Hub which enables users to receive alerts in real-time. Also, alert details are sent

to an MYSQL database which is later displayed in a chart form on Equine Home Hub (shown in figure 10 in the supporting diagram section). The design to the system also involves an active log session to keep track of every trigger storing the component type, timestamp, and other information of the component.

5.4.5 Security

Security for the Internet of Things applications has been a major concern in the tech industry today. Therefore, in ensuring high-level security, this implementation provides users with a policy guide detailing the dos and don'ts when interacting with the system. (shown in figure 6). Also, the raspberry pi located on the server unit was given a static IP address assigned by the dynamic host configuration protocol on the user network (DHCP). This is to ensure that the Equine MQ model uses the same IP address when connecting to the user router as a way to shield itself from being hacked. Moreover, all SSH functionalities are disabled from the server unit to prevent hackers from gaining access to the system. Also, users are advised to keep the server unit in a secured room as mentioned earlier.

5.4.6 Intelligence

The radar movement highly depends on the roles stored in the behavioral logic controller as it uses the preprocessing functions of the training module. The training module upon system activation is fed with images of friends and family to which the Facial Holder layer (FHL) applies a Gaussian blur kernel function on images to reduce the noises found in them. After this, frames are processed further in the Facial entity layer (FEL) to detect edges using a canny detection algorithm for boundaries of the frames, after which a threshold is applied to each frame to remove unwanted regions. After a successful process, the frames are stored into a dataset folder with the label given to them by the user which is later trained by the Facial content layer (FCL) and passed to the facial recognition module to be used by the behavioral logic. This, therefore, enables the system to have make quick comparison of frames as they captured by the camera module.

Chapter 6: Testing & Results

Equine Model as identified throughout the entire report holds multiple systems in place to ensure user security as well as capture experience on the platform. Based on this approach, testing of the various parts of the model was smooth and easier to follow up when problems arise. The equine model includes three testing procedures such as HTTP Testing, System Calibration & Component Testing, and Recognizer Testing. This chapter provides details of the test taken and some results from the system.

As mentioned earlier, the use of the Laravel web framework ensures a high level of security on all platforms providing backend services such as cross-site request forgery, user authentication, data encryption, Hashing, and authorization. Based on this, testing of these platforms was quite a breeze as the test implementations involves fewer lines of codes. Some HTTP tastings performed are as follows: Cookies, Debugging Responses, File Upload, Browser Dusk, and Database Testing

6.1 Unit Testing

6.1.2 Cookie Testing

During cookie testing, the Laravel function called 'withCookie' method was used to check cookies created in the web browser before sending a request to the main application. This, however, ensured that sensitive information was not stored in the cookie. After several attempts, of testing, results showed no stored session or id in the browser indicating its success.

6.1.3 Debugging Responses

Debugging responses was also used in the testing phase to prevent the application from crashing. With the uses of factories and seeding that comes with the Laravel package, platforms of the equine model were injected with false data to check if they would be inserted into the database. After conducting the test, platforms rejected the injections as well as redirected users to the login page to be authenticated utilizing the cross-site request forgery function from Laravel.

6.1.4 Session / Authentication

Sessions in this implementation were treated differently in both the shop and Equine Home Hub. This was done because of the number of users each platform has and the roles and permissions involved. During the Sessions test of the platform, a "withSession" function from the Laravel package was used to check the state of the authenticated user, in this case, the admin account, friends account, member account and user account. If a session state is maintained, other users of the platform would not be able to sign in.

6.1.5 Browser Testing using Laravel Dusk package

Browser Testing was implemented, to ensure that the platform runs on all browsers. As an easy approach for this, the Laravel dusk package was used for browser automation. After conducting the test, the platform showed high performance on chrome as the package utilizes from ChromeDriver is pre-installed with it. The platforms on firefox, however, show some form of lag in its runtime when the cache memory is cleared completely.

6.2 Calibration

The Calibration and Components testing was done to check the performance of each component of the robotic monitoring kit. This helps know if there is a leak in the pipeline of the data storage unit (active logs & database). As indicated earlier, the robotics monitoring kit identifies each component entered as objects, therefore, in the calibration test application, instances of the class, the components inherited are created and used throughout the calibration application. In running the application, components that are to be tested are specified with the runtime as an integer value. If an empty input is passed as an argument, the application is terminated from that session. However, if the right entries are made, the application would loop through part of the program based on the runtime provided at the start.

6.2.1 Buzzer Unit Test

The buzzer unit test in the calibration application sends data to the buzzer module to evoke the "buzzerOn" method from its class. If the buzzer is activated the buzzer module would begin to sound an alarm in forms of beeps as a result of the runtime passed. While running, information from the buzzer module is stored in an active log session and database.

6.2.2 Power Unit Test

The power unit is the most important component included in the system. It consists of a sync power, alarm power, board power and camera power. Therefore, calibrating the unit would determine the power flow to the server unit, monitoring unit and buzzer unit. In testing the unit, the power name would be provided at the first level (eg. Power) then the power station at which you want to activate in the next level (eg. Sync power (SP-01), buzzer (EP-01), main board (MP-01), camera power (CP-01). After which the runtime would need to specify to run the application. While running, information from the buzzer module is stored in an active log session.

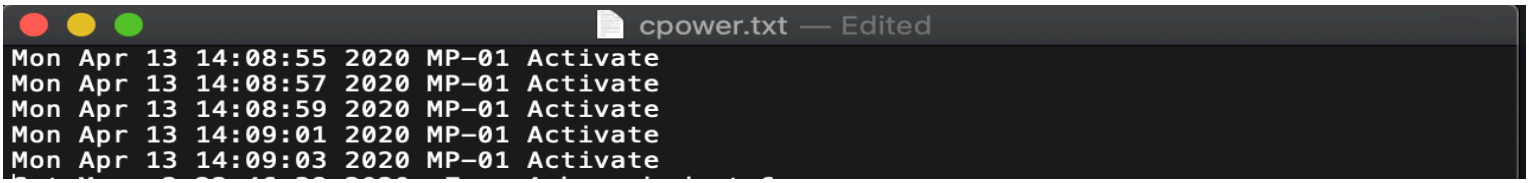
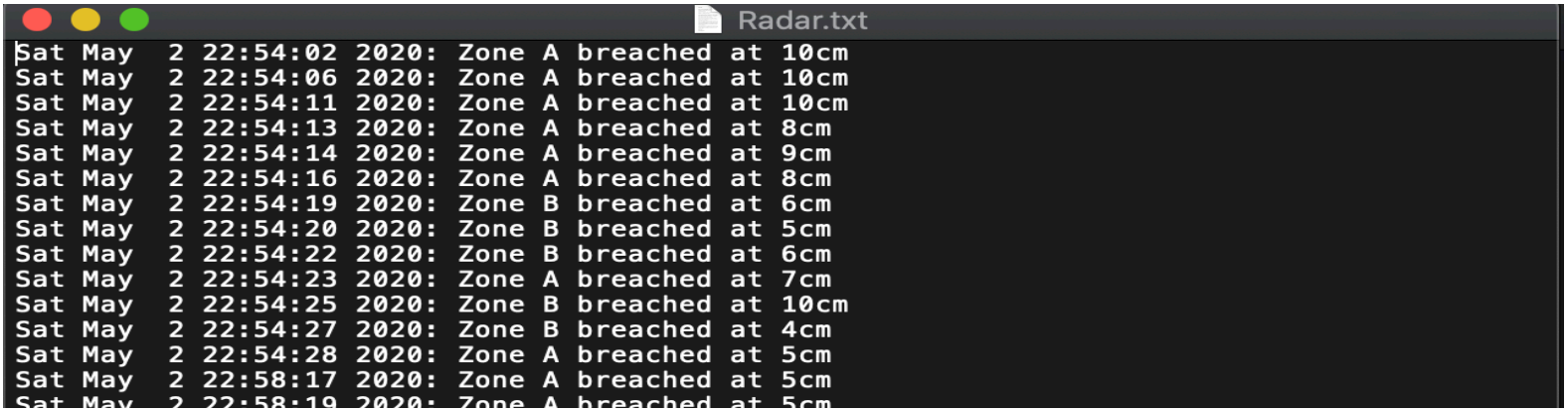


Figure 6.2.2 Main Board Power Unit Log File

6.2.3 Radar Unit Test

The radar unit test also in the calibration application sends data to the radar module requesting for its current state as it tries to evoke the "getDistance" method from its class. If both radar objects are activated, information from the radar module would be stored in the active log session as shown below:

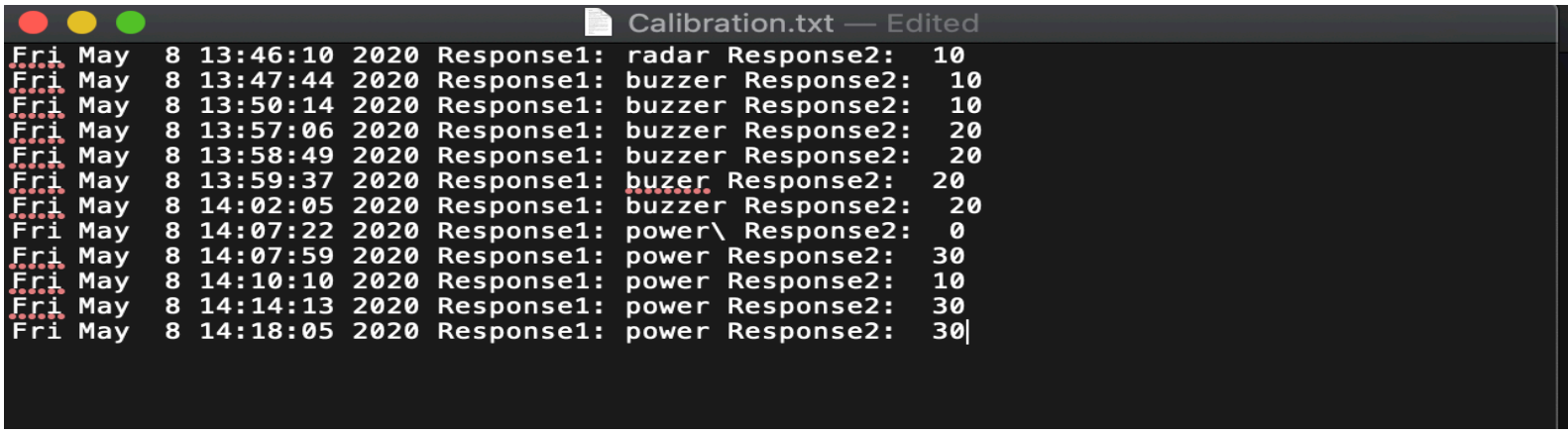
Figure 6.2.3. Radar Module Log File



6.2.4 Calibration Results.

After a successful run of the application, information passed is stored in a calibration log session detailing the components selected and the runtime, the timestamp and calibration rank (shown below)

Figure 6.2.4 Calibration Application Log File



6.3 Detection & Facial Recognition

The Facial Recognition test was initially designed to serve as the application to add family and friends' image to the dataset stored, located on the server unit. However, this application causes the system to lag due to its heavy CPU demand, so it was used only for testing the camera module and facial recognition function. During testing, the name of the user is provided which acts as the labels tagged to the frame captured. After which the user would stare in the camera after 10 seconds window for the camera to capture frames of the users' faces. After this, the system is trained by identifying the number of faces stored in the datasets. After successfully training the module, the camera module would open a window and try to detect objects in front of it, if there is a match in the dataset, the name would be provided with the accuracy level. (shown in figure 6.3b)

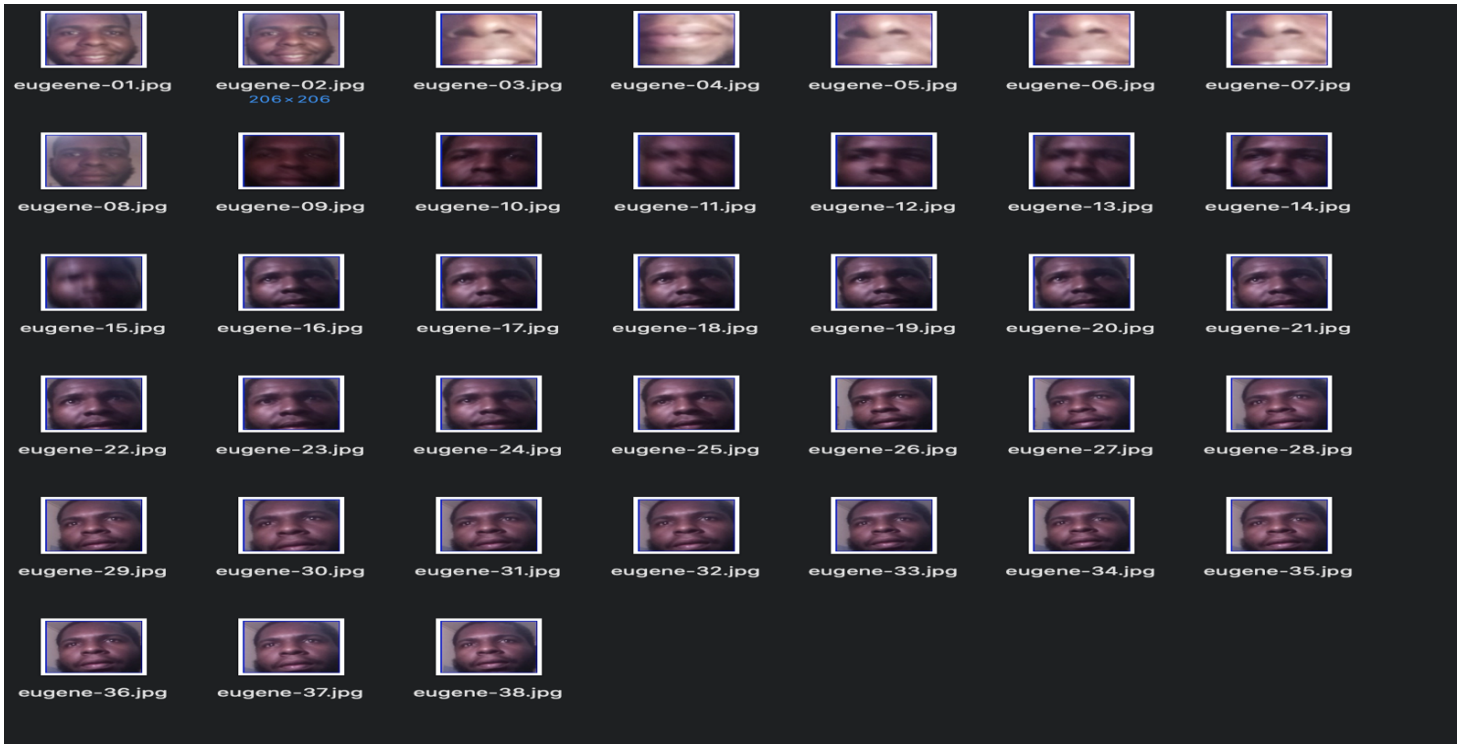


Figure 6.3a. Frames in the dataset

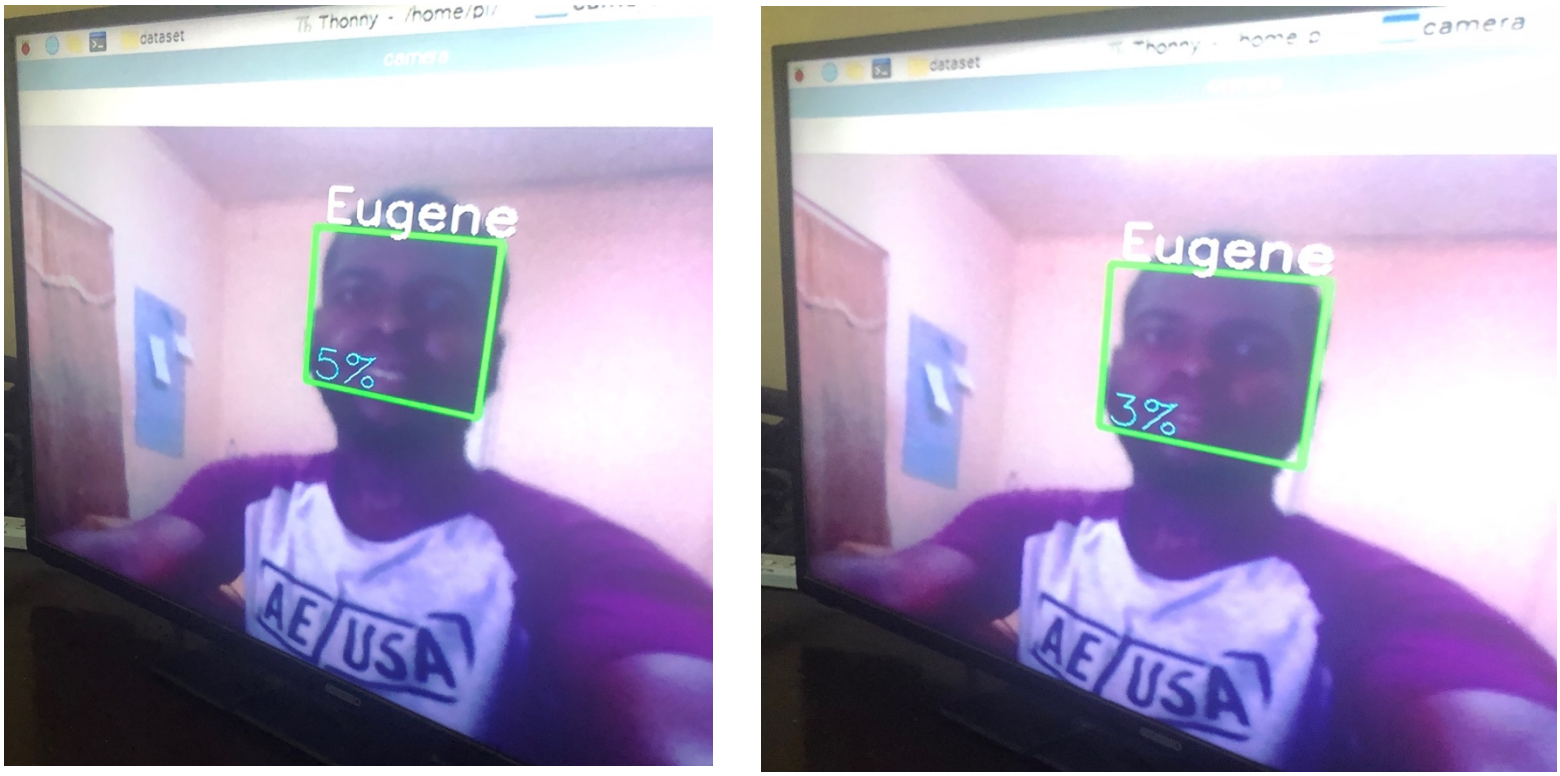


Fig 6.3b Facial Recognition results for night test

Chapter 7: Conclusion & Limitations

The chapter gives an overview of this applied project highlighting some limitations and challenges as well as observations.

Overview

As proposed earlier on, the equine model represents an integration of different systems that work together to provide an efficient and effective security tool. The model proposed targeted low-income earners living in Africa who have difficulty in purchasing the state-of-the-art security system. The approach applied took into account different perspectives of the user reach such as a variety of web systems, robotic monitoring, a mobile application, statistical analysis on security, and a cost and profit model. The goal of the model, however, is not to prove the inefficiency of the pre-existing security model but to provide a different approach in solving security issues in Africa.

Limitations and Challenges.

During the implementation of the equine model, a couple of challenges were faced which prevented further progress. Some challenges faced are listed below.

Pandemic - Covid-19

The project initially began on 27th September 2019 and was supposed to have ended on 27th April 2020. However, due to the pandemic, this duration was prolonged as the university had to shut down. Based on this, the resources and components needed to develop the actual model was limited in supply. Also, the case of the monitoring kit was designed to be 3d printed, however, due to the closure of university facilities, 3d printing machines become inaccessible which therefore lead to improvising other materials for devices.

Deep Learning Framework.

The goal of the monitoring kit was to create a system that could learn by itself using the convolution neural network, however, this part of the project was stripped and narrowed down to OpenCV analysis as the development of the deep learning framework on the raspberry pi failed countlessly.

MQTT incompatibility with Laravel.

All web-based applications of the model were written in bootstrap on the frontend and Laravel on the backend. Although the Laravel web framework provides high secured endpoints with its security services, it was difficult connecting the MQTT broker protocol to the framework. This was because of the backend code of the device which was written in python.

Some **key observations** noticed during the implementation are as follows:

Time out

The home monitoring was initially designed to run for a long period. However. it malfunctions after 2 hours of running due to power constraints. The kit sometimes shakes as it struggles to get the needed power to perform its function.

Light Intensity

Upon testing the facial recognition function, I encountered some problems which facial detection as the camera fails to see part of my face.

CPU -overload

During the implementation and run of the application, the CPU of the unit gets extremely hot and displays a temperature sign on the GUI.

Reduction in the useful life of components

During the implementation, the buzzer component which was used for alerting the user became faint as observed.

Chapter 7: Future work

The model meets its goal of ensuring user security as well as capture user experience in the E-commerce layer and system administration platform. However, with regards to the intelligence of the robotic monitoring kit, the addition of a deep network to analyze images and train itself would help it function very well. Also, communication between another equine system using Bluetooth technology could help widen the range it covers. Moreover, implementing a uniform backend platform across all platforms would benefit the system in providing a faster response and shorter runtime when executing its functions. Lastly, the development of a mobile application that functions the equine portal would allow the system to flash in notifications without the user being on the platform.

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Supporting Diagrams

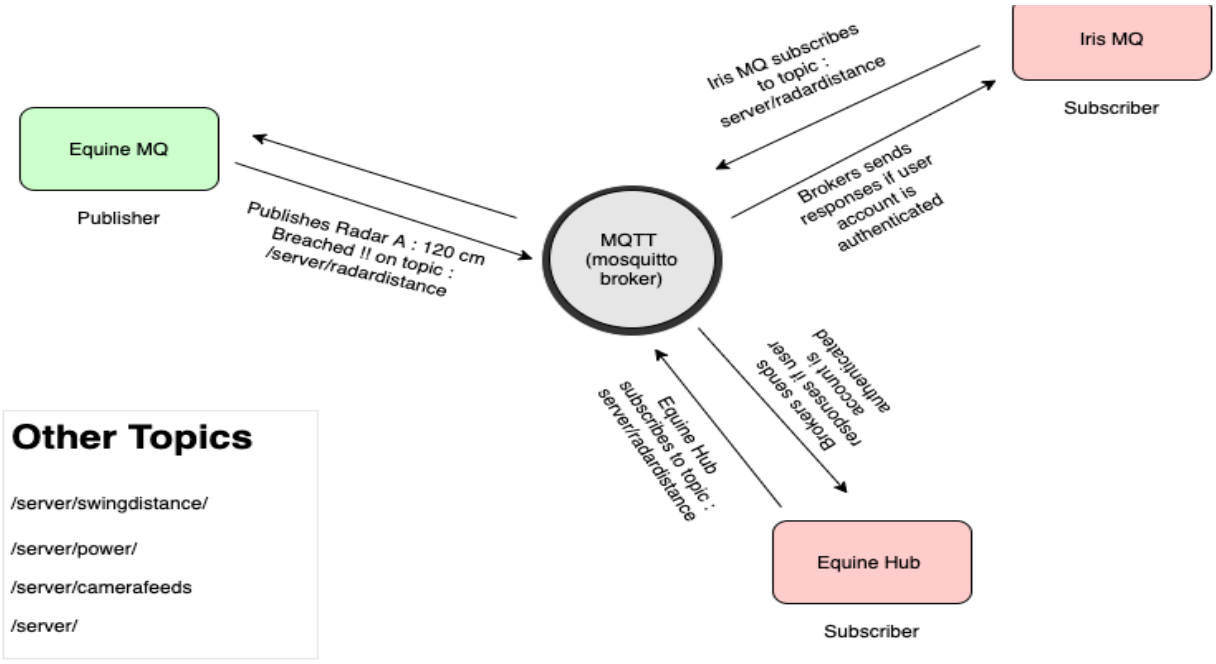


Figure 1: Diagram showing MQTT connection with the Equine Hub

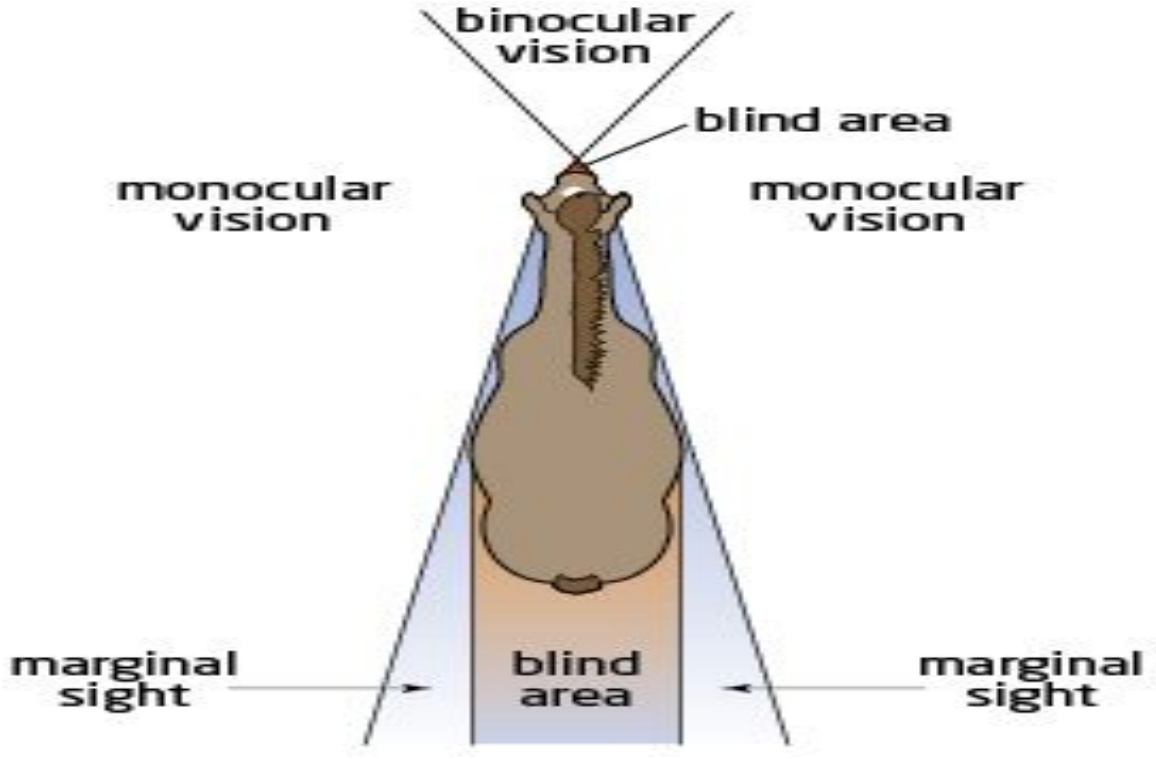


Figure 2: Diagram Showing The Features Of An Equine Mammal

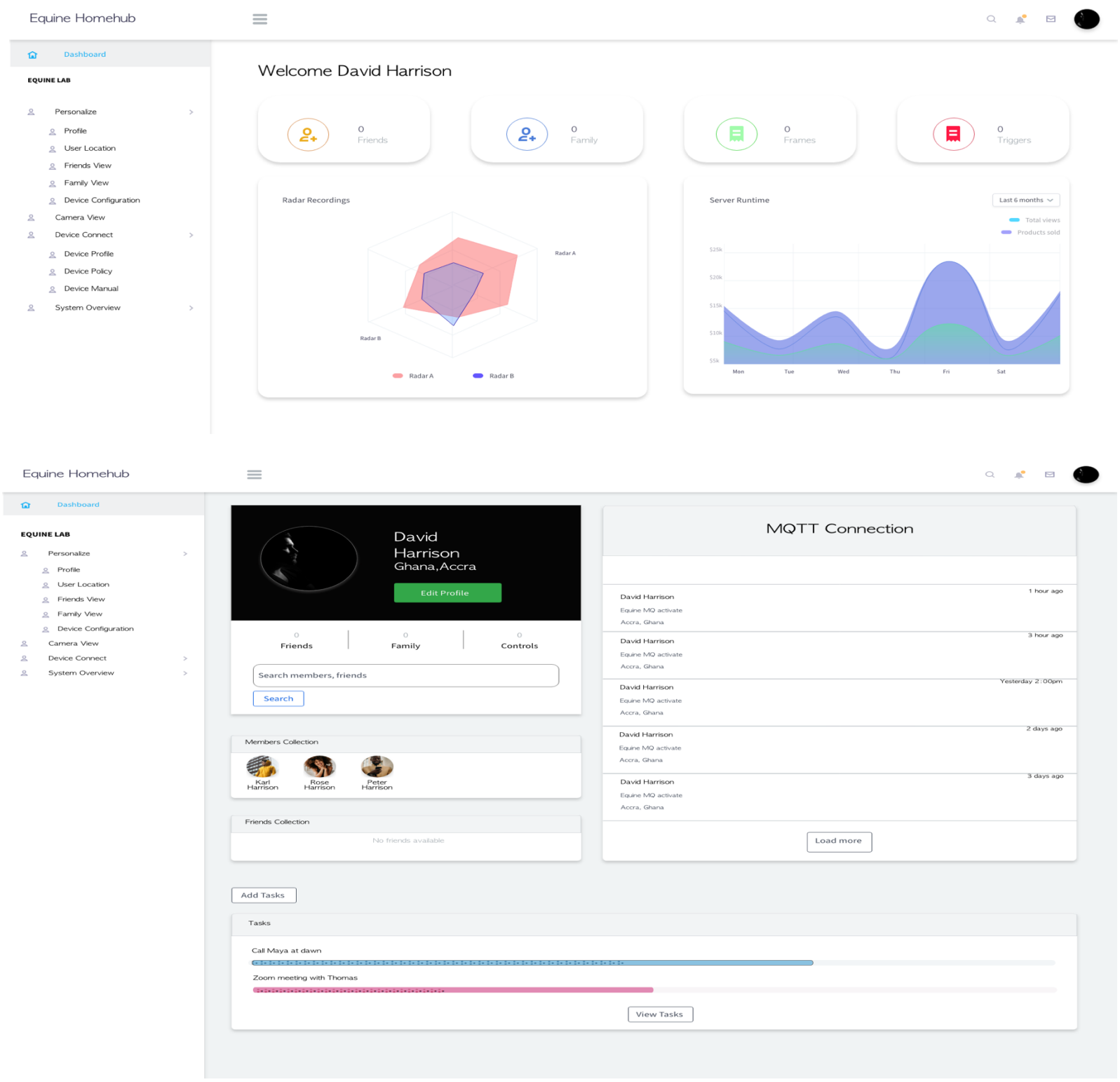


Figure 5: Diagrams Showing UI/UX Designs

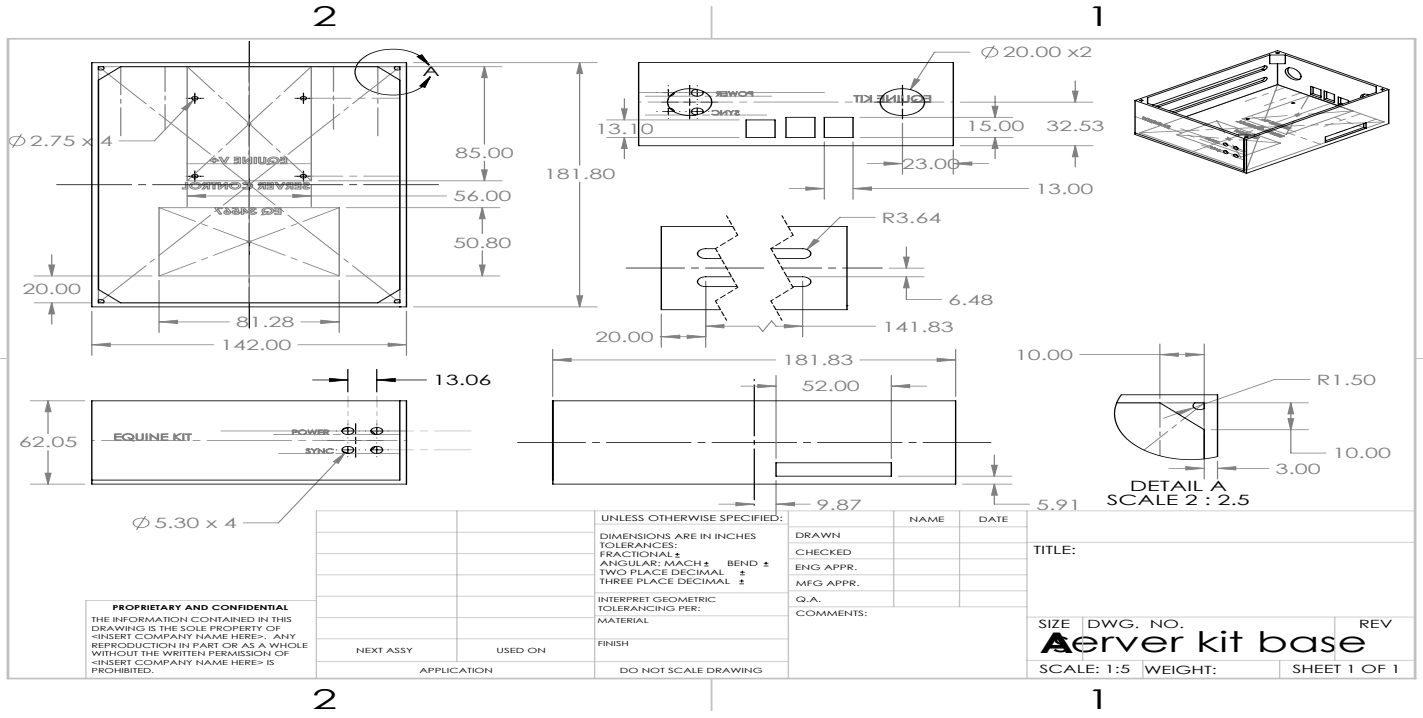


Figure 8a: Blueprint Of The Server Unit (Actual)

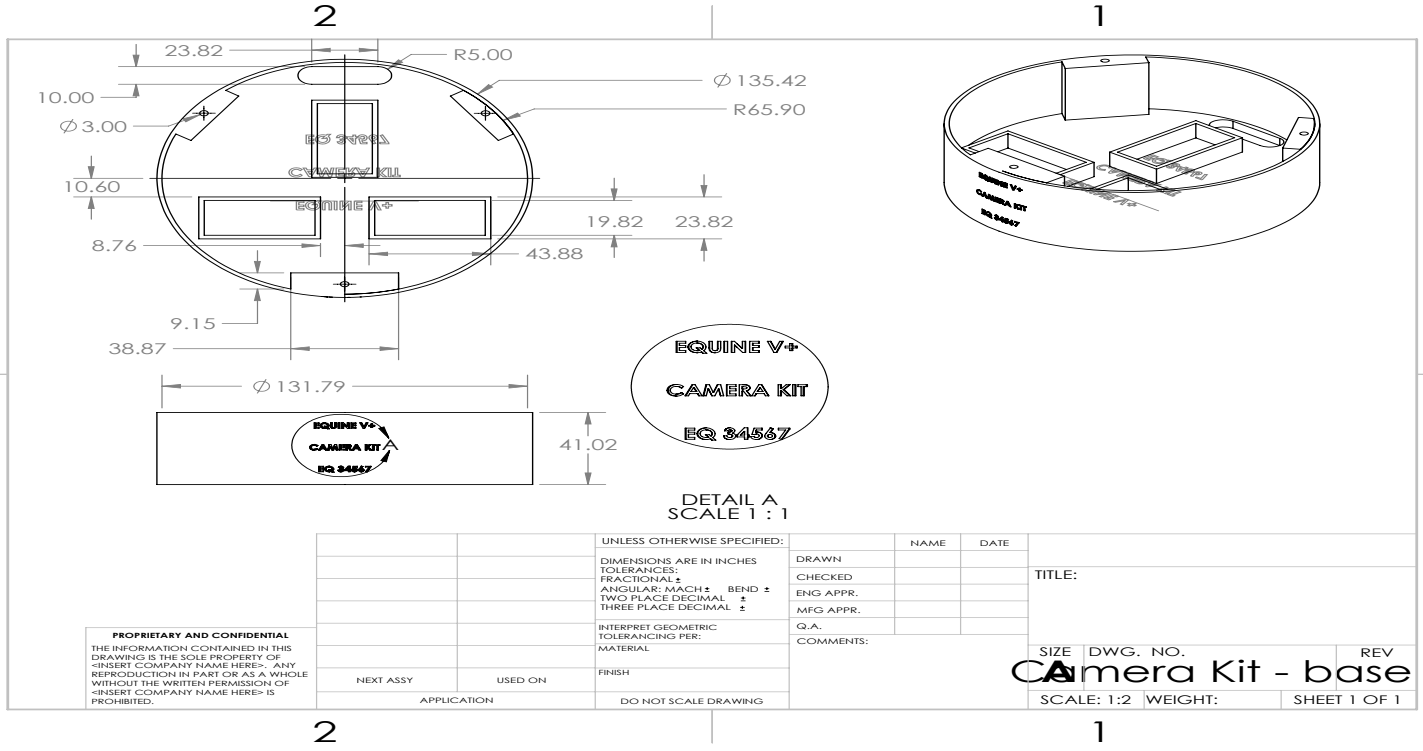
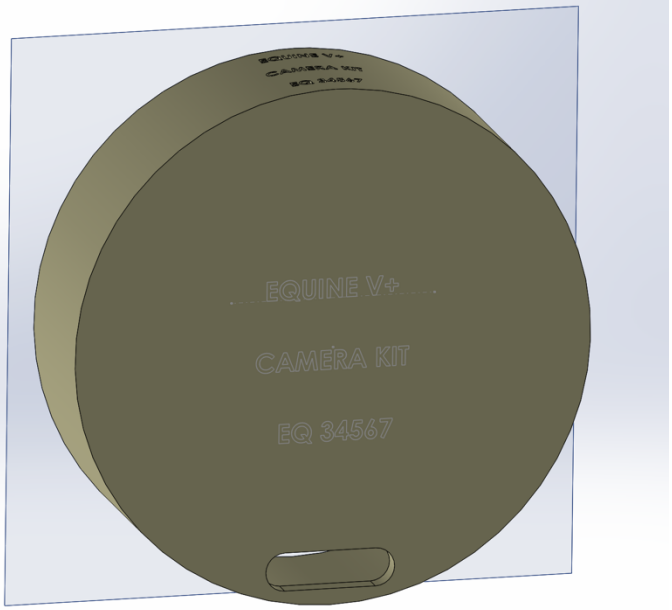
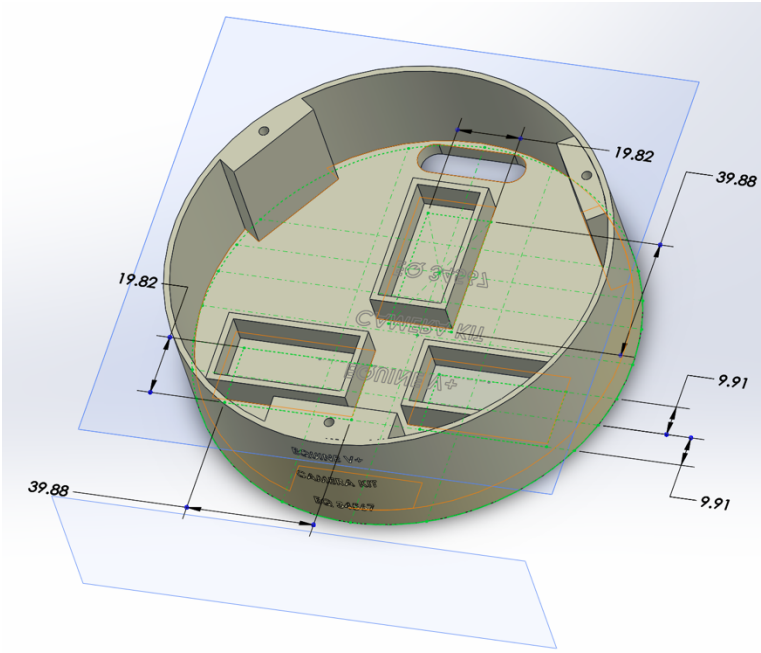


Figure 8b: Blueprint Of Camera Unit



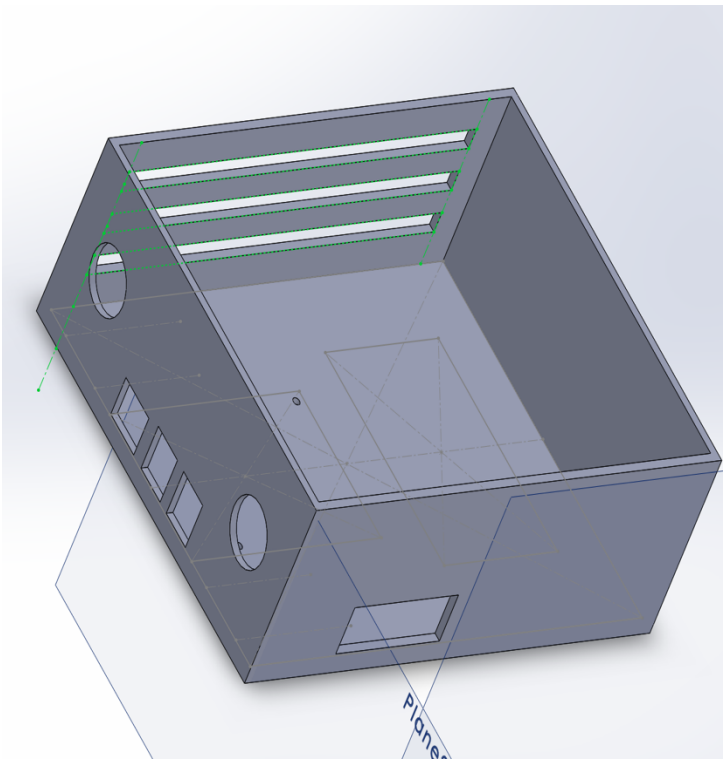
Back view

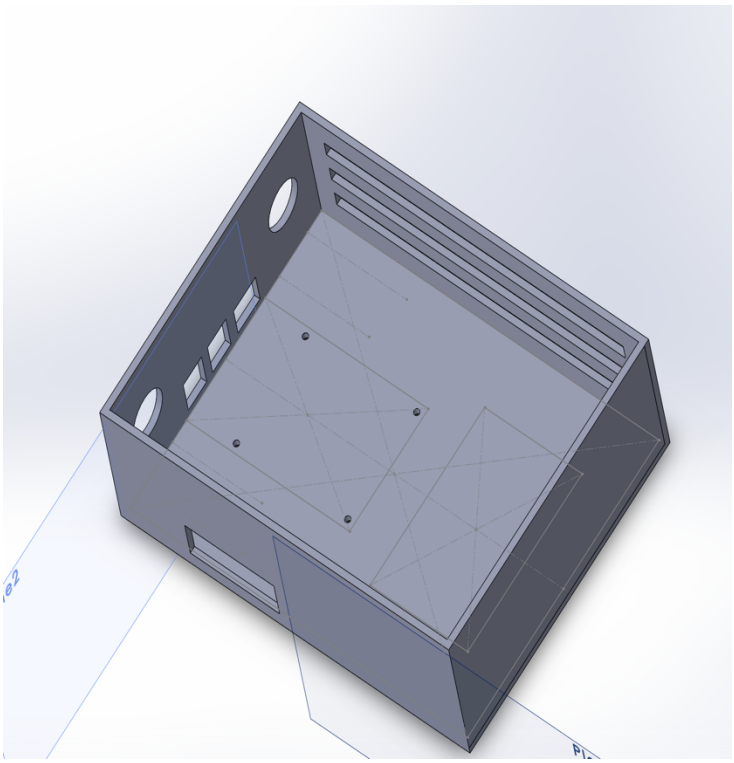


Top View

Front View

Figure 9a: Home Monitoring Kit Embodiment View





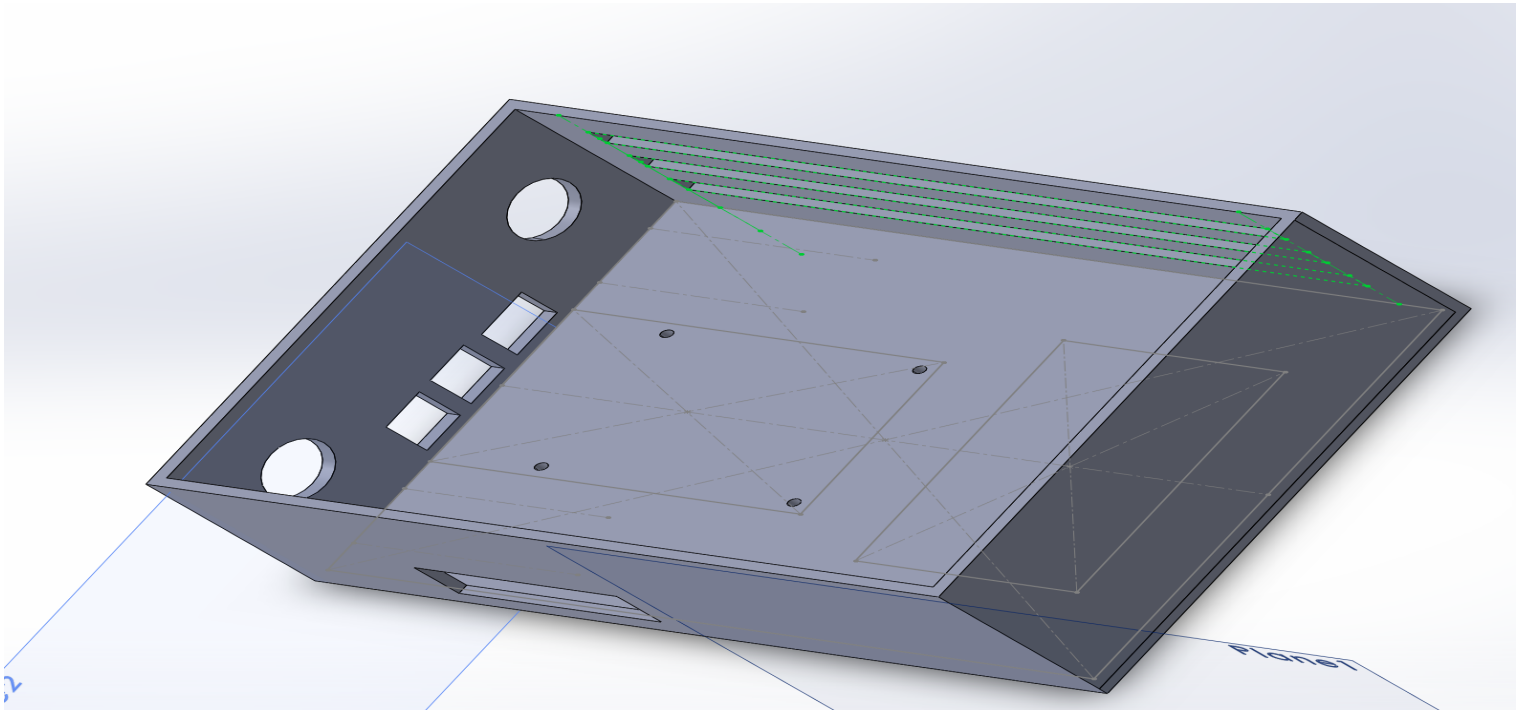


Figure 9b: Server Unit Embodiment View

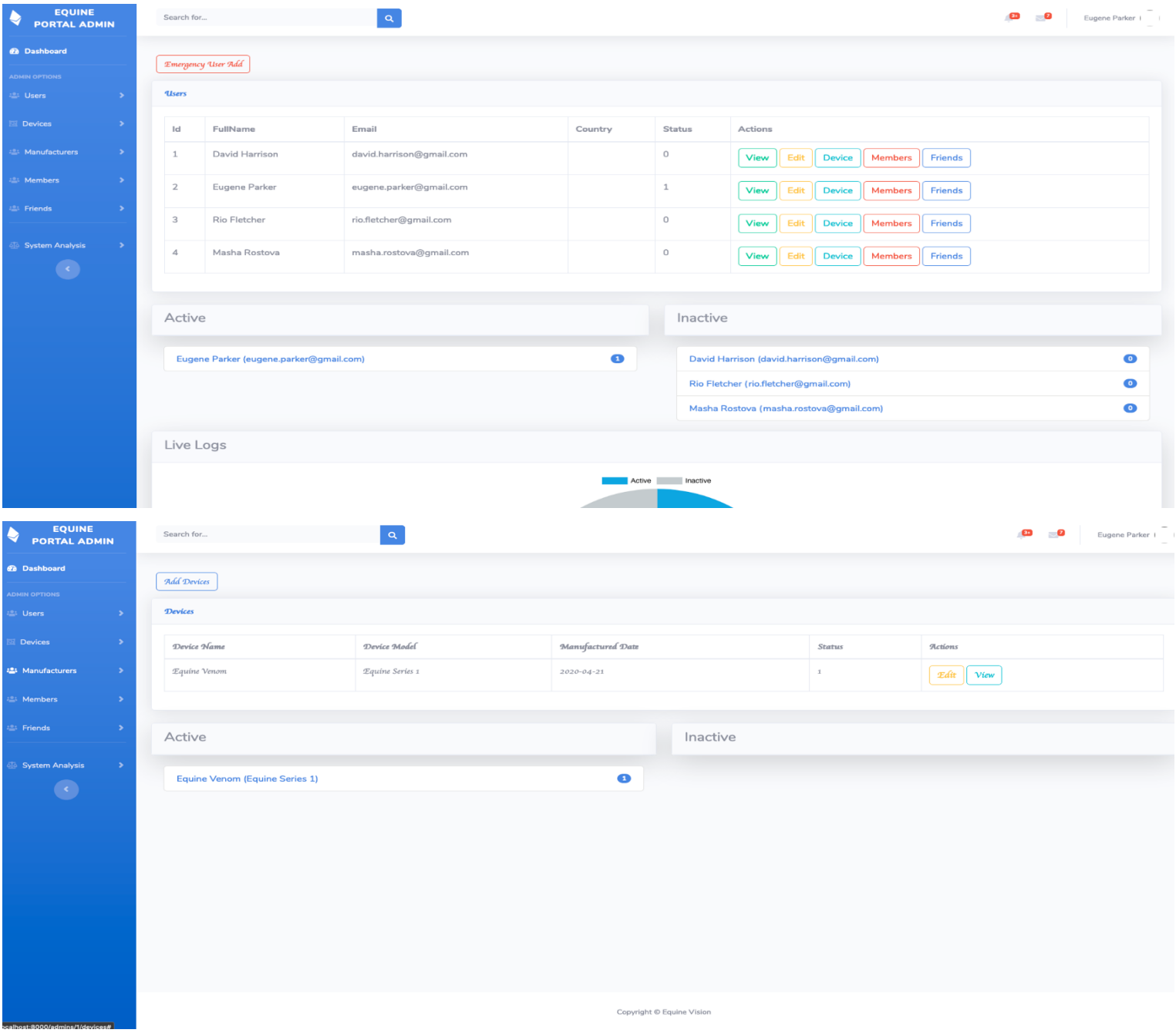


Figure 10: Image Showing Some Admin Controls Of Home Hub

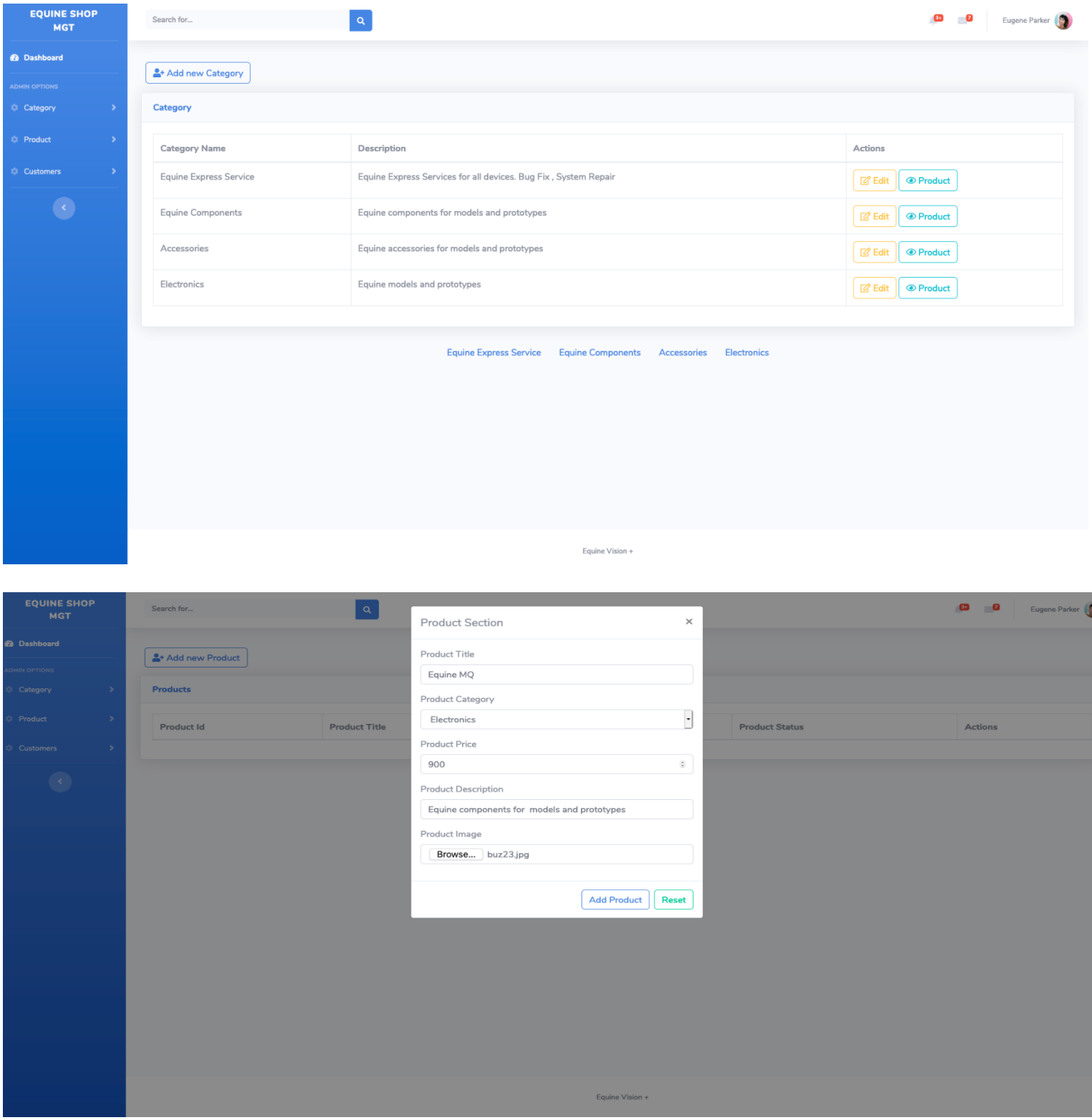
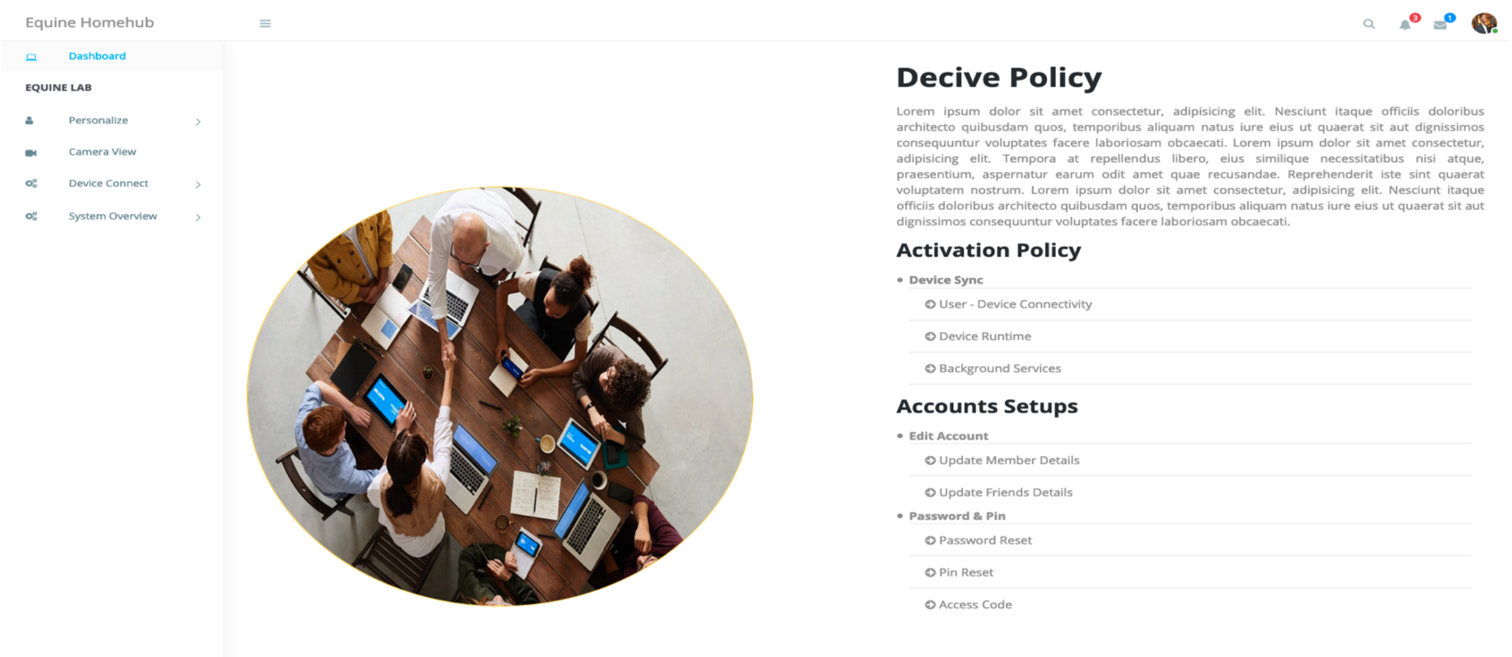


Figure 11: Image Showing Admin Controls To Portal



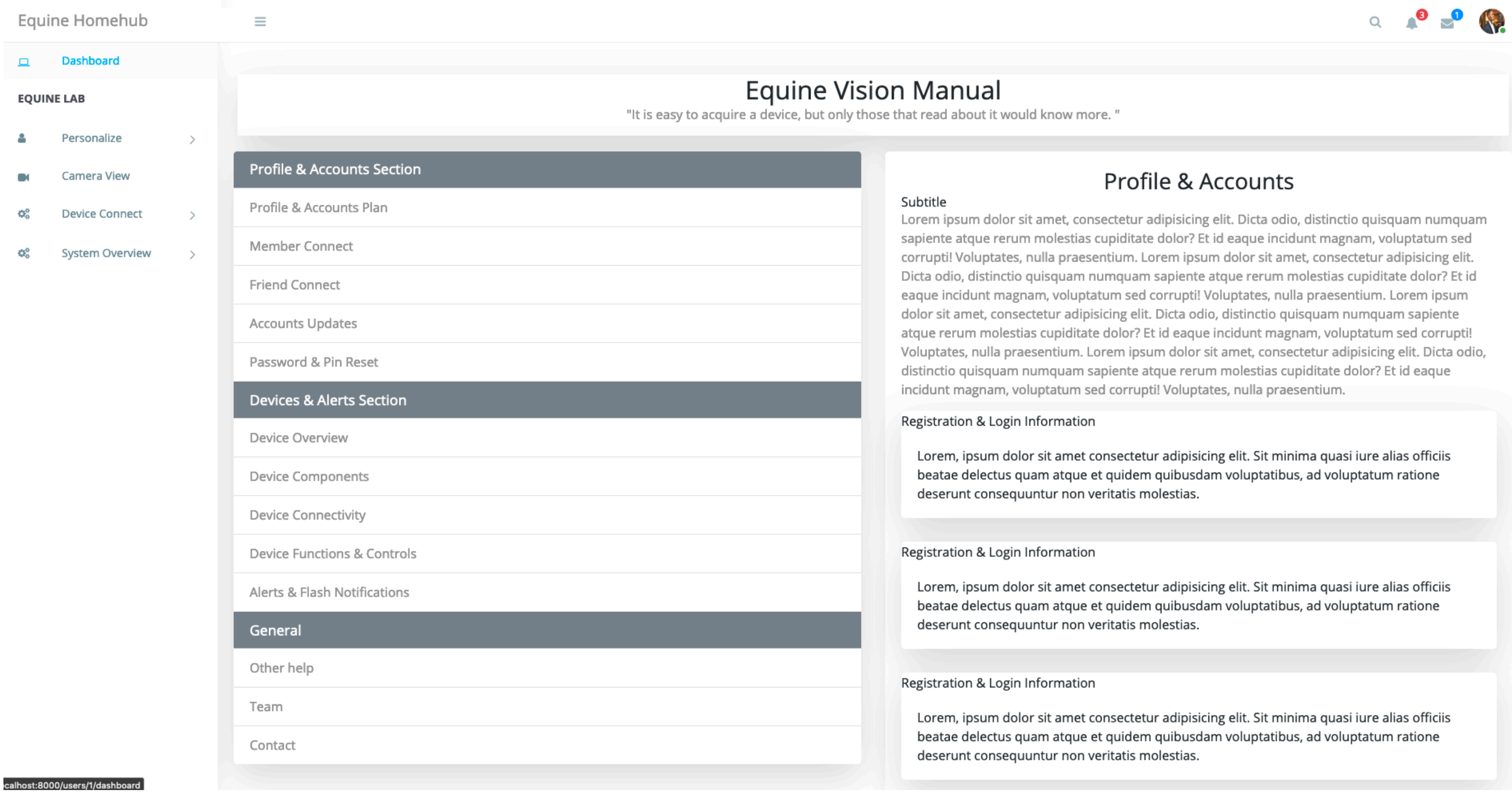


Figure 12: Image Showing Device Policy & Manual On Home Hub

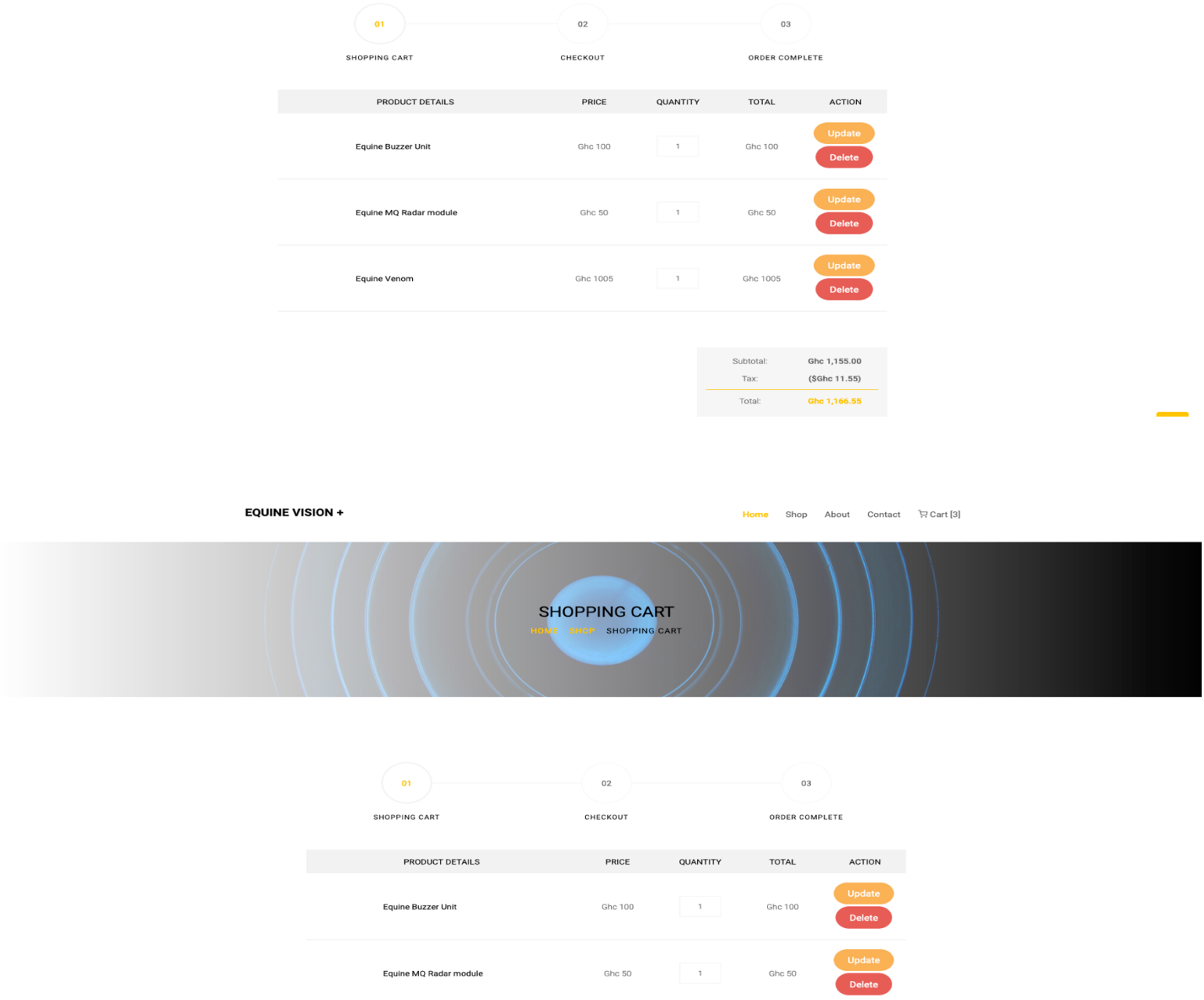


Figure 13: Image Showing Cart Selection By A User

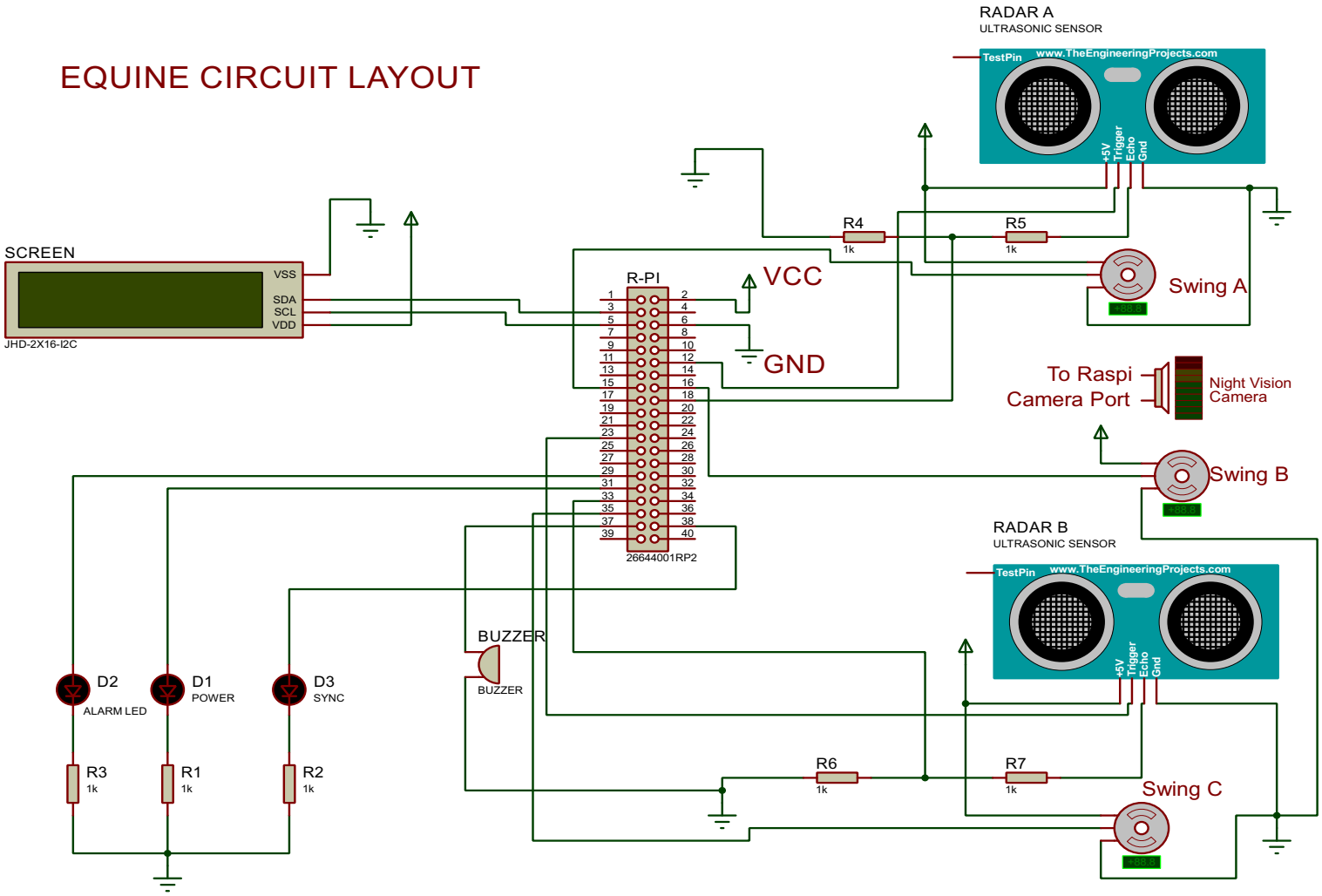


Figure 14: Image Showing Circuit Of The Home Monitoring Kit

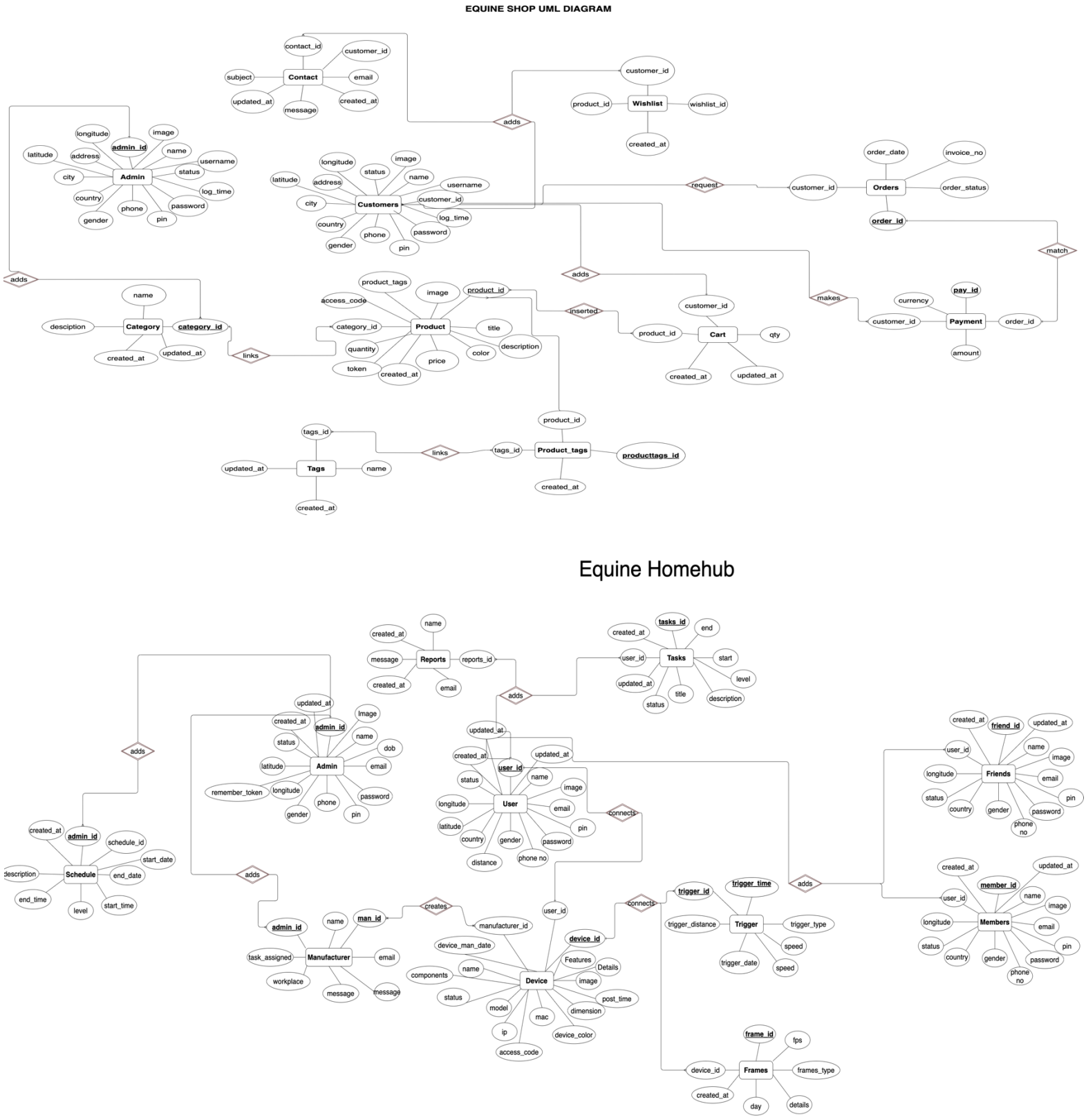


Figure 15: Diagram Showing Database Relationship (In Depth)

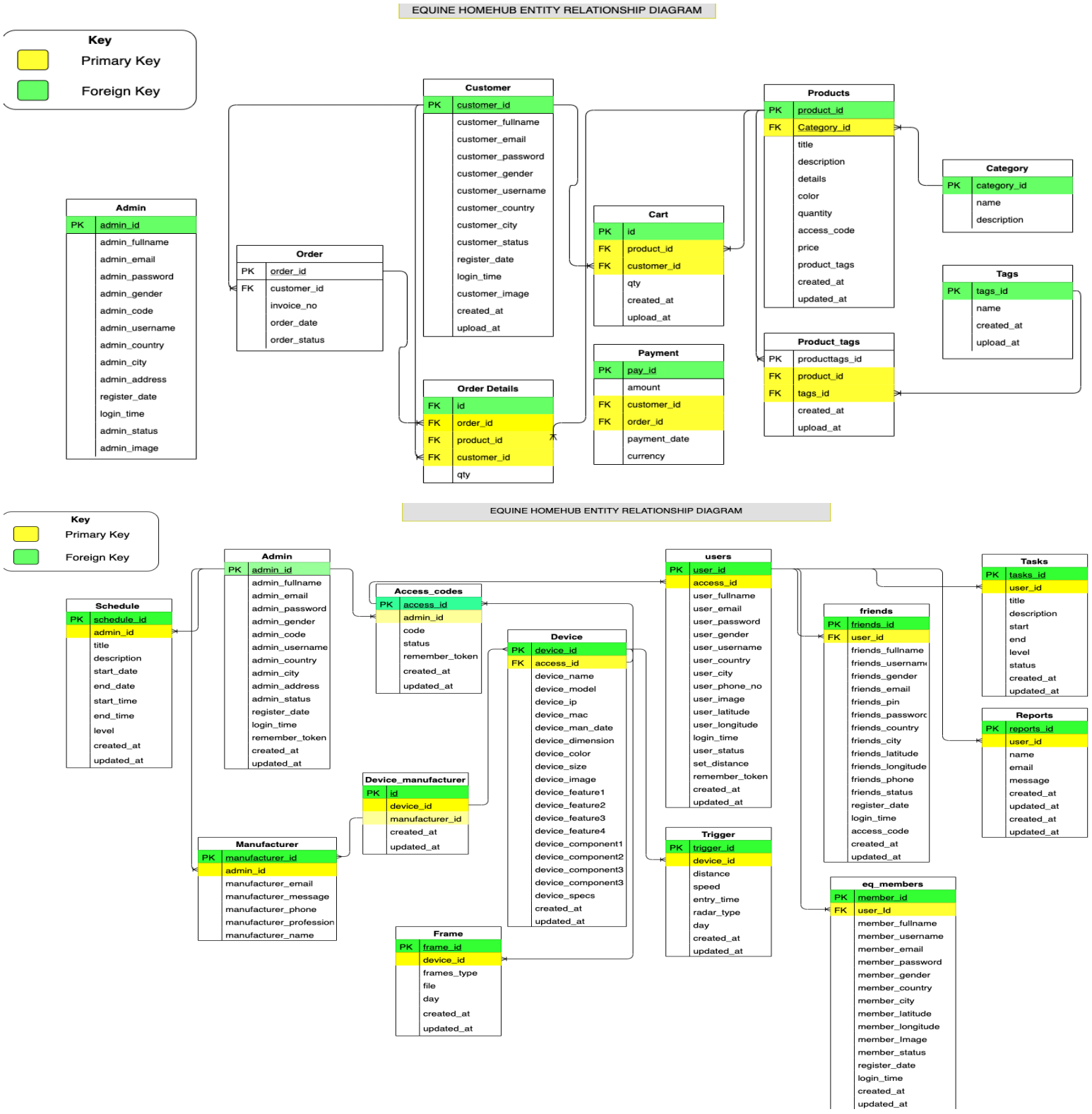


Figure 16: Diagram Showing Database Schema

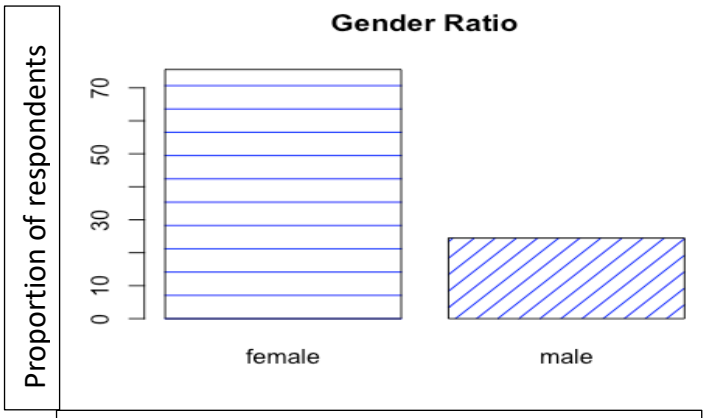


Figure 17 a: Graph showing proportion of gender of the respondents.

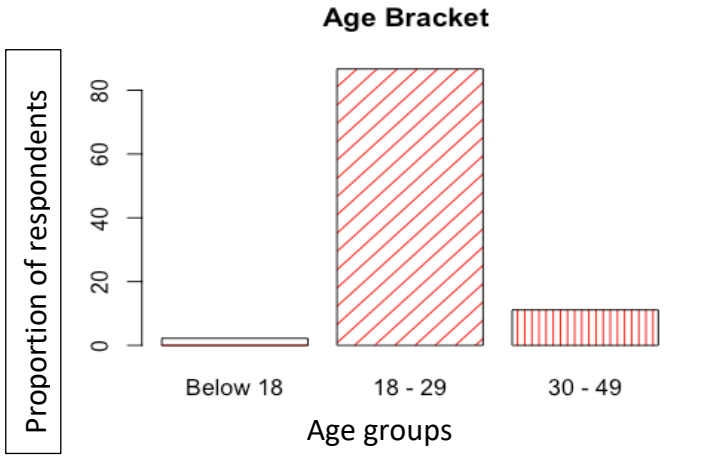


Figure 17b: Graph showing proportion of ages

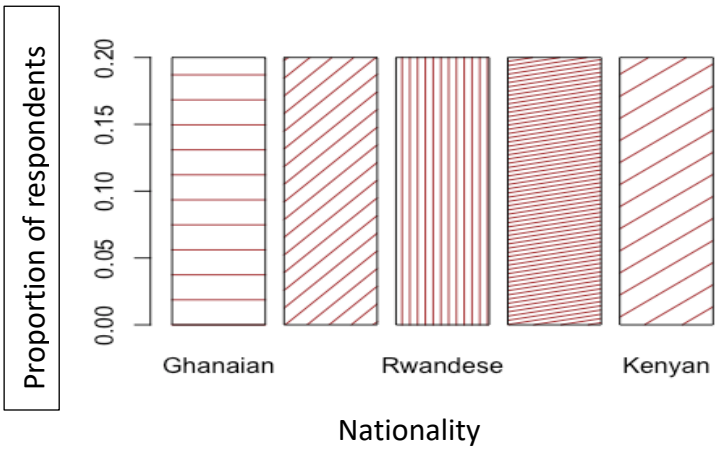


Figure 17c: Sample Size

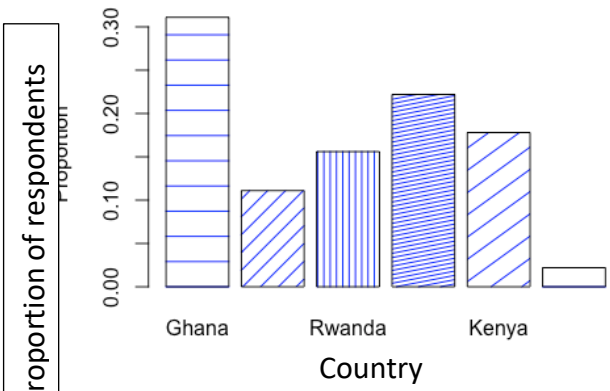


Figure 17d: Residing countries of respondents

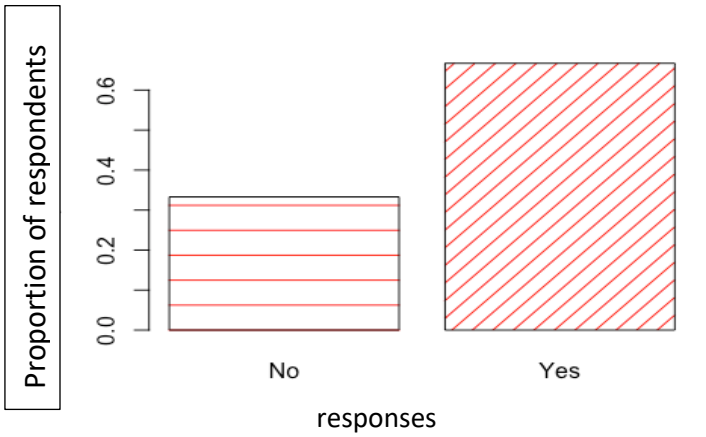


Figure18a: Proportion of respondents who have previously used home security

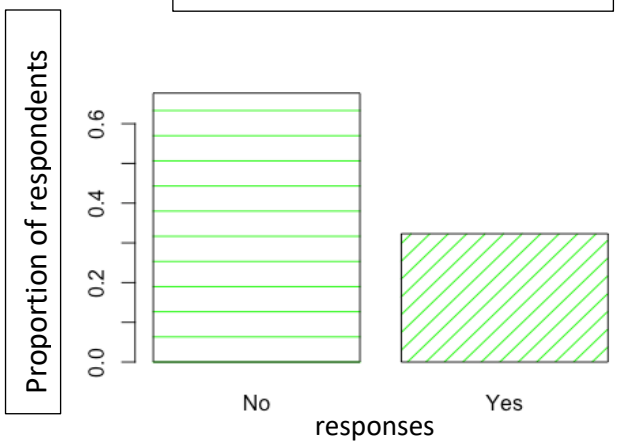


Figure 18b: Proportion of respondents who have previously used CCTV systems

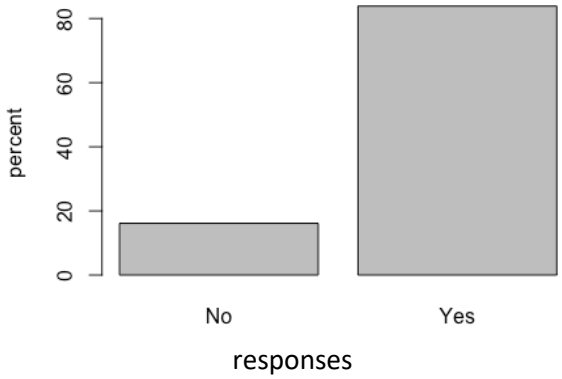


Figure 18c: Proportion of respondents who previously used Extra locks

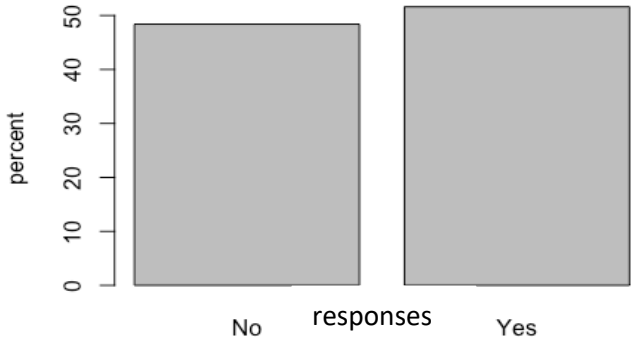


Figure 18d: Proportion of respondents who previously used Wired burglary alarms

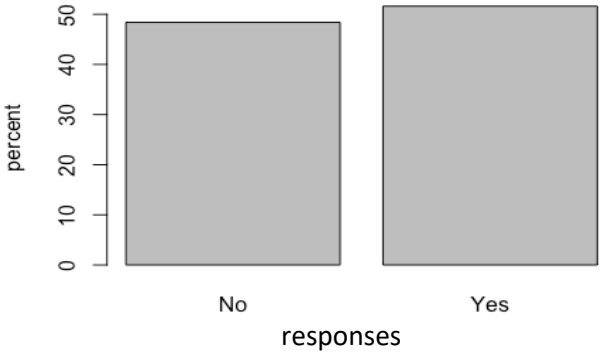


Figure 18e: Proportion of respondents who previously used Trap doors

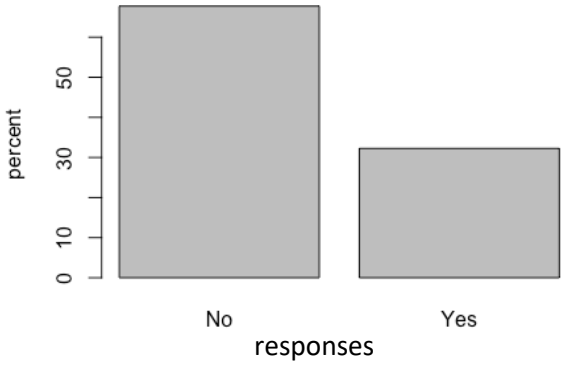


Figure 18f: Proportion of respondents who previously used Burglary proof

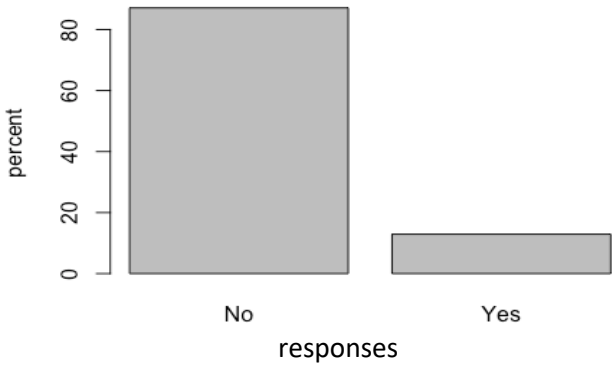


Figure 18g: Proportion of respondents who previously used Security guards

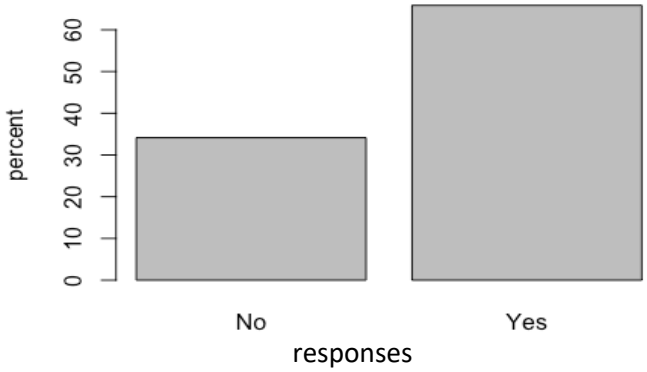


Figure 19a: Proportion of respondents who currently using security systems

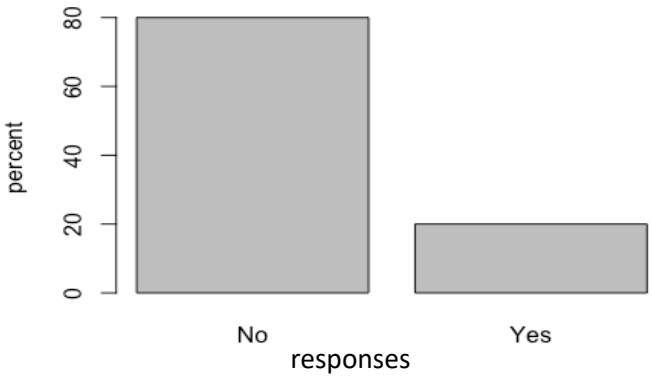


Figure 19b: Proportion of respondents who currently use CCTV systems

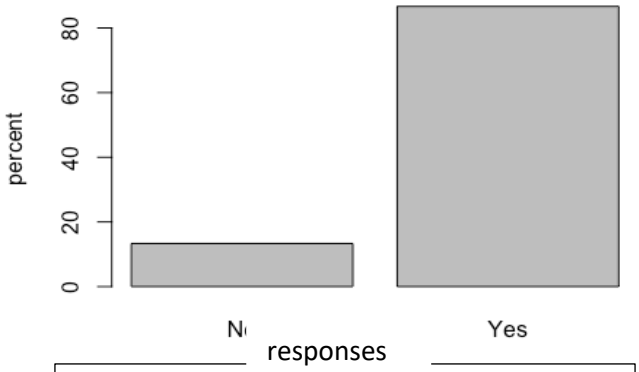


Figure 19c: Proportion of respondents who currently use Extra Locks

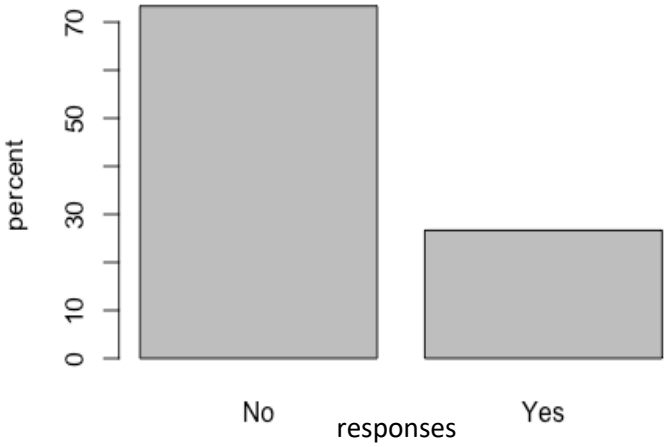


Figure 19e: Proportion of respondents who currently use burglary proof

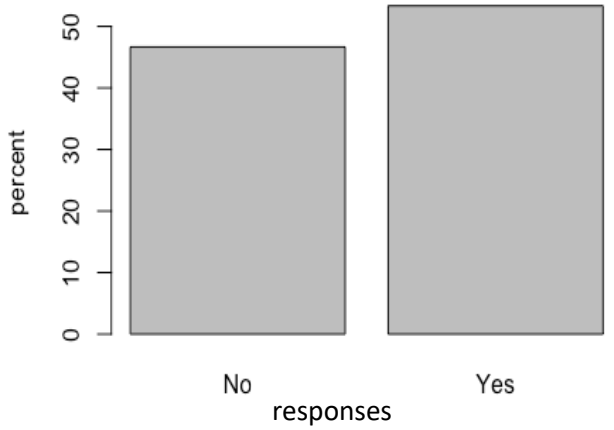


Figure 19f: Proportion of respondents who currently use wired burglary alarms

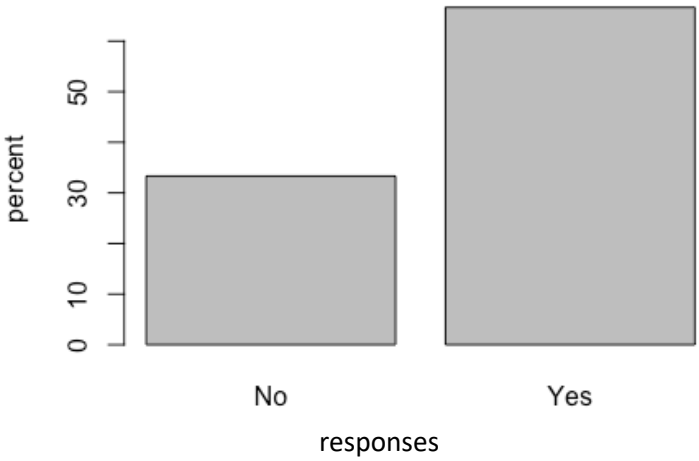


Figure 20a: Proportion of respondents who consider feature as an important factor to purchase a security system

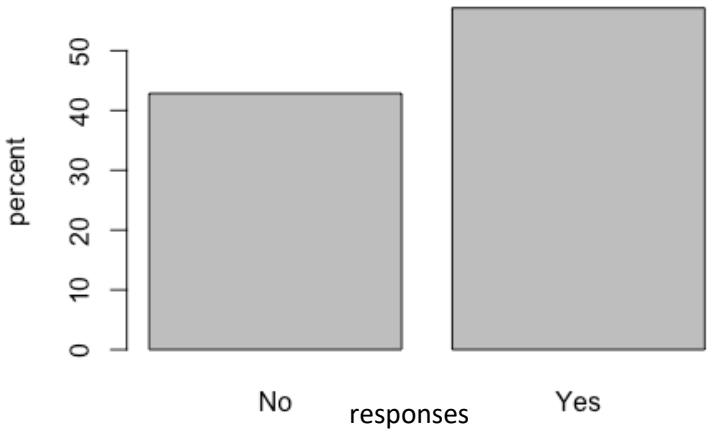


Figure 20b: Proportion of respondents who consider simplicity as an important factor to purchase a security system

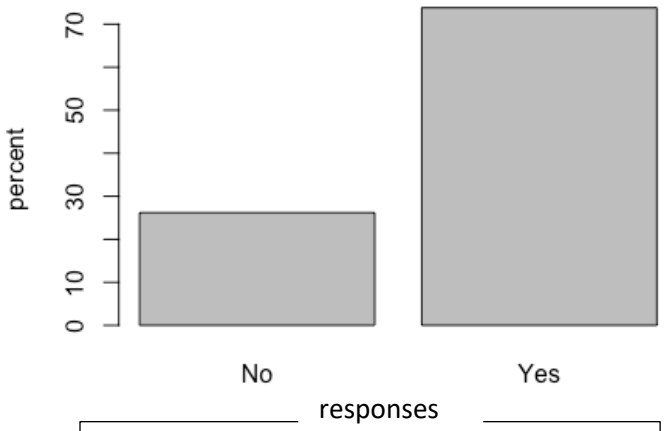


Figure 20c: Proportion of respondents who consider price as an important factor to purchase a security system

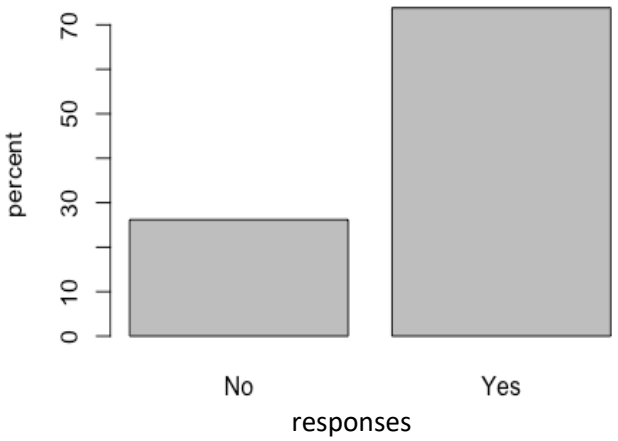


Figure 20d: Proportion of respondents who consider performance as an important factor to purchase a security

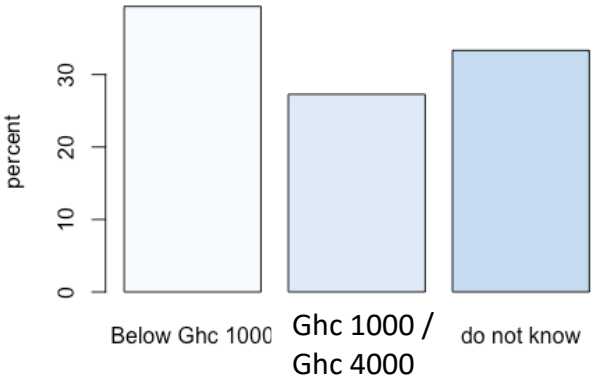


Figure 21: Security Expenses considered by respondents

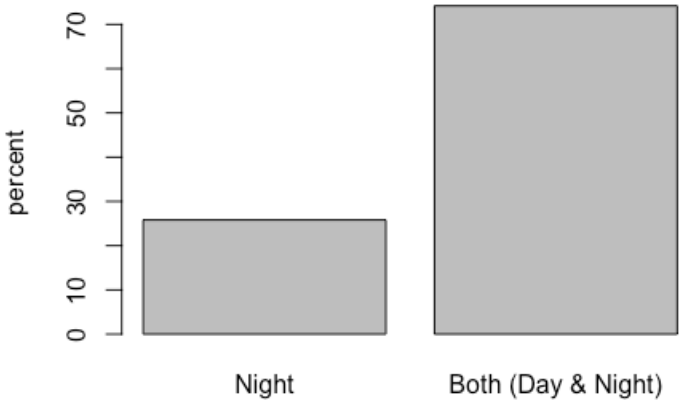


Figure 22: Times security systems are activated

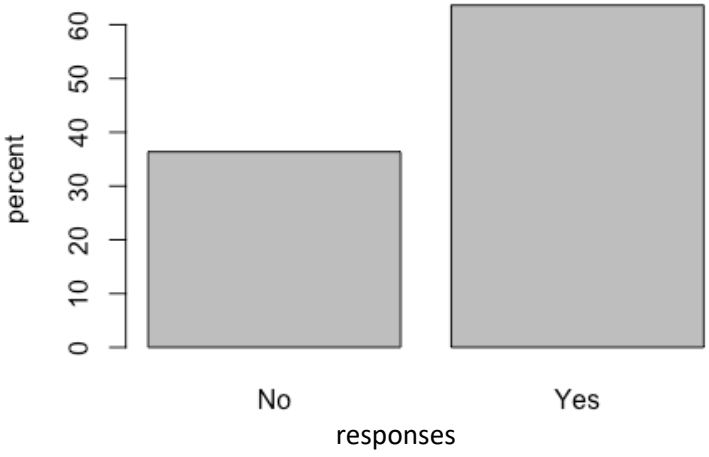


Figure 23: Proportion of respondents who have experience home burglary

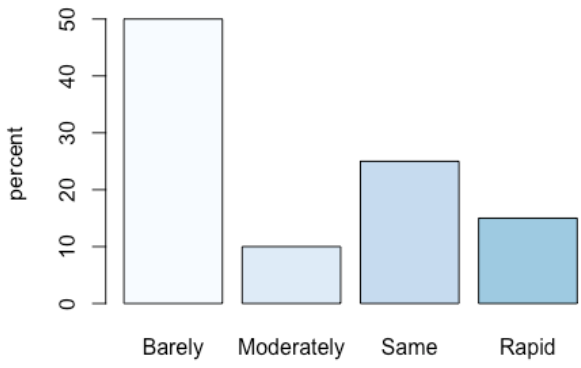


Figure 24: Proportion of respondents indicating the level influence by security systems

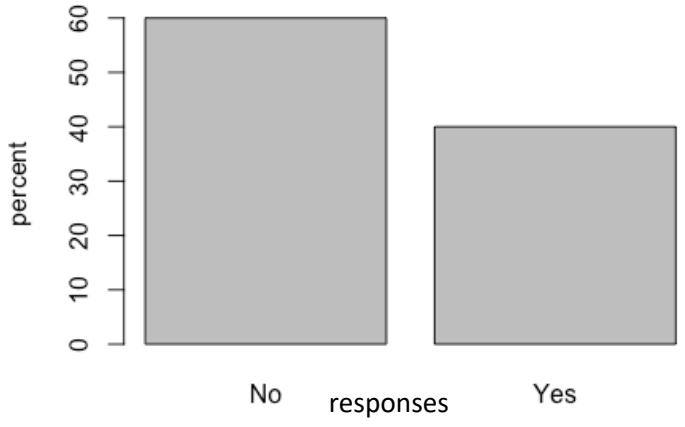


Figure 25: Proportion of respondents who were satisfied with the security systems

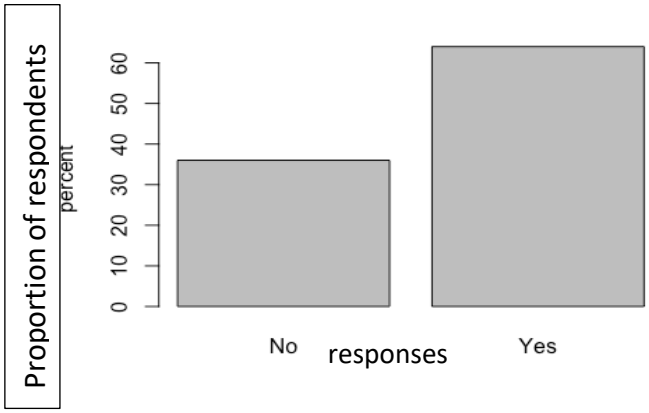


Figure 26a: Proportion of respondents who consider friends and family as alternative when there is breach.

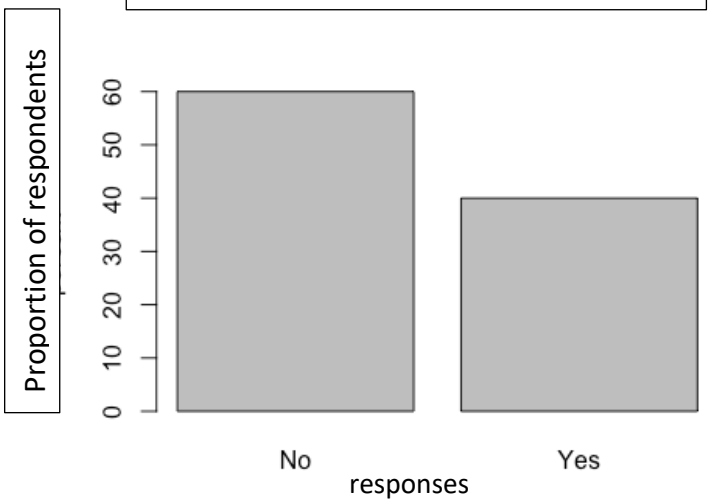


Figure 26b: Proportion of respondents who consider police services as alternative when there is breach.

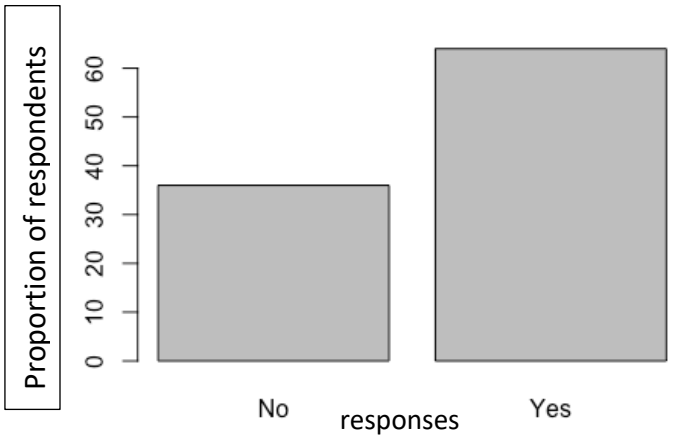


Figure 27c: Proportion of respondents who consider self-protection when there is breach.

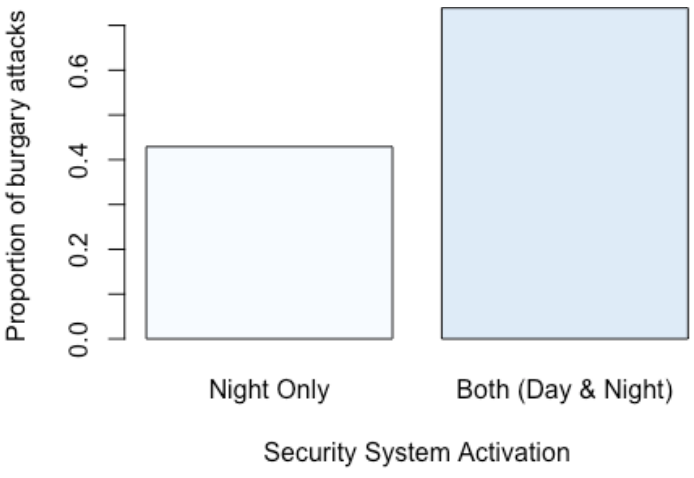


Figure 27: Relationship between security activation and burglary attacks

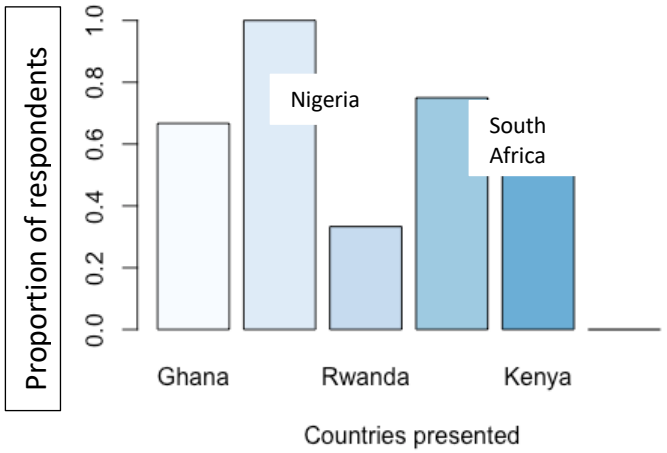


Figure 28: Relationship between the country one resides in and the frequency of attacks

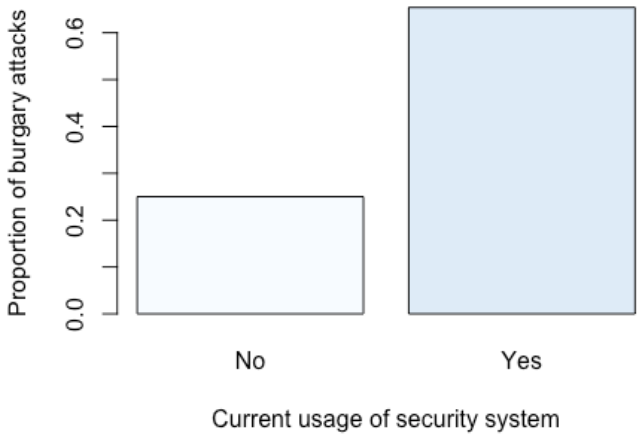


Figure 29a: Relationship between current security system usage and burglary

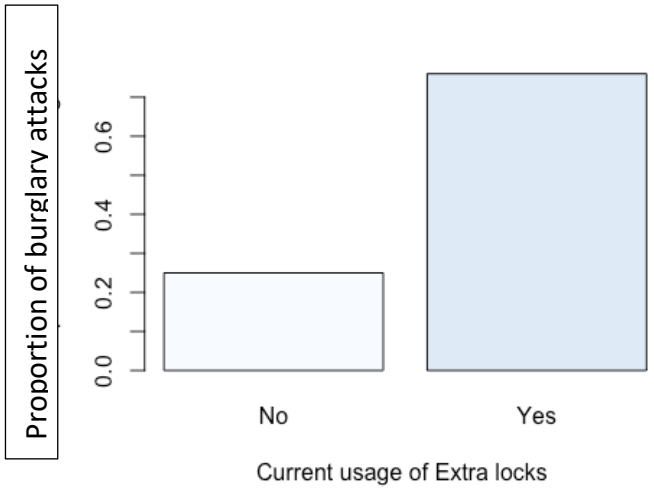


Figure 29b: Relationship between current usage of extra locks and burglary attacks

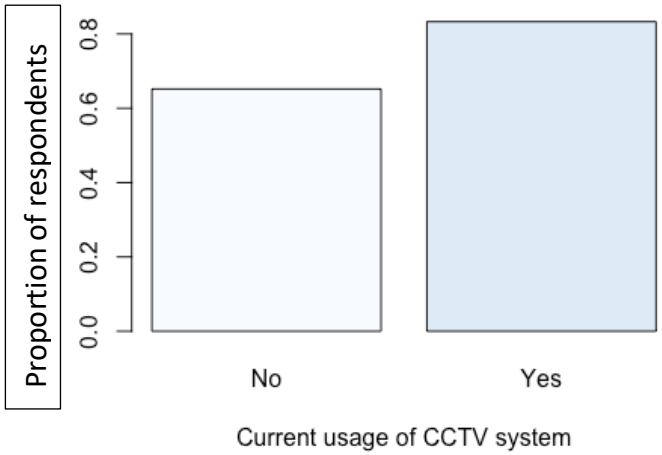


Figure 29c: Relationship between current CCTV system usage and burglary attacks

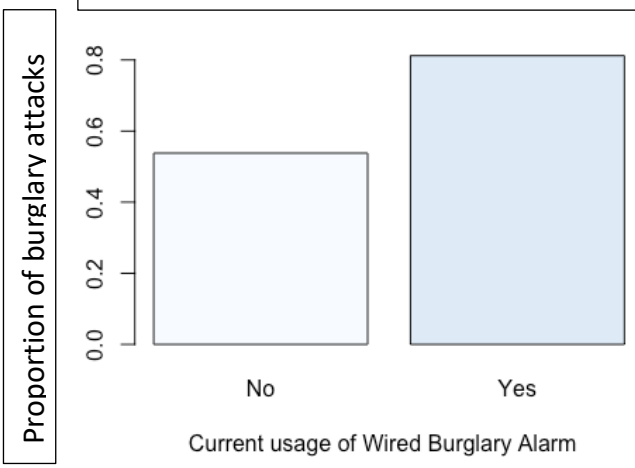


Figure 29d: Relationship between current usage of wired burglary alarms and burglary attacks

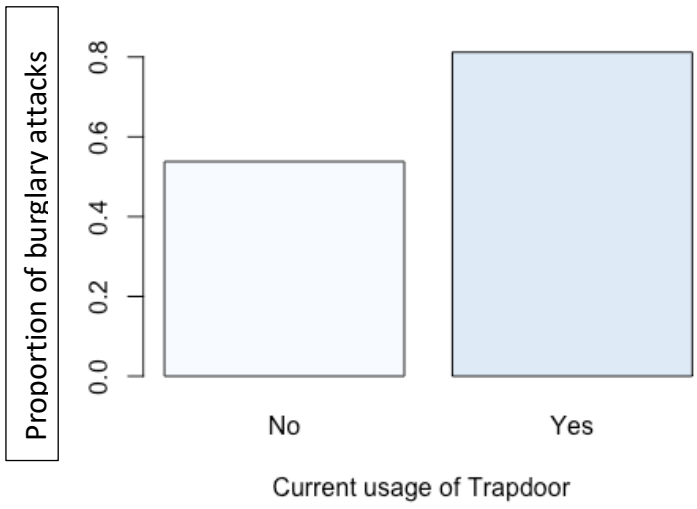


Figure 29e: Relationship between current trap door usage and burglary attacks

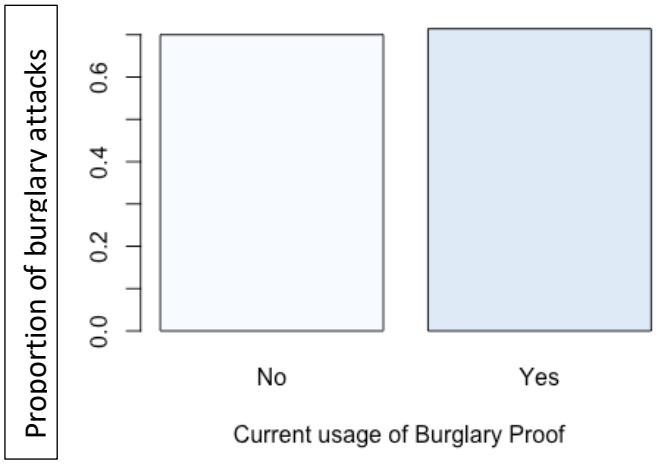


Figure 29e: Relationship between current burglary proof usage and burglary

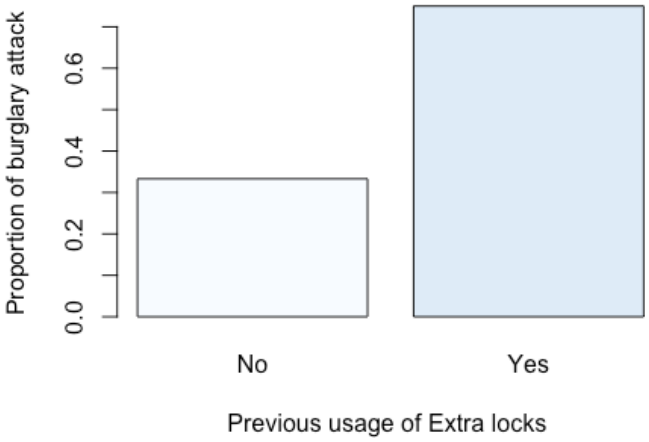


Figure 30a: Relationship between previous usage of Extra locks and burglary attacks

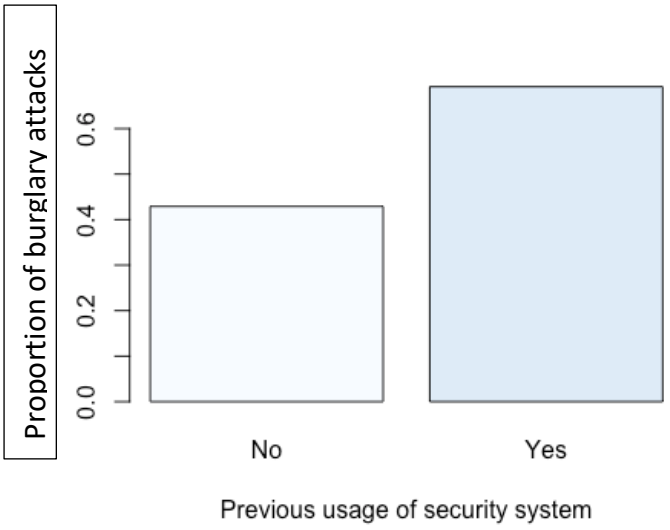


Figure 30b: Relationship between previous usage of security system and burglary attacks

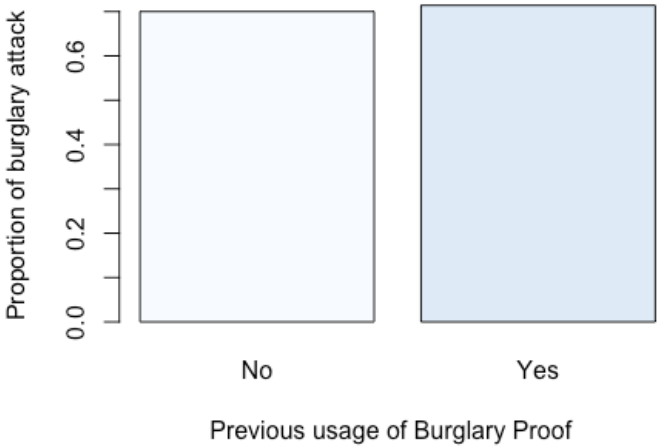


Figure 30c: Relationship between previous usage of burglary proof and burglary attacks

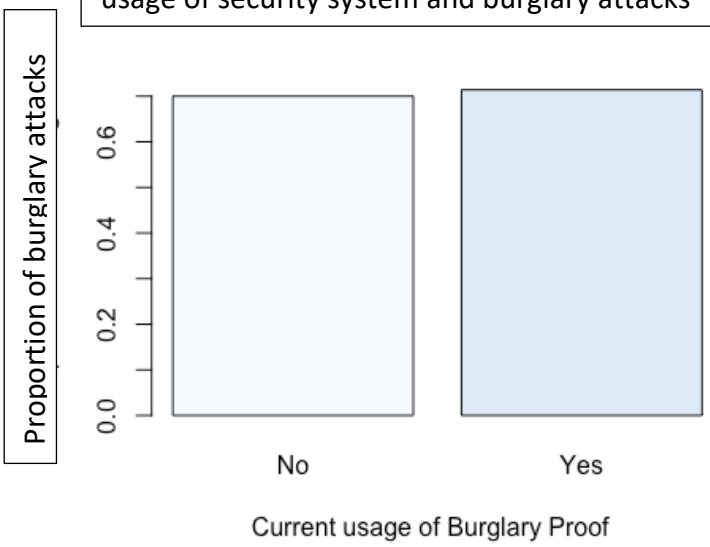


Figure 30d: Relationship between previous usage of CCTV systems and burglary attacks

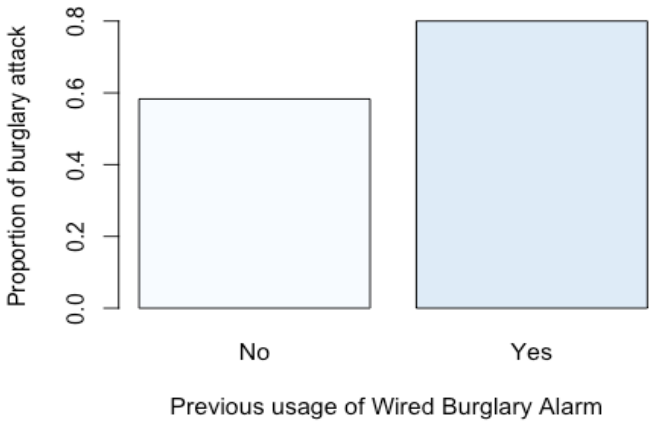


Figure 30e: Relationship between previous usage of wired burglary alarm and burglary attacks

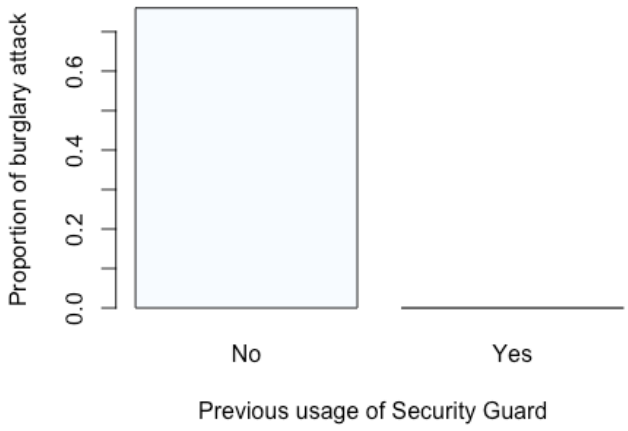


Figure 30g: Relationship between previous usage of security guards and burglary attacks

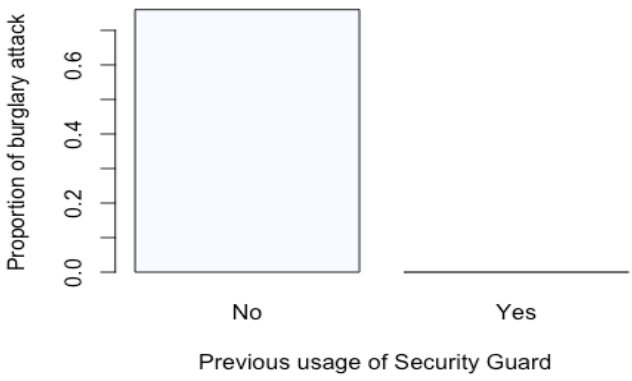


Figure 30h: Relationship between previous usage of trapdoor and burglary attacks

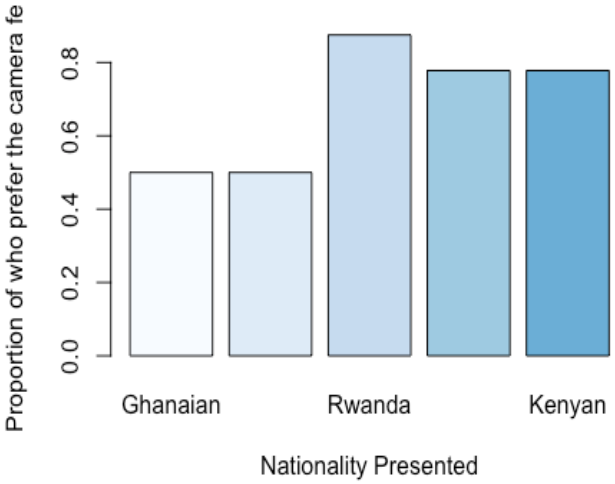


Figure 32b: Proportion of respondents Across countries presented who prefer camera feeds feature of the equine model

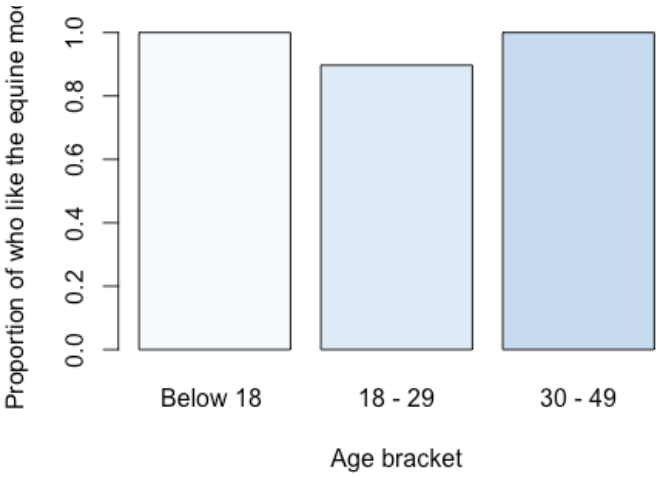


Figure 32b: Proportion of respondents Across Age groups prefer the equine model

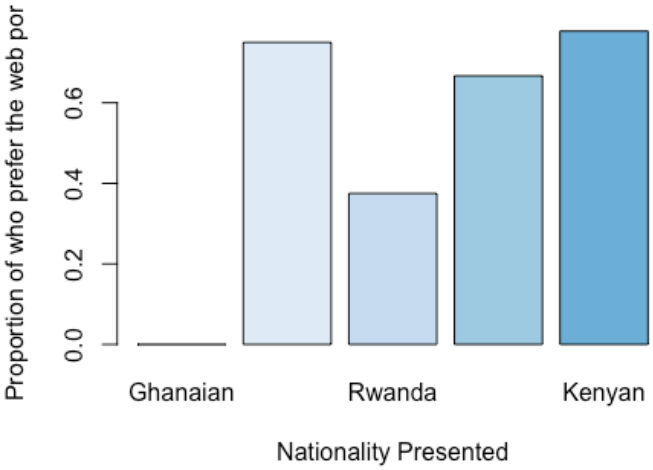


Figure 32b: Proportion of respondents Across nationality presented who prefer web portal of the equine model

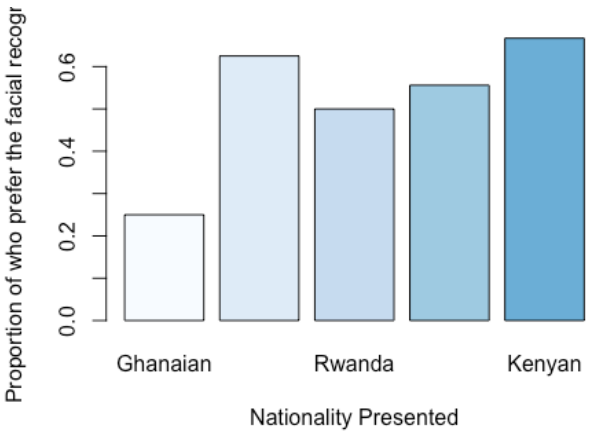


Figure 32b: Proportion of respondents Across nationalities presented who prefer web portal of the equine model

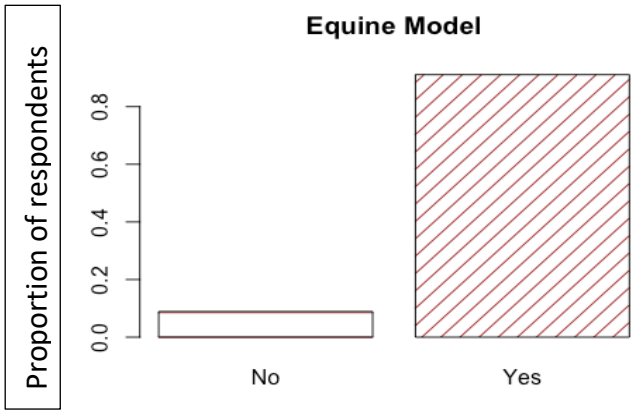


Figure 33a: Proportion of respondents prefer the equine model

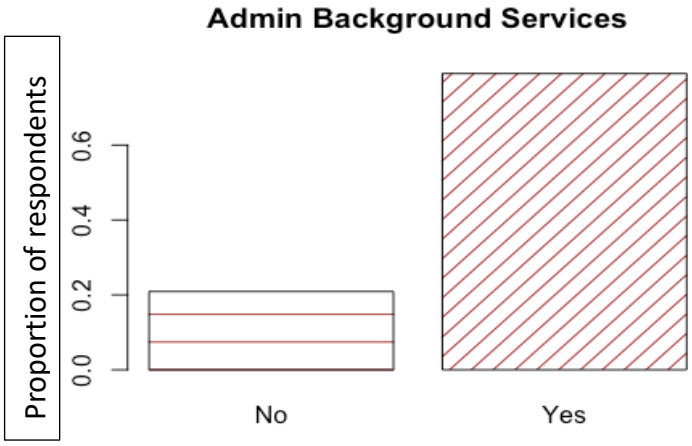


Figure 33b: Proportion of respondents prefer administrator services

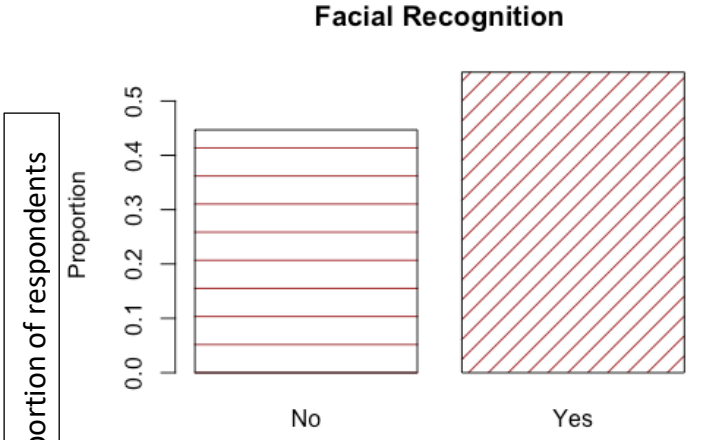


Figure 33c: Proportion of respondents prefer facial recognition feature of the equine model

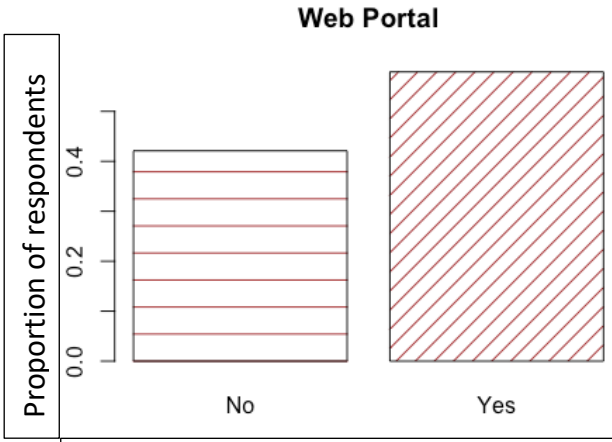


Figure 33d: Proportion of respondents prefer web portal prefer web portal feature of the equine model

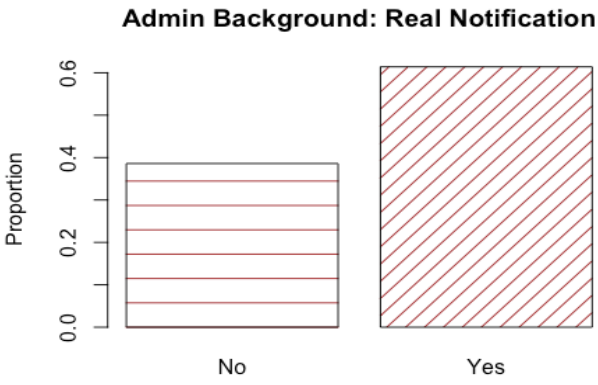


Figure 33e: Proportion of respondents prefer real-time notifications feature of the equine model

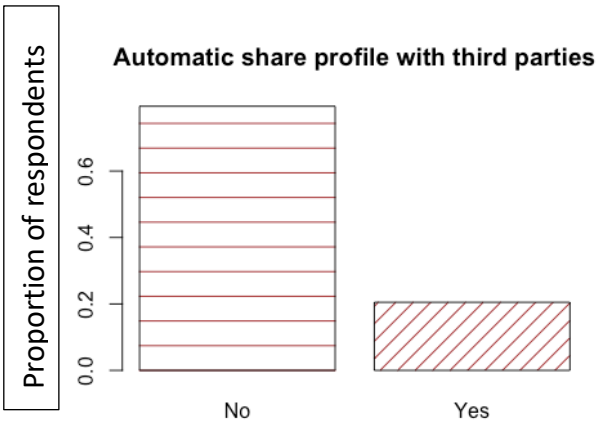


Figure 33f: Proportion of respondents prefer admin support during login

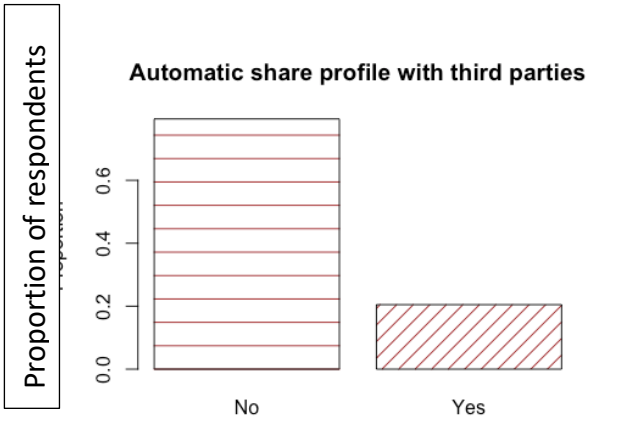


Figure 33g: Proportion of respondents prefer admin support with third parties app

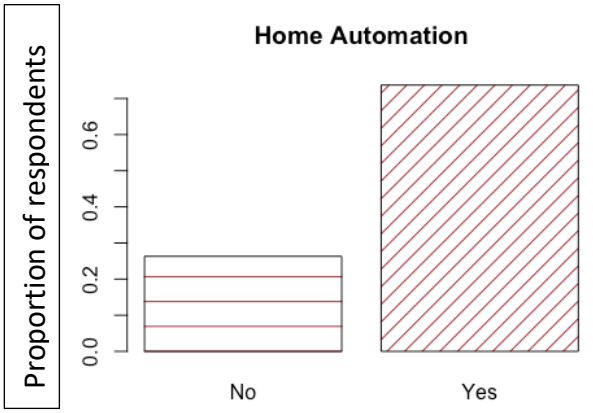


Figure 33h: Proportion of respondents prefer home automation feature of the equine model

Appendix

Equine Control Board Color Code Sheet

RADAR COMPONENT COLOR CODE					
COMPONENT	**COMPONENT CODE**	**GND**	**ECHO**	**TRIG**	**VCC**
Radar A	RA-01	White	Green / (White)	Cyan / (Blue)	Red
Radar B	RB-01	Red	Green / (Blue)	Purple / (White)	White

POWER COMPONENT COLOR CODE				
COMPONENT	**COMPONENT CODE**	**TYPE**	**DATA**	**GND**
On-board Power	MP-01	Board Power	Blue	Blue
On-board Data Sync	MS-01	Board Sync	Green	
Camera Power	MC-01	Camera Power	Yellow / (Grey)	
Buzzer Power	MB-01	Buzzer Power	Grey	

SWING COMPONENT COLOR CODE				
Component	**Component Code**	**GND**	**DATA**	**VCC**
Swing A	SA-01	Purple	Green	Red
Swing B	SB-01	Blue	Orange	Cyan
Swing C	SC-01	Purple	White	Red

BUZZER COMPONENT COLOR CODE			
Component	**Component Code**	**DATA**	**GND**
Buzzer A	BUZ-01	Red	Black
Buzzer B	BUZ-02	White	
Buzzer C	BUZ-03	Cyan	

Table 1: Equine MQ Control Board Color Code

Equine Control Board Pin Code Sheet			
RADAR COMPONENT PINS			
COMPONENT	COMPONENT CODE	TRIG	ECHO
Radar A	RA-01	18	24
Radar B	RB-01	5	6
SWING COMPONENT PINS			
COMPONENT	COMPONENT CODE	DATA	
Swing A	SA-01	22	
Swing B	SB-01	23	
Swing C	SC-01	27	

BUZZER COMPONENT PINS		
COMPONENT	COMPONENT CODE	DATA
Buzzer A	BUZ-01	16
Buzzer B	BUZ-02	20
Buzzer C	BUZ-03	

POWER COMPONENT PINS		
COMPONENT	COMPONENT CODE	DATA
On-board Power	MP-01	19
On-board Sync	MS-01	21
Camera Power	MC-01	13
Buzzer Power	MB-01	12

Table 2 : Equine MQ Control Board Pin Code

Bill of Materials			
Materials	Price	Quantity	Amount
Raspberry Pi	$ 35	1	$ 35
Ultra-Sonic	$ 2	2	$ 4
Servo motor	$ 5.5	3	$ 16.5
Leds	$ 0.55	7	$ 1.25
Lcd display	$ 2.5	1	$ 3.85
Jumper Wires	$ 0.34	50	$ 17
Buzzer unit	$ 2.49	3	$ 7.47
Proto board	$10	1	$15

Fabricated case	$2.5	2	$ 5
		Total Cost	$ 105.07

Exchange Rate as 31st March 2020	
USD – GHC	GHC 5.76

Total Cost of components => $ 105.07 * 5.76

⇨ 605.2032

Table 3: Bill of materials for Equine MQ

Project Charter				
1. General Project Information				
Project Name:	Equine Vision +			
Proposed Date:	22nd September 2019			
Project Start Date:	27th September 2019			
Project End Date:	11th March 2019			
2. Project Team				
Title	**Name**	**Department**	**Telephone**	**E-mail**
Project Supervisor	Mr. Francis Gatsi	Networks & Engineering Department	00000000000	Francis.gatsi@ashesi.edu.gh
Project Manager	Eugene Parker	IT Department	02079743714	Eugene.parker@ashesi.edu.gh
Project Coordinator	Eugene Parker	IT Department	02079743714	Eugene.parker@ashesi.edu.gh
UI / UX Designer	Eugene Parker	IT Department	02079743714	Eugene.parker@ashesi.edu.gh
Framework Developer	Eugene Parker	IT Department	02079743714	Eugene.parker@ashesi.edu.gh
Backend Developer	Eugene Parker	IT Department	02079743714	Eugene.parker@ashesi.edu.gh
Database Developer	Eugene Parker	IT Department	02079743714	Eugene.parker@ashesi.edu.gh
IOT Developer	Eugene Parker	IT Department	02079743714	Eugene.parker@ashesi.edu.gh
Modelling & Financial Analyst	Eugene Parker	IT Department	02079743714	Eugene.parker@ashesi.edu.gh
3. Stakeholders *This section takes in account two main group of individuals* *1. Those interested in the project* 2. *Those affected by the project*				
1. Project Supervisor – Mr. Francis Gatsi				

2. Project Manager – Eugene Parker
3. Customers - Residents in Africa
4. Security Firms in Africa

4. Project Scope Statement

Project Budget Information

This section describes the project needs this project addresses.

The Equine board allocates a total of Ghc 1000 to the development of this project called the Equine Vision + . Equine Vision + comprises several departments to which Ghc 400 is allocated to the IT department for developmental tools and the remaining Ghc 600 to the IOT department.

Project Objectives

1. Provides security companies in Africa relevant analysis on the current security status of residents
2. Broaden the ecosystem of security of residents living in Africa

Deliverables

List the high level products to be created (eg. Improved xxx, process , employee manual)

1. A shop platform for easy tracking of product
2. A web portal for hosting friends and family accounts
3. A policy guide to inform users of ways to run the application to prevent unauthorized access
4. A manual guide to teach users how to connect the portal to the device
5. A report feature that enables users to communicate directly to the admin
6. A live camera feature that enables users to view their environment through the device.
7. A mobile application for sending alerts when security is breached .
8. A robotic monitoring kit that allows user to detect early intrusion in restricted areas.
9. A facial recognition feature that enables users to identify strangers
10. A deep learning pipeline feature that enables users to store faces of friends and family

Scope

List what the project will and will not address

1. This project will address the problems surrounding security in Africa, and security technology used by residents that creates vulnerabilities.
2. This project will provide customers with a web platform, mobile application and robotic monitoring kit to help improve their security usage and experience.

Project Milestones

Propose start dates and end dates for project phases

1. Project start → 27th September 2019
2. Minimum Viable Product → 15th January 2020
3. Project Finish → 11th March 2020

Major Known Risks (including significant Assumptions)

Identify obstacles that may cause the project to fail.

Risk Factor	Risk Rating (High, Medium, Low)
Team members Injury	Low
Poor communication with Supervisor	Low
Team member falling sick	High
Team member departure from project	Low

External Dependencies

Will the project success depend on coordination of efforts between the project team and one or more other individuals or groups?

1. The database developer. To successfully integrate the web portal and device, Equine Vision + needs an expert who understand various forms of database management systems and a suitable infrastructure to meet requirements given. Vital information will be required from this individual

2. The IOT developer. To successfully implement the IOT backend, Equine Vision + needs a professional who understand control systems and networking. Vital information will be required from this individual.

5. Communication Strategy

Specify how the project manager will communicate to the Executive Sponsor,Project Team members and Stakeholders

1. Private meetings
2. Virtual Meetings (Zoom)
3. Phone calls
4. E-mails

6. Sign-off

Position	Name	Signature	Date (MM/DD/YYYY)
Project Supervisor	Mr. Francis Gatsi		19th May 2020
Project Manager	Eugene Parker		19th May 2020
Project Coordinator	Eugene Parker		19th May 2020
UI / UX Designer	Eugene Parker		19th May 2020
Framework Developer	Eugene Parker		19th May 2020
Backend Developer	Eugene Parker		19th May 2020
Database Developer	Eugene Parker		19th May 2020
IOT Developer	Eugene Parker		19th May 2020

Modelling & Financial Analyst	Eugene Parker		19th May 2020

Table 4: Equine Model Project Charter

Section 1: System & Marketing Questionnaire

Section 1 collects the first set of information about security and privacy concern pertaining to the interest of customers & early adopters. The structure of the survey included mandatory skips for some questions while were more general. In addition, some questions had multiple selections as a way to rank categories.

General Information

Frequency	Code	Responses		Variable Name	Type/Length
1. What is your gender?				**EQGEN**	num 1
41	1	Female			
21	2	Male			

2. What age group do you belong to?			**EQAGE**	num 2
1	1	Below 18		
52	2	18 - 29		
9	3	30 - 49		
0	4	Above 50		

3. What is your nationality?			**EQNAT**	num 3
47	1	Ghanaian		
3	2	Nigerian		
10	3	Rwandese		
4	4	South African		
1	5	Kenyan		

4. What country do you reside in?			**EQCON**	num 4
45	1	Ghana		
1	2	Nigeria		
7	3	Rwanda		
3	4	South Africa		
1	5	Kenya		
2	7	United States		

Information on Home Security

5. Have you previously used home security?			**EQPUSE**	num 5

42	1	Yes
20	0	No (*skip to question 6*)

6. What type of home security did you used previously?		**EQPTYPE**	num 6
17	1	CCTV	
21	2	Extra Locks	
16	3	Wired Burglary alarm	
14	4	Trapdoor	
24	5	Burglary Proof	
4	6	NA	
3	7	Guards	

7. What factors do you consider when choosing a type of home security?		**EQSFEA**	num 7
32	1	Price	
36	2	Features	
51	3	Performance	
30	4	Simplicity	
	6	NA	

8. Do you currently use a home security?		**EQCUSE**	num 8
40	1	Yes	
21	2	No (*skip to question 12*)	
	6		

9. What type of home security did you used previously?		**EQCTYPE**	num 9
14	1	CCTV	
23	2	Extra Locks	
15	3	Wired Burglary alarm	
13	4	Trapdoor	
24	5	Burglary Proof	
4	6	NA	
3	7	Guard	

10. How much do you spend on home security on an average?		**EQSEXPENSE**	num 10
2	1	Below Ghc 1000	
15	2	Ghc 1000 - 4999	
3	3	Ghc 5000 +	
25	4	Do not know	
	6	NA	

11. At what time is your security active?		**EQSACTIVE**	num 11
0	1	Day	
9	2	Night	

32	3	Both (*Day & Night*)
	6	NA

12. Have you experienced home burglary?		**EQBSTATUS**	num 12
18	1	Yes	
28	2	No	
	6	NA	

13. How has the use of home security affected the frequency of burglary attacks?		**EQSINFLU**	num 13
1	1	Barely Improved	
7	2	Moderately Improved	
2	3	Same	
9	4	Rapidly Improved	
	6	NA	

14. Are you satisfied with your home security?		**EQSSATIS**	num 14
17	1	Yes	
9	2	No	
	6	NA	

15. In case your home security is breached, what alternative Will you seek ?		**EQSALTER**	num 15
7	1	Call a friend	
27	2	Call the Police	
16	3	Self-protect	
	6	NA	

Equine Model

Equine model are built using a conceptual approach that uses the user environment as a security weapon.

16. Would you purchase the security system described above?		**EQMODEL**	num 16
48	1	Yes	
6	2	No	

17. Based on your needs, which features are most important to you?		**EQMFEA**	num 17
13	1	Web Portal	
38	2	Home monitoring system	
32	3	Live Updates	
29	4	Real Time Automation	
29	5	Facial Recognition Model	

	6	NA

Information on System Privacy

18. Would you want the admin to keep background process on your account for easy tracking?		**EQASERVICE**	num 18
36	1	Yes	
21	2	No	

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18. What functionality would you like the system administrator to perform (without your permission) ?		**EQASTYPE**	num 19
13	1	Live tracking of your location	
5	2	Automatic share of user data to third parties	
12	3	User Login tracks	
12	4	Real-time notifications	
28	5	Only act when the system is breached	
23	6	None of the above	

Table 5: Codebook