BUSITEMA UNIVERSITY

FACULTY OF ENGINEERING

DEPARTMENT OF COMPUTER ENGINEERING

A BEEHIVE INTRUSION AND HONEY MOBITORING SYSTEM

BY

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DECLARATION

I, KYAMPEIRE HADIJAH BU/UG/2013/42 do hereby declare that this project report is original and has not been submitted for any other degree award to any university before.

Signature: ……………………. Date……………………….

APPROVAL

This Project Report has been submitted with the approval of the following supervisor.

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DEDICATION

I dedicate this project report to my beloved parents Mr Ismail Omega and Mrs Kanifa Omega for the love and support they have provided to me throughout this project period, my sisters Kemigisha Mariam and Kyasimire Safina for the advice and financial support they rendered to me during the research period.

I also dedicate it to my project supervisor Mr. Alunyu Andrew Egwar for his tremendous effort and guidance in relation to my project report , the courage, and the moral & support he offered to me during my research period MAY the almighty ALLAH BLESS him.

ACKNOWLEDGEMENT

My supervisor, Mr. Alunyu Andrew Egwar, for helping me to accomplish this project report. Thank you so much for the aid offered to me.

Also, I acknowledge all the other department lecturers who have always given me time for consultation regardless of whether they are my supervisors or not, thank you for the helping attitude.

Many fellow students offered help in form of advice and information and it is also greatly recognized.

Special thanks to my family for their never ending financial and advisory support. May Allah reward them abundantly.

Above all, I acknowledge the Almighty Allah for the gift of life, wisdom and guidance for without Him, I would not have been able to accomplish this project report.

LIST OF ABBREVIATIONS

GSM	Global System for Mobile Communication
LCD	Liquid Crystal Display
PCB	Printed Circuit Board
SMS	Short Message Service
WSN	Wireless Sensor Network

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ABSTRACT

A beehive is a wooden structure that is designed special for bees to stay in as they multiply and produce their products. In Uganda, beekeeping is increasing due to its great benefits in terms of its products namely honey and wax and it being highly profitable which increases the country's economy as compared to other Agricultural practices like poultry keeping among others. However, beekeeping is normally done some distance from the homesteads due to the bee behaviors, therefore if not monitored regularly it can be of great loss to the farmers. The currently used beehives do not have an automated mechanism for monitoring honey and detecting intrusion. This has led to decrease in the country's economy and losses to the bee farmers. In this system, the weight sensor is used to detect increase in the weight of honey combs then the system reports beehive full and the LDR is for detecting change in light intensity then report intrusion. A GSM modem is used to notify the user about the honey accumulation and intrusion at the hive so that the necessary actions are taken to avoid losses. This system will reduce the increasing losses in Agriculture mainly from the beekeeping sector.

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CHAPTER ONE

INTRODUCTION

1.1 Background of study

Beekeeping is one of the oldest branches of agriculture which includes the collection and care of the bee swarms, pollination of field crops by bees, the study of bee products and the breeding of the bees for large scale honey production [1]. It greatly contributes to the economy of a country due to the highly priced products like honey and wax [2]. The government of Uganda, through the plan for modernization of agriculture, is promoting beekeeping extension services particularly among the rural poor. This program has assisted poor farmers to invest in beekeeping through group organizations [3].

Beekeeping in Uganda has continued to be traditionally based with production and currently there are three common methods of production used in Uganda [4];

Firstly, Honey hunting where honey is collected from wild colonies in trees, caves, etc. This method has drastically diminished in the wake of the new / improved technologies.

Secondly, Traditional log hive method where traditional log hives made out of bamboo and logs are used and harvests are done at random using rudimentary methods. The majority of the original traditional beekeepers in Uganda still use log hives. These hives require replacement every 2 years.

Thirdly, Traditional improved hives, called the "Top-bar hives". These were developed as man struggled to domesticate bees commercially.

However, the above methods due to their associated challenges of one time harvest, regular replacement and poor technology for monitoring the right time for maximal harvest the above methods have not been efficient as bee farming has been observed declining which has not only posed a great threat to the world's economy but also the agricultural produce [5]. This decline has been as a result of many factors including lack of knowledge about the availability of honey, intrusion, diseases, parasites, pesticides, the environment, and socio-economic factors [6]. The challenge of lacking knowledge about when to harvest and what to harvest has greatly affected the quality of honey collected thus reduction in the economy [7], also it results into the bees eating all the honey in case the weather is cold, or even intruders/ thieves come and steal the honey. Also our local Ugandan beekeepers currently use their local knowledge and predictions on telling when honey has accumulated, for example they estimate an interval of three months from the previous harvest, observing the bees being too hostile and protective of their hive and also the blackness of the beehive entry holes. This makes it inefficient and time consuming incase the beehives are far from home, and also for the blackness of the entry holes if it's for the second and above times it will always be black and hence one wont base on such observations for long.

Therefore there is need for a system that will help in monitoring honey production and accumulation in the beehive and prevent the other associated problems.

1.2 Problem statement

In the light of increasing number of bee colonies in the world, the key issue in question is the Safety and production knowledge associated to the bee hives and colonies. Protecting the population of honey bees worldwide, as well as enabling them to maximize their productivity, is an important concern. Due to lack of technological knowledge about honey harvesting, traditional bee farmers do not hesitate to grab whatever they find in the hive during the flow season even before the honey ripens which has resulted into poor quality honey [8]. Therefore if this challenge persists it might result into much decline in the country's economy as well as agricultural produces. Existing beehive monitoring methods are not so reliable as regards Safety and detection of honey for harvest because they mostly focus on the health of the bee, this project work sought to monitor the beehives for honey accumulation and intrusion occurrences.

1.3 Objectives

The objectives of this study are divided into two parts that is main objective and specific objectives.

1.3.1 Main objective

To Design and develop a beehive intrusion and honey monitoring system to improve the bee farming sector.

1.3.2 Specific objectives

1. To study and review literature related to the current beehive management and monitoring systems in order to identify system requirements.
2. To design a beehive intrusion and honey monitoring system.
3. To develop a system that assists bee farmers to wirelessly monitor their bee hives and colonies system.
4. To test and validate the beehive intrusion and honey monitoring system.

1.4 Justification

Bee farming is among the major agricultural sectors that contribute much to the world's economy through the bee products like honey and the existence of beehives is a critical predictor of the planet's future health and agricultural sustainability. Bee farmers are constantly facing a challenge of monitoring honey in the beehive which has resulted to poor quality produce or even no produce thus monitoring beehives is required in order to ensure good quality honey which will increase income or even be used as medicine.

1.5 Scope

1.5.1 Technical scope

The beehive intrusion and honey monitoring system has a sensor that takes the weight measurements of the honey combs full of honey, another sensor that detects intrusion inside the beehive. An alert message is sent by the system to the user's mobile by use of the GSM module in reaction to the occurrence of the above two conditions. However it does not directly harvest honey and neither does it catch the thief.

1.5.2 Geographical scope

The System has been developed to help the traditional bee farmers in Uganda and other places where apiculture is practiced. It will be most applicable in the modern bee hives leaving out the wild bee hives and colonies which are just made by bees themselves in an open place.

1.5.3 Time scope

Development of the system took me about six months.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter summarizes all the related literature about existing and related beehive monitoring systems, technologies that are in place to improve Apiculture and its produce as they contribute much to the economy. The review includes research work from journals, reports and books cited with the objective of revealing contributions, weakness and gaps within the related systems.

2.2 Key Terms

2.2.1 Swarming

Swarming is a natural way of proliferation of bee colonies when a part of the bee colony leaves the living place to establish a new colony in a new place at least some kilometers away from the current place of living. This mechanism of proliferation harms industrial beekeeping where proliferation of colonies is done in a controlled way ensuring that the new colony remains reachable for the beekeeper. Swarming of honey bee colonies is one of the factors that reduces profitability of beekeeping.

There are no easy detectable indications of preswarming conditions that would be visible for a beekeeper without opening the hive as swarming is a highly stochastic process that depends on genetical and other peculiarities of a particular bee colony [9].

2.2.2 Flight Activity

The flight activity of a honey bee colony is an important indicator of its strength and condition. Flight activity is affected by many factors both internal and external to a colony, such as population, presence of an egg-laying queen, weather conditions, availability of nectar and pollen, disease, and exposure to toxins [10]. Despite this complexity, activity counters provide useful practical information. For example, they reveal phenomena such as swarming, an event of importance to beekeepers that is brief and difficult to predict, but is marked by large numbers of bees leaving the hive. Bromenshenk et al. found two measures derived from activity counts most useful: net losses, and the coefficient of variation for activity between hives at the same site.

2.2.3 Foraging

Foraging is a practice or bees flying far from their bee hives to look for food. For bees, their forage or food supply consists of nectar and pollen from blooming plants within flight range [11]. The forage sources for honey bees are an important consideration for beekeepers. As a rule of thumb the foraging area around a beehive extends for two miles (3 km), although bees have been observed foraging twice and three times this distance from the hive. Experiments have shown that beehives within 4 miles of a food source will gain weight, but beyond that the energy expended is greater than that gained during the foraging flight [12].

2.2.4 Bee Hives

These are structures where bees are kept and all their production activities take place there. Early forms of honey collecting entailed the destruction of the entire colony when the honey was harvested. They can be traditional, top-bar and frame hives [13].

2.3 Related Systems

2.3.1 A wsn-based automatic monitoring system for the foraging behaviour of honey bees and environmental factors of beehives.

This system was developed for monitoring honey bee behavior in 2016. This system can detect both the environmental factors and foraging activities with a high temporal resolution. The proposed counting algorithm can accurately detect honey bees' outgoing and incoming activities. The monitoring system can be installed at the entrance of a beehive. The WSN-based monitoring system can not only detect the environmental factors both inside and outside the beehive, but also provide the long-term data of incoming and outgoing foraging activities of honey bees with a high temporal resolution. The results show that the average counting accuracy of incoming and outgoing behavior is 84.92% and 85.95%, respectively. Moreover, the long-term monitoring data that represent the frequencies of incoming and outgoing activities and the beehive related environmental factors are also analyzed. According to the data, honey bees become more energetic when the daily average ambient temperature is higher than 25 °C, and the average ambient relative humidity is between 60%RH and 70%RH. The experimental results show that the proposed monitoring system can reliably collect environmental data and the data related to the activities of honey bees simultaneously [14].

2.3.2 Smart beehive for agriculture, environmental, and honey bee health monitoring

In this system, there is utilization of heterogeneous wireless sensor networks technologies to gather data unobtrusively from a beehive, describing the conditions and activity of the honey bee colony. A wide range of sensors are deployed for monitoring the multidimensional conditions within a living beehive (including oxygen, carbon dioxide, pollutant levels, temperature, and humidity). Meteorological and environmental conditions outside the hive were also monitored throughout the deployment. The data is then analyzed from a biological perspective to provide insights into honey bee behavior and health. This led to the development of an algorithm for automatically determining the status of the bee colony. Analysis was also undertaken from a meteorological perspective, which led to the development of an algorithm for predicting short term external weather conditions (rain) based on the conditions observed within the hive. The meteorological conditions were seen to have an impact on the data provided by biological sensors (bees) and physical sensors [15].

2.3.3 Automatic microclimate controlled beehive observation system.

This system was developed to address one of the factors that has led to reduction of bee farming which is swarming. Swarming has been a problem to the bee farming industry therefore it needs monitoring by monitoring microclimate changes [16]. One of the reasons of microclimate changes could be warm-up before take-off. This kind of phenomena is observed when colonies start flying from the place outside the hive [17]. This system consists of

1) Control subsystem: The control subsystem consists of a computer and software. The computer receives data from the measuring subsystem to store it in memory and analyze it.

2) Measuring (temperature and relative humidity) subsystem: Here seven sensors of temperature and humidity are placed in each of two hives (middle of each wall, top and floor of the hive and entrance). Two additional sensors are placed under the hive to monitor the outside temperature and humidity. MD3020 microcircuit with HIH3610 humidity sensor and DS18S20 temperature sensor is used for temperature and relative humidity measurement inside and outside of the hive [16].

3) Video recording subsystem: Video monitoring of the front of the beehive (video camera 1) as well as environment (video camera 2) is switched on when untypical changes of microclimate are detected. The system currently is installed to monitor two bee hives with colonies. It can be extended to a bigger number of observed hives increasing the number of sensors or reducing the

number of sensors per hive. Two additional sensors are placed under the hive to monitor the outside temperature and humidity being protected from direct sun or rain influence.

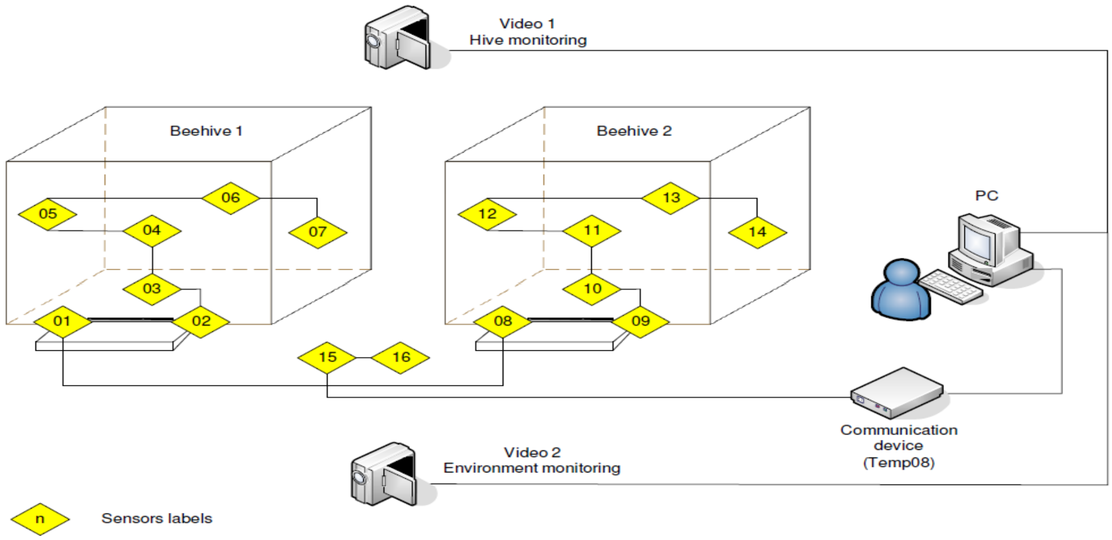


Figure 1 shows the arrangement of the system [16].

2.3.4 Video monitoring of honey bee colonies at the hive entrance.

This system was aimed at keeping tracking of the flight of bees. The flight activity of a honey bee colony is an important indicator of its strength and condition [18]. Beekeepers assess colony health by manually inspecting hives, beginning with visual observation of flight activity. In this system commercially-available activity counters are based on infrared sensing [19]. A device is placed in the hive entrance that consists of up to 32 bidirectional, bee-sized tunnels, each equipped with a dual photoreceptor to determine direction of movement.

This approach monitors flights to and from the bee colony using a camera positioned over the unmodified entrance of a standard hive. We use a Unibrain Fire-iTM digital board camera equipped with a wide angle lens (f = 2:1mm: 80_ horizontal view angle).

This wide angle view covers the entire 40cm (16 in) width of the entrance platform while mounting the camera only 20cm (8 in) above that platform.

Thus the camera can be attached within the height of a single primary hive body itself rather than relying on the presence of at least one expansion box.

Figure 2**.** Structure of the system [20]**.**

This system, it will propose the use of video for activity monitoring at the hive entrance in a practical setting.

2.3.5 Application of temperature measurements for bee colony monitoring.

In apiculture, one of the major problems is to monitor honeybee colonies for their health, population, other biological activities indicating production of honeybee products and environmental conditions affecting the colony health. Beside honeybee diseases, Varroa destructor infestation and pesticides, one of the most common problems in apiculture is colony losses because of food shortage in hives, queen loss, and loss of broad by unusual alteration in environmental conditions such as temperature, humidity and the length of the winter season. Usage of ICT in apiculture mainly can increase the beekeepers' knowledge about behavior of individual bee colonies and improve the efficiency of beekeeping by bringing it to the next technological level. In the previous 20th century, when information technologies were not widely available, measurements of the bee colony temperature were done manually using thermocouples and later special temperature loggers or iButtons were used.

One of the first practical experiments was made by W.E.Dunham in 1926, when he used eight thermocouples, which were placed into one hive in different places. Each hour temperature measurements were made and manually fixed. He concluded that temperature fluctuations in the bee ball are not so high, comparing to temperature in the empty places of the hive.

Temperature measurements can provide a beekeeper with actual and real time data and information about the bee colony behavior. Based on temperature information beekeepers can detect such colony events like increased food consumption, start of brood rearing, recognition of the pre-swarming state or death of the bee colony [21].

2.3.6 Automated monitoring of flight activity at a beehive entrance using infrared light sensors.

The main function of the system was to count the number of bees moving in and out of a hive, and to determine their direction of movement. To correlate bee activity with environmental factors, the system also monitored the temperature inside and outside the hive, solar radiation, humidity, wind speed, and the weight of the hive. All the data acquisition was conducted and controlled by a single-board computer, based on an Intel 8088 microprocessor. In a field test, data acquisition was carried out at preset, 15-min intervals. Data from a representative period of 4 days are presented and indicate satisfactory operation of the system. The system also shows potential for studying bee movement inside hives during an overwintering period [22].

2.3.7 Monitoring of swarming sounds in bee hives for early detection of the swarming period

Swarming means honey loss since bees start collecting the honey to migrate. Here for a method that enables the prediction of the swarming is required to prevent the queen from leaving the hives. In this experiment an acoustic method based on labelling of sounds is proposed to predict the swarming period. Three hives were monitored during 270 h. The microphones were sited inside the hives together with a temperature and humidity sensor. The sounds were recorded with a sample rate of 2 kHz, and analyzed via Matlab and Cool Edit Pro. During this period 9 swarming activities occurred. Swarming is indicated by an increase in the power spectral density at about 110 Hz; approaching to swarm the sound augmented in amplitude and frequency to 300 Hz, occasionally a rapid change occurred from 150 Hz to 500 Hz. Another finding indicating the initiation of a swarming period is the raise in temperature from 33 °C to 35 °C until the actual time of swarming when the temperature starts dropping to 32 °C. With more activity, ventilation from bee wings causes drop of temperature. Less information comes from the correlation between sound and humidity since this parameter is too much influenced by the external conditions and no significant variation occurred according to a swarm. This increase of temperature, together with the changes in acoustical features of the sound recorded in the hive, may be used as a predictor for swarming of the bees to reduce honey loss [23].

Table 1 comparison table with advantages and drawbacks of some of the related systems

System	**Advantage(s)**	**Drawback(s)**
1. A WNS-based automatic monitoring system for the foraging behavior of honey bees and environmental factors of beehives.	It can detect both the environmental factors and foraging activities with a high temporal resolution	It only puts foraging into consideration, it doesn't focus on the bee products like honey. It also costly compared to the proposed system.
2.Smart beehive for agriculture, environmental, and honey bee health monitoring	It provides data about the conditions of the beehive including bee activities inside.	It is costly and requires much technology since it uses an algorithm.
3. Automatic microclimate controlled beehive observation system.	The system provides convenient interpretation of data both working with real time data as well as with historical data stored in the data base.	Relatively slow speed of changes of temperature and relative humidity in the hive during normal work of the colony is a good precondition to be able to detect swarming-related changes in the bee colony behavior.
4. Video monitoring of honey bee colonies at the hive entrance	It also monitors the flight of bees to tell their health conditions.	Obstruction of bee movement and spurious counts caused by debris in the tunnels, which must be cleaned regularly.
5. Application of temperature measurements for bee colony monitoring.	It helps in monitoring the colony health through temperature regulations.	It is costly and therefore still limited to countries like

		Denmark, Sweden, Norway, Latvia and Germany.
6. Automated monitoring of flight activity at a beehive entrance using infrared light sensors.	It helps to keep the farmer updated about the bee population and knowing their flight direction.	It was only focused on the flight of bees and environmental factors without monitoring the major aspects in a bee hive like products.
7. Monitoring of swarming sounds in beehives for early detection of the swarming period.	It helps the farmers detect swarming as early as possible and prepare for it.	It doesn’t stop bees from swarming it just monitors and detects.

2.5 The designed System

With this system, bee farmers and agricultural organizations will be given the system to deploy in the new beehives or even the already used. This system after being installed in a beehive it will use the weight sensor to measure a massive weight change and it will send an alert message to the farmers mobile phone about presence of enough honey, it will also use a light dependent resistor which will be inside the dark beehive then in case of and exposure to light it will send a signal to the GSM which will send a message to the farmer about intrusion. The farmers will be required to enter their phone numbers into the system so that the GSM can send alert messages about the conditions of the beehive regarding intrusion and accumulation of honey.

Accuracy of this system

- ✓ This system keeps the farmer updated about the state of the beehive regarding intrusion and honey accumulation by sending messages to his mobile phone, thus it enables the bee farmer monitor his bee colony wirelessly.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter explains the procedures and methods that I intend to use in data collection, purposes and relevancies of those methods or procedures and the techniques that will be used to meet the above mentioned objectives.

3.1 Requirements Elicitation / System Study

This involved the process of gathering information about the beehive intrusion and honey monitoring system to be developed and existing systems, and later determining the user and system requirements. This was achieved through data collection and data analysis, the following mechanisms were used.

3.1.1 Data Collection Methods

A number of research mechanisms were utilized in collecting the kind of data I needed to accomplish the project. The major ones included:

Document review

This involved reading documentaries whose major source was text books, journals, conference proceedings, magazines and newspapers from different scholars and researchers on the Google scholar site and offline etc. This method helped me to widen my knowledge scope as far as the bee farming sector was concerned, thus I got to know about the gaps in the existing system and I made my system cover some of those gaps.

Interview

This was mainly conducted on the people who are to be users of the system, largely the traditional bee farmers in Uganda particularly around Busitema village and other people who have expertise knowledge in bee keeping.

3.1.2 Data analysis

This is the process of systematically applying statistical and/or logical techniques to describe and illustrate, condense and recap, and evaluate data. A qualitative and quantitative approach was taken and consistence of the data was ensured in order to come up with effective system[24].

3.3 Requirements Analysis

Requirements analysis is the process of determining user expectations for a new or modified product taking account of the possibly conflicting requirements of the various stakeholders, analyzing, documenting, validating and managing software or system requirements. The requirement analysis aimed at extracting requirements from all the collected data for designing the system. This describes the respective system requirements that were captured by the developed beehive intrusion and honey monitoring system, requirements were classified into: functional and non-functional requirements

Functional requirements captured the intended behavior of the system. This behavior may be expressed as services, tasks or functions the system is required to perform.

Non-functional requirements may also be referred to as system qualities for example reliability. They captured required or desirable properties of the system.

3.4 System Design

Before implementation the system, there was need to have a professional design. In this project, I involved software and hardware (physical components) to design all the components of the system.

3.4.1 Hardware

To design the hardware components of the system prototype, the following tools/resources were used.

- Atmega328PP chip for Arduino.
- GSM module
- Electronic components (Diodes, capacitors, resistors and transistors). Different components were used mainly to regulate and direct rightful amounts of current in the system.
- Light dependent resistor sensor.
- Weight sensor.
- Mobile phone.
- Liquid crystal display

- Beehive prototype.
- PCB was used for holding and housing the system components

3.4.2 Software

To design the software components of the system prototype, the following tools were used.

- WINAVR C editor and compiler
- Proteus simulation software
- Arduino programming platform

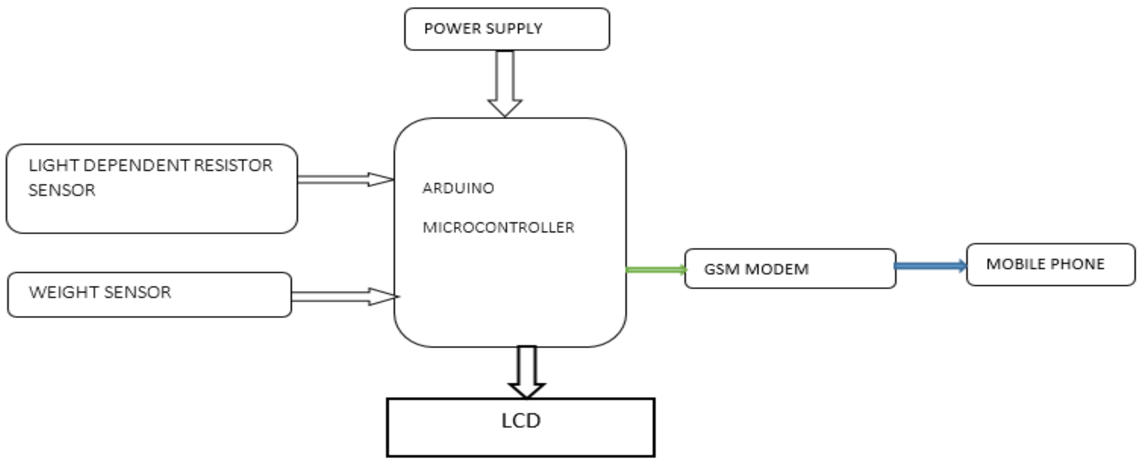


Figure 3 physical design

Sensing elements. These comprise light dependent resistor sensor and weight sensor, their purpose is providing the notification signal in case of increase in light intensity, and measuring signals after taking a given measurement to the micro controller unit respectively.

Micro-controller. This provides processed data that will send instruction to the GSM module.

GSM modem. This is an interface between the mobile phone and the micro controller unit at the station and contains a SIM card.

Mobile phone. This is the farmer's personal mobile phone whether basic or smart and it's where the SMS would be displayed.

Display element. A Liquid Crystal display was used in this system to display the status of the beehive. This is an output device in particular used for presentation of information in visual or tactile form.

3.5 System Implementation

Once designed, the system implementation was achieved by connecting the sensors into a provisional bee hive, programming the GSM to communicate from those sensors to the phone. The program was coded in embedded C language in Arduino 1.5.6 –r2; it then went through various levels of simulations to ensure that the system attained the required standard. The program was then loaded onto the microcontroller.

The weight sensor was connected in the inside bottom of the bee hive to take measurements in case of weight changes of which it would imply honey accumulation a signal to the GSM which would then alert the farmer through his phone.

The light dependent resistor was placed in the middle of the upper beehive so that in case of anyone opening from any end it can be exposed to light and it sends a signal to the GSM which sends then alert the farmer through his phone.

3.6.0 Testing and Validation

The developed system was tested using different techniques and these include:

3.6.1 Unit testing

This method involved testing individual units of source code or development process to determine whether they are fit for use. This included testing all the different modules and classes independently.

3.6.2 Integration testing

The different codes were brought together and tested for inter-process communication; this also helped to know that the combined units work by the help of a compiler.

3.6.3 System testing

This was carried out to ensure whether the system was in line with the specified requirements. It took place on the overall integrated system.

CHAPTER FOUR

SYSTEM ANALYSIS AND DESIGN

4.0 Introduction

This chapter provides a description and analysis of the developed system, requirements, design.

4.1 Functional Analysis

The system automatically and continuously reads the output from the weight sensor which is placed at the bottom of the beehive, whenever the critical weight/set weight is recorded, the system sends an alert message to the farmer via the GSM that adequate honey has accumulated. As for the light dependent resistor, it is placed in the top corner opposite the opening of the beehive so as to detect any opening therefore in case of any strong light it will output a signal to the GSM which will then send a message to the farmer about intrusion and also will trigger the alarm.

4.2 Requirements Analysis

Requirement elicitation was done to determine functional requirements and non-functional requirement that favor or hinder functionality of the system.

4.2.1 Functional Requirements

These requirements often result into a functional model that includes all the hierarchical breakdown of the major functional blocks of the system. They serve as the basis for the system testing and validation. The main functional requirements for this project include:

The system’s ability to automatically determine the weight of honey and the light intensity within the hive.

The system’s ability to suggest that the honeycombs are full after considering a given weight from the weight sensor.

The system’s ability to send alert messages to the farmer once the weight sensor confirms that the honeycombs are full and the LDR senses a change in light intensity.

4.2.2 Non-Functional Requirements

While designing the system, some non-functional requirements were achieved therefore the system users by using this system will gain the following results

Performance requirements: the system will have a fast response time in that it responds quickly to a change in the weight readings and the light intensity.

Availability: The system will be able to run 24/7.

The system also will be able to perform a lot of computations and still function effectively.

4.3 System Design

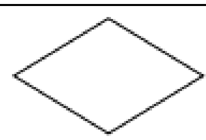
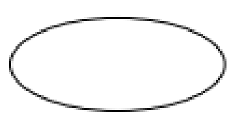
System design is the process of defining the architecture, components, modules, interfaces and data for a system to satisfy specified requirements. It can be seen as the application of systems theory to product development[25].

This system architectural design gives a high level view of the system with the main components of the system, the services each component provides and how the different components communicate to the system.

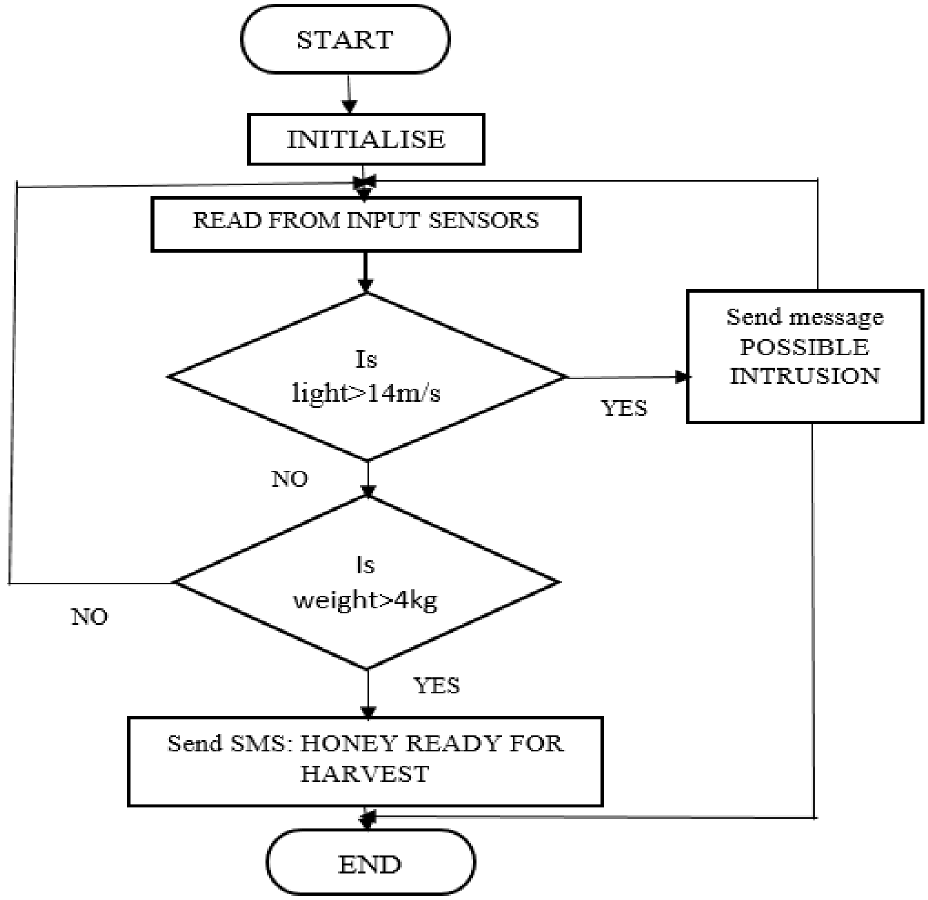
4.3.1 Logical design of the system.

This shows the movement of signals, how data is transformed from inputs to produce outputs, how to make decisions depending on queries, the start and stop of the program.

Table 2 symbols used in the flow chart

Name	**Symbol**	**Description**
Data flow		This shows the movement of data through the system
Process		This transforms data from inputs to produce outputs
Decision box		This makes a decision depending on query. It is usually limited to only two options; YES and NO
Initiator or terminator		This shows the start and stop of the program

The following data flow/ logic diagram or flow chart was used with the above key symbols.



4.3.2 The Physical Design;

This describes how the application can be developed/implemented on a physical platform. It represents how the logical design can be implemented on the physical platforms using appropriate technologies.

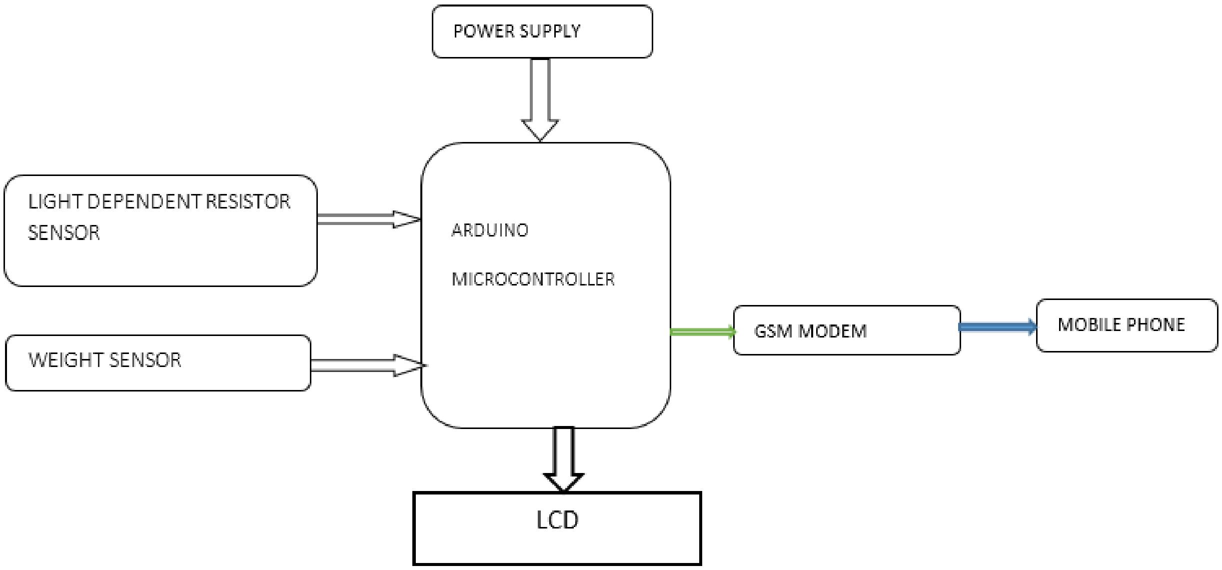
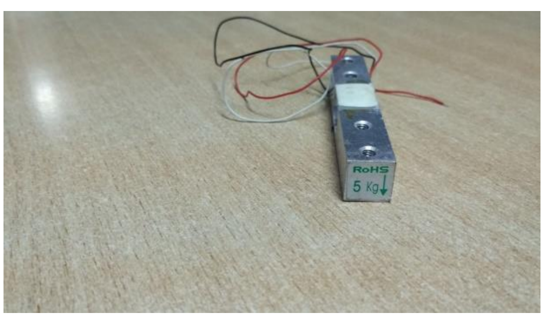
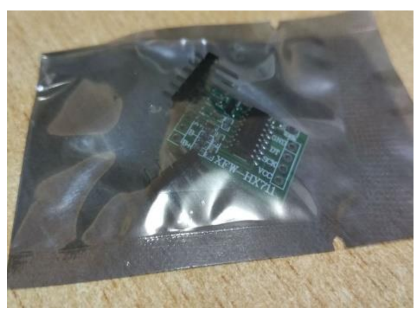


Figure 4 design

Sensing elements. These comprise of the light dependent resistor sensor and the weight sensor, their purpose is providing the notification signals in case of increase in light intensity, and after sensing any change in weight respectively, then the readings are taken to the microcontroller to compare with the logic flow.

Weight sensor with its HX711 amplifier





A load cell (weight sensor) is a force sensing module - a carefully designed metal structure, with small elements called strain gauges mounted in precise locations on the structure. Load cells are designed to measure a specific force, and ignore other forces being applied. The electrical signal output by the load cell is very small and requires specialized amplification. This Single Point Load Cell is used in small jewelry scales and kitchen scales. It’s mounted by bolting down the end of the load cell where the wires are attached, and applying force on the other end in the direction of the arrow[26].

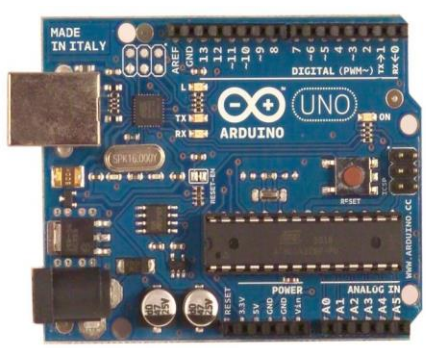
Sensor Properties

Sensor Type	Shear Load Cell
Weight Capacity Max	5 kg
Maximum Overload	6 kg
Temperature Effect on Span	250 mg/°C
Temperature Effect on Zero	500 mg/°C

Hx711 amplifier; The Load Cell Amplifier is a small breakout board for the HX711 IC that allows you to easily read load cells to measure weight. By connecting the amplifier to your microcontroller you will be able to read the changes in the resistance of the load cell, and with some calibration you'll be able to get very accurate weight measurements.

Arduino Microcontroller

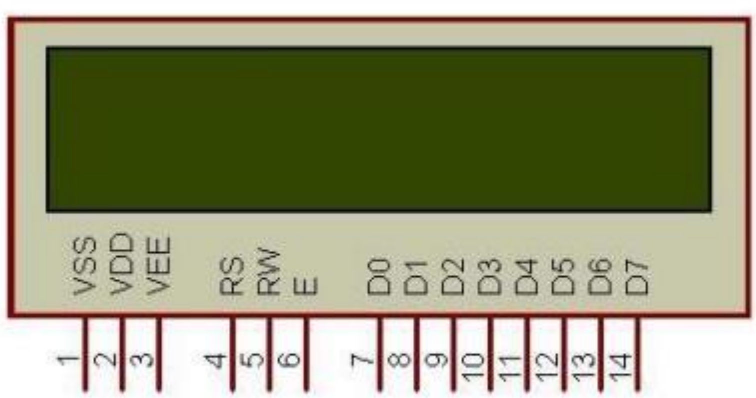
This provides processed data that will send instruction to the GSM module. A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of flash is also often included on chip, as well as a typically small amount of RAM. The Arduino microcontroller is programmed via the Arduino board called the Arduino Uno board. The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button[27]. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.



GSM modem. This is an interface between the mobile phone and the micro controller unit at the station and contains a SIM card. The wireless communication was used to transmit the acquired critical values as detected by the weight sensor and the light dependent resistor. The module that was utilised was SIM900 GSM modem[28].

Mobile phone. This will be the farmer's personal mobile phone whether basic or smart and it's where the SMS will be displayed.

Display element. A Liquid Crystal display was used in this system to display the status of the beehive. This is an output device in particular used for presentation of information in visual or tactile form. An LCD is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically modulated optical device made up of any number of segments filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in colour or monochrome[29].



Connectors (wires). These are signal carriers that transfer signal inform of voltage values from one point to another in the circuit.

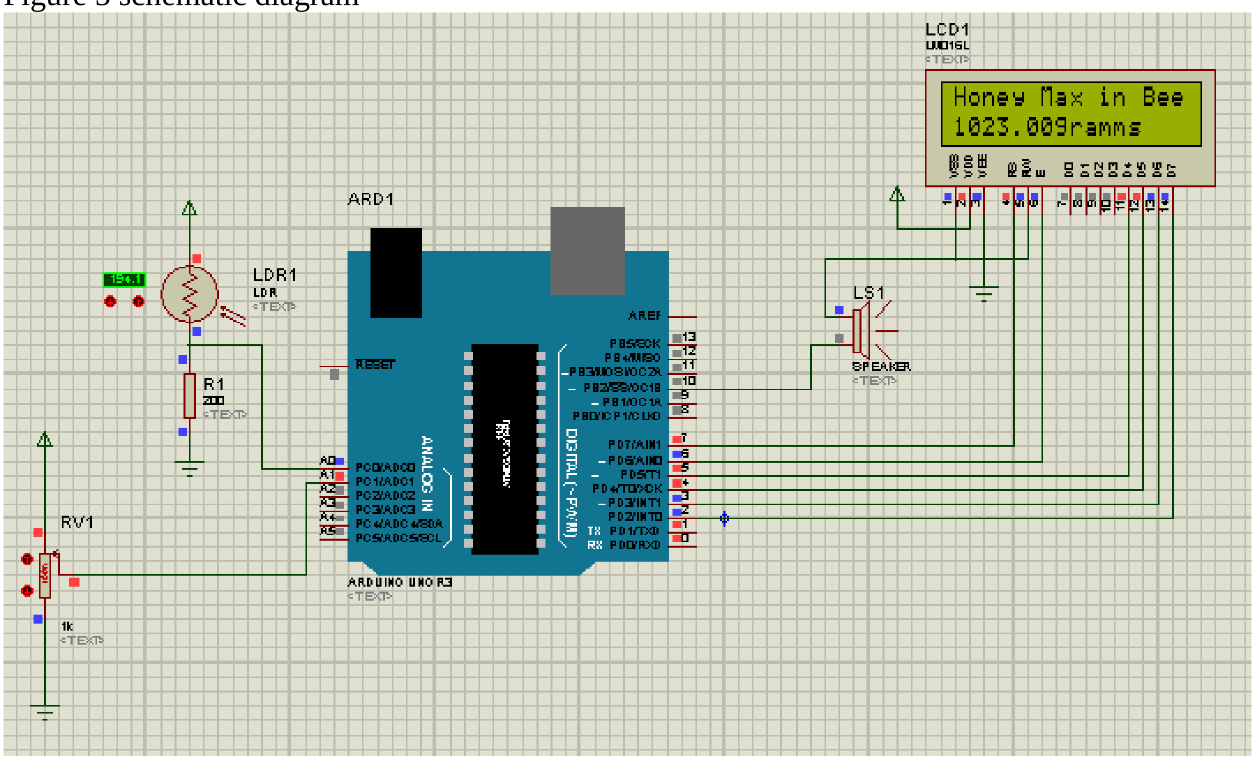
Power supply

A power supply is a component that supplies power to at least one electric load. Typically, it converts one type of electrical power to another, but it may also convert a different form of energy such as solar, mechanical, or chemical - into electrical energy.

4.3.3 Schematic diagram

This was designed in proteus to guide in the actual set up of the system.

Figure 5 schematic diagram



CHAPTER FIVE
IMPLEMENTATION AND TESTING

5.0 Introduction

This chapter discusses the project results, explaining the different tools used while developing the system, the minimum hardware requirements needed for the deployment of the system, how the system will operate and how it will be used.

5.1 Development Platforms

Before development began it was necessary to choose an Integrated Development Environment (IDE) with which the system would be coded, The IDEs chosen was Arduino platform for coding hardware and Proteus where the system design is made as well as simulating the various system components.

5.1.1 Arduino.

Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment.

Why Arduino

Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50.

Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.

Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.

5.1.2 Proteus

Proteus consists of many separate programs plus a large number of additional files (e.g. libraries and models). This is an open source platform where all the circuit designs were made as well as simulation to test how the various components work[30].

5.2 Code Designs

The codes of the system were designed using Arduino programming language. Some codes have been explained below.

5.2.1 Weight sensor code

If a given weight is exerted on the sensor the weight readings are displayed on the liquid crystal display (LCD), then if it is increased up to the required weight for confirmation of a full beehive, then the system sends a message to the farmer's mobile phone via the GSM telling him that "HONEY IS FULL PLEASE COME AND HARVEST."

```
Serial.print("Reading: ");
 double kg = (scale.get_units());
  Serial.print(kg);
  lcd.setCursor(0,0);
  lcd.print("WEIGHT: ");
  lcd.print(scale.get_units(), 3);
  lcd.print("Kg");

  Serial.print(" kg"); //Change this to kg and re-adjust the calibration factor if you follow SI units like a sane person
  Serial.print(" calibration_factor: ");
  Serial.print(calibration_factor);
  Serial.println();
 delay(1000);
GSM CODE ;
if ( kg>4){
  lcd.setCursor(0,0);
  lcd.print("HONEY FULL        ");
  lcd.setCursor(0,1);
```

```
  lcd.print("HARVEST PLEASE     ");
  Serial.print("HONEY FULL");
   mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
  delay(1000);  // Delay of 1000 milli seconds or 1 second
  mySerial.println("AT+CMGS=\"+256772898977\"\r"); // Replace x with mobile number
  delay(1000);
  mySerial.println("AT+CMGS=\"+256781980273\"\r"); // Replace x with mobile number
  delay(1000);
  mySerial.println("honey is full come and empty the beehive thank you");// The SMS text you want to send
  delay(1000);
   mySerial.println((char)26);// ASCII code of CTRL+Z
  delay(10000);
  Serial.println("Message sent");
```

5.2.2 Light Dependent Resistor Code

These set a value of the light intensity where the light dependent resistor will vary. If the light intensity is above 14m/s the LDR sends a signal to the controller which sends an SMS to the farmer that possible intrusion is detected.

```
if (ldr>14){
  Serial.print("intruder detected");
lcd.setCursor(0,0);
  lcd.print("INTRUDER DETECTED ");
  lcd.setCursor(0,1);
  lcd.print("HURRY PLEASE     ");
   mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
  delay(1000);  // Delay of 1000 milli seconds or 1 second
  mySerial.println("AT+CMGS=\"+256772898977\"\r"); // Replace x with mobile number
  delay(1000);
  mySerial.println("AT+CMGS=\"+256781980273\"\r"); // Replace x with mobile number
  delay(1000);
```

```
  mySerial.println("An intruder is detected in the beehive please come      ");// The SMS text you want to send
  delay(1000);
   mySerial.println((char)26);// ASCII code of CTRL+Z
  delay(10000);
  Serial.println("Message sent");
```

5.3 System testing

This was conducted on a complete, integrated system to evaluate the system's compliance with its specified requirements.

For module unit testing, the C code (program) was tested first, before it was embedded onto the microcontroller, and it was running without errors. This included the source codes for implementing the sensor unit, microcontroller operations and control functions. Also, the independent hardware components of the system were tested before connection. As for integrated system testing, after embedding all the C source codes onto the microcontroller, and connecting all the other components on the Printed circuit board, the system was tested for inter-process communication and it was a success.

5.4 System verification

This was done to ascertain that the system was meeting its specification and delivering the functionality it was expected to do. The system was checked for accuracy, performance, and completeness.

Accuracy: The system was checked to find whether it was working well at different intervals of time and in all the tests carried out correct results were output. This proved that system is accurate.

Performance: The system was checked to find out the time it takes to react to any abnormal condition(when the light intensity changes in the beehive or increase in the weights of the honeycombs) and output the results, the system response was fast. This proves that the system's performance is good.

Completeness: The system was checked to find out whether all the functionalities specified during the design stage were satisfied. The system had all the functionalities and was therefore declared complete.

5.5 Validation of the system

During the implementation process, verification of the system was performed by checking that the system was meeting the specified functional and non-functional requirements. This is where I tested the system functionality against the requirements.

This was done by connecting a weight sensor, LDR, LCD, GSM and other components to the microcontroller and establishing the communication between them and the system was running normally by indicating response to increase in the weight of honeycombs and change in light intensity within the hive.

5.6 System evaluation

The developed system once deployed will meet all of the required objectives that is determining the weight of the honeycombs, detecting intrusion, and notifying the farmer wireless about the state of the hive regardless of distance.

Comparing my system with other related ones;

This system will consider some of the most problems facing our local farmers and when compared to others it is cheaper to deploy hence it will be affordable by majority. The other related systems have been considering the bee health but my system is unique it goes ahead to ensure good harvests and this will help in improving the Agricultural sector thus increasing the world's economy.

Cost efficiency by this system has been met because the system has been built with minimum cost which is worth the work it is to serve and will be affordable by the target group.

CHAPTER SIX
DISCUSSION AND RECOMMENDATIONS

6.0 Introduction

This chapter discusses the results of the system, conclusion as derived from the observation and findings from the study, design, implementation, testing and validation of the system. Then it gives recommendations for further study and improvements.

6.1 Summary of Work Done.

The main objective of this project was to design and implement a beehive intrusion and monitoring system that determines the fullness of honeycombs and the possibility of an intruder. The system is able to measures the weight of honeycombs and the light intensity inside the beehive, compare with the estimated values in the code according to the test prototype then it sends messages in case any of those conditions is met.

The work done can be summarized in three stages,

a. Choosing the project

After much thinking, observation and consultations I came up with the idea to help the agricultural sector specifically bee farming as bees are most important to our living. I had to first see the problems that have not been addressed yet and they might affect the produces in that sector hence I came up with a beehive intrusion and monitoring system. After identifying the problem I was given a go ahead by the project coordinators that is Miss Ansigwire Barbra kabwiga and Mr. Ocen Gilbert, they then assigned me a supervisor, Mr. Alunyu Andrew who helped and guided me model well the system to achieve my objectives.

b. Planning, executing and management of the project

This stage involved a number of activities that ranged from problem identification, problem modelling, system analysis, researching, design and development, documentation, and management among many others.

c. Documentation

This started with documenting every work on each and every stage of my progress in this project. Records regarding my thoughts, observations, readouts and advice from my supervisor and other lecturers thought our regular meetings were kept in a good custody. On a general ground, the project was streamlined towards the technicalities of designing and developing a beehive intrusion and honey monitoring system for local bee keepers.

6.2 Critical Analysis /Appraisal of the work

I have been committed for a period of eight months while working on a system that automatically monitors the status of a beehive regarding honey rise and intrusion. The system has been tested, validated and proven to work and it can now be used on current beehives.

The system as a whole has also achieved the main objective as it was proposed.

Basing on the design setup of the system, this system can be set up to work in current beehives. The system at hand is fully operational and its guidelines on future usage are provided in the recommendation.

I am convinced beyond doubt that this system is going to help the local bee farmers as well as the modern ones to keep track of their apiary wirelessly hence it will be time saving.

However the system has a limit of operation, it won't help the farmer harvest the honey or even catch the intruder.

6.3 Recommendations.

My system can currently work on one beehive only which means it might be costly for large scale farmers, I therefore recommend advancement and maybe use one GSM for a group of hives so as to reduce costs.

I also recommend the use of more than one weight sensor so as to get accurate value even if there is poor distribution of honeycombs.

As far as powering the system is concerned I recommend the use of solar because it can be reliable and less costly

6.4 Conclusion.

Premature harvest is a major problem in beekeeping, therefore I have designed such a system which automatically monitors the status of a beehive regarding honey rise and intrusion then alerts the people by using GSM to send a message to their mobile phones.

REFERENCES

[1] Y. Humbatov, "Current State and Development of Beekeeping in Azerbaijan," *Components of Scientific and Technological Progress,* no. 3, pp. 24-27, 2015.

[2] R. Krell, *Value-added products from beekeeping* (no. 124). Food & Agriculture Org., 1996.

[3] M. Ogaba, "Household poverty reduction through bee-keeping amongst Uganda rural women," *Standing Commission of Beekeeping for Rural Development, Monmouth,* 2002.

[4] E. Crane, "The past and present status of beekeeping with stingless bees," *Bee World,* vol. 73, no. 1, pp. 29-42, 1992.

[5] A. Mujuni, K. Natukunda, and D. Kugonza, "Factors affecting the adoption of beekeeping and associated technologies in Bushenyi District, Western Uganda," *Development,* vol. 24, no. 08, 2012.

[6] M. D. Meixner, "A historical review of managed honey bee populations in Europe and the United States and the factors that may affect them," *Journal of invertebrate pathology,* vol. 103, pp. S80-S95, 2010.

[7] T. Ermias, "Bee Colonies And People Under The Same Roof," *Bee World,* vol. 89, no. 2, pp. 21-24, 2012.

[8] W. Brown, *Surviving the Apocalypse in the Suburbs: The Thrivalist's Guide to Life Without Oil*. New Society Publishers, 2011.

[9] L. Conradt and T. J. Roper, "Consensus decision making in animals," *Trends in ecology & evolution,* vol. 20, no. 8, pp. 449-456, 2005.

[10] E. A. Capaldi *et al.*, "Ontogeny of orientation flight in the honeybee revealed by harmonic radar," *Nature*, vol. 403, no. 6769, pp. 537-540, 2000.

[11] P. Visscher and R. Dukas, "Survivorship of foraging honey bees," *Insectes Sociaux,* vol. 44, no. 1, pp. 1-5, 1997.

[12] T. D. Seeley, *Honeybee ecology: a study of adaptation in social life*. Princeton University Press, 2014.

[13] S. O. Adjare, *Beekeeping in Africa* (no. 68/6). FAO, 1990.

[14] J.-A. Jiang *et al.*, "A WSN-based automatic monitoring system for the foraging behavior of honey bees and environmental factors of beehives," *Computers and Electronics in Agriculture,* vol. 123, pp. 304-318, 2016.

[15] F. E. Murphy, M. Magno, P. Whelan, and E. P. Vici, "b+ WSN: Smart beehive for agriculture, environmental, and honey bee health monitoring—Preliminary results and analysis," in *Sensors Applications Symposium (SAS), 2015 IEEE*, 2015, pp. 1-6: IEEE.

[16] J. Meitalovs, A. Histjajevs, and E. Stalidzans, "Automatic microclimate controlled beehive observation system," in *8th International Scientific Conference Engineering for Rural Development*, 2009, pp. 265-271.

[17] T. D. Seeley, M. Kleinhenz, B. Bujok, and J. Tautz, "Thorough warm-up before take-off in honey bee swarms," *Naturwissenschaften,* vol. 90, no. 6, pp. 256-260, 2003.

[18] J. Campbell, L. Mummert, and R. Sukthankar, "Video monitoring of honey bee colonies at the hive entrance," *Visual observation & analysis of animal & insect behavior, ICPR,* vol. 8, pp. 1-4, 2008.

[19] M. Struye, H. Mortier, G. Arnold, C. Miniggio, and R. Borneck, "Microprocessor-controlled monitoring of honeybee flight activity at the hive entrance," *Apidologie,* vol. 25, pp. 384-384, 1994.

[20] A. Zacepins and T. Karasha, "Web based system for the bee colony remote monitoring," in *Application of Information and Communication Technologies (AICT), 2012 6th International Conference on*, 2012, pp. 1-4: IEEE.

[21] A. Zacepins and T. Karasha, "Application of temperature measurements for the bee colony monitoring: a review," in *Proceedings of the 12th International Scientific Conference "Engineering for Rural Development*, 2013, pp. 126-131.

[22] C. Liu, J. Leonard, and J. Feddes, "Automated monitoring of flight activity at a beehive entrance using infrared light sensors," *Journal of Apicultural Research,* vol. 29, no. 1, pp. 20-27, 1990.

[23] S. Ferrari, M. Silva, M. Guarino, and D. Berckmans, "Monitoring of swarming sounds in bee hives for early detection of the swarming period," *Computers and electronics in agriculture,* vol. 64, no. 1, pp. 72-77, 2008.

[24] F. Rabiee, "Focus-group interview and data analysis," *Proceedings of the nutrition society,* vol. 63, no. 04, pp. 655-660, 2004.

[25] D. A. Norman and S. W. Draper, "User centered system design," *New Perspectives on Human-Computer Interaction, L. Erlbaum Associates Inc., Hillsdale, NJ,* vol. 3, 1986.

[26] M. Vidrascu, P. Svasta, and M. Vladescu, "High reliability wireless sensor node for bee hive monitoring," in *Design and Technology in Electronic Packaging (SIITME), 2016 IEEE 22nd International Symposium for*, 2016, pp. 134-138: IEEE.

[27] Y. A. Badamasi, "The working principle of an Arduino," in *Electronics, Computer and Computation (ICECCO), 2014 11th International Conference on*, 2014, pp. 1-4: IEEE.

[28] M. S. Zaghloul, "GSM-GPRS Arduino Shield (GS-001) with SIM 900 chip module in wireless data transmission system for data acquisition and control of power induction furnace," *International Journal of Scientific & Engineering Research*, vol. 5, no. 4, p. 776, 2014.

[29] P. A. Penz, "Method of using a liquid crystal display device as a data input device," ed: Google Patents, 1980.

[30] R. M. Haralick *et al.*, "Proteus: a reconfigurable computational network for computer vision," *Machine Vision and Applications*, vol. 8, no. 2, pp. 85-100, 1995.

APPENDICES

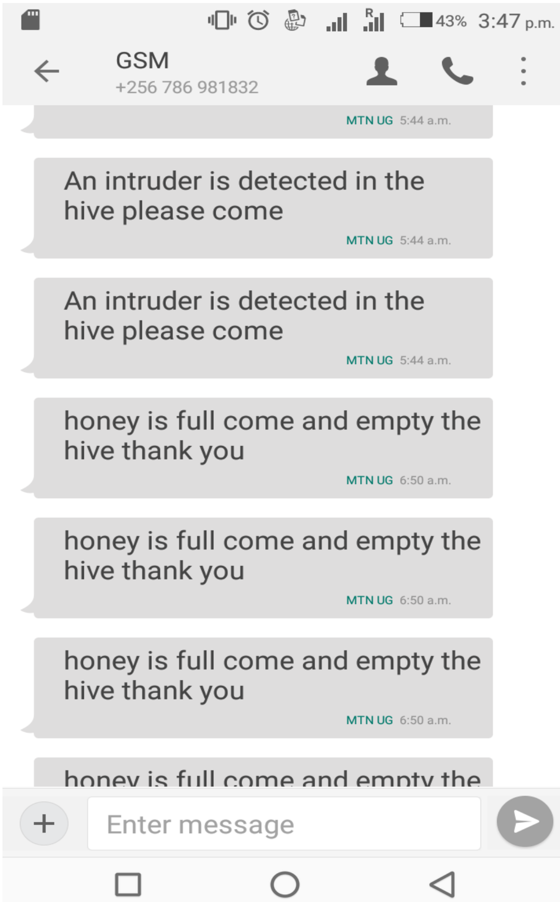
APPENDIX 1: Project code design

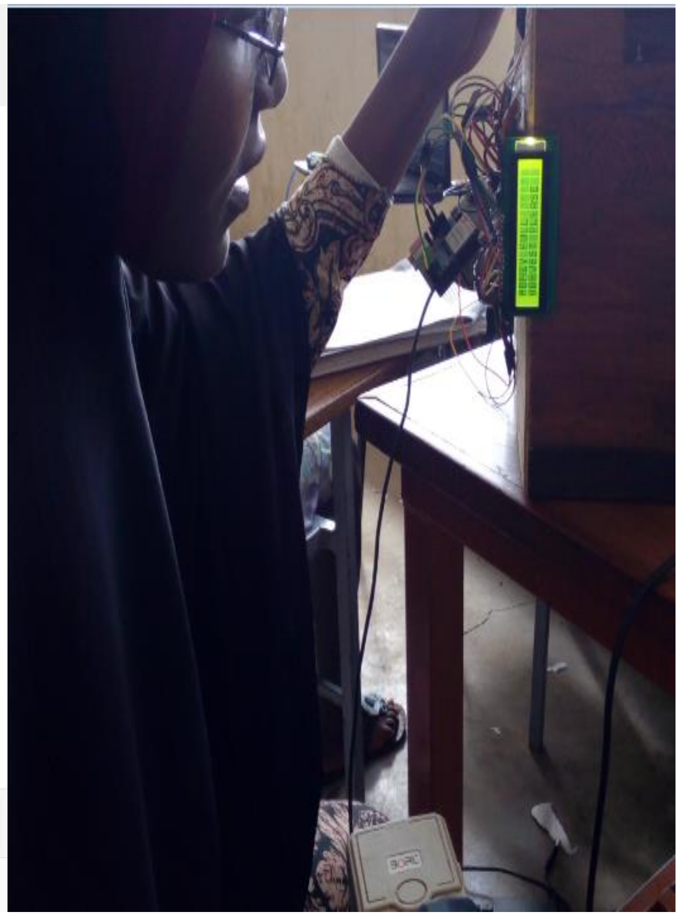
```
#include "HX711.h"  //You must have this library in your arduino library folder
#include<LiquidCrystal.h>
 #include <SoftwareSerial.h>
SoftwareSerial mySerial(2,3);
LiquidCrystal lcd (8,9,10,11,12,13);
HX711 scale(0,0);
 int kg=0;
//Change this calibration factor as per your load cell once it is found you many need to vary it in
thousands
float calibration_factor = -65325; //-106600 worked for my 40Kg max scale setup
//                    SETUP
void setup() {
  Serial.begin(9600);
  mySerial.begin(9600);
  pinMode(A5, INPUT);
  lcd.begin(16,2);
  lcd.print("INITIALIZING...");
  delay(3000);
  Serial.println("HX711 Calibration");
  Serial.println("Remove all weight from scale");
  Serial.println("After readings begin, place known weight on scale");
  Serial.println("Press a,s,d,f to increase calibration factor by 10,100,1000,10000 respectively");
  Serial.println("Press z,x,c,v to decrease calibration factor by 10,100,1000,10000 respectively");
  Serial.println("Press t for tare");
  scale.set_scale();
  scale.tare(); //Reset the scale to 0
  lcd.setCursor(0,0);
  lcd.print("STARTED...            ");
  long zero_factor = scale.read_average(); //Get a baseline reading
```

```
  Serial.print("Zero factor: "); //This can be used to remove the need to tare the scale. Useful in
permanent scale projects.
  Serial.println(zero_factor);
    scale.set_scale(calibration_factor); //Adjust to this calibration factor
  Serial.print("Reading: ");
 double g = (scale.get_units());
}
//                         LOOP
void loop() {
  int ldr = analogRead(A5);
  Serial.print("Reading: ");
  Serial.print(kg);
  lcd.setCursor(0,0);
  lcd.print("                                   ");
  lcd.setCursor(0,1);
  lcd.print("                                     ");
  lcd.setCursor(0,0);
  lcd.print("WEIGHT: ");
  lcd.print(kg);
  lcd.print("Kg");
  Serial.print(" kg");
  Serial.print(" calibration_factor: ");
  Serial.print(calibration_factor);
  Serial.println();
    if ( kg>4){
  lcd.setCursor(0,0);
  lcd.print("HONEY FULL       ");
  lcd.setCursor(0,1);
  lcd.print("HARVEST PLEASE     ");
  Serial.print("HONEY FULL");
   mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
```

```
 delay(1000);  // Delay of 1000 milli seconds or 1 second
 mySerial.println("AT+CMGS=\"+256772898977\"\r"); // Replace x with mobile number
 delay(1000);
 mySerial.println("honey is full come and empty the hive thank you")
 delay(1000);
  mySerial.println((char)26);// ASCII code of CTRL+Z
 delay(10000);
 Serial.println("Message sent");
}else{
 kg=kg+1;
 delay(4000); }
if (ldr>14){
 Serial.print("intruder detected");
lcd.setCursor(0,0);
 lcd.print("INTRUDER DETECTED      ");
 lcd.setCursor(0,1);
 lcd.print("HURRY PLEASE     ");
  mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
 delay(1000);  // Delay of 1000 milli seconds or 1 second
 mySerial.println("AT+CMGS=\"+256772898977\"\r"); // Replace x with mobile number
 delay(1000);
 mySerial.println("An intruder is detected in the hive please come     ");
 delay(1000);
  mySerial.println((char)26);// ASCII code of CTRL+Z
 delay(10000);
 Serial.println("Message sent");
}else{
 Serial.print("empty");
}
```

APPENDIX 2:system testing and sms sent by the GSM to my phone





APPENDIX 3: Field photos during research

APPENDIX 4: Six interview questions used during research.

This entire research was covering a sample population of all local farmers in Uganda. But the sample space was narrowed to a total of four farmers from eastern and western Uganda.

This interview was conducted on selected beekeepers in those areas among which there was a small scale local beekeeper who had about 150 beehives in a center named Makina, Busia District.

Question one: How do you know the right time to harvest honey?

Question two: how soon do you harvest honey after setting up a new colony?

Question three: do you always find enough honey filling the hive?

Question four: what season gives the highest production and why?

Question five: what is the average amount of honey per harvest?

Question six: to what extent do intruders or thieves affect the general produce?

After analyzing their response**,** I found out that most of the local farmers just use their experience to estimate after every three months. Or they observe the bees being hostile and protective of their hives and also they can predict by observe the holes of entrance turning to dark black.

As for the period lag, most of our local farmers after setting up a new colony they wait for three months and then the go for harvesting.

I also found out that honey is not always enough since honey production can be affected by many factors like seasonal changes, availability of suitable feeds for bees around and foraging behaviors of the bees among others.

I also found out that normally to many farmers, the dry seasons always is the convenient time for good harvests since bees don’t stay inside the hive, the bees always go out to look for food and come back to make honey. As for the rainy season bees fear getting out and hence they stay in the hive feeding on their own honey. This sometimes leads to completely no produce or very low produce thus a bee farmer need proper timing.

From Analysis, for the world vision beehives currently being used mostly, farmers get 5kg produce for a better harvest. Others defer according to size and size of honey combs built.

Lastly, from many farmers’ analysis the intruders affect the produce at a large scale since they don’t even use the technical ways of the farmers.