Abstract

The Cattle Health Monitoring System is an innovative project that seeks to enhance the well-being of cattle by leveraging the power of wireless sensor networks. The system utilizes a state-of-the-art electronic device that is affixed to the ear of the animal to capture and transmit real-time data on critical health parameters such as heart rate, blood oxygen levels, and eating patterns. Additionally, the system is designed to monitor the surrounding environmental factors, including temperature, humidity, and presence of toxic gases, which can negatively impact the health and productivity of the cattle.

By continuously gathering and analyzing this data, the Cattle Health Monitoring System empowers livestock farmers to detect early signs of disease, distress, or environmental hazards that can adversely affect the health and productivity of their livestock. With this information, livestock farmers can take timely and informed decisions to optimize the health, welfare, and profitability of their cattle operations. Ultimately, the Cattle Health Monitoring System represents a transformative solution that promises to revolutionize the way we monitor and manage the health and well-being of our livestock.

Acknowledgement

I would like to express my sincere gratitude towards following individuals and organizations for supporting the development of this project throughout the period. First of all, I would like to express my sincere Thanks to my Supervisor, Associate Professor Dr. Muhammad Iqbal for his insightful comments and guidelines. His supervision guided me towards achieving the goals more effectively and efficiently.

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I am deeply indebted to all of my Teachers who cherished my skills and equipped me with the ability to develop a utility item in the form of this project. In addition, I would like to Express Thanks to Final Year Project Committee for providing the students with development framework and guidance in project development stages, timelines and documentation. Their positive input at several stages has helped for a better and organized development process.

More importantly, I must express my very profound gratitude towards my Parents and family for their continuous support, extreme helpfulness and encouragement throughout my life. This endeavour was undoubtedly impossible without their support.

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Chapter 1

Introduction

This project aims to make livestock farming easier and more efficient by developing a technological solution based on Wireless Sensor Networks (WSN) that could help the farmers monitor their livestock health stats in real-time and make informed decisions and avoid any potential threats or dangers to their livestock. Comprising of an electronic device mounted on the cattle body, the project includes complete software package that brings the details of Cattle Health Specs right in the Mobile phones of farmers.

The primary objective of this project is to make the monitoring easier from distances while the secondary objective focuses on ensuring a safer surrounding environment for cattle by monitoring the environmental variables and providing alters and warnings to the user in case of danger.

Combined, this project provides a complete package of Hardware and Software that could potentially improve the way livestock farming works for masses.

The project enables monitoring of following variables

- Monitoring Heart-rate and Blood Oxidation Level in cattle using IR Biosensors.
- Monitoring Body temperature of the animal
- Recognizing motion patterns to identify eating movement activities.
- Keep track of the Environmental Temperature and Humidity Levels
- Detection of Hazardous Gases in the environment

1.1 Motivation

The traditional livestock farming is showing its age in the modern era in different form including low Milk production, frequent disease, reduced reproduction and increased life losses. High usage of artificially processed food could be blamed for this. The society needs advancement in livestock Farming sector to improve the livestock health for better production. Monitoring accounts to bring a significant ease in livestock farming and avoid potential threats to their lives by timely decisions.

1.2 Objective

The main Goal of this project is to explore the possibilities and methods of detecting the diseases in livestock before it becomes a potential risk for cattle. Moreover, the project covers the development of prototype wearable sensor design to read the desired variables and make them accessible to user over wide area network (WAN).

1.3 Methodology

The research includes finding the possible and effective stats to be monitored for the health monitoring and safety of livestock.

The project includes development of a wearable hardware device capable of monitoring the mentioned factors and transmit data to a cloud hosted database using WiFi network.

The project includes development of software to host and save data in cloud. Furthermore, it covers the development of Mobile App to make the cloud hosted data accessible to user.

Chapter 2

Literature Review

2.1 Literature Review

The concept of equipping cattle with different types of electronic devices is around for a decade. Sometime there are GPS systems to track their location or NFC tags to keep track of their movement in and out of the farm. A few commercial devices focus on monitoring their activities using Motion Sensors. However, monitoring their health is not under a common focus. The brief analysis of different sensors and monitoring techniques was provided by Lee Mingyung and Seo Seongwon in their study. It greatly contributed in providing information about the type of effective variables to be monitored [1],

The information about possibility of detection of diseases using bio-sensors was obtained from a survey paper published by Sharma B. and K. Deepika which provides a deep insight about the respective types of monitoring patterns that can help predict the possibility of disease in cattle [2].

The general framework for this project was inspired by approaches mentioned in an arti-

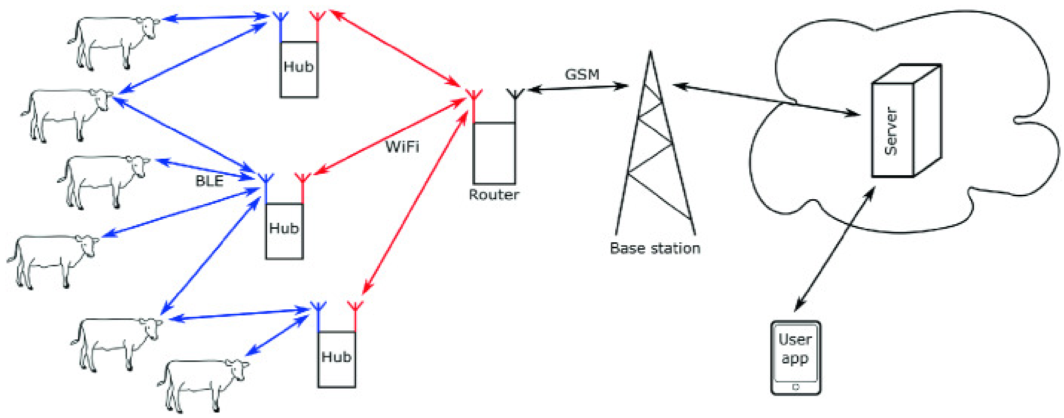

Figure 2.1: Design methodology proposed by Unold O. and Nikodem M.

cle published by G. Suseendran and D. Balaganesh. They proposed a complete model of an electronic system capable of monitoring data using different sensors and transmitting it using Wireless networks [3]. Furthermore, an interesting way to connect sensor nodes to a central hub and transmitting data using GSM was proposed by Unold O. and Nikodem M. in their article previewed in figure 2.1 [4]

2.1.1 Bio Sensors

This project uses heart rate monitoring of cattle as a key aspect of disease detection method paired with other sensors to ensure authenticity of received data. It involves a lot of complexities and confusions in monitoring and data processing patterns. However, there are several ways for the monitoring of heart rate. This project select a particular sensor MAX30102, for this purpose. The decision of its selection was made by the information obtained from a review paper published by Nie and Luwei [5]. Moreover, reading the blood oxidation level and body temperature along with heart rate gives an enhanced level of details and improved satisfaction about the results obtained.

2.1.2 Motion Tracking and Activity Monitoring

Analyzing the activities of livestock using Inertial Measurement techniques is very common among the research community. Several articles propose their methods of tracking different activity patterns. Fan, Bowen and Bryant, Racheal presented a brief comparison and review of different commercially available health monitoring and motion tracking devices in their review paper [6]. A Japanese Firm, DESAMIS Co. Ltd. developed an Artificial Intelligence based solution named U-Motion which is being distributed as a commercial product. It uses a necklace style electronic device that predicts the diseases and health status using 6 Dimensional Activity tracking algorithms explained in Figure 2.2.

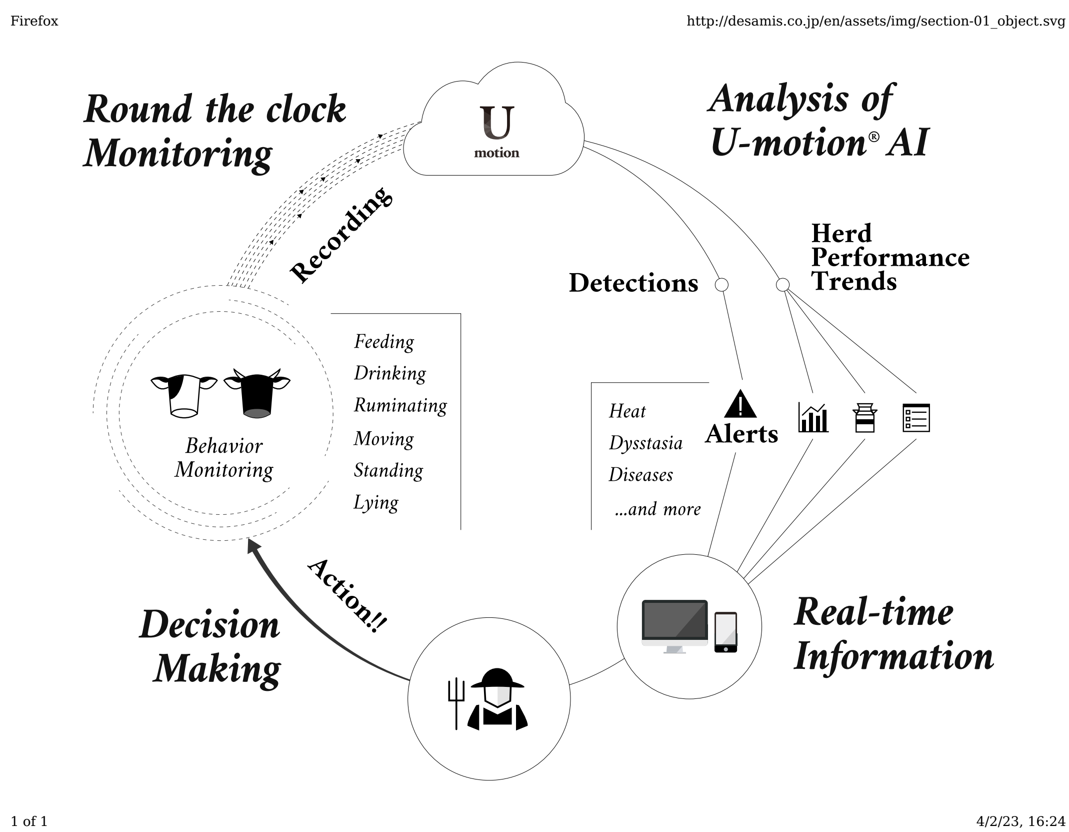

Figure 2.2: Courtesy of the DESAMIS Co. Ltd

Although this approach was appealing for developing an advanced and more capable system, the Components required were not readily available. Moreover, the technology proposed by DESAMIS Co. Ltd was not publicly available. All of these factors resulted in the decision of neglecting this design framework despite it being the best.

Chapter 3

Requirements Specifications

The Non-functional and Functional Requirements are categorized into various groups based on relations and objective of requirements. Each requirement is assigned an ID. All the Functional and Non-Functional requirements along with their sub sections are presented in this chapter.

3.1 Non-functional Requirements

3.1.1 Product requirements

Table 3.1 presents the product requirements with their priority ...

Table 3.1: Product Requirements

ID	Priority	Details
NR-01-001	1	**Performance:** This project satisfies the desired performance criteria.
NR-01-002	1	**Accuracy:** The results obtained from this project resembles with the actual results under similar conditions.
NR-01-003	1	**Usability:** This project is acceptable for the intended use case.
NR-01-004	1	**Reliability:** This project is reliable with a specified margin of tolerance for operating conditions.
NR-01-005	2	**Portability:** This project can be operated as a standalone system
NR-01-006	2	**Scalability:** This project offers scalability allowing user to increase the number of sensor nodes.
NR-01-007	1	**Accessibility:** This project is accessible for public use without any restrictions.

3.1.2 Organisational requirements

The organizational requirements are as tabulated in Table 3.2 . . .

Table 3.2: Organizational Requirements

ID	Priority	Details
NR-02-001	1	**Delivery:** The system development process and deliverable documents comply with process and deliverable defined in the document “CIIT-CE-02H Degree Project Student’s Handbook”.
NR-02-002	1	**Standard:** The standard of the final product are of undergraduate level.

3.1.3 External requirements

The external requirements are as tabulated in Table 3.3 ...

Table 3.3: External Requirements

ID	Priority	Details
NR-02-001	3	**Security:** This is a degree project having no strict security requirements.
NR-02-002	1	**Ethical:** The application does not use any type of un-ethical electronic material while project development and execution.
NR-02-003	1	**Legislative:** The application does not use any private or confidential data, or network information that may infringe copyrights and/or confidentiality of any personnel not directly involved in this product.
NR-02-004	2	**Safety:** This application is safe to operate, handle and store. It does not pose any threat to human life or property in any way.

3.2 Functional Requirements

3.2.1 Category 1

The functional requirements of category 1 for this project are described in Table 3.4 ...

Table 3.4: Functional Requirements Category 1

ID	Priority	Details
NR-01-001	1	**Micro-controller:** ESP32 SoM as a micro-controller handles the interfacing with peripherals and execution of algorithms for data processing.
NR-01-002	1	**Power Management:** A Boost converter network ensures smooth power delivery with focus on efficiency.
NR-01-003	1	**BMS:** BMS manages the battery charging and discharging.
NR-01-004	1	**Bio-sensors Sensor:** Bio-sensors equip the project with ability to read biological variables of cattle.
NR-01-005	2	**Environmental Sensors:** Environmental sensors to provide additional safety in hazardous conditions.
NR-01-006	1	**Network Interfacing:** Network Interfacing provides a protocol for sensor nodes to communicate with the host.

3.2.2 Category 2

The application is intended to generate ... Following requirements should be met under given priorities in Table 3.5 ...

Table 3.5: Functional Requirements Category 2

ID	Priority	Details
NR-02-001	1	**Database:** Database receives data from sensor nodes and acts as a server for communication between nodes and user interface.
NR-02-002	1	**Mobile App:** Mobile application provides a dashboard for user to access data in real-time.
NR-02-003	1	**Secure Communication:** The communication between user, database and sensor node provides a secure, SSL protected communication.
NR-02-004	2	**Sign In:** The access of user dashboard is protected by Sign In Page.
NR-02-005	2	**User Friendly UI:** The App UI is user friendly and easy to use.

3.2.3 United Nations Sustainable Development Goals

This project contributes the following United Nations SDGs mentioned in Table 3.6.

Table 3.6: United Nations SDGs

ID	Priority	Details
SDG 12	1	**Sustainable Consumption and Production Patterns:** This project focuses on improvement of Cattle health to improve food production in livestock sector.
SDG 15	2	**Protect, restore and promote sustainable use of terrestrial ecosystems:** The outcomes of this project satisfy this SDG by protecting habitats for livestock animals.

Chapter 4

Project Design

4.1 Methodology

The first prototype developed for proof of concept is shown in the figure 4.1. Several types of sensors and controllers were tested and their results were compared in order to ensure the proper functionality of the project. This prototype design was implemented after testing of sensors and other components individually and then combining them all to bring a complete functional unit.

The prototype was helpful in initial verification of the requirements and provided confidence in regards of the direction of development. The size constraints were especially taken into consideration to ensure the application is suitable for animal as a wearable device. In this regard, highly integrated components were used and power management system was figured out to provide the maximum running time with smallest possible size.

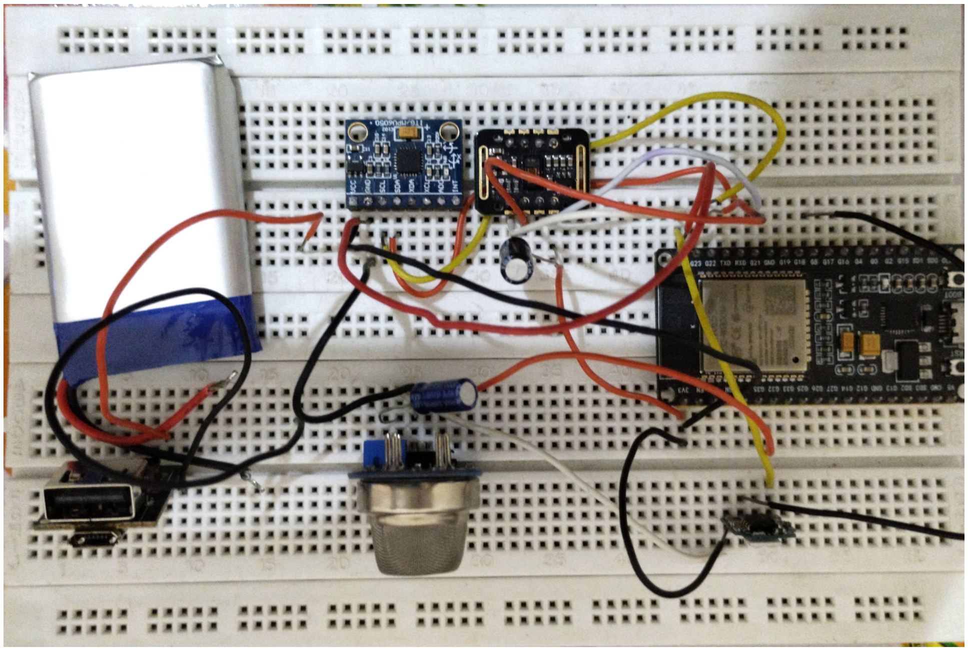

Figure 4.1: First Prototype Application

4.2 Architecture Overview

The design of the intended product is explained graphically with the help of a diagram shown in figure 4.2. The diagram explains the overall interactions of the modules and their placements.

The sensor nodes are mounted on the ear of the animal. The network connection is required in the vicinity of cattle shed. The sensor node automatically searches for network and connects. The WiFi access point manages the communication between sensor Node and Database Server using Internet connection. This approach however, is very similar to the model proposed in [7]. The selection of firebase as a database server was inspired by the analysis in an article by Wu-Jeng and Yen [8].

The user access information through a mobile app which provides a complete dashboard to check information about different animal.

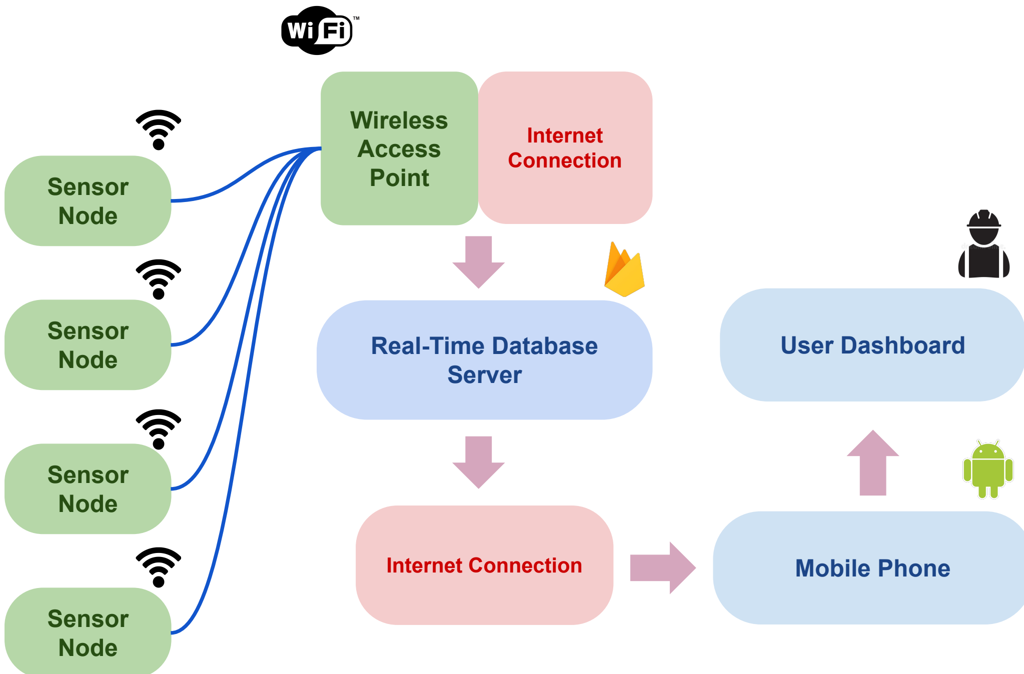

Figure 4.2: Top level Architecture Overview

The user dashboard provides features to deliver a warning to the user in case of emergency. This makes Remote monitoring of livestock, a more sensible option. An open source Development platform was used for mobile application development. It uses Google's Android SDK as a base. The User Interface is created from scratch. The deep information about interfacing of mobile app with Database was obtained from the article by Haki and Aydin Ahmet. The provided detailed guidelines about the development of application and its interfacing with remote database server.

4.3 Design Description

The cattle health monitoring system is designed to monitor the health and well-being of livestock in real-time. It uses multiple sensors, including a heart rate sensor, gas sensor, accelerometer, and temperature/humidity sensor, which are all controlled by an ESP32 micro-controller. The system is powered by a 3.7V 1000mAh lithium-polymer battery, which is managed by a BMS and boost converter to ensure reliable operation. The system can communicate with cloud-based databases using Wi-Fi, making it easy to monitor cattle health in remote locations.

4.3.1 Hardware Design

The description for each module is provided below:

4.3.1.1 Micro-controller: ESP32

The ESP32 micro-controller is used in the cattle health monitoring system, which provides Wi-Fi capabilities to communicate with cloud-based databases. The ESP32 has 2.4 GHz Wi-Fi and Bluetooth capabilities, which can be used to send data to the cloud. Figure 4.3 represent an ESP32 Development kit with pinouts.

- CPU: Dual-core 32-bit processor, operating at 160 or 240 MHz
- Memory: 520KB SRAM, 4MB Flash memory
- Wi-Fi: 802.11 b/g/n/e/i
- GPIO: 34 pins
- Interfaces: UART, SPI, I2C, I2S, PWM, ADC/DAC

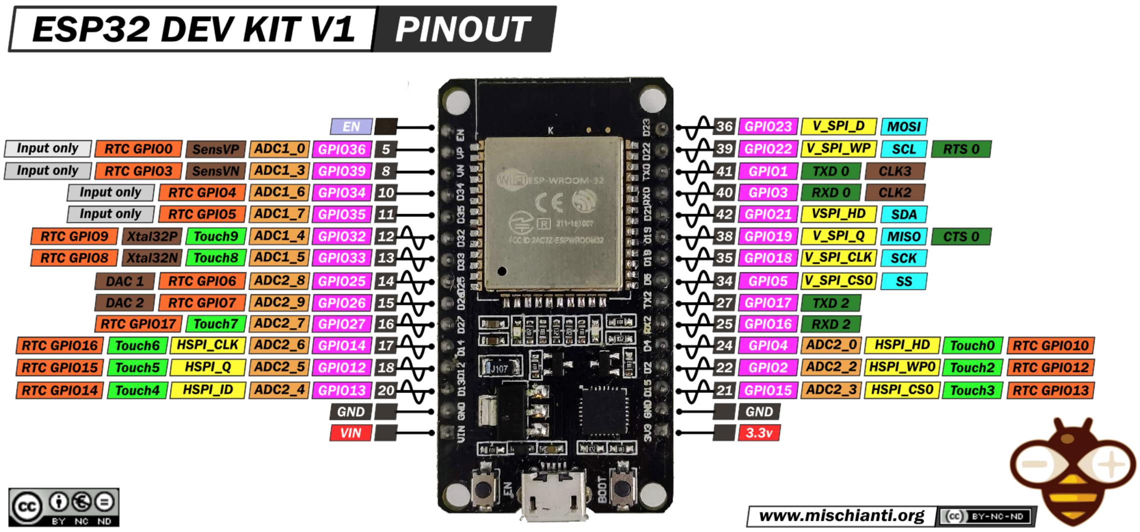

Figure 4.3: ESP32 Development Kit

4.3.1.2 Heart Rate Sensor: MAX30102

The MAX30102 heart rate sensor is used to read the heart rate and blood oxygenation level of the cattle. The sensor is placed on the ear of the cattle, and the readings are taken using the ESP32 micro-controller. The Heart Rate Sensor MAX30102 is visualized in Figure 4.4.

- Supply Voltage: 3.3V
- Communication Interface: I2C
- LED Wavelength: 660nm/880nm
- Oxygen Saturation Resolution: 1

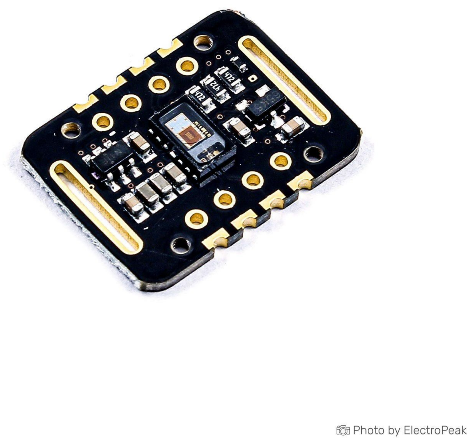

Figure 4.4: MAX30102 Heart Rate and SPO2 sensor

4.3.1.3 Gas Sensor: MQ-135

The MQ-135 gas sensor is used to detect any dangerous gas in the environment where the cattle are living. The gas sensor can detect various gases such as ammonia, nitrogen oxides, benzene, and smoke. The sensor sends the data to the ESP32 micro-controller, which then sends the data to the cloud. The MQ-135 sensor is visualized in 4.5.

- Supply Voltage: 3.3V - 5V
- Detection Gas: Ammonia, Nitrogen Oxides, Benzene, Smoke, etc.
- Sensitivity: Adjustable
- Communication Interface: Analog

Figure 4.5: MQ-135 Gas Sensor

4.3.1.4 Accelerometer and Gyroscope: MPU6050

The MPU6050 accelerometer and gyroscope are used to detect the motion and activity of the cattle. The sensor is placed on the ear of the cattle, and the readings are taken using the ESP32 micro-controller. The MPU6050 sensor is visualized in 4.6.

- Supply Voltage: 3.3V
- Communication Interface: I2C
- Resolution: 16-bit
- Acceleration Range: ±2g, ±4g, ±8g, ±16g

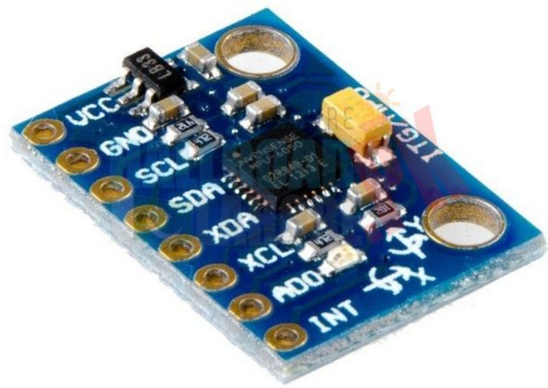

Figure 4.6: MPU6050 IMU

4.3.1.5 Temperature and Humidity Sensor: DHT11

The DHT11 temperature and humidity sensor are used to measure the temperature and humidity of the environment where the cattle are living. The sensor sends the data to the ESP32 microcontroller, which then sends the data to the cloud. The DHT11 sensor is visualized in 4.7.

- Supply Voltage: 3.3V - 5V
- Temperature Range: 0°C - 50°C
- Humidity Range: 20
- Communication Interface: Digital

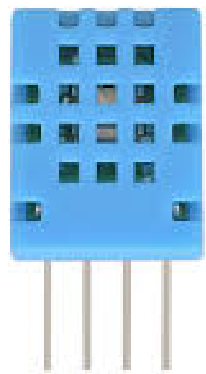

Figure 4.7: DHT11 Temperature and Humidity Sensor

4.3.1.6 Battery and Power Management System

The cattle health monitoring system is powered by a 3.7V 1000mAH LiPo battery. The battery is connected to a boost converter, which converts the voltage to 5V, which is required for the sensors and micro-controller. The power management system is responsible for managing the charging of the battery and ensuring the safe operation of the system. The lithium battery in use is represented in Figure 4.8 while the Battery Management System module cis represented in Figrue 4.9

- Battery: 3.7V 1000mAH LiPo
- Charging: 5V Micro USB
- Boost Converter: DC-DC Step-Up Converter
- Power Management: Battery Management System (BMS)

Figure 4.8: Lithium Polymer, 3.7V Rechargeable Battery

Figure 4.9: Boost converter and BMS

4.3.2 Embedded Software Design

4.3.2.1 Firmware Design

The firmware for the cattle health monitoring system is designed to read data from the various sensors, process the data, and send it to a cloud-based database. The firmware is written in C++ and is based on the Arduino framework. In this regard, an article by Gong and Dong-Hwan helped [9]. The firmware is divided into several modules to improve code readability and maintainability.

4.3.2.2 Sensor Data Collection

The firmware reads data from the various sensors using their respective communication protocols. The heart rate sensor (MAX30102),accelerometer (MPU6050) use I2C Protocol while temperature/humidity sensor (DHT11), gas sensor (MQ-135) use generic GPIO interface to communicate with ESP32. Wi-Fi communication is used to transmit data to the cloud-based database.

4.3.2.3 Sensor Data Processing

The firmware processes the sensor data using algorithms to detect patterns and anomalies in the data. For example, the firmware uses signal processing algorithms to detect the heart rate and blood oxygenation level from the heart rate sensor data.

Specific to MAX30102, the response from sensor is highly fluctuating because of changes of infrared light patterns. To solve this problem, heavy filtering is applied to the data in order to smooth out the obtained curve and get stable results. Firstly, the data received passed through low pass filter and stored in FIFO registers where moving average is applied to get the results. In depth details about the low pass filtering in embedded environments was provided by Miroslav Matejček and Mikuláš Šostronek in their article [10]. However the moving average filtering using FIFOs is inspired by the design presented by Kostalampros and Ioannis-Vatistas in their paper [11]

In MPU6050, an algorithm is designed which performs several checks to detect if animal is stationary, grazing or standing. The early inspiration comes from an article by Bowen Fan , Racheal Bryant and Andrew Greer [12].

4.3.2.4 Data Transmission

The firmware uses Wi-Fi communication to transmit data to cloud-based databases. The data is sent in a structured format that includes the sensor readings in a specific manner.

4.3.2.5 Firmware Update

The firmware can be updated by manually plugging in the Micro-USB Cable and programming using a serial port of computer. This enables servicing and maintainability of the product.

4.3.2.6 Cloud-Based Data Storage and Analysis

The data collected from the sensors is stored in a cloud-based database, where it can be analyzed and visualized using mobile application. The data can be used to monitor the health and well-being of the cattle over time, allowing for early detection of any issues. More details were acquired from an article by Cai, Hongming and Xu, Boyi and Jiang in which they brifly explained the techniques of Cloud hosted IOT Database desing and management [13].

4.3.3 Mobile Application Design

The mobile app for the cattle health monitoring system is designed to allow farmers or caretakers to easily monitor the health and well-being of their cattle remotely. The app provides a simple and intuitive interface that displays real-time sensor data from the cattle health monitoring system.

4.3.3.1 Dashboard

The dashboard is the main screen of the app and displays a summary of the cattle's health status. It shows important information such as heart rate, blood oxygen level, temperature, humidity, and gas levels. The dashboard also includes alerts for any abnormal sensor readings, allowing caretakers to quickly respond to any issues.

4.3.3.2 Sensor Data Visualization

The app includes interactive charts and graphs that visualize sensor data over time. This allows caretakers to easily track changes in sensor readings and identify patterns or anomalies in the data.

4.3.3.3 Alerts and Notifications

The app includes alerts and notifications for abnormal sensor readings, allowing caretakers to take immediate action if necessary. For example, if the heart rate sensor detects a high heart rate or low blood oxygen level, the app will send an alert to the caretaker's phone.

4.3.3.4 Historical Data

The app includes a historical data feature that allows caretakers to view past sensor readings for each of the sensors. This can be useful for identifying long-term trends in the cattle's health and making informed decisions about their care.

Overall, the mobile app for the cattle health monitoring system is designed to provide caretakers with an easy and convenient way to monitor the health and well-being of their cattle remotely. The app provides real-time sensor data visualization, alerts and notifications for abnormal readings, historical data, and settings and configuration options.

Chapter 5

Implementation

We have implemented the suggested design on both hardware and software platforms to realize the concept. The hardware schematic was created and tested for each peripheral independently before integrating the system together. All of the individual sensors were configured in order to receive data in the desired format. Furthermore, different sensor types were tested in order to select and finalize a single one depending on the best performance metrics. . . .

5.1 Development Stages

Following were the discrete phases we have experienced incrementally to realize our product in the given time:

5.1.1 Hardware Components and Software Platform Selection

We started the project by creating a list of possible monitoring options for livestock. Later the finalized options were shortlisted based on the availability of sensors and feasibility of implementation.

The C++ programming language was decided with Arduino Framework as a Hardware Abstraction Layer for convenience in firmware development using available library components for different sensors. It helped reducing the development time significantly.

5.1.2 Schematic Design

The hardware components of the system were tested independently by interfacing with the host micro-controller. This likely involved testing the heart rate sensor, gas sensor, accelerometer, temperature and humidity sensor and battery management system individually to ensure they were all functioning properly.

After each individual hardware component was tested and verified to be working, the next step would have been to integrate all of the components together into a single system. This likely involved creating a schematic that illustrated how each component was connected and how data was being transmitted between them.

Once the schematic was finalized, the components were integrated together to create the final hardware design of the cattle health monitoring system. This likely involved connecting each component according to the schematic and testing the system as a whole to ensure all of the components were working together properly.

Below are the schematics for each peripheral.

5.1.2.1 ESP32 Schematic

Figure 5.1 previews the interconnection of ESP32 Dev-kit along with Power input and sensor interface.

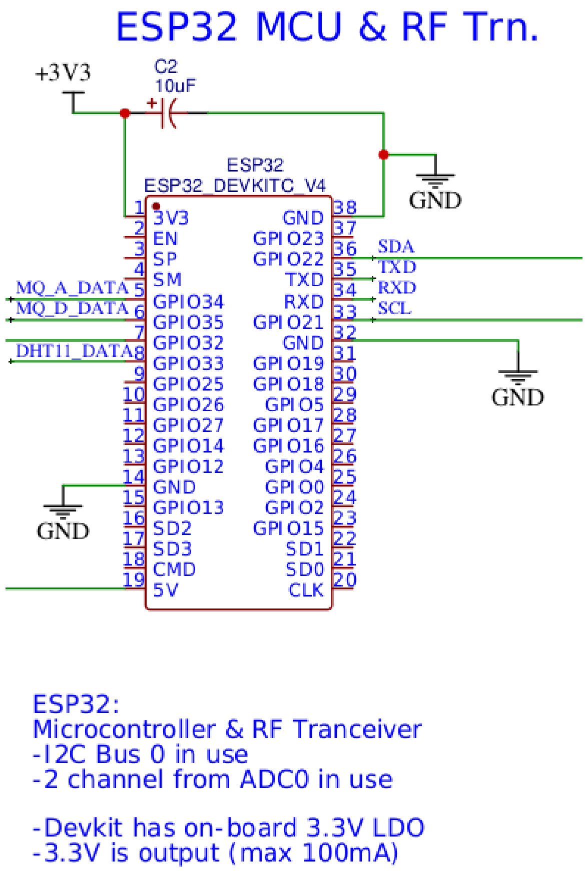

Figure 5.1: ESP32 Schematic Design

5.1.2.2 MAX30102 Interface

The interfacing of MAX30102 over I2C Could be seen in Figure 5.2.

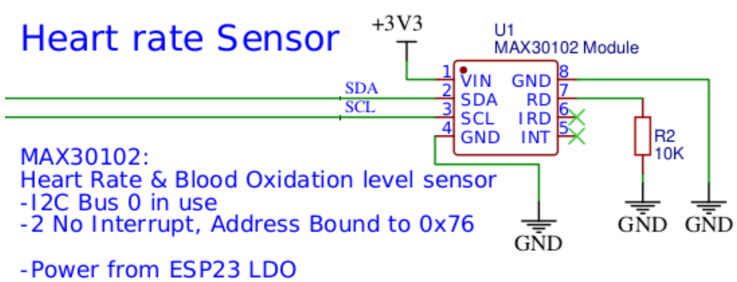

Figure 5.2: MAX30102 Interfacing with MCU

5.1.2.3 MPU6050 Interface

The interfacing of MPU6050 over I2C Could be seen in Figure 5.3.

Figure 5.3: Accelerometer Interfacing with MCU

5.1.2.4 DHT11 Interface

The interfacing of DHT11 over GPIO Could be seen in Figure 5.4.

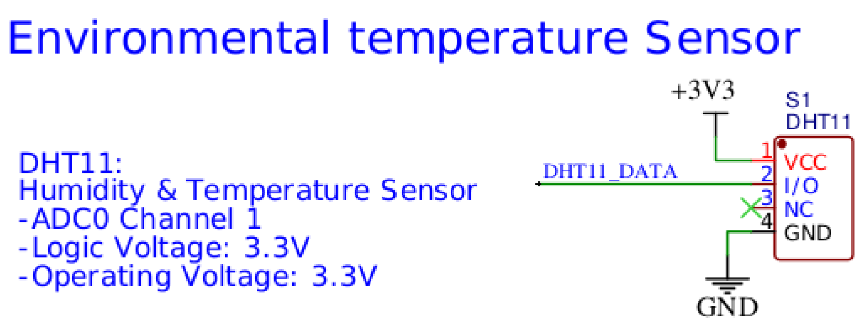

Figure 5.4: DHT11 Interfacing with MCU

5.1.2.5 MQ-135 Interface

The interfacing of MQ135 over Analog Input Could be seen in Figure 5.5.

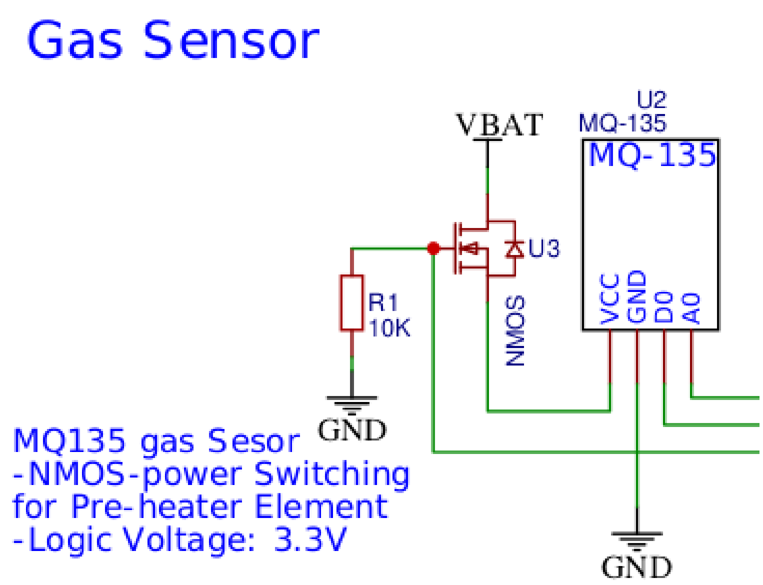

Figure 5.5: MQ135 Interfacing with MCU

5.1.2.6 Power and Battery

The connections of Lipo battery Could be seen in Figure 5.6.

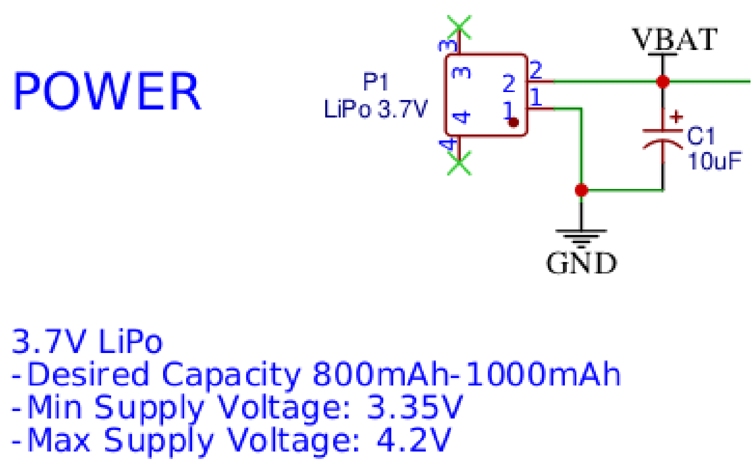

Figure 5.6: Battery power feeding to Voltage Regulator

5.1.3 Firmware Design

The C++ programming language is used with Arduino Framework as a Hardware Abstraction Layer for convenience in firmware development using available library components for different sensors. It helped reducing the development time significantly. Figure 5.7 represents a brief overview of firmware execution sequence in the form of a flowchart.

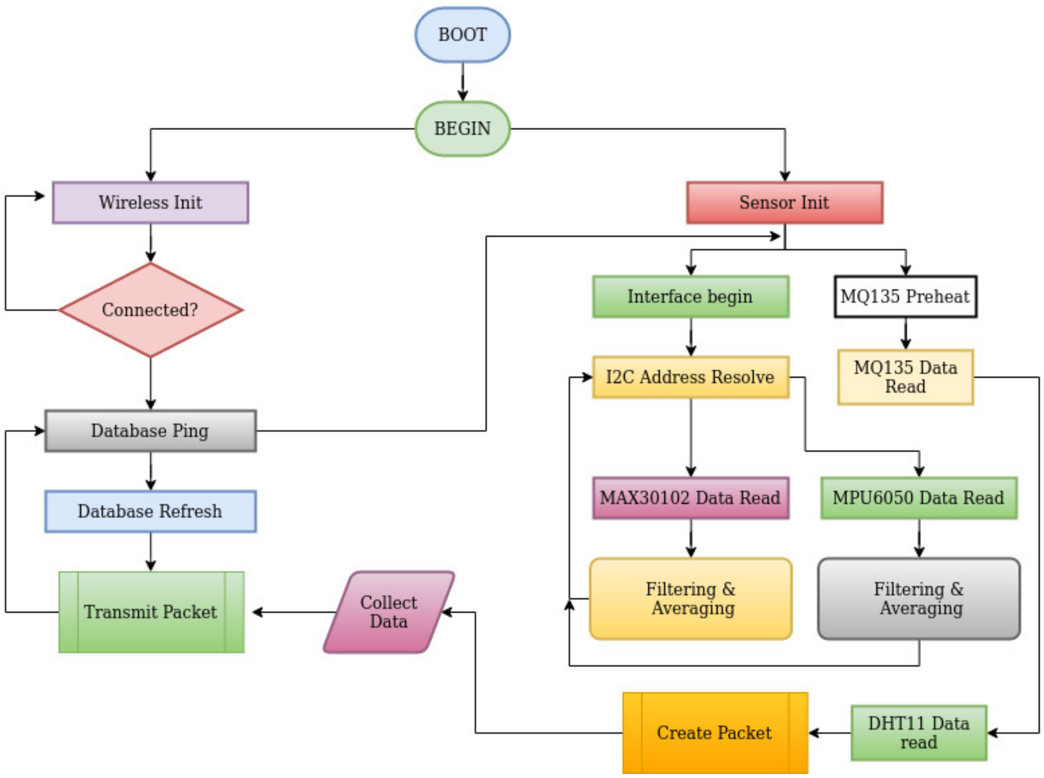

Figure 5.7: Program Flow Sequence

5.1.4 System Integration

The next step followed was to The ESP32 Micro-controller receives power from the Power management module. It has an on board regulator to ensure sufficient supply of power to ESP32 Core and all other peripherals.

Moreover, the interface connections for each peripherals are visualized in the schematic. More detailed view of the schematic could be found in 5.1.3 System Integration.

The figure 5.8 shows the complete schematic design which is fully tested and verified for the application.

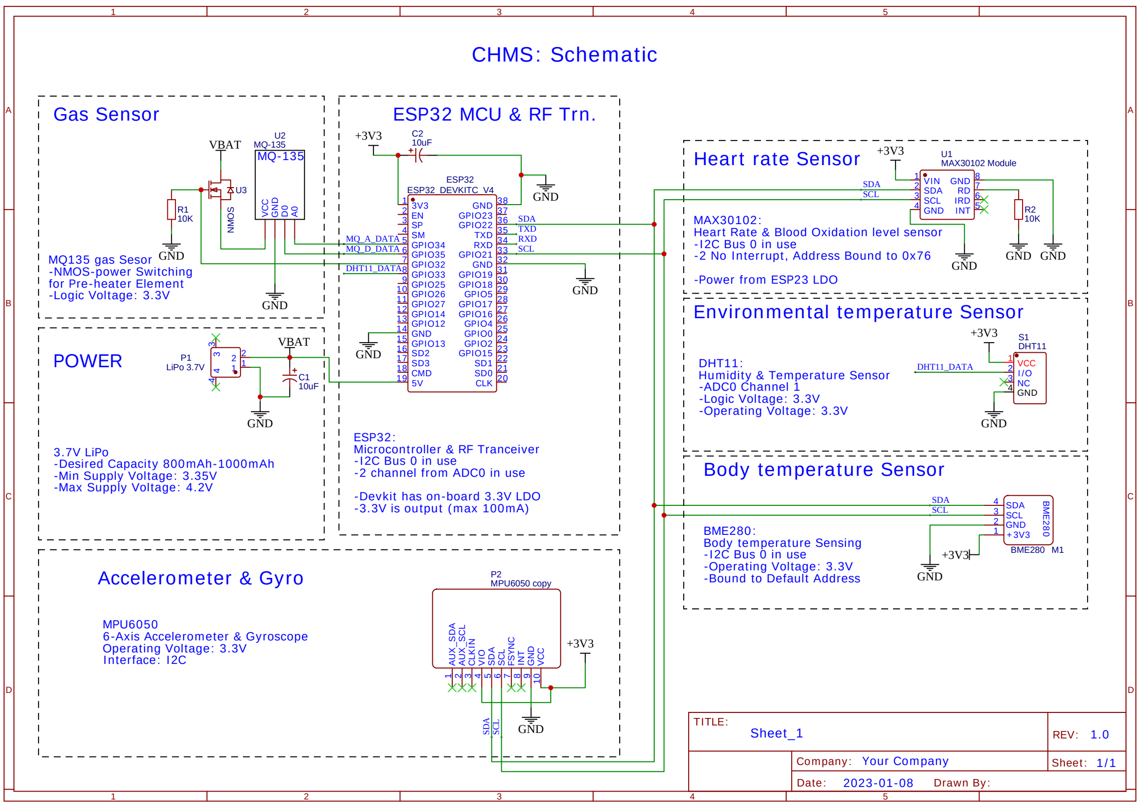

Figure 5.8: System Schematic Design

5.1.5 3D Enclosure Design

Following the wearable nature of the target product, it was necessary to design a compact enclosure box to hold all components together and keep firm during harsh operational environments. To satisfy this requirement, a 3D Model was created in FreeCAD modeling tool. A local 3D Printing service was used to print the Model in physical form. Later, post processing and tooling was required to fit components in it perfectly. Velcro Tapes are used to tie down the enclosure to the ear of cattle.

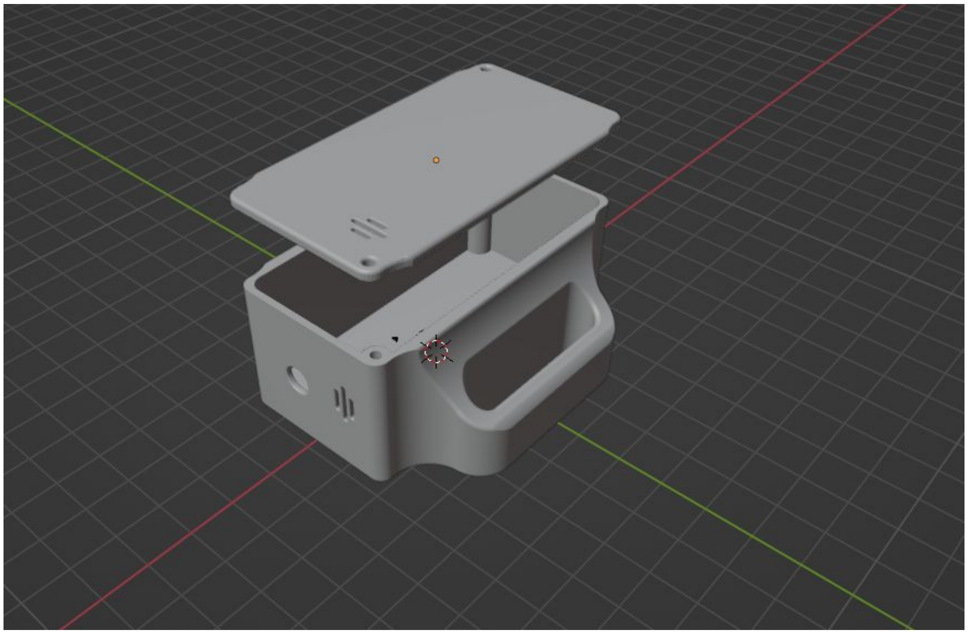

Figure 5.9: 3D CAD View of Enclosure

5.2 User Interface

User Interface is an extremely important consideration for any project that requires human-machine interaction. The Easily Accessible User Interface is critical requirement. In this regard, we have prepared a mobile application that serves as UI Dashboard for user to interact and stay informed. At first, the user is welcomed by a starting page shown in Figure 5.10. It features a Sign in Page for additional security of database information as show in Figure 5.11.

At the dashboard Page, User can see the Status of Each Animal under their name. The names however, are customizable by the user. Figure 5.12 represents the User Dashboard design.

In order to gain more information about each of the cattle, the user can click on the respective icon block to expand the details. Figure 5.13 shows a complete sensor data visualization in real-time.

Figure 5.10: Mobile APP: Start Page

Figure 5.11: Mobile APP: Login Page

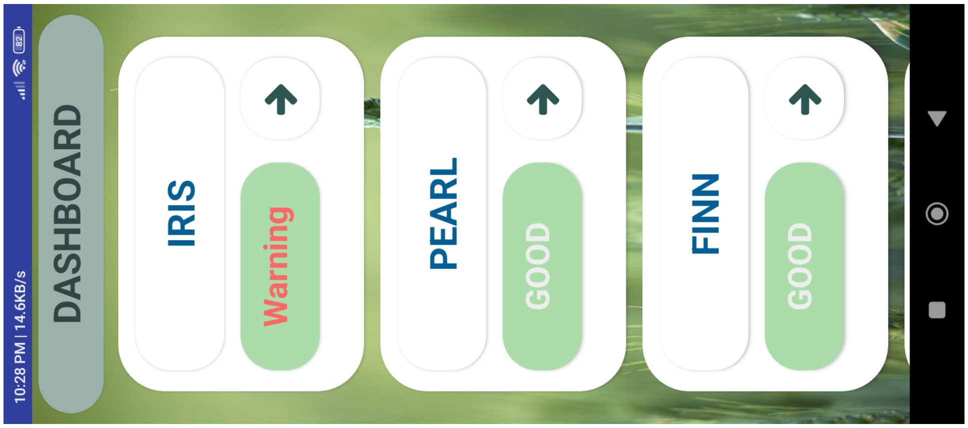

Figure 5.12: Mobile APP: Dashboard

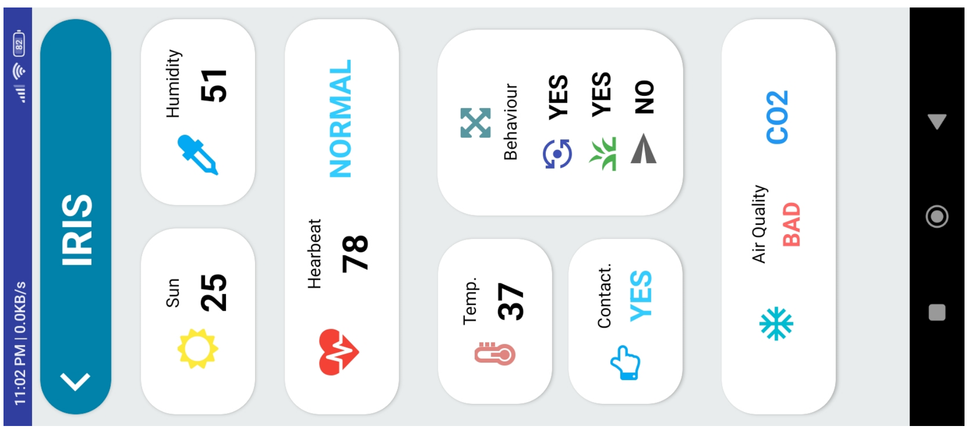

Figure 5.13: Mobile APP: Sensor Data

Chapter 6

Evaluation

After going through the designing and implementation phase of our project the next thing that comes is the evaluation phase. It is a systematic and objective assessment of an ongoing or completed project whereas the main aim is to determine the relevance and level of achievement of project objectives, development effectiveness, efficiency, impact and sustainability. Focused and thorough testing the whole design led to us to some results. While designing and implementing, we have to check that if each module is working properly and giving correct output according to our input.

The Evaluation Phase can be divided into three steps:

- Unit Testing
- Function Testing
- Comparison and Results concluded from these testing

6.1 Unit Testing

In this phase, I tested the functionality of each module independently and realized its response in the desired manner. Testing of the Heart Rate Sensor was the most challenging as it's response varied greatly and initially, It was a tedious process to figure out the issue and it's solution. After trial and error, I finally got to know the issue and resolved it. Similarly, the use MPU-6050 for Cattle Activity Tracking was very challenging. After planting the sensor on cattle and recording it's activity for longer duration provided with the desired data to be used for algorithm development. It's testing was done by planting sensor on cattle and checking response using serial port.

6.2 Function Testing

After integrating the system, the testing was done by connecting system to wireless access point with internet access. I verified the system in a step by step manner. Firstly, tracking its connection to Wifi and then monitoring the Ping requests sent to database. After that, I verified the communication with Database and transmission of sensor data. Later the mobile application was integrated to the database and complete system was verified. The changes in sensor data reflected successfully to database and then mobile application.

6.2.1 Testing Requirements

Table 6.1 represents the testing requirements in detail.

Table 6.1: Testing Requirements

Requirement Tested	**Phase 1**	**Phase 2**	**Final status**	**Details (if any)**
Micro-controller	OK	OK	OK	Working as desired
Power Efficient	Poor	OK	OK	Acceptable(12-Day Runtime)
Network Interface	OK	Fail	OK	Working as desired
Database Connectivity	OK	OK	OK	Working as desired
Heart-Rate Monitor	OK	OK	OK	Tolerance: +/-6bmp
SPO2 Monitor	OK	Fail	Fail	FIFO Out of Memory
Activity Monitor	OK	OK	OK	Working as Desired
Mobile App	Fail	OK	OK	Working as Desired
Secure Communication	OK	OK	OK	Sign In page, Secure API Key
Small Size	Fail	OK	OK	Acceptable size

6.3 Results

After thorough testing of the system, we proceeded for investigation of our implemented techniques. This section covers in depth information about the design testing and evaluation.

6.3.1 Cloud Database

Firebase Cloud Database functionality was testing by monitoring the write requests and verifying with the data transmitted by Hardware. Figure 6.1 previews the Firebase Database with data transmitted by the hardware components.

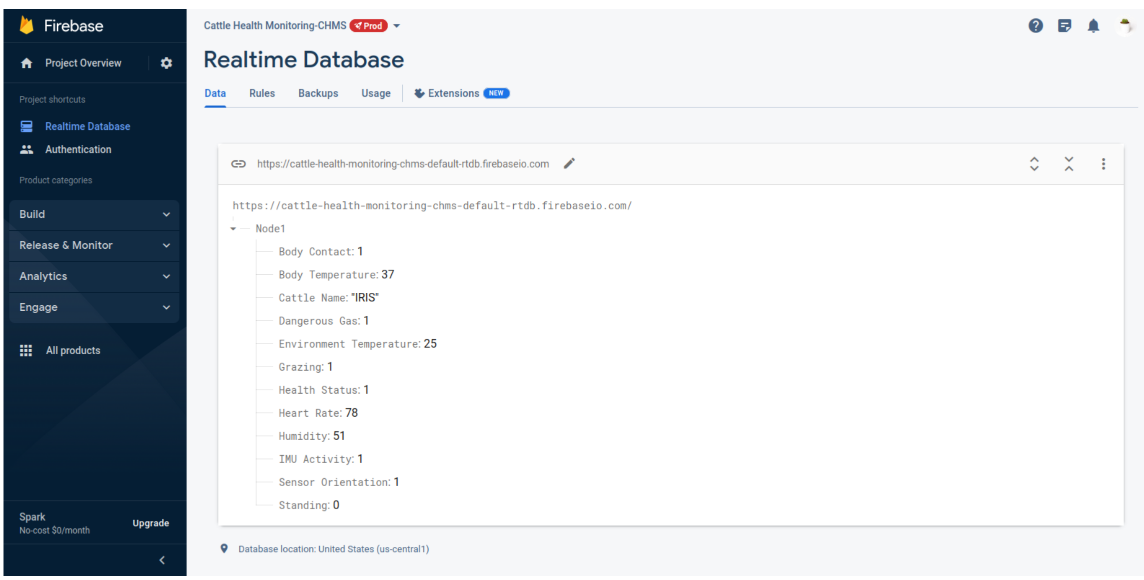

Figure 6.1: Firebase Cloud Database

6.3.2 Hardware View

Figure 6.2: Top Side: Hardware

Figure 6.3: Bottom Side: Hardware

Chapter 7

Conclusion and Future Work

7.1 Conclusion

The Cattle Health Monitoring System is an innovative project that seeks to enhance the well-being of cattle by leveraging the power of wireless sensor networks. The system utilizes a state-of-the-art electronic device that is affixed to the ear of the animal to capture and transmit real-time data on critical health parameters such as heart rate, blood oxygen levels, and eating patterns. Additionally, the system is designed to monitor the surrounding environmental factors, including temperature, humidity, and presence of toxic gases, which can negative impact the health and productivity of the cattle.

7.2 Future Work

There could be several improvements possible to the system. Some of the ideas for future development are mentioned below:

Reduced Size: The current system has acceptable size but the size can be reduced further by redesigning the enclosure.

Custom Circuit Board: Currently, the system is built using pre-made modules available in the market. However, a custom designed circuit board can help reduce the size, lower the power consumption and make it fit in a sleeker package.

Reduced Power Consumption: A different combination of battery type, capacity and related power management circuitry may yield a higher run-time off a battery. A custom PCB may also help in this regard.

LoRaWAN Connectivity: Wi-Fi has limitations of shorter range. A technology called LoRaWAN Can help improve the connection range up to several Kilo Meters. The Firebase Library needs heavy modifications in this regard.

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Appendix A: List of components

- ESP32-Devkit Micro-controller and Wi-Fi Transceiver
- MAX30102 Bio-Sensor
- MPU6050 Inertial Measurement Unit
- DHT11 Temperature and Humidity Sensor
- MQ-135 Gas Sensor
- Lithium Polymer, 3.7V, 1000mAh Battery
- Battery Charging System and Boost converter
- 3D Printed Enclosure Box (optional)
- Velcro Tape (optional)
- Jumper Wires

Appendix B: Project Timeline

Table 7.1: Project Timeline

Tasks	**Start Date**	**End Date**
Project Planning and Literature Review	Sept. 16th,2022	Sept. 30th, 2022
Component Availability Research	October 1st, 2022	October 15th, 2022
Design Phase and Integration Testing	Oct. 15th,2022	Nov. 15th, 2022
Testing Phase-1 (Components Testing)	Nov. 15th,2022	Dec. 20th, 2022
Mobile Application and UI Design	January 12th, 2022	February 10th, 2022
3D Enclosure Design and Printing	February 11th, 2022	March 20th, 2022
Assembling the Prototype and Field Testing	March 21th,2022	April 30th, 2022
Documentation Phase	May 1st, 2023	May 20th, 2022