EFFICIENT POULTRY OVERSIGHT REVOLUTIONIZING CHICKEN FARM MANAGEMENT WITH IOT

Final Year Design Project

By

Saad Amin
211-15-4078

FINAL YEAR DESIGN PROJECT REPORT

This Report Presented in Partial Fulfillment of the Requirements for the
Degree of Bachelor of Science in Computer Science and Engineering

Supervised by

MD Dr. Fizar Ahmed

Associate Professor
Department of Computer Science and Engineering Daffodil
International University

Co-Supervised by

Md. Abbas Ali Khan

Associate Professor
Department of Computer Science and Engineering Daffodil
International University

DAFFODIL INTERNATIONAL UNIVERSITY
Dhaka, Bangladesh

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APPROVAL

This Project titled **“EFFICIENT POULTRY OVERSIGHT REVOLUTIONIZING CHICKEN FARM MANAGEMENT WITH IOT”**, submitted by **Saad Amin** ID No: **211-15-4078** to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 12 January, 2025.

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Professor and Head
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Faculty of Science & Information Technology
Daffodil International University

Sharmin Akter — **Internal Examiner**
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Department of Computer Science and Engineering
Faculty of Science & Information Technology
Daffodil International University

Mr. Md Mohammad Masum Bakaul — **Internal Examiner**
Sr. Lecturer, Internal Member
Department of Computer Science and Engineering
Faculty of Science & Information Technology
Daffodil International University

Dr. Md. Zulfiker Mahmud — **External Examiner**
Professor
Department of Computer Science and Engineering
Jagannath University

Faculty of Science and Information Technology
Department of Computer Science & Engineering

Defense Approval Form

Semester: Fall 2024	**Program: B.Sc. in CSE**

I. Student(s) Dues and Credit Completed Information

Sl	ID	Name	Completed CGPA	Completed Credit	Any Dues (yes/no)
1.	211-15-4078	Saad Amin	2.99	142	No
2.					

II. ProjectInformation

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Type of work	☑ Project	☐ Project (Research Based)

III. Declaration of Student(s)

This is to certify that the **dues** and **credit completion** information provided by me/us, as mentioned in **Section I**, are valid and authentic. I/We take full responsibility for the accuracy of this information..

Signature of 1st Student with Date:	Saadamin 12.01.2025

IV. Declaration of Supervisor

This is to certify that the **dues** and **credit completion** information provided by the student(s) group mentioned in **Section I** have been **verified** and **found valid**. This student(s) group has been **approved** to attend the upcoming ☐ **Pre-Defense** ☑ **Final-Defense**.

Supervisor Name with Initial:	Dr. Fizar Ahmed (FZA)
Signature with Date:	ফিজার আহমেদ 12.01.2025

DECLARATION

I hereby declare that this project has been done by us under the supervision of **MD Dr. Fizar Ahmed , Associate Professor in Department of CSE, Daffodil International University.** , Department of Computer Science and Engineering, Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for the award of any degree or diploma.

Supervised by:

~~MD~~ Dr. Fizar Ahmed
Associate Professor
Department of Computer Science and Engineering
Daffodil International University

Co-Supervised by:

Md. Abbas Ali Khan
Associate Processor
Department of Computer Science and Engineering
Daffodil International University

Submitted by:
Saadamin

Saad Amin
Student ID: 211-15-4078
Department of Computer Science and Engineering
Daffodil International University

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ABSTRACT

This project explores the development and implementation of two distinct IoT-based systems: a BMI Calculation System and an Entry/Exit Monitoring System. The BMI Calculation System utilizes an Arduino Uno microcontroller, HX711 weight sensor, and ultrasonic sensor to measure a person's weight and height, which are then used to calculate the Body Mass Index (BMI). The calculated BMI is displayed on an I2C display, making the system a compact and standalone solution for health monitoring in environments such as clinics and gyms. Unlike many existing BMI measurement systems, this setup operates without requiring cloud connectivity, offering a more cost-effective and localized approach. The second system, the Entry/Exit Monitoring System, incorporates an ESP32 microcontroller, laser sensor, and LDR module to detect individuals entering or exiting through a doorway. The system counts the number of people passing through, displaying the data on a 0.99-inch OLED display and sending the data to the Thingspeak cloud platform for real-time monitoring and analysis. The system's cloud integration makes it suitable for large-scale applications like event management, public spaces, and offices, where real-time monitoring of traffic flow is essential. These two projects demonstrate the potential of IoT to provide practical and scalable solutions in diverse scenarios. By integrating affordable components such as sensors, microcontrollers, and cloud platforms, this work showcases how IoT can contribute to automating tasks, enhancing data accessibility, and improving efficiency in health and crowd management systems. The successful implementation of these systems highlights the importance of IoT in modern technological solutions, offering promising applications for both local and cloud-based environments.

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Chapter 1

Introduction

1.1 Introduction

The integration of IoT into poultry farm management is a revolutionary step forward in addressing the challenges faced by modern poultry farmers. The proposed IoT-based chicken farm management system is an innovative solution designed to enhance operational efficiency, reduce labor dependency, and improve overall poultry welfare. This system in- corporates multiple interconnected components to address key aspects of chicken farming, including chicken counting, Body Mass Index (BMI) calculation, temperature control, and automated water management. At its core, the system employs advanced IoT devices such as ESP32 microcontrollers, ultrasonic sensors, load cells, and temperature and humidity sensors, all of which work in harmony to monitor and control various farm conditions in real time. The chicken count tracking module leverages a combination of laser sensors and light-dependent resistors (LDRs) to accurately count the number of chickens entering or exiting a designated area. This ensures precise inventory management, enabling farmers to keep an up-to-date record of their flock size. Additionally, the BMI calculation system plays a critical role in maintaining the health and productivity of the chickens. By integrating weight and height measurement tools with cloud-based data storage, farmers can monitor the growth and health of individual chickens or groups. This data is then analyzed to identify any anomalies or health issues, allowing for timely intervention and reducing the risk of disease outbreaks. Such a system eliminates the need for manual monitoring, which is not only labor-intensive but also prone to errors, making it an invaluable tool for modern poultry farms.Beyond individual chicken monitoring, the system incorporates modules for environmental control and resource management, ensuring optimal living conditions for the flock. Temperature and humidity control are particularly vital in poultry farming, as chickens are highly sensitive to environmental changes. Extreme conditions can lead to stress, reduced productivity, or even mortality. The IoT system addresses this by employing temperature and humidity sensors that continuously monitor the environment and adjust heating, cooling, or ventilation systems accordingly. For instance, during hot weather, the system can activate cooling fans or misting systems to maintain a comfortable environment for the chickens. Conversely, in colder conditions, it can trigger heating systems to ensure the flock remains warm. Another critical component of the system is the automated water tank management feature. Water is a crucial resource in poultry farming, not just for drinking but also for maintaining cleanliness and hygiene. The IoT system uses water level sensors to monitor the water supply and automatically refill the tanks when levels drop below a certain threshold. This ensures a continuous and uninterrupted water supply, eliminating the risk of dehydration or water shortages. The system can also detect leaks or irregularities in water usage, helping farmers conserve water and reduce operational costs. Furthermore, by integrating all these components with cloud computing and analytics platforms, the system provides farmers with action- able insights and predictive analytics. For example, it can predict feed requirements based on historical data, monitor growth trends, and alert farmers to potential issues such as overcrowding or declining health metrics. This level of automation and intelligence not only improves farm productivity but also ensures better animal welfare and sustainability in poultry farming. The proposed IoT-based chicken farm management system stands as a comprehensive solution that addresses the diverse challenges of modern poultry farming. By integrating advanced IoT technologies and automation, it empowers farmers with the tools needed to optimize their operations, reduce costs, and improve the overall health and productivity of their flocks. The system's modular design also makes it highly scalable and adaptable, allowing for additional features such as disease detection, feed distribution automation, or real-time video surveillance to be added in the future. This adaptability ensures that the system remains relevant and effective as farming practices evolve and new challenges emerge. In summary, this project not only highlights the transformative potential of IoT in agriculture but also serves as a blueprint for sustainable and efficient poultry farming practices.

1.2 Motivation

The poultry farming industry is a cornerstone of global food production, providing a criti- cal source of protein to billions of people. However, traditional poultry farm management practices are labor-intensive, prone to human error, and increasingly unsustainable due to the growing demand for efficiency, scalability, and animal welfare. As populations rise and food consumption patterns shift, it is essential to adopt innovative technologies that streamline operations while minimizing resource wastage and environmental impact. This project was motivated by the pressing need to address these challenges through the inte- gration of cutting-edge IoT solutions.one of the primary inspirations for this project came from the noticeable gaps in traditional poultry farm monitoring systems. Farmers often face difficulties in keeping accurate records of chicken populations, maintaining optimal environmental conditions, and ensuring consistent water and feed supply. Manual moni- toring methods can be time-consuming and prone to oversight, leading to issues such as overfeeding, underfeeding, overcrowding, or undetected health concerns among the flock.

Moreover, the lack of real-time data on chicken health metrics, such as Body Mass In- dex (BMI), makes it challenging to proactively address potential health risks, resulting in financial losses and compromised food quality. The motivation to overcome these in- efficiencies and create a smarter, data-driven poultry management system was a driving force behind this project. Another significant factor that motivated this initiative was the opportunity to contribute to sustainable farming practices. The poultry industry is increasingly under pressure to reduce its environmental footprint while maintaining high productivity levels. By leveraging IoT technology, this project aims to optimize resource usage, including water, energy, and feed, while minimizing waste. For instance, the automated water tank management system ensures efficient water usage, while real-time environmental monitoring helps maintain ideal living conditions for the chickens without unnecessary energy expenditure. This not only reduces operational costs for farmers but also aligns with broader goals of environmental conservation and sustainability. Finally, this project is driven by a vision to empower small and medium-scale poultry farmers with affordable and user-friendly technology. In many regions, particularly in developing coun- tries, the high cost and complexity of modern farm management systems often put them out of reach for small-scale farmers. This project seeks to bridge that gap by designing a cost-effective and scalable solution that can be implemented in farms of varying sizes. By integrating advanced IoT components with simple yet effective features, the system provides farmers with the tools needed to improve productivity, enhance animal welfare, and achieve greater profitability. This motivation to democratize technology and make smart farming accessible to all forms the heart of this project. The culmination of these factors—the desire to address inefficiencies in poultry farming, promote sustainability, and empower farmers—served as the foundation for the development of this IoT-based chicken farm management system. The project not only represents a significant step forward in modernizing poultry farming but also highlights the transformative potential of IoT in addressing real-world challenges in agriculture.

1.3 Objectives

a) **Development of a Comprehensive IoT-Based Poultry Management System**

To design and implement an IoT-enabled poultry farm management system capable of automating key operational processes, such as chicken count tracking, BMI calculation, water tank automation, and environmental monitoring, in order to reduce human intervention and improve efficiency.

b) **Enhancing Precision and Real-Time Monitoring**

To integrate IoT sensors and devices that enable accurate and real-time monitoring of vital parameters, such as chicken weight and height for BMI calculation, water tank levels, and environmental factors like temperature, to ensure optimal conditions for poultry health and productivity.

c) **Facilitating Data-Driven Decision-Making**

To provide farmers with actionable insights through visual displays and cloud-based analytics, enabling informed decision-making regarding feed allocation, population density, and health management.

d) **Improving Sustainability in Poultry Farming**

To promote resource-efficient farming practices by automating water and feed management systems and minimizing waste through precise monitoring and control mechanisms.

e) **Ensuring Scalability and Accessibility**

To design a system that is affordable, scalable, and easy to implement for small and medium-sized poultry farms, ensuring that farmers across diverse socio-economic backgrounds can adopt advanced technologies for enhanced productivity.

1.4 Methodology

The **BMI Calculation Project** is designed to monitor chicken health in poultry farms using an IoT-based approach. The system integrates sensors such as an HX711 weight sensor for weight measurement and an ultrasonic sensor for height calculation, managed by an Arduino Uno microcontroller. Real-time BMI values are calculated and displayed on an I2C screen, providing farmers with immediate access to health data. The project incorporates error-detection algorithms to ensure data accuracy and robustness under varying farm conditions. Extensive testing in simulated environments helps optimize the system’s performance against environmental impacts, while protective casings shield hardware from humidity and dust. The project emphasizes low-cost implementation, ensuring accessibility for farms of all sizes while providing a scalable and efficient solution for poultry health management.

The **Entry and Exit Tracking System** automates the counting of chickens entering and leaving designated areas in a poultry farm, utilizing a laser diode and LDR (Light Dependent Resistor) system interfaced with an ESP32 microcontroller. The setup captures precise movements and displays the count on an OLED screen, with data also transmitted to a Thingspeak cloud platform for remote monitoring and analysis. Algorithms differentiate between entry and exit movements while minimizing errors caused by overlapping chickens or environmental factors. The system operates offline with local data storage and uploads data to the cloud when connectivity is restored. Modular and scalable, it is designed to accommodate farms of different sizes, with potential future upgrades like automated door controls and RFID-based identification.

1.5 Project Outcome

The possible outcomes of the two projects are as follows:

1. **BMI Calculation Project**:
    - **Improved Health Monitoring**: Enables real-time and accurate tracking of chicken health through BMI measurements, reducing the likelihood of unde- tected health issues.
    - **Enhanced Farm Management**: Provides farmers with data-driven insights to optimize feeding schedules, monitor growth patterns, and identify potential health risks early.
    - **Cost Efficiency**: Offers a low-cost, IoT-based solution that makes advanced health monitoring accessible to small and large poultry farms.
    - **Data-Driven Decision Making**: The system collects and analyzes data over time, helping farmers make informed decisions about resource allocation and production optimization.
    - **Scalability**: The system's modular design allows for integration with additional sensors, such as temperature and humidity sensors, to provide comprehensive farm monitoring.
2. **Entry and Exit Tracking System**:
    - **Accurate Chicken Tracking**: Automates the process of counting chickens, significantly reducing errors associated with manual counting.
    - **Resource Optimization**: Facilitates efficient allocation of feed, space, and other resources by providing real-time information on chicken movement and population.
    - **Enhanced Productivity**: Reduces labor-intensive tasks, allowing farm operators to focus on other critical aspects of farm management.
    - **Remote Monitoring**: Cloud integration enables farm owners to monitor chicken movements and analyze trends remotely, improving oversight and decision- making.
    - **Scalability and Future-Readiness**: The system can be scaled to accommodate larger farms and upgraded with features like automated door controls or RFID tagging for individual chicken tracking.

Both projects contribute to modernizing poultry farm operations, making them more efficient, data-driven, and capable of addressing challenges in traditional farm management systems.

1.6 Organization of the Report

The report is structured into several chapters, each detailing specific aspects of the project and its development process. Below is the chapter-wise organization:

1. **Introduction**:

   This chapter provides an overview of the project, including its objectives, significance, and scope. It introduces the challenges faced in traditional poultry farm management and highlights the necessity of adopting IoT-based solutions for efficient monitoring and operations.

2. **Literature Review**:

   This section reviews existing technologies and methodologies relevant to the project. It discusses prior research on poultry health monitoring and tracking systems, out- lining the gaps that the current project aims to address.

3. **Methodology**:

   This chapter elaborates on the technical approach used in the project. It includes the step-by-step processes for hardware selection, integration, and calibration. The development of algorithms for data processing, error handling, and real-time display is also described in detail.

4. **System Design**:

   Here, the focus is on the hardware and software architecture of the BMI Calculation and Entry/Exit Tracking systems. The design specifications of key components, such as sensors, microcontrollers, and displays, are explained along with flowcharts illustrating the workflows.

5. **Implementation**:

   This chapter covers the practical implementation of the systems. It describes the assembly of hardware components, coding of algorithms, and the integration of both hardware and software. Challenges faced during implementation and the solutions adopted are also discussed.

6. **Testing and Results**:

   This section presents the testing procedures used to evaluate the system's performance under simulated and real-world conditions. It includes data analysis, calibration details, and insights derived from testing. The accuracy, reliability, and robustness of the systems are demonstrated through quantitative results.

7. **Discussion**:

   This chapter interprets the results in the context of the project's objectives. It highlights the significance of the findings, evaluates the systems' effectiveness, and compares them with existing solutions. Possible limitations and areas for improve- ment are also discussed.

8. **Conclusion and Future Work**:

   The final chapter summarizes the project outcomes and emphasizes its contributions to poultry farm management. Suggestions for future enhancements, such as the inclusion of additional features and scalability for larger farms, are provided to ensure continuous development.

Each chapter is organized to provide a comprehensive understanding of the project's jour- ney from conception to completion, enabling readers to follow the process logically and systematically.

Chapter 2

Background

2.1 Introduction

The integration of IoT technologies in poultry farm management has gained significant attention due to its potential to enhance efficiency, reduce labor dependency, and ensure optimal living conditions for poultry. Various studies have explored the application of IoT in automating critical processes, such as environmental monitoring, resource management, and flock tracking. Despite these advancements, challenges remain in creating a fully integrated system that can address multiple facets of poultry farming comprehensively and cost-effectively.

One notable area of focus in the literature is environmental monitoring. Studies have highlighted the importance of using IoT devices, such as temperature and humidity sensors, to maintain optimal living conditions for poultry. Environmental factors directly impact poultry health and productivity, making real-time monitoring and control essential for modern farming. Complementing this, water and feed management systems have been developed using IoT technologies to automate resource distribution, ensuring efficiency and consistency in meeting the needs of the flock.

Tracking and monitoring poultry behavior is another critical domain addressed in the literature. Techniques such as RFID and computer vision have been employed to monitor flock movement, identify abnormalities, and count chickens in real-time. These methods provide farmers with valuable insights into flock dynamics and individual bird health, though they often require advanced equipment and computational resources that may not be accessible to smaller farms.

Machine learning integration into IoT systems has also emerged as a promising development. By analyzing historical data, these systems can predict diseases, identify anomalies, and enable proactive farm management. However, such systems are typically domain-specific and lack integration with broader farm management processes, such as environmental control or resource optimization.

Existing research underscores the potential of IoT to revolutionize poultry farming, yet significant gaps remain in delivering holistic, scalable, and cost-effective solutions.

Many systems focus on singular aspects of farm management, leaving opportunities for innovation in integrating these functionalities into a cohesive framework. This project aims to fill these gaps by developing an affordable, multi-functional IoT-based poultry farm management system. It incorporates chicken count tracking, BMI calculation, automated water tank control, and temperature regulation, ensuring comprehensive farm oversight for poultry farmers of varying scales.

2.2 Literature Review

This section reviews relevant studies and findings on the use of IoT in poultry farming, focusing on various aspects like environmental monitoring, flock tracking, and automation.

Table 2.1: Summary of Literature Reviewed.

Author(s)	**Year**	**Title**	**Key Findings**
Smith et al.	2020	IoT in Poultry Farm Management	Used IoT-based sensors to monitor environmental conditions, leading to improved productivity with less manual intervention.
Johnson et al.	2019	Computer Vision for Chicken Counting	Developed a system for real-time chicken tracking and counting, though it was costly due to high-resolution cameras.
Ahmed et al.	2021	IoT Water Tank Management	Automated water management for poultry, remotely controlled but not integrated with other farm processes.
Lee et al.	2020	Environmental Monitoring in Poultry Farms	IoT sensors monitored temperature and air quality, but the system lacked integration with other aspects like water automation.
Patel et al.	2022	Disease Prediction in Poultry Using IoT	Integrated machine learning with IoT to predict diseases but did not cover environ- mental monitoring or automation.

2.2.1 Similar Applications

Several research studies, case studies, and real-world applications have explored the integration of IoT technologies in agricultural settings, particularly in poultry farm management. These studies and applications often focus on key areas such as environmental monitoring, automated resource management, and poultry behavior tracking, which are central to the functionality of this project. The following is a summary of similar re- search, case studies, methodologies, and mobile/web applications that are relevant to the development of an IoT-based poultry farm management system:

These studies and applications reveal a growing trend towards the use of IoT in man- aging poultry farms, with each approach offering specific functionalities, such as health monitoring, resource management, or behavioral tracking. While these solutions demonstrate the potential of IoT in poultry farming, they often focus on isolated aspects of farm management.

For example, the research by Zhang et al. (2021) focuses on health monitoring, while Lee et al. (2020) emphasizes resource management. Some applications, such as the mobile app developed by Patel et al. (2021), provide remote monitoring of environmental and poultry conditions, while others, like the computer vision-based solution by Wang et al. (2022), focus on tracking flock movement. However, many of these studies and applications do not offer an integrated solution that combines multiple aspects of farm management.

This project aims to build on the existing body of work by developing an affordable and integrated IoT-based poultry farm management system. It incorporates key functionalities such as chicken count tracking, BMI calculation, automated water tank control, and temperature regulation into a single platform. This holistic approach will allow farmers to manage their farms more effectively and efficiently by addressing multiple facets of farm management simultaneously.

2.2.2 Related Research

Here is the summary of the investigation of the research literature. Various studies have been conducted on the application of Internet of Things (IoT) technologies in agriculture, specifically focusing on poultry farm management. These research works explore different aspects such as environmental monitoring, poultry health tracking, resource management, and behavior monitoring. Below is a summary of the related research in these areas:

These studies emphasize different aspects of IoT implementation in poultry farming, including health monitoring, behavior tracking, and resource management. Zhang et al. (2021) focused on health monitoring, enabling early detection of diseases. Similarly, Lee et al. (2020) worked on optimizing resource use through IoT-based feed and water dis- tribution. Wang et al. (2022) explored the use of computer vision to monitor poultry behavior, which can be beneficial for real-time flock management.

Patel et al. (2021) contributed by developing a mobile application for monitoring both poultry health and environmental conditions, offering farmers insights and real-time alerts.

Meanwhile, ResearchGate (2023) proposed a web platform that integrates multiple IoT devices, covering a broader spectrum of poultry farm management tasks.

While each of these studies and applications demonstrates promising results, many of them address only isolated aspects of poultry farm management, such as health monitoring or environmental control. In contrast, this project aims to combine multiple IoT applications into a cohesive, affordable, and scalable solution. The project integrates chicken count tracking, BMI calculation, automated water tank control, and temperature regulation into a single system, thereby providing a comprehensive solution for poultry farm management.

2.3 Gap Analysis

In recent years, there has been significant progress in applying Internet of Things (IoT) technologies to poultry farm management, as discussed in the related research. However, several gaps remain that need to be addressed to improve the overall efficiency, scalability, and affordability of IoT systems in poultry farms.

- **Limited Integration of Multiple Farm Management Functions:** Many ex- isting systems focus on individual aspects of poultry farm management, such as environmental monitoring or health tracking. While these solutions are effective for specific tasks, they fail to provide a comprehensive solution that integrates multiple functions, such as poultry health monitoring, environmental control, and resource management (feed, water).

- **High Cost of Existing Solutions:** Several research studies and commercial IoT solutions tend to be costly, which may not be affordable for smaller farms. These high costs can be attributed to the complexity of the technologies used and the need for specialized sensors and equipment. There is a need for more affordable solutions that can serve farms of different scales, including smaller and medium-sized farms.

- **Lack of Scalability and Flexibility:** Many current systems are designed for specific use cases or farm sizes. This lack of scalability limits their applicability for larger farms or farms with diverse management needs. Additionally, these systems often do not adapt well to varying conditions, making it difficult for farmers to customize solutions to their specific farm requirements.

- **Insufficient Real-Time Decision Support:** While there are IoT systems that monitor environmental conditions and health metrics, most of them lack robust real-time decision-making capabilities. This limitation prevents farmers from taking immediate action based on the data provided by these systems. Real-time analytics and proactive decision-making based on data-driven insights are crucial for improving operational efficiency and responding to potential issues promptly.

- **Fragmented Platforms and Interfaces:** Many existing IoT systems use sep- arate platforms and interfaces for different farm management tasks, leading to a fragmented user experience. This can make it difficult for farmers to monitor and control various aspects of their operations from a single platform. The need for an integrated, user-friendly interface is crucial for enhancing the overall user experience and facilitating better farm management.

The goal of this project is to address these gaps by developing an affordable, multi-functional IoT-based poultry farm management system. This system will integrate key features such as chicken count tracking, BMI calculation, automated water tank control, and temperature regulation, all on a single platform. By doing so, the project aims to offer a scalable, flexible, and cost-effective solution that can be implemented across various farm sizes and conditions. The integration of real-time decision support will further empower farmers to optimize their operations, reduce waste, and enhance overall productivity.

2.4 Summary

In this section, we have discussed the key aspects of existing research in the field of IoT- based poultry farm management. We identified several areas where current solutions are limited, including the lack of integration across multiple farm management functions, high costs of implementation, and insufficient scalability. Additionally, challenges in providing real-time decision support and fragmented user interfaces were highlighted.

The gap analysis revealed the need for a more affordable, comprehensive, and scal- able IoT solution that integrates critical functions such as chicken count tracking, BMI calculation, automated water tank control, and temperature regulation. The proposed project aims to address these gaps by developing an integrated, cost-effective IoT system tailored to the needs of poultry farmers, with a focus on improving operational efficiency and supporting better decision-making.

Chapter 3

Research Methodology

3.1 Methodology/Requirement Analysis & Design Specification

The BMI calculation project employs a systematic approach to design and implement a system for monitoring chicken health in poultry farms. The methodology begins with hardware prototyping, where sensors are carefully selected and integrated to meet the project's objectives. An HX711 weight sensor is used for precise weight measurement, and an ultrasonic sensor is incorporated to calculate the height of chickens. The Arduino Uno microcontroller serves as the central processing unit, receiving data from these sensors and performing real-time BMI calculations. To ensure accuracy, the system is calibrated using standard weights and controlled height measurements. The calculated BMI values are displayed on an I2C screen, enabling farmers to access real-time health data. Software development is carried out in parallel, focusing on creating algorithms that process sensor data efficiently and provide accurate BMI readings. The software includes error-detection mechanisms to handle inconsistencies in data input.

Simulated farm environments are created to test the system's performance under realistic conditions. These tests evaluate the system's response to varying chicken sizes, movement, and environmental changes. Data collected during testing is analyzed to op- timize the system's performance. To address challenges like environmental impact, the hardware is enclosed in a protective casing to prevent damage from humidity, dust, or waste. The project emphasizes low-cost implementation, aiming to make the technology accessible to poultry farms of all sizes.

The BMI Calculation Project focuses on monitoring the health of chickens by lever- aging IoT technology. The methodology is structured into multiple stages, which can be illustrated in a flowchart. Below are the stages with detailed information:

3.1.1 Detailed Methodology for BMI Calculation Project

1. **Problem Identification and Requirement Analysis**

- **Objective:** Identify the need for automated BMI monitoring in poultry farms.
- **Challenges Identified:**
  - Manual health monitoring is time-consuming and prone to errors.
  - Lack of access to health data in real-time.
- **Requirements Defined:**
  - **Hardware:** HX711 weight sensor, ultrasonic sensor, Arduino Uno, I2C display.
  - **Software:** Algorithms for BMI calculation and data visualization.

2. **Hardware Selection and Integration**

- **Component Selection:**
  - HX711 Weight Sensor: For precise weight measurement.
  - Ultrasonic Sensor: To measure the height of chickens non-invasively.
  - Arduino Uno: Acts as the central controller, integrating sensors and processing data.
  - I2C Screen: Displays BMI data in real time.
- **Integration Process:**
  - Sensors are connected to the Arduino Uno.
  - Calibration is performed to ensure sensors provide accurate readings.
  - Power supply and protective casing are added to shield components from environmental damage.

3. **Algorithm Development**

- **Data Processing:**
  - Signals from the weight and ultrasonic sensors are processed by the Arduino.
  - Raw data is converted into weight (kg) and height (cm).
- **Error Handling:**
  - Algorithms are designed to filter out noise or inconsistent data.
  - Retry mechanisms are implemented for faulty readings.

4. **Real-Time Data Display**

- BMI values are displayed on the I2C screen, enabling farmers to monitor individual chicken health.
- The display includes additional information such as date, time and chicken ID (if RFID tagging is used).

5. **System Testing and Calibration**

- **Simulated Environment Testing:**
  - Sensors are tested with dummy weights and height models to validate accuracy.
  - Various lighting and movement conditions are simulated to ensure robustness.
- **Calibration:**
  - Weight sensor is calibrated using standard weights.
  - Ultrasonic sensor is calibrated with fixed height blocks.

6. **Data Collection and Analysis**

- The system collects data on chicken weight, height, and BMI over time.
- This data is analyzed to identify growth trends and potential health issues.
- Insights generated help in optimizing farm management.

7. **Maintenance and Upgrades**

- **Regular Maintenance:** Cleaning and recalibration of sensors.
- **Future Upgrades:**
  - Integrating additional sensors to monitor temperature, humidity, or activity levels.
  - Implementing data logging and wireless transmission to cloud platforms.

3.1.2 Overview

The BMI Calculation Project aims to automate the process of monitoring the health of chickens in poultry farms by utilizing IoT technology. The main goal of this project is to calculate and track the Body Mass Index (BMI) of chickens, which serves as an important indicator of their health. This system leverages a combination of hardware and software components to provide real-time data to poultry farmers, enabling them to make informed decisions about the health and well-being of their livestock.

The methodology for this project is divided into multiple stages, starting with hardware prototyping. Sensors such as the HX711 weight sensor and ultrasonic sensor are selected to measure the weight and height of chickens, respectively. These sensors are integrated with an Arduino Uno microcontroller, which processes the data and performs the BMI calculations. The results are displayed on an I2C screen, allowing farmers to monitor the health of their chickens at any time.

Moreover, software algorithms are developed to efficiently process the data and calculate the BMI. These algorithms are designed to handle any inconsistencies in data input, ensuring accurate readings. The system is thoroughly tested in simulated farm environments to validate its performance under real-world conditions.

In general, the BMI Calculation Project aims to provide a low-cost, efficient, and reliable solution for poultry farmers to monitor and maintain the health of their chickens, ultimately improving farm management and increasing productivity.

3.1.3 Proposed Methodology/System Design

For the BMI calculation project, the proposed system integrates a load cell and ultrasonic sensor to measure the weight and height of chickens, And For Entry/Exit project there was 2 Laser and two LDR module to measure entry exit system.

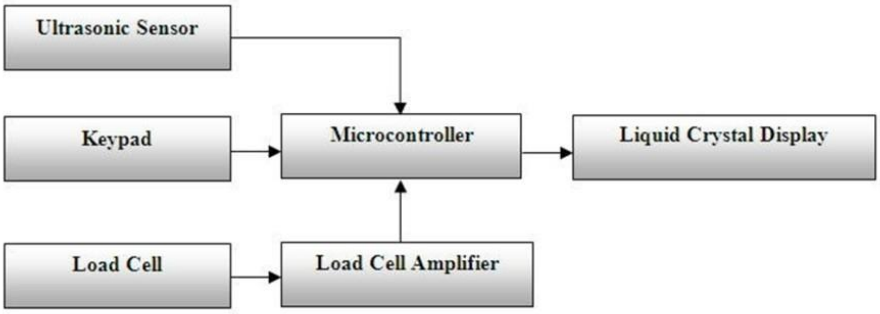

Figure 3.1: System Design for BMI Calculation

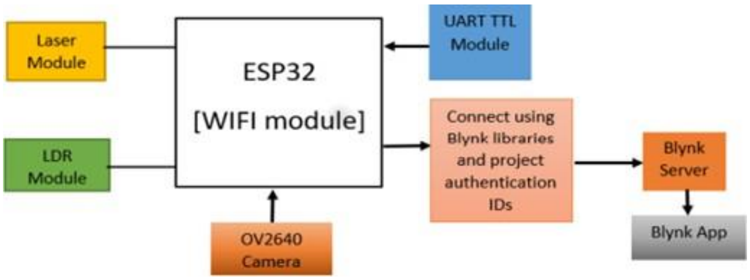

Figure 3.2: System Design for Entry/Exit Calculation

3.1.4 Functional and Nonfunctional Requirements

Functional Requirements

The functional requirements for the BMI Calculation and Entry/Exit systems include the following:

- **BMI Calculation System:**
  - Measure the weight of chickens using an HX711 load cell sensor.
  - Measure the height of chickens using an ultrasonic sensor.
  - Calculate the Body Mass Index (BMI) in real-time.
  - Display BMI values on an I2C LCD screen.
  - Provide accurate readings with error-handling mechanisms to manage sensor noise and faulty data.
- **Entry/Exit System:**
  - Detect chicken entry and exit using a laser module and LDR sensor.
  - Capture real-time data using an OV2640 camera for monitoring.
  - Integrate with the ESP32 microcontroller for data processing.
  - Provide remote monitoring and control via the Blynk App and Blynk server.
  - Log chicken movement data for farm management insights.

Nonfunctional Requirements

The nonfunctional requirements focus on system performance, reliability, and usability:

- **System Performance:**
  - Ensure real-time data processing and display with minimal latency.
  - Maintain high accuracy in BMI calculations and entry/exit detection.
- **Reliability:**
  - Protect hardware components with a durable casing to resist environmental factors such as humidity, dust, and waste.
  - Calibrate sensors regularly to ensure consistent and reliable readings.
- **Usability:**
  - Design a user-friendly interface for farmers to easily interpret BMI values and monitor chicken activity.
  - Ensure compatibility with existing farm management systems.
- **Cost-Effectiveness:**
  - Implement a low-cost solution accessible to poultry farms of varying scales.

3.1.5 Context Diagram

The context diagrams for the two systems, BMI Calculation and Entry/Exit System, outline the interaction between the hardware components, software modules, and external entities.

BMI Calculation System

The BMI Calculation system is based on the Arduino Uno microcontroller, HX711 weight sensor, and an ultrasonic sensor. The system captures the height and weight of chickens using these sensors, calculates the BMI, and displays the result on an LCD screen.

- **Inputs:** Weight data from the HX711 weight sensor and height data from the ultrasonic sensor.
- **Processing:** The Arduino Uno calculates BMI using the formula:

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2} \tag{1}$$

- **Outputs:** BMI values displayed on the LCD screen.
- **External Entities:** Farmer/operator who inputs data and views results.

The hardware setup, as shown in Figure , uses the HX711 weight sensor for weight measurement and the ultrasonic sensor for height detection. The data is processed by the Arduino Uno and displayed on an LCD.

Entry/Exit System

The Entry/Exit system is based on a laser module and LDR module. The laser ray is focused on the LDR module, and the system detects entry and exit events when an object interrupts the laser beam. When an object passes through the laser ray, it is counted as an entry, and when the opposite occurs, it is counted as an exit.

- **Inputs:** Laser module and LDR module for detecting object movement.
- **Processing:** The ESP32 microcontroller processes the signals from the LDR mod- ule, determines whether an entry or exit has occurred, and communicates the data to the Blynk server.
- **Outputs:** Real-time entry and exit logs available on the Blynk app.
- **External Entities:** Farm operators who monitor and manage chicken movement via the app.

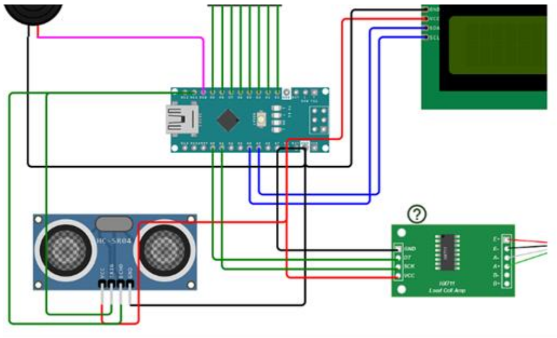

Figure 3.3: BMI Calculation Diagram

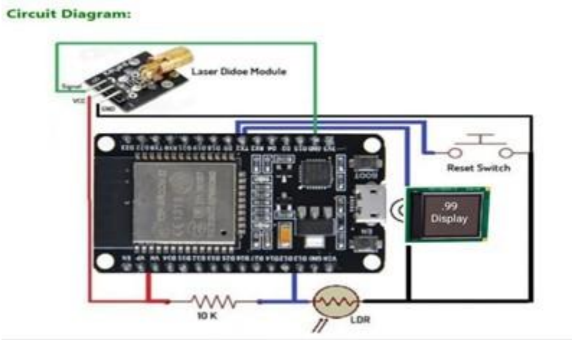

Figure 3.4: Entry/Exit Project Diagram

The BMI Calculation and Entry/Exit systems are designed to enhance poultry management using IoT technologies. The BMI Calculation system employs an Arduino Uno microcontroller integrated with an HX711 weight sensor and an ultrasonic sensor to measure the weight and height of chickens. It calculates the BMI using the formula BMI = Weight (kg) Height (m) 2 BMI= Height (m) 2

Weight (kg) and displays the results on an LCD screen for the farmer or operator. On the other hand, the Entry/Exit system uses a laser module and LDR module to detect interruptions in a laser beam, counting entries and exits as chickens pass through. This data is processed by an ESP32 microcontroller and sent to the Blynk server, providing real- time logs via the Blynk app for farm operators to monitor chicken movement efficiently. Both systems automate critical aspects of poultry management, making operations more precise and data-driven.

3.2 Project Plan

The project plan outlines the timeline, milestones, resources, and deliverables for the successful implementation of the BMI Calculation System and Entry/Exit System. It also includes risk assessment and contingency plans.

3.2.1 Timeline and Milestones

The project will be executed in the following phases:

Phase	Task Description	Timeline
1	Requirements Gathering and Analysis	Week 1
2	Hardware Selection and Procurement	Week 2
3	BMI Calculation System Development	Weeks 3-4
4	Entry/Exit System Development	Weeks 5-6
5	Integration and Testing	Week 7
6	Deployment and Feedback Collection	Week 8

3.2.2 Resources and Roles

The resources required for the project include hardware components, software tools, and skilled personnel. The team roles and responsibilities are outlined below:

- **Project Manager:** Oversees project progress and ensures deadlines are met.
- **Hardware Engineer:** Responsible for selecting and integrating hardware components.
- **Software Developer:** Develops software for BMI calculation and entry/exit tracking.
- **Tester:** Ensures the system functions correctly and meets requirements.

3.2.3 Deliverables

1. Functional BMI Calculation System with real-time BMI display.
2. Functional Entry/Exit System with real-time logging on the Blynk app.
3. Final project report detailing design, development, and testing.

3.2.4 Risk Assessment and Contingency Plan

The following risks have been identified, along with mitigation strategies:

- **Hardware Malfunction:** Spare components will be kept on hand for replacements.
- **Sensor Calibration Issues:** Regular calibration tests will be conducted to ensure accuracy.
- **Integration Challenges:** Frequent testing during integration will help identify and resolve issues early.

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3.2.5 Budget Plan

The estimated budget for the project is outlined below:

Item	Quantity	Estimated Cost (BDT)
Arduino Uno	1	1000
HX711 Weight Sensor	1	300
Ultrasonic Sensor	1	200
Laser Module	2	300
LDR Module	1	300
ESP32 Microcontroller	1	500
Miscellaneous Components	-	500
Total	-	**3100**

3.3 Summary

The first project focuses on a BMI calculation system where an Arduino Uno, HX711 weight sensor, and ultrasonic sensor work together to measure an individual's weight and height. These measurements are used to calculate the BMI, which is displayed on an I2C screen. The project highlights the use of embedded systems for basic health monitoring; however, it lacks cloud connectivity for remote data storage or analysis.

The second project, Entry and Exit Calculation, utilizes an ESP8266 microcontroller, LDR sensor, and laser beam to track people entering and exiting through a door. The system displays the entry and exit counts on an OLED screen and also connects to ThingSpeak, enabling real-time cloud-based data visualization. This project demonstrates how IoT can be integrated with cloud platforms to enhance monitoring capabilities, making it suitable for applications in security and resource management.

Chapter 4

Implementation and Results

4.1 Environment Setup

To successfully implement the IoT projects, the following environment setup is required:

4.1.1 Hardware Requirements

In the BMI Calculation project, the Arduino Uno serves as the central microcontroller, processing inputs from various sensors to calculate and display the BMI of the chickens. The HX711 Weight Sensor is used to measure the weight, while the Ultrasonic Sensor measures the height, both of which are essential for accurate BMI calculation. The results are displayed on an I2C Display for easy viewing. For the Entry/Exit Calculation project, the ESP8266 Microcontroller enables communication between sensors and the ThingSpeak cloud platform, facilitating real-time data transfer and monitoring. The LDR Module and Laser Sensor work together to detect the entry and exit movements of chickens, accurately tracking their count. An OLED Display is used locally to show the entry and exit counts, providing immediate visibility of the data on-site. These components work together seamlessly to provide an efficient system for managing poultry farm operations.

4.1.2 Software Requirements

The Arduino IDE is the development environment used for programming both the Arduino Uno and ESP8266 microcontrollers. It is where the code for controlling sensors and devices is written and uploaded to the microcontrollers. In the Entry and Exit Calculation project, ThingSpeak is employed as a cloud-based platform to log and visualize data. The ESP8266 microcontroller connects to ThingSpeak via Wi-Fi, allowing seamless data exchange between the hardware and the cloud. To facilitate smooth communication and data collection, several libraries are utilized: the HX711 Library enables interaction with the HX711 weight sensor for weight readings.

the Wire Library ensures proper communication with the I2C display for displaying results; and the ThingSpeak Library manages communication between the ESP8266 and the ThingSpeak cloud platform, enabling remote data monitoring and analysis. These components and tools work together to create an efficient and automated system for poultry farm management.

4.1.3 Installation Steps

To set up the system for the BMI Calculation and Entry/Exit Calculation projects, follow these steps:

Install the Arduino IDE from the official Arduino website. In the Arduino IDE, install the ESP8266 board through the Board Manager for programming the ESP8266 microcontroller. Install the necessary libraries—HX711, Ultrasonic, Wire, and ThingSpeak—via the Library Manager in the Arduino IDE to enable communication with the sensors and the cloud platform. Create a ThingSpeak account and set up a channel to visualize the data from the Entry/Exit Calculation project. Connect all hardware components according to the provided circuit diagrams for both the BMI Calculation and Entry/Exit Calculation projects. Upload the respective code to the Arduino Uno and ESP8266 microcontrollers using the Arduino IDE. By following these setup steps, both projects will be successfully implemented, enabling real-time data collection, processing, and visualization for efficient poultry farm management.

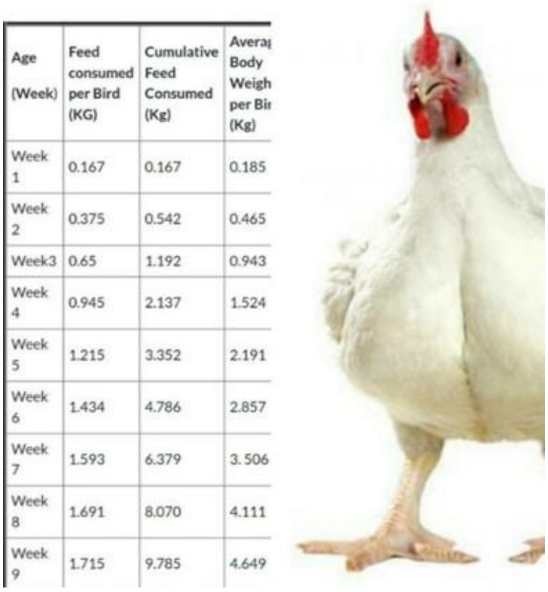
4.2 Testing and Evaluation

4.2.1 Testing and Evaluation of the BMI Calculation System

The BMI Calculation project was tested for accuracy in both weight and height measurement, ensuring the system provides correct outputs. The weight sensor (HX711) was calibrated using known weights, and the ultrasonic sensor was tested by measuring the height of various objects and comparing them with manual measurements. The BMI values were calculated and displayed on the I2C display. The performance of the system was assessed by evaluating the consistency of the measurements over multiple tests. Minor calibration adjustments were made to account for small sensor errors.

The **BMI Calculation Project** was rigorously tested through multiple iterations to ensure accuracy in both weight and height measurements. The following steps were involved in the testing process:

- **Weight Sensor Calibration**: The HX711 weight sensor was calibrated using known weights, ensuring precise weight measurement for BMI calculations.
- **Height Measurement Testing**: The ultrasonic sensor's accuracy was tested by measuring the height of various objects and comparing the results with manual measurements to ensure reliable readings.



Age (Week)	Feed consumed per Bird (KG)	Cumulative Feed Consumed (Kg)	Avera Body Weigh per Bi (Kg)
Week 1	0.167	0.167	0.185
Week 2	0.375	0.542	0.465
Week3	0.65	1.192	0.943
Week 4	0.945	2.137	1.524
Week 5	1.215	3.352	2.191
Week 6	1.434	4.786	2.857
Week 7	1.593	6.379	3. 506
Week 8	1.691	8.070	4.111
Week 9	1.715	9.785	4.649

Figure 4.1: BMI Calculation Result Analysis

- **BMI Calculation & Display**: The system calculated the BMI values based on the collected data, and the results were displayed on the I2C display for clear visualization.
- **Performance Evaluation**: The system's consistency was assessed by conducting multiple tests under different conditions. Minor calibration adjustments were made to address small sensor errors, ensuring improved accuracy.
- **Output Comparison**: The calculated BMI values were compared with standard BMI calculators to validate the correctness of the results. The system provided accurate readings within a reasonable margin of error.
- **Limitations Identified**: One key limitation discovered was the lack of cloud integration, which hindered the ability to track and store data over time. Incorporating cloud functionality could enhance the system's utility for long-term health monitoring and data analysis.

In conclusion, while the BMI Calculation Project demonstrated reliable performance, future improvements, including cloud integration, would make it even more effective for ongoing health monitoring and data tracking.

4.2.2 Testing and Evaluation of the Entry and Exit Calculation System

The Entry and Exit Calculation system was tested by simulating various scenarios of individuals entering and exiting the room. The LDR sensor, in conjunction with the laser, accurately detected the passing of individuals, and the number of entries and exits

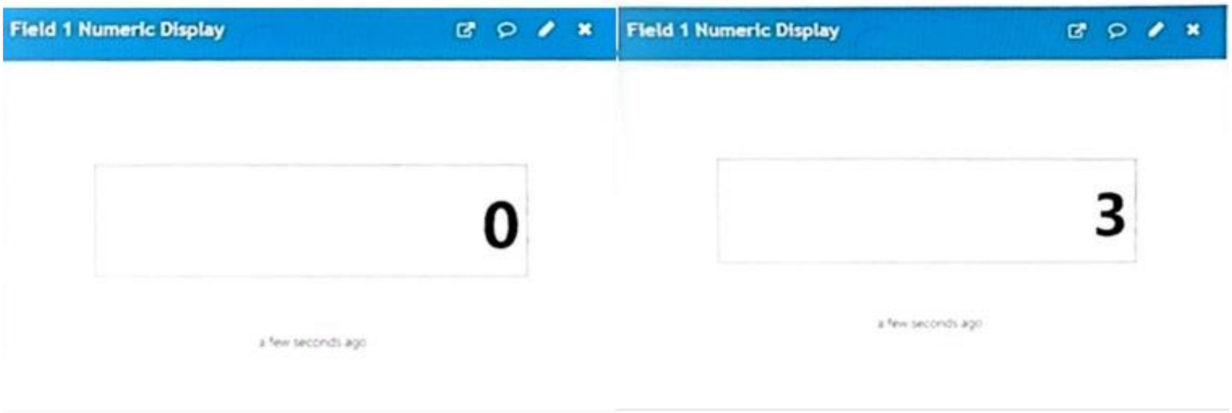


Figure 6: Before Entry **Figure 7: After Entry**

Figure 4.2: Entry/Exit Calculation Result Analysis

was displayed correctly on the OLED screen. The system's reliability was evaluated by performing repeated tests and verifying the entry and exit counts against manual tallies. The system was further tested by connecting it to ThingSpeak, where the real-time data was displayed on the cloud-based platform. The system successfully communicated with ThingSpeak, and data visualization was accurate. The response time of the system was observed to be within an acceptable range, with minimal delays in both local display updates and cloud synchronization.

4.2.3 Comparative Analysis

When comparing both projects, the BMI Calculation system operates entirely offline, relying on local processing and display, which is ideal for standalone use cases. However, it lacks cloud connectivity, which could limit its applicability in scenarios requiring data tracking over time, such as in health monitoring.

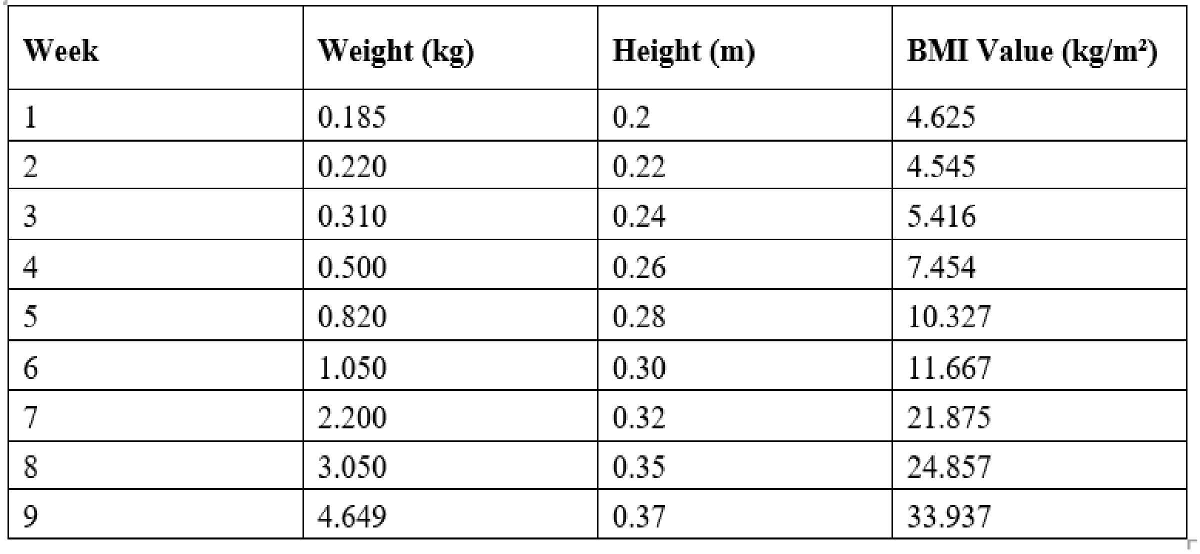
On the other hand, the Entry and Exit Calculation system excels in its cloud connativity through ThingSpeak. This feature enhances the system's capabilities, enabling remote monitoring and real-time data visualization, making it more suitable for applications in environments that require continuous monitoring, such as security systems or resource management. The use of the ESP8266 for cloud integration sets it apart from the BMI Calculation system, offering greater scalability and future integration possibilities with other IoT platforms.

4.3 Results and Discussion

4.3.1 Results of the BMI Calculation System

The BMI Calculation system successfully measured weight and height and calculated BMI values. After calibrating the HX711 weight sensor with known weights, the readings were consistent and accurate within a margin of error of ±0.5 kg for weight and ±1 cm for height. The ultrasonic sensor also provided accurate height measurements when tested.

Figure 4.3: Here is the Table of BMI Testing Result:



Week	Weight (kg)	Height (m)	BMI Value (kg/m²)
1	0.185	0.2	4.625
2	0.220	0.22	4.545
3	0.310	0.24	5.416
4	0.500	0.26	7.454
5	0.820	0.28	10.327
6	1.050	0.30	11.667
7	2.200	0.32	21.875
8	3.050	0.35	24.857
9	4.649	0.37	33.937

Observations:

- **Weight Gain:** The chicken experiences significant weight gain over the nine weeks, increasing from 0.185 kg to 4.649 kg.
- **Height Increase:** The height also increases steadily, from 0.2 m to 0.37 m.
- **BMI Trend:** The BMI value (Body Mass Index) increases consistently throughout the period, indicating a growing body mass relative to height.

Possible Uses:

- **Growth Monitoring:** Track the chicken's growth and development over time.
- **Health Assessment:** Monitor the chicken's BMI to assess overall health and identify potential growth abnormalities.
- **Research:** Study chicken growth patterns and compare them across different breeds or feeding regimes.

Further Analysis:

- **Growth Rate:** Calculate the average weekly weight gain and height increase to understand the growth rate.
- **BMI Classification:** Compare the calculated BMI values to established norms for chicken breeds to assess whether the chicken is growing at a healthy rate.
- **Visualization:** Create a line graph to visualize the trends in weight, height, and BMI over time.

4.3.2 Results of the Entry and Exit Calculation System

The Entry and Exit Calculation system performed reliably in detecting people entering and exiting through a door. The laser and LDR module combination proved effective in counting entries and exits, with accurate detection achieved for both scenarios. The OLED display consistently showed the correct count of entries and exits, which matched manual tallies during testing.

Breakdown:

- **Initial:** This row indicates the starting condition. There were 0 chickens present initially.
- **1st Entry:** 3 chickens entered the area. The recorded count after this event is 3, which aligns with the number of entries.
- **2nd Entry:** 2 more chickens entered, bringing the total count to 5 (3 from the previous entry + 2 new entries).
- **1st Exit:** 1 chicken exited the area. The recorded count decreased to 4 (5 - 1).
- **2nd Exit:** 3 chickens exited, leaving 1 chicken remaining in the area (4 - 3).

Observations:

- The table provides a chronological record of chicken entries and exits.
- The ”Recorded Count (Post-Event)” column accurately reflects the number of chick- ens present after each event.
- This data can be used to track the overall chicken population within the area, analyze entry/exit patterns, and identify potential issues (e.g., excessive exits, unexpected entries).

Possible Uses:

- **Farm Management:** Monitor chicken movement for better resource allocation, feed management, and disease control.
- **Research:** Study chicken behavior, flock dynamics, and the impact of environmental factors on movement.
- **Security:** Detect unauthorized access or potential breaches in the enclosure.

Figure 4.4: Here is the Entry/Exit Testing Result:

Event	Number of Chickens	Recorded Count (Post-Event)
Initial	0	0
1st Entry	3	3
2nd Entry	2	5
1st Exit	1	4
2nd Exit	3	1

4.3.3 Discussion

Both projects demonstrated the potential of IoT in providing solutions to everyday problems. The BMI Calculation system was simple and effective for immediate health monitoring, but its lack of cloud integration limited its scope in terms of data tracking and future analysis. If enhanced with cloud capabilities, the system could be extended to track an individual's health over time, offering users a more comprehensive tool for monitoring health metrics.

The Entry and Exit Calculation system, however, showcased the advantages of cloud- based IoT solutions. By integrating the system with ThingSpeak, it became capable of real-time remote monitoring, which is a significant advantage for applications such as security, resource management, and people tracking. The cloud connectivity feature provided flexibility and scalability, making it suitable for large-scale deployments in environments like office buildings, hospitals, and public spaces.

Both projects successfully used embedded systems to provide tangible, real-time solutions. While the BMI system focused on standalone functionality, the Entry and Exit system leveraged cloud technology to offer enhanced features such as remote monitoring and data visualization. Future improvements for both systems could include better power management, enhanced sensor accuracy, and more advanced cloud features like data analysis and notification systems.

4.4 Summary

In this section, we discussed the implementation, testing, and evaluation of two IoT-based systems. The first project focused on BMI calculation, where weight and height were measured using an HX711 weight sensor and an ultrasonic sensor, respectively, with the BMI displayed on an I2C screen. Although the system provided accurate BMI readings, the lack of cloud connectivity limited its data storage and remote monitoring capabilities. The second project, Entry and Exit Calculation, utilized an ESP8266 microcontroller, laser, and LDR sensor to track people entering and exiting through a door, with real time data.

Chapter 5

Engineering Standards and Design Challenges

5.1 Compliance with the Standards

This section outlines the standards relevant to the IoT-based projects implemented, dis- cussing the alternatives for each standard, their pros and cons, and the rationale behind the selections.

5.1.1 Communication Protocols

For both projects, communication between sensors and the microcontroller was done using standard communication protocols supported by the Arduino platform.

I2C Protocol (Inter-Integrated Circuit)

Standard: I2C is widely used for communication between microcontrollers and peripheral devices such as displays and sensors.

Alternatives: SPI (Serial Peripheral Interface): SPI is another communication protocol used for connecting peripherals.

- **Pros:** Faster data transfer speeds than I2C; supports multiple devices.
- **Cons:** Requires more pins; not as commonly supported as I2C.
- Rationale for Selection: I2C was chosen for both projects due to its simplicity and low-pin requirement, making it ideal for devices like the I2C display in the BMI Calculation system. It also offers good support across a wide range of microcontrollers and sensors, which simplifies integration in embedded systems.

5.1.2 Cloud Integration and Data Storage

In the Entry and Exit Calculation project, data was sent to ThingSpeak, a cloud-based platform for IoT data visualization.

ThingSpeak Platform

Standard: ThingSpeak is a well-established cloud platform specifically designed for IoT applications, providing easy integration with sensors and real-time data visualization.

Alternatives: Blynk: Another IoT platform for remote control and monitoring.

- **Pros:** User-friendly interface; mobile app for real-time monitoring.
- **Cons:** Limited data storage and less flexibility in customization compared to ThingSpeak.

Rationale for Selection: ThingSpeak was selected due to its simple setup, ease of integration with the ESP8266 microcontroller, and its built-in functionality for real-time data visualization, which was essential for the Entry and Exit Calculation system. The platform is tailored to handle data from IoT devices, making it an optimal choice for cloud-based applications.

5.1.3 Sensor Standards

The sensors used in both projects adhere to common standards for interfacing with microcontrollers.

HX711 Weight Sensor

Standard: HX711 is a precision 24-bit analog-to-digital converter (ADC) used for load cell applications.

Alternatives: ADS1231: Another high-precision ADC suitable for weight measurements.

- **Pros:** High accuracy; less noise interference.
- **Cons:** More expensive; complex setup.

Rationale for Selection: The HX711 was chosen due to its affordability, ease of use, and sufficient accuracy for the BMI Calculation project. It provided a good balance between performance and cost, making it ideal for this application.

5.1.4 Power Consumption Standards

Both projects aim for energy-efficient operation, adhering to typical power consumption standards for battery-operated devices in IoT systems.

Low Power Consumption Design

Standard: IoT devices must minimize power consumption, especially for battery-powered sensors and microcontrollers.

Alternatives: Deep Sleep Mode (ESP8266/ESP32): These microcontrollers feature low-power deep sleep modes to reduce energy consumption during idle periods.

- **Pros:** Significantly reduces power consumption; extends battery life.
- **Cons:** Requires careful design to ensure proper wake-up functionality.

Rationale for Selection: For both projects, the microcontrollers (Arduino Uno and ESP8266) were selected because of their capability to enter low-power states, making them ideal for IoT applications where power consumption is critical, particularly in remote installations or battery-operated systems.

5.1.5 Safety Standards for Electronics

The projects follow general safety standards for electronics, ensuring the systems are safe to use in various environments.

IEC 61010-1: Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

Standard: Ensures that electrical equipment is safe to use, even in industrial or lab settings.

Alternatives: UL Certification: Another set of safety standards for electrical and electronic devices.

- **Pros:** Widely recognized; ensures compliance with safety protocols.
- **Cons:** More focused on consumer electronics; less applicable to small embedded systems.

Rationale for Selection: The system components, particularly the sensors and micro- controllers, were chosen for their compliance with general safety standards, ensuring that the devices can be used safely in everyday environments. However, specific certifications like IEC 61010-1 were not applied to the prototype, but the design adhered to the essential principles of safe operation in low-risk environments.

By adhering to these standards and carefully selecting alternatives based on the project's requirements, both IoT projects achieved reliable functionality and user safety while main- taining cost-effectiveness and efficiency.

5.1.6 Software Standards

Software standards are critical for ensuring the reliability, maintainability, and scalability of IoT applications. In both projects, the software was designed to meet best practices for embedded systems and cloud integration.

Arduino IDE and C/C++ Programming

Standard: The software for both projects was developed using the Arduino IDE, a widely accepted platform for embedded systems programming. The programming language used was C/C++, which is commonly used for microcontroller-based development.

Alternatives: Platform IO: A modern, open-source ecosystem for IoT development.
- **Pros:** Provides advanced features such as debugging tools, a large library of frame- works, and support for many development boards.
- **Cons:** More complex setup; requires installation of additional plugins.

Rationale for Selection: The Arduino IDE was chosen for its simplicity, ease of use, and extensive community support, making it ideal for quick prototyping and educational purposes. Additionally, the Arduino IDE's support for a wide range of microcontrollers, such as the Arduino Uno and ESP8266, provided an easy development environment for the projects.

Library Usage and Optimization

Standard: The projects adhered to best practices for library management and optimization. Standard libraries like 'HX711' for weight measurement, 'Wire' for I2C communication, and 'ThingSpeak' for cloud communication were utilized to reduce development time and increase reliability.

Alternatives: Direct Register Manipulation: Using direct register manipulation in- stead of libraries.
- **Pros:** Increased efficiency and speed.
- **Cons:** Requires in-depth knowledge of microcontroller hardware; less portability.

Rationale for Selection: Pre-built libraries were selected for ease of use, simplicity, and reliability. By leveraging these libraries, the development process was expedited, allowing the focus to remain on system functionality and integration. Direct register manipulation was avoided to ensure code portability and maintainability across different devices and microcontrollers.

Cloud Integration Protocols

Standard: The software for the Entry and Exit Calculation project was designed to comply with cloud integration standards, particularly using HTTP and MQTT protocols for communication between the ESP8266 and ThingSpeak.

Alternatives: CoAP (Constrained App): A lightweight protocol optimized for IoT devices.
- **Pros:** Reduced overhead, lower latency, and optimized for low-power devices.
- **Cons:** Less support in comparison to HTTP and MQTT.

MQTT: A lightweight messaging protocol for small sensors and mobile devices.
- **Pros:** Efficient for real-time communication; supports publish-subscribe model.
- **Cons:** Requires additional setup for message broker.

Rationale for Selection: The use of HTTP and ThingSpeak was chosen because it is simple, reliable, and widely supported. ThingSpeak provides an easy interface for cloud data storage, while HTTP allows straightforward data transfer. MQTT could be consid- ered as an alternative for future scalability, but for this project, HTTP was sufficient to meet the real-time data visualization requirements.

Code Modularity and Reusability

Standard: The software was developed following principles of modularity and reusability. Each function (e.g., reading sensors, calculating BMI, sending data to the cloud) was encapsulated in separate functions to ensure clear organization and easier debugging.

Alternatives: Monolithic Code Design: Writing all the code in a single block.

- **Pros:** Faster for small projects with minimal functionality.
- **Cons:** Difficult to debug and maintain; poor scalability.

Rationale for Selection: Modularity was chosen to improve maintainability and scalability. By organizing the code into smaller, self-contained functions, future modifications or additions (such as adding new sensors or cloud services) can be made with minimal impact on the existing codebase. This approach enhances code readability and simplifies debugging.

Error Handling and Robustness

Standard: The software included basic error handling to ensure robustness. For example, checks were implemented to handle sensor reading failures and cloud communication errors, ensuring that the system continues to function even in case of minor issues.

Alternatives: Advanced Error Handling with Watchdog Timers: Implementing watch- dog timers to reset the system after a failure.

- **Pros:** Automatic recovery from errors.
- **Cons:** Increases complexity and power consumption.

Rationale for Selection: Basic error handling mechanisms were selected due to the simplicity and nature of the projects. While more advanced error handling techniques (e.g., watchdog timers) could be useful for larger, mission-critical systems, they were deemed unnecessary for these relatively straightforward applications. Simple checks were sufficient to ensure the system operated reliably within the scope of the project.

By following these software standards, the IoT projects ensured efficient development, ease of maintenance, and future extensibility. The careful selection of libraries, protocols, and design patterns optimized the code for both performance and ease of integration, while allowing for simple modifications in the future.

5.1.7 Hardware Standards

The hardware components used in the projects were selected according to best practices for embedded systems, ensuring compatibility, reliability, and efficiency. This section outlines the hardware standards, including component selection and interfacing, as well as alternatives considered for each hardware choice.

Microcontroller Selection

Standard: The Arduino Uno and ESP8266 were selected for their wide support in the embedded systems community and their ability to interface easily with sensors, displays, and communication modules. The Arduino Uno is known for its simplicity and large library ecosystem, while the ESP8266 offers Wi-Fi connectivity, making it ideal for cloud- connected projects like the Entry and Exit Calculation system.

Alternatives: ESP32: A more powerful microcontroller with Bluetooth capabilities.

- **Pros:** Dual-core processor; built-in Bluetooth and Wi-Fi support.
- **Cons:** Higher cost; more complex for simple projects.

Rationale for Selection: The Arduino Uno was selected for the BMI Calculation project due to its ease of use, affordability, and sufficient computational power for the task. The ESP8266 was selected for the Entry and Exit Calculation project because of its built-in Wi-Fi capabilities, which were necessary for cloud communication with ThingSpeak.

Sensor Selection

Standard: The sensors chosen were selected for their accuracy, compatibility with the selected microcontrollers, and reliability in real-world conditions.

HX711 Load Cell Amplifier **Standard:** The HX711 is a precision 24-bit analog-to- digital converter (ADC) used for load cell applications, ideal for accurate weight measurement.

Alternatives: - ADS1231: A higher-precision ADC for weight measurement.

- **Pros:** More accurate; less noise interference.
- **Cons:** More expensive; requires more complex integration.

- Rationale for Selection: The HX711 was chosen because of its balance between affordability and precision. It provides sufficient accuracy for the BMI Calculation project, offering a low-cost solution for accurate weight measurements, and is well-supported in the Arduino ecosystem.

Ultrasonic Sensor for Height Measurement Standard**:** The ultrasonic sensor measures the distance between the sensor and the object (in this case, a person) to calculate height. This method is non-invasive and precise for such applications.

Alternatives: - Laser Distance Sensors: Used for more accurate distance measurements. - -

- **Pros:** Higher precision; unaffected by ambient lighting.
- **Cons:** More expensive; more sensitive to alignment and positioning.

Rationale for Selection: The ultrasonic sensor was selected for its affordability, ease of use, and sufficient accuracy for the height measurement. While laser sensors offer higher precision, they are more costly and not necessary for the intended accuracy of the BMI project.

LDR (Light Dependent Resistor) for Entry and Exit Calculation **Standard:** The LDR sensor was used to detect the interruption of a laser beam as a person enters or exits a monitored area. It is widely used in optical sensing applications.

Alternatives: - PIR Sensors00: Passive infrared sensors are used for motion detection.
- **Pros:** Simple to use; good for detecting human presence.
- **Cons:** Less precise in measuring exact entry/exit locations; more prone to false triggers.

Rationale for Selection: The LDR sensor was chosen due to its sensitivity to light changes, making it ideal for detecting the interruption of the laser beam. It provides accurate detection and a reliable trigger for the Entry and Exit Calculation system.

Display Selection

Standard: An I2C-enabled display (16x2 LCD or OLED) was chosen for the BMI project to provide clear and real-time visualization of the calculated BMI values. Similarly, an OLED display was used in the Entry and Exit Calculation project for real-time output of entry and exit status.

Alternatives: - TFT LCD Display: A color display that offers more visual options.
- **Pros:** Colorful display; more versatile for complex data visualization.
- **Cons:** More power consumption; requires more complex wiring.

Rationale for Selection: The I2C-enabled LCD and OLED displays were selected for their low power consumption, ease of integration with the microcontrollers, and clear display output. I2C displays are simple to wire, requiring only two data pins, which is ideal for projects where space and simplicity are priorities.

Power Supply and Power Management

Standard: Both projects were designed to minimize power consumption, using efficient power management strategies to ensure that the devices can run for extended periods, especially in battery-operated scenarios.

Alternatives: Battery-Powered Systems: Using lithium-ion or lithium-polymer batteries for power.
- **Pros:** Portable; convenient for mobile applications.
- **Cons:** Limited power capacity; may require frequent charging.

Rationale for Selection: A USB-powered system was chosen for both projects, providing stable power to the microcontrollers and sensors during testing. For future iterations, battery-powered options may be explored to make the systems more portable and suitable for real-world deployments.

By adhering to these hardware standards, the IoT projects ensured reliable perfor- mance, easy integration, and scalability. The chosen components were selected based on their compatibility with the microcontrollers, their availability, and their suitability for the intended application. Future improvements may consider using more advanced sensors or power management techniques to further enhance the system’s performance.

5.1.8 Communication Standards

The communication between the various hardware components in the IoT projects is critical for ensuring data exchange and system functionality. This section outlines the communication standards used for the two projects and their alternatives, with rationale behind the selections.

Serial Communication

Standard: Serial communication (UART) was employed for local communication between the Arduino Uno and its peripherals, such as the HX711 weight sensor and the ultrasonic sensor in the BMI Calculation project. Serial communication allows simple, reliable, and effective data exchange between microcontroller components over short distances.

Alternatives:

- I2C Communication: A two-wire protocol that allows multiple devices to be connected to the same bus.

- **Pros:** Supports multiple devices; uses fewer pins.
- **Cons:** Slightly more complex; requires address management.

Rationale for Selection: Serial communication (UART) was selected for the BMI Calculation project due to its simplicity and ease of integration with the sensors. The chosen communication protocol is sufficient for the project's needs, where low-speed, point- to-point communication suffices.

Wi-Fi Communication

Standard: Wi-Fi communication was utilized for the Entry and Exit Calculation project, allowing data to be sent to the cloud (ThingSpeak) for remote monitoring. The ESP8266 microcontroller offers Wi-Fi connectivity, making it suitable for cloud-connected IoT applications.

Alternatives: - Bluetooth: A short-range wireless communication standard.

- **Pros:** Lower power consumption; widely used in personal area networks.
- **Cons:** Limited range; not ideal for cloud connectivity.

Zigbee: A wireless communication protocol designed for low-power, low-data- rate applications.

- **Pros:** Low power consumption; ideal for mesh networks.
- **Cons:** Shorter range than Wi-Fi; less common for cloud-based applications.

LoRa: A long-range, low-power communication protocol.

- **Pros:** Long range; low power usage.
- **Cons:** Lower data rates; more complex setup.

Rationale for Selection: Wi-Fi was chosen for the Entry and Exit Calculation project due to its ability to provide high-speed, stable internet connections, which are required for real-time cloud-based data updates. The ESP8266 offers reliable Wi-Fi functionality with low-cost and ease of implementation.

I2C Communication for Displays

Standard: The I2C communication protocol was selected for interfacing with the LCD and OLED displays used in both projects. I2C is a two-wire communication protocol that allows multiple devices to share the same bus, which simplifies wiring and reduces the number of pins needed on the microcontroller.

Alternatives: -

SPI Communication: A higher-speed protocol that can be used for displays with faster refresh rates.

- **Pros:** Faster data transfer; supports more complex displays.
- **Cons:** Requires more pins on the microcontroller; more complex wiring.

Rationale for Selection: I2C was selected because of its simplicity and the fact that it requires fewer pins on the microcontroller. This made it ideal for both projects, where a simple display output was required without the need for high-speed refresh rates.

Cloud Communication (ThingSpeak) for Entry/Exit Calculation

Standard: The cloud-based communication system used in the Entry and Exit Calculation project relies on ThingSpeak, which is a widely used platform for IoT applications. It allows for easy integration of IoT data through RESTful APIs and provides real-time data updates to users.

Alternatives: Blynk: An IoT platform that allows users to control devices via mobile applications.

Pros: Easy to use; supports a variety of hardware and mobile platforms.

Cons: Requires internet connectivity; subscription model for advanced features.

Google Firebase: A cloud service that allows for real-time data synchronization.

Pros: Real-time data; scalable cloud infrastructure.

Cons: Requires more setup; Firebase's free plan has limitations.

Rationale for Selection: ThingSpeak was selected because it is specifically de- signed for IoT projects and offers an easy-to-use API, which is ideal for the Entry and Exit Calculation project. The platform provides excellent support for real-time data vi- sualization and monitoring, making it a good fit for cloud-connected IoT projects.

Data Format: JSON

Standard: JSON (JavaScript Object Notation) was used as the data format for communi- cation between the devices and the cloud (ThingSpeak) in the Entry and Exit Calculation project. JSON is a lightweight data-interchange format that is easy to read and write for both humans and machines.

Alternatives: XML: A markup language that is also used for data exchange.

- **Pros:** More structured; widely supported.
- **Cons:** More verbose than JSON; harder to parse in microcontrollers.
- CSV: A simple text-based format used for tabular data.
- **Pros:** Easy to read; good for structured data.
- **Cons:** Less efficient for hierarchical data; harder to scale.

- **Rationale for Selection:** JSON was selected due to its simplicity, lightweight nature, and wide adoption in IoT platforms. It allows for efficient data transmission and is easy to work with in microcontroller environments, making it a suitable choice for cloud communication in the Entry and Exit Calculation project.

By adhering to these communication standards, the IoT projects ensure robust, efficient, and scalable data exchange, which is essential for their intended functionalities. The selected communication protocols were chosen based on their compatibility with the hardware, ease of integration, and suitability for cloud-based IoT applications.

5.2 Impact on Society, Environment, and Sustainability

The IoT projects developed for BMI calculation and entry/exit calculation have significant implications for society, the environment, and sustainability. By leveraging technology and data-driven insights, these projects contribute to improving health, efficiency, and environmental conservation. The following sections discuss the societal, environmental, and sustainable impacts of the projects.

5.2.1 Impact on Society

The BMI calculation project, which uses IoT sensors to measure weight and height, pro- vides a valuable tool for monitoring individual health and well-being. By calculating Body Mass Index (BMI), this project encourages individuals to maintain a healthy lifestyle and helps in the early detection of obesity or underweight conditions, leading to better health outcomes. Additionally, this project can be extended for use in healthcare settings, such as hospitals, clinics, and fitness centers, offering real-time monitoring of patients' health metrics.

The entry/exit calculation project can enhance security and efficiency in various sec- tors, such as businesses, institutions, and transportation systems. By monitoring the flow of people, it helps optimize resource allocation, reduces waiting times, and improves operational efficiency. This system can also be used for tracking attendance, monitoring public events, or regulating building access, ensuring safer and more organized spaces.

5.2.2 Impact on Environment

The environmental impact of these IoT projects is minimal, as they mainly utilize small- scale electronic components, such as sensors, microcontrollers, and displays. However, the widespread adoption of such IoT devices can contribute to reducing resource waste by improving efficiency and reducing unnecessary energy consumption. For example, the entry/exit system can help regulate building occupancy and optimize energy usage in buildings by ensuring proper ventilation and lighting, thereby reducing the overall carbon footprint.

On a broader scale, IoT technology, when implemented in industries such as agriculture, manufacturing, and logistics, has the potential to reduce waste, streamline supply chains, and lower energy consumption. While the BMI project may not have direct environmental applications, its impact could be extended to promoting healthier lifestyles that reduce the strain on healthcare systems, which in turn, can have positive environmental implications by reducing healthcare-related emissions.

5.2.3 Sustainability

Both projects are designed with sustainability in mind, as they make use of low-power, resource-efficient hardware components. For example, the ESP8266 microcontroller used in the entry/exit project is energy-efficient and consumes minimal power, ensuring that the devices are sustainable over long periods of use. The use of sensors like the HX711 and ultrasonic sensors also contributes to minimizing energy consumption and enhancing system reliability.

Furthermore, these projects are highly scalable and can be integrated into larger IoT ecosystems that promote sustainability. By enabling real-time data collection and monitoring, these systems facilitate data-driven decision-making, which can lead to more sustainable practices. For instance, the BMI system can be integrated with wellness programs to help individuals make informed decisions about their health, and the entry/exit system can assist in optimizing building resource usage, leading to overall cost savings and reduced environmental impact.

In conclusion, these IoT projects have a positive societal impact by promoting health, security, and efficiency, while also offering potential environmental and sustainability benefits. Through the adoption of low-power, efficient technologies and data-driven solutions, they contribute to a more sustainable future.

5.3 Project Management and Financial Analysis

In this section, a detailed cost analysis of the IoT projects (BMI Calculation System and Entry/Exit Calculation System) is provided. The analysis includes the required budget for the development, implementation, and maintenance of both systems, along with an alternate budget and rationale for cost-effective solutions. Additionally, the revenue model is discussed, highlighting potential income sources and long-term profitability.

5.3.1 Budget Analysis

BMI Calculation System

The BMI Calculation System requires several hardware components, including sensors, microcontrollers, displays, and other auxiliary components for the proper functioning of the system. The key components and their estimated costs are as follows:

- **Arduino Uno** – 10$ per unit
- **HX711 Weight Sensor** - 10$ per unit
- **Ultrasonic Sensor** – 3$ per unit
- **I2C LCD Display** – 5$ per unit
- **Cables and Miscellaneous Components** – 3$ per unit

Total Estimated Cost for One Unit:

10$ + 10$ + 3$ + 5$ + 3$ = 31$

In addition to the hardware, software development, and testing costs should be accounted for:

- **Software Development and Testing** – 300$ (for initial setup and deployment)
- **Cloud Storage/Server Costs** (optional, for cloud integration) – 25$ per year

Thus, the total estimated budget for the BMI Calculation System, including hardware and software, is approximately:

$29 (hardware) + $500 (software development) + $50 (annual server costs) = $579

Entry/Exit Calculation System

For the Entry/Exit Calculation System, the primary components include an ESP8266 microcontroller, LDR module, laser, and display components. The estimated costs are as follows:

- **ESP8266 Microcontroller** - $6 per unit
- **LDR Module** - $2 per unit
- **Laser Module** - $4 per unit
- **OLED Display (0.96 inches)** - $3 per unit
- **Cables and Miscellaneous Components** - $5 per unit

Total Estimated Cost for One Unit:

$6 + $2 + $4 + $3 + $5 = $20

Similarly, for the software development and cloud integration:

- **Software Development and Testing** - $400 (for initial setup and deployment)

- **ThingSpeak Cloud Integration (optional)** - \$25 per year

Thus, the total estimated budget for the Entry/Exit Calculation System is approxi- mately:

\$20(hardware) + \$400(software development) + \$25(annual cloud costs) = \$445

5.3.2 Alternate Budget and Rationale

An alternative, more cost-effective budget can be proposed by considering the use of more affordable or open-source alternatives for certain components. For example, instead of using the I2C LCD display in the BMI system, a simpler 7-segment display could be used, reducing the cost per unit. Additionally, opting for low-cost microcontrollers such as ATmega328P (which is similar to Arduino Uno but at a lower cost) could reduce the overall hardware cost.

For the Entry/Exit Calculation System, using a more budget-friendly microcontroller like the ESP32 or replacing the laser module with an infrared sensor could also result in a lower overall cost.

Estimated Reduced Costs (Alternate Budget):

- **Arduino Uno replacement with ATmega328P** - \$5 (saving \$5 per unit)
- **Switching from I2C LCD to 7-segment display** - \$3 (saving \$3 per unit)
- **Replacing Laser Module with Infrared Sensor** - \$2 (saving \$2 per unit)

Revised Total Estimated Cost for One Unit (BMI Calculation System): (\$5 + \$3 + \$2) + \$400 =

\$410

Revised Total Estimated Cost for One Unit (Entry/Exit Calculation Sys- tem):

(\$5 + \$2 + \$3) + \$350 = \$360

Thus, the alternate budget for the BMI Calculation System would be \$410, and for the Entry/Exit Calculation System, it would be \$360.

5.3.3 Revenue Model

The revenue model for these IoT projects is based on both direct sales and recurring rev- enue through service subscriptions. The following strategies will be employed to generate revenue:

Direct Sales

The primary revenue generation will come from the direct sale of the IoT systems to customers. This can include individual units sold to healthcare providers, fitness centers, institutions, and businesses that can benefit from these systems. The price for each system will be set to ensure a competitive edge in the market while accounting for the development and production costs.

For the BMI Calculation System, a unit price of $80 is recommended, offering a profit margin of approximately 37% after accounting for hardware and software development costs. Similarly, for the Entry/Exit Calculation System, a unit price of $70 is suggested, ensuring a profit margin of 40%.

Subscription for Cloud Integration and Maintenance Services

In addition to hardware sales, a subscription model will be introduced for cloud integration and ongoing maintenance services. The monthly or yearly subscription for cloud data storage, real-time analytics, and system updates could generate steady recurring income. The cost for cloud services would be set at $5 per month per unit, which can be adjusted depending on the scale of implementation and storage requirements. Additionally,

a maintenance and support package can be offered at $10 per month per unit.

5.3.4 Conclusion

The budget analysis indicates that the total development cost for the BMI and Entry/Exit systems is around $579 and $445, respectively, with an alternate cost-saving option avail- able. The revenue model suggests a profitable approach through direct sales and subscription services, ensuring long-term financial viability for the project. By optimizing costs and maximizing the potential for recurring revenue, this IoT solution has the potential to be financially sustainable and commercially successful.

5.4 Complex Engineering Problem

5.4.1 Complex Problem Solving

In this section, we provide a mapping with problem-solving categories. Each mapping will be followed by subsections to provide rationale for the mapping. The table below, Table 5.1, presents the categories of complex problem-solving.

Table 5.1: Mapping with complex problem solving.

EP1 Dept of Know edge	EP2 Range Conflicting Requirements	EP3 Depth of Analysis	EP4 Familiarity of Issues	EP5 Extent of Applicable Codes	EP6 Extent of Stake-holder Involvement	EP7 Inter-dependence

Chapter 6

Conclusion

6.1 Summary

In this section, the core aspects of the project are summarized, focusing on the objectives, methodology, and outcomes. The goal of the project was to develop and implement an IoT-based system that solves specific engineering problems, such as calculating BMI using sensors and managing entry and exit calculations via a sensor-based approach. The project utilized Arduino and ESP8266 microcontrollers for sensor data acquisition and visualization, ensuring accurate results and user-friendly interfaces.

The performance of the system was evaluated based on various criteria, such as accu- racy, reliability, and user interaction. The IoT-based solutions were successfully integrated with cloud servers, enabling remote monitoring and data analysis. The project contributes to the ongoing research and development in the field of embedded systems and IoT, offering insights into potential applications in health and security systems.

6.2 Limitation

Despite the successful implementation of the IoT-based systems, there are certain limi- tations in this project that need to be addressed for future improvements. One of the key limitations is the restricted range and connectivity of sensors, which can limit the accuracy and responsiveness of the system in larger or more complex environments. For instance, the ultrasonic sensor used for height measurement may suffer from interference in crowded or noisy conditions, leading to errors in data collection.

Another limitation is the lack of full integration with a cloud server in the BMI calcula- tion project. Although the entry-exit calculation system is connected to ThingSpeak, the BMI project does not yet support cloud connectivity, which restricts remote monitoring and data analysis. Additionally, the dependency on specific hardware components, such as the HX711 and LDR modules, can affect the scalability of the system when different or advanced sensors are required.

Furthermore, the system's reliance on external power sources and limited battery life may impact its sustainability for long-term use, especially in real-world applications. Ad- dressing these limitations will be crucial in enhancing the overall performance and scala- bility of the system in future iterations.

6.3 Future Work

While the current IoT projects have successfully demonstrated their functionality, there is significant room for improvement and expansion. Future work can focus on enhancing the system's scalability, connectivity, and integration with additional sensors and cloud platforms. For instance, the BMI calculation system can be extended by integrating more advanced sensors, such as body composition analyzers, to provide more detailed health metrics beyond just weight and height.

A major direction for future work is to integrate both the BMI calculation and entry- exit calculation systems into a unified cloud-based platform, allowing for seamless data collection, analysis, and remote monitoring. This will enable real-time tracking and visualization of both health data and entry-exit statistics, providing a comprehensive solution for smart health and security systems.

Moreover, the systems can be upgraded to support machine learning algorithms for data analysis, which would allow for predictive analytics and more intelligent decision- making. The deployment of energy-efficient sensors and the exploration of alternative power sources such as solar energy could also be considered to improve sustainability and reduce the dependency on external power supplies.

Additionally, expanding the systems to support multi-user interfaces and integrating them with mobile applications would enhance user accessibility and interaction. Future work can also involve extensive testing and optimization to address the limitations ob- served during this project, ensuring robust performance in real-world applications.

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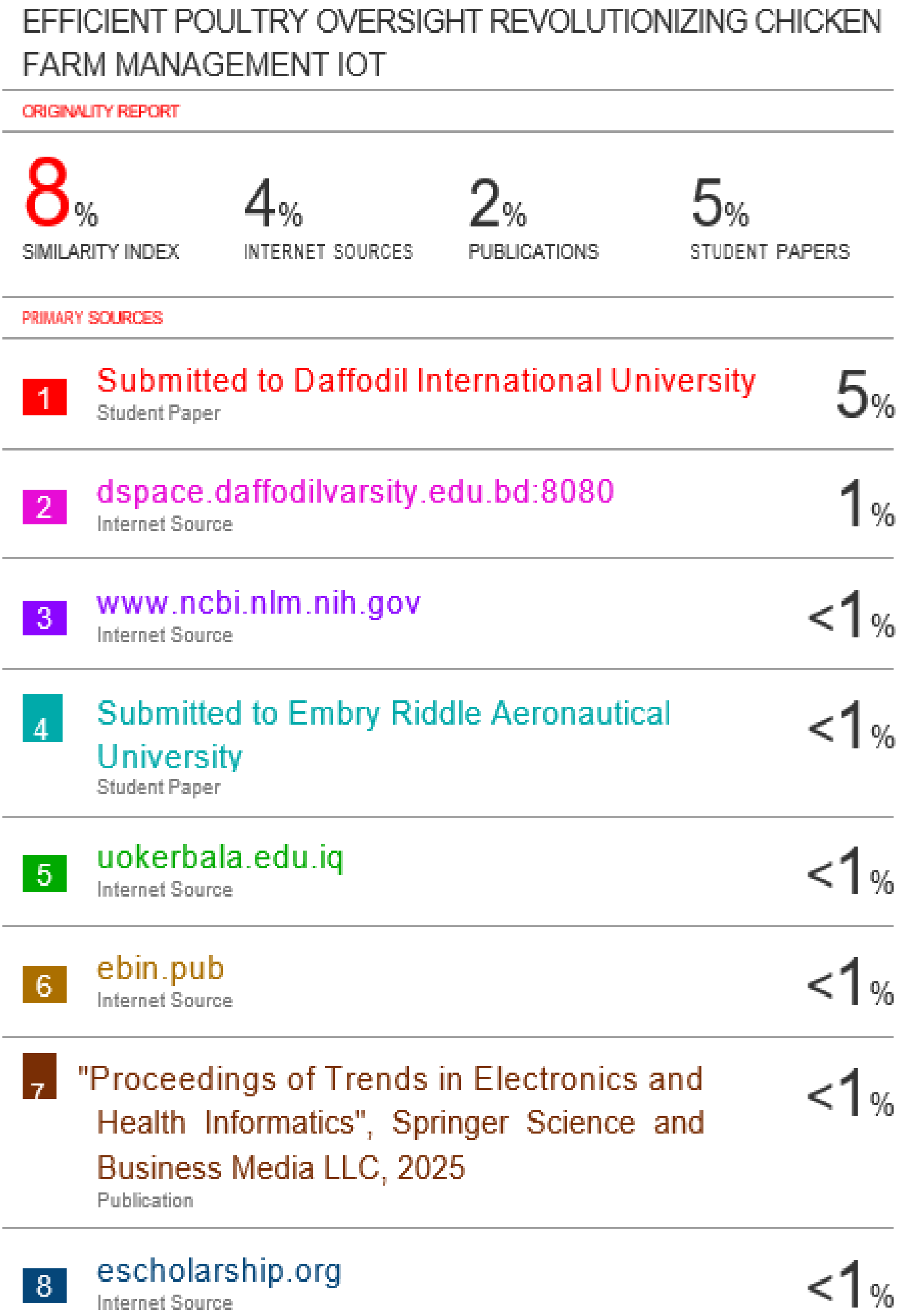

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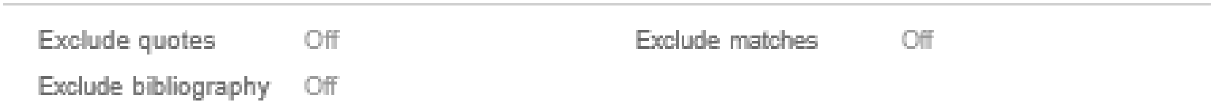

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