

PawConnect

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Certificate

We accept the work contained in this report as a confirmation to the required standard for the partial fulfillment of the degree of BS(EE).

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Dedication

we dedicate this work to my parents, whose support and sacrifices have been with me every step of the way. Their trust in me and the way they've always stood by me made it possible for me to reach this point. I also dedicate this to my siblings for their constant support and understanding. Having them around through all the ups and downs of this journey truly made a difference. This work is for all of you.

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Abstract

There has been a growing use of Internet of Things (IoT) technologies, which have allowed the automation and remote control of day-to-day activities. In this project, we introduce PawConnect, an IoT-based intelligent pet feeder that will help automatize the feeding schedules and give live monitoring and environmental awareness. The system is designed based on ESP32 module as the main controller and allows remote monitoring of pets by means of live video streaming. A load cell that has an HX711 amplifier is used to measure the weight of the food to be able to control the portion accurately. The process of dispensing food is automated by a servo motor, which guarantees feeds on time and in a controlled manner. DHT11 and DHT22 sensors are used to measure temperature and humidity to monitor the environmental conditions and keep the pets comfortable. The system offers real-time LCD status locally (a 16×2 LCD) and is cooled by a fan to maintain the correct temperature. The supply is regulated 5V with specific current carrying to operate the motor. The feeder is linked to a cloud based system where it is monitored remotely, controlled to feed and the feeding report generated. The suggested system is more effective in managing pets by increasing the accuracy of feeding, remote monitoring, and environmental consciousness, which is why it is a viable option in the present-day pets management.

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1 Introduction

Technology is increasingly being used by people in their lives. This has altered the way we attend to things particularly at home. Raising pets is one of such activities. The care of pets is unique as it deals with emotions as well as the more practical aspects such as feeding them when they are hungry to ensure their wellness and comfort.[1]

Internet of Things has brought transformation in such fields as healthcare, transportation and home automation. In the case of pet care technology is not as widely utilized. This is an issue since there is an increasing number of people with pets and they are struggling to look after them due to their busy schedules.[?]

There are individuals who believe that intelligent systems will be able to assist in this matter. Such systems are the ones that will ensure that things get easier as we monitor our pets remotely and are more dependable. It is not easy to go away with the old mode of attending to pets and adopt smart systems.[2] Often these systems are more of ensuring ease rather than accuracy. At times they check on pets better than they take care of them. This implies that we are having systems which are not actually addressing the problems that the pet owners are experiencing.[3]

This paper is attempting to determine how we can develop a better and more feasible system, to take care of pets. We would like to have a system that would simplify and improve the pet care. What we are targeting is pet care. We desire to enhance the manner in which pets are handled. Raising pets is not to be underestimated and we must find a means of simplifying it to both the owner and the pet.[4]

1.1 Project Background and Overview

The idea of taking care of a pet sounds like a job. Life can be hectic and very complicated. Our time schedules become cluttered, even ordinary things such as feeding our pets at

the right time can be a problem.[5] This is where technology, such as the Internet of Things(IoT) comes in to the rescue. IoT has actually transformed the functionality of our daily devices. It helps with care. We are able to use it to feed our pets at the right time.[6]

Homes to fitness trackers can no longer be seen as mere objects. They are able to feel, hear and react. Care has also begun to be affected by this change.[7] The case of smart pet feeders is an instance, which aims at automatizing the feeding process and simplifying it on our part. Most of these systems are still, however, pretty basic, if we take a closer look. They computerize the feeding schedule, and not the quality of care. Our project, PawConnect goes one step further with this. Of simply automating the feeding schedules it is trying to develop an aware, responsive and reliable system. It integrates weight feeding, environmental monitoring and live video streaming into a single platform. This is not simply convenience, but uniformity and regulation in our absence.[8]

1.2 Problem Statement

A pet feeding system must not just dispense food on a set time in a world. It must be able to give the right quantity of food provided enable us to control our pets remotely and give feedback on environmental conditions and feeding. It must feel as though it were a continuation of us. But this is not the case. The majority of the available systems are time-based, and cannot guarantee the portion control. When the mechanism gets stuck or sprays unevenly there is generally no means to test.[8] Most systems have control but no real-time feedback as we give commands without understanding what is occurring. This brings the expectation and receiving at variance. Pets can either be over fed, under fed or abandoned in conditions. This impacts their health in the long run and our confidence in automated systems.[9]

1.3 Overview of the current strategies

A few efforts have been undertaken to enhance pet feeding systems each of which will focus on a different aspect of the issue. There are IoT-based feeders, which are much concerned with scheduling and mobile app control which enables us to remotely activate

feeding. This also makes things convenient though it does not address the problem of portion accuracy. Computer vision is used by other systems, such as YOLOv5 to detect pets and tailor feeding. These are spectacular methods.[10] They also bring about complexity and cost. RFID or long-range communication systems can be used in controlled environments, such as animal facilities. These systems are dependable. Not aimed at an average household. So as much as each method adds to the mix no one of them is able to merge accuracy, monitoring, simplicity and affordability in a single system.[11]

1.4 Research Gap and Motivation

Herein the real gap is evident.

This is still missing systems that are a combination of:

- weight-based feeding
- Live video surveillance (real-time)
- Environmental awareness
- Economical and convenient design.

The majority of studies concentrate on either an advanced intelligence or a basic automation but seldom attain a balance of the two. It is this imbalance that drives us. We would like to develop a system that can be well-functioning in the real-life situation something that a common user can count on day by day without having to set it up or spend a lot of money.[12]

1.5 Objectives of the Study

The study has the following objectives:

The key questions of the research are:

- To determine an automated pet feeding system where the portion is properly controlled with a load cell.[13]
- To support monitoring and control by using cloud connectivity.[?]

- To add video streaming in ESP32-CAM to observe in real time.[?]
- To check the environmental conditions such as temperature and humidity.
- To keep feeding records and feeding logs to help the user access.

All of them help to make the system seem complete and reliable.

1.6 Importance of the Research

This research is significant on levels. In a way it also deals with a real world challenge of pet owners. Attending regular care in hectic lives. Uncertainty can be minimized by a system, such as, PawConnect. Guarantee tranquility. In a perspective, the project adds value to designing IoT systems through illustrating how various components can be implemented into one system.[14] It demonstrates that there are no effective solutions that necessarily involve high-end technologies; sometimes the intelligent use of different components will help to attain better outcomes. On a level, it has to deal with the complexity of technology being shifted towards more human-centered applications. When it is not only the automation that is desired, but helpful support.[8]

2 Literature Review

The fast evolution of communication and embedded systems has had a great impact on the creation of intelligent and automated solutions in different fields. The area of pet care is not an exception, and the introduction of IoT technology allowed to turn the traditional feeding systems into intelligent connected gadgets. One such system is the PawConnect system. This project modifies the framework to be applied to the PawConnect system by mapping the concepts of IoT, sensing and system design to the identical framework. This chapter critically analyzes the technologies, motivations, system design principles and challenges behind the IoT-based pet feeders. It also determines the shortcomings of current strategies. Lays the groundwork of the suggested PawConnect system.[15]

2.1 Smart IoT Domestic Systems

IoT has emerged as a facilitator in ensuring that conventional household appliances become smart. To give an example, smart lighting systems and automated climate control solutions are geared to change according to the user preferences with the least amount of manual input. They usually work on the bases of sensors, microcontrollers and cloud-based platforms that allow the systems to gather information, process it and react in an organized and effective way.[16] They gather information, analyze and take action. The same applies to pet care systems, which can be automated in terms of feeding, monitoring and environmental control. Nevertheless, as opposed to smart home applications pet care adds another responsibility. Failure in one of the lighting systems can be inconveniencing. Breakage in a feeding system has immediate impact on a living being. This increases the significance of reliability and accuracy within systems.[?]

2.2 Smart Pet Feeding Systems: Introduction

Intelligent pet feeders are created to automate the feeding schedules and lessen the dependence on routines. On a level, which can be configured by users, feeding times and amounts can be set. More sophisticated systems further enhance this feature by providing remote access, monitoring and tracking of data. Although these have been made, most systems continue to be centered around a functionality- automated food dispensing.[17] A more detailed method of pet care that covers not only behavioral types but also the environment is not always well integrated into current systems. Consequently, an evident discrepancy between customer expectations and the real capabilities provided by these solutions can be observed.

2.3 Survey of Existing IoT-based Pet Feeders

A number of studies have suggested the IoT-based feeding systems that had an ability to monitor. These systems are typically programmed with computers such as ESP32 or Arduino. These are integrated with Wi-Fi components such that individuals can operate them with web applications. Nevertheless, a number of existing designs continue to employ a timer to dispense.[?] This usually does not provide regular quantities. Individuals require restraint of portions. Microcontroller-based systems, such as ESP32, can assist. Apps or web applications can be used to control them. This facilitates receiving the amount each time.[5]

2.4 Smart and AI-powered Feeding Solutions

To overcome some of these constraints researchers have looked into systems that use artificial intelligence and machine learning. As an example vision-based systems employ models such as YOLOv5 to identify and detect pets to feed them. The goal of these systems is to bring in some flexibility, in which feeding choices are determined by behavior instead of time-based plans. These approaches however have trade-offs. They demand computing power, add complexity to the system and usually become expensive.[18]

2.5 Feeding systems Sensing technologies

Sensors contribute to enrich the accuracy and functionality of feeding systems. Load cells are highly recommended in weight based measurement that serves as a good substitute of time-based dispensing.[19] Environmental sensors (temperature, humidity sensors etc) are often included. The otherwise insufficient integration of sensing technologies shows a missed opportunity to enhance the system awareness.[20]

2.6 Monitoring and Control Systems on the Cloud

The use of cloud platforms is a necessary part of applications allowing access remotely, data storage and system control.

With cloud integration in feeding systems the user is able to:

- Monitor feeding activity
- Control feeding remotely
- Access historical data

But the extent of interaction in it differs greatly. There are simple control systems and systems which strive to provide features better than simple such as notifications and analytics.[15]

2.7 Critical Literature Review

When collectively considered research shows an appearance. Other systems lack sophisticated systems in that they compromise accuracy.[21] Intelligence is the goal of others. Become overly complex. Not many find a balance between functionality, reliability and usability. The other similar problem is the absence of integration. Functionalities like portion control, environmental monitoring and live feedback are not always designed as a comprehensive system but rather either not designed at all or only in a form of one functionality.[22]

2.8 Research Gap Identification

Facilitated by the examination of the extant sources there is a definite gap that opens up.

It is necessary to have a system that:

- Maintains proportion of control via sensing.
- Gives live tracking, with visual feedback.
- Incorporates environmental awareness
- Little expensive and simple to use.

To seal this gap, the proposed PawConnect system is designed to ensure practical implementation, and not individual features. The aim is to have an easy to use solution that is not only technically reliable, but practical in practical scenarios as well.[8]

3 Requirement Specifications

This chapter outlines the technical specifications of PawConnect system such as hardware, software, functionality of the system as well as the web outputs to be expected. The objective is to define well how the system would be set to work; the components that would be needed in the successful deployment of the system.[17]

3.1 Functional Requirements

The system will have to serve the following functions:

- The robot will automatically dispense food by use of a servo motor system.
- The system will respond to the amount of food by a load cell (through HX711 module).
- The system will be monitoring the temperature and humidity with the help of a DHT sensor.
- The system will be connected to the cloud (Firebase) by providing real-time data.
- The system will enable the users to access live data even at a distance.
- The system will turn on a cooling fan when the temperature is at a specified point.
- The system will have live video streaming with ESP32-CAM.

3.2 Non-Functional Requirements

The system must be able to work when there is no internet or a very slow internet. That is, data should be updated real-time and with minimum latency. The design must be

small and fit into the interiors. The systems must be convenient and remote monitoring.[?
]

3.3 Hardware Requirements

The hardware used includes:

- ESP32: Overview ES32-based main microcontroller with Wi-Fi.[19]



Figure 3.1: ESP32

Power Pins

Pin	Use
3V3	3.3V Power
VIN / 5V	Power Input
GND	Ground

Safe GPIO Pins

GPIO4, GPIO5, GPIO18, GPIO19, GPIO21, GPIO22, GPIO23, GPIO25, GPIO26,
GPIO27, GPIO32, GPIO33

Communication Pins

I2C

Function	GPIO
SDA	GPIO21
SCL	GPIO22

SPI

Function	GPIO
MOSI	GPIO23
MISO	GPIO19
SCK	GPIO18
CS	GPIO5

UART

TX	GPIO1
RX	GPIO3

Analog Pins (ADC)

GPIO32–39, GPIO25–27, GPIO12–15, GPIO4, GPIO2

DAC Pins

GPIO25, GPIO26

Input Only Pins

GPIO34, GPIO35, GPIO36, GPIO39

Avoid These Pins

Pin	Reason
GPIO6–11	Used by Flash Memory
GPIO0,2,12,15	Boot Pins
GPIO1,3	USB Serial Pins

- DHT 11/DHT22 Sensor: Temperature and Humidity sensing.

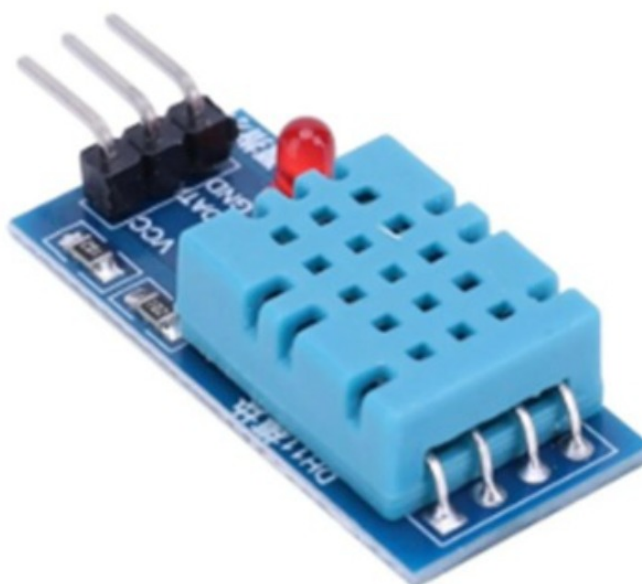


Figure 3.2: DHT 11/DHT22 Sensor

DHT11 and DHT22 are sensors used for:

- Temperature sensing
- Humidity sensing

Difference Between DHT11 and DHT22

Feature	DHT11	DHT22
Temperature Range	0°C to 50°C	-40°C to 80°C
Humidity Range	20–80%	0–100%
Accuracy	Low	High
Price	Cheap	Expensive

Pin Configuration

Pin	Function
VCC	Power
DATA	Signal
GND	Ground

Connection with ESP32

DHT Pin	ESP32 Pin
VCC	3.3V
DATA	GPIO4
GND	GND

Applications

- Weather Station
- Smart Home
- Greenhouse Monitoring
- Room Temperature Monitoring

- HX711 Module + Load Cell: Finds the weight of food.[23]



Figure 3.3: HX711 Module + Load Cell

HX711 module with a Load Cell is used to measure weight.

It converts the small signal from the load cell into digital data for ESP32 or Arduino.

Components

- HX711 Module
- Load Cell
- ESP32 / Arduino

Working

1. Load cell senses force or weight.
2. HX711 amplifies the signal.
3. ESP32 reads the weight value.

HX711 Pin Configuration

HX711 Pin	Function
VCC	Power
GND	Ground
DT	Data Output
SCK	Clock

Connection with ESP32

HX711	ESP32
VCC	3.3V
GND	GND
DT	GPIO4
SCK	GPIO5

Load Cell Wire Colors

Wire Color	Function
Red	E+
Black	E-
White	A-
Green	A+

Applications

- Digital Weighing Machine
- Smart Kitchen Scale
- Food Weight Measurement
- Industrial Weighing System

- Servo Motor (MG996R): Controllability of food dispensing mechanism.[24]



Figure 3.4: Servo Motor (MG996R)

The MG996R is a high torque servo motor used for precise angle control. It is commonly used in robotics and automation systems like food dispensing mechanisms.

Working Principle

The servo motor rotates to a specific angle using PWM signals from ESP32 or Arduino. Common angles include:

- 0°
- 90°
- 180°

Pin Configuration

Wire Color	Function
Red	VCC (5V)
Brown	GND
Orange/Yellow	PWM Signal

Connection with ESP32

MG996R	ESP32
Red	External 5V Supply
Brown	GND
Orange	GPIO18

Important Note

- Do not power servo from ESP32 3.3V pin
- Always use external 5V supply

Specifications

Feature	Value
Operating Voltage	4.8V–7.2V
Rotation Angle	0°–180°
Torque	High
Control Type	PWM

Applications

- Food Dispensing Systems
- Robotics
- RC Vehicles
- Smart Locks

- DC Fan: Regulates the conditions of the temperature.



Figure 3.5: DC Fan

A DC fan is an electric fan powered by direct current (5V, 12V, or 24V). It is used to regulate temperature by providing airflow and cooling electronic systems or enclosed spaces.

Working Principle

When power is supplied, the motor inside the fan rotates the blades and produces airflow. This airflow helps reduce heat buildup in systems.

The fan can be controlled using ESP32 or Arduino through ON/OFF switching or PWM speed control.

Types of DC Fans

Type	Description
2-wire fan	Basic ON/OFF control
3-wire fan	Includes speed feedback (tachometer)
4-wire PWM fan	Precise speed control using PWM

Connection with ESP32

Important: ESP32 cannot drive a DC fan directly. A MOSFET or relay is required.

Fan Wire	Connection
Positive (Red)	External 5V/12V supply
Negative (Black)	GND via MOSFET/Relay

Required Components

- N-channel MOSFET (IRF520 / IRLZ44N)
- Flyback diode (e.g., 1N4007)
- External power supply

Control Methods

- ON/OFF control using digital pin
- PWM control for speed regulation

Applications

- Temperature control systems
- Electronics cooling

- Smart IoT devices
 - Food dispensing systems
- LCD

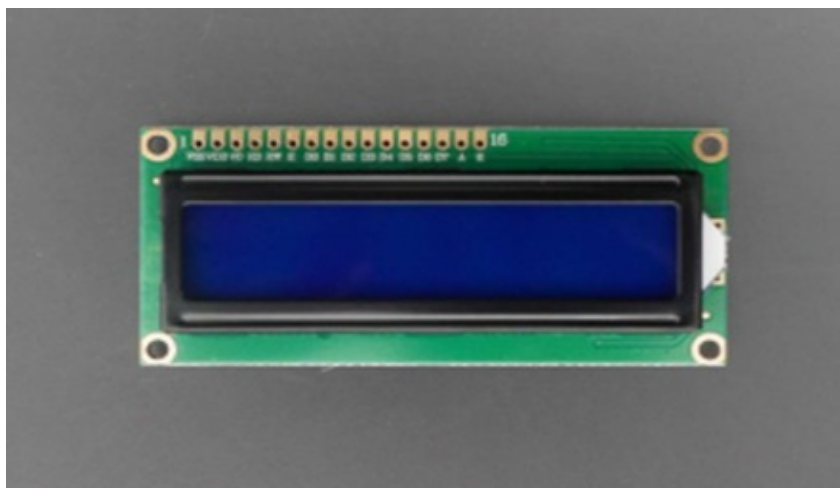


Figure 3.6: LCD

An LCD (Liquid Crystal Display) is used to display text, numbers, and sensor data in electronic projects. The most common type is the 16x2 LCD, which has 16 columns and 2 rows.

Types of LCD

Type	Description
16x2 LCD	Basic text display
20x4 LCD	Larger display (20 columns, 4 rows)
I2C LCD	Uses only 2 communication wires

16x2 LCD Pin Description

Pin	Function
VSS	Ground
VDD	Power (5V)
V0	Contrast control
RS	Register Select
RW	Read/Write
E	Enable
D0–D7	Data pins
A	Backlight +
K	Backlight -

Connection with ESP32 (I2C LCD)

I2C LCD Pin	ESP32 Pin
VCC	3.3V / 5V
GND	GND
SDA	GPIO21
SCL	GPIO22

Working

- ESP32 sends data to LCD
- LCD displays text or sensor values
- Used for real-time monitoring

Applications

- Temperature display systems

- Smart weighing machines
 - IoT dashboards
 - Sensor monitoring systems
- Camera



Figure 3.7: Camera V380 pro

The V380 is a smart WiFi security camera used for real-time video monitoring. It allows users to view live video remotely using a mobile application.

Working Principle

The camera captures video and sends it through WiFi to a cloud server or directly to a mobile app. Users can access live streaming, recordings, and alerts from anywhere.

Features

- Wireless WiFi connectivity
- HD video recording (depends on model)
- Night vision capability
- Motion detection alerts
- Mobile app control (V380 App)

Connectivity

- Connects via WiFi router
- Controlled using mobile application
- Supports remote viewing over internet

Applications

- Home security systems
- Office monitoring
- Baby monitoring
- Smart surveillance systems

Advantages

- Easy installation
 - Remote access from anywhere
 - Low cost security solution
 - Motion detection support
- Power Supply Module
 - Linking of wires, bread board and mechanical container.

3.4 Software Requirements

- Firebase Realtime Database: Data store and live monitors on the cloud.

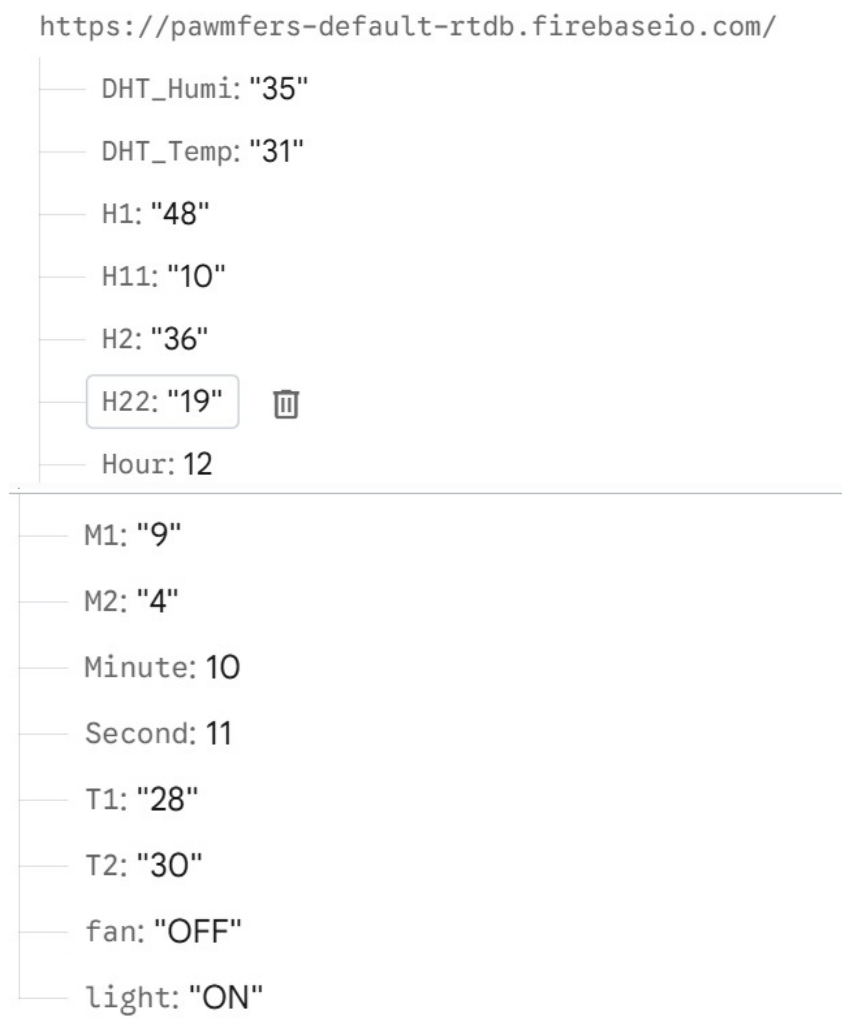


Figure 3.8: Firebase Realtime Database

- Arduino IDE: To program ESP32.
- Business logic: Programming language- Embedded C/C++
- Wi-Fi Connection: To communicate with the IoT.

3.5 System Operation

The core controller is ESP32-CAM. Sensors (temperature, humidity and weight) are constantly read and sent to Firebase. Upon the triggering of feeding, the servo motor

turns so that it delivers food. The load cell will be used to make sure the proper amount is provided. In case the temperature exceeds predetermined value, the fan will be turned on. All the parameters can be tracked remotely by the users with the help of Firebase, as well as a live camera stream.[19]

3.6 Results

This section will include:

- Screenshots of real-time sensor data from Firebase
- Output readings (temperature, humidity, weight values)
- Feeding mechanism results
- System performance observations

DHT 11	
<i>Temperature</i>	23
<i>Humidity</i>	44

DHT22	
<i>Temperaure</i>	23
<i>Humidity</i>	33


Appliances	
<i>Fan</i>	<i>on</i>
<i>Light</i>	<i>OFF</i>
<i>Feed</i>	

Figure 3.9: App results

3.7 Live IoT Values

The system provides real-time values such as:

- Temperature (°C)
- Humidity (%)
- Food Weight (grams)
- Feeding status (ON/OFF)

These values are continuously updated on Firebase and can be accessed remotely.

3.8 Hardware Implementation

This section shows how the system is set up physically. It includes all the parts, like the ESP32, sensors, servo motor and feeding container. The setup gives a picture of how everything fits together. The ESP32, sensors, servo motor and feeding container are all part of the system. They are connected to make the system work.

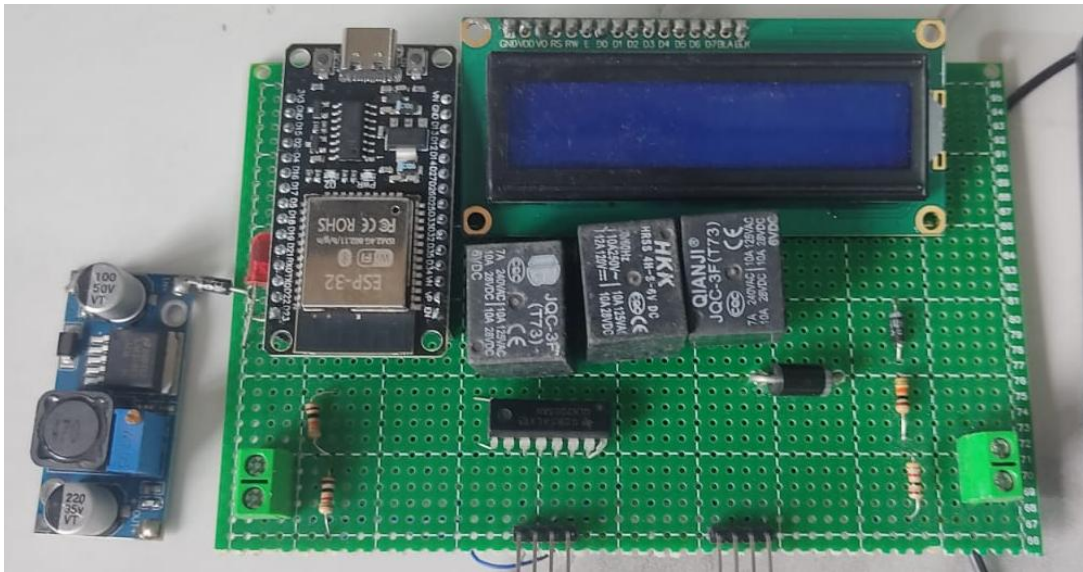


Figure 3.10: Hardware Implementation

3.9 Schematic Diagram

This diagram shows how all the hardware parts are connected. It includes the power supply and the sensor interfacing and the actuator connections, with the ESP32. The ESP32 is connected to all these hardware components.[25]

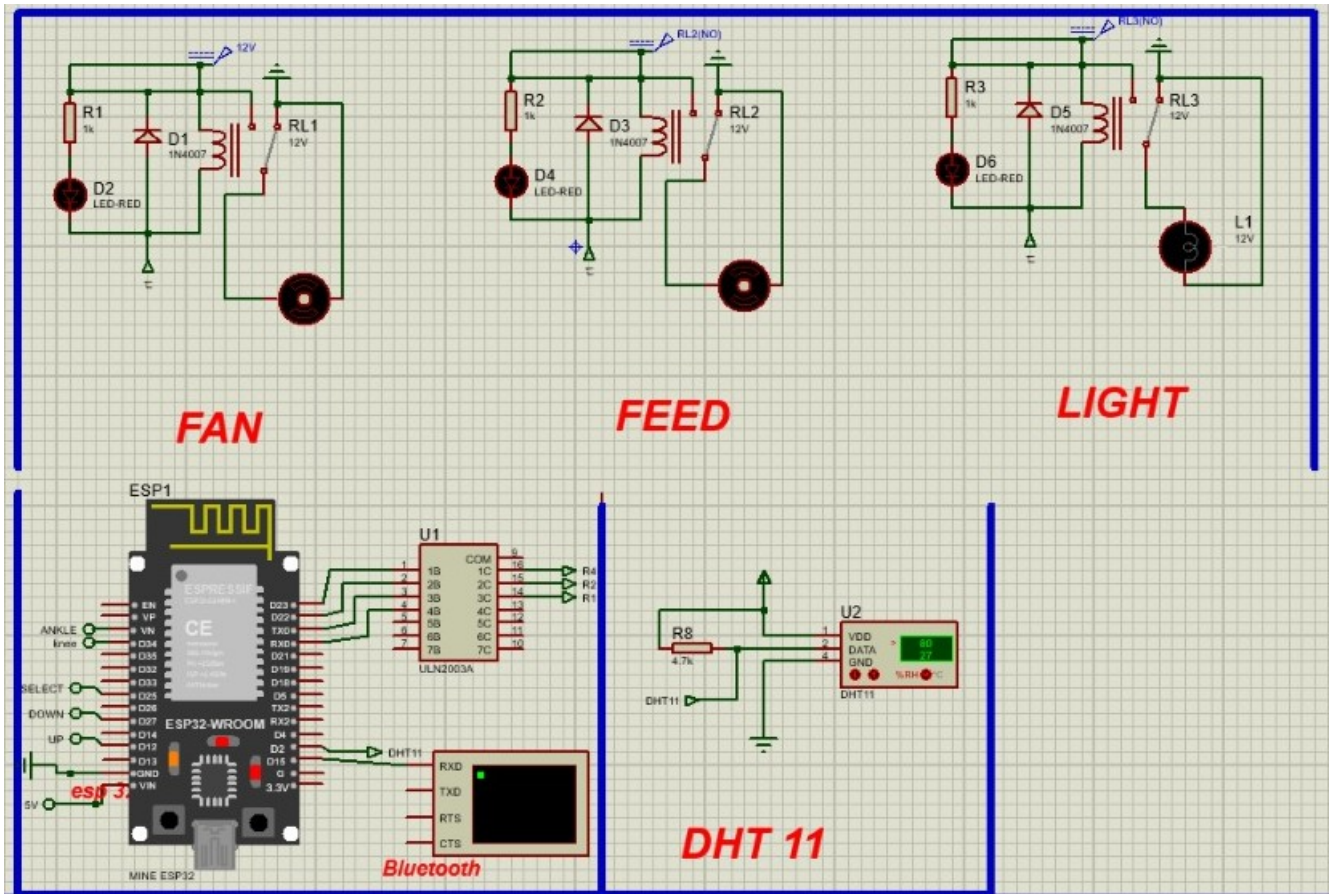


Figure 3.11: Schematic Diagram

4 System Design

The PawConnect system has a design that shows how all its parts work together. This design is like a plan that explains how the different components, such as the hardware and the software are connected and talk to each other.[10] The goal of the PawConnect system design is to make sure the pet feeder works properly and reliably when people use it every day. The PawConnect system design also includes how the different parts communicate with each other so the pet feeder can do its job in a controlled way.[6]

4.1 System Architecture

PawConnect is an IoT-based pet feeder, which links a physical feeder to a user application using wireless communication. The system consists of three components, namely, the feeder unit, the communication link and the user interface. The feeder unit consists of a motor and a microcontroller that assists in dispensing food and a few electronic components. It is the feeder unit that actually dispenses the food in the quantities. The communication channel is Wi-Fi to transmit commands between the application and the device and vice versa.[15] This system involves the communication link and the feeder unit and the user interface working together to make this system work. The feeder unit is essential since it dispenses the food. Communication link is also vital as it enables the application and the device to communicate with one another. The user interface enables the user to operate feeding and monitor the system status via a computer or phone. During operation, user will make a feeding request via the app. The command is sent to the microcontroller via Wi-Fi. The microcontroller then switches on the motor to dispense food. The system informs me that it has been done and a confirmation is given.[3]

4.2 Design Constraints

When we were designing PawConnect, we considered the issues that we could encounter. The system was constructed using low-cost parts, which means that it lacks a significant amount of power to process things and a significant amount of memory. This is why we ensured that the design of PawConnect is simple to read and does not include things which are not required.[9]

This assists PawConnect to work effectively and not encounter difficulties. PawConnect requires the Wi-Fi connection to communicate with the user application and the device. When the internet is not functioning well or is slow it may slow down the commands and PawConnect may require more time to work. On the side the part of PawConnect providing food can have issues, such as the motor not spinning evenly or food being released. When we were designing PawConnect we considered these issues in order to make the system continue being useful and working on a daily basis.[22]

4.3 Design Methodology

PawConnect is developed in a modular fashion, i.e., the system is divided into smaller, autonomous parts. Each part of the system is proven individually prior to being incorporated into the entire system. The system work begins with the definition of what the system requirements are and then we choose appropriate hardware components, to the system and then we plan the general structure of the system. When this is established, the components of hardware and software are created sequentially and combined and integrated. The computer program is configured in such a manner that it maintains everything in order.[?] This is achieved through the separation of the software into components such as communication, command handling and motor control of the software. The separation of the communication part, the command handling part and the motor control part simplifies the software. The communication part is also easier to test. The motor control part and the command handling part. It is easier to update the part of the communication or command handling part or motor control part when changes are required.[26]

4.3.1 High-Level Design

On a larger scale, there are various perspectives of the system.

Conceptual View: The system consists of four components, the user application, the Wi-Fi communication component, the microcontroller and the feeding component. The application on the user side performs its functions and the Wi-Fi communication module performs its functions. All these sections are combined to complete the feeding process. Of significance is the feeding mechanism. It collaborates with the user application, the Wi-Fi communication module as well as the microcontroller to accomplish the task.[7]

Process View: The system consists of four components: user application, Wi-Fi communication module, microcontroller and the feeding mechanism. The user application performs its task and the Wi-Fi communication module performs its task. All these are designed to complete the feeding process. The feeding mechanism matters. It collaborates with the user application, the Wi-Fi communication module and the microcontroller to accomplish the task.[?]

Physical View: The installations are made as a single unit at the point of the feeder. It operates either on a smartphone or a computer. The system and the device communicate to one another, wirelessly via Wi-Fi.[27]

Module View: The system software is divided into components, such as communication and motor control and command handling. These parts constitute the system software. All these components of the system software are created separately. All these are then combined to create the system software.[6]

Security View: The system has basic access control to ensure that only authorized users can deliver commands to feed. This prevents those who should not access it accidentally or even deliberately turn on the system.[12]

4.3.2 Low-Level Design

The system consists of components that interact. The microcontroller is busy with many tasks. The microcontroller is connected to Wi-Fi. Commands are sent to the microcontroller. The microcontroller determines what to do. The motor is operated by the microcontroller. The system is simple, and easy to fix since each job only does one thing. The application contains sections that transmit commands display what is taking place

and assist the user. This renders the system user friendly. The modules liaise with the hardware in real-time using wireless communication. The general structure is maintained simple in order to ensure that the system will respond fast and can maintain stability in the course of its operation.[28]

4.4 Data Management and Storage Design

PawConnect maintains basic records of feeding activity for tracking purposes. Depending on the implementation, this data can be stored locally on the device or on a cloud-based system. The main data elements include a command identifier, timestamp, feeding status, portion value, and user identification. These records help in monitoring system usage and keeping a history of feeding actions. This data is mainly used for tracking and ensuring that each feeding request is properly executed and recorded.[8]

4.4.1 GUI Design

The user interface is made to be easy to use. It is supposed to be simple so people can use the system without knowing a lot about technology. The main screen has things like a button to start the feed a display to show the system status and a light to show if it is connected. When you tell the system to do something it lets you know what happened after it is done feeding. They kept the layout simple so people can use the system fast. It is not confusing. The system is easy to use. The user interface is simple. The feed button and system status display are on the screen and the connection indicator is there too.[19]

4.4.2 External Interfaces

PawConnect interacts with external systems mainly through its mobile or web application. This application serves as the primary control interface for the user. The system also uses Wi-Fi to connect the application to the microcontroller. This connection helps exchange all commands and responses. It does not need outside connections making it simple, stable and easy to take care of.[24]

5 System Implementation

This chapter explains how the PawConnect system was developed and put into practice. It covers how the hardware components were assembled, how the software was written, and how both were combined to form a working system.[?]

5.1 Hardware Implementation

The main part of PawConnect is the ESP32-CAM. This is the component that makes everything work. The ESP32-CAM handles the Wi-Fi connection it gets the commands and it sends the signals to the parts. It has Wi-Fi built in so it can connect directly to the user interface without needing any modules. To keep an eye on the environment the DHT22 sensor is used. The DHT22 sensor gives us readings of the temperature and the humidity. The DHT22 sensor is connected to the ESP32-CAM. The DHT22 sensor sends the data at intervals. This way we can see what is going on around the food. For measuring the portions a load cell is used with the HX711 module. The load cell turns the weight of the food into a signal. This electrical signal is very weak so the HX711 module makes it stronger. Turns it into a value that the ESP32-CAM can understand. The HX711 and the load cell work together and this means the system can measure how much food is being given out. The part that gives out the food is controlled by a servo motor, the MG996R. The MG996R servo motor is connected to the ESP32-CAM. By changing the signal the MG996R servo motor moves to the position. The food comes out in a controlled way. The MG996R servo motor is very important because it helps to give out the food in the amount. This means the food is given out in the amount every time. All the parts of PawConnect are powered by a power supply that makes sure everything works smoothly. The wiring is done properly to avoid any problems with the signals and to make sure the sensor readings are accurate. The ESP32-CAM and the

other components, like the DHT22 sensor and the load cell all work together to make PawConnect work properly.[29][27][13]

5.2 Software Implementation

PawConnect software is created to control the system and manage communications between the device and the user. Embedded C/C++ is used in the programming of ESP32-CAM. The system is first connected to a Wi-Fi network and it initializes the rest of the components including the servo motor, DHT22 sensor and HX711 module. As the space to communicate between the application and the device, firebase is implemented. As a user types a command, it is stored in Firebase and constantly checked by ESP32. When a new command is received, the controller interprets it and makes the appropriate action, e.g. switching on the servo motor. It is also possible to monitor sensor data such as temperature, humidity and weight via Firebase. The code has been sequenced into different functions of communication, sensor reading, and motor control thus making the system easier to manage and update.[11][30]

5.3 Communication Setup

The user and the device talk to each other using Wi-Fi. The ESP32-CAM joins a network that we already set up and shares information with the user application. When the user tells the device to do something like give food this message goes over the network and the ESP32-CAM gets it. The controller looks at this message. Does what it needs to do. The device can also send back information from sensors. How the system is doing so the user can keep an eye on things using the application.[9][7]

5.3.1 Integration of Hardware and Software

When we have set up the hardware and the software we need to integrate the system. This is so that all the parts can work together properly. The ESP32-CAM is like the brain of the system. It connects what the user wants to do with the actions that need to happen. The sensor readings from the DHT22 and the load cell are looked at by the microcontroller. Then it sends control signals to the servo motor based on what the

user tells it to do. This way we can be sure that the feeding actions happen like they are supposed to. We do some testing to make sure each part of the system is working correctly. We want to know that the whole system is working smoothly and that all the parts are doing what they are supposed to do.[4][8]

5.3.2 System Operation

During standard operation, the user would give a command to feed via the application. This command is relayed to the ESP32-CAM where it is processed. It then switches on the servo motor to turn and spray out food. Meanwhile, the load cell records the quantity of food emitted, so this maintains control of portions. The DHT22 sensor can also be used to monitor the environmental conditions by the system. After the process is done, the system will inform the user of the current status.[31][11]

5.4 Implementation Challenges

There were a number of technical problems faced during implementation. The problem was one of the primary ones as the stable Wi-Fi connection was to be guaranteed to conduct communication constantly. Any types of fluctuation in the network impacted on response time. The other difficulty was one of weighing the load cell to measure the weights. The module HX711 had to be properly calibrated to ensure good readings. The servo motor had to be carefully adjusted as well in order to have a smooth and even movement to dispense food. The challenge was encountered with testing and modifications, enhancing the general reliability of the system.[14][29]

6 System Testing and Evaluation

PawConnect system testing involved executing of the entire integrated system to determine whether the system meets the intended requirements. This was not just meant to check functionality but also to check how the system performs in real life application. They were both performance and usability oriented as well as strengths and weaknesses of the system were identified.[15][11]

6.1 Testing Approach

The tests were carried out in phases. Each of the individual parts were tested individually with the ESP32-CAM, servo motor, DHT22 sensor, and load cell with HX711 to ensure that they worked properly. Subsequently, the entire system was tested as a systems provided. Functional and real-time testing were conducted to note the responses of the system when it is operating in normal conditions.[16][29]

6.2 Functional Testing

Functional tests were conducted to make sure that everything is functioning as intended. The application relayed feeding commands and responses of the system were monitored. The ESP32-CAM was able to read the Firebase commands and command the servo motor to serve food. DHT22 sensor readings and load cell were also checked, and it was discovered that the sensor readings and load cell were similar after calibration.

6.3 GUI and Usability Testing

The user interface was also tested to ensure that it can easily be used. Primarily, simple operations like sending feeding instructions and seeing the status of the system were tested. We noticed that the interface is easy to use and comprehend. The system can be used without any technical skills and the system responses are easily visible.

6.3.1 Performance and Reliability Testing

Response time and consistency were used to evaluate the system. The latency in experience between issuing a command and action of feeding was monitored at various conditions of the network. The system was effective in the case of stable Wi-Fi. There was some delay observed in case of weak network. Through throughout testing, it was established that the system works well but there were slight differences that were caused by mechanical differences.

6.3.2 Exception Handling

Conditions such as network interruption were tested on the system. Delays in executing the commandoes were experienced in case of weak or lost connection though it was not total failure. One has basic handling so that the system can keep operating until the connection has been re-established. But, in future improvements, more advanced handling can be implemented.

6.4 Evaluation of Results

The assessment demonstrates that PawConnect can execute its desired purpose, which is to feed pets in a controlled manner. The system is controllable remotely, has minimal monitoring features and has a minimal user interface. Concurrently, some constraints were identified. The system relies on Wi-Fi connection and may be compromised by network problems. Converting the mechanical factors can also affect the consistency like being blocked by food. All in all the system is very reliable during the normal operation, however, it can be enhanced to be more robust and even consistent.

7 Conclusion

This project showcased the design and development of the PawConnect which is an IoT-based smart pet feeding system that would offer an easy and dependable method to monitor the feeding of pets remotely. The system will combine hardware devices including ESP32-CAM, servo motor, DHT22 sensor and load cell with HX711 and a software interface powered by Firebase to communicate.

The principal goal of the project was to create a device that is able to deliver food in a regulated fashion, and at the same time enable a user to control it remotely. This aim was met with fulfilment of the functionality of a working prototype that will respond to user commands, dispensation of food and basic monitoring of conditions in the system.

The system was put onto test in varying conditions to test its performance. These findings revealed that the system was working well when there is stability in the network and can carry out its desired functions. Its simplicity of use is achieved by use of a simplified interface and useful monitoring features are added as it integrates sensors.

Simultaneously, some constraints were determined. The system relies on a consistent Wi-Fi connection, and performance can be impaired in case there are issues with the network. Sanctions in the dispensing mechanism that are mechanical in nature and adjustments to the load cell are also a concern to overall accuracy and consistency.

All in all, PawConnect is a feasible prototype of an automated pet feeder that incorporates inexpensive parts. Although the current implementation supports the fundamental requirements, additional enhancement can be achieved through future development to increase reliability, accuracy and the overall performance of the system.

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A User Manual of PawConnect

In this appendix, the user manual of PawConnect system is given. It outlines the process of the installation, operation and maintenance of the system by the users without the need of having specialized technical skills.

A.1 Introduction

PawConnect is a smart pet feeder that is IoT-based and automated to feed your pets and monitor them remotely. The system enables users to feed their pets, check the environment, and see a live video of their pets via a linked platform.

A.2 System Overview

The system will comprise of a feeder unit, cloud platform and user interface. The feeder unit consists of ESP32-CAM, load cell with HX711, DHT sensor, servo motor and cooling fan. These elements collaborate to deliver food, keep track and transmit information to the cloud through Wi-Fi.

A.3 Installation and Set up

The feeder is to be placed on a stable surface and it should be connected to a power supply. Once it is turned on, the system will have a pre-programmed connection to a Wi-Fi network with pre-dedicated credentials. After being connected, it begins to transmit data to the cloud platform. It is the responsibility of the user to make sure that the application or Firebase interface is correctly set up.

A.4 Operation

The application allows users to remotely control feeding. Upon transmission of a command, the ESP32-CAM controls the servo motor to feed out food. The load cell guarantees that the weight of the food is duly controlled.

The system also gives the real-time temperature and humidity readings. The cooling fan is automatically activated in case the temperature is higher than a predetermined limit. Live videos streaming enables users to follow pets when they are being fed.

A.5 Features

PawConnect offers remote monitoring, portion control and automated feeding, environmental sensing and live video streaming. It also offers feeding records and system status on the cloud to the users.

A.6 User Interface

The user interface is intuitive. It shows the status of the system, sensor values and feeding options. Real-time information about temperature, humidity, food weight and feeding is available.

A.7 Maintenance and Safety

It is important to keep the system free of dirt and water. Make sure feeding container doesn't clog. The sensors, wiring and load cell should be checked regularly and, if needed, the load cell calibrated.

A.8 Troubleshooting

Non-responsive systems may have poor Wi-Fi or power supply. Feeding problems could be servos getting stuck and incorrect measurements may result from sensor drift that needs recalibrating. Light issues can be fixed by rebooting the system.

A.9 Limitations

Internet connection is required for the system to operate. This can occasionally cause a delay and other mechanical elements can cause minor deficits in accuracy.

A.10 Conclusion

PawConnect aims to offer an easy-to-use and consistent pet feeding system. This manual helps users to use it effectively and maintain its smooth operation.