Pet Treat System
(PTS)

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Table of Contents

List of Figures

List of Tables

I. Introduction

No matter where American pet owners live and whatever their age or ethnicity, they stand united in believing that their pets make a positive contribution to their lives. In fact, more than 90% of dog owners agree that their dogs have a positive impact on their mental or physical health. Pet owners consider their pets to be part of the family and have a deep connection with their pets. As a result, 75% of cat or dog owners admit that they buy pet products to pamper their pets [1].

According to the National Pet Owners Survey, conducted by the American Pet Products Association in 2018, about 68% of U.S. households, or about 85 million families, own a pet. This number is up from 56% of U.S. households in 1988. Number of cats in the U.S. have increased from 86.4 million to 95.6 million in the past five years, and the number of dogs has increased from 78.2 million to 89.7 million during the same time period [2]. Table 1 provides the number of U.S. households that own a pet based on the type of animal [3].

Table 1. The number of U.S. households that own a pet, by type of animal (millions)

Pet	Number
Dog	60.2
Cat	47.1
Freshwater Fish	12.5
Bird	7.9
Small Animal.	6.7
Reptile.	4.7
Horse	2.6
Saltwater Fish	2.5

Source: [3]

Therefore, it is not surprising that the pet industry is worth more than $60 billion. The pet industry showed more than 4% increase from 2015 to 2016 and has tripled since 1996 and is expected to grow by 11% by 2024 [3]. When considering the pet ownership trends, it becomes clear that Millennials, individuals in the age range of 18 to 34 years old, tend to be pet owners more than their previous generations. Millennials account for 35% of pet owners. Specifically, about 75% of Millennials have dogs and 51% have cats. Also, 43% of Millennials who do not have a pet yet, say that they want one in the future [4]. Millennials are less likely to be homeowners, car owners, or parents than their predecessors, but they lead in one category, owning pets. In fact, for these individuals, pets are becoming a replacement for children. Millennials are 50% less likely to get married or live with a partner compared to individuals 50 years ago. Figure 1. Provides the average age of marriage in the U.S., indicating that it has increased [5].

Figure 1. Average age of marriage in the U.S.
Source: [5]

According to an article in Harvard Business Review in 2016, Millennials are workaholics. They work hard and take less vacations. Millennials work an average of 45 hours per week [6]. Therefore, as pet owners, they spend lots of time outside the home, leaving their pets alone.

II. Problem Statement

The busy lifestyle of individuals in the 21st century, and the fact that they are away from home for long hours, leaving their pets alone, can cause several problems for pet owners and their pets. These problems include:

- Separation anxiety and loneliness for the pets.
- Lack of stimulation for pets, since their owner is not there to play with them.
- Dangerous situations, because no one is at home to see what the pets are doing.
- Feeding issues such as over-feeding and under-feeding.
- Concerning for the pet owner because of their inability to view/monitor their pets.

The system here focuses on the concept of Internet of Things (IoT) by specifically considering and addressing the situations in which pets are left at home for long hours without anyone providing them with food, attention, or stimulation. IoT is a system of connected devices, objects, animals, or people that provide the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction [7].

A pet treat system (PTS) that is managed via an app would be desirable for pet owners, especially the younger generations or Millennials, because these individuals are tech savvy and are the most comfortable age group for working with apps. Figure 2 provides information regarding the amount of time using apps per user in one month for different age groups. According to this report, individuals between the ages of 18-24 and 25-34 spend about 93.5 and 85.6 hours per month on their mobile apps [8].

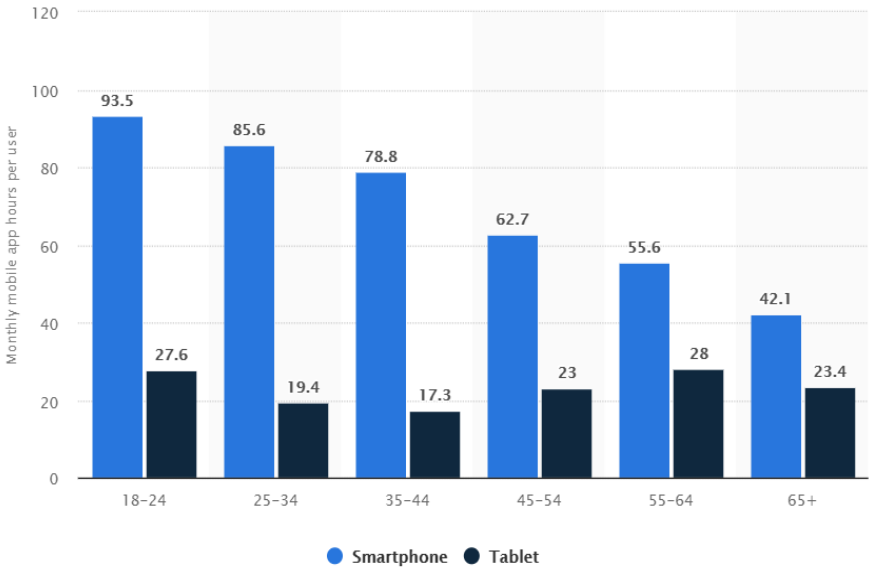


Figure 2. Number of mobile app hours per user in the U.S. in 2016, by age group
Source: [8]

Therefore, the pet treat system and its mobile app management capability fit the interests of busy pet owners, especially the younger generation. Figure 3 provides an illustration of the pet treat system and its capabilities. More specifically, the system enables pet owners to:

- Serve the meal through an Android app.
- Customize food portions to avoid over- and under-feeding.
- View pets in real time through an IP camera.
- Attract pet's attention via a buzzer or customized audio messages.
- Inform the pet owner if the pet has not been fed.

Furthermore, the system is:

- Compatible with Google Home and Amazon Alexa, but, won´t be developed at the present project.
- Equipped with a wide viewing angle camera with HD and night vision features.

Figure 3. Illustration of the pet treat system and its capabilities (self-made)

III. Solution

In present days, taking care of pets is a matter of responsibility that is even contemplated by the laws. Many animal protection organizations such as People for the Ethical Treatment of Animals (PETA) and International Society for Animal Rights (ISAR) help raise awareness against animal cruelty and abuse and educate individuals about this important cause. The present project is aimed at developing a device that helps pet owners provide food and attention to their pets even in their busiest days or when they are out of town for short business trips. Hence, the present project is proposing a device that operates with a custom Android app for monitoring pet activities thought its IP Camera which has night vision and a wide viewing range. The servomotor assembly moves the spoon 90 degrees in order to pour the food into the serving plate. The amount of meal or the feeding portion is determined based on the number of times that spoon turns on and rotates. The PIR sensor determines if the pet is close or not. Also, the buzzer is useful to provide an auditory stimulus to attract pet's attention for feeding times.

These functions are controlled by the Android app into a user-friendly interface. The present project represents a positive impact in the way that we interact and take care of our pets, it sort, the need to call for a friend or family in cases where the owner absent for a short period of time.

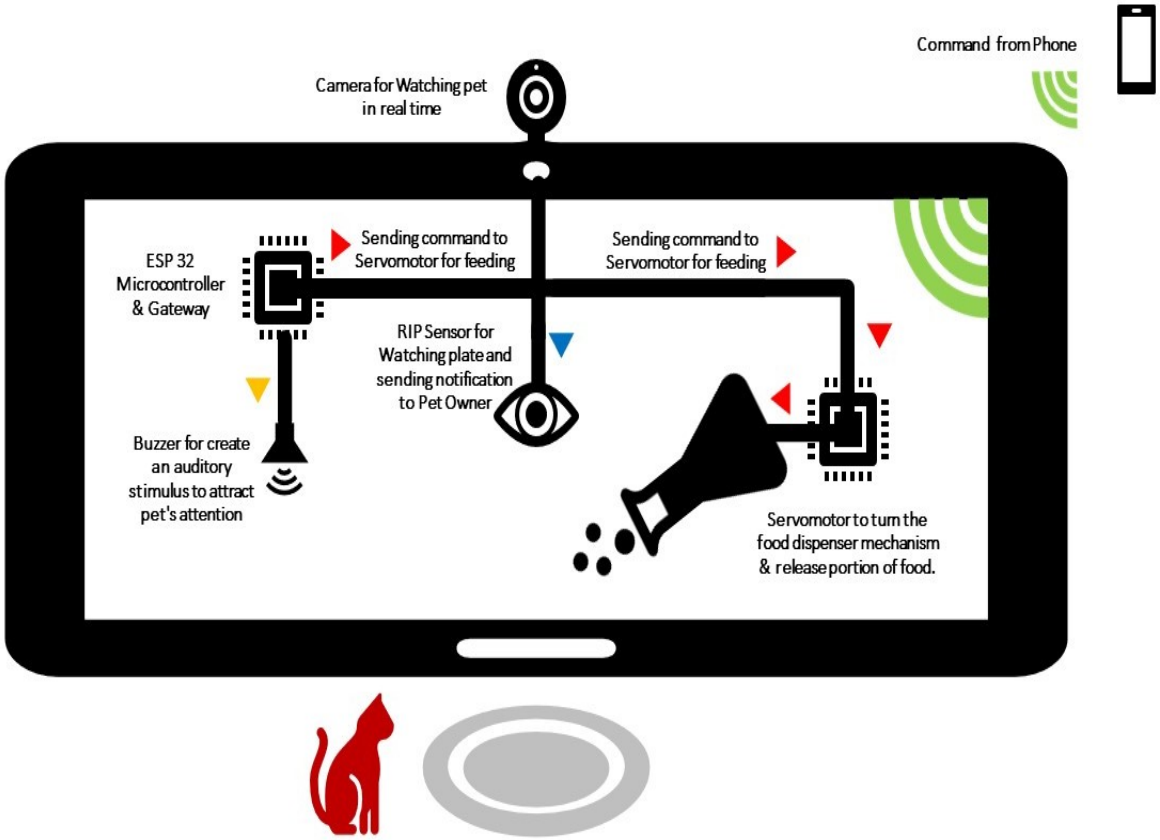


Figure 4. Illustration of the solution (self-made)

A. Technical Specifications

The main specifications of the device are listed in Table 2. The Wi-Fi standard protocol allows to work over a wide range of Android terminals. Buzzer speaker and night vision camera are desirable features to attract pet's attention and monitor their activities at night, respectively. The plastic enclosure for the device is non-flammable for safety reasons.

Table 2. Technical Specifications of the device

Description	Indicator
Grid Supply	240/120 VAC 60/50Hz
Power Supply	12VDC, 5A
PIR Sensitivity	Trigger up to 1m
Servomotor Angle	0-180°, 500RPM
Buzzer Speaker	2 KHz
Wansview	IP Cam, Night Vision
Wireless Protocol	Wi-Fi 802.11 b/g/n Plastic
Enclosure	Non-flammable PVC
Feeding Reserve	500g, 50gr per spoon

B. Parts

This section provides a list of required parts for the pet treat system. The automatic pet feeder requires an ESP32 as a gateway and as the main microcontroller to take charge of all parts involved in the system [9]. Please refer to figure 5.

Figure 5. ESP32 development board
Source: [10]

A servomotor is placed to turn the food dispenser and release the specified portion of pet food into the service plate. Then, the microcontroller communicates with the servomotor to rest it in its initial position [11]. Figure 6 provides an image of the servomotor.

Figure 6. 12v servomotor
Source: [12]

An IP camera is placed to remotely view the pet and check whether or not the pet has had the meal. The PZT camera has the ability to move the point of view to check the surrounding environment and let the pet owner see what the pet is doing [13]. The IP camera is shown in Figure 7. It is equipped with night vision to allow for viewing the pets in the dark.

Figure 7. Wansview 1080P K3 IP camera with night vision
Source: [14]

The PIR sensor depicted in Figure 8 detects the presence of the pet in order to provide the confirmation that the pet has taken the food [15]. When the system releases the pet food, the camera takes a picture and sends it to pet owner's email address as a confirmation for the feeding process.

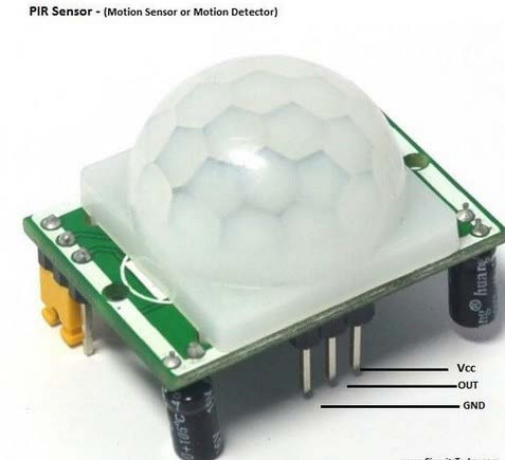


Figure 8. PIR Sensor
Source: [16]

The AA buzzer speaker shown in Figure 9 is used to create an auditory stimulus to attract pet's attention to the system for the feeding time, so that whenever the buzzer is activated, the pet would come to take the meal. This process can create classical conditioning over time and teach the pet to approach the feeder whenever the buzzer is activated by the pet owner [17].

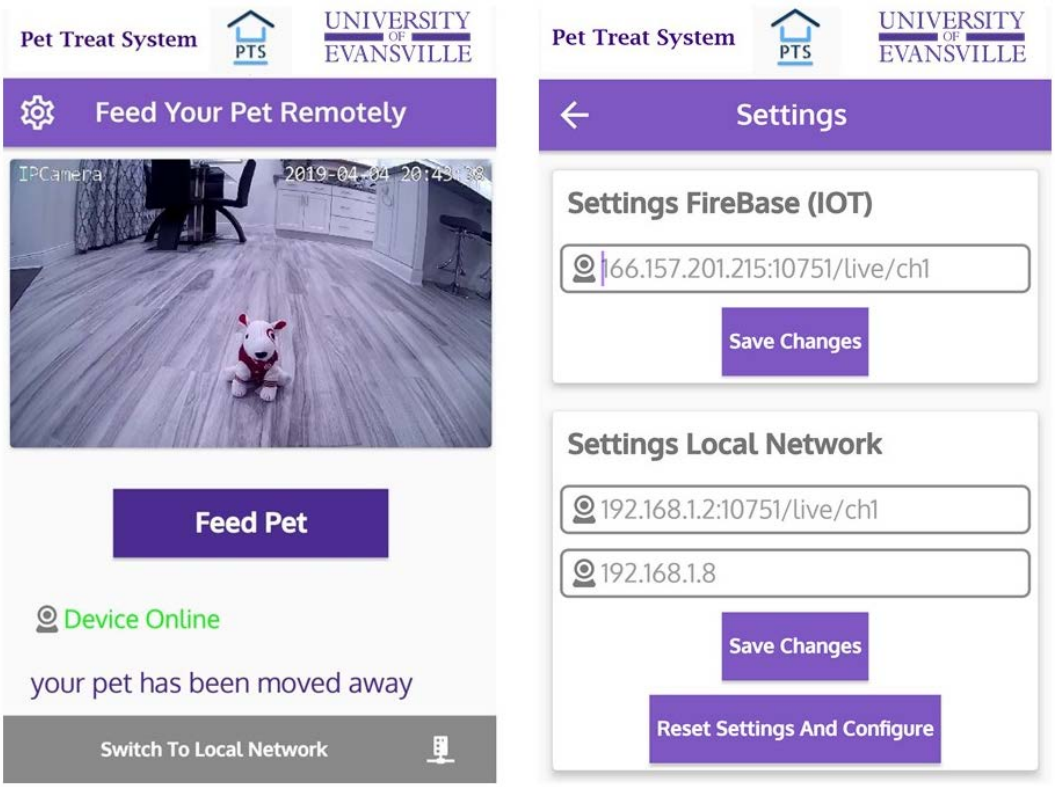
Figure 9. Buzzer speaker
Source: [18]

The switching power supply is used to provide power with the proper voltage for all parts included in the pet feeder device. The 12V power supply is depicted in Figure 10.

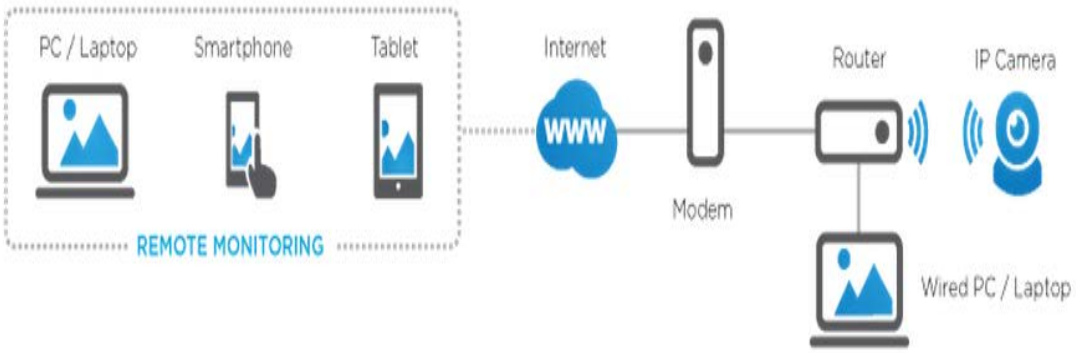
Figure 10. 12V Power Supply up to 5A
Source: [19]

C. Application and Circuit Diagram

Figure 11a illustrates the Android app interface. Figure 11b illustrates the IP camera solution for PTS, and Figure 11c illustrates the circuit design and wiring connection for the pet treat system.

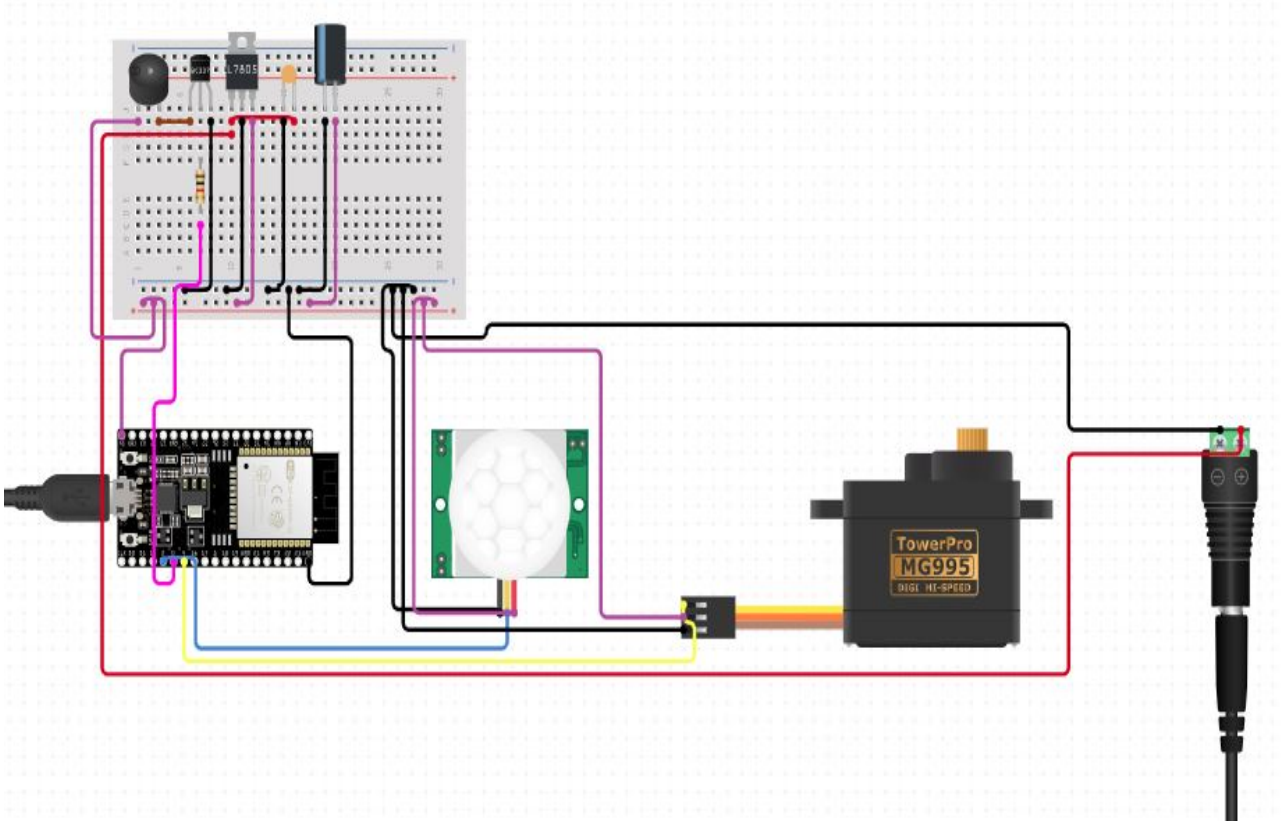


11a. Android App for PTS (Self-made)



11b. IP Camera Solution Design

Source: [20]



11c. Circuit Design

Source: [21]

Figure 11. Application and IP Camera diagram and Circuit Design

D. Usage Flow

Figure 12 illustrates the hardware flowchart. It shows how different hardware in the system are connected to each other in order for the system to operate.

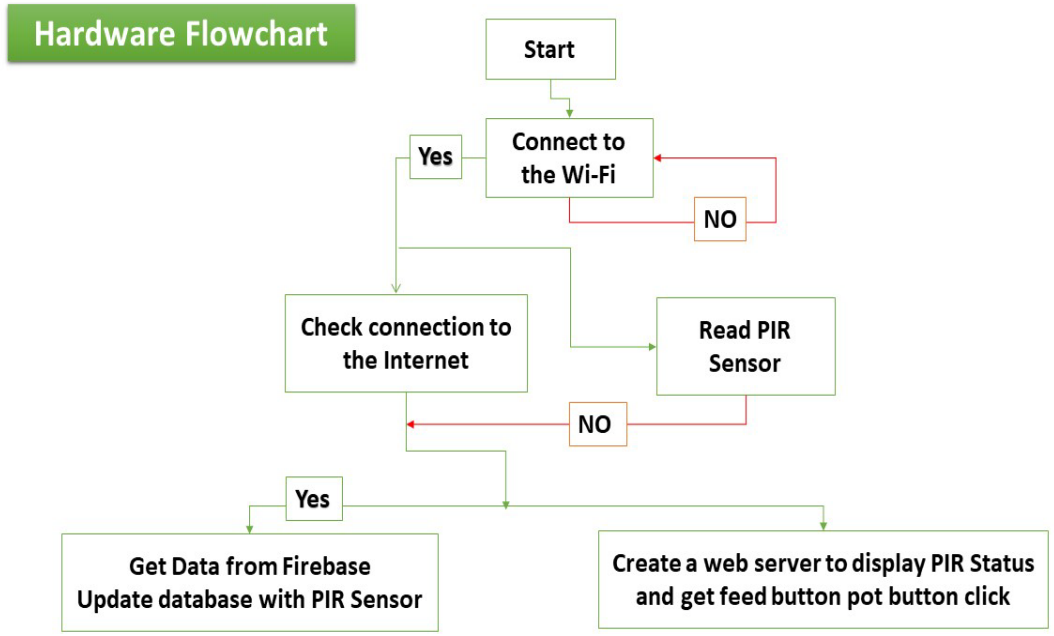


Figure 12. Hardware Flowchart (Self-made)

Figure 13 provides the flowchart for how the software system operates. The process to set up and use the application for the pet treat system consists of 1) configuring the IP address of the camera in the settings to get live steaming of the pet feeder camera out put and 2) saving the changes by clicking on “Save Changes” button to store the IP addresses of camera and hardware device to work with the local network connection.

The usage process with the Internet consists of 1) establishing connection with Google firebase to get hardware device status (e.g., device last online and pet movement status), 2) establishing simulation connection with RTSP (real time streaming protocol) service to get live video footage of camera, 3) pressing “Feed pet” to turn on the servo motor placed in the device

to dispense food for the pet, 4) Pressing “settings” button located on the left corner of the tool bar to reconfigure the camera IP address at any time in the app, 5) pressing “switch to local network” to send a command to change the hardware device status to “off.” When the hardware receives the command, the Internet connectivity to local network is turned off by disconnecting from the Firebase server, and after this process the screen switches to Local server screen.

The usage process without the Internet consists of 1) checking for the device IP address to fetch data in connection with server created by esp32 by its inbuilt Wi-Fi, 2) establishing simulations connection With RTSP Service to get live video footage from the camera, 3) turning the servo motor in the device by pressing the “Feed Pet” button to dispense food for the pet, 4) pressing the “Settings” button to reconfigure the camera IP address at any time in the app.

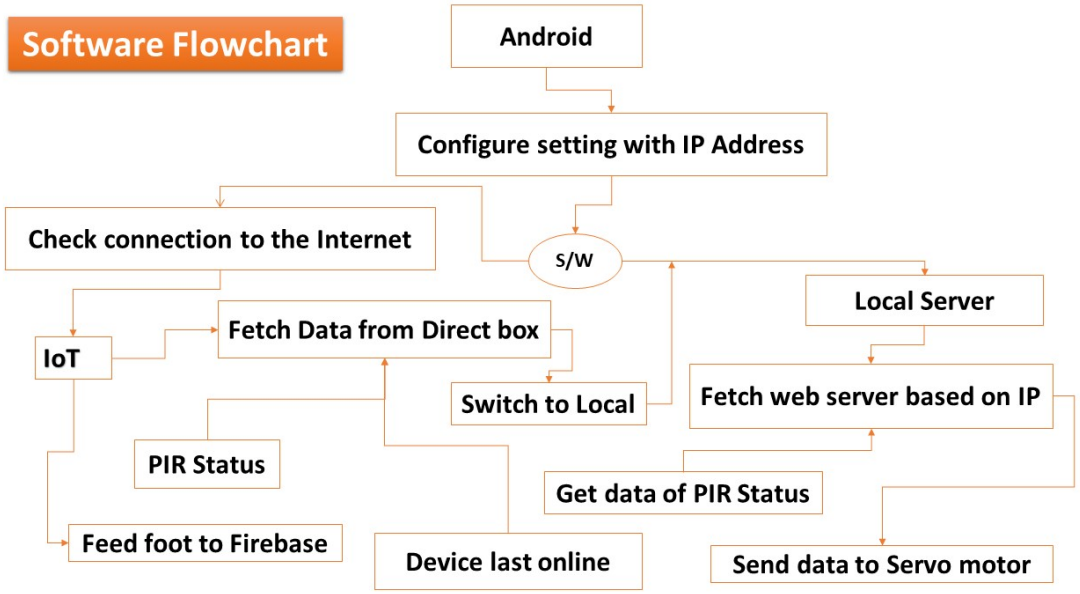


Figure 13. Software Flowchart (Self-made)

E. Standards Compliance and Safety

Similar to other electrical devices, the power supply is the first part of the device to

consider with regards to compliance with safety standards regulated by the American National Standards Institute (ANSI). This part is in accordance with the underwritten laboratories (UL) and the FCC, and thus is electrically safe for house and office use [22]. Also, it is noteworthy that the plastic enclosure is made of non-flammable PVC in accordance with the national fire protection association (NPFA) regulations demand for electronic enclosures [23].

Another important safety feature is related to the feeder. The feeder in the device should be made of BPA-free plastic and/or stainless-steel material. BPA stands for Bisphenol A, a synthetic estrogen chemical that is commonly used to harden polycarbonate plastics and epoxy resin. BPA has been found in baby products, sports bottles, and some other products used to hold edibles [24]. Research has shown that even at low amounts, BPA can cause damage to health. According to the Environmental Working Group (EWG), in laboratory studies, BPA exposure has triggered disorders such as impaired brain and neurological functions, cancer, and cardiovascular system damage [25]. With this type of effect on humans, BPA can impact pets as well. Therefore, the feeder should be BPA-free and certified as food-safe by the U.S. Food and Drug Administration (FDA).

Finally, according to Lisa Yakas, Senior Certification Project Manager for Consumer Products at NSF International (the public health and safety organization), pet bowls can be a breeding ground for bacteria and other microbes that can make pets and pet owners sick [26]. In fact, a study by NSF International in 2011 found that pet bowls were one of the top five dirtiest places in the home [27]. Therefore, the pet treat system has stainless steel and dishwasher safe pet bowls (where the pet food is available for pets to feed from).

F. Manufacturability

The low cost of the required parts listed in Table 2 indicate its suitability for

manufacturing and commercial production. The required parts can be fitted into a properly designed plastic enclosure to mount the IP camera and place the plastic spoon and servomotor system. The case could be created using a 3D printer for the demo model and molded from plastic for the commercial models. As discussed in the introduction section, the pet industry is growing rapidly, and the younger generation is a desirable target market for the pet treat system. As such, with low cost of production, especially in large scales, the system could be a desirable item for manufacturers.

G. Tasks

The tasks necessary to complete the project are listed below:

1. Building the food dispenser by using a plastic bottle in a way to fit the spoon into the servomotor so that it is on its 0% at the initial position.
2. Custom Android app development for controlling the feeder features as well as viewing the IP camera videos and controlling the buzzer.
3. Building the back panel and fixing all parts/components in order to get everything to work together, and then wiring all the component parts.
4. Developing the firmware for ESP32 and its apps.
5. Configuring the IP camera in the Dynamic DNS mode, using the web setup.
6. Synchronizing the camera with the Android phone app.
7. Conducting the initial testing and validation of the performance of the system.

H. Costs

Table 3 provides the cost of each item required for completing the project. As listed in the table, the total cost is $250 dollars. The main driver of cost is the IP camera which costs $90, and the least expensive component is the buzzer speaker with the cost of $10.

Table 3. Bill of materials and their costs

Quantity	P/N	Description	Cost (USD)
1	ESP32	Wi-Fi development board	30
1	Mega-2560	PIR Sensor	30
1	55G Servo	Sun Founder	30
1	95DB	Buzzer speaker	10
1	1080p K3	Wans view IP camera	90
1	-	12v power supply	20
1	-	Plastic enclosure	20
1	-	Materials and marshaling	20
Total			**250**

4. Results and Conclusion

The system can be useful to feed pets such as dogs and cats. The automatic feeder can also be used for aquarium fish. Considering the popularity of pets and the growing interest among individuals, especially the younger generation, to be pet owners and keeping in mind the busy lifestyle of individuals in the 21st century, this system is expected to be demanded and have a good business potential. This system is in line with the IoT concept, because:

- It allows the owner to watch and feed his/her pet by using a custom developed Android app. The system makes it possible to release food to the pet's dish.
- It uses a buzzer speaker to train the pet to associate the sound with the feeding time.
- Having a PIR Motion detector sensor helps the owner to know when their pets needs food and they can release the food.

Appendix A

Android Code for PTS

```
#include <WiFi.h>                 //  library for wifi
#include "FirebaseESP32.h"        //  library to use firebase
#include <Servo.h>                // library for servo motor with esp32

// Set these to run example.
#define FIREBASE_HOST "ptsue-3bb79.firebaseio.com"                    //  firebase
Database key for remote connection (IOT)
#define FIREBASE_AUTH "7Qop9XsbbPdUvFMBVflYBw8xihIeRX8XTbtkbPyy"
//  firebase server key for remote connection (IOT)
#define WIFI_SSID "PetHotSpot"                                        //  SSID (wifi id)
#define WIFI_PASSWORD "12345678"                                      //  password

#define PIR_PIN  23      //  pir sensor pin  = D23
#define BUZZER_PIN 12  // buzzer pin      = D35
int n = 0;

WiFiServer server(80);                    /// assigning server port
Servo myservo;                          //  starting of servo declaration
String devicestatus,authfeeder,authmobile;     // strings and components for code
int servoangle;
int sevostatus,pirstatus,hardwarepirstatus;
String header;
FirebaseData firebaseData;              // firebase database
boolean servoworking;
boolean workingonline=true;

void setup() {
  Serial.begin(9600);
  pinMode(PIR_PIN,INPUT);           // need to declare pin type ( for sensors (input) for
output device like led buzzers etc (OUTPUT)
  pinMode(BUZZER_PIN,OUTPUT);
  myservo.attach(4);                // attach servo pin to pin 2


  // connect to wifi.
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  Serial.print("connecting");
  while (WiFi.status() != WL_CONNECTED) {           // checks of sucessfull connection
     delay(500);
     Serial.print(".");
    }
```

```
  Serial.println("");
  Serial.print("connected: ");                  // if connected
  Serial.println(WiFi.localIP());                 // print ip address of hardware device eg
(192.168.0.103)
  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);   // begining of firebase by
using above server key and database key
  Firebase.reconnectWiFi(true);
 // server.begin();
  String path="/petfeeder1";                      // path in database base for petfeeder
hardware
  String jsonStr;
}


// loop is the pain part in arduino ide it starts every function we can give it a delay to
run it after regular intervals but we are not givving any delay
void loop() {
   getAllIotLogs();             // this fetches iot database details like (pir status ) (hardware
need to be run in iot or local server ) (lastonline )
   readPIRstatus();             // reads pir sensor data
   if (devicestatus=="on"){       // checks (hardware need to be run in iot or local server )
when it is on it will run in iot mode
         workWithInternet();
         workingonline=true;
       }
   else if(devicestatus!="on") {
        workWithoutInternet();
        workingonline=false;
       }
  //delay(500);

}

void toneBuzzer(){
  Serial.println("Buzzing Started");
  digitalWrite(BUZZER_PIN, HIGH);
  delay(400);
  digitalWrite(BUZZER_PIN, LOW);
  delay(100);
  digitalWrite(BUZZER_PIN, HIGH);
  delay(200);
 digitalWrite(BUZZER_PIN, HIGH);
  delay(400);
  digitalWrite(BUZZER_PIN, LOW);
  delay(100);
  digitalWrite(BUZZER_PIN, HIGH);
```

```
  delay(200);
  digitalWrite(BUZZER_PIN, HIGH);
  delay(400);
  digitalWrite(BUZZER_PIN, LOW);
  delay(100);
  digitalWrite(BUZZER_PIN, HIGH);
  delay(200);
  digitalWrite(BUZZER_PIN, LOW);
}
void getAllIotLogs(){
  Firebase.getInt(firebaseData,"/petfeeder1/servoangle");
  servoangle=firebaseData.intData();
  Firebase.getInt(firebaseData,"/petfeeder1/feedfoodstatus");
  sevostatus=firebaseData.intData();
  Firebase.getInt(firebaseData,"/petfeeder1/pirstatus");
  pirstatus=firebaseData.intData();
  Firebase.getString(firebaseData,"/petfeeder1/internetstatus");
  devicestatus=firebaseData.stringData();
  Firebase.getString(firebaseData,"/petfeeder1/authmobile");
  authmobile=firebaseData.stringData();
}

void workWithInternet(){
  //readPIRstatus();
    confirminternetStatus();
     if(sevostatus){
        operateServomotor(servoangle);
      }

}


void readPIRstatus(){
  if(digitalRead(PIR_PIN)==HIGH){
    hardwarepirstatus=1;
    Serial.println("Motion Detected");
  }
  else if(digitalRead(PIR_PIN)==LOW){
    hardwarepirstatus=0;
  }
  if(workingonline){
   Firebase.setInt(firebaseData,"/petfeeder1/pirstatus",hardwarepirstatus);
   Serial.println(" motion detection passed to server");
  }

}
```

```
void operateServomotor(int pos){
   servoworking=true;
   int i;
  // myservo.write(pos);
   Serial.println("turning position of servo motor ");
   delay(15);
   for (i = 0; i <= pos; i += 1)
   { // goes from 0 degrees to 180 degrees
   myservo.write(i);            // tell servo to go to position in variable 'pos'
   delay(60);                   // waits 60ms for the servo to reach the position
    }
  for (i = pos; i >= 0; i -= 1)
   { // goes from 180 degrees to 0 degrees
   myservo.write(i);            // tell servo to go to position in variable 'pos'
   delay(15);                   // waits 15ms for the servo to reach the position
   }
   //myservo.detach();
   if(Firebase.setInt(firebaseData,"/petfeeder1/feedfoodstatus",0)){
     Serial.println("Feeding food completed");
     delay(2000);
      toneBuzzer();
   }

  // if(workingonline){
  //   workWithoutInternet();
  // }

}
   // this function will tells the firebase about the internet availability
  void confirminternetStatus(){
    if(Firebase.setString(firebaseData,"/petfeeder1/authfeeder",authmobile)){
     Serial.println("PASSED mobile auth");
   }
  }

  void workWithoutInternet(){
   readPIRstatus();
  Serial.println("Working in ofline ");
  server.begin();
  Serial.println(WiFi.localIP());
  WiFiClient client = server.available();
   if(client){
     Serial.println("new Client");
     String currentline="";
     while(client.connected()){
```

```
      if(client.available()){
        char c=client.read();
        Serial.write(c);
        header+=c;
        if(c=='\n'){
          if(currentline.length()==0){
            client.println("HTTP/1.1 200 OK");
          client.println("Content-type:text/html");
           client.println("Connection: close");
          client.println();
            client.println("<!DOCTYPE HTML><html><head><meta name=\"viewport\"
content=\"width=device-width, initial-scale=1\">");
        //  client.println("<meta http-equiv=\"refresh\" content=\"3\"></head>");
           client.println("<h1>");
           client.print(hardwarepirstatus);
         client.println("</h1>");
          if(header.indexOf("GET /servostatus/on/90")>=0){  // need not change it here
            Serial.println("Start Servomotor");
            operateServomotor(180); // change its position here for local network ( this line
sends angle to rotate into the operateservomotor class

          }
           if(header.indexOf("GET /completeservo")>=0){
            Serial.println("Return back   Servomotor");
          }
          break;
          }else{
            currentline="";
          }
        }
        else if(c!='\r'){
          currentline+=c;
        }
      }
    }
    header="";
    client.stop();
    Serial.println("Client Disconnecetd ");
    Serial.println("");
    }
  }
```

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