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IoT Pet Feeding Robot

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ABSTRACT

Pets require special treatment and care. However, due to today's busy lifestyles, fulfilling this responsibility has become more challenging. Therefore, this paper introduces the design and development of an IoT-based pet feeding robot aimed at improving pet care through automation and remote monitoring. It incorporates an ESP-32 CAM module for real-time video streaming and a robust food dispensing mechanism to ensure timely and precise feeding. The robot's movement can be controlled via a web application using a virtual joystick. Additionally, the food dispensing mechanism, fixed within the robot, is equipped with ultrasonic sensors and load cells to detect food and water levels. This information can be monitored by the user through the Blynk app, enabling them to refill water or food as necessary by adjusting the feeding schedule. The Blynk Application facilitates feeding control, enabling pet owners to schedule feeding times. This system enhances pet monitoring, providing owners with greater flexibility to meet their pets' essential care, nutritional and medical needs, even amidst their busy schedules.

1. Introduction

The Internet of Things (IoT) encompasses a wide variety of applications made possible by connecting devices like sensors, actuators and monitors, which can be accessed *via* the Internet and mobile phones [1]. IoT is widely used for many applications such as smart farming systems [2-4], home surveillances [5,6], child safety [7], poultry monitoring [8-11], waste management system [12-14], health monitoring system [15], fluid viscosity measurement [16], vehicle accident detection system [17], social distancing monitoring [18], pest monitoring system [19] and pet monitoring system [20-29]. An IoT pet feeding robot is a new technology designed to assist pet owners in caring for their pets when they are away from home. Even if the owners are not present, their pets can be fed. The IoT pet feeding robot is designed to provide pet owners with convenience by helping them feed their pets easily and intelligently from anywhere around the world [24-27]. As pet owners, users

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should be aware that their dogs require proper dietary control as well. Whether the user is away from home suddenly or simply wants one less duty to worry about, the cherished pet will be cared for and fed on time, every time. The IoT pet feeding robot will solve a problem by providing a healthy amount of food throughout the day, regardless of the owner's schedule. Animal feed systems may be built to work as automated devices, allowing the user to feed their pets whenever and from anywhere they want over the internet. The goal of having sensors in a system like this is to entirely automate the feeding process with minimal human intervention [29].

Ramli *et al.,* [28] addressed the various challenges faced by modern cat owners. This system featured automated food dispensing, waste management and live online video monitoring, ensuring the health and comfort of cats when their owners are away. The use of components such as the Durian Uno processor, ESP8266-01 Wi-Fi module and multiple servo motors, combined with software like Arduino IDE and Blynk, provided a comprehensive approach to pet care. The detailed design, including the feeding mechanism, air circulation system and waste management enclosure, reflected careful attention to feline needs. A user-friendly interface further enhanced the experience. However, this system is not equipped with water tank.

Boateng *et al.,* [27] proposed an automated pet feeder. The core component is the ESP32 microcontroller. The system, managed *via* MIT App Inventor II, dispenses dog food using voice commands or button controls. It also scheduled hydration and covertly administers medications. Users can monitor food and water levels through three integrated software platforms: Gmail, ThingSpeak and a database website.

Similarly, Majid *et al.,* [29] focused on utilizing the IoT in a cat feeding and monitoring system. The system scheduled feeding, measured the feed volume in the tank, tracked the remaining feed in the bowl, identified which cats have eaten and monitored room conditions. It used the ESP32 microcontroller, various sensors, a DC motor and the Firebase Realtime Database. Data transmission between the system and the database occurred within 0.5 seconds. The feeder dispensed precise portions with a 96.94% accuracy rate. When the feed volume drops below 15%, the smartphone app notifies the user that the supply is low. The system identified cats eating through an RFID reader and tag with a 95.83% accuracy rate. Room monitoring is achieved with an ESP32-Cam and Ngrok, enabling remote access outside the local network.

Pulainthran *et al.,* [21] proposed an IoT Based Smart Pet Cage which integrated multiple sensors into a pet cage to enhance safety and automation. A temperature sensor monitored the ambient temperature and if it exceeds a preset limit, a notification is sent to the owner and the cage door opened to allow the pet to move to a safer environment. A weight sensor is utilized for automated feeding, dispensing food based on the pet's required weight. Additionally, a water level sensor ensured a constant water supply; if the water level dropped below a certain point, it automatically pumps water into the feeder bottle. The IoT system enabled the owner to manually control the cage, including opening and closing the gate. The cage setup facilitates easy testing and implementation of these features.

Quiñonez *et al.,* [22] proposed a communication architecture based on IoT technology to control and monitor pets feeding system to manage dog feeding in a healthy and efficient manner by providing the appropriate amount of food based on the dog's daily energy needs. This system is composed of two main components: an Arduino board, a Sim900 module for sending and receiving text messages and an ESP8266 Wi-Fi module for internet connectivity to receive user tweets. These modules enable remote communication with the device through the Arduino board. Additionally, an Android mobile app, designed following Google material design principles, allows owners to feed their dog, schedule feedings, check feeding history and receive notifications when the food supply is low. However, these systems do not have live video monitoring systems.

Hence, there is a need to develop a mobile IoT pet feeding system capable of moving around and monitoring pets all the time. We propose an automatic feeding robot where the user can schedule feeding times on the Blynk application. The system also weighs the leftover food in the storage box at scheduled times and the weight of the leftover food will be displayed on the Blynk app. The developed system will monitor the feeding process through live streaming video over the web page platform. Users can also monitor the food and water level through the Blynk app. The robot is equipped with ultrasonic sensors and a load cell to sense the level and weight of the food and water, ensuring precise food dispensing, minimizing waste and preventing overfeeding. Table 1 shows the comparison of the proposed IoT based pet feeding system with the existing work.

Table 1
Comparison of the proposed IoT based pet feeding system with the existing work

Features	Proposed IoT Pet Feeding system	Ramli *et al.,* [29]	Pulainthran *et al.,* [21]	Quiñonez *et al.,* [22]
Food tank	√	√	√	√
Water tank	√	√	√	√
Live video streaming	√	X	X	X
Food level, water level and leftover food weight monitoring system on application	√	√	√	√

2. Methodology

Figure 1 depicts the block diagram of the proposed system. The flow lines illustrate the system's inputs and outputs. The association between the Arduino board and the Arduino engine shield (L298N H-Bridge) is unidirectional. The primary control unit of this system is the Arduino MEGA, powered by a 5V Power module. It comprises power supply units, the Arduino MEGA microcontroller, an LCD display, motor drivers, a DC motor and an ESP32 camera module. The main control unit for robot movement is the L298N motor drive, powered by a 12V Power module. The control system manages all tasks, including feeding the dogs/cats at specified times. It is governed by a microcontroller.

The Arduino MEGA receives various input signals, such as those from an ultrasonic sensor and outputs signals through its outputs, for example, to a display. The Arduino MEGA is an excellent microcontroller board for applications requiring numerous input/output ports or substantial computing power.

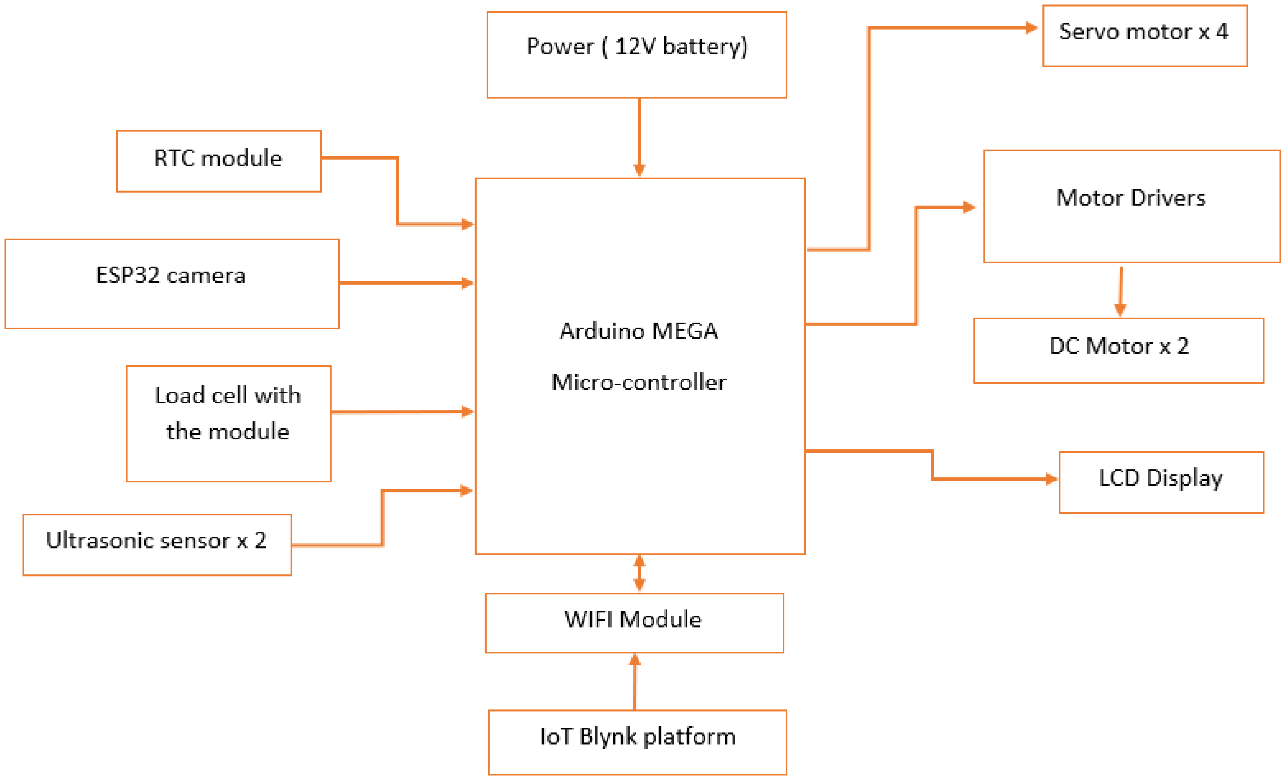


Fig. 1. Block diagram of the proposed system

The Arduino MEGA microcontroller controls all input and output units: the power supply, ESP32 camera module, motor drivers, LCD display, DC motor and servo motor. It analyses received inputs and controls the output to the servo motor to slide the food tray lid. The DC motor, powered by a 12V battery, drives the robot's movement, controlled by the motor driver using the L298N module. Wi-Fi modules on the robots enable communication, linked to the Blynk app for command transmission. The ESP32 CAM sends fundamental commands to adjust engine speeds for directional control. Inputs to the Arduino MEGA include the Real-Time Clock (RTC) module, ESP32 camera, load cell, ultrasonic sensor and LCD display. Two DC motors propel the robot, while four servo motors control water pipe, food supply and lid movement. Data from sensors is sent to the Blynk app for monitoring. The robot's movement circuit diagram is depicted in Figure 2. The power module, powered by 12V, activates the L298N motor drive, controlling two DC motors. Code uploaded to the ESP32 CAM enables control *via* a virtual joystick, transmitting signals to the L298N motor drive to instruct the DC motors.

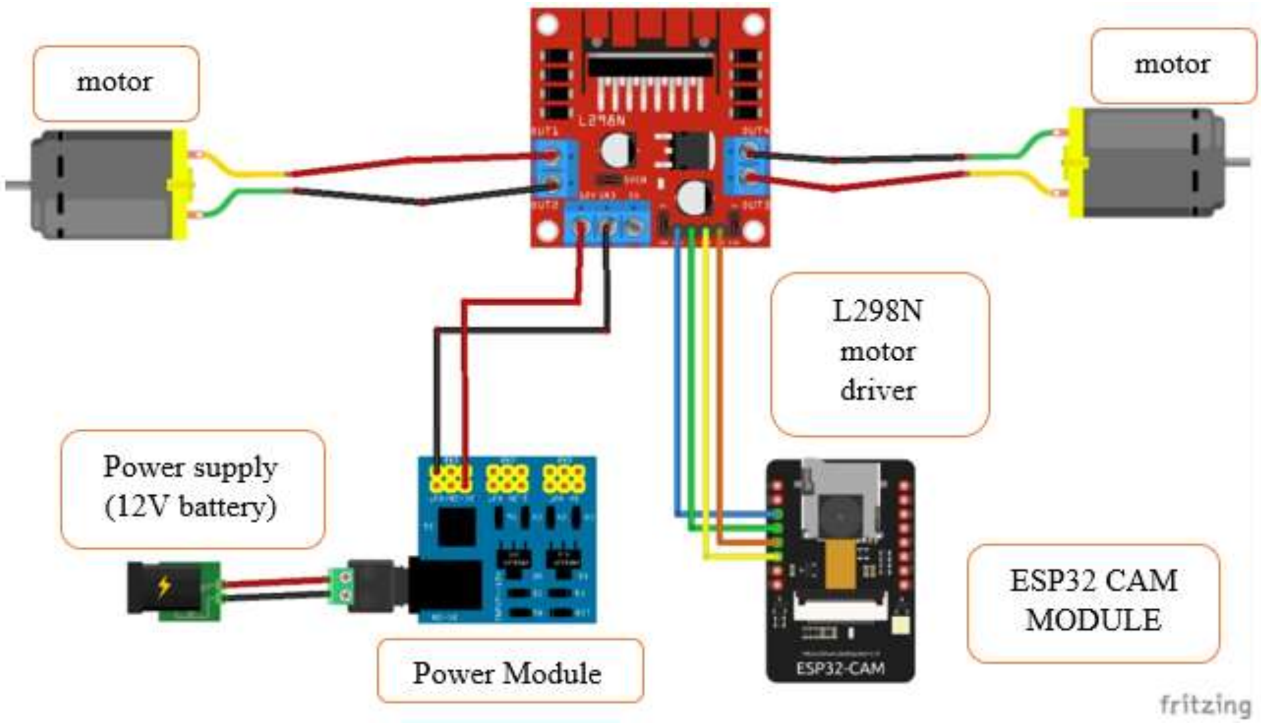


Fig. 2. Circuit design of the robot movement

The circuit diagram of the proposed feeding mechanism is shown in Figure 3. The power module can be divided into 3 different types of voltage, 3V, 5V and 12V. The 12V powers up the Arduino MEGA module while 3V powers up the four servo motors. The input and output list of the Arduino MEGA is an RTC module, an I2C LCD display module, two ultrasonic modules, four servo motors, a load cell with an HX711 module and ESP8266 Wi-Fi Module.

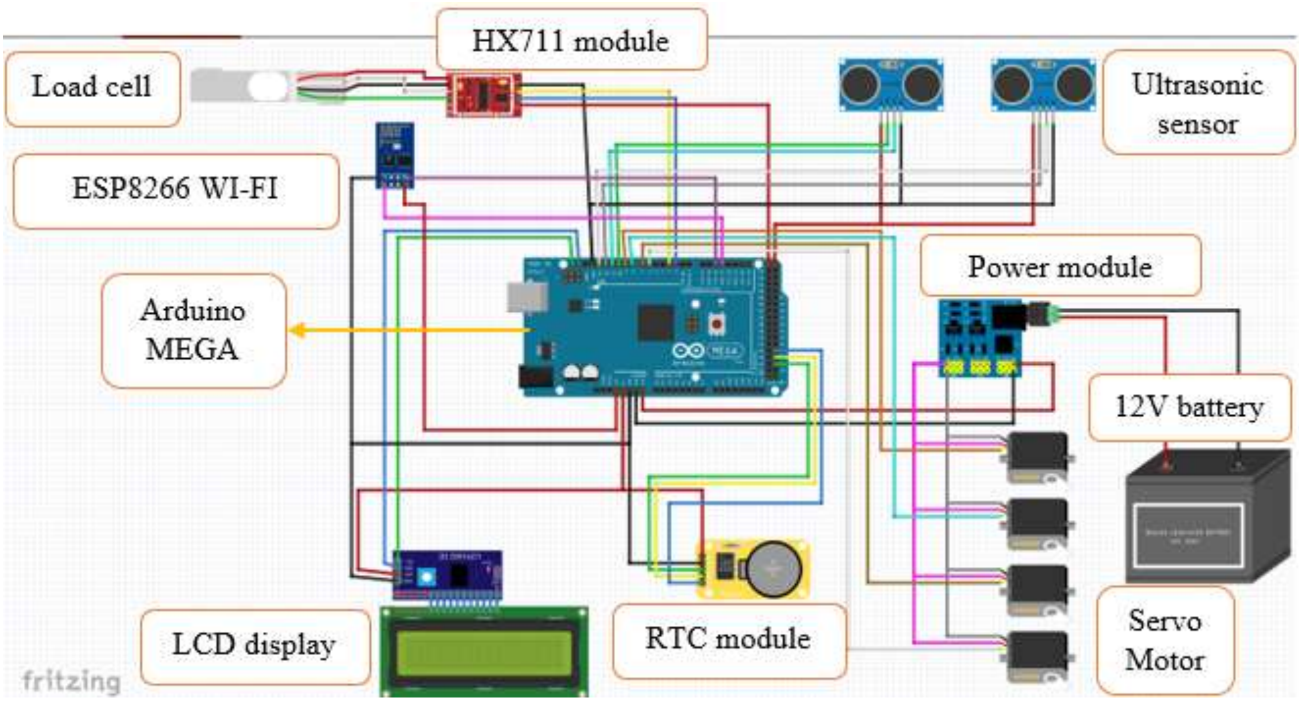
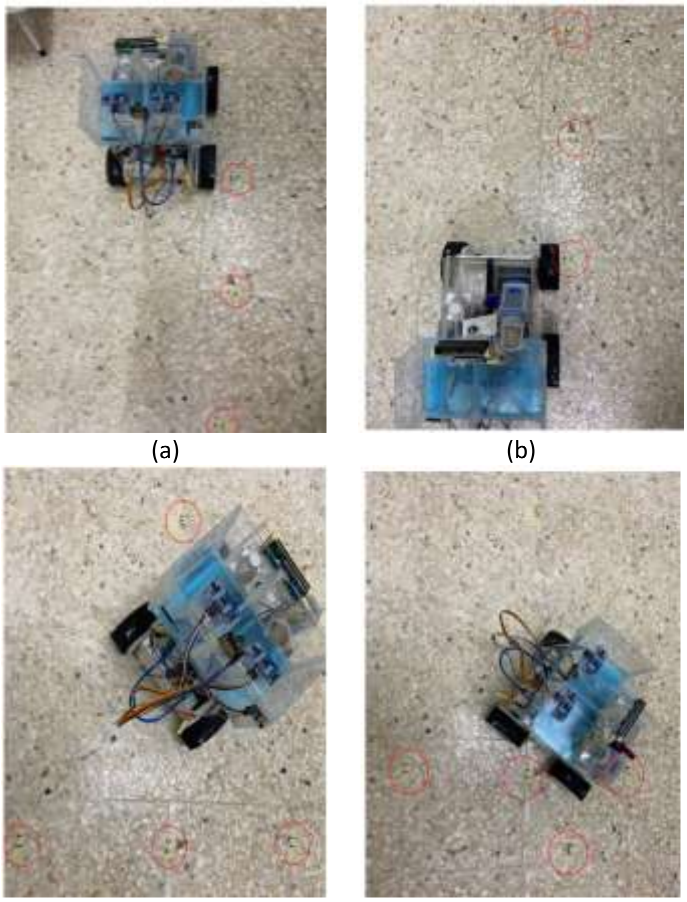


Fig. 3. The circuit design of feeding mechanism

3. Results

3.1 Movement of IoT Feeding Robot

The IoT pet feeding robot's movement is controlled *via* a virtual joystick in a web application, enabling it to navigate forward, backward, left and right based on joystick inputs. In Figure 4(a), the robot advances from the L1 lane to L3 upon signal reception from the forward virtual joystick. After initialization, it moves forward for two seconds at 500 rpm. Figure 4(b) depicts the robot reversing from L3 to L1 with the backward virtual joystick, following the same process as forward movement. Speed remains constant until reaching L1. In Figure 4(c), the robot transitions from L1 to L2 and turns left using the left virtual joystick. Similarly, in Figure 4(d), it advances from L1 to L2 and turns right under the control of the right virtual joystick.



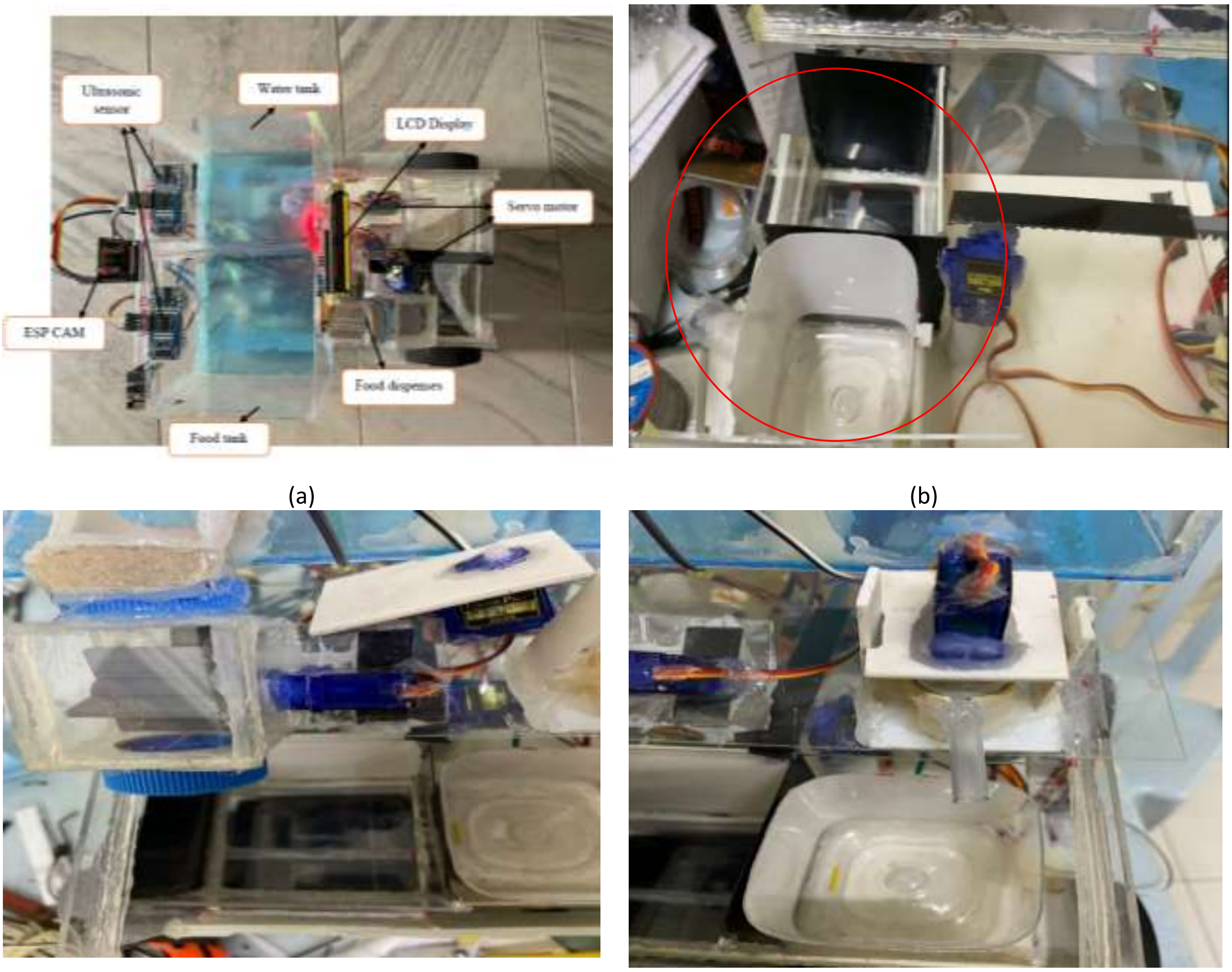
(a) (b) (c) (d)

Fig. 4. Movements of IoT pet feeding robot (a) Forward (b) Backward (c) Left (d) Right

3.2 The Feeding Mechanism of the Robot

Figure 5(a) shows the top view of the robot. In this view, the ESP32 CAM and two ultrasonic sensors are visible, with one sensor designated for food and the other for water. Additionally, the food and water storage boxes are observable. An LCD is attached to the front of these storage boxes. Figure 5(b) illustrates the upper lid in an open position. The RTC module timer is set to open the lid at 10:30 am, 1:30 pm and 8:30 pm for mealtimes. The meal schedules can be programmed by the users depending on their usual pet feeding time on the Blynk application. The upper lid servo motor operates based on these mealtimes, depositing food into the container highlighted with a red circle.

Once the upper lid opens, the pet has 5 minutes to access the food container. After this period, the lid automatically closes as programmed. The lid opening and closing time can be programmed depending on the pet's eating duration. Figure 5(c) highlights the food distribution box/valve, shown in a red circle. The food is dispensed from the distribution box into the food container only when the upper lid is open and it is dispensed for 2 seconds. Figure 5(d) displays the water container. After the food is deposited, the servo motor-controlled water line activates, pouring water into the water container for 1 second. Following these operations, the pets can access the food and water provided by the robot.



(a) (b) (c) (d)

Fig. 5. The prototype (a) Top View (b) Upper Lid in the open stage (c) Food dropping in stage (d) Water line (controlled by the servo motor)

Figure 6 shows the upper lid in the closed position. The lid closes automatically after the pet has eaten the food and drunk the water. The lid remains open for 5 minutes before closing, regardless of whether the food and water have been finished by the pet.

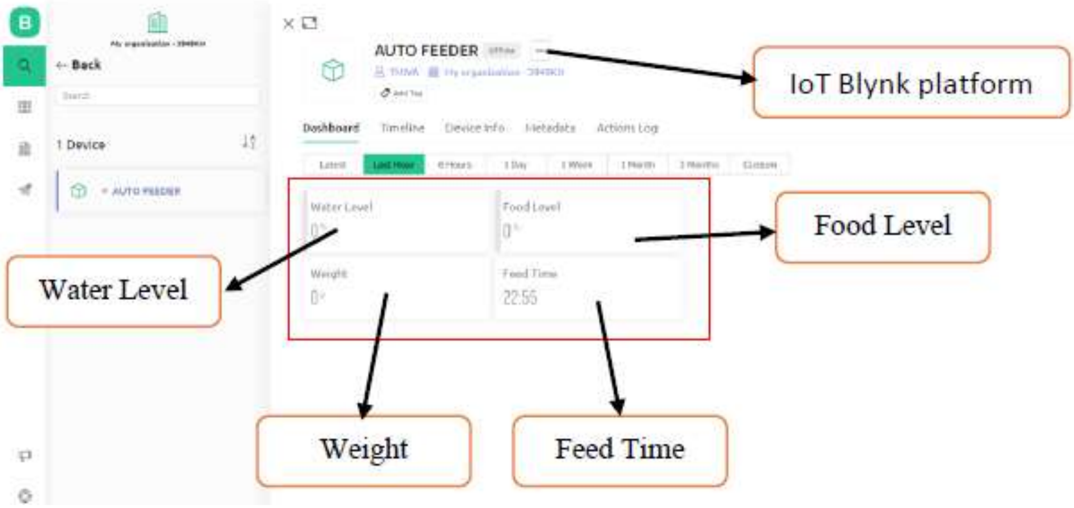
Fig. 6. IoT pet feeding robot (upper lid) in the closed stage

Figure 7(a) shows the bottom lid sliding open. After the upper lid closes, the bottom lid slides open. When the bottom lid slides open, the leftover food drops back into the storage box (highlighted in red). Figure 7(b) shows the bottom lid sliding closed. Once the food has completely dropped into the storage box, the bottom lid closes. The opening and closing of the bottom lid are assisted by a servo motor, with gears and tracks facilitating the sliding mechanism.

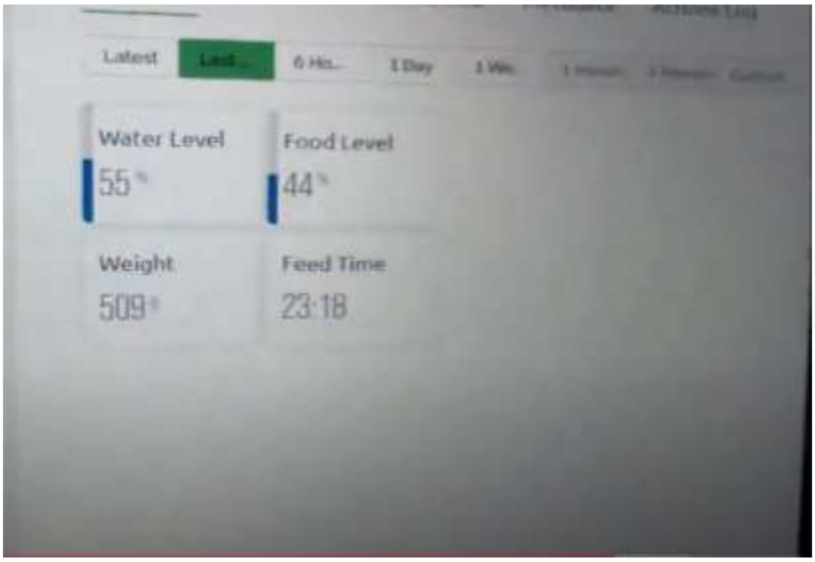
(a) (b)

Fig. 7. Bottom lid (a) In the open stage (b) In the close stage

Figure 8 shows the Blynk app on the web server. The Blynk app starts operating once it is connected to the ESP8266 module. When the ESP8266 Wi-Fi connects to the internet, the Blynk app goes online. All the robot's parameters appear on the web server, including water and food levels, leftover food weight and feeding time. These parameters can be observed in the red box highlighted in the Figure 8(a). Figure 8(b) shows the values of water and food level, weight of the leftover food and the feeding time. These parameters can be monitored via the Blynk app by the users.



(a)



(b)

Fig. 8. The Blynk app *via* web page (a) Full view (b) With parameter values

As shown in Figure 9, the virtual joystick controls the robot *via* the ESP32-CAM, which is connected to the L298N motor driver. The virtual joystick can move the robot forward, backward, right and left. The pet owner can manually control the robot using the virtual joystick. Furthermore, pet owners can monitor their pets through live streaming video on the web page platform, as shown in Figure 9.

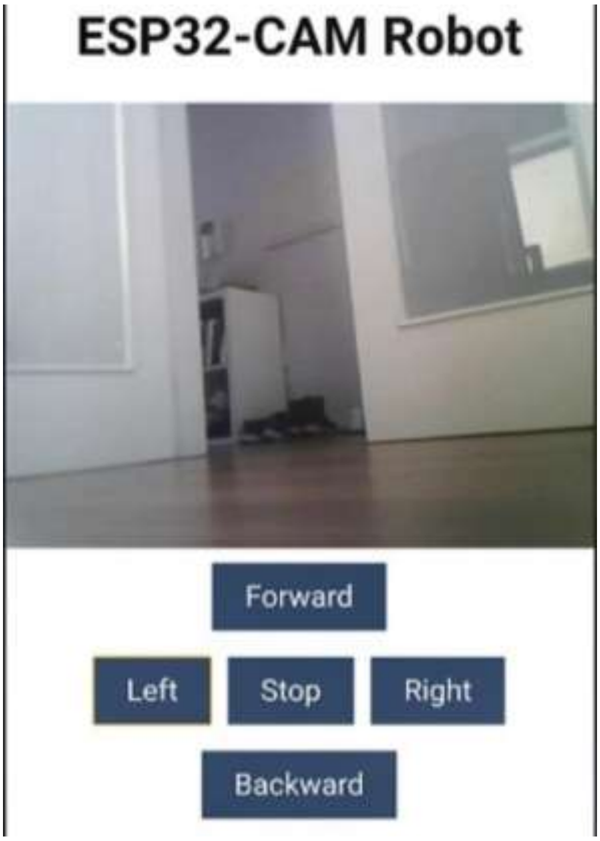


Fig. 9. Virtual joystick and online video streaming

4. Conclusions

In this study, a robot is designed to monitor pets on a daily basis was developed using an Arduino MEGA, ESP8266 Wi-Fi module, ultrasonic sensors, RTC module, servo motor, LCD display, load cell with HX711 module, ESP32 CAM module, power module and power supply. The system monitors water and food levels through the sensors, displaying the information on the LCD to the user and Blynk app. Additionally, the system allows pet owners to monitor their pets *via* live video streaming on the web. This project can be used in practical situations as a daily portable, robust tool to encourage pet owners to look after their animals while they are away from home. It ensures pets follow a proper diet and stay healthy. This project can be enhanced to industrial standards by adding certain entertainment features, such as playing with the pet to ensure they feel entertained. The robot can also be equipped to alert the owner when the food has expired. Food can spoil under certain circumstances, such as when water accidentally splashes on it, potentially causing the growth of fungi or mole. Thus, if the food spoils, the robot can alert the owner to discard the leftover food from the storage box. Additionally, the tires can be replaced with tank treads or caterpillar track tires for more stable movement.

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