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Development of Pet Shelter with IoT-based Monitoring System

Muhammad Firdaus Ramli[1], Masnani Mohamed[1]*

[1] *Department of Electronic Engineering, Faculty of Electrical and Electronic Engineering Universiti Tun Hussein Onn Malaysia (UTHM), Parit Raja, 86400, MALAYSIA*

*Corresponding Author: masnani@uthm.edu.my
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Abstract

The increasing demands of contemporary work have led to a rising trend of cats being left alone at home due to their owners' busy schedules. This situation often results in inadvertent neglect of the cats' nutritional needs and well-being. To address this problem, a pet shelter has developed an IoT-based monitoring system aimed at ensuring optimal conditions for food and litter containers, as well as maintaining suitable ambient temperatures. The system addresses the challenge of providing food automatically by estimating the required quantity over a set period, thus extending its duration and alleviating the burden of constant monitoring. Moreover, the implementation of an automated waste separation system for the litter box significantly enhances efficiency, reducing the time investment required for upkeep and enhancing convenience for cat owners. Additionally, the system enables owners to monitor their cats' condition through online footage, promoting comprehensive well-being. Real-time ambient temperature measurements further empower owners to maintain an optimal temperature range for their cats. In conclusion, these advancements in pet care technology benefit both pets and their human caretakers by ensuring optimal conditions and alleviating the challenges associated with caring for cats left alone at home.

1. Introduction

This work is dedicated to creating a comprehensive protection system for pets, with a specific emphasis on cats, utilizing an Internet of Things (IoT) monitoring system. Western Europe's preference for cats, numbering 74 million compared to 66 million dogs, underscores their popularity among pet owners (FEDIAF, 2018) [1]. The widespread issue of uncleanliness prompts owners to seek behavioral analysis.

Animals, particularly cats, are cherished in communities for the sense of completeness they bring to households and their ability to alleviate loneliness. To enhance feline care, a specialized automated system designed for indoor cats is proposed, incorporating home automation and modern technologies strategically placed in sleeping and littering areas. The IoT's global application through Wi-Fi enables remote control over health, intelligence, and temperature. This work encompasses monitoring systems, automated feeding, temperature control, and real-time health interventions. The automatic feeding function ensures a seamless and customizable experience for precise control over feeding schedules. Addressing the common problem of cats being left unmonitored during owners' work-related absences, the aims to alleviate issues such as mistreatment, reduced food supply, and potential health concerns. The lack of routine litter box cleaning exacerbates these challenges. Motivated by these issues, the work seeks to construct a cat shelter integrated with an IoT monitoring

Evolution in Electrical and Electronic Engineering Vol. 5 No. 1 (2024) p. 60-68

system, emphasizing temperature control, and aims to develop a feeder with precise food container control and a smart litter box featuring a motorized system for automated waste separation at specific intervals. The system involves both software and hardware development. In software, we control the Blynk interface, and in hardware, we focus on tasks like temperature reading and managing cat waste. Components include the Durian Uno processor, ESP8266-01 Wi-Fi module, DHT11 sensor, and FS90R Servo Motor. Software tools used are Arduino IDE, Blynk, Fritzing, and Proteus for circuit simulation [2].

2. Materials and Methods

2.1 Hardware component

Table 1 *Hardware components*

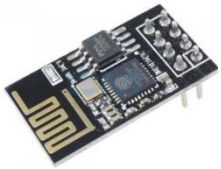
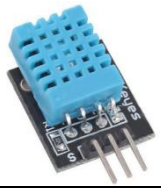
Hardware	Description
Durian Uno (D-Uno) 	D-Uno, a dual-core processor, concurrently executes multiple programs within a circuit. Operating as a control unit, it manages input and output pins separately, facilitating communication between software and hardware for coordinated processes like feeder, temperature control, and litter box functions.
ESP8266-01 Wi-Fi serial transceiver module. 	The ESP8266-01 Wi-Fi serial transceiver module links microcontrollers wirelessly. It empowers the Durian Uno with wireless capability, facilitating direct Wi-Fi connection and enabling software control over hardware functionality [3].
FS90R Servo Motor 	The Durian Uno system incorporates the FS90R servo motor to automate container movements for an automatic feeder. Precise wiring to designated Durian Uno pins ensures optimal control. The servo motor's specs, including power supply and dimensions, make it suitable for the application, while timer-based control enhances precision [4].
MG996R Servo Motor 	The MG996R Servo Motor, renowned in robotics and automation, offers precision and versatile applications with robust features. Notable for impressive torque within a 180-degree range, it finds use in tasks demanding strength and accuracy, guaranteeing durability and stability [5].
DHT11 sensor module 	The DHT11 Temperature Humidity Sensor Module, featuring a capacitive moisture sensor and transducer, excels in accurate readings (20-80% humidity, 0–50 °C temperature). Widely adopted for its affordability, digital interface, and microcontroller compatibility [6].
DC Motor Brushless Fan 	The Brushless Fan DC motor is crucial for maintaining a cat's optimal temperature range (25-32 degrees Celsius). Operating at DC 5V with impressive specifications, it efficiently extracts hot air. Programmed for temperature control, it ensures a comfortable environment, prioritizing the cat's well-being in Malaysia's local conditions.

Table 1 outlines the hardware components, featuring the Durian Uno (D-Uno), a dual-core processor managing coordinated processes. The ESP8266-01 Wi-Fi module provides wireless capability, enabling direct Wi-Fi connection for software control. Servo motors FS90R and MG996R automate feeder movements with precision and stability. The DHT11 sensor excels in temperature and humidity readings, while the Brushless Fan DC motor efficiently regulates the cat's environment within the optimal temperature range of 25-32 degrees Celsius.

2.2 Software application

The Arduino Integrated Development Environment (IDE) is crucial for software development of the system. Employed for programming the D-Uno board, the IDE facilitates the visualization of instructions in code. This simplifies coding and debugging, ensuring the board, as shown in Fig. 1, performs as intended. The Arduino IDE, a comprehensive platform for coding IoT devices, provides a user-friendly interface and rich libraries. Developers can easily generate, compile, and upload code to implement desired functions. This IDE is essential for IoT development, enabling the smooth integration of sensors and the efficient utilization of sensor data, thereby enhancing the responsiveness of IoT applications. As the IoT landscape evolves, the Arduino IDE remains a valuable resource for realizing developers' aspirations [7].

Fig. 1 *Arduino Integrated Development Environment (IDE).*

2.3 Block diagram

The block diagram, as illustrated in Fig. 2, highlights input and output specifics in a D-Uno microcontroller-based cat care system, featuring a temperature sensor, servo motor, and Wi-Fi transmitter. The system is divided into two parts: sensor operation ensures an ideal temperature for the cat and automates feeding and waste separation, while the monitoring system provides real-time updates on the cat's condition for better care. The initial phase focuses on creating a safe environment using a continuous temperature sensor. The system adjusts the habitat temperature based on real-time data, activating cooling or heating devices as needed. A scheduled servo motor automates feeding and waste separation, ensuring nutritional needs are met and maintaining cleanliness. Technology streamlines these activities, reducing the owner's effort and promoting a consistent care routine in the cat care system created with the D-Uno microcontroller.

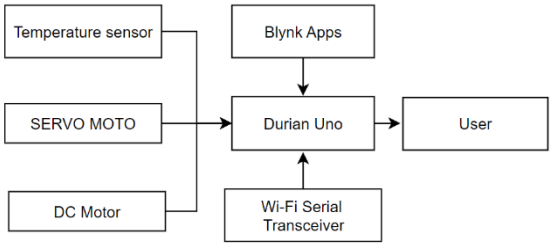


Fig. 2 *Block diagram of hardware implementation.*

2.4 Flowchart

Fig. 3 illustrates the systematic flowchart for the hardware and software development, testing, and integration. Clear decision points and troubleshooting paths guide stakeholders through the process. The integration of the DHT11 sensor, FS90R and MG996R servo motors, DC motor, and software components like Arduino IDE and Blynk is depicted seamlessly. This visual tool emphasizes parallel development, iterative testing, and troubleshooting.

The aims of the system are to support cat owners by monitoring dietary intake, optimizing environmental temperature, and ensuring litter cleanliness. A sophisticated sensor system accurately monitors ambient temperature, maintaining a comfortable range for the cat's health.

Evolution in Electrical and Electronic Engineering Vol. 5 No. 1 (2024) p. 60-68

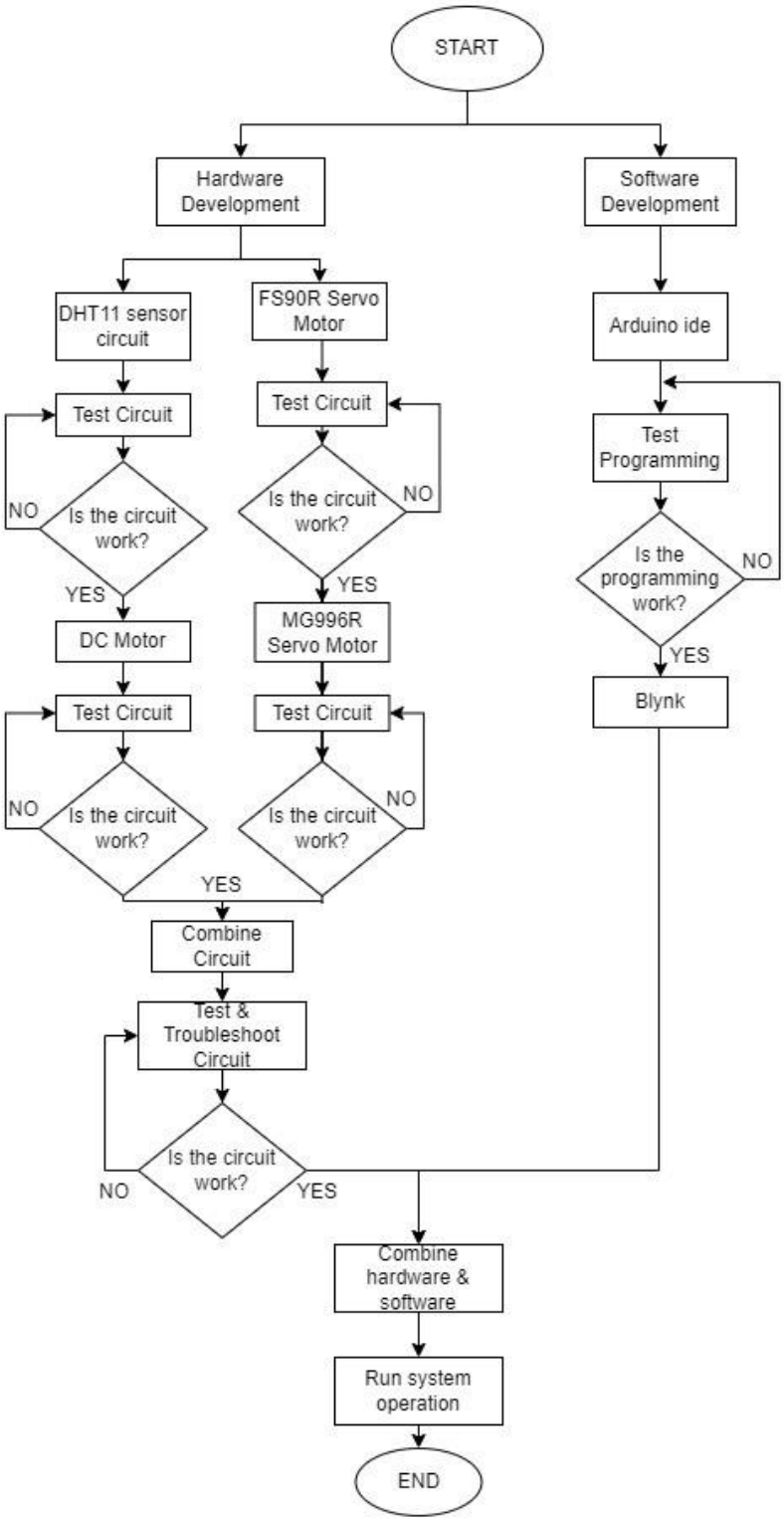


Fig. 3 *Flowchart of the entire process.*

2.5 Framework

In Fig. 4, components are depicted connected to the Durian Uno microcontroller board, which serves as the primary controller orchestrating the circuit's activities. A 9 V Power Supply provides voltage through Vin and GND connections, while a Servo Motor (SG90) enables precise angle rotations via PWM, 5 V, and GND terminals. Additionally, a DC Motor, linked to an H-bridge module, drives various components for this technical study, exploring the responsibilities and interconnections of these circuit elements.

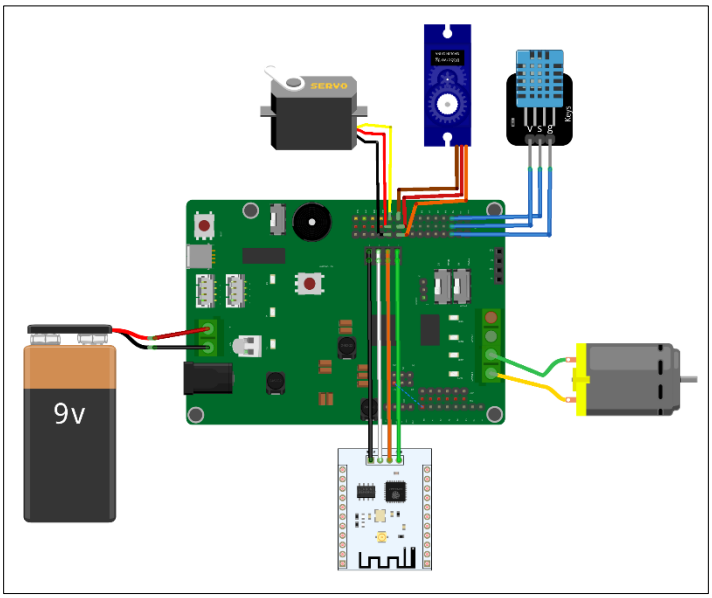


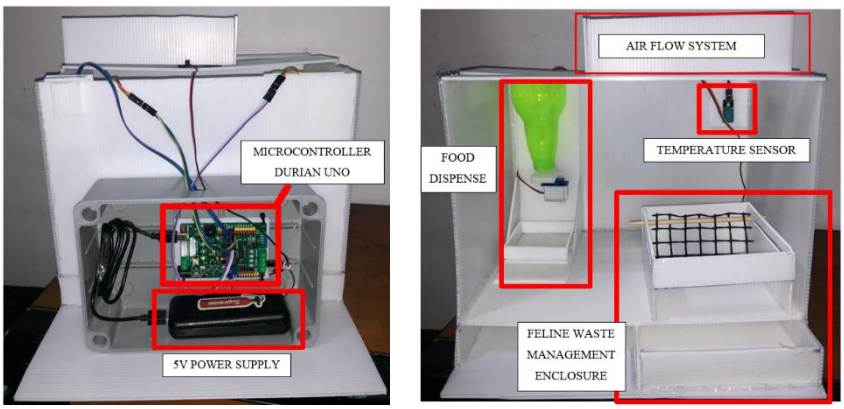
Fig. 4 *Circuit diagram.*

3. Result and Discussion

3.1 Prototype of The System

The prototype, as shown in Fig. 5(a) and Fig. 5(b), features the system controller Fig. 5(a) with the Microcontroller D-Uno serving as the central hub, overseeing attached hardware components. Guided by the D-Uno system, the sensor and irrigation systems seamlessly operate, harmonizing their functions with the power supply. This integration ensures smooth and efficient performance, allowing for a cohesive and well-coordinated execution of tasks. Data collected by the sensor is displayed on Blynk.

Fig. 5 (b) displays parts of the prototype, showcasing the user-controlled feeder with an FS90R servo motor for food release. The DHT11 temperature sensor monitors environmental temperature, activating a fan if it exceeds 32 degrees Celsius, expelling hot air and presenting information on Blynk. The MG996R Servo Motor facilitates litter box cleaning with a button press, ensuring a sanitary space for the cat's waste elimination.



(a) **(b)**

Fig. 5 *Prototype (a) System controller; (b) design*

3.2 Design Breakdown

3.2.1 Feeder

The cat food dispenser, part of a feeder system, includes a green translucent storage container, a controlled opening and closing mechanism, and a designated food drop area for convenient cat access. Attached to a container food, it offers practical automated feeding. The servo motor, integrated with Blynk and Durian Uno,

Evolution in Electrical and Electronic Engineering Vol. 5 No. 1 (2024) p. 60-68

facilitates precise control. Activating the timer function allows the servo motor to smoothly open and close the food container, minimizing waste and promoting feeding efficiency, as depicted in Fig. 6.

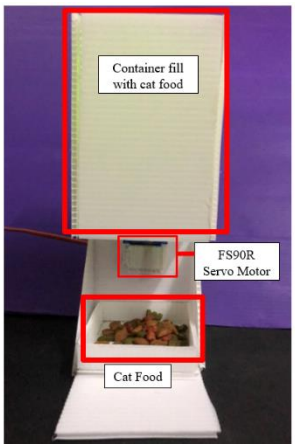


Fig. 6 *Food dispenser*

3.2.2 Air Circulation System

The air circulation part of the prototype incorporates a fan with black blades and white, expelling hot air to regulate temperature and prevent overheating. An electronic component monitors temperature fluctuations, ensuring the system stays within the optimal range. This configuration proactively addresses the risk of overheating, maintaining operational stability. When the temperature exceeds 30 degrees Celsius, the DC motor rotates clockwise, extracting hot air for a cooling effect. Conversely, when the temperature falls below 29 degrees Celsius, the fan closes to maintain the optimum temperature range for the cat, specifically between 32 and 25 degrees Celsius, aligning with Malaysia's local climate, as shown in Fig. 7.

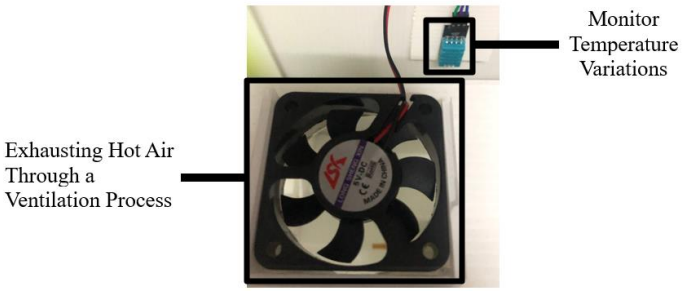


Fig. 7 *Air Circulation system*

3.2.3 Feline Waste Management Enclosure

The feline waste management enclosure is a crucial part of the prototype. It serves as the designated area for feline urination. The cat litter box is divided into two sections: the upper area, labeled the "Feline Waste Containment Area," is where the cat deposits waste, featuring a grid cover for waste separation. The lower half functions as an empty storage space without necessary cleaning items for maintaining cleanliness. Constructed entirely of plastic, the enclosure is placed on the floor against a wall, showcasing a design commonly found in cat litter boxes. Additionally, the MG996R Servo Motor integrated into the enclosure, as further detailed in Fig. 8, plays a crucial role in waste management. It rotates from 0 to 360 degrees clockwise with a 2-second delay, effectively pushing all accumulated cat feces in the litter box with a net into the storage room, ensuring cleanliness. Subsequently, the MG996R Servo Motor rotates from 360 to 0 degrees counterclockwise with a 2-second delay, pulling the net back to its original state.

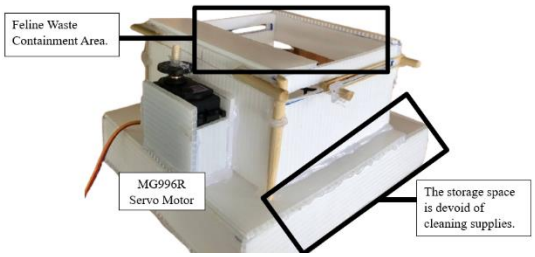


Fig. 8 *Feline Waste Management Enclosure*

3.3 User Interface

Fig. 9 illustrates the Blynk program interface, presenting essential information about the cat's well-being and surroundings. The interface displays real-time data, including temperature (31.3°C) and humidity (71%). Bar graphs showcase historical data for temperature and humidity across different time intervals. Manual controls for fan speed and food input are provided, along with buttons for fan and feeder activation. Additionally, an automatic food timer ensures timed dispensing.

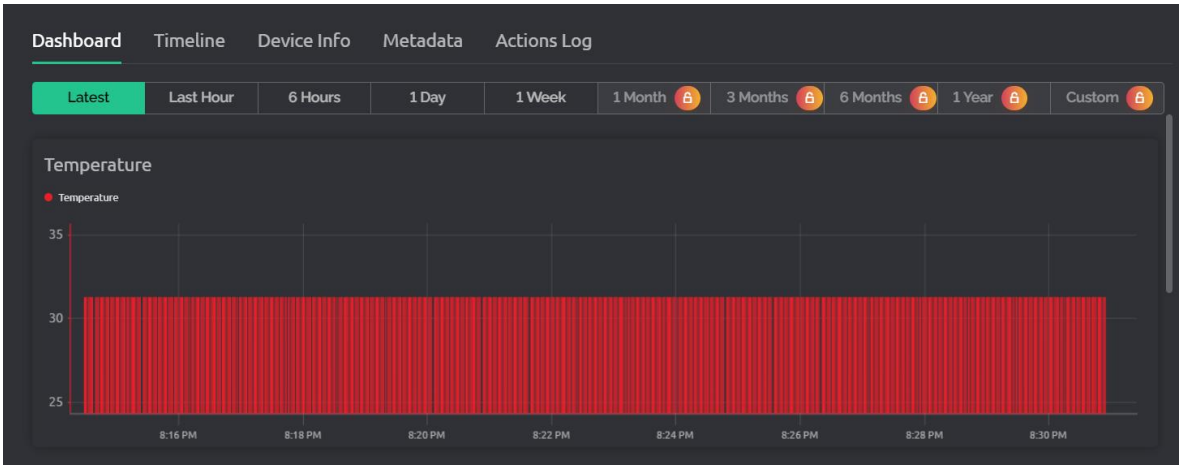
Fig. 9 *The User Interface of Blynk.*

3.4 Temperature And Humidity Reading Result

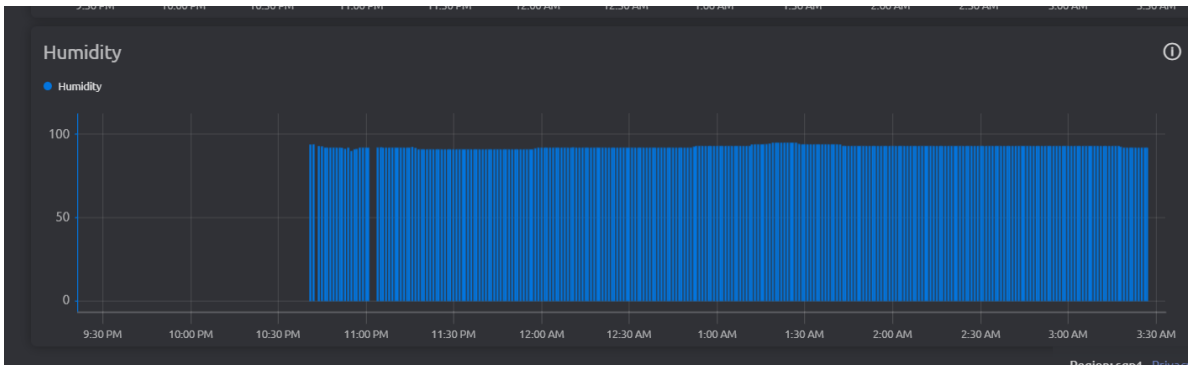
Fig. 10(a) and Fig. 10(b) show the interface of the Blynk web program changing temperature result. The web dashboard on Blynk features a comprehensive display, including graphs showcasing both temperature and humidity readings over time. Users can easily navigate through different time periods to observe trends in temperature and humidity. This interactive dashboard provides users with the ability to remotely monitor and adjust the fan's temperature and humidity settings, serving as a convenient and centralized control hub for optimizing the environment. It essentially functions as a remote control for managing both temperature and humidity parameters.

Additionally, the data displayed in Fig. 10(a) and Fig. 10(b) represent a 6-hour timeframe, allowing users to analyze temperature and humidity trends over an extended duration. This extended timeframe offers valuable insights into environmental changes and patterns, facilitating informed decision-making regarding environmental adjustments. With this detailed information, users can make proactive changes to optimize the environment for their specific needs and preferences. Overall, the extended data collection period enhances the utility and effectiveness of the Blynk web program as a tool for environmental monitoring and control.

Evolution in Electrical and Electronic Engineering Vol. 5 No. 1 (2024) p. 60-68



(a)



(b)

Fig. 10 *Dashboard of (a) Temperature; (b) Humidity*

4. Conclusion

In conclusion, the development of the Pet Shelter with an IoT-based Monitoring System offers a comprehensive solution to the challenges faced by cat owners in today's busy world. The system's features, including automatic food dispensing, waste separation, and real-time monitoring through online footage, contribute to the well-being of cats left alone at home. The integration of hardware components like the Durian Uno processor, ESP8266-01 Wi-Fi module, and various servo motors, along with software applications like Arduino IDE and Blynk, showcases a holistic approach to feline care. The prototype's design breakdown, including the feeder system, air circulation system, and the Feline Waste Management Enclosure, demonstrates a thoughtful consideration of the cat's needs. The user-friendly interface presented enhances the overall user experience. Ultimately, this work not only addresses the practical challenges of cat ownership but also embraces technological innovation to create a more convenient and automated solution for pet owners, promoting the well-being of both pets and their human caretakers.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author attests to having sole responsibility for the following: planning and designing the study, data collection, analysis and interpretation of the outcomes, and paper writing.

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