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IoT-based smart cat home with sensor integration and B lynk application for real-time monitoring of cat temperature, feed, and activity

Andini Sintawati* & Alda Emly Tambunan

Department of Informatics, Faculty of Industrial Technology, Gunadarma University, Jl. KH. Noer Ali Kampus J, RT.005/RW.006A, Jakasampurna, Kec. Bekasi Sel., Kota Bks, Jawa Barat 17145, Indonesia
* e-mail: anies@staff.gunadarma.ac.id

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ABSTRACT

Cats are one of the most popular pets in Indonesia, especially purebred cats that require special care, including temperature control, lighting, and food and water availability. Cat owners often face challenges when leaving their pets for extended periods, necessitating an effective monitoring system for their pets. This study aimed to design and implement an Internet of Things (IoT)-based Smart Cat Home system to monitor and control cage conditions in real time. The system uses ESP32 and ESP32-CAM microcontrollers, DHT22 sensors for temperature and humidity, LDR sensors for lighting, Load Cell sensors for food and water, and the Blynk application as a remote monitoring medium. The research methods included requirements analysis, hardware and software design, sensor integration, and functional testing. The test results show that the system works in automatic mode with a 95% success rate and responds quickly to commands. The developed Smart Cat Home system has been proven to work well and reliably to help cat owners monitor cage conditions efficiently and remotely.

Keywords: IoT; Smart Cat Home; Cats

1. INTRODUCTION

Humans are social creatures who are highly dependent on the presence of others in their daily lives. Routine activities often lead to boredom, leading many people to choose to keep pets at home. In Indonesia, cats are the most common pets. is the most popular pet (Mukti et al., 2022). According to a survey conducted by the research institute Rakuten Insight Global, more than half of the population (59%) stated they own a pet. The survey involved 97,000 respondents from various countries, including China, the Philippines, Hong Kong, India, Indonesia, Japan, South Korea, Malaysia, Taiwan, Thailand, and Vietnam. However, pet preferences vary by country. Rakuten noted that cats are the most popular pets among Indonesians, with 47% of respondents choosing them (Rakuten Insight, 2021).

Currently, purebred cats are a popular choice for pet ownership. Caring for purebred cats requires special attention, given the higher cost of food and more intensive fur care required. Furthermore, proper temperature control is crucial for preventing cat illnesses. With Smart Cat Home, cat owners can rest assured that they can leave their cats at home without having to pay for boarding services. Given that humans are now inseparable from social media, the Smart Cat Home is designed to monitor food and water in the cage, the temperature inside the cage, and is equipped with a camera that allows owners to monitor their cat's activities via the Blynk platform in video format (Ginting et al., 2023).

Based on the previous explanation, this system is implemented in the Smart Cat Home concept based on the Internet of Things (IoT). This system is designed with a control mechanism that uses the Blynk application as a real-time monitoring medium (Indobot Academy, 2024) . In its application, the DHT22 sensor is used to measure the temperature inside the cage, whereas the LDR and Load Cell sensors function to detect and calculate the weight of the available food and drink (Wijayanti et al., 2023). In addition, the ESP32-CAM is used as a video capture device to visually monitor the cat's activity inside the cage. This system is specifically designed for cat cages, especially for owners of purebred cats who must leave their pets unattended for long periods. By utilizing Internet of Things (IoT) technology, this system allows direct monitoring of the cat's condition through an Internet connection in the same network, so that owners can more easily and efficiently monitor the condition of their cats (Putu et al., 2021; Febriana et al., 2023).

2. METHODS

2.1. Analysis Series by Block Diagram

The block diagram in Figure 1 describes the channel work of the Smart Cat Home system based *on the Internet of Things* (IoT), which was designed to monitor the condition of the cat pen in real time. The system is divided into three main components: input, processing, and output.

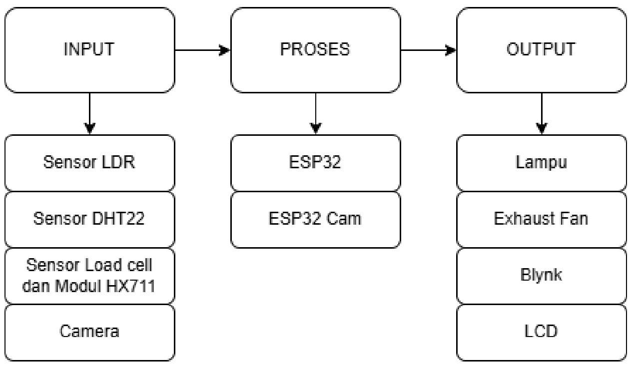

Figure 1Block Diagram

2.2. Analysis Series

Figure 2 shows the circuit diagram of an Internet of Things (IoT)-based Smart Cat Home system designed to automatically monitor the condition of a cat enclosure. The circuit consists of several main components interconnected via an ESP32 microcontroller and ESP32-CAM module. Data is communicated wirelessly via Wi-Fi and sent to the Blynk platform for real-time display on the user's device.

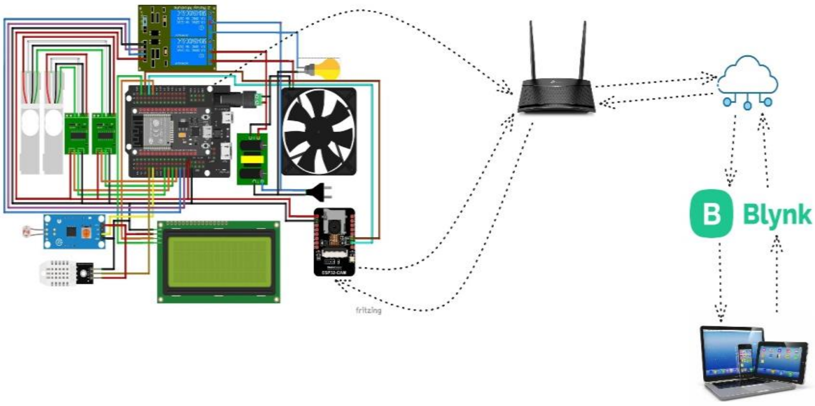

Figure 2Circuit Diagram

This circuit is an automatic monitoring and control tool for cat cages, based on the ESP32 microcontroller. This system integrates various sensors and actuators to enable remote monitoring using the Blynk platform (Sidik et al., 2022). The DHT22 sensor was used to measure the temperature and humidity inside the cage, whereas the LDR sensor detected light intensity to automatically regulate the lights (Novadi et al., 2020). In addition, this system is also equipped with a load cell connected to the HX711 module to monitor food and water waste in the cage. All sensor data will be displayed on the LCD installed in the cage and also in the Blynk application (Budiman, & Ramdhani, 2021) . This system uses lights and exhaust fans controlled by a relay module via command signals from ESP32. The lights turn on automatically when the light around the cage dims based on the LDR sensor reading (its resistance value is less than 600 ohms), and the fan turns on when the temperature in the cage exceeds or equals 33 °C. In addition, this system is equipped with an ESP32-CAM that allows owners to visually monitor the condition of the cage through live video streaming within the same local network using the Blynk application. All these functions work in an integrated manner, allowing real-time monitoring of the cage, both close up via the LCD and remotely via the application on a smartphone.

2.3. Flowchart Analysis

The flowchart in Figure 3 illustrates the architecture and workflow of an Internet of Things (IoT)-based Smart Cat Home system, which has three main processes: Wi-Fi network initialization and connection, sensor data processing and actuator control, and video capture and streaming via ESP32-CAM camera (Sonya, 2024). These three parts are integrated into a single IoT ecosystem, enabling automatic, adaptive, and real-time monitoring of the cat cage's condition. This system is not only a monitoring tool but also a form of smart home implementation for pets, with a combination of sensors, actuators, and digital interfaces (Abdullah et al., 2023).

In the first stage, the initialization and network connection process begins when the system prepares all components, such as the DHT22 temperature and humidity sensor, LDR light sensor, Load Cell weight sensor, and LCD for local display. In this stage, the Blynk credentials were configured to connect the device to the IoT cloud platform. If the connection to the Wi-Fi network fails, the system automatically enters Access Point mode and opens a web portal for the user to select the SSID and manually enter the password. When authentication is successful, the device immediately connects to the network and proceeds to the next stage. This process reflects a fallback strategy mechanism, where the system is designed to remain adaptive and functional even in the event of a network outage.

The second stage is reading sensor data and controlling the actuators, which is run by the ESP32 microcontroller as the main control center. Once the Blynk connection is active, the microcontroller begins reading the value from the LDR sensor to detect the intensity of ambient light. If the sensor resistance value indicates dark conditions (below 600 Ω), the light is automatically turned on, while in bright conditions the light is turned off. The next process is reading the temperature and humidity through the DHT22 sensor. When the temperature reaches or exceeds 33°C, the system will turn on the fan to maintain air circulation inside the cage to keep it cool. In addition, two Load Cell sensors are used to weigh food and drink. All collected data is then displayed on the LCD, providing direct feedback to the user about the actual conditions in the cage. With this mechanism, the system ensures the welfare of pets is maintained without the need for constant manual supervision.

The third step involves streaming video through the ESP32-CAM camera module. This stage begins with initializing the stream server and providing Blynk credentials. Once connected to the network, the system configures the local IP address used for video streaming. If the camera is working properly, the streaming server starts running and waits for requests from clients. When the user opens the app or website to access the video, the system broadcasts the live view. This process continues as long as the client connection is active, allowing for real-time visual monitoring of the enclosure. The stream can be accessed through the Blynk app or a browser with the displayed IP address, making the system flexible for remote access and control.

From the ESP32 programming side, the system was developed using various libraries such as BlynkSimpleEsp32.h, WiFiManager.h, and LiquidCrystal_I2C.h to support automatic connection, data communication, and visual display. The program code includes the pin initialization process, sensor reading, actuator control, and Wi-Fi connection management (Maulana, 2024). The code structure also shows the use of time intervals to display data alternately on the LCD as well as flashing LED indicators as connection status markers. In addition, there is a manual load calibration feature via serial communication to ensure accurate Load Cell measurement results. From this program analysis, it is clear that the system has a modular design with high efficiency and utilizes the ESP32's multitasking capabilities to run various functions simultaneously.

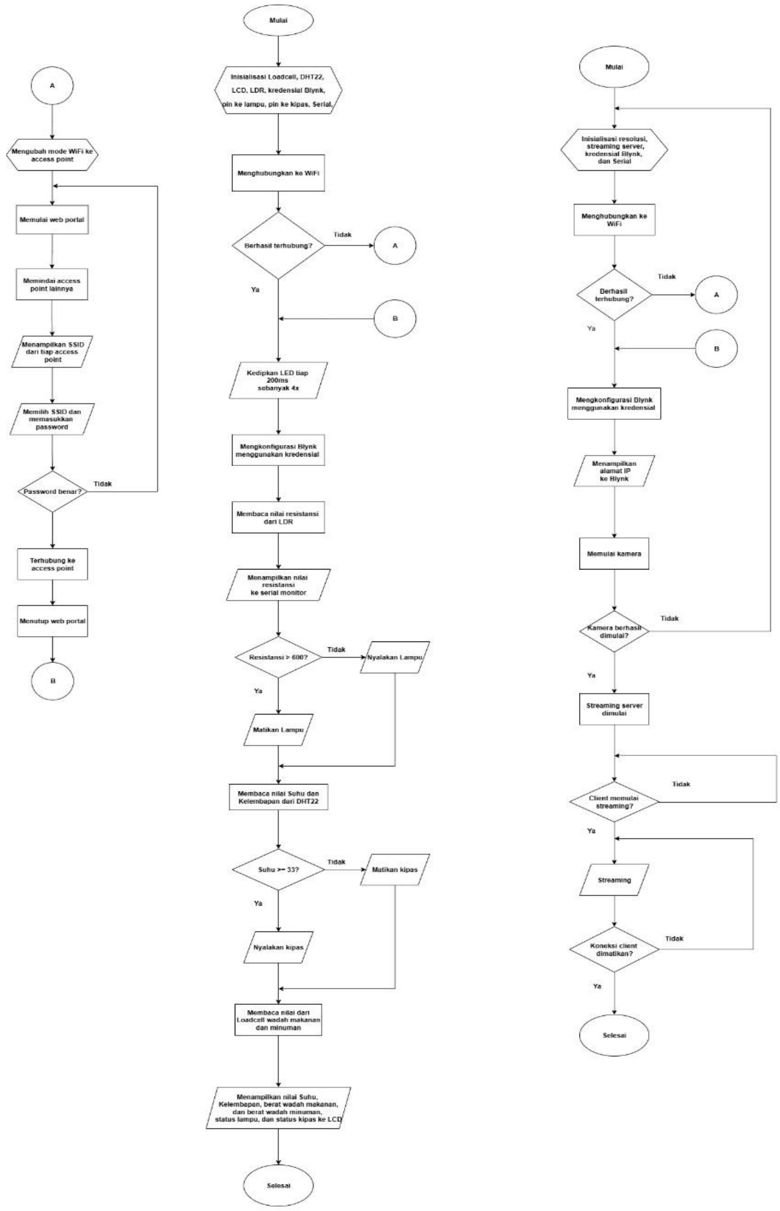

Figure 3. Flowchart

As for the ESP32-CAM module, the program focuses on managing the OV2640 camera and streaming server. The setup function manages the Wi-Fi connection, initializes Blynk, and runs the web server and camera. The loop function maintains a stable connection and periodically monitors signal strength. If the signal weakens, the system displays the signal quality status in the app. Furthermore, the Over-The-Air (OTA) update feature allows firmware updates without having to remove the device, making the system easier for long-term maintenance and development (Yulita et al., 2022). The camera is initialized with specific resolution parameters, and if it fails to activate, the system automatically restarts to maintain operational reliability.

Overall, the Smart Cat Home is an IoT-based automation system that combines hardware and software with the concept of sensor data integration, actuator control, and digital visualization. Users can monitor cage conditions, such as temperature, humidity, food and drink weight, and lighting, through the Blynk application in three main tabs: Monitoring, Camera, and Monitoring 2. This interface displays real-time data through widgets such as LCD, gauges, value displays, and SuperChart for historical data. This system provides a smart solution for modern pet management with the concepts of automation, connectivity, and efficiency, which reflects the real application of IoT technology in everyday life.

3. RESULT AND DISCUSSION

3.1. How to Operate the Tool

The Internet of Things (IoT)-based Smart Cat Home device operates through three main stages: power connection, network connection verification, and monitoring via the Blynk application. First, users must connect the adapter for the ESP32 and ESP32-CAM microcontrollers to a power source to provide sufficient power to the system. Once the device is powered on, the LCD indicator displays the network connection status. If the device is not yet connected to a Wi-Fi network, users must connect it manually through the configuration mode or web portal provided by the system (Putu et al., 2023).

Once the Wi-Fi connection is successful, the device displays the sensor values and actuator status on the LCD screen. Users can then open the Blynk app on their mobile devices for real-time monitoring. The app allows users to view data on temperature, humidity, light intensity, and the weight of their cat food and drink. This allows users to ensure optimal conditions in their cats' enclosures without the need for direct monitoring.

3.2. Sensor Testing

The sensor testing phase was conducted to ensure that all the sensors in the system were working properly and providing accurate readings. The sensors tested included the DHT22, LDR, and two load cell sensors used for food and drink containers. This test was crucial for ensuring the reliability of the data sent to the Blynk monitoring system. The DHT22 sensor measures the indoor temperature and humidity. When the temperature reached ≥ 33°C, the system automatically activated a relay and turned on the exhaust fan to lower the room temperature.

Table 1. DHT22 Sensor Test Results

Test	Temperature Value	Relay Condition	Exhaust Fan Condition	Success
1	35°C	Active	Active	Succeed
2	31°C	Dead	Dead	Succeed
3	27°C	Dead	Dead	Succeed
4	33°C	Active	Active	Succeed
5	30°C	Dead	Dead	Succeed
6	32°C	Dead	Dead	Succeed
7	34°C	Active	Dead	Fail
8	29°C	Dead	Dead	Succeed
9	33°C	Dead	Dead	Fail
10	34°C	Active	Active	Succeed
Average Success Rate				80%

Based on Table 1, the DHT22 sensor showed an 80% success rate, with two failures owing to a mismatch between the temperature readings and actuator activation. Overall, the sensor operated stably and automatically responded to changes in the ambient temperature.

An LDR sensor was used to measure the light intensity around the device. If the sensor resistance value is above 600, the system automatically turns on the lights to provide additional illumination.

Table 2. LDR Sensor Test Results

Test	LDR Value	Relay Condition	Light Condition	Success
1	479	Dead	Dead	Succeed
2	665	Active	Active	Succeed
3	533	Dead	Dead	Succeed
4	445	Dead	Dead	Succeed
5	710	Active	Dead	Fail
Average Success Rate				90%

The test results in Table 2 show that the LDR sensor had a 90% success rate, with only one reading error due to a difference in the resistance threshold. Overall, the sensor was able to detect changes in light intensity effectively and automatically control the lighting.

Load Cell Sensor Testing (Food Container)

Load cell sensors in food containers are used to measure the weight of the food. The measured data is then compared with a digital scale to determine the sensor's accuracy.

Table 3 Load Cell Sensor Test Results for Food Containers

Test	Load Value (Kg)	Load Cell Output (Kg)	Difference (Kg)	Accuracy (%)
1	0.50	0.48	0.02	96.00%
2	0.27	0.24	0.03	88.89%
3	1.00	0.97	0.03	97.00%
4	0.75	0.76	0.01	98.67%
5	0.84	0.82	0.02	97.62%
Average Accuracy				95.63%

Based on Table 3, the load cell sensor in the feed container had high accuracy, averaging 95.63%. This demonstrates that the sensor is capable of measuring feed weight precisely and is reliable for real-time monitoring.

Table 4. Load Cell Sensor Test Results for Drinking Containers

Test	Volume Value (L)	Output Load Cell (L)	Difference (L)	Accuracy (%)
1	0.17	0.15	0.02	88.23%
2	0.75	0.73	0.02	97.33%
3	0.89	0.85	0.04	95.51%
4	0.34	0.33	0.01	97.05%
5	0.23	0.22	0.01	95.65%
Average Accuracy				94.75%

The load cell sensor for the water container also performed well, with an accuracy rate of 94.75%. The two sensors were placed side by side to make it easier for cats to access food and water (Table 4).

3.3. Tool Testing

After all components were assembled, a thorough system test was conducted to ensure that the sensors, actuators, and microcontroller were functioning as designed. Test results showed that the system was able to respond automatically and in real time to changes in temperature, light, and feed and drink weight.

Table 5. Tool Test Results

Test	DHT, Fan Relay, and Fan	LDR, Light Relay, and Light	Load, Load Cell, LCD
1	34°C, Active, Active	723, Active, Active	0.80 kg, 0.78 kg, 0.78 kg
2	29°C, Dead, Dead	310, Dead, Dead	0.00 kg, 0.00 kg, 0.00 kg
3	33°C, Active, Active	280, Dead, Dead	0.60 L, 0.58 L, 0.58 L
4	30°C, Off, Off	650, Active, Active	0.25 kg, 0.23 kg, 0.23 kg
5	34°C, Active, Active	730, Active, Active	0.90 L, 0.88 L, 0.88 L

The results Table 5 showed the system was responsive and automatic. The DHT22 sensor activates the fan at high temperatures, the LDR adjusts the lighting according to light intensity, and the load cell displays the weight with high accuracy on the LCD.

3.4. Application Testing

The app was tested to ensure all sensor data could be sent in real time to the Blynk platform. Users can monitor temperature, light, and the weight of feed and water directly through the app's widget.

Table 6. Application Test Results

Test	Temperature Gauge	LDR Value	Food Container	Drinking Container	Fan Status	Light Status
1	34°C	720	0.78 kg	0.00 L	Active	Active
2	29°C	310	0.00 kg	0.00 L	Dead	Dead
3	33°C	280	0.00 kg	0.58 L	Active	Dead
4	30°C	650	0.23 kg	0.00 L	Dead	Active
5	34°C	730	0.00 kg	0.87 L	Active	Active

Based on test results (Table 6), the Blynk application is capable of displaying sensor data with high accuracy and minimal delay. The temperature and LDR widgets display values that correspond to physical conditions, while the fan and light indicators automatically adjust according to system logic. Thus, the Smart Cat Home IoT system was determined to function optimally in terms of both hardware and software.

4. CONCLUSION

Based on the results of implementation and a series of tests, the Smart Cat Home system based on the Internet of Things (IoT) was successfully realized with in-line functionality with objective study. The system can monitor the temperature and humidity of the pen via the DHT22 sensor, detect light intensity using an LDR, and measure the availability of feed and water using load cell sensors. All data are presented in real time in the Blynk application, and The ESP32-CAM module provides live video access for continuous visual monitoring of the conditions of the pen. The hard and soft integration devices showed good responsiveness, the and Blynk application played a role as an interface control for a stable distance, displaying the metric environment and actuator status in a way that is synchronous with the change in the physical field. The overall success level was 96%, which included a success DHT22 sensor reading, 80% for the LDR sensor, and approximately 90% for the load cell reading of approximately 95 %, followed by success levels for the actuator (fan and lights) and camera streaming stability were also high. Findings This confirm that built design effective as solution monitoring and maintenance pen cats, in particular for cat race in need control environment more precision, so that owner can ensure comfort And fulfillment need animal pets when abandoned in range longer time.

Ethical Approval

Ethical approval was not required for this study

Informed Consent Statement

Not Applicable

Authors' Contributions

AS contributed to the research conceptualization, system design, hardware and software integration, data analysis, and drafting of the manuscript. AET contributed to sensor implementation, system testing and validation, data collection, and revision of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data Availability Statement

The data presented in this study are available on request from the corresponding author due to privacy reasons.

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Notes on Contributors

Andini Sintawati
Andini Sintawati is affiliated with University of Gunadarma.

Alda Emly Tambunan
Alda Emly Tambunan is affiliated with University of Gunadarma .

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