An Automatic Internet Of Things-Based System For Breeding Rabbit in Cage

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***Abstract*— Rabbits, low-maintenance mammals in terms of cost and space requirements, require meticulous care, encompassing disease control, feeding, and cage maintenance. To address these concerns, an automated system for feeding, drinking, temperature control, and monitoring rabbit manure gas levels within the cage was developed, all remotely accessible. The system comprises ultrasonic sensors, DHT11 sensors, MQ-135 gas sensors, a real-time clock (RTC), an Arduino Mega 2560 with built-in Wi-Fi, relays, servo motors, mini water pumps, mini fans, and a heat lamp. The feeding and drinking functions are automated, triggered by RTC sensor data or can be manually controlled through the Arduino IoT Cloud dashboard. Temperature regulation is managed based on data from the DHT11 sensor, and gas levels in the rabbit manure are monitored using the MQ-135 gas sensor. Conducting 30 tests for each primary function, including automatic and manual feeding/drinking, temperature control, and disinfectant spraying, these functions performed as designed. An exception occurred three times when the DHT11 microcontroller sensors lost connection, rendering the input from these sensors unusable. To address this issue, the addition of an extra voltage supply to the Arduino Mega 2560 microcontroller is proposed, mitigating this vulnerability.**

***Index Terms*— Internet of Things; IoT Cloud Dashboard; Rabbit; SQL Database.**

I. Introduction

Rabbits belong to the mammalian order Lagomorpha, family Leporidae, and are categorized into eight genera: Bunolagus, Nesolagus, Romelagus, Brachylagus, Sylvilagus, Oryctolagus, and Poelagus[1]. Rabbits can serve as both pets and livestock. As pets, they can be trained for discipline and have stress-reducing effects on their owners[2]. They are easy to raise, requiring minimal capital and land, and they exhibit a high reproductive rate.

In a livestock capacity, rabbits offer not only consumable meat but also valuable fur, skin, and manure[3][4]. According to data from the Department of Food Security and Livestock in West Java, the rabbit population in West Java reached a total of 2,602,469 individuals from 2012 to 2020[5], with a total rabbit meat production of 18,462 tons from 2013 to 2021.

Due to its favorable meat composition, rabbit meat can be considered an alternative to chicken and beef [6]. Rabbit meat contains only 8% fat and cholesterol, which is lower than chicken and beef, with fat contents of 12% and 24%, respectively[7]. Rabbit meat also boasts a protein content of 12%, which is higher than other livestock with protein contents ranging from 17% to 20%[8].

Raising rabbits requires careful attention to various aspects, including sanitation and preventive measures, disease control, animal care, feeding practices, and cage maintenance. Rabbits are known to be prone to stress for various reasons, and emotional stress can lead to health issues such as leukopenia[9], cardiomyopathy[10], and gastric lesions[11].

Leveraging technology can significantly enhance rabbit farming practice[12], offering increased efficiency in raising rabbits as livestock or pets. One form of technological integration is the development of an Internet of Things (IoT)-based system for rabbit cages, featuring various remote control capabilities.

The Internet of Things (IoT) is a concept where devices are interconnected on a network and can communicate with each other and share data[13]. IoT is becoming an integral part of our daily lives, manifesting in various aspects of our surroundings. Essentially, IoT represents a technological advancement that integrates a wide range of intelligent devices, sensors, and smart systems[14].

In a study conducted by Nanda Budiarta Sabela and their team in 2021, a device was developed for feeding rabbits, connected to a smartphone using the ESP8266 microcontroller and relay[15]. In 2022, Dedi Hermanto designed an automated rabbit waste cleaning system connected to a waste receptacle via the Telegram application on a smartphone, utilizing the ESP8266 microcontroller[16]. Furthermore, in 2022, research by Jikti Khairina involved designing a waste cleaning and cage temperature control system with a Raspberry Pi microcontroller, connecting to a Blynk application on a smartphone[17].

Consequently, this research introduces an IoT-based rabbit cage system with the capability to provide feed and water, regulate cage temperature, perform disinfectant spraying, and measure rabbit waste levels. This system operates automatically based on predefined schedules, can be manually controlled remotely through the Arduino IoT Cloud dashboard, and is equipped to store measurement data in a MySQL database.

II. METHODS

The method employed in this research involved several stages, including system design, encompassing block diagram system design, system flow chart design, system design, software design, and program code design.

A. *Block Diagram System Design*

The block diagram system design marked the initial stage in this research. The system was conceived using electronic components, represented in Figure 1 as a block diagram. These electronic components include an HC-SR04 ultrasonic sensor, DHT11 sensor, real-time clock (RTC) sensor, Arduino Mega 2560 with built-in Wi-Fi, relay, servo motor, mini pump, mini blower fan, and heat lamp. The HC-SR04 ultrasonic sensor serves as an input component for measuring remaining food and water levels in the storage containers, utilizing ultrasonic waves to measure distances ranging from 2 cm to 400 cm[18].

Another input component is the DHT11 sensor, which measures temperature and humidity in the cage environment, providing calibrated digital signal output. The RTC sensor contributes real-time data to the system.

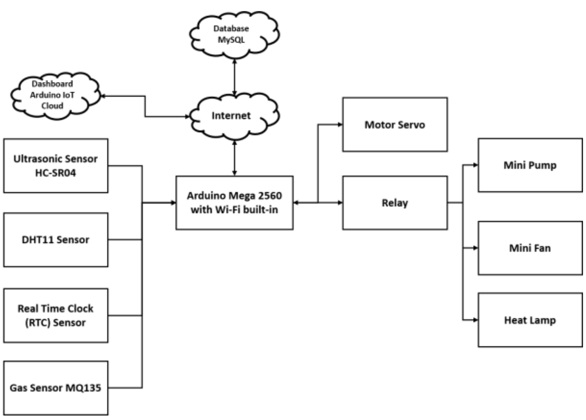

Fig. 1. Block Diagram System

In the processing section, the Arduino Mega 2560 with built-in Wi-Fi functions as the microcontroller for input and output processing, connecting the system to the Arduino IoT Cloud dashboard and the MySQL database. This component is an ATmega2560 microcontroller modified to incorporate an ESP8266 microcontroller on the same board[19].

Notably, the Arduino Mega RobotDyn offers a key distinction from the Arduino Mega 2560 as it can directly connect to the internet via serial communication with the ESP8266, eliminating the need for an additional ESP module.

The output components include the servo motor, which opens the food container cover, and the relay, serving as a switch for the mini pump, mini fan, and heat lamp. Additionally, the Arduino IoT Cloud dashboard functions as both input and output. Arduino IoT Cloud is one of the Arduino services providing cloud services for IoT platforms, enabling data transfer between IoT devices and Arduino IoT Cloud[20][21].

The MySQL database serves as an output, representing a popular open-source SQL (Structured Query Language) database management system developed, distributed, and supported by Oracle Corporation[22].

B. *System Flow Chart Design*

The system's operation is visually represented in the flowchart depicted in Figure 2. The system begins by initializing the ESP8266 to connect to Wi-Fi. In the event of a failed Wi-Fi connection, the initialization process repeats until successful. Upon successful Wi-Fi connection, the RTC sensor is activated. If the RTC sensor indicates that it's time for feeding, the servo motor rotates, and the water pump is activated. If it's not feeding time, DHT11 sensor is activated and checks temperature in the surrounding cage environment. If the temperature is less than 26° celcius, heat lamp and mini fan are activated. If the temperature is in the 26° - 36° celcius, heat lamp and mini fan will be deactivated. However, if the temperature is greater than 36° celcius, heat lamp turns off and mini fan is activated. The feeding process was conducted in accordance with a preset schedule, and adjustments to the cage environment temperature were automatically made by the system based on various temperature conditions that have been set. Then the ultrasonic sensor and MQ4 sensor are activated. The readings from these sensors are subsequently uploaded to both the IoT cloud dashboard and the MySQL database.

Following this, a condition is checked for input from the dashboard, encompassing button inputs like "feed," "water," "lamp," "fan," and "disinfectant." If the condition is met, each process occurs based on the specific button input. Activating the "feed" button triggers the servo motor, the "water" button activates the water pump, the "lamp" button activates the lamp, the "fan" button engages the fan, and the "disinfectant" button initiates the water pump, this is a manual mode feature that has been programmed into the system to control several electronic components. If none of these conditions are met, the system concludes its operation.

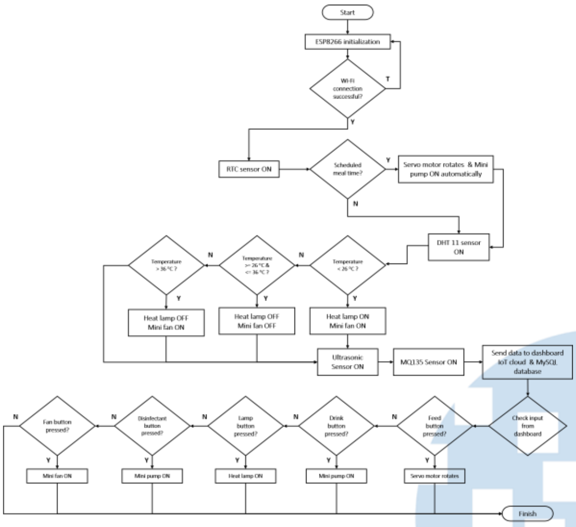

Fig. 2. System Flow Chart Design

C. System Design

The schematic diagram of the system with four main functions is presented in Figure 3. The first primary function is feed and water delivery, which can be executed automatically based on input from the RTC sensor and a pre-set schedule or manually via the "feed" and "water" buttons.

The second function involves automatic cage temperature control, relying on temperature measurements from the DHT11 sensor, or manual control through the Arduino IoT Cloud dashboard, which utilizes a heat lamp and a mini fan as outputs.

Subsequently, the system includes the capability to measure the concentration of rabbit manure gas using the MQ135 sensor and offers a disinfectant spray function that can be controlled from the dashboard, utilizing a mini water pump and a relay to operate the pump. The system's prototype is depicted in Figure 4.

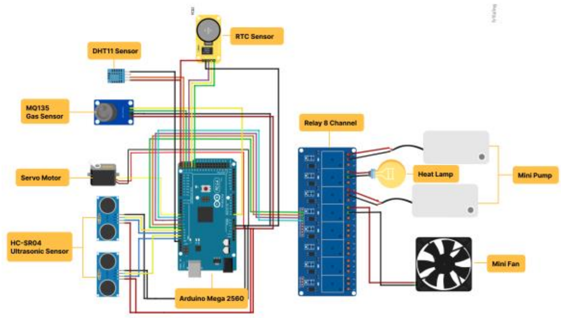

Fig. 3. System Circuit

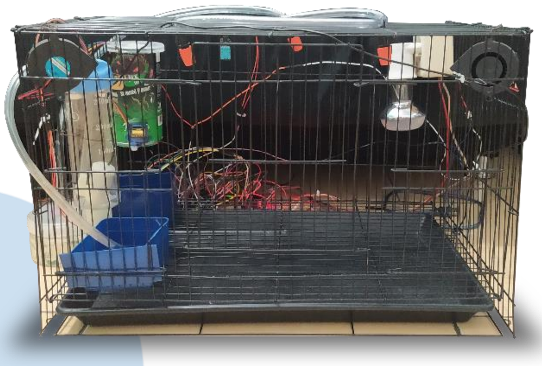

Fig. 4. System Prototype

D. Software Design

The software design encompasses the development of the Arduino IoT Cloud dashboard, MySQL database design, program code design, and website design. The dashboard design begins by defining the variables associated with the dashboard's widgets. The layout of the dashboard is thoughtfully organized, incorporating essential widgets, as illustrated in Figure 5. Notably, this dashboard is accessible via mobile devices through the installation of the Arduino IoT Cloud application.

Fig. 5. Arduino IoT Cloud Dashboard

The MySQL database design involves creating a new database in PHPMyAdmin and establishing new tables along with their respective columns. These columns are configured with various settings, including data types, null value acceptance, and other identifiers, as depicted in Figure 6.

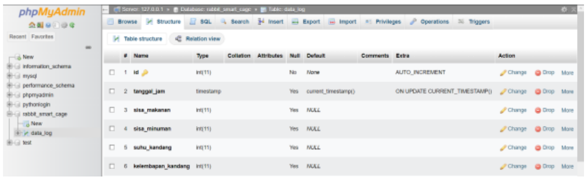

Fig. 6. MySQL Database Preview

Next, the program code is developed using the C## programming language through the Arduino IDE software. The overall program flow of the system is illustrated in Algorithm 1.

The website design in this system employs the Bootstrap framework and the PHP programming language. The website design process initiates with customizing the visual template from Bootstrap, transforming the appearance of web pages designed to display the system's data history into a layout resembling Figure 7.

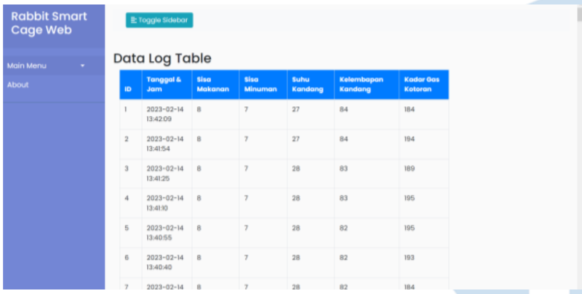

Fig. 7. Website Appearance

III. Testing and Results

The testing of the primary functions of the system is divided into several stages. The initial stage encompasses the testing of automated feeding and watering, wherein feed and water dispensing was scheduled at three specific times: 12:50-12:55, 13:00-13:05, and 13:10. The test results demonstrate that the system operates in accordance with the designed program, as evidenced by the servo motor's rotation and the activation of the mini water pump according to the predefined schedule.

The test results are visually presented in Figure 8, where a value of 0 indicates that the water pump and servo motor are in an "off" state, while a value of 1 signifies that the water pump and servo motor are in an operational state.

Subsequently, a manual feed and water dispensing test was conducted 30 times, revealing that the system effectively responds to inputs provided via the dashboard. The outcomes of this test are summarized in Table 1.

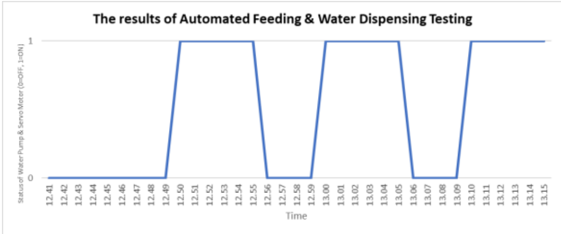

Fig. 8. Chart of Automated Feeding & Water Dispensing Test Results

TABLE I. RESULTS OF MANUAL FEEDING AND WATER DISPENSING TEST

Dashboard Input	Servo Motor Status	Mini Pump Status
Feed Button OFF & Drink Button OFF	OFF	OFF
Feed Button OFF & Drink Button ON	OFF	ON
Feed Button ON & Drink Button OFF	ON	OFF
Feed Button ON & Drink Button ON	ON	ON

Following that, an automated cage temperature control test was carried out at room temperature conditions at home, the testing process is detailed in Figure 9. Involving the design of three conditions in the program, as specified in Table 2. This ensured that the heat lamp and mini fan would activate and deactivate based on preset temperature values in the program. Of the 30 tests conducted, the results indicated that the automated cage temperature control function in the system operated successfully according to the design. The system effectively controlled the heat lamp and mini fan based on the specified temperature values. However, there were three instances of disconnection between the DHT11 sensor and the microcontroller during testing. The test results are depicted in Figure 10, where an active condition is denoted by the number 1, and an inactive condition is denoted by the number 0.

Fig. 9. Cage Environment Temperature Setting Function Testing Process

TABLE II. TEMPERATURE CONDITION SETTINGS IN THE SYSTEM

Temperature	Heat Lamp Status	Mini Fan Status
Less than 26° C	ON	ON
Greater than or equal to 26°C and less than or equal to 36°C.	OFF	OFF
Greater than 36° C	OFF	ON

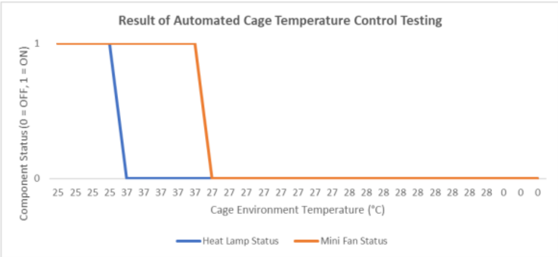

Fig. 10. Chart of Results of Automated Cage Temperature Control Testing

Subsequently, a test was performed to measure the gas content in rabbit waste. The aim of this test was to evaluate whether the MQ-135 sensor could measure the environmental conditions in the cage and detect when the rabbit waste container was full. The testing process is detailed in Figure 11, including the sensor's proximity to the gas emitted by an electric lighter and the rabbit's waste and urine. From the 30 tests conducted, the results demonstrated that the system effectively measured changes in gas levels. The test results are presented graphically in Figure 12, and the range of gas level conditions in the cage environment is documented in Table 3.

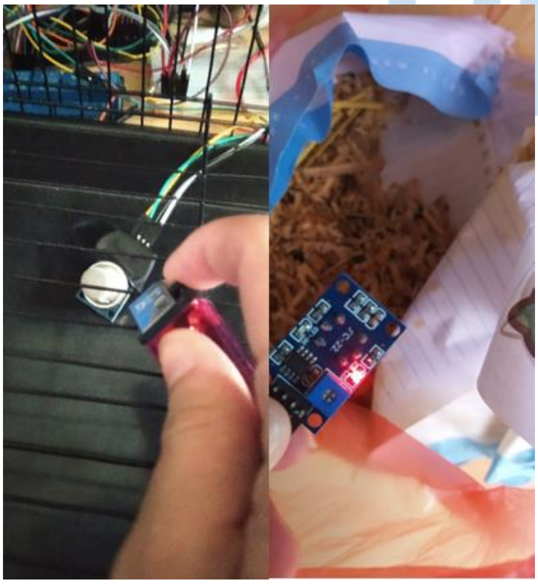

Fig. 11. Gas Content Testing Process

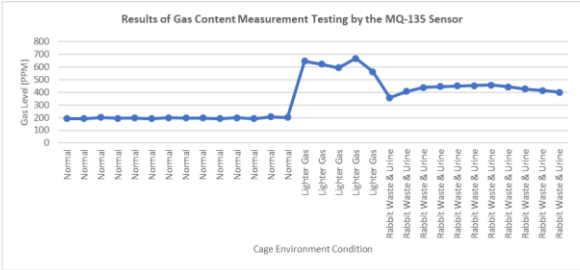

Fig. 12. Chart of Gas Content Measurement Testing Results

TABLE III. GAS LEVEL CONDITIONS IN THE CAGE ENVIRONMENT

Status	Range of Gas Levels (PPM)
Normal	192-206
Rabbit Waste & Urine	358-458
Lighter Gas	564-668

Finally, the disinfectant spraying function was tested to evaluate the system's response to inputs from the dashboard. The test was carried out by providing input from the dashboard by pressing the disinfectant button 15 times to "on" mode and 15 times to "off" mode to see whether the mini pump works according to the input given. Out of a total of 30 tests, it was observed that the system consistently produced outputs in accordance with the given inputs, the testing process is detailed in Figure 13. The test results are summarized in Table 4.

Fig. 13. Disinfectant Spracy Function Testing Process

TABLE IV. DISINFECTANT SPRAY FUNCTION TEST RESULTS

Dashboard Input	Mini Pump Status Count	
	ON	OFF
Disinfectant Button OFF	0	15
Disinfectant Button ON	15	0

IV. CONCLUSIONS

Based on the conducted tests, it can be concluded that the system has successfully achieved the expected functionality. This is evident from the automated feeding and watering tests, which operated seamlessly according to the predefined schedule, as well as the manual feed and water dispensing based on dashboard inputs.

Moreover, the system effectively measured changes in air quality with the MQ-135 sensor when there was a significant amount of rabbit waste, validating its utility. The manual disinfectant spraying function performed as designed. While the tests for both automated and manual cage temperature control were consistent with the programmed parameters, there were three instances of disconnection between the DHT11 sensor and the microcontroller, which, though tolerable, warrants attention.

Additionally, the system's response time ranged from approximately 15 seconds and beyond for processing inputs from the Arduino IoT Cloud dashboard, as the input reading process by the microcontroller was set at a 15-second interval in the program.

Throughout the design and testing phases, weaknesses in the system were identified, offering valuable recommendations for further development. These include the incorporation of backup power sources to ensure the system's optimal operation. Furthermore, the consideration of cameras can enhance the system by enabling the monitoring of rabbit activities.

REFERENCES

[1] M. Ren *et al.*, "Biology of the Rabbit," *Medical Journal of Peking Union Medical College Hospital*, vol. 13, no. 5, pp. 880–887, 2022, doi: 10.12290/XHYXZZ.2022-0190.

[2] R. Juliadilla and S. C. Hastuti, "Peran Pet (Hewan Peliharaan) pada Tingkat Stres Pegawai Purnatugas," *Jurnal Psikologi Integratif*, vol. 6, no. 2, pp. 153–175, Jan. 2019, doi: 10.14421/JPSI.V6I2.1488.

[3] H. Hendriette and J. Purwono, "Strategi Pengembangan Usaha Peternakan Kelinci Pada Kampoeng Kelinci di Desa Gunung Mulya Kecamatan Tenjolaya Kabupaten Bogor," *Bogor Agricultural University*, 2014.

[4] V. Cesari, M. Zucali, L. Bava, G. Gislon, A. Tamburini, and I. Toschi, "Environmental Impact of Rabbit Meat: The Effect of Production Efficiency," *Meat Sci*, vol. 145, pp. 447–454, Nov. 2018, doi: 10.1016/J.MEATSCI.2018.07.011.

[5] Dinas Ketahanan Pangan Dan Peternakan Provinsi Jawa Barat, "Populasi Kelinci Berdasarkan Jenis Kelamin dan Kabupaten/Kota di Jawa Barat," https://opendata.jabarprov.go.id/. Accessed: Dec. 08, 2022. [Online]. Available: https://opendata.jabarprov.go.id/id/dataset/populasi-kelinci-berdasarkan-jenis-kelamin-dan-kabupatenkota-di-jawa-barat.

[6] R. Masanto, *Beternak Kelinci Potong*. Penebar Swadaya, 2010.

[7] M. Cullere and A. Dalle Zotte, "Rabbit meat production and consumption: State of knowledge and future perspectives," *Meat Sci*, vol. 143, pp. 137–146, Sep. 2018, doi: 10.1016/J.MEATSCI.2018.04.029.

[8] T.A. Ruleva, N.Y. Sarbatova, and K.Y. Shebela, "Nutritional Value of Rabbit Meat," *World science*, vol. 4, no. 4 (4), 2015.

[9] L. B. Nice and H. L. Katz, "Emotional Leucopenia in Rabbits," *https://doi.org/10.1152/ajplegacy.1936.117.3.571*, vol. 117, no. 3, pp. 571–575, Oct. 1936, doi: 10.1152/AJPLEGACY.1936.117.3.571.

[10] H. W. Weber and J. J. Van Der Walt, "Cardiomyopathy in Crowded Rabbits.," *Recent Adv Stud Cardiac Struct Metab*, vol. 6, pp. 471–477, 1975.

[11] J. O. Iversen, G. L. Hoff, T. M. Yuill, and R. P. Hanson, "Gastric lesions in the snowshoe hare," *J Wildl Dis*, vol. 8, no. 1, pp. 7–9, 1972, doi: 10.7589/0090-3558-8.1.7.

[12] G. Kartasasmita, *Pembangunan untuk Rakyat : Memadukan Pertumbuhan dan Pemerataan*. Jakarta: Pustaka Cidesindo, 1996.

[13] J. H. Nord, A. Koohang, and J. Paliszkiewicz, "The Internet of Things: Review and Theoretical Framework," *Expert Syst Appl*, vol. 133, pp. 97–108, Nov. 2019, doi: 10.1016/J.ESWA.2019.05.014.

[14] S. Kumar, P. Tiwari, and M. Zymbler, "Internet of Things is a revolutionary approach for future technology enhancement: a review", doi: 10.1186/s40537-019-0268-2.

[15] N. B. Sabela, A. R. Fadhillah, R. J. Sakinah, and D. Siswanto, "Implementasi Proyek Independen Melalui Inovasi Teknologi Pemberian Pakan Ternak Kelinci Berbasis IoT (Internet of Things) dalam Meningkatkan Efisiensi Kinerja Peternak," *Universitas Widyagama Malang*, p. 8, 2021.

[16] D. Hermanto and D. Yendri, "Rancang Bangun Sistem Pembersih Kotoran Otomatis pada Kandang Kelinci Berbasis IoT (Internet of Things)," *Universitas Andalas*, vol. 3, no. 02, pp. 146–154, Oct. 2022, doi: 10.25077/chipset.3.02.146-154.2022.

[17] J. Khairina and M. Nasir, "Sistem Monitoring Pembersihan Kotoran Dan Pengaturan Suhu Kandang Kelinci Berbasis Raspberry Pi," *Journal of Artificial Intelligence and Software Engineering (J-AISE)*, vol. 2, no. 1, May 2022, doi: 10.30811/JAISE.V2I1.3085.

[18] E. J. Morgan, "HC-SR04 Ultrasonic Sensor Datasheet." Accessed: Jan. 24, 2023. [Online]. Available: https://datasheetspdf.com/pdf/1380136/ETC/HC-SR04/1.

[19] Fernando Koyanagi, "Arduino MEGA 2560 With WiFi Built-in ESP8266." Accessed: Jan. 24, 2023. [Online]. Available: https://www.instructables.com/Arduino-MEGA-2560-With-WiFi-Built-in-ESP8266/.

[20] A. Kurniawan, "Arduino IoT Cloud," *Beginning Arduino Nano 33 IoT*, pp. 131–155, 2021, doi: 10.1007/978-1-4842-6446-1_5.

[21] T. Fatema, M. A. Hakim, T. K. Mim, M. J. Mitu, and B. Paul, "IoT cloud based noise intensity monitoring system," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 30, no. 1, pp. 289–298, Apr. 2023, doi: 10.11591/IJEECS.V30.I1.PP289-298.

[22] B. Christudas, "MySQL," *Practical Microservices Architectural Patterns*, pp. 877–884, 2019, doi: 10.1007/978-1-4842-4501-9_27.