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Embedded System

Intelligent Monitoring System for Broiler Chicken Houses Blower using Fuzzy Logic

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A B S T R A C T

This research presents the design and implementation of an intelligent early warning system for monitoring blower performance in Closed House broiler farms. The system aims to reduce financial losses and mitigate livestock health risks caused by poor air circulation due to blower degradation or failure. It integrates multiple sensors, including anemometers for wind speed, MQ-135 for ammonia gas, and MQ-7 for carbon monoxide. Data are processed by an ESP32 microcontroller within a distributed architecture of two monitoring boxes connected via NRF24L01 wireless modules. A fuzzy logic algorithm enables multi-variable decision-making, allowing the system to activate backup blowers, trigger alarms, and send real-time notifications through Telegram. Experimental results confirm system reliability, with anemometer accuracy ranging from 85% to 92%, buzzer intensity reaching 92–115 dB, and stable wireless communication up to 91 meters. The fuzzy logic controller successfully classified environmental conditions and blower performance, generating tiered alerts (Warning 1, Warning 2, Emergency). The findings demonstrate that the proposed system provides a proactive and intelligent solution, offering greater adaptability than conventional threshold-based methods while supporting productivity and animal welfare in poultry farming.

INTRODUCTION

The livestock sector is a strategic component of Indonesia's economy, particularly in meeting the public's demand for animal protein. Broiler chickens, with a short production cycle of 30-60 days, have become a dominant source of meat in the domestic market [1]. National Food Agency (BAPNAS) data shows that per capita consumption of chicken meat in Indonesia reached 7.46 kg per year in 2023, a significant increase from 5.7 kg per capita in 2019.1 This rising demand has driven breeders to adopt Closed House systems to optimize environmental factors such as temperature, humidity, and air circulation [2],[5].

Despite their advantages, Closed House systems pose a new challenge: the need for stringent monitoring of air quality. Poor air quality can lead to heat stress, which reduces productivity, increases disease susceptibility, and can even cause mass mortality [2][6]. A primary cause of poor air quality is the accumulation of harmful gases like ammonia (>25 ppm) and carbon monoxide (>20 ppm), which can damage the respiratory and immune systems of the chickens [3][4].

The main cause of this gas accumulation is inadequate air circulation, often due to the degraded performance or failure of blower fans [11]. A typical single-level chicken coop uses four blower fans, with three operating continuously and one running intermittently. Failure of any of these fans often goes unnoticed until air quality has severely deteriorated. The lack of an effective early warning system for fan degradation leads to delayed corrective action, causing significant financial losses [4][5].

Therefore, there is an urgent need for a sophisticated monitoring system that can detect not only total fan failure but also a gradual decrease in performance. Such a system would enable preventive maintenance, reduce the risk of chicken mortality, and improve overall farm efficiency and sustainability.

Several previous studies have explored automated monitoring systems in poultry farming, including IoT-based cage security with fuzzy logic and Telegram alerts [7], computer vision-based chicken coop monitoring [8], and microcontroller-based early warning systems [9]. However, most existing systems focus on ambient temperature or security rather than directly evaluating individual blower degradation alongside hazardous gas accumulation.

This research addresses this critical need by proposing a novel, microcontroller-based intelligent system for real-time monitoring of blower fans. The system utilizes a fuzzy logic algorithm, which

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is well-suited for handling the complex, multi-variable data from the chicken coop environment. The intellectual contribution of this work lies in the practical application of fuzzy logic for a real-world, multi-sensor control system. This report provides a detailed analysis of the system's design, implementation, and validation, positioning it as a strong candidate for publication in a peer-reviewed journal.

METHOD

The system architecture was chosen after a House of Quality (HOQ) analysis that compared three alternative solutions: Fuzzy Logic, Voltage Sensor, and PID Controller. The Fuzzy Logic approach was selected as the optimal solution due to its superior score in addressing both primary features (computing, notification, sensing, and compatibility capabilities) and additional features (low energy consumption, low cost, real-time operation, and ease of implementation).[1]

II.I. Hardware Design and Implementation

The system is implemented using a two-box distributed architecture to minimize cabling and accommodate the large distances within the chicken coop. The two boxes communicate wirelessly via NRF24L01 PA/LNA modules, which were selected for their low power consumption and reliable communication range of up to 100 meters [10].

Box Monitoring 1 (Transmitter) is located near the gas-sensitive area of the coop. It contains:

1. ESP32 Microcontroller: The central processing unit, with a clock speed of 240 MHz and 520 KB of RAM [12].
2. MQ-135 Gas Sensor: Measures ammonia (NH3) concentration within a range of 5-500 ppm, with high sensitivity to NH3.
3. MQ-7 Gas Sensor: Measures carbon monoxide (CO) concentration within a range of 10-2000 ppm [13].
4. NRF24L01 Module: Transmits the processed gas status data to Box Monitoring 2.

Box Monitoring 2 (Receiver) is located near the blower fans. It contains:

1. ESP32 Microcontroller: Processes data received from Box Monitoring 1 and controls the actuators.
2. Four Anemometer Cup Sensors: Individually measure the wind speed generated by each of the four blower fans [14].
3. 4-Channel Relay Module: Serves as a low-power switch for high-power devices, used to activate the blowers and contactors.
4. Buzzer: An audible alarm to alert personnel, with an output exceeding 80 dB.
5. NRF24L01 Module: Receives the gas status data from Box Monitoring 1.
6. AC/DC 5V-2A Power Supply: Provides continuous power to the system.

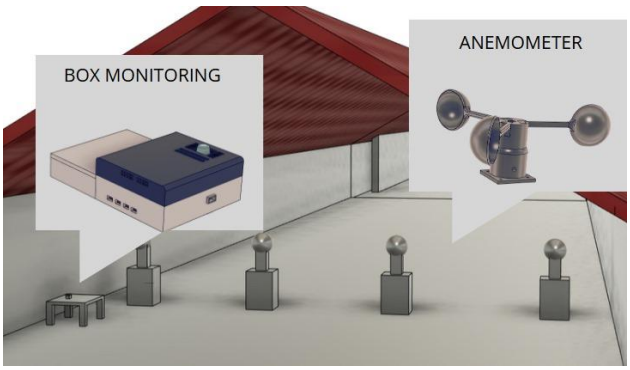


Figure 1 System Design

Figure 1 shows the monitoring system for air conditions and blower performance in a closed-house chicken coop. This system consists of two main components: the Monitoring Box and the anemometer sensors. The monitoring box is used to detect gas levels such as ammonia inside the coop, which can affect the chickens' health. This sensor is integrated with a relay that functions to control devices, such as activating a backup fan if conditions above the threshold are detected. There are four anemometer sensors in the coop, corresponding to the number of blowers, which are used to measure wind speed or blower rotation.

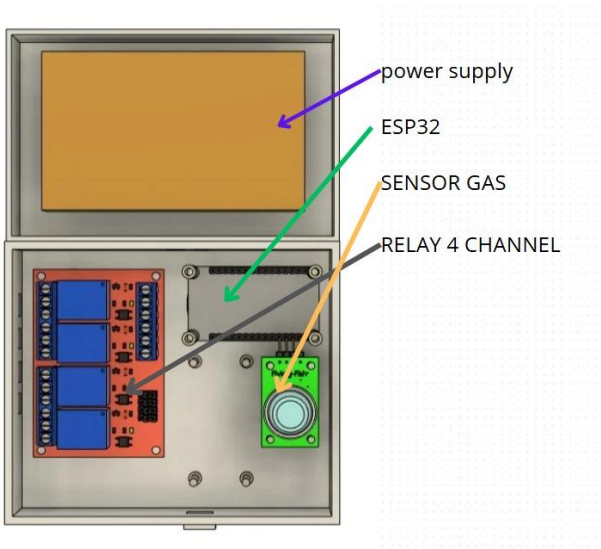


Figure 2 Box Monitoring

Figure 2 shows the internal design of the monitoring box used to monitor air conditions and wind speed in a closed-house chicken coop. This device consists of several main components. The power supply provides power for the entire system to operate continuously. The ESP32 functions as the main microcontroller that manages data from the sensors and controls the relay. The gas sensor is used to detect the concentration of harmful gases, such as ammonia, which can affect the chickens' health. The 4-channel relay is used to control external devices, such as backup fans, based on the data obtained from the sensors.

This blower monitoring system is designed to maintain air quality in broiler chicken houses using the ESP32 as the main controller. The system utilizes two primary sensors: a gas sensor to detect ammonia levels inside the coop and a cup anemometer sensor to measure wind speed. Data from both sensors are sent to the

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ESP32, which then processes the information to make automatic decisions.

If the sensor detects that the ammonia level exceeds the threshold, the ESP32 will automatically activate additional fans to improve air circulation and reduce ammonia levels. On the other hand, if the anemometer sensor detects wind speed below the predetermined threshold (e.g., 3.2 m/s) [11], the system will automatically replace the faulty fan with another blower. In addition, a buzzer is used to provide a physical warning, and the system also sends notifications to the user so that they always receive real-time information about air conditions and blower performance.

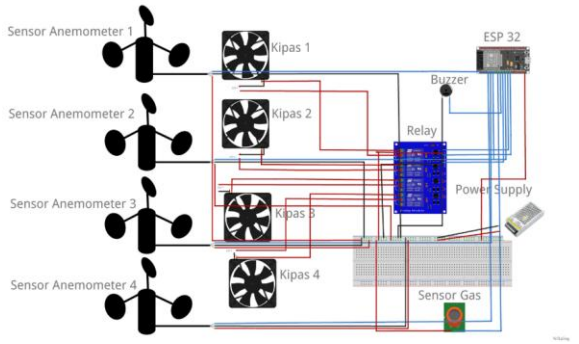


Figure 3 Schematic System

Figure 3 shows the schematic circuit that uses the ESP32 as the control center with inputs from the anemometer sensors and the gas sensor. In this system, the ESP32 is connected to four anemometer sensors, each used to read wind speed from four different fans in the closed-house chicken coop. Each anemometer has the following connections: Pin D4 (GPIO4) is used to read data from anemometer 1, Pin D16 (GPIO16) for anemometer 2, Pin D17 (GPIO17) for anemometer 3, and Pin D18 (GPIO18) for anemometer 4. All four anemometers are connected to VCC and GND for power supply.
In addition, the gas sensor is used to detect ammonia levels inside the coop. This sensor is connected to Pin D35 (GPIO35) to read analog data of ammonia concentration, with additional connections to VCC and GND as the power supply.
For fan control, a 4-channel relay module is used. Pin D14 (GPIO14) controls fan 1, Pin D27 (GPIO27) for fan 2, Pin D26 (GPIO26) for fan 3, and Pin D25 (GPIO25) for fan 4. This relay module is connected to AC fans (220 V) to enable automatic replacement of a fan if damage or decreased performance is detected.

A buzzer, which is used to provide an audible warning, is connected to Pin D23 (GPIO23), with additional connections to VCC and GND for power. All components receive power from the VIN pin as the main power source of the ESP32, with GND as the ground line connected throughout the system.

II. Software Design and Logic
The system's intelligence is driven by a fuzzy logic algorithm, which consists of three main stages: fuzzification, rule base evaluation, and defuzzification [15]. The software is programmed using the Arduino IDE.
1. Fuzzification:

The raw numerical data from the sensors is converted into fuzzy sets. Three primary input variables were defined:

1. Wind Speed: Categorized into three fuzzy sets: low (<2.2 m/s), medium (1.8 m/s to 3.4 m/s), and high (>3 m/s).
2. Ammonia (NH3) Gas Level: Categorized into low (<20 ppm), medium (15-30 ppm), and high (>25 ppm).
3. Carbon Monoxide (CO) Gas Level: Categorized into low (<20 ppm), medium (10-50 ppm), and high (>50 ppm).

2. Rule Base:

Based on the fuzzy rule base shown in the figure, the decision-making system is designed by considering three input variables: status_gas, jumlah_lemah (number of weakened components), and jumlah_rusak (number of damaged components), with the output variable being level_aksi (action level). The status_gas variable consists of three conditions: safe, alert, and dangerous. Meanwhile, the output variable level_aksi has four categories: normal, warning_1, warning_2, and emergency.

If the gas condition is detected as safe and there are no weakened or damaged components, then the action is set to normal. If the gas condition is still safe but there are weakened or damaged components, the system will issue either warning_1 or warning_2 depending on the severity. In the alert gas condition, if accompanied by weakened or damaged components, the action level increases from warning_1 up to emergency. Meanwhile, if the gas is already in a dangerous condition, even without any weakened or damaged components, the system directly sets the action level to emergency.

3. Defuzzification:
The final stage converts the fuzzy output back into a crisp, numerical value to trigger a specific action. The output action levels are: Normal (0), Warning 1 (1), Warning 2 (2), and Emergency (3).1 These levels control the activation of additional blowers and the buzzer.1

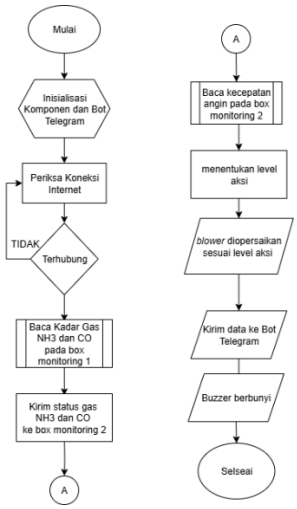


Figure 4 General System Flowchart

Figure 4 The process begins with the initialization of the main system components, including the Telegram Bot module used as

a notification medium. Next, the system checks the internet connection, and if not connected, it will continuously attempt to reconnect until successful. Once the internet connection is available, Monitoring Box 1 reads the levels of hazardous gases, namely ammonia (NH_3) and carbon monoxide (CO). The data readings are then transmitted to Monitoring Box 2 as the gas status. Monitoring Box 2 subsequently measures the wind speed from the fans using an anemometer sensor. Based on the action status determined by the fuzzy logic system, the fans are operated to maintain optimal air circulation. The fan condition data and the system's processing results are then sent to the Telegram Bot for real-time monitoring by the user. If dangerous conditions are detected, the buzzer is activated as a warning alarm. This process runs continuously, enabling the system to provide both information and early warnings regarding air quality and fan performance in the chicken house.

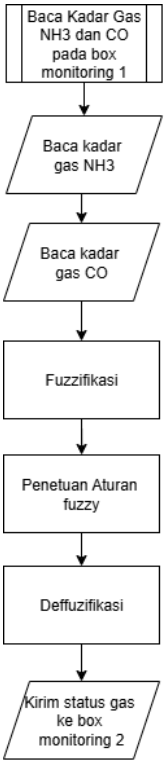


Figure 5 Flowchart in Box Monitoring 1

The flowchart for monitoring box 1 figure 2 illustrates the process of gas level monitoring within the system. The first step is measuring NH_3 and CO gas levels using sensors installed on monitoring box 1. Next, the system sequentially reads the concentrations of ammonia (NH_3) and carbon monoxide (CO). The measurement data then enters the fuzzification stage, where the numeric gas concentration values are converted into membership degrees according to the fuzzy membership functions. Afterward, the system determines the fuzzy rules based on the pre-designed rule base to assess the air conditions inside the poultry house. The next step is defuzzification, where the fuzzy output, initially in the form of fuzzy sets, is converted back into gas status. Finally, the resulting gas status is sent to monitoring box 2.



Figure 6 Flowchart in the Box Monitoring 2

The flowchart in Figure 6 illustrates the workflow of the fuzzy logic–based decision-making system in Monitoring Box 2, which is designed to control blower operation based on the detected wind speed. The process begins with reading the wind speed from the anemometer sensor. The wind speed data is then read and processed as numeric input. Next, the data undergoes fuzzification, where it is converted into linguistic values such as "low," "medium," or "high" using fuzzy membership functions. After fuzzification, the system determines the appropriate fuzzy rules, which are pre-designed IF-THEN logic rules used to define the system's response to specific wind speed conditions. The results of applying these fuzzy rules then undergo defuzzification, where the linguistic values are converted back into numeric outputs to determine the actions to be taken. Finally, based on the defuzzification results, the blower is operated according to the resulting action level. Thus, this system enables decision-making in response to changes in blower wind speed.

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Figure 7 Impelmentaion System

Figure 7 The blower monitoring system for broiler chicken houses based on a microcontroller was implemented directly in the field. In the initial design, the system utilized a single monitoring box containing the relay, gas sensors, microcontroller, and power supply. However, during field implementation, the design was modified due to the 40-meter distance between the relay installation and the gas sensors, requiring the system to be divided into two separate monitoring boxes.

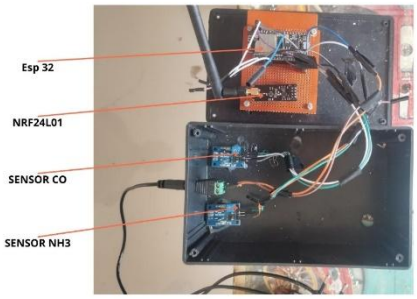


Figure 8 Box Monitoring 1

Monitoring Box 1, placed near the gas sensors, functions to detect air quality inside the house and consists of an ESP32 microcontroller, MQ-135 sensor for ammonia detection, MQ-7 sensor for carbon monoxide detection, and an NRF24L01 wireless communication module to transmit sensor data to Monitoring Box 2.

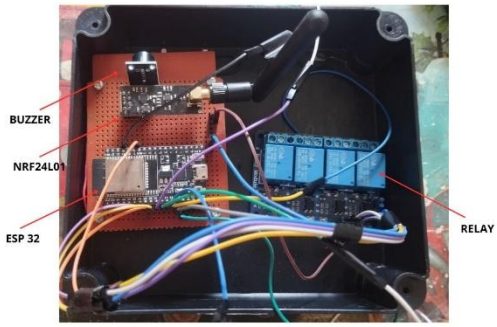


Figure 9 Box Monitoring 2

Meanwhile, Monitoring Box 2, installed near the blowers, is responsible for controlling the warning system and actuators, and contains an ESP32 microcontroller, a 4-channel relay module connected to the blowers, anemometer sensors to monitor wind speed, a buzzer for alarm notifications, and an NRF24L01 module to receive data from Monitoring Box 1.



Figure 10 Bot Telegram

The implementation begins with the creation of a Telegram bot. The bot is created via a Telegram command to a bot called BotFather. When the newbot command is entered, the process continues with selecting a name and username for the bot. The bot for this system is named Botfarm with the username Botfarm1_bot. After the username and name are entered, the bot sends a response containing information about the chatbot link that has been created and the token to access the bot's API.

This user ID is used in the program code of Monitoring Box 2 to connect Monitoring Box 2 with the Telegram bot. The user ID is used to identify the user who will receive notifications from the Telegram bot, ensuring that only registered users can receive notifications from the bot.

RESULTS AND DISCUSSION

Anemometer testing and Analysis

The Anemometer Sensor Test aims to evaluate the sensor's ability to measure wind speed. In the system, this sensor is placed in front of the blower to observe the decrease in wind speed produced when the blower's performance declines.

The test was carried out by placing the Anemometer sensor in front of the blower to measure wind speed. Then, the Kestrel 3000 measuring device was placed in front of the blower to measure wind speed as well. Afterward, the readings from the Anemometer sensor were compared with the readings from the Kestrel 3000. The test was repeated multiple times to determine the sensor's accuracy in accordance with the system specifications of 0–4.2 m/s.

Table 1 Result Acuracy Anemometer Sensors

Pengujian Ke-	Kecepatan Alat Ukur	Keluaran Anemometer (m/s)				Selisih (m/s)				Akurasi (%)			
		A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
1	3,5	3,4	3,7	3,1	3,1	0,1	0,3	0,4	0,4	97,1	91,4	88,6	88,6
2	3,6	3,1	4,1	4,1	3,2	0,5	0,5	0,5	0,4	86,1	86,1	86,1	88,9
3	3,5	3,2	3,9	3	4	0,3	0,4	0,5	0,5	91,4	88,6	85,7	85,7
4	3,8	3,3	3,2	4,2	3,5	0,5	0,6	0,4	0,3	86,9	84,3	89,5	92,1
5	3,7	3,1	4	4,1	3,4	0,6	0,3	0,4	0,3	83,8	91,2	89,2	91,2
6	3,4	3,8	3	4	3,7	0,4	0,4	0,6	0,3	88,3	88,3	82,4	91,1
7	3,6	4	3,1	3,2	3,3	0,4	0,5	0,4	0,3	88,9	86,2	88,9	91,2
8	3,7	3,2	3,2	4,3	3,1	0,5	0,5	0,6	0,6	86,5	86,5	83,8	83,8
9	3,4	3	3,9	4	3,8	0,4	0,5	0,6	0,4	88,3	85,3	82,4	88,3
10	3,4	3,9	4	3	3,8	0,5	0,6	0,4	0,4	85,3	82,3	88,9	88,9
Rata-Rata										88,2	87,2	86,5	88,9

Based on the table 1 of anemometer testing with the blower, the sensor accuracy values were obtained in the range of 85–92%. In general, all four anemometers demonstrated fairly good performance with an average accuracy above 85%, making them still feasible for use as wind speed monitoring devices on the blower. From the average results, anemometer A4 showed the highest accuracy compared to the other sensors, while anemometer A3 had the lowest accuracy. This can be seen from the larger deviation values on A3 compared to the other sensors.

The sensor performance also showed variation in each test. Anemometers A1 and A4 tended to be more stable with measurement deviations ranging from 0.3–0.5 m/s, while A2 and A3 more frequently experienced deviations of 0.5–0.6 m/s. These differences may be caused by factors such as calibration, the positioning of the sensors relative to the airflow direction, or inherent sensitivity variations of each sensor. Nevertheless, the level of deviation observed is still considered acceptable for field applications.

From these results, it can be concluded that the anemometers used are capable of providing a reasonably accurate representation of blower wind speed conditions. Although there are slight differences between the sensors, this does not significantly affect the main purpose of the system, which is to detect changes in blower performance or indications of failure. Therefore, the use of these anemometers remains relevant and effective in the blower monitoring system for poultry houses [11][14].

Furthermore, in the blower condition rule table, it was found that the fuzzy system was able to detect fan status based on the wind speed produced. The designed rule base could distinguish fan conditions into three categories: active, weak active, and damaged. For example, in rule 1, when only one blower is active while the others are on standby, the system classifies the condition as “active” with the corresponding notification. In the next rules, blower conditions showing reduced speed were successfully identified as “weak active,” while in cases of very low or no rotation, the system detected the condition as “damaged.” From the nine tested rules, all showed “appropriate” results, indicating that the designed fuzzy rule base can successfully classify blower conditions according to the actual state.

Buzzer Testing and Analysis

The test was carried out using an online sound meter on the website youlean.co and the laptop’s built-in microphone. The buzzer was placed close to the laptop microphone and activated. The test was conducted five times in a noisy chicken house, and the values displayed on the sound meter were recorded. The measured values were then compared with the system’s buzzer standard, which is >80 dB.

Table 2 Result Buzzer testing

Pengujian Ke	Besar bunyi (dB)	Keterangan
1	112	Memenuhi
2	115	Memenuhi
3	94	Memenuhi
4	92	Memenuhi
5	99	Memenuhi

Based on the table 2, the noise level produced ranged from 92 dB to 115 dB. All test results showed that the buzzer was able to generate sound with high intensity and met the standard for audio warnings, making it clearly audible to both users and farmworkers around the broiler chicken house.

The measurements indicated variations in sound output, with the highest value recorded at 115 dB and the lowest at 92 dB. This variation may have been caused by factors such as the input voltage supplied to the buzzer, environmental conditions during measurement, or the sensitivity of the sound measuring device. Despite these differences, all results still fell within a sound level range that can function effectively as a warning alarm.

Therefore, it can be concluded that the tested buzzer has good performance and is suitable for use as an early warning device in the monitoring system. The noise level it produces is sufficient to attract the user’s attention in the event of abnormal conditions or emergencies, thereby supporting the main objective of the designed warning system.

Modul NRF24L01 testing and analysis

The test was carried out using two NRF24L01 modules. One NRF24L01 was set as the transmitter and the other as the receiver. On the receiving NRF24L01, it was observed whether the simple message sent was successfully received at the specified distance by monitoring the blinking of the built-in LED on the receiving ESP32. If a message was received, the LED would light up, and if not, it would remain off.

Table 3 Result Modul NRF24L01

Pengujian ke-	Jarak antar transceiver (Meter)	Led	Pengiriman data (berhasil / gagal)
1	30	Menyala	Berhasil
2	40	Menyala	Berhasil
3	50	Menyala	Berhasil
4	60	Menyala	Berhasil
5	70	Menyala	Berhasil
6	80	Menyala	Berhasil
7	91	Menyala	Berhasil

Based on the table 3 of the NRF24L01 module communication test between monitoring box 1 and monitoring box 2, it was observed that data transmission could be carried out effectively over distances ranging from 30 meters to 91 meters. In all tests, the LED indicator remained on, indicating that the connection between the transmitter and receiver was maintained, and data transmission was successful without any interruptions or communication failures.

These results demonstrate that the NRF24L01 module can operate stably over medium to long distances under the tested

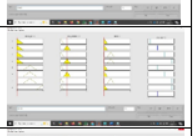
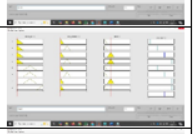
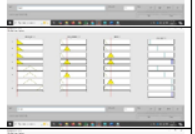
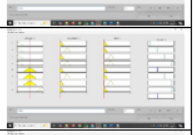
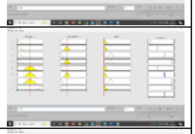
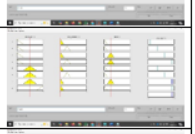
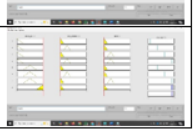
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conditions. The maximum distance tested was 91 meters, and the module was still able to transmit data effectively. This confirms that the module has a sufficiently high reliability for connecting two devices separated by tens of meters, in line with the needs of a poultry house monitoring system that requires communication between boxes at a distance of around 50 meters.

Fuzzy logic teting and analysis

The test was conducted in MATLAB by inputting parameters such as ammonia gas levels, carbon monoxide gas levels, and wind speed, followed by the output of action status. The test results were then evaluated to determine whether they were in accordance with the established rules or not.

Table 4 Result fuzzy logic

Status Gas	Status Kipas			Level Aksi	Keterangan	Hasil Pengujian
	Aktif	Aktif Lemah	Rusak			
Aman	1	0	0	0	-	
Aman	1	1	0	1	Peringatan 1	
Aman	2	0	1	2	Peringatan 2	
Aman	2	≥1	≥1	3	Darurat	
Waspada	2	0	0	1	Peringatan 1	
Waspada	2	1	0	2	Peringatan 2	
Waspada	3	≥0	1	3	Darurat	
Bahaya	4	≥0	≥0	3	Darurat	

Based on the table 4 results with inputs including ammonia gas levels, carbon monoxide levels, and fan wind speed, the analysis shows that the system is capable of providing tiered responses according to the conditions in the poultry house environment. When gas levels are still considered safe, the system remains sensitive to fan performance. If all fans are functioning normally, the Action Level is 0 (Normal). However, if one fan begins to weaken, the system raises the status to Level 1 (Warning 1), and if one fan is damaged, it rises to Level 2 (Warning 2). If a combination of weak and damaged fans is detected, even when gas levels are still within safe limits, the system immediately triggers Level 3 (Emergency) to prevent serious air circulation disruptions.

Furthermore, when the gas status changes to Caution, the system responds more decisively. If the fans are still normal, the status is immediately raised to Level 1 (Warning 1) due to the increased potential risk from gas. If a fan begins to weaken, the system raises the level to 2 (Warning 2), and if a fan is damaged, the condition is directly categorized as Level 3 (Emergency). Under Dangerous gas conditions, regardless of fan status, the system always outputs Level 3 (Emergency) because the safety of the chickens and the stability of the environment must be the top priority.

General System Testing and Analysis

The test was carried out by connecting both monitoring boxes. First, monitoring box 1 measured the levels of ammonia gas and carbon monoxide gas. Then, the gas status data was sent to monitoring box 2. Next, monitoring box 2 measured the wind speed from the anemometer sensor. Afterward, the output was obtained, showing the number of damaged and weakened fans, as well as the action level. If the action level was triggered, the buzzer would sound and a notification would be sent to the user via Telegram.

Table 5 Result General testing

Rule Ke-	NH3(ppm)	CO (ppm)	Status Gas	Statsu Kipas			Level aksi	Notifikasi	Buzzer	Respon time (s)	Keterangan
				Aktif	Rusak	Aktif lemah					
1	12	7	Aman	1	0	0	0	-	-	-	Sesuai
2	10	8	Aman	1	0	1	1	Peringatan 1	Hidup	1	Sesuai
3	14	10	Aman	2	1	0	2	Peringatan 2	Hidup	1	Sesuai
4	13	5	Aman	2	≥ 1	≥ 1	3	Darurat	Hidup	1	Sesuai
5	22	7	Waspada	2	0	0	1	Peringatan 1	Hidup	2	Sesuai
6	10	30	waspada	2	0	1	2	Peringatan 2	Hidup	2	Sesuai
7	14	32	waspada	3	1	≥ 0	3	Darurat	Hidup	3	Sesuai
8	32	40	Bahaya	4	≥ 0	≥ 0	3	Darurat	Hidup	3	Sesuai

Based on the table 5 of the overall system testing, it was found that the combination of gas sensors (NH_3 and CO) with blower conditions is capable of providing an accurate assessment of wind speed inside the poultry house. Under safe conditions (rules 1 to 4), even with variations in gas levels, the system still considers the environment non-hazardous as long as NH_3 concentrations remain below 20 ppm and CO below 20 ppm. However, the action level can still increase if any fans are damaged or weakened. This demonstrates that the system does not assess solely based on gas levels but also considers fan performance as a critical factor in maintaining proper air circulation.

Under caution conditions (rules 5 and 6), increases in NH_3 or CO concentrations begin to affect the system's assessment even if the fans are still operational. The system provides tiered warnings to signal that the environment is becoming potentially hazardous. Furthermore, under dangerous conditions (rules 7 and 8), gas concentrations exceed the threshold, prompting the system to automatically escalate the action level to emergency. At this stage, the buzzer activates, and an emergency notification is sent as a signal that immediate action is required to prevent greater risks to the chickens.

Overall, the system demonstrates good and consistent performance in detecting poultry house environmental conditions. The combination of gas indicators and fan status makes the system smarter than relying on a single parameter alone. With real-time notifications complemented by a buzzer alarm, this system proves effective as an early warning tool to

maintain air quality and prevent potential chicken mortality in the broiler house [7][11].

Theoretically, the implementation of this system can also reduce chicken mortality because the main issue in Closed House systems—difficulty in monitoring blower conditions in real time (CEP)—can be addressed. By detecting both fan weaknesses and increases in hazardous gas concentrations simultaneously, farmers can take preventive measures more quickly before conditions reach a critical phase. This prevention plays an important role in reducing heat stress and exposure to harmful gases, which are often key factors contributing to high broiler mortality rates. Thus, this monitoring system not only provides information but also serves as an effective solution for maintaining blower performance, air quality, and reducing chicken mortality in the poultry house.

CONCLUSIONS

This project successfully designed and implemented an intelligent monitoring system for broiler chicken coops. The system's effectiveness was validated through a series of tests on its key components and overall logic. The anemometer sensors were found to be sufficiently accurate (85-92%) for their purpose of detecting fan degradation, and the buzzer proved effective as an alarm with its high sound output (92-115 dB). The wireless communication using NRF24L01 modules was stable up to 91 meters, confirming the feasibility of the distributed system architecture.

The core of the system, the fuzzy logic algorithm, proved highly effective in combining multi-variable inputs (gas levels and fan condition) to provide a nuanced, tiered response. This makes the system far more adaptive and proactive than simple threshold-based control systems. The system's ability to classify conditions and trigger proportional alarms and notifications to the user demonstrates its potential to enhance operational efficiency, reduce financial risk, and improve animal welfare in the poultry industry.

Future Work:
For future iterations, it is recommended to expand the system's capabilities by integrating additional environmental sensors, such as those for temperature and humidity, to enable more proactive environmental control.1 Furthermore, exploring alternative communication protocols like LoRaWAN could improve scalability for larger farms.1 Finally, developing a dedicated mobile or web application would transform the simple Telegram notification system into a more interactive and user-friendly platform, allowing for historical data visualization and remote management.

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