JURNAL TEKNOLOGI REKAYASA INFORMASI DAN KOMPUTER
E-ISSN: 2797-1724, DOI: 10.30811/jtrik.v9i1.8700
Vol. 9 No. 1 2026 pp. 28-36

Design of Monitoring and Control Devices for Bird Repellents in Rice Fields Based on IoT

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Article info: Received on 04/11/2025, Revised on 18/01/2026, Accepted 21/02/2026

Abstract

Technological developments are advancing rapidly every year, such as the technology developed in various aspects of life, one of them is the Internet of Things, one of which can be applied in agriculture. The role of IoT in agriculture: In general, farmers have problems with rice quality due to pests in rice fields, which is a serious problem, such as bird pests. This results in a decline in rice quality. In this study, the author came up with an idea to solve this problem by designing an IoT-based bird repellent system. The author also hopes that this research can help the community or farmers in repelling birds from rice fields in a way that can be controlled or monitored using an IoT application. This study uses the QoS method, which functions as a measurement of network performance. The results of network measurement using the QoS method showed an average throughput of 75 kbps, packet loss of 0.1%, and delay of 61 ms. Based on the testing, the rice pest repellent showed performance capable of detecting bird pests at the distances of 80 cm, and was also able to detect grasshoppers at a distances of 20 cm. On the other hand, this device was also able to detect humans at a distances of 500 cm. During operation, when bird pests are detected, the gearbox motor will move automatically, and the DC siren will activate automatically, indicating the presence of bird pests.

Keywords: Internet of Things, Bird Pests, ESP 32-Cam

1. Introduction

Technological developments are advancing rapidly every year, especially in the digital era, where technology has penetrated almost every aspect of human life, including agriculture. One of the most influential technological innovations is the Internet of Things (IoT), which enables physical devices to communicate, collect, and exchange data through the internet without requiring continuous human intervention. IoT technology has the potential to significantly improve efficiency, productivity, and sustainability in agricultural activities. In the agricultural sector, particularly in rice farming, IoT can transform traditional farming practices into modern, automated systems that are more precise, efficient, and reliable. Traditionally, many farming activities still rely on manual labor, which requires continuous monitoring and physical presence in the field. This approach is not only time-consuming but also less effective, especially when farmers must divide their attention between multiple tasks or fields. By implementing IoT-based systems, farmers can remotely monitor and control agricultural processes using sensors, microcontrollers, and wireless communication networks, allowing them to make faster and more accurate decisions based on real-time data [1].

One important application of IoT in rice fields is bird pest control. Bird pests are one of the major threats to rice crops, especially during the grain-filling stage, when birds feed on the rice grains and reduce overall yield. The conventional method commonly used by farmers to repel birds involves hanging old cans, plastic objects, or traditional scarecrow-like ornaments in the rice field. These objects produce noise when moved by the wind, which helps scare birds away. However, this method has several limitations. First, it depends heavily on environmental factors such as wind to generate sound, which makes it unreliable during calm weather conditions. Second, birds can gradually adapt to static objects and repetitive sounds, reducing the effectiveness of the deterrent over time. Third, farmers often need to manually monitor and adjust these devices, which increases labor requirements and reduces efficiency. IoT-based bird pest control systems offer a more advanced and effective alternative. By integrating sensors such as motion detectors, sound sensors, or cameras with microcontrollers and wireless communication modules, the system can automatically detect the presence of birds in real time. When bird activity is detected, the system can trigger various deterrent mechanisms, such as activating speakers that emit predator sounds, ultrasonic waves, or sudden noise patterns that are more effective in repelling birds. Additionally, these systems can be connected to cloud platforms or mobile applications, allowing farmers to monitor pest activity remotely and receive notifications when bird intrusions occur. This enables farmers to take timely action without needing to be physically present in the field at all times. Furthermore, IoT systems can also collect and store data related to pest activity, environmental conditions, and system performance. This data can be analyzed to identify patterns and optimize pest control strategies in the future. For example, farmers can determine peak bird activity times and adjust deterrent schedules accordingly to maximize effectiveness while minimizing energy consumption. IoT-based solutions can also be powered using renewable energy sources such as solar panels, making them more sustainable and suitable for remote agricultural areas with limited access to electricity. Overall, the implementation of IoT technology in rice field bird pest control represents a significant step toward smart agriculture. It not only reduces the reliance on manual labor but also improves the efficiency, accuracy, and effectiveness of pest management. By adopting IoT-based systems, farmers can protect their crops more efficiently, reduce yield losses, and increase overall productivity. In the long term, this technological advancement can contribute to improving food security, enhancing farmer welfare, and supporting the modernization of the agricultural sector [2].

Based on this problem, the author created a tool and monitoring system that can help farmers repel pests in rice fields. Therefore, IoT technology will be used to change the system from manual to an automated system connected to the internet. The tool is equipped with a camera and connected to the network so that it can detect rice pests in the fields. The input from the detected rice pests will activate the gearbox motor and DC siren. The way it works is that when the camera detects birds in the rice field area, the gearbox motor and siren will activate, resulting in the movement of the gearbox motor to move the rice field ornaments and the DC siren as a means of repelling rice pests

2. Method

This study uses the Qos method to measure the network quality of the bird repellent device in rice fields. Using this technique, it is possible to determine the quality of a network to another network through a series of desired connections or access points.

A. Internet Of Thing (IoT)

The Internet of Things (IoT) is an innovation that can help solve existing problems by combining technology and social impact. From a technical standardization perspective, IoT can be considered a global infrastructure that meets the information needs of society with advanced services that enable seamless physical and virtual interconnectivity based on existing information and communication technology developments.[3]

Figure 1. Internet of Thing

B. ESP 32-Cam

ESP Cam is a dual-mode Wi-Fi + Bluetooth development board using an antenna and a PCB board core based on the ESP 32 chip. This module can work independently as a minimum system. This module is equipped with an OV2640 camera and can be used for purposes such as CCTV, taking pictures, and so on. [4]

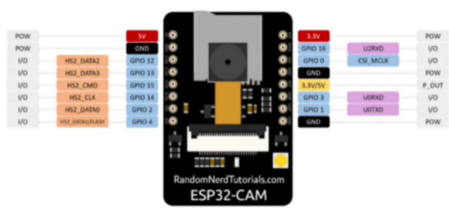

Figure 2. ESP 32-Cam

C. Relay

A relay is an electrically operated switch and is an electromechanical component consisting of two main parts, namely an electromagnet (coil) and a mechanical part (a set of switch contacts). Relays use the electromagnetic principle to move the switch contacts so that a small electric current (low power) can conduct higher voltage electricity. For example, a relay that uses a 5V and 50 mA electromagnet is capable to moving the relay armature (which functions as a switch) to conduct 220V 2A electricity. [5]

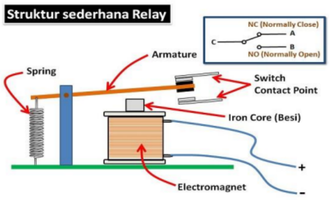

Figure 3. Relay

D. Gearbox Motor

In some machine units, the motor gearbox has a power transmission system, namely a gearbox that functions to transmit power or machine power to another part of the machine. Therefore, the motor gearbox is a very important component in making a robot or other devices, and it is useful for changing the torque or speed of the motor through the addition of mechanical gears.[6]

Figure 4. Gearbox Motor

E. Dc Siren

A siren is a device that produces a loud, buzzing sound used to alert or remind people of a dangerous or emergency. Sirens are commonly used in situations such as fires, natural disasters, or war warnings. The sound of a siren can attract the attention of people in the vicinity, prompting them to take the action.[7]

Figure 5. Dc Siren

F. Web

A web is a page of information available via the Internet that can be used anywhere as long as you are connected to the Internet. A website is a collection of several structures consisting of text, images, sounds, and animations, making it a very attractive medium for accessing various information. Technically, a website is a collection of web pages, generally summarized in one domain or subdomain that exists on the World Wide Web (www) on the Internet.[8]

Figure 6. Web

G. Solar Charger

A charge controller regulates the flow of electricity from the solar module to the battery. This device also has many functions that are primarily aimed at protecting the battery. A battery charger or charge controller is an electronic device used to regulate the direct current (DC) flowing into the battery and from the battery to the load. The charge controller prevents overcharging (excessive charging when the battery is already full) and overvoltage from the solar panel.[9]

Figure 7. Solar Charger

H. Solar Cells

Solar cells are a set of modules for converting solar energy into electrical energy. Solar cells are often called photovoltaic cells. Photovoltaics is a technology that converts solar radiation directly into electrical energy. The solar energy converted by these silicon cells produces direct current (DC) electricity, which is used to charge batteries or accumulators.[10]

Figure 8. Solar Cells

I. Quality of Service

Quality of Service (QoS) is a method used to measure the performance of a network. QoS is used to determine the characteristics and properties of a service.

3. Results and Discussion

A. Result of Device Circuits

Figure 1 Prototype Circuits

Based on the results of the prototype design in the research entitled "Design and Construction of Monitoring and Control Devices for Bird Repellents in Rice Fields Based on IoT," the working methods and functions related to each component in the prototype device were revealed.

B. Solar Panel Testing

The process of measuring voltage on solar panels operating under intense sunlight. This measurement was carried out with the aim of understanding the extent of the solar panel's performance in generating electricity.

Table 1. Solar Panel Testing Results

No	Time (Hours:Minutes)	Solar Cell (Volts)
1	08:50	21.19 V
2	09.05	20.99 V
3	09.20	20.81 V
4	15.32	21.04 V
5	15.45	20:06
6	16:25	19.20 V

Table 1 shows the results of solar panel voltage testing conducted in six experiments. From the table, it can be concluded that the higher the temperature of the sunlight, the higher the voltage value of the solar panel.

C. Solar Charger Testing

The testing was conducted by installing the solar panel on the Solar Charger Controller module and battery. The module has three terminals: an input terminal for the solar panel, an input terminal for the battery, and an output terminal for the load. The testing was conducted during the daytime under sunlight, as documented in the solar charger voltage measurements.

Table 2. Solar Charger Testing Result

No	Time (Hours:Minutes)	Battery Voltage (Volts)
1..	08.50	14.1 V
2.	09.05	14.4 V
3.	09.20	14.5 V
4.	15.32	14.4 V
5.	15.44	13.36 V
6.	16.25	13.20 V

The measurements involved measuring the voltage from the solar panel and battery, as well as the current flowing to the battery. The output energy from the solar panel can be calculated by multiplying the panel's power by the duration of the panel's operation.

D. ESP 32-Cam Testing

In pest testing on rice plants, an ESP32-Cam camera was used, connected to an IP address that had been programmed to 192.168.108.220, so that it could be accessed via an internet browser.

Table 3. ESP 32-Cam testing

No	Pest Type	Pest Distance (cm)	Description
1.	Bird	10 cm	Detected
2.	Bird	20 cm	Detected
3	Birds	30 cm	Detected
4.	Bird	40 cm	Detected
5.	Bird	50 cm	Detected
6.	Bird	60 cm	Detected
7.	Bird	70 cm	Detected
8.	Bird	80 cm	Detected
9.	Bird	90 cm	Not detected
10.	Bird	100 cm	Not detected

The results of testing related to bird pest detection at a distance of 10 cm per test point are clearly illustrated. The data collected from comparing bird pest detection through images with detection using real birds provides interesting conclusions.

E. Relay Testing

In the relay test data results, there was an effort to detect pests on rice plants by identifying two main conditions: HIGH and LOW conditions.

Table 4. Relay Testing

No	Type	Coil Condition	Relay Position	Description
1.	Bird	HIGH	No (open)	Detected
		LOW	NC (Closed)	Not detected
2.	Locust	HIGH	No (open)	Detected
		LOW	NC (Closed)	Not detected
3.	Person	HIGH	No (Open)	Detected
		LOW	NC (Closed)	Not Detected

Table 4 Shows the results of three relay tests with bird pests, grasshoppers, and humans. It can be concluded that when no pests are detected, the relay will be in the closed position.

F. Gearbox Motor Testing

Testing on the gearbox motor related to pests on rice plants. When pests are detected, the gearbox motor will move automatically for a period of five seconds, as indicated by the current supplied by the relay.

Table 5. Gearbox Motor Testing

No.	Description	Gearbox Motor Description
1.	Bird Pests Detected	Moving
	Bird Pests Not Detected	Stopped
2.	Locust Pests Detected	Moving
	Locust Pests Detected	Stop
3.	Person detected	Moving
	Person detected	Stop

The result of testing a gearbox motor that has two conditions. When pests are detected, the DC motor will start moving. Conversely, if no pests are detected, the DC motor will stop or remain inactive.

G. DC siren testing

Testing of the siren in the context of pests on rice plants. The function of the siren is to repel rice pests through loud sounds, encouraging the pests to move away. The siren works when it receives a current signal from the relay when pests are detected.

Table 6. DC Siren Testing

No.	Pest Description	Description of DC Siren
1.	Detected Bird Pests	ON
	Bird Pests Not Detected	OFF
2.	Locust Pests Detected	ON
	Locust Pests Not Detected	OFF
3.	Person detected	ON
	Person not detected	OFF

H. Troughput Testing

Throughput testing is a measurement method used to evaluate the extent to which a network or system is capable of transferring data within a certain period of time, usually measured in bits per second (bps) or other forms such as kbps or mbps.

Table 7. Troughput Testing

No	Throughput	Description	
		Index	Category
10 cm Distance Test	55k Kbps	2	Medium
20 cm Distance Test	43k kbps	2	Medium
30 cm Distance Test	49 kbps	2	Medium
40 cm Distance Test	40 kbps	2	Medium
50 cm Distance Test	62k kbps	3	Good
60 cm Distance Test	93 kbps	4	Very Good
Total		75k kbps	

The throughput measurement results in the table reflect the performance of the network or system in six different trials. There is variation in the throughput achieved in each trial.

I. Packet Loss Testing

Packet loss testing is conducted to measure the percentage of data packets that are lost or fail to reach their destination. This measurement provides an indication of network connection reliability.

Table 8. Packet Loss Testing

No	Packet Loss	Description	
		Index	Category
10 cm Distance Test	0.2	4	10 cm Distance Test
20 cm Distance Test	0.2	4	20 cm Distance Test
30 cm Distance Test	0.3	4	30 cm Distance Test
40 cm Distance Test	0.1	4	40 cm Distance Test
50 cm Distance Test	0.1	4	50 cm Distance Test
60 cm Distance Test	0.1	4	60 cm Distance Test
Total		0.1	

Packet loss testing is conducted to measure the percentage of data packets that are lost or fail to reach their destination. This measurement provides an indication of network connection reliability.

J. Delay Testing

The main purpose of delay testing is to measure the time interval required for data packets to reach their destination after testing.

Table 9
Delay Testing

No	Delay	Description	
		Index	Category
10 cm Distance Test	56 ms	4	10 cm Distance Test
20 cm Distance Test	75 ms	4	20 cm Distance Test
30 cm Distance Test	67 ms	4	30 cm Distance Test
40 cm Distance Test	76 ms	4	40 cm Distance Test
50 cm Distance Test	55 ms	4	50 cm Distance Test
60 cm Distance Test	38 ms	4	60 cm Distance Test
Total		61 ms	

From the results of six experiments conducted, variations in the main measurement parameter, namely delay in data transfer, can be identified.

4. Conclusions

The following conclusions can be drawn after conducting research on the design of monitoring and control devices for repelling birds from rice fields based on IoT:

1. Creating a device with a monitoring system that can assist rice farmers in overcoming and repelling birds in rice fields.
2. The program and tools produced can operate automatically and manually, thereby saving farmers time in dealing with bird pest control.
3. The system uses an ESP 32-Cam to detect the movement of living creatures (bird pests), a siren to repel bird pests and rice pests by emitting ultrasonic sounds, a screen to display real-time rice field monitoring, and a gearbox motor to move scarecrows to repel birds in the rice fields.
4. The QOS testing results indicate that the system responds well, and the results from the Wireshark application show an average throughput of 75 kbps, packet loss of 0.1%, and a delay of 61 ms.

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