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Passive Infrared (PIR) Sensor Based on Arduino in Rice Pest Repellent Device Based on Classic Life Cycle Method

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Abstract

The research aims to design a system to repel rice pests in rice fields by moving the scarecrow using a servo motor while sounding the speaker according to the infrared signal detection from the PIR sensor. The research method used is the waterfall method, and the research implementation time is approximately three months, starting from the proposal seminar. The rice pest repellent test was carried out by testing the reading of the infrared signal received by the PIR sensor, then moving the servo and turning on the speaker to repel bird pests in the rice fields

Keywords: Pest Repellent, Padi, Arduino, System

Abstrak

Tujuan penelitian adalah merancang sistem yang bertujuan untuk mengusir hama padi di sawah dengan menggerakkan orang-orangan sawah menggunakan motor servo sambil membunyikan speaker sesuai deteksi sinyal inframerah dari sensor PIR. Metode penelitian yang digunakan adalah metode waterfall, waktu pelaksanaan penelitian kurang lebih tiga bulan dimulai dari seminar proposal. Uji pengusir hama padi dilakukan dengan menguji pembacaan sinyal inframerah yang diterima sensor PIR, kemudian menggerakkan servo dan menyalakan speaker untuk mengusir hama burung di sawah.

Kata-kata kunci: *Penolak Hama, Padi, Arduino, sistem*

1. Introduction

The agricultural industry plays a vital role in meeting the ever-increasing basic needs of humanity **[1]**. Assistance in the form of cash, labor, and technology is needed to manage biological natural resources to achieve significant benefits for human welfare and the business world in the agricultural sector. To match basic needs with output, the agricultural sector also requires the availability of people and land. This industry represents government initiatives and plans to reduce poverty rates **[2]**. However, agricultural land, expected to be the leading food producer, tends to decrease due to the shift to non-agricultural land. The Directorate of Land Development records that the agricultural sector in Indonesia has experienced a widespread decline, namely around 18.30 million hectares or 28.50% of the total agricultural land in Indonesia, which covers an area of around 64.30 million **[3]**.

Another problem experienced by farmers is the presence of rice plant pests, which cause damage to the plants. Plant pests such as birds before they reach a more severe and widespread stage. However, farmers often need to pay more attention to this due to a lack of knowledge and assume that this problem often occurs from planting to harvest. For this reason, to make it easier for farmers to deal with pests, a tool is needed to help control them, so they do not suffer significant losses. An example is the use of the Arduino Uno microcontroller.

Massimo Banzi and David Cuartielles discovered Arduino with the initial aim of helping students create devices and interactions at a low price. Arduino comes from Italian, which means brave friend [4]. The first launch of the Arduino Uno R3 type was the Arduino Uno R3 type, released in 2011. R3 means the third revision of this type, which will be used to create the automatic door project [5]. Arduino Uno is a type of board containing a microcontroller the size of a credit card equipped with several pins that communicate with other equipment. Arduino is a versatile microcontroller that allows it to be programmed.

This research used the Classic Life Cycle approach to overcome pest problems threatening rice production and developed midges based on infrared passive sensors (PIR) and Arduino microcontrollers. The PIR sensor, which can detect the movement of living things based on infrared radiation, is combined with Arduino to create a responsive and efficient automatic midges' system. The Classic Life Cycle method, which includes requirements analysis, system design, implementation, testing, and maintenance, is applied to ensure systematic and structured tool development. This study evaluates the effectiveness of pest detection by PIR sensors, system responsiveness from detection to activation of repellent, energy consumption, environmental impact, and farmer satisfaction with using this tool. The expected result is midges that are effective and efficient in keeping rice plants from pest attacks and environmentally friendly and acceptable to farmers as a practical and innovative solution in agriculture.

The novelty in this research is the development of rice midges by integrating Arduino-based infrared passive sensors (PIR) using the Classic Life Cycle method. Unlike conventional approaches that are often less effective and potentially damaging to the environment, this tool is designed to detect pest movements in real-time through a PIR sensor, activating the midge's mechanism automatically and efficiently. The use of Arduino allows flexible programming and high precision in system control. The Classic Life Cycle method ensures a structured and iterative development process, from field-specific needs analysis, optimal architectural design, and implementation with reliable component integration to ongoing testing and maintenance. This innovation increases the effectiveness of pest expulsion and introduces environmentally friendly and sustainable solutions for farmers, answering the main challenges in rice cultivation with the latest technological approaches.

Design is the depiction, planning, and making of sketches or the arrangement of several separate elements into a complete and functioning unit. Based on this understanding, design can be interpreted as translating analysis results into software packages and then creating or improving an existing system [6].

The PIR (Passive InfraRed) motion sensor functions as a movement detector, detecting the presence of infrared rays [7]. The PIR sensor is passive, meaning that it does not emit infrared rays but only receives infrared radiation from outside.

The PIR sensor responds to energy from passive infrared emissions from every object it detects. One object that has passive infrared radiation is the human body. The PIR sensor can capture the heat energy emitted by objects with the absolute average human body temperature [6].

IDE is an abbreviation for Integrated Development Environment. Ide is a program used to create programs on all microcontrollers, such as the ESP 8266 NodeMCU and Arduino Mega [8]. Programs written using the Arduino IDE software are called Sketch. Sketch is written in a text editor and saved in a file with the extension.

The Arduino IDE also has libraries that provide additional functionality in sketches, such as working with hardware or manipulating data. Select a library in Sketch from Sketch and then select Import Library [9].

2. Method

a. Research Stages

Research methods are activities to collect data or information related to similar research to design a system **[10]**. System design requires a research method so that the research process runs in accordance with the research objectives. The research location is the rice fields of Banyaka Village, Kalukku District, Mamuju Regency, West Sulawesi Province.

The method used in this research is the waterfall method. The waterfall method (classic life cycle) describes a systematic and sequential approach to software creation and development; the flow starts from analyzing user needs and then goes to the design, implementation, and, finally, testing stages. The author uses this method because it suits the research needs to be conducted. The steps in the waterfall method are as follows: (1) this needs analysis stage is carried out to help describe user needs into a system which will then be made into a device that provides solutions **[11] [12]**. At this stage, the tool is designed to repel rice pests by moving the scarecrow using a servo and turning on the sound from the speaker based on the PIR sensor readings, (2) software and hardware design stages. This rice pest-repellent system consists of hardware and software. The hardware consists of an Arduino Uno microcontroller, MG996R servo motor, speakers, breadboard, and jumper cable. The software consists of Arduino IDE software for writing programs to the Arduino so that sensor data can be read, and the Arduino moves the servo and turns on the speaker according to the PIR sensor readings, as well as (3) implementation and testing stages. The system is tested at this stage to ensure everything is running well. Testing is comprehensive, both hardware and software. System testing is carried out by moving the PIR sensor.

b. Proposed system design

The proposed system design is a rice pest repellent that repels bird pests based on changes in infrared light sensors from an object detected by a PIR sensor. The system will be active if the sensor receives changes in infrared light. The proposed system is presented on **Figure 1.**

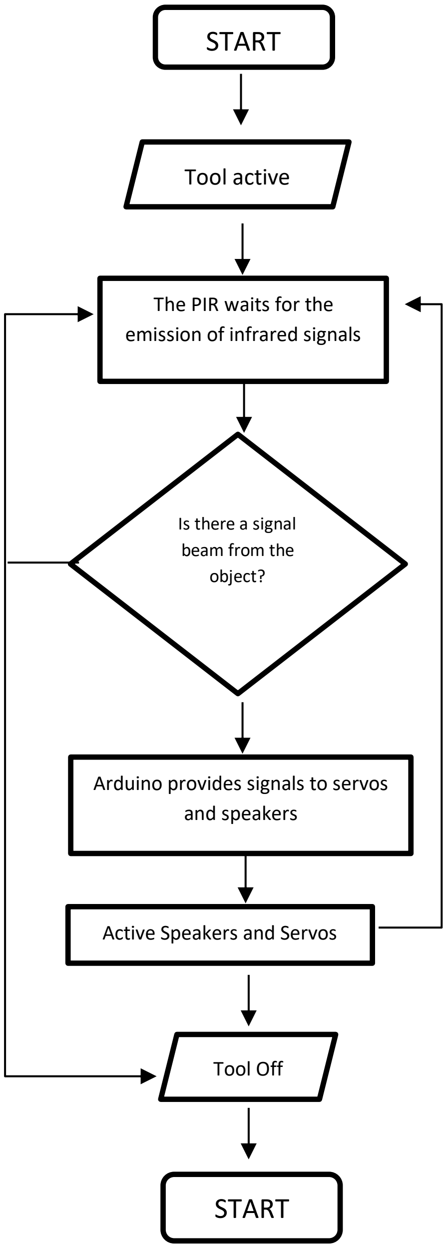

Figure 1. Flowchart of the Proposed System

3. Results and Discussion

A general overview of the research object was carried out at the research location, the rice field location in Banyaka Village, Kalukku District, Mamuju Regency, West Sulawesi Province, according to the research schedule. Based on the results of the midge survey conducted by researchers in rice fields, the researchers summarized them and put them in **Table 1.**

Table 1. Survey Results

Location	Object	Amount	Wide	Height
Rice Fields	Midges (Scarecrow)	2 Fruits	26 cm	170 cm

According to data obtained from research results in rice fields, there are 2 midges (scarecrows) with dimensions of 26 cm x 170 cm. This data was obtained by conducting interviews with sources who owned their own rice fields.

Hardware assembly is carried out after all the necessary hardware components have been collected and connected to each other to form a series of tools, which will later be given logic according to the research title. This hardware assembly stage consists of Arduino Uno, MG996R Servo Motor, Battery, Breadboard, and jumper cables. All tools and modules will be assembled to be connected and integrated according to system needs and functions. Based on several series of tools and modules above, they will be assembled into one which forms a rice pest repellent in the form of a scarecrow and repels bird pests in rice fields. The hardware circuit is presented in **Figure 2**.

Figure 2. Hardware circuit

3.1 Hardware Testing

1. Testing the Arduino Uno circuit

Testing of the Arduino Uno hardware circuit is carried out by connecting several modules to see whether the Arduino functions as a control system that works to turn on the servo and speaker to repel bird pests in the rice fields according to the logic and functions that have been written using the C programming language. Display of the hardware circuit Arduino Uno can be seen in **Figure 3**.

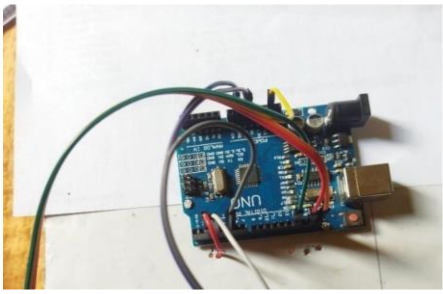

Figure 3. Arduino Test Circuit

2. PIR Sensor Testing

This test is to find out whether the PIR sensor can detect movements provided by the researcher and those around it, to what extent the PIR sensor can still detect, whether the signal can be read by the system, and whether it can send the data serially to Arduino. This test is carried out by bringing the object closer to the direction the PIR sensor can reach. When it is read by the PIR sensor, the PIR sensor sensitivity value will be displayed on the Arduino IDE serial monitor. This test starts at 0.5 m, and the PIR sensor's maximum distance is no longer enough to read objects. After the maximum distance is known, the next test is carried out by providing predetermined object barriers, namely humans and birds. The servo or (scarecrow) will move when the sensor reads the infrared signal from a minimum distance of 0.5 m to a maximum distance of 7.5 m. **Table 2** shows the results of testing the PIR sensor based on distance from humans and birds.

Table 2. PIR Sensor Testing

No.	Distance	Success Percentage based on moving servo (scarecrow).				Information
		Man	**Servo**	**Bird**	**Servo**	
1.	0,5 m	100%	Move	75%	Move	Succeed
2.	1 m	75%	Move	50%	Move	Succeed
3.	1,5 m	75%	Move	50%	Move	Succeed
4.	2 m	100%	Move	50%	Move	Succeed
5.	2,5 m	100%	Move	75%	Move	Succeed
6.	3 m	25%	Shut up	25%	Shut up	Fail
7.	3,5 m	75%	Move	100%	Move	Succeed
8.	4 m	100%	Move	75%	Move	Succeed
9.	4,5 m	100%	Move	75%	Move	Succeed
10.	5 m	100%	Move	75%	Move	Succeed
11.	5,5 m	75%	Move	75%	Move	Succeed
12.	6 m	0%	Move	25%	Shut up	Fail
13.	6,5 m	25%	Move	0%	Shut up	Fail
14.	7 m	25%	Shut up	0%	Shut up	Fail
15.	7,5 m	0%	Shut up	0%	Shut up	Fail

c. MG996R Servo Motor Testing

The servo motor used in designing rice irrigation regulators uses the MG996R servo motor. Two servo motors were used to design the tool. The servo motor moves the entrance and exit doors by providing Pulse Wide Modulation/ PWM via the control cable. The duration of the pulse, or "pulse," will determine the rotation angular position of the servo motor shaft. In this series of scarecrows, both servos move to the right and left and move the scarecrow. This test is carried out to determine whether the servo motor components can work according to the program logic. Testing begins by configuring the input, power, and negative pin of the MG996R servo motor with Arduino Uno. Following is the installation of the pins on the two servo motors to the Arduino Uno:

1. Servo motor one at the entrance: The VCC cable is connected to the Arduino 5V pin, the ground cable is connected to the Arduino Ground pin, and the input cable is connected to the Arduino PWM pin at pin 8.
2. Two servo motors on exit: VCC cable is connected to the Arduino 5V pin: The Ground cable is connected to the Arduino Ground pin, and The input cable is connected to the Arduino PWM pin at pin 9

Servo motor circuit testing is carried out by providing logic 0 and 1 to the servo motor's input pins. Table 3 shows a table of tests.

Table 3. MG996R Servo Motor Test Results

PWM	Input 1	Input 2	Servo Condition	Voltage
0	0	0	Shut up	0
1	1	0	Servo 1 Moves	6 *Volt*
1	0	1	Servo 2 Moves	6 *Volt*

Based on the experiment results above, the test to move the two servos was successful by providing voltage and giving a value of 1 to the program and a value of 0 to make the servo in a stationary position.

d. Buzzer Speaker Testing

Buzzer Speaker Reaction Testing is carried out after the program is created. This test determines whether the program can turn on the buzzer speaker based on the program rules. When the sensor reads the infrared signal (Active), the speaker will turn on for a few seconds. Speaker test results in **Table 4**.

Table 4. Buzzer Speaker Test Results

th test	Sensor PIR	Status Speaker	Information
1.	Active	Sound	Succeed
2.	Active	Sound	Succeed
3.	Non-active	No Sound	Fail
4.	Active	Sound	Succeed
5.	Non-active	No Sound	Fail

e. Software Testing

This test aims to determine whether the Arduino IDE (Integrated Development Environment) application program that will be uploaded to Arduino is correct or still needs improvement. Verify/Compile carries out this test so it will look like in **Figure 4.**

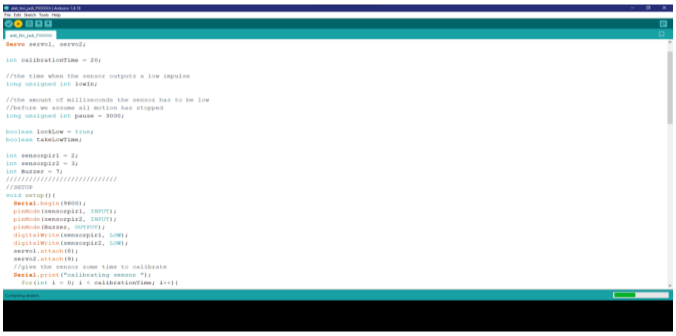

Figure 4. Compiling process

After the Verify/Compile process has gone well, the next step is to upload the program by connecting the Arduino Uno to the computer using a USB cable and then clicking upload on the Arduino IDE program. If the upload process is successful, it will look like Figure 18, namely there is a Done Uploading notification which indicates the program has been successfully uploaded, is presented in **Figure 5.**

Figure 5. The Uploading Process is Successful

A prototype of a rice pest repellent using a PIR sensor based on an Arduino Uno was implemented in a miniature rice field. Miniature rice fields are made using cardboard and cork with a length of 30 cm, width 30 cm, and height of 12 cm. A pole to place the PIR sensor and speaker is in the middle of the miniature rice field. At the front, there are 2 scarecrows which are 10 cm high and 5 cm wide. In the picture below, the shape of a miniature rice field building will be shown in **Figure 6.**

Figure 6. Pest Repellent Display

The overall hardware implementation system is divided into three parts: PIR sensor, scarecrow, and system control center. There are 2 scarecrows moved by 2 servos with 1 scarecrow, 1 servo each. The servo is embedded in cardboard with the control center, the scarecrow moves sideways to the right and left, and the speaker is attached to the sensor pole (bottom of the PIR sensor). The system control center for electronic components, such as the Arduino Uno microcontroller and MG996R servo, is installed in the box. **Figure 7** shows the hardware implementation and system control center.

Figure 7. Hardware Implementation

4. Conclusion

Based on the results of designing a rice pest repellent tool using an Arduino-based passive infrared (PIR) sensor, and the research that has been carried out, it can be concluded that:

a. The design of a rice pest repellent tool using an Arduino-based passive infrared (PIR) sensor uses two devices, namely hardware and software. The hardware is an Arduino Uno, MG996R Servo Motor, Buzzer Speaker, and PIR Sensor. Meanwhile, the software is in the form of an Arduino IDE application, a program used to write programming logic on the Arduino Uno, move the Servo, and sound the speakers.

b. The way this rice pest repellent tool works using an Arduino-based passive infrared (PIR) sensor is by receiving infrared signal input from the PIR sensor, which is then sent to the Arduino Uno microcontroller, the Arduino Uno then moves the servo (scarecrow) and sounds the speaker based on the reading. objects received by the PIR sensor.

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