Automatic farmer pest repellent with Arduino ATmega2560 based on sound displacement technique

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Abstract. Increasing pest population is the main cause of reduced crop yields and causes farmers to suffer heavy losses. The purpose of this study is to realize a tool that can help repel bird and mouse pests automatically. The prototype of this tool is controlled using the Arduino ATmega2560 which will regulate the performance of sensors and servo motors as a mechanical system that pulls bells producing sound to repel birds and controls the buzzer to repel rice field pests. This tool works if the ultrasonic sensor or PIR sensor detects the presence of pests. The power source used is in the form of an accumulator with an output voltage of 12 volts, a servo motor as a motor driver for bells, and a buzzer to repel bird and mouse pests. The testing process carried out on this prototype shows that overall this tool can perform its functions properly.

1. Introduction
Indonesia has long been known as one of the agrarian countries with an area of agricultural land, especially rice farming, reaching millions of hectares. According to the Central Statistics Agency (BPS), Indonesia’s paddy land area in 2015 was 8,087,393 hectares. In 2018 the area of rice harvested land was 10,990,007 hectares with a productivity of 51.84 Ku/ha, resulting in a total of 56,974,642 tons of rice. This should make Indonesia the largest rice producing country in the world [1,2].

But despite the abundance of rice crop yields, currently there are still some obstacles that can be the cause of losses in the profession of farming. One of the causes of these losses is the presence of rice pests that are difficult to control. In Indonesia, the losses suffered by rice farmers are 200,000-300,000 tons per year. Various ways have been carried out by farmers to control rice pests. However, the methods carried out by farmers apparently have not been effective enough in the process of pest control [3].

Starting from the background of these problems we have developed a tool in the form of a prototype of rice pest repellent. Automatic Farmer Pest Repellent is a rice pest repellent in the form of birds and rats that works automatically based on Arduino technology and sensors using servo motors that are connected with bells as the main tool to repel rice pests and use the buzzer feature. Buzzer is an additional feature to optimize the performance of tools in repelling rice pests.

2. Literature review
2.1. Pests and its repellent techniques
Pests are organisms that can damage plants. One of the rice pests that cause crop losses is birds and rats. Farmers in Indonesia in general still use traditional methods to repel these pests, for example by
installing scarecrows, or by stretching ropes suspended by plastic or other objects that can emit sounds to repel pests such as birds and the like. The system still works manually, the rope can move if moved by the farmer. This method is deemed ineffective because the farmer must always be in the location of the rice field to move the repellent rope directly. At this time began to be developed eviction techniques by using sounds with frequencies that can interfere with hearing pests. Rat have a greater hearing threshold than humans, which is between 1KHz-70 KHz. Birds have almost the same hearing threshold as humans, but their most sensitive hearing limit is at the 1KHz-4Kz frequency [4].

2.2. Ultrasonic sensor
An ultrasonic sensor is a sensor that works by utilizing reflections of sound waves. In simple terms, this sensor will work by issuing ultrasonic waves until the wave meets an object. The object is caused by the sensor. This sensor has a working frequency of 40 kHz, a maximum range of 4m, and has an effective angle of 15°. Figure 1 is an image of an ultrasonic sensor [5].

![Figure 1. Ultrasonic sensor.](image)

2.3. PIR sensor
PIR sensor (Passive Infra-Red) is a sensor used to detect infrared light from an object. This sensor is passive, meaning that the sensor does not emit infrared light but only receives infrared radiation from the outside. PIR sensors have a maximum range of 7m with an effective angle <110°. Images from the PIR sensor can be seen in figure 2 [6].

![Figure 2. PIR sensor.](image)

2.4. Arduino ATmega2560
Arduino ATmega2560 is a microcontroller based on the ATmega2560 datasheet. This microcontroller has more digital I/O Pins and analog input pins than Arduino UNO, namely 54 I/O pins, and 16 analog inputs. Arduino ATmega 2560 can be seen in Figure 3. The programming language used by Arduino is C language [7].

![Figure 3. Arduino ATmega 2560.](image)
2.5. **Buzzer**
Buzzer devices that can emit sound waves. In general, the buzzer is used as an indicator of something, for example for security sensor indicators and so on. The buzzer can work well in producing frequencies in the range of 1 - 5 kHz to 100 kHz for Ultrasound applications. The buzzer operational voltage is usually in the range of 3Volt-12 Volt [8].

3. **Method**
We implemented Design and Development approach with the following stages of research:

3.1. **Study of literature**
Literature studies are conducted by looking for references that are relevant to the tools to be developed. The literature used is in the form of journals, theories, and articles that support the creation of the automatic farmer pest repellent.

3.2. **Make of tool design**
At this stage, the design of the tool will be developed. Automatic Farmer Pest Repellent is a rice pest repellent device in the form of birds and rat that work automatically based on Arduino technology and sensors using a servo motor which is connected with a bell thread as the main tool for rice pest repellent and uses the buzzer feature. The bell is an additional feature to optimize the performance of the device to repel pests. For the energy source, this tool uses an accumulator with 12Volt output.

3.3. **Prepare tools and materials**
At this stage, the procurement of tools and materials will be used following the design that has been made before.

3.4. **Tool assembly**
In the process of designing the outline, two design processes are carried out. The first design process is software design in the form of Arduino programming. After the program is complete then hardware design is adjusted to the design that has been planned.

3.5. **Trials**
At the last stage, a trial phase was carried out on products that had been developed previously to find out whether the product could work well or not. Tests carried out include testing the ultrasonic sensor and the PIR sensor is giving a signal to drive the servo motor so that the pest repellent bells sound and turn on the buzzer to repel the pest. If the results of the trial still show that there is an error in the performance of the tool then the process returns to the design process to then be tested again until the tool can work properly.

4. **Results and discussion**

4.1. **Prototype design**
The tool developed is a prototype designed to repel mouse pests and bird pests on rice plants. In this prototype, two sensors were used to detect pests, namely ultrasonic sensors, and PIR sensors. The prototype dimension that will be made has a width of 40cm and a length of 50cm with a scale of 1: 100. This means that the prototype created can reach an area of 4mx5m for the actual area.

If an ultrasonic sensor has a maximum range of 4m and an effective angle of 15°, the width of the sensor range is 1.04m. Whereas the PIR sensor has a maximum range of 7m and an effective angle of <110° if the desired range is 4m the width of the sensor range is 11.4m. The range width for the two sensors is obtained by the following equation:
Wide ultrasonic sensor range
\[ \tan \theta = \frac{y}{x} \]
\[ \tan 82.5^\circ = \frac{4m}{x} \]

\[ x = \frac{4m}{\tan 82.5^\circ} = 0.52m \]

The broad picture of the ultrasonic sensor can be seen in Figure 4.

![Figure 4](image)

**Figure 4.** Range of ultrasonic sensor.

Wide PIR sensor range
\[ \tan \theta = \frac{y}{x} \]
\[ \tan 35^\circ = \frac{4m}{x} \]

\[ x = \frac{4m}{\tan 35^\circ} = 11.4m \]

The broad picture of the PIR sensor can be seen in Figure 5.

![Figure 5](image)

**Figure 5.** Range of PIR sensor.
The sensor specifications as described, then for an area of 4m x 5m, 10 ultrasonic sensors and 3 PIR sensors are needed to reach the entire area. The range of the entire sensor can be seen in Figure 6 and Figure 7.

**Figure 6.** Placement and scope of ultrasonic sensors.

**Figure 7.** Placement and scope of PIR sensors.

Then the design of the prototype developed can be seen in Figure 8.

**Figure 8.** Top-view prototype design.

Information:
MS : Servo motor
SU : Ultrasonic sensor
SP : PIR sensor
In this prototype, Arduino ATmega2560 is used as a microcontroller in controlling the system. The sensors used to change are approved in this prototype, namely the ultrasonic sensor used for protection of bird pests, and the PIR sensor for the protection of rat pests that use servo motors as the driving motor of nylon thread, and activates the buzzer. Threaded bells installation to repel birds, and installation of buzzers to repel rats.

The number of sensors installed is 10 HC-SR04 ultrasonic sensors and 3 HC-SR501 PIR sensors. In determining the number of sensors it must be adjusted to the maximum coverage and effective angle of each sensor so that the entire area of the prototype can be properly covered. The power source of this tool uses an Accumulator with 12V output.

4.2. Flowchart of prototype

The system flow chart of this prototype can be seen in Figure 9 and Figure 10.

![Flowchart](image)

Figure 9. Ultrasonic sensor flow chart.

The diagram in Figure 9 shows how the system works in arranging ultrasonic sensors on the prototype. Previously it was mentioned that in this prototype we used 10 HC-SR04 ultrasonic sensors. From this system we can see that:

- Ultrasonic sensors 1, 2 and 3 are connected to the first servo motor,
- Ultrasonic sensors 4 and 5 are connected with a second servo motor,
- Ultrasonic sensors 6 and 7 are connected to the third servo motor,
- Ultrasonic sensors 8, 9, and 10 connected to the fourth servo motor.

Each servo motor has been connected with a bell so that when an ultrasonic sensor reads the existence of a pest it will move the servo motor connected to the sensor, and the bell on the thread will produce a sound that can repel the bird pest. The system will continue to loop until there are no sensors that read the existence of pests.
Figure 10. Flow chart sensor PIR.

The flow chart in Figure 10 shows how the system works in managing the HC-SR501 PIR sensor on the prototype. The number of PIR sensors used in this prototype is 3 pieces. From this system, we can see that each PIR sensor is connected to the buzzer and all servo motors. When there is a sensor that reads the presence of pests, the system will turn on the buzzer to repel the rat pests, and the servo motor will move and move the bellows thread to avoid the rat pests so as not to go further into the area. The system will continue to loop until there are no sensors that read the presence of pests.

4.3. Design result

The prototype that has been developed can be seen in Figure 11. The point of placement of the ultrasonic sensor and placement of the PIR sensor has been adjusted to the maximum range and the effective angle of each sensor so that the entire prototype area can be covered by the sensor. The bells we use for prototypes are 26mm in size, but if this prototype will be developed back into a larger scale, the bell size can be adjusted back as needed. The small size of the prototype made us decide the location of the accumulator and Arduino installation on the prototype stored at the bottom of the tool. If this tool will be developed into a ready-made tool, the installation of accumulators and other main tools can be installed in the middle of the prototype area.

Figure 11. Prototype.
4.4. Prototype testing

Testing on the prototype includes testing the sensor function in moving the motor, each of which is done 10 times for each sensor. The test results for ultrasonic sensors can be seen in Table 1, and the test results for PIR sensors can be seen in Table 1.

Table 1. Ultrasonic sensor testing in performing servo motor functions.

| Ultrasonic Sensor | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| SU1               | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SU2               | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SU3               | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SU4               | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SU5               | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SU6               | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SU7               | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SU8               | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SU9               | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SU10              | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |

Information, SU : Ultrasonic sensor

From Table 1, it can be seen that based on the results of the tests that have been carried out as many as 10 times all ultrasonic sensors installed on the prototype can function properly and can run servo motors that are connected with bell.

Table 2. PIR sensor testing in performing servo motor and buzzer functions.

| PIR | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | m   | b   | m   | b   | m   | b   | m   | b   | m   | b   |
| SP1 | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SP2 | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |
| SP3 | √   | √   | √   | √   | √   | √   | √   | √   | √   | √   |

Information:
SP : PIR sensor
m : Servo motor
b : Buzzer

From Table 2, it can be seen that based on the results of tests carried out all sensors can function properly and can perform servo motor functions and buzzer functions on the prototype.

5. Conclusion

The tool developed in this study is a prototype of pest repellents, especially pests of birds and rats that can work automatically. Expulsion techniques are carried out by hearing a pest. It is expected that later this prototype can be developed into a tool on a large scale so that it can be installed and used directly by farmers and pests that can work automatically. Repel techniques are carried out by generating sounds that can interfere with hearing a pest. It is expected that later this prototype can be developed again into a tool on a larger scale so that it can be installed and used directly by farmers.
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