Electronic Networking System With Laser Light To Detect And Repel Sparrow Pests

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***Abstract* – Rice is one of the staple foods of the Indonesian population and has an important role in the formation of the Gross Domestic Product (GDP). However, this role has not been able to run well because many pests attack and cause crop failure, one of which is sparrow pests. For this reason, a study was conducted using ultrasonic sound to disturb the pests so that they do not land and leave the rice plant. The ultrasonic sound is emitted when the bird approaches and breaks the electronic net of the laser beam spread over the rice plant. This prototype was built using the NodeMCU ESP32 microcontroller as the controller and system. And telegram is used as a supporting application to give on/off commands and battery percentage detectors to facilitate use. According to the the research, the prototype functions properly and the disturbed by ultrasonic sound with frequencies ranging from 0 - 22,000 Hz and sound pressure levels between 31.6 - 93.2 decibels.**

Keywords: ESP32, Laser, Rice, Sparrows, Ultrasonic waves.

I. INTRODUCTION

The ordinary Indonesian works as a farmer and produces a range of goods since the nation has strong soil fertility, a climate and weather that are ideal for agricultural industry. Because of this, Indonesia’s agriculture sector is still necessary to carry out its function in the country’s economy by generating GDP (Gross Domestic Product) [1]. Naturally, the agriculture sector must produce the best outcomes possible in order to achieve this. However, this cannot be accomplished because of pests that assault the agricultural sector. These pests include insect, birds and rodents, among others.

Farmers defense this by using insecticides to stop bugs from attacking the crop. While insecticides are typically applied when the plant is still young and do not reach the fruit, this is less effective for birds that attack the crop around harvest time and target the fruit directly. In the Indonesian agricultural sector, rice, a seasonal crop belonging to the *poaceae* group, is one of the key commodities that is frequently targeted by birds [2]. This can be attributed to fact that around 90% of Indonesians eat rice or rice derivatives as a staple meal [3].

The Javanese sparrow, also knows as the *bondol*, the *peking bondol*, the hajj *bondol*, the crested *manyar*, the golden *manyar* and the erasian sparrow are among the several bird species that prey on rice plants [4]. These birds, which feed on seeds, congregate in groups or clusters near rice fields. While a swarm typically comprises of hundreds to dozens of birds, the birds often visit rice plants in the morning and afternoon together. According to Salsabila (1991), this bird pest may consume an average of 5 g of rice per bird per day [5]. As a result, farmers suffer greatly from this avian pest, which can cause crop loss or a 30-50% drop in rice production [5]-[6]. The *bondol* bird has the greatest rate of grain or rice eating, according to study by Ziyadah (2011). Additionally, this kind of bird is versatile and often combines with other species [4].

Scarecrows and cans woven with ropes attached to guard posts are commonly employed by farms to ward off bird infestations [4]. However, farmers must keep an eye on the birds from the guardhouse and change the rope when birds are present, so this method is still ineffective. Additionally, the birds are no longer bothered by the sound of the scarecrow or the used cans since they have become accustomed to it. This led to a new invention: covering the yellowing rice with nylon nets. This works well, but the birds start to adjust by flying more slowly and eventually utilize the netting as a place to dwell. Birds can occasionally become trapped in the nets an perish as a result. Since these nets need to cover the whole rice field, their installation is also quite difficult.

Research will be conducted using the internet of things system, which is a concept that aims to enhance the advantages of internet connectivity, in order to help develop answers to solve this [7]. Giving instructions and using a tool can be done more quickly and efficiently with the help of the Internet of Things idea. The IoT idea is applied to usage of the Telegram application to run the developed prototype, just like it will be in the prototype that will be designed in this research. A chat bot, often known as a “telegram bot” is a messaging service program that uses a unique account to automatically respond to messages [8]. Telegram will be linked to the ESP 32 using this capability, allowing orders to be sent to the prototype later on. The ESP 32 is WiFi-enabled electronic gadget that allows for wireless internet connectivity.

Later on, this ESP 32 will be linked to additional gadgets like laser diodes, which are Light Amplification by Stimulated of Radiation, or the method of enhancing light by stimulated radiation emission, is what laser diodes, which are electrical devices, do [9]. Another kind of solid substance laser is the semiconductor laser, which is also what the laser diode is. Additionally, the LDR (Light Dependent Resistance) sensor is connected to a type of resistor whose resistance value is influenced by the amount of light it recives; the more light it recives, the higher the resistance value. This is because the LDR ha a semiconductor disk with two electrodes on its surface [10]. Regarding the output, sparrows will be disturbed by ultrasonic sound, a form of sound wave with a frequency higher than 20,000 Hz.

According to earlier studies, there are a number of strategies to combat bird pests, including employing servo circuits or buzzers or other loud noises to deter them and PIR sensors to identify their presence. Detecting bird pests with laser light [11]-[12] and repelling them with ultrasonic sound and similar devices or servo circuit movement [4] [6], employing RWCL motion sensors for bird pests detection, servo circuits for disruptor motion, ultrasonic sound for distruptor sound and laser light to block bird pests’ eyesight [13] and utilizing organic insecticides to protect against bird pests [5].

Research will be done to create a prototype of a sparrow pest repellent for rice plants based on the problem’s background and the literature review. This will help farmer identify solution to combat and lessen bird pests in rice plants, specially an electronic network system that uses laser light to detect and repel sparrow pests. The NodeMCU ESP32 microcontroller used in the prototype will produce ultrasonic sound waves that will distrupt birds’ hearing and deter them from approaching the rice field region. This is further supported by study by Eduardus, Irawadi and Ajie Wibowo, which found that using ultrasonic waves to deter birds is an effective method [5]. A laser beam that is reflected by a mirror will be utilized to create an electronic net that covers the rice fields in order to identify the presence of birds. The laser beam’s reflection will terminate at the LDR sensor and if it is broken, the speaker outputs an ultrasonic sound. The prototype will be linked to a Telegram bot, a unique Telegram account that may automatically respond to messages, in order to make operation easier [14]. An IoT application called Telegram allows users to transmit commands that the ESP32 will process [15]-[16]. This is what the Telegram bot is supposed to do. Users may remotely switch off the gadget and check the battery level using the Telegram app, minimizing the need to visit the field each time.

II. METHOD

This research begins with a literature study to identify problems by studying related journals and matching them with the situation in the field. From this, the title, problem formulation, objectives and benefits of the research conducted are obtained. After getting all these things, it is continued with the design of the tool prototype that will be made according to the learning that has been done. Next, after the prototype of the tool is complete, testing is carried out along with matching the previous study and design. If the test is successful, the tool prototype can enter the next stage, otherwise the tool prototype will be revised again. After all these things are completed, the research can be declared complete.

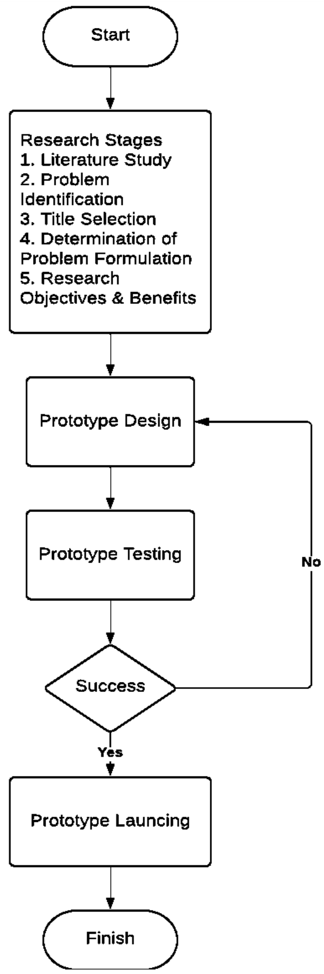

Figure 1 Research Method Flowchart

A. 2D Design

The design below is a 2-dimensional design for an electronic network system with laser light to detect and repel sparrow pests, where there is a laser diode that becomes an electronic network, a flat mirror to reflect laser light, an LDR sensor to capture the reflection of laser light, a speaker for sound output, a control box as a microprocessor control and a battery as a power source.

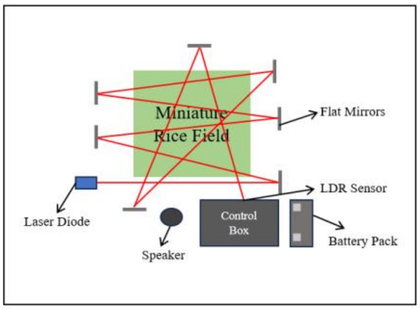

Figure 2 2D Prototype Design

The working system of the prototype will be by detecting the presence of sparrows using a laser beam reflected by a mirror to the LDR sensor and forming a net which, if the formed net is interrupted, will produce an output in the form of ultrasonic sound through a speaker to repel sparrows.

B. Hardware Design

In the hardware design of the electronic networking system with laser light to detect and repel sparrow pests, a 12 Volt battery is used as an energy source so that a stepdown is needed to reduce the voltage to 5 Volts, 2 NodeMCU ESP32 which functions for control and systems, relays to facilitate on/off systems, LDR sensors to receive laser light, current sensors to measure power and dfplayer to process output to speakers.

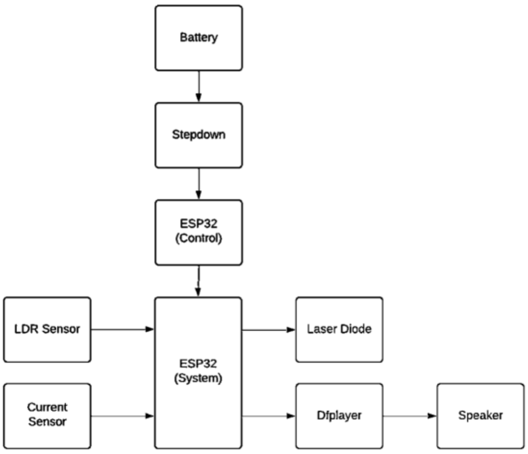

Figure 3 Hardware Block Diagram

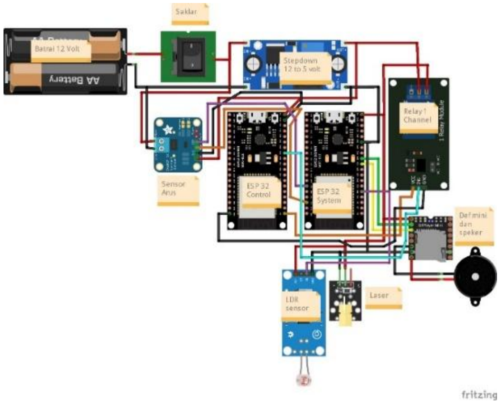

Figure 4 Hardware Schematic

C. System Flowchart

For software design, a program is made in the Arduino IDE (Integrated Development Environment) application, after which the program will be uploaded to the NodeMCU module board. After the device is turned on manually, the device will be run through the telegram application with the command "turn on the Tool" to turn on the system, which if the light received by the ldr sensor is less than 70 lumens then the speaker will turn on and emit ultrasonic sound. And for the second command, namely "check Power" to find out the percentage of battery remaining in the tool.

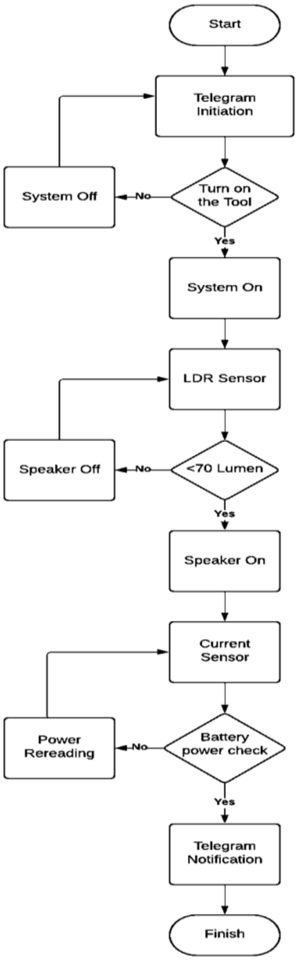

Figure 5 System Flowchart

D. Ultrasonic Sound

Ultrasonic sound is a sound that has a frequency of more than 20,000 Hz which is the frequency level of bird hearing. Therefore, this sound will be used as the output of a prototype that serves to repel sparrow pests. When the laser beam that has formed a net is blocked by birds so that the LDR sensor does not receive light from the laser beam, the speaker will sound and produce ultrasonic sound output. To find out the bird's reaction to the ultrasonic sound that will be applied to the prototype, pre-research was carried out by testing the ultrasonic sound in the rice field area. The ultrasonic sound used is an ultrasonic sound that originated from the YouTube application[17]. There are 2 types of ultrasonic sounds that will be tested on sparrows to find out which ultrasonic sound is more disturbing to sparrows. Before being tested on sparrows, 2 types of ultrasonic sound were defined which will be referred to as first ultrasonic sound and second ultrasonic sound to differentiate the 2 types of ultrasonic sound. Some things that are done are:

a. Measuring the level of ultrasonic sound intensity using a sound level meter device so that first ultrasonic sound has a decibel range of 31-93 dB and second ultrasonic sound has 45-93 dB.

Figure 6 Decibel Measurement Process Using A Sound Level Meter

b. Define the frequency and decibel of ultrasonic sounds using a simple program using the python language by reading ultrasonic sound files that have been converted into files with the .wav format. The following program is used to get the frequency and decibel of both ultrasonic sounds:

```
# Fungsi untuk mengubah amplitudo menjadi desibel
def amplitude_to_db(amplitude):
    return 20 * np.log10(np.abs(amplitude) + 1e-6)  # Tambahkan epsilon untuk menghindari log(0)

# Baca file audio (.wav)
def analyze_audio(file_path):
    # Baca file audio
    sample_rate, data = wavfile.read(file_path)

    # Jika data memiliki lebih dari satu channel, ambil channel pertama
    if len(data.shape) > 1:
        data = data[:, 0]

    # Lakukan noise reduction menggunakan noisereduce
    import noisereduce as nr
    reduced_noise = nr.reduce_noise(y=data, sr=sample_rate)

    # Panjang sampel
    n = len(reduced_noise)  # Gunakan reduced_noise

    # Lakukan FFT
    fft_result = np.fft.fft(reduced_noise)  # Gunakan reduced_noise
    freqs = np.fft.fftfreq(n, 1 / sample_rate)

    # Ambil hanya bagian positif (frekuensi dan amplitudo)
    positive_freqs = freqs[:n // 2]
    positive_amplitude = np.abs(fft_result[:n // 2])

    # Konversi amplitudo ke desibel
    db = amplitude_to_db(positive_amplitude)
```

Figure 7 The Program to Get The Frequency And Decibel of Ultrasonic Sound

Based on a simple program that has been made, first ultrasonic sound has a frequency of 0-22000 HZ and a sound intensity level of 25-170 decibels, while second ultrasonic sound has a frequency of 0-22000 and a sound intensity level of 10-145 decibels or can be seen in the following graph:

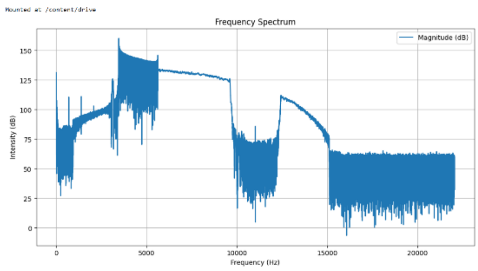

Figure 8 Frequency and Decibel Chart of First Ultrasonic Sound

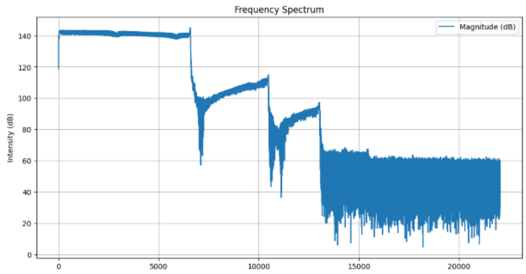

Figure 9 Frequency and Decibel Chart of Second Ultrasonic Sound

After defining the ultrasonic sound, then pre-research is carried out to find out the bird's reaction to ultrasonic sound by placing a bluetooth speaker in the middle of the rice field and when the bird starts to land on the rice plant, the ultrasonic sound will be turned on from a distance.

Figure 10 Placement of Speakers in The Middle of Rice Fields

III. RESULTS AND DISCUSSION

A. Results of Field Ultrasonic Sound Testing

The table below shows the test results of the two types of ultrasonic sound in the rice field area:

Table 1 Testing Results of 2 Types of Ultrasonic Sounds

No	Sound Type	Bird Reaction	
1	First Ultrasonic Sound	First Rice Fields	Distracted
		Second Rice Fields	Not Distracted
		Third Rice Fields	Distracted
2	Second Ultrasonic Sound	First Rice Fields	A Bit Distracted
		Second Rice Fields	Distracted
		Third Rice Fields	Distracted

Following field testing, it was discovered that second ultrasonic sound is more upsetting to birds. As a result, second ultrasonic sound will be utilized in the prototype. The description of second ultrasonic sound testing is as follows :

Table 2 Result of the Second Ultrasonic Sound Test in First Rice Field

No	Time Range	Decibel Range	Birds Reaction
1	0 - 13 seconds	52,9 - 92 dB	No reaction
2	14 - 30 seconds	49,7 - 93,2 dB	Going away and not coming back

Table 3 Result of the Second Ultrasonic Sound Test in Second Rice Field

No	Time Range	Decibel Range	Birds Reaction
1	0 - 18 seconds	34,6 - 63 dB	No reaction
2	19 - 23 seconds	57,9 - 69,9 dB	Fly, then land again
3	24 - 30 seconds	45,5 -68,6 dB	Going away and not coming back

Table 4 Result of the Second Ultrasonic Sound Test in Third Rice Field

No	Time Range	Decibel Range	Birds Reaction
1	0 - 6 seconds	34,1 – 89,3 dB	3 flying birds
2	7 - 23 seconds	68,7 – 93 dB	All the birds went away
3	24 - 30 seconds	31,6 – 92,9 dB	Back closer, then further away

With a decibel range of 49.9 to 93.2 dB in the first rice field, 45.5 to 69.9 in the second and 31.6 to 93 dB in the third, it evident from the three tables above that second ultrasonic sound disturbs sparrows. The average sparrow is most disturbed from the middle to the end of the second ultrasonic sound.

B. Tool and Feature Testing Results

These are the finished outcomes of the prototype that was created once the design, assembly and program input were finished :

Figure 11 The Final Prototype

Figure 11 shows that the laser is operating well and that the glass reflects the laser light to the LDR sensor, creating a net or to put it more precisely, the following:

Figure 12 Appearance when the laser beam forms a web

Based on figure 11 and figure 12, the performance of the device on the tool is described as follows :

Table 5 Device Performance on The Prototype

No	Device	Going Well	Not Going Well
1	ESP32(Control)	√	
2	ESP32(System)	√	
3	Relay	√	
4	Current Sensor	√	
5	Dfplayer	√	
6	Laser	√	
7	LDR Sensor	√	
8	Speaker	√	
9	Battery Indicator	√	

And here is the state and description of the features contained in the prototype :

Table 6 Performance of prototype features

No	Prototype Features	Status
1	Telegram function on/off	Going Well
2	When laser reflection receives the LDR sensor, the speaker is silent	Going Well
3	When the laser reflection to the LDR sensor is disrupted, a speaker sounds	Going Well
4	Telegram is able to monitor battery power	Going Well

Table 6 lists functions that use telegrams to check battery power and turn on/off devices. When the Telegram application is used, the following screen appears :

Figure 13 How it looks when Telegram is used

In Figure 13, "*Apa yang bisa dibantu*" it means "How can I help you", *"nyalakan Alat"* it means "Turn on the device", "*Alat telah dihidupkan!"* it means "The device has been turned on!", *"cek daya batrai"* it means "Check battery power", *"Sisa Batrai 97,50%"* it means "Battery remaining 97.50%", *"matikan Alat"* it means "Turn off the device" and *"Alat telah dimatikan!"* it means "The device has been turned off!". It is evident from the presented pictures and tables that the prototype is capable of operating and performing as intended.

C. Error

Based on research conducted by Maharani Ratna Palupi and Budhy Basuki on the frequency and level of sound that effectively repels birds, it is found that the sound pressure level of 85 dB is the threshold of bird hearing pain [18], which in this study will be used as the theoretical dB value used as a variable to find the percent error using the galad formula (1). Therefore, the following are the results of testing the percent error from the test results on ultrasonic sound interference to sparrows:

$$\frac{dB\ testing\ result - dB\ theory}{dB\ theory} \times 100\% \qquad (1)$$

$$= \frac{93 - 85}{85} \times 100\%$$

$$= \frac{8}{85} \times 100\% = 9.41\%$$

D. Comparison with previous research

The provides a new fact for related research because previous research only mentioned that ultrasonic sound was a sound that disturbed sparrows[13]. It also demonstrates that research on bird hearing thresholds of 85 dB [18] is included with the ultrasonic sound decibel range obtained which is 31.6 to 93.2 dB. These findings based on pre-resesearch and test results on prototypes and telegrams show that what disturbs sparrows more than the frequency of ultrasonic sound is the decibel or sound intensity level.

Regarding the prototype, it is more effective than earlier studies that used servo circuits, ropes and cans [1] [13] [15] or servos and scarecrows [2] [5] to repel sparrows. It also uses laser reflection to detect the presence of sparrows, which is more effective than RWCL sensors, which can only detect the presence of birds well if there are more than three birds [4] [13].

E. Advantages

1. Compared to nylon nets that need to be stretched over rice plants, installation is less complicated.
2. In contrast to nylon nets, birds are unable to perch.
3. Remotely controllable.

F. Disadvantages

1. The glass's placement needs to be exact and constant.
2. The device will keep sounding if the light is reflected wrongly.
3. The battery has to be charged if it runs low.

IV. Conclusion

Research and testing have shown that the prototype works and performs as indeed specifically, the laser light can be reflected towards the LDR sensor by creating a net, the speaker is capable of delivering ultrasonic sound when the laser light reflection is interrupted and the Telegram can operate correctly to turn off the tool so that it can be controlled remotely. It can also provide battery percentage information, minimizing the need to visit the field to determine the remaining battery percentage. The decibel magnitude of ultrasonic sound, which ranges from 31.6 to 93.2 dB, is discovered to be what disturbs and affects sparrows, whereas frequency, which has a value of 22,000 Hz, has no effect on sparrows. Using the decibel range value of the research findings and the threshold value of bird hearing from earlier studies, the galad formula produced a percent inaccuracy value for sounds that disturb birds of 9.41%. additionally, learn some of the prototype's benefit and drawbacks that may be taken into account for future studies.

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