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PEST CONTROL SYSTEM ON AGRICULTURAL LAND USING IOT ELECTRONIC CONTROLLER

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ABSTRACT
This research aims to assist farmers in controlling plant pests, birds and insect, by applying an appropriate electronic technology. The system operates in an automatic and remote-controlled modes using IoT technology. We used a solar powered systems that are environmentally friendly with zero carbon emissions, as an energy source for the systems. The test results showed that the bird pest control system worked well according to the automatic and remote-control modes design. We compare those two methods to evaluate the most effective between those two methods. Bird pest control using two actuators, sound and movement, outsmart control using only sound by success ratio 70:50. The insect pest control system worked well with the remote-control mode through Telegram application on farmers' smartphones.
Keywords : *Pest Control, Agriculture, Automatic, Remote Control*

1. Introduction

Indonesia is blessed with abundant natural wealth and relies heavily on the agricultural sector for livelihood. Agriculture contributes significantly to national income and has an important role in absorbing labor, providing food, and clothing for the population. The agricultural food crop sector is generally preferred by Indonesians, specifically rice, as their daily main food intake.

One obstacle in producing agricultural commodities is pests and disease. This attack cause gaps between potential and actual rice yields. Efforts have been made to control pest attacks on plants using chemical or physical components. Chemical components include fertilizers and pesticides to control insect pests and plant diseases. The physical components include weather or climate conditions, manual control using scarecrows (Mayland et al., 2014), or direct eviction using rope movements or *gongs* as a sound source. These physical components mainly control pests other than insects, such as rats and birds.

Pest control efforts manual require much time and effort with no guarantee for effective results (Tracey et al., 2007). This condition drives research on the use of technology to assist farmers in controlling pests. Technology is intended to help farmers to control pest attacks. Some of these researches focused on controlling plant pests, specifically birds (Bhatt et al., 2012), (Marcoň et al., 2021), and insects (Kale et al., 2012), (Shi et al., 2015).

This research was inspired by the results of previous research to develop the system to build a pest control systems, bird and insect specifically, to be operated on rice field. This IoT-based operating system is expected to help farmers to control plant pests on their agricultural land. The system not only operates automatically based on sensor input, but also in remote-controlled mode using user interface Telegram application. This system utilizes sound and a dc motor that moves the rope to expelled the birds, and utilize ultraviolet light to trap insects. In terms of the energy sources, this research used solar cells systems. As a tropical country, Indonesia is Rich in Solar Energy. Solar powered systems use the sun's potentially inexhaustible energy and are also more environmentally friendly with zero carbon emissions (Abayomi-Alli et al., 2018), (Cho et al., 2020).

Many research worldwide explored the application of IoT technology in agriculture (Katiyar & Farhana, 2021), (Sekaran et al., 2020), (Jannan & Supriyono, 2018). This technology is expected to accelerate agricultural modernization, integrate smart agriculture, and solve farmers' problems efficiently (Mandal S., Ali I., 2020). This 21st Century is the right time to move forward towards a modern and sustainable agriculture to face the challenges posed to food production in this time (Saiz-Rubio & Rovira-Más, 2020).

IoT technology facilitates the collection of environmental data without the farmer having to always be on the farm site (George & Drăgulinescu, 2019), (Keswani et al., 2019). This data is an important input for farmer in taking immediate action to get more optimal agricultural results. Moreover, the technology enables an architecture for mobile agriculture services based on the Sensor Cloud substructure (Donzia et al., 2019).

One key element of smart farming is an agricultural management information system, automation, monitoring, planning, decision making, documentation, and operation management. Some research applied this technology to help farmers work related to irrigation (Bhoi et al., 2021), (Rawal, 2017), (Maharani & Handaga, 2022). Previous research also used it to monitor agricultural land (M.Gogoi, 2015), (Rohmah et al., 2021), and protect plants from animal disturbance (Balakrishna et al., 2021), (Giordano et al., 2018), and from pests and diseases (Muruganantham et al., 2019), or protect crop from theft (Hulcr & Cognato, 2010).

Specific purpose of IoT application on controlling agricultural pest is done in several researches. Combination of IoT and UAVs (Unmanned Aerial Vehicles) was used developing agriculture framework for providing profound insights into the specific relationship between the occurrence of pests/diseases and weather parameters (Gao, 2020). The research used the IoT technology to collect real-time weather parameters, and UAVs to capture the images of farmland to be used in analyzing the occurrence of pests and diseases of crops. Another research used IoT on developing an automatic and remote-control bird pest expulsion system from rice field (Rohmah, 2024). This research used three types of sensors, one of which is camera operated sensor. Using this type of sensor, the system can determine whether an object entering the rice field is a bird or not, and then expel it if the object is a bird.

Our research's aim is developing a system using IoT specifically to control not only bird pests, but also insect pests. Unlike other research, the system built with two modes of operation automatically and remote controlled. The system is expected to be an appropriate system to help farmers with small areas of rice fields, which is common in Indonesia. And it's also common in Indonesia, that the rice field area far from electric source, so this system is energized by solar panel.

2. Research Methods

This research designs plant pest control systems for bird pest and insect. The bird pest control system using movement and sound mechanisms to expelled birds from rice field. The insect pest control system using ultraviolet light to attracts and trap insects. This system uses a 20WP solar panel that supplies power to all the components. Solar panels ensure the pest control system works without electricity supply from State Electricity Company. This solar panel is equipped with a Solar Charge Controller (SCC) to monitor the output voltage and a 12 V battery charging device. This SCC stops charging the battery when fully charged, and will start charging the battery when it is monitored that the battery condition has dropped to 50% of its full capacity (Suriadi et al., 2019).

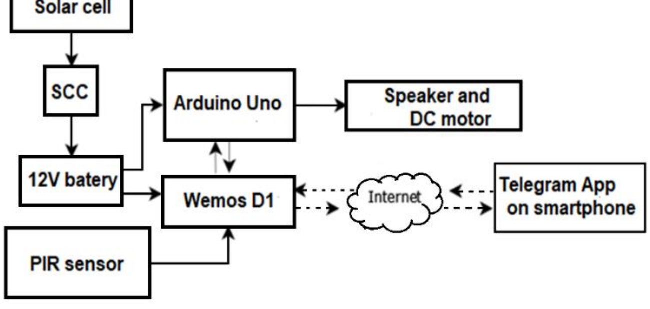

Fig. 1. The Design of Bird Pest Control System

The bird pest control system was developed with automatic and remote manual control modes. The automatic control operates based on motion sensor input which detects bird movements, by activating loudspeakers and dc motors. On the other hand, the remote manual control is remotely controlled through smartphone by implementing IoT technology. Figure 1 shows the block diagram of the bird pest control. Signal acquisition is using a Passive Infrared (PIR) sensor that detects the movement of bird. As a movement is detected, the sensor sends signal to the Wemos D1 mini microcontroller. The Wemos output signal is then sent to the Arduino Uno to activate the actuator for a short duration of time. Wemos D1 is also simultaneously sends notifications to the farmer via internet. Farmer get notification on his smartphone using Telegram application. After receive a notification, farmer can then remotely control the movement of the dc motor and sound for as long as he wants.

The pest control system was developed by applying an ultraviolet light trap to catch the insects. The light trap success depends up on the intensity and wavelength of the light. According to Subandi, light with a certain intensity and color is attractive and influences insect behavior (Subandi, 2016). Another research explained that the highest number of nocturnal insects were caught in blue light traps, meaning ultraviolet (UV) light is more effective than other colored light (Faradila et al., 2020). The system developed in this research applies IoT technology to help users to turn on or turn off the UV lights. Figure 2 shows the schematic diagram of the insect pest control system. This control system uses power from the same battery as the bird pest control system. Insect control system does not work automatically, instead of works on remote controlled mode via internet using Telegram app. Wemos D1 pass through farmer instruction to Arduino to operate the UV lamp, to turn on or turn off the lamp. Wemos D1 also send notifications to farmer to indicate that the light is on or off.

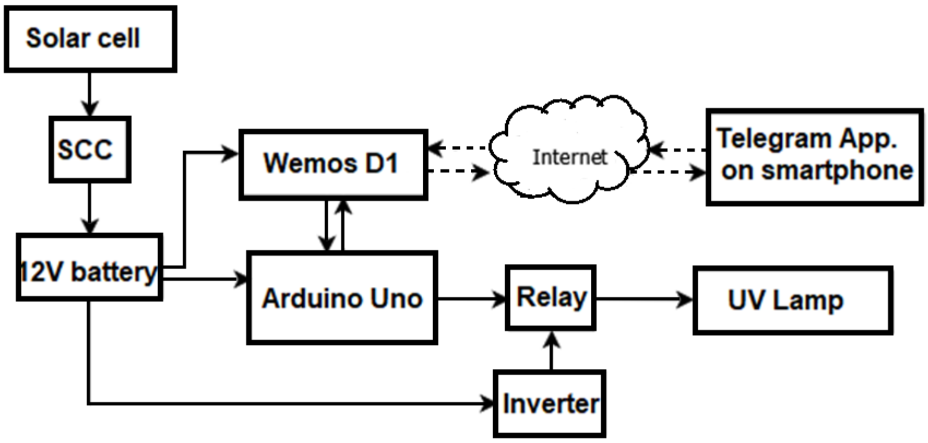

Fig. 2. The Design of Insect Pest Control System

Figures 3 show the flow chart of software program design for the bird control programs. The process in bird pest control began when the Wemos D1 mini is connected to the internet. The PIR sensor is always in standby mode, ready to detect any movement. Whenever any motion is detected, system then activates the loudspeaker or buzzer and drives the dc motor. Simultaneously, system sent notification to users. Farmer will then can operate actuator as he wants. Even when the PIR sensor does not detect any movement, farmer can still operate the loudspeaker or buzzer and dc motor remotely using Telegram app. Figures 4 show the flow chart of software program design for the pest control programs. The system began after the Wemos D1 mini is connected to the internet. Farmer remotely operate the UV lamp through Telegram app. The overall software design for this control system is made in the Arduino Integrated Development Environment (IDE).

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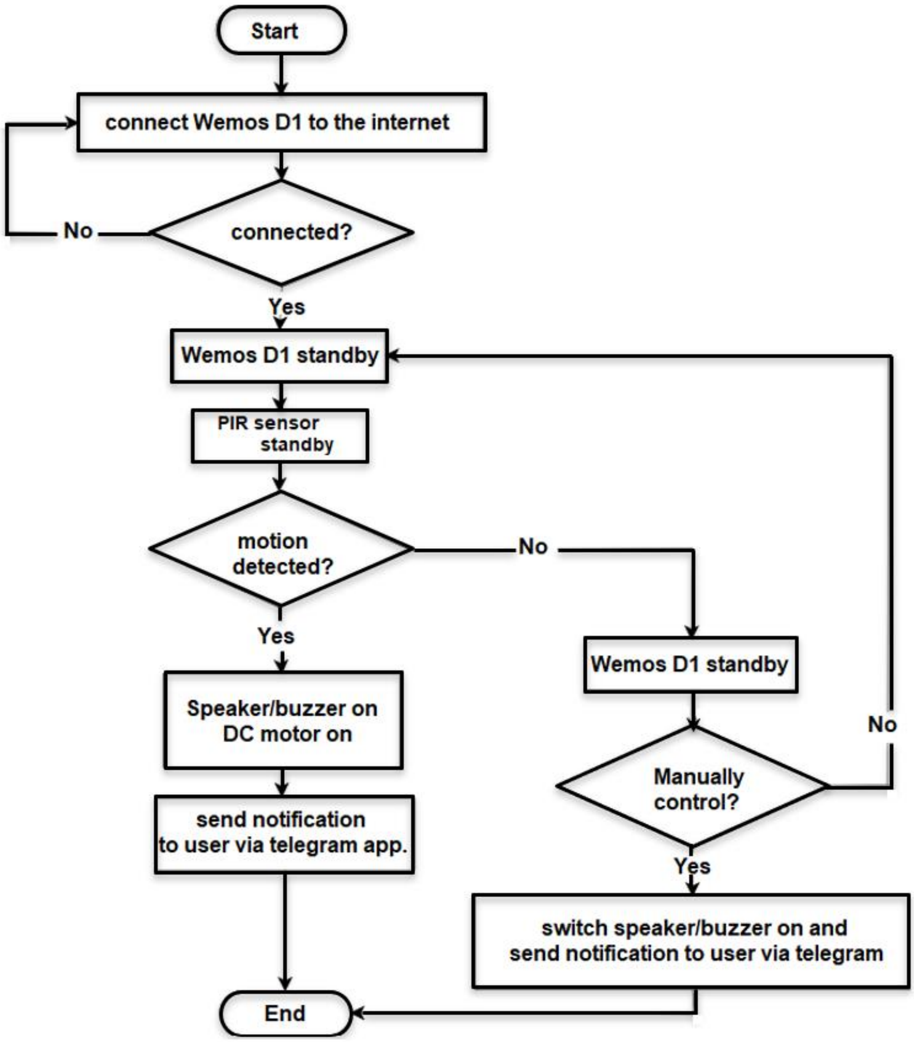


Fig. 3. Bird Pest Control Systems Computational Process

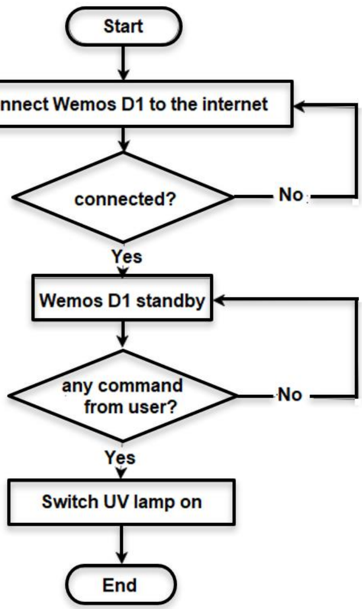
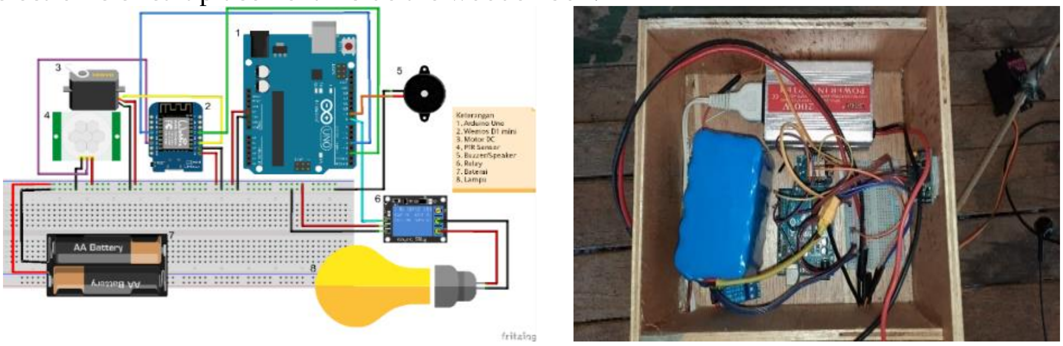


Fig. 4. Insect Pest Control Systems Computational Process

4. Results and Discussions

Figure 5a shows the wiring diagram of the developed electronic circuit. The pest control system circuit is placed in a box to protect its components. This box is designed using a lightweight sheet wood because it is flexible and less costly. Moreover, the sheet wood makes the components inside not experience excessive heating when used in the field. Figure 5b shows electronic circuit placement inside the wooden box.



(a) (b)

Fig. 5. (a) Wiring Diagram of The Developed Electronic Circuit (b) Placement Electronic Circuit in A Wooden Box

4. 1. Test and results on media interface using Telegram

The media interface was tested to determine whether the control system was working through the notifications sent. The test also determined the presence of a pause generated while sending commands to the controlling system and receiving notifications. Figure 6 shows information display on smartphone screen. The test results show that the system has worked according to the design. The delay is an average of 3.6 seconds for receiving notifications and 7.1 seconds for sending orders through the application. The delay is 3.8 for sending commands through Telegram for the average insect pest control system.

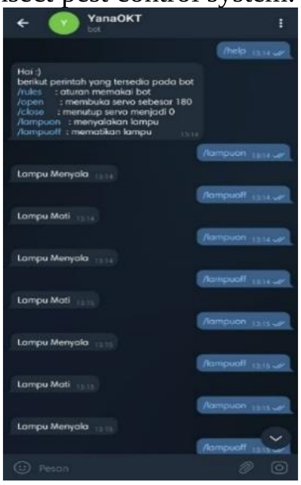


Fig. 6. The Results of Testing The Control System Media Interface And Delay Testing on Telegram

4. 2. Test and Results in Actual Rice Fields

The last control system test was performed in the rice fields of Gonilan, Kartasura, Jawa Tengah province. During the test, the land was in the ready-to-harvest stage, meaning the attack of bird and insect pests was more than during the planting season. Figure 7 shows the experimental process of bird pest control system test. During the test, the box was placed on the edge of the land in the middle position, and the rope was attached to a dc motor as a movement mechanism. Tests were conducted at certain times from 11 a.m. to 1 p.m., and from 4 to 5 p.m. in the afternoon. As for the insect pest control system test, the test conducted from 8 a.m. to 9 p.m. for two hours in each session, as seen in Figure 8.

Fig. 7. Bird Pest Control Trial With Sound and Movement as Actuator at Actual Rice Field

Fig. 8. Insect control trials during the day (left) and night (right)

Table 1 - Testing Results of Bird Pest Control System Using Sound Mechanism.

Detection by PIR Sensor	Sound active (Yes/No)	Pest
Detected	Yes	Not Expelled
Detected	Yes	Expelled
Not detected	No	Not Expelled
Detected	Yes	Expelled
Detected	Yes	Expelled
Detected	Yes	Not Expelled
Not detected	No	Not Expelled
Detected	Yes	Expelled
Not detected	No	Not Expelled
Detected	Yes	Expelled

The test results for the bird pest control system show that the system works well according to the design. All bird pest control actuators work based on the signal input from sensors. However, there were shortcomings in the movement mechanism. This deficiency was due to the heavy load because the rope used had a length and load exceeding what the motion mechanism could withstand. However, the motion mechanism for a limited rope length works according to sensor input. Tables 1 and 2 show the trial results on bird expulsion using sound only and combination of sound and rope movement as actuators, respectively. The sound-only mechanism resulted in 50% bird expulsion, whereas the sound and actuators motion gave better result in 70% success.

Table 2 - Testing Results of Bird Pest Control System Using Sound and Motion Mechanism.

Detection by PIR Sensor	Sound active (Yes/No)	Pest
Detected	Yes	Not Expelled
Detected	Yes	Expelled
Not detected	No	Not Expelled
Detected	Yes	Expelled
Detected	Yes	Expelled
Detected	Yes	Not Expelled
Not detected	No	Not Expelled
Detected	Yes	Expelled
Not detected	No	Not Expelled
Detected	Yes	Expelled

The insect pest control system was tested for two days, collecting data on the total insects trapped by the tool. The system was operated remotely through Telegram on users' smartphone. Tables 3 and 4 show the results of system testing. The test was performed from 8 a.m. to 8 p.m., with a two-hour pause in data collection. The rice fields' insect pest control system test showed that the system worked well. The catch from afternoon to evening was more than in from morning to afternoon because ultraviolet light attracts more insects. Additionally, the results showed that weather factors affect insect catches. This is because insects are more active in sunny weather than in raining or after.

Table 3 - Testing Results of Bird Pest Control System Using Sound and Motion Mechanism.

Testing time	Weather conditions	Number of insects trapped
8 – 10 a.m.	sunny	5
12 – 2 p.m.	sunny	2
4 – 6 p.m.	cloudy	14
6 – 8 p.m.	cloudless	53

Table 4 - Results of the Second Day Insect Pest Control System Test.

Testing time	Weather conditions	Number of insects trapped
8 – 10 a.m.	cloudy	3
12 – 2 p.m.	cloudy	0
4 – 6 p.m.	cloudy, after the rain	16
6 – 8 p.m.	cloudy, after the rain	6

5. Conclusion

The results indicated opportunities for implementing IoT technology using solar panels in agriculture. Users interface with Telegram on smartphones facilitates remote control through the internet network. Moreover, the prototype of the bird and insect pest control system developed in this research worked according to the design. The trial results showed that the prototype bird pest control system with sound and movement actuators had higher success than only sound actuators, with a ratio of 70:50. The insect pest control system prototype also showed that the system-controlled operation through this application on users' smartphone worked as expected. Additionally, this finding showed more insects catches in the evenings because ultraviolet light is more visible than in the mornings. Further research in this study is implementing more powerful solar panel to overcome the shortcoming in rope movement. Next research will also expanding agricultural pest control, with the development of a control system for rat pest control. In bird pest identification, the further research is in implementing image processing to improve accuracy in bird identification.

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