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Design Tools for controlling Brown planthopper pests using ultrasonic waves

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Madiun, Indonesia. August 21st 2019

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Design Tools for ControllingBrown Planthopper Pests Using Ultrasonic Waves

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Abstract. The brown planthopper pest is a main pest of rice production in East Java and mostly Indonesia areas. The main controls of brown planthopper are mostly using chemical pesticides, which caused resistance on pest. Resistant varieties are the main choice for overcoming attacks of planthopper. However, resistant varieties had limitations because brown planthopper adapted to new biotypes. Conventional Integrated Pest Management (IPM) is reactive to pest attacks and often continues to rely on insecticides. One of the promising ecofriendly technologiesis ultrasonic waves. This study the aim was to design a planthopper pest control system in a room using the HC-SR04 ultrasonic sensor with a frequency of 40 KHz. The trial in the first stage was limited to testing the functionality to the system and testing the range of tools carried out to determine the area covered by the wave ultrasonic. The results of testofthe system are all system components are working properly. The ranges of the tools area maximum range is three meters in surrounding of the ultrasonic sensor.

1. Introduction

Planthopper,*Nilaparvatalugens*Stål is the most dangerous pest in tropical climates especially Southeast Asia [1]. The morphology of plant hopper small size 4 -5 mm with brown color, the femaleproducing egs 100-500 eggs in normal temperature (± 25°C). The adults of planthopper reach to 30 days lifetime[2], distributed widely in South, Southeast, and East Asia; the South Pacific islands; and Australia [3]. Various methods applied to overcome this pest attack, both using biological and chemical methods. Those both method has limited in point of view effectiveness and side effects caused such us environment and resistant issues. Chemical method of pest control has been found to be very effective but quite expensive to maintain. Also, these chemicals are highly poisonous and harsh both to human beings and pest. Air and water pollution is most important risk factor arising due to the use of chemical method. Human risk factors such as respiratory diseases, particularly for bronchial asthma and chronic obstructive pulmonary disease (COPD).In addition, it carries genetic mutations to offspring produced from internal pests that.According to those arising issues, the alternate methods of control increasingly[4] including the acoustic method with ultrasonic wave.

The method developed in this study is a physics method using ultrasonic waves. Ultrasonic waves are a strategic step, since the effects of waves that damage the body's tissues with no pollution impact. This is evident to several studies that have been conducted using ultrasonic waves, such as to overcome beetle pests, planthopper, and mice [5]. The type of ultrasonic wave used in this study is a longitudinal wave. Longitudinal waves are waves that have a vibration direction parallel to the direction of propagation which possible for back and for moved. When slinky is moved back and forth then slinky will form a density and stretch.

The ultrasound sensor is one sensor that produces analog quantities for using in tools. One type of sensor that is often used is parallax ultrasound, which has output as digital scale. In build a ultrasonic tool, many components are arranged including ultrasound wave generators and transmitters. The components are embedded in the board with integrated circuit with microcontroller. Other components that also used are registers, AT commands, and I / O systems. Recently, the microcontroller has been packaged in an active module kit such as the Arduino board [6] with many types based on capacity.

Several studies on control pest, especially insects are limited. Pramana et.al (2017) applied the research, used frequency of ultrasonic waves above 20 Khz and showed results afraidness of insect pest on apes.Similarly, Utama (2017) conducted a study to design a mosquito repeler system to use ultrasonic sensor with solar panel as energy sources, results showed tools triggeredmosquito movement up to 15-42.5 %. The results also indicate the mosquito reaction pattern movement which tends to stay away from ultrasonic wave sources. Yusianto and Sudibyo (2016) also carried out the brown planthopper pest control design for rice plants[7] with low effect on controlling planthopper.

Brown Planthopper as an insect group, able to listening sounds above the threshold of the average human hearing capacity, which is more than 20 kHz. Ultrasonic waves are ranged of 30-100 kHz expressed as very high-amplitude [8], which able to capture by the antenna of planthopper.When ultrasonic waves are emitted, the senses of the planthopper will recognize the sound caused by ultrasound waves as a threat, so that if the planthopper is continuously in the vortex of the wave, they will be uncomfortable and eventually stay away[9].

The aim of this research is to design a prototype of a planthopper repellent (call 'OUTWERE') in a room using the HC-SR04 ultrasonic sensor with a frequency of 40 KHz. The trial was carried out to determine the performance of ultrasound distance range. The system can provide information on areas covered by waves whose output is displayed on the LCD 16x2 cm.

2. Methods

2.1 The component of "Outwere" repellent

In this study the structure of planthopper pest control system devices (Outwere) using 3 main components;arduinouno (Fig. 1), sensor ultrasonic HC-SR04 (Fig. 2),and LCD 16x2 cm (Fig. 3). The Arduino board (figure 1)type is a ready-to-use hardware with microcontroller ATMEGA328 modules and IDE software to program so that we can easily use them. This microcontroller consists of CPU, memory, and I / O that we can control by programming it. I / O is also often referred to as GPIO (General-Purpose Purpose Input Output Pins) which means, the pin that we can program as input or output as needed[10]. The information about coverage area ultrasonic will be displayed on a 16x2 LCD (figure 2).

Figure1. Arduino-ATmega 328 Microcontroller

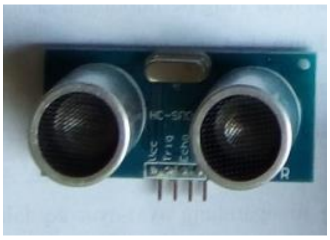

Figure 2. HC-SR04 Ultrasonic.

Figure 3. 16x2 Liquid Christal Display.

Ultrasonic Sensor HC-SR04 (figure 2) is a sensor issued by Devantech Company which widely used in the world of robotics and aeronautics. This sensor serves to measure the distance between 3 cm to 3 meters. The HC-SR04 sensor has 2 main sensor parts namely transmitter (N1076) and receiver (N1081). The transmitter sensor emits an ultrasonic signal with a frequency of 40 KHz and the receiving sensor captures the reflected 40 KHz frequency [11].

2.2 The Design Of Ultrasonic Brown Planthopper Pest Repeller

The design part of planthopper pest control systems is achieved by generation of Pulse Width Modulation (PWM) wave frequency by Arduino And HC-SR04 (Figure4). The design briefly explains the details of a Mockup diagram of planthopper pest control systems with all components. Arduino requires 5-9 V regulated voltage to operate. HC-SR04 requires 5V regulated voltage to operate. The LCD is connected to the microcontroller to display the coverage area frequency ultrasonic. Whereby, the HC-SR04 data port is connected to microcontroller at PORT 4,5,6,7. The conductors were arranged in an isosceles triangle construction. The layout and dimensions to the model are shown in Figure 4.

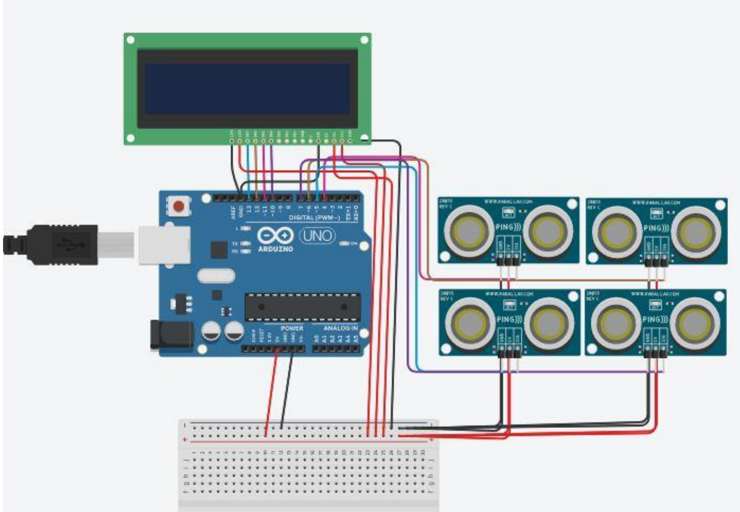

Figure 4. Complete design of ultrasonic waves to control brown planthopper pest

3. Results and Discussions

The results of the brown plant hopper pest control system (Outwere) were arranged by the Atmega 326 microcontroller with the Arduino Uno board as the control center. HC-SR04was used as actuators to produce Ultrasonic sound waves. For the wideness of range, four HC-SR04 sensors are gathered (Figure 5). All the components are wrapped with paperboard as packaging tools and displayed used a 1. 25 m single pillar (Figure 6). These designs to give comfortable and easy use of tools in test room.

Figure 5. 'OUTWERE' frontal site

Figure 6. 'outwere' in staging

Test functionality by checking each device function, the results of the functional test can be seen in table 1

Table 1. Test result for functionality

No	Device	Trials	Results
1	Microcontroller	Upload and run programs	Ok
2	LCD	Display information	Ok
3	HC-SR04	Measure Distance	Ok

The test results for each component in Outwere (table 1) are work well based on each results test. The microcontroller is tested by uploading the source sketch program, and the results are that the program runs well without errors. The LCD indicated works well by displaying welcome posts with a blue backlight. HC-SR04 given 10uS pulse is required at the trigger input and starts the ranging, then the module will send out an eight cycle burst of ultrasound at 40 kHz and raise its echo setting. The Echo is a distance object that is pulse width and the range in proportion. Then calculate the range through the time interval between sending trigger signal and receiving echoes signal. We suggest to use over the 60ms measurement cycle, in order to prevent trigger signal to the echo signal[11].

After the functionality, test is completed, it is continued with the ultrasonic wave range test using the principle of finding the distance through the ultrasonic waves that are emitted and received again. Ultrasonic sensors mounted on four sides can be used to determine the area that can be reached by ultrasonic waves. The formula used for the area calculation in this system is shown in the following formula (1)

$$L= (p1+p2+5)*(l1+l2+5) \quad (1)$$

p1, p2 are the length values of the measurements of two ultrasonic sensors on two opposite sides.*l*1, *l*2 are the width values of the measurements of the ultrasonic sensors on the 2 sides of the opposite. Because the position of 2 opposite sensors has a distance of 8 cm, the length and width are added to the value of 8cm.

The trial area calculation is done by comparing the area that has been determined by the area of the ultrasonic sensor calculation results. The results of the trial calculation of the area of the ultrasonic waves are seen in table 2.

Table 2. Measurement Area Ultrasonic Wave

No	Actual area (cm^2)	Sensing Area (cm^2)	absolute error (cm^2)	Average absolute error (cm^2)	Average relative error (%)
	400	420	20		
1	400	400	0	13,4	3,4
	400	420	20		
	2500	2652	152		
2	2500	2756	256	204	8,16
	2500	2704	204		
	4000	4264	264		
3	4000	4335	335	396,3	9,9
	4000	4590	590		
	6000	6448	448		
4	6000	6875	875	556	9,27
	6000	6375	375		

Table 2 is the first stage of a trial to find out wideness ultrasonic wave range of brown plant hopper pest control devices “Outwere." In this study, a test area was prepared with an area ranging from 400

cm^2 - 6000 cm^2. In testing in a room of 400 cm^2, the measurement results obtained by the instrument amounted to 420 cm^2,400cm2, 420 $cm^2$with an average error value of 34 where the average relative error was found to be 8.5%. The second test in a room with an area of 2500 cm^2 from the measurement results obtained an area of 2652 cm2, 2756 cm^2, 2704cm^2 so it is known that the average absolute error is 204 cm^2 and Average relative error is 8.16%. The third test in a room with an area of 4000 cm2 obtained the results from an area of 4264cm^2, 4335cm^2, 4590cm^2. The average absolute error from the third test was 396.3 cm^2 and the average relative error was 9.9%. For the 4th test, a room of 6000 cm^2 was used, and the results of the ultrasonic sensor were 6448 cm^2, 6875 cm^2, 6375 cm^2 with an average absolute error of 556 cm^2 and Average relative error of 9.27%. The results in Table 2 shows the ultrasonic waves from HC-SR04 can still reach an area of 6000 cm^2 even though the calculation results of ultrasonic sensors still show differences between the actual area and the sensing area with an average relative error between 8.16% - 9.27%.The range of error may have occurred caused the range of between two opposite sensors. The maximum effective ranges of the tools are three meters from each sensor. This resulting comforted with Mansyur, et. al (2009) [9].

The last trial was the exposure of ultrasonic waves to brown plant hopper who was carried out in a closed room with a size of 120x50x30 cm. in the initial stages of this study tried to see the behavior of brown plant hopper in a container given ultrasonic waves for 15 minutes. This exposure test room can be seen in Figure 7. In the test room, a sample of 80 brown plant hopper was inserted, then the 'outwere' tool was placed in the middle and turned on for 15 minutes. Observations showed that no brown plant hopper was perched at the center of the wave. During the wave exposure, brown plant hopper moves away from the ultrasonic wave center.

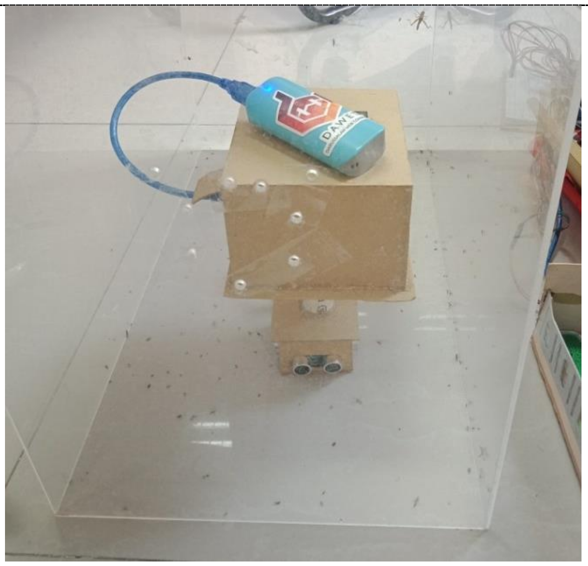

Figure 7. Test room of exposure ultrasonic waves to brown plant hopper

The results of this research showed the planthopper are triggered to move away from the sensors and the range. These current results agreed with some Mansyur, et. al (2009) [9] and Julian & K. Triyan (2017) [8] since the ultrasonic give an effect to behavior movement.

4. Conclusion

The tools of Outware reading need improvement since average reading relative error between 8.16% - 9.27% to get more precisely measurement. The effective ranges of tools are three meters from the sensors. We suggest to deeply studies in arrangement of components to get the wider effect of controlling pest, including for setting frequency used in the tool.

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