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Design of Poison Lawn Springer Robot Using Proportional Integral Derivative Algorithm With Remote Control System

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ABSTRACT

Grass, a plant found on Earth, is also referenced in the Koran. However, it can pose challenges for other plants and is often managed by farmers through methods like cutting or applying poison, which can be risky due to potential accidents such as insecticide poisoning. To address this, a remote-controlled robot was created to automatically spray grass poison using the PID (Proportional Integral Derivative) method. Testing with a multimeter confirmed the robot operates at 11.1 VDC, utilizing a 5-12VDC motor running at 3000 rpm with a motor gearbox to handle a 5 Kg torque load. Control is managed via a Bluetooth module, specifically the HC-05, linked to an Android Bluetooth system with a maximum transmission range of 0-10 meters. The robot is programmed to water grass based on its height: grass 10-15 centimeters tall receives water with 11.1 VDC after a delay of 1.5 seconds (PID 1), while grass 20-30 centimeters tall is watered with 14.8 VDC after a delay of 3 seconds (PID 2). A 16 VDC pump motor operating at 1500 rpm is used for watering. After implementing the PID-based lawn watering system, the P value was determined as 14.56, I value as 22.08, and D value as 15.5. In summary, the grass poison sprinkler robot is capable of detecting grass height via an ultrasonic sensor and can be controlled remotely through the HC-05 interface module.

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1. INTRODUCTION

Grass is a type of plant with narrow, tapering leaves that sprout from the base of its stem. It is commonly cultivated for decorative purposes, medicinal use, and as feed for animals. However, when it grows in agricultural fields, it can impede the growth of main crops and is therefore considered a nuisance plant or weed. Nonetheless, grass serves as a primary food source for herbivores and other plant-eating animals. Several types of grass commonly cultivated in Indonesia include Japanese grass, mini elephant grass, Peking grass, Manila grass, sedge grass, chives, and weeds. To prevent grass from overgrowing, various methods are employed to control it, such as manually cutting it with a hoe or a lawn mower, as well as using grass poison for eradication[1].

Grass poison is the most effective way to control the growth of wild grass in plantation areas and rice fields. By using this poison, farmers no longer need to bother weeding them one by one using a hoe. Conversely, grass poison, commonly known as paraquat, poses significant danger if humans inhale it, leading to insecticide poisoning. Insecticide poisoning occurs when insect poison is ingested, inhaled, or absorbed through the skin in large quantities. This condition is classified as dangerous, and must receive immediate medical treatment. To anticipate the problem of someone being exposed to insecticide poisoning due to manually operating a grass poison sprinkler, researchers want to design a device or a kind of robot that aims to be able to be controlled remotely to water the grass with grass poison[2], [3], [4]. Apart from that, this tool is able to move from one place to another so that the tool can poison grass in many places. In designing a remote control robot system using automatic watering, using the PID Control Tunning method[5], [6].

PID control is a combination of Proportional, Integral and Derivative control. The purpose of this merger is because if each controller stands alone, when there is a deficiency in the controller, then the controller is unable to correct the deficiency. Therefore, combining the three control elements will mutually fill any resulting deficiencies. The advantage of PID control is based on each P, I and D control, namely to speed up system reactions[7], [8], [9]. In designing a plant watering robot, starting from developing an application or software using the Mitt App Inventor application which is connected to the HC-05 interface, and then designing a prototype or robot project using an Arduino type controller, driver IC module and DC motor and the final stage of the PID method in the research testing and application[10], [11], [12], [13], [14].

The research carried out will discuss watering poisoned grass on research objects in the form of weeds in house yards, and types of grass objects that are usually poisoned, types of weeds or types of wild grass that grow in residential yards. Meanwhile, if the type of grass is in the weed category, or grass that is more than 1 meter high, generally it is not watered by poisoning, but by cutting it using a lawn mower.

The advantages of this grass poison sprinkler robot design include that. The advantage of this tool is that it allows users to avoid direct contact with grass poison, thereby preventing inhalation and insecticide poisoning. However, the design has limitations, including a maximum poison capacity of 2.5 liters and a spray power of approximately 0.21 psi. These specifications resulted from calibrating water pressure against gravitational force, yielding a water level of around 0.15 liters. The current robot design resembles a robot car, indicating potential for further development. Additionally, the control system's range is limited to 10 meters due to its use of the HC-05 interface. One solution to extend coverage over greater distances is to employ a radiolink transmitter of the RC type, although this approach carries drawbacks, including high costs and susceptibility to interference from other radiolink devices.

2. RESEARCH METHOD

Research methods are the procedures for how research will be carried out. This research method is often confused with research procedures or research techniques. Research methods encompass the processes involved in conducting research, whereas research procedures pertain to the instruments utilized for data measurement or collection. Consequently, research methods encompass both research procedures and techniques. In the conducted research, a qualitative approach was employed, characterized by its descriptive nature and emphasis on analytical processes and subjective meanings from the perspective of the subjects. Theoretical frameworks guided the research to ensure alignment between the research focus and the realities observed in the field[15], [16], [17], [18].

2.1. Tool Design Flowchart

The working system of the flowchart in the tool design, when the robot is activated, will undergo an initialization process, namely the process where the ultrasonic sensor positions itself as input, relay, IC driver, as output and the HC-05 interface as an intermediary between the interface to Android. After the interface and Android are connected, the controller will compare the data sent by Android, whether the data is written or not. If the data sent is written and legible, then the device design will be active according to the written command, while if it is not written, the device design will not work or not respond[19], [20], [21].

It explains the working system of tool design using the PID method, where the control system for the robot car to move forward, left, right and backward is controlled using remote control by utilizing the control system from the Bluetooth and Android networks. Meanwhile, for grass detection, it will be read by the ultrasonic sensor, and when the ultrasonic sensor detects the distance from PID 1, then relay1 will be active and the pump will also be active with voltage 1 (11.1Vdc) while for PID 2, then relay2 will be active and the pump will also active with voltage 2 (14.8Vdc).

3. RESULTS AND DISCUSSION

Analysis of the data required in making a grass poison sprinkler robot using the PID algorithm by utilizing a remote control system, finding several hardware data or input, controller and output modules including:

1. Ultrasonic Sensor ultrasonic SFR 05, where the ultrasonic working voltage is 5VDC and GND. Apart from that, the sensor has a Transmitter (Sender) and receiver (receiver) pin.
2. IC Driver
   To drive a dc motor with a voltage of 12VDC and reverse the rotation of the dc motor, a driver IC is needed. The driver IC in this study uses the l298d IC type with a working voltage of 12VDC
3. Interface module
   How to connect Android hardware to a grass poisoning robot car, using a Bluetooth network, so you need an HC-05 interface module which is connected via an Android address.
4. DC motors
   The driving motor uses a 12VDC dc motor with a power of 90 Rpm and type JGY-370.
5. Relays
   The automatic switch system used is a 5 VDC relay type where the voltage is taken from the electricity supply of the Arduino nano. The relay used is a 2 channel relay type, so the relay can be active alternately or turn on and off simultaneously.

3.1. Test Results for Voltage Measurement with a Multitester

The test results on the grass poison sprinkler robot have two tests, namely testing with commands or sketch programs, and testing the voltage between the controller and the load, so that you know the output voltage and the input voltage.

a. Testing the controller with Driver IC

The driver IC used is a L298N type driver IC with a nano type board. Meanwhile, the working voltage on the driver IC used is 7.4VDC. The results of testing the IC driver with Arduino nano are shown in table 1 below.

Table 1. Test Results for Controller, Driver IC and DC Motor load

Voltage	Motor Pins	Status	Information
3.3 VDC	A1	HIGH	Not moving
	A2	HIGH	Not moving
	B1	HIGH	Not moving
	B2	HIGH	Not moving
5 VDC	A1	HIGH	Move Slowly
	A2	HIGH	Move Slowly
	B1	HIGH	Move Slowly
	B2	HIGH	Move Slowly
7.4-11.1VDC (External Voltage)	A1	HIGH	Move quickly
	A2	HIGH	Move quickly
	B1	HIGH	Move quickly
	B2	HIGH	Move quickly

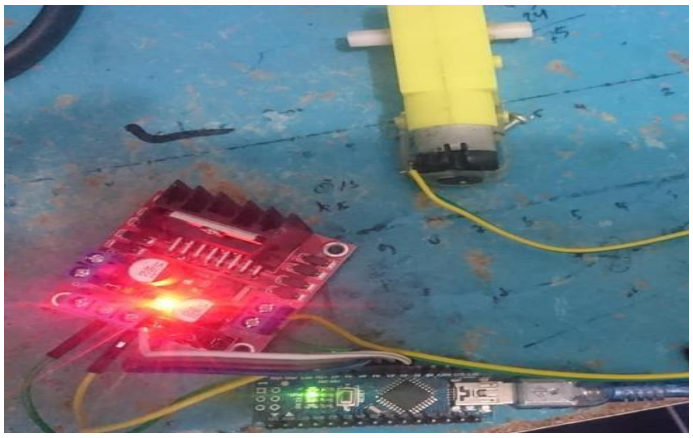

Figure 1. Arduino with Driver IC

Based on figure 1 above, it shows a dc motor with a working voltage of 5 to 12 VDC, and has a frequency of 50Hz, and has north and south poles. So you can find the RPM of the wheel drive motor, shown in the equation below.

$$\boldsymbol{N = (f \,.\, 120) : P}$$

Information :
N : Number of Revolutions Per Minute (Rpm)
f : Frequency (Hz)
P : Number of poles (Coils)

The datasheet for the two types of motors used in the robot design is shown in the table below.

Table 2. Motor Speed Specifications / Minute

Motor type	Vin	Electric Current	N = (F . 120) : P
Wheel Drive Motor	6-12 VDC	70mA-250mA	Not moving
Pump Motor	12 VDC	0,5-0,7mA	Move quickly

Figure 2. Grass poison pump motor view

Water discharge refers to the amount of liquid flowing across a specific cross-section or that can be managed within a given timeframe. Symbolically, discharge is denoted by Q and is determined by the volume of liquid and the duration of its flow.

To illustrate, when a pump motor operating at 12VDC releases water, it can produce 700ml of water in 30 seconds. Therefore, the water discharge rate is calculated as 1.4 liters per minute (LPM) or approximately 0.023 liters per second (l/s). This calculation is supported by the following equation.

$$Q = V / t$$

Information :
Q = Fluid flow rate (m3/s)
t = time (s)
V = fluid flow speed (m/s)

Meanwhile, the nozzle output has a thread size of 19 mm, and the length of the hose for draining grass poison is around 0.8 m. Obtain a water volume value of around 15.2ml/s according to the equation below.

$$V = A . L$$

Information :
V = Volume of flowing water (m3)
A = cross-sectional area (m2)
L = Pipe length (m)

After finding the volume of water in the hose, to find out the water discharge released by the nozzle with a 19mm thread, and the water volume is 15.2 ml/s, the water discharge released by the nozzle is around 289ml/s or the equivalent of 17.3 LPM. As shown in the equation below.

$$Q = A.V$$

Information :
Q = Fluid flow rate (m3/s)
A = cross-sectional area (m2)
V = Volume of flowing water (m3)

b. Testing controllers with ultrasonic sensors

The sensors employed in this study utilize ultrasonic or distance measurement technology. These sensors serve the purpose of determining the distance between objects and the sensor. When the distance falls below a specified threshold, the sensor transmits data to the Arduino controller. The sensors operate at a voltage of 3.3VDC, drawing power from the Arduino Nano controller supply. The test outcomes for the SFR05 ultrasonic sensor are detailed in the following table.

Table 3. Controller test results with SFR 05

Voltage	Distance
5 VDC	16 cm
	20 cm
	25 cm
	30 cm

The table above explains the ultrasonic sensor which works from a distance of 16 cm, so if you add a command if it is less than 16 cm, or more than 30 cm, the other output is active or not.

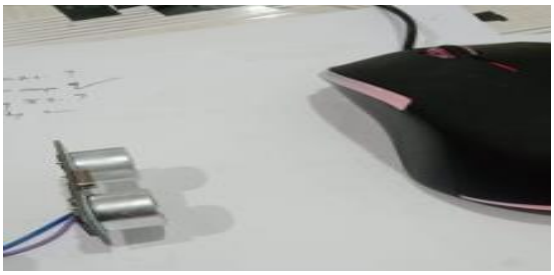

Figure 3. Ultrasonic sensor testing

The image above shows the SFR-05 or ultrasonic sensor being blocked by an object, so it displays distance data according to table 3 or the serial monitor display. For mathematical calculations:

$$S = 340.t/2$$

Information:
S = Distance of object
T = Difference in time when the wave is transmitted and received

c. Testing the controller with the HC-05 interface

The interface used is the HC-05 type, where the interface is used to connect an Android device to an Arduino nano device, by utilizing the transmitter and receiver pin functions on each controller and Arduino module. The results of the tests carried out are shown in table 4 below.

Table 4. Arduino test results with hc05 interface

Voltage	Controller	Interface	Address	Data	Distance
5VDC	RX TX	RX TX	*detected*	Not sent	-
5 VDC	RX TX	TX RX	*detected*	Sent	0 -10m

The table above explains that the Arduino receiver (RX) pin must be connected to the transmitter (TX) pin of the HC-05 interface and supplied with 5VDC voltage, so that the data sent by Android can be read by the controller through the interface or data sent and received.

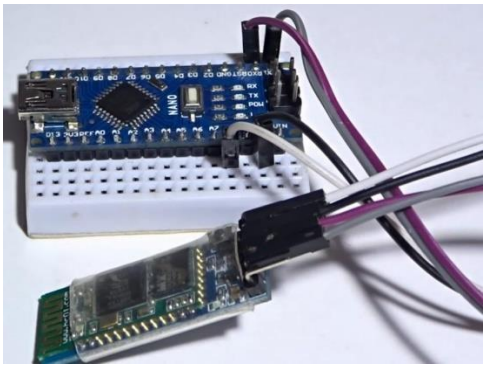

Figure 4. Testing Arduino Nano with HC-05 interface

The picture above explains how to send data between the HC-05 interface and the Arduino nano controller. Testing can be seen by comparing the data sent by the input (Android) with the data received by the Arduino (Serial monitor). Meanwhile, testing in another way, namely connecting the input (Android) with the interface address of HC-05.

3.2. PID (Proportional Integral and Derivative) Method Testing

The use of an ultrasonic sensor must be compared with the reading from a ruler or ruler, so that the difference results are obtained which will later be converted into a distance comparison difference or error.

Table 5. Comparison Results of Ultrasonic Sensors with Ruler at a delay of 1000ms or 1 s

Voltage	Ultrasonic sensor 1 and object (Su)	Ruler and objects (Sp)	Distance Difference (Sp|u)
1	1 cm	2 cm	1 cm.
2	5 cm	6 cm	1 cm
3	10 cm	11 cm	1 cm
4	15 cm	15 cm	0 cm

5	20 cm	21 cm	1cm
6	25 cm	27 cm	2 cm
7	30 cm	32cm	2 cm
8	35 cm	37cm	2 cm
9	40 cm	4 3 cm	3 cm
0	50 cm	53 cm	3 cm
Error -	231 cm		
Error +		247 cm	
Error rata”			16 cm

From the calibration data of the ultrasonic sensor obtained, it can be seen that the difference in the measurement distance between the ultrasonic sensor and the object and the ruler and the object is found.

a. Distance difference ($S_{p|u}$) or error e(t)

Total distance difference = Ruler distance difference – ultrasonic distance difference (Sp|u) or e (t) = 247 – 231 = 16 cm

b. Pump voltage difference (∂)

The grass poison sprinkler pump has 2 different voltages, where if the us 1 sensor range detects grass height in the range 15cm to 20 cm, then the pump will be supplied with a voltage of 11.1 VDC, and if the range is 21 to 30, then the pump will be supplied with a voltage of 14.8VDC.

Voltage difference = Condition 2 voltage – Condition 1 voltage VA/B = VB- VA

= 14.8 – 11.1

= 3.7 VDC

The average error between the ultrasonic sensor and the manual ruler is 1.6 cm (calibration advantages and disadvantages: 10). Meanwhile, for error (e) found (ruler and object reading - ultrasonic reading), found error value (e) = 16.

c. Gain Constant (K)

K = e (t) / ∂

K = 16 / 3.7 = 4.32

3.3. Application of Grass Poison Sprinkler Robot Car Controller

The application used to control the grass poisoning robot car uses the Mitt App Inventor application. This application was chosen because it is more practical, writing sketches does not use commands, but uses a blog program system.

The way to design a command application for the grass poison sprinkler robot car control system in the design of this tool includes:

a. Log in to Mozzilla/Google Chrome. Next go to http://ai2.appinventor.mit.edu/
b. The App Inventor initial display will appear
c. Next, click start new project, so the Create new App Inventor Project column will appear. In the Project name column, enter the name of the application that we will create.
d. If you have reached the step of naming the project, then press OK. So we will be taken to the Designer appearance
e. Click layout on the Pallet then select / Drag Vertical Arrangement to Screen 1. This step aims to arrange the button display layout in the Android application.
f. In this step we will set Vertical Arrangement1. In Properties - Vertical Arrangement 1.
   Height : Fill parent
   Width : Fill parent
   BackgroundColor : None
g. Create a button display for the listPicker and labels found in the User Interface, while for the clock it can be found in Sensor, while for Bluetooth Client it can be found in Connectivity.
h. Enter the image in the Text For List Picker1, (the image is the Bluetooth symbol) then change the Text for Label 1 to press Bluetooth, and the text is changed to Not Connected and colored red.
i. Now we just have to go to the final stage, which is just to enter the program block, by: clicking BLOCK at the end of the application. Then the Program Code block Writing Display will appear
j. At this stage, we will enter the block program language that will run the application we created. By clicking on the existing block. For example, we want to display the When Screen program language block. Back Pressed do (this is a command to press screen 1 to display the next command), then just click, block.
k. Enter the program language block which aims to run Android applications for Arduino.
l. If the program language block has been created, the last step we need to do is save the application to Android or download it, by clicking Build then 2 options will appear, App (provide QR code for.apk) which functions to download the application via additional software on Android, MIT AI2 Companion, can be downloaded on Playstore, and the other App (save. apk to my computer), can be downloaded via computer/laptop and then installed on Android.

3.4. Overall Testing

Based on the overall test results from testing using a multitester, and using the PID method, it was found that the robot has two working systems, namely the first system is a remote control system, where to control the robot car moving forward, backward, left and right using a remote control system with utilizing the HC-05 interface module with a working voltage of 5VDC supplied from Arduino nano. For the HC-05 interface testing distance is 0 to 10 m. Meanwhile, the DC motor driving the wheels works at a voltage of 7.4 Vdc which is connected to the L298n driver IC, with the command HIGH to be active and LOW to be silent. Meanwhile, for watering plants, the PID method is used and a multitester measurement system is used. The SFR 05 ultrasonic sensor works on 5VDC voltage, and this voltage is supplied from the Arduino nano controller.

After testing and comparing the measurement results between the ultrasonic sensor and the ruler, we found that the test results had a total distance difference (Sp|u) of 16cm, or an average of 1.6cm. Meanwhile the difference in voltage A and B is at a value of 3.7 Vdc, where the detection distance is for a distance of 15cm to 20cm, then relay 1 when the distance measured is between 15cm to 25cm, relay 1 activates while relay 2 remains inactive, supplying the pump with a voltage of 11.1VDC. Conversely, when the distance is between 25cm to 30cm, relay 1 deactivates and relay 2 activates, supplying the pump with a voltage of 14.8VDC. The pump outputs water at a rate of approximately 700ml every 30 seconds with a 12VDC input, resulting in a water flow rate of 1.4 liters per minute (LPM) or about 0.0231 liters per second (L/s), equivalent to 0.016 LPM.

Additionally, the nozzle has a thread size of 19mm, and the draining hose for the grass poison measures approximately 0.8 meters in length. The water flow rate through the nozzle is measured at approximately 15.2ml/s. Considering these values, the water discharge from the nozzle is estimated to be around 289ml/s or 0.289 LPM. Moreover, the PID (Proportional Integral Derivative) parameters obtained from mathematical testing are as follows: Kp = 0.97, Ki = 0.06, and Kd = 2.23.

3.5. Overview Of Tool Module Installation

An illustration of the installation of the tool module is shown in the image below. This is done to minimize excessive cable usage and prevent repeated hardware installation, resulting in trouble in the form of overhead due to frequent interruptions.

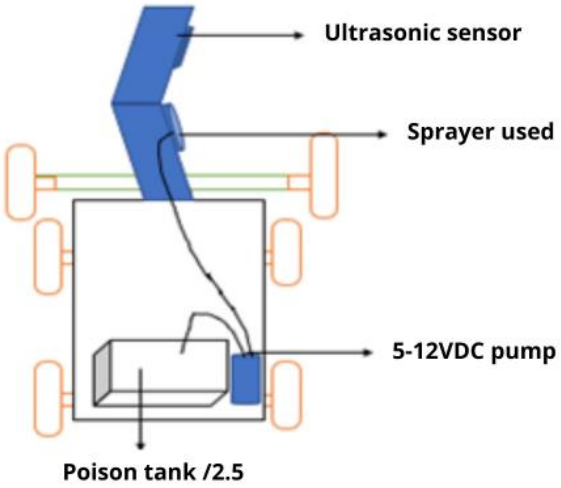

Figure 5. Top view of the robot

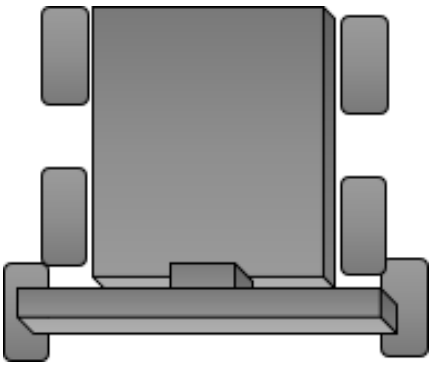

Figure 6. Display of the design of a Robot Car without Sprinklers

4. CONCLUSION

To anticipate the occurrence of grass insecticide poisoning by inhalation by users or users who want to water poison grass manually, a weed poison watering robot was designed using microcontroller technology. The robot can be controlled using remote commands from Android, namely using the Android control system (Bluetooth) with a maximum sending distance of 10 meters. The use of a Bluetooth network is because the Bluetooth frequency system cannot be disturbed by reading the address of the interface device. Apart from that, the grass poison watering robot will also water using the PID method with a PID1 distance of 15 to 20cm, the pump will be active with a voltage of 11.1 vdc. Meanwhile, with a PID distance of 2, a distance of 25 to 30, the pump will be active with a voltage of 14.8vdc

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