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Automatic Pesticide Sprayer Bot

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Abstract: Pesticide spraying is a necessary activity in agriculture to get higher yields and protect our crops from weeds, insects, and fungi. As a result, manual pesticide spraying is practiced in most parts of India. Manual spraying results in direct contact with pesticides, which give birth to numerous health problems, including severe diseases for farmers. As a part of the solution, we propose an automatic pesticide sprayer. Using this bot, farmers will be able to spray pesticides remotely without any physical contact during spraying. Generally, more than one person is involved in manual spraying, but using this bot, a single person can operate spraying activities using a mobile application remotely.

Keywords: — Pesticide spraying, Automatic spraying, Agriculture, Manual Spraying, Pesticides.

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1. Introduction

Agriculture is one of the huge and important sectors that fulfils the food requirements of the world. Agriculture involves different activities, of which pesticide spraying is the major one. Farmers used to spray pesticides to protect their crops from insects, weeds, fungi, and many other diseases. Due to the lack of cheap technology available for pesticide spraying, the majority of farmers use traditional spraying methods, i.e., manual pesticide spraying. This traditional method is not only time-consuming but also hectic and inefficient at the same time. In manual spraying, farmers carry heavy pesticide-loaded tanks on their backs, and they have to spray all day into the fields. This increases the difficulty of spraying for farmers. In manual spraying, farmers are exposed to poisonous pesticides, which are hazardous to both the farmer's life as well as to working labour [1].

According to many studies done worldwide on farmers affected by exposure to poisonous pesticides, the casualties are in the thousands. Exposure to these poisonous pesticides causes a variety of diseases, including skin irritation, eye irritation, respiratory problems, and even cancer [2].All of these practises are done due to the limited availability of cheap spraying technologies for contactless spraying. The automatic pesticide sprayer bot that we propose can be the solution for all those problems faced by farmers. This bot can be operated over Wi-Fi technology, which will ensure contactless spraying. This bot itself will be able to spray into the crop, which will be operated by the farmer at a distance. The bot has two spoke wheels, a tank for pesticide, a DC water pump, high-torque DC motors, a lithium-ion battery, an ESP8266 Wi-Fi module, and a motor driver. The communication between the operator and the bot will be done over Wi-Fi, which has a range of up to 8 to 10 meters.

The remainder of the paper is organized as follows: Section 2 presents a literature review, Section 3 presents the methodology, Section 4 presents the results and discussion, Section 5 presents the study's limitations, and Section 6 concludes the paper.

2. Literature review

Today's world requires technology. Every sector is growing by introducing modern technologies to their work and enjoying high efficiency and huge profit. Similarly, agriculture also takes a step forward in using new technologies in its agricultural work [2]. It is also a sector that requires huge amounts of labour and intense physical work. Technology is the thing that can change the face of agriculture forever [3]. Agriculture means practising numerous practices, right from sowing the seed to cutting the crops. Pesticide spraying is one of those activities that is so hectic, inefficient, and hazardous[4].

Advanced and expensive technologies are unaffordable to common farmers, and they require cheaper equipment with well-equipped technology. 80% of farmers use the traditional spraying method for pesticide spraying [5]. Traditional spraying involves direct contact with hazardous pesticides. Farmers become chronically intoxicated while performing activities such as mixing, loading, spraying, and cleaning spray pumps, which can lead to chronic diseases such as skin cancer, respiratory diseases, multiple basal cell carcinomas, and squamous cell carcinomas [6].The farmers feel fatigued, dizzy, or have headaches because of the constant manual spraying [7].

Today's world requires technology. Every sector is growing by introducing modern technologies to their work and enjoying high efficiency and huge profit. Similarly, agriculture also takes a step forward by using new technologies in its agricultural work. It is also a sector that requires huge amounts of labour and intense physical work. Technology is the thing that can change the face of agriculture forever. Because the insects and pests are living under the crop's leaves, it is difficult for laborers to spray under the leaves of the crop. This results in reduced yields, lower crop quality, and damage to the crops. In this paper, the aim is to design and develop an autonomous pesticide sprayer for the chilli fustigation system. In chilli fustigation farms, pests such as mites, snails, and maggots are common types of pests that can be found by making the plants their source of food and breeding ground. Normally, the workers need to manually spray the pesticide while wearing protective gear and walking through the crops. This method is inefficient, and the hazardous chemicals used in spraying can be fatal to workers even when they are wearing protective gear, according to research, because the gear does not stop the chemical but only reduces the amount of exposure.Further, the study is intended to implement a flexible sprayer arm to spray the pesticide under the crop's leaves [4].

The main goal of the paper "Health impact of pesticide using method at sprayed worker farmer in Sumber Mufakat Village, Karo" (5) was to learn about the health effects of pesticides and different spraying methods used by workers and farmers in Sumber Mufakat Village, Kabanjahe Karo.This is an analytical survey with a cross-sectional design to find out the health impact of the pesticides sprayed on farmers and workers. This research concluded that there was a significant relationship between pesticide-using methods and the health impacts on farmers and workers.

In the paper "Design and Implementation of Solar Powered Automatic Pesticide Sprayer for Agriculture" [7], the author develops a pesticide mixer that automatically mixes the pesticide and water in a particular ratio, and the mixer is automatically sprayed onto the field on the programmed date with the help of a PLC. Also, soil moisture conditions and the water level are monitored using moisture sensors and ultrasonic sensors. If the soil moisture level is low or high, the transmitter RF sends a signal to the receiver RF, and accordingly, the motor is turned on or off with the help of the PLC. The PLC is programmed with the date and time for the automatic pesticide mixer operation. Manual mode is also available in case of emergency by turning on even before the scheduled date arrives.

Multipurpose pesticide sprayers can also be seen on the market. A manually operated pesticide and fertiliser sprayer [8] can be effective for middle-class farmers, but it also adds a manual touch to pesticide spraying. So, this type of manual sprayer again makes the job worse for farmers.

The proposed automatic robot can walk at any point of the plant and farm crops autonomously while spraying pesticides using a CNC machine[9].The robot is designed to plant plants with solid media and with planting area dimensions that can be adjusted to meet the needs [10].

Different technologies, such as controlling the robot's movement with a PLC microcontroller, can be used to make the robot autonomous. It is possible to obtain online flow control of spray, linear, and automatic flow control by using a PID controller in the closed loop feedback of sprinkler motors [11]. The automaticity of the bot can be increased by using a lidar sensor. Plant detection, autonomous control, and autonomous spraying can be achieved by lidar[12][13] [14].

3. Methodology

The manufacturing of the bot is divided into three parts. In the first part, 3-D modeling of the bot's frame was done, the second one is hardware interfacing and the third one is programming and communication i.e. the software part was done in the third part. In the first part, measurements of all its components and their arrangement were done. After that assemble them as per the 3-D model.

A. *3D MODELLING*

The 3-D model of the bot was prepared using online software called Tinkercad. It is basic modeling software that provides the environment for simple and quick modeling of any object. [Fig 1]

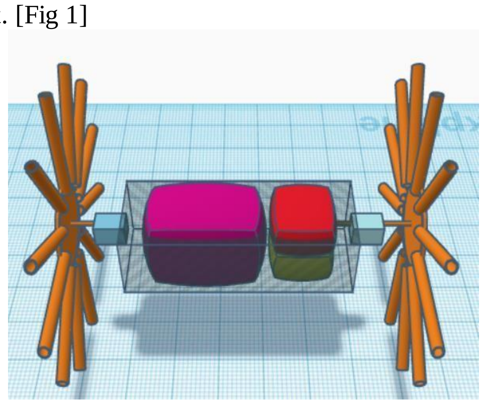

Figure 1: 3D MODEL

B. *HARDWARE*

Aluminum pipes of 6mm diameter were required for wheels. The bot has a total of two wheels, each wheel will have 12 such pipes i.e., overall 24 pipes for 2 wheels of the bot. 6 mm plywood for the container present between the wheels as it needs to be strong and rigid. A small 400ml tank for carrying pesticides, 50+ nut bolts to attach aluminum pipes to plywood. As a modification to the bot, we used T-shape connectors at the end of the aluminum rod which will be in contact with the ground, a 3mm pipe with a nozzle for spraying[15].

C. *ELECTRONIC COMPONENTS AND SOFTWARE*

To get sufficient torque, 2 motors of 60 rpm each were used. Each motor can provide a torque of 2 kg-cm and draws a max load current of 300 mA. A 12V DC pump is used for spraying pesticides, its working current is between 0.5 to 0.7A. Its power requirements are between 4W-7W, and its max water flow is between 1-3L/min. The 2-channel LM298 series motor driver was used to run the DC pump and our main wheel motors. 12V li-ion batteries are being used to power up the whole assembly. ESP 8266 Wi-Fi module is used as a microcontroller. Its operation voltage is 3.3V[16].

The free online IoT platform called Blynk was used to remotely operate the bot. It is available in both a web app and an android application. In this application, there are two sliders one for controlling the speed of the bot and another one for pump operation. Four buttons are used to set the forward and backward motion of the bot. A joystick for better handling purposes is also in the interface. ESP 8266 module was programmed with the Arduino IDE which is an Arduino Integrated Development Environment[17].

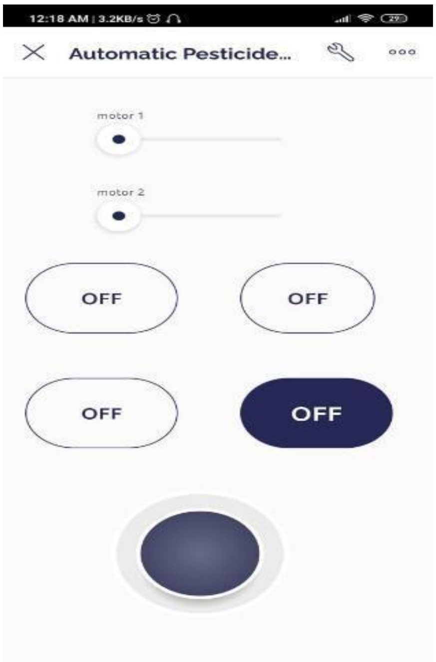

Figure 1: Blynk Software Console

After collecting all hardware components assemble them according to the 3-D model. There are two main parts made and those are wheels and containers.

a) Wheel Dimensions

Bot assembly has two wheels. Each wheel consists of 12 aluminum rods having a T-shape connector at the end of each wheel. The length of each aluminum rod is 24 cm from the ground. All Aluminum rods are fixed with nuts and bolts to a 3mm plywood disc with a diameter of 18 cm. Rods are fixed such that they are 3 cm inside the disc. Thus, after adding the length of the rod and disc the diameter of the wheel becomes 54 cm. 12 wheel rods were fixed on the circumference of plywood. The angle between the two aluminum rods is 30^0.

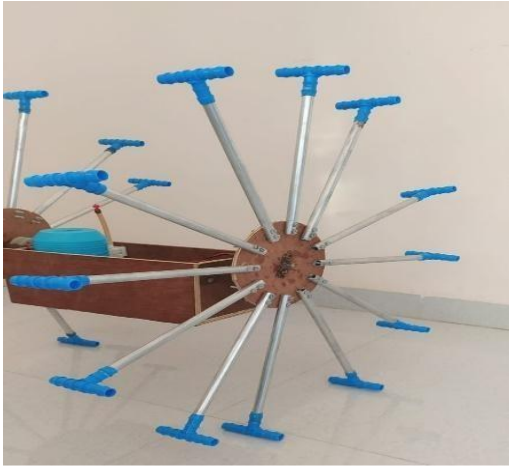

Figure 2: Spoke Wheel Design

b) Container Dimensions

The container is the part between the two wheels of the bot, and it will carry all the electronic components along with the pesticide tank and the DC pump. The container is a rectangular box of 29 cm in length, 12 cm in height, and a width of 14 cm. Its sizing is sufficient to hold a pesticide tank with a pump and all electronic components. [Fig IV]

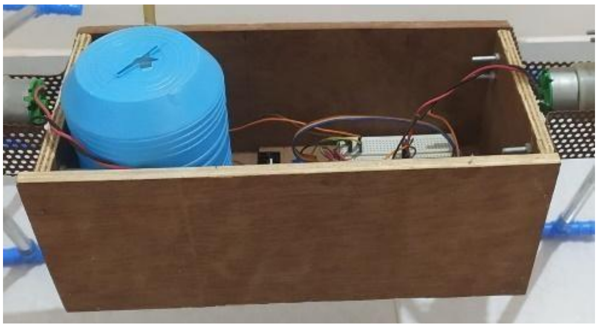

Figure 3: Container with Electronic Circuit

c) Communication with Bot

Once all components were collected and manufactured all required parts, the only thing is left is the programming of the microcontroller board and designing UI in the Blynk console. [18] By using Arduino IDE[19][20], the programming of the ESP 8266 Wi-Fi module was done. On Blynk, the GUI was designed in which there are buttons and sliders to operate the bot [Fig 2.]. Once we made all electronic components connections, the bot can operate with the Blynk console. ESP 8266 Wi-Fi module has a Wi-Fi transceiver with an operating range between 2400-2484 MHz and it also supports TCP/IP[21] communication stack and Wi-Fi security including WAP3 [Fig 5].

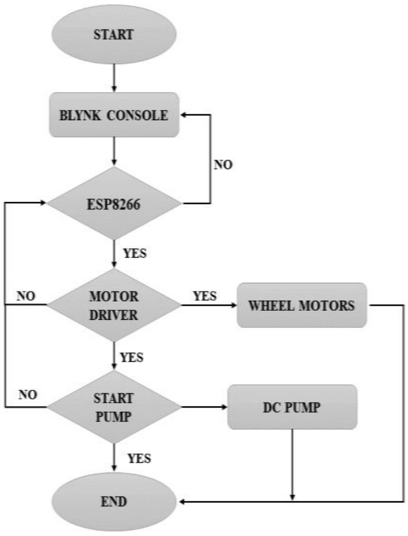

Figure 4: Communication Flowchart between Bot and Mobile Application

4. Result and Discussions

When the bot was manufactured completely, the bot was tested testing on 3 different surfaces. The first surface is a plane surface, the second one is on the playground, and the third is on rocky soil which is like farm soil. While its first testing, instead of wheels the container between the wheels started rotating. This happens due to the torque produced by the motors adds up and rotates the container which was not expected as the probable outcome. The ends of aluminum rods of wheels were found to get fixed and dip into the ground which makes it unable to move forward even though enough torque is provided by the motors which leads the containers to rotate. To overcome this t-shape connectors were fitted at the end of each rod of the wheel. Due to this arrangement, the problem of fixing of rod's end of wheels into the ground was solved.

The second modification was done by attaching two small wheels of 7.5 cm in diameter to the front and back side of the container to counter the torque generated by the DC motors of the wheels. This arrangement ensures that the container does not rotate. After these two modifications, Bot was able to run. After testing the bot on the first three surfaces max efficiency of the bot was seen on the second surface in which testing was carried out on the normal ground. In the first test which was carried out on a plane surface, wheels manage to roll but not with that efficiency. Less friction was the issue with the plane surface. On the third rocky soil surface, the bot was perfectly moving in the presence of small rocks but struggles to move in large rocks.

5. Limitations

Bots have a limited range, due to which users or farmers have very little flexibility to operate the bot because of the WiFi technology that is being used for communication between the Blynk app and the bot. This gives the bot a short operating range of 10-15 meters. Muddy situations in the rainy season can create difficulties for the bot's smooth operation because, in the muddy soil of a farm, spoke wheels might not get good performance as spokes can get fixed into the mud. Network issues can be a big issue on the farm, as the esp. 8266 Wi-Fi module runs in the frequency range of 2400-2484 MHz.

6. Conclusion

Once the bot is completed and ready for testing, and after considering different parameters, it will be able to spray on the farm. The spraying can be controlled by the farmer or the user remotely within the Wi-Fi range. It will be able to spray directly into the crops by passing through them. Currently, considering the height of the bot, it will mostly be able to spray on short crops. It is perfect to spray on crops like grains, soybeans, wheat, cotton, and many more in their initial growing stage. It will be able to spray on all those farms in their growing stage because of the small height of the bot. Spoke wheels make the bot more rigid on uneven farmland with rocks and soil. Those special design wheels will make it possible to run our bot in farm soil conditions. The bot may face problems in muddy soil conditions because its wheel has spokes, which are easy to get stuck in in muddy soil conditions.

The two-wheel configuration is unstable because the torque produced by the motors adds up to rotate the payload box, which is in between the wheels. An additional two wheels must be attached to the payload box to counterbalance the torque produced by the motors. As a result, our two-wheeled robot now has four wheels. But still, it can run on the ground. In the future, the main focus will be on increasing the range of operation of the bot, as for now it can only be operated within a very short range. The plan is to use the Zigbee protocol for communication, as it allows connectivity over a long range. As for now, we used to frequently charge the batteries, but for the next use we are planning to set up solar charging, which will solve the problem of regular charging. Different nozzles and their combinations for spraying can be used, which can cover a larger area.

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