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RESEARCH ARTICLE

Internet of Things (IoT) based Pesticide Spraying Robot - A Revolution in Smart Farming

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Abstract

Objective: To design a spraying robot based on IoT that uses less pesticide while posing fewer threats to humans and the environment. **Methods:** The proposed approach uses the ARM7 controller coupled with the robotic platform. **Findings:** A quantitative comparison with recently proposed spraying robots with our robot revealed that our robot is not only superior in range (50 m) of pesticide spreading, but it is also used less power (3.3 V only), could carry relatively huge weight (three liters), it has got optimal control navigation, and most importantly, it is economically feasible that it only needed less than USD 250 to fabricate. **Novelty:** Since Bluetooth controls the robot, pesticide treatments can be planned entirely through Bluetooth. In response to a precise command to the controller, the pump will turn on wherever the farmer wants to spray pesticides. The robot may be made to go forward, backward, right, left, or stop by giving it commands.

Keywords: IoT; ARM 7 Controller; Bluetooth; Pesticides; Smart Farming

1 Introduction

Agricultural equipment makers and engineers have strived to reduce human effort for many years. Numerous initiatives have also been made to minimize the labor necessary for various farm activities. To counteract this fundamental problem, smart agriculture has just been launched, in which IoT-assisted robots will be used to spray pesticides and identify crop health. Nonetheless, the proposed robots need to be improved.

For example, while proposing an innovative automatic pesticide spraying bot that is mounted to the robotic arm and provides both vertical and horizontal locomotion,[(1)] claimed that the motor provides the rotational restriction crucial for the sprayer mechanism. However, due to the use of mechanical parts, accurate optimal control navigation may not be possible with this robot. An aircraft-type autonomous agricultural drone for spraying pesticides was designed to fly under different altitude ranges and speeds. It could, however, carry only 2 liters of pesticides as a payload[2].

Lakhiar et al.[3] aimed to increase the use of modern technology in the agricultural sector by proposing affordable approaches for farmers. It is also widely discussed how innovative agricultural technology might solve a few issues with intensive farming. Kalpana et al.[4] described an approach for developing autonomous pesticide-spraying agricultural drones. The envisioned agricultural drone may spray pesticides over farm areas using any GCS-specified trajectory. The ground control station and the drone are the two main parts of the drone system. On top of a lightweight plywood and foam pad chassis, the twin-tail pusher agricultural drone's airframe was constructed from fiberglass composites that reduce the drone's weight. But, this design has limited functions. A robot for spraying fertilizers and pesticides developed by[5] has tremendously reduced labor costs, but the crop coverage of this robot is less compared to the existing or our robot.

By integrating various sensors (moisture detector, temperature sensor, ultrasonic sensor),[6] designed a prototype 'Agrobot' that successfully detected soil moisture in farming sectors. Because various sensors have been put together, maneuvering might be a big issue that cannot frequently sense the whole area of the land. A pesticide spraying robot has been designed that is guided by rancher instructions. It is more cost-effective since this Agrobot uses fewer expensive components. The rancher may move the robot about the field using any Android PDA with this application installed. Due to an IoT application, ranchers have less control over pesticide spraying equipment[7]. A pesticide spraying device (or agricultural robot) that incorporated a solitary siphon engine along with an ultrasonic sensor was designed by Kanna and Vikram[8]. Due to adopting a mechanical sprayer to produce pressurized pesticides for the farmers, maneuvering is often tricky with this proposed robot.

Since most agricultural stakeholders are poor, especially in India, the first factor that draws their attention is the price. The other priorities of the farmers may be: the device needs to be simple and consumes less power, yet, and it has to carry relatively hefty weights. To succeed in the market, living up to their expectations is difficult. The same is true for the IoT in smart agriculture.

The fundamental aim of this research was to create an automated pesticide spraying robot that will demand fewer human efforts while also prioritizing farmer safety. By keeping those aspects in mind, we designed an agricultural robot (Figure 1, vehicle prototype), which is economically feasible and less power-consuming (only 3.3 V) one, and, yet, it is capable of carrying up to 3 kg of pesticides that assists farmers in pesticide spraying while reducing workload.

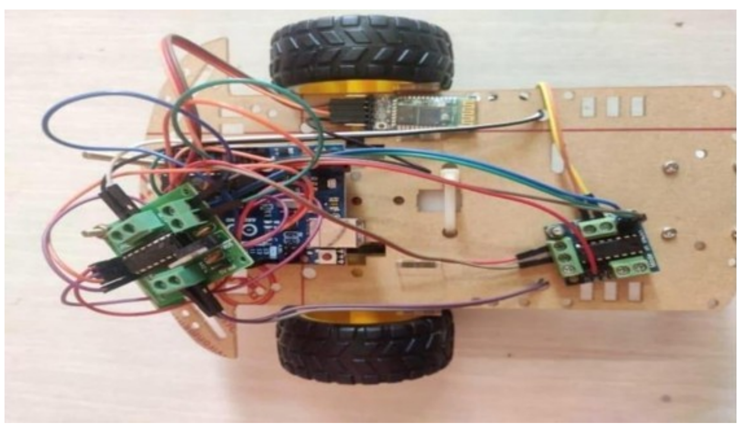

Fig 1. Vehicle Prototype

2 Methodology

As was discussed in the introduction, the existing robots or agri-robots suffered in several aspects, and we tried to minimize those gaps while developing our robot. The proposed robot in this research is superior in several factors: economically feasible, high spreading range, optimal maneuvering navigation, and increased weight-carrying capability. Apart from conventional methods, various sprayers are available such as foot sprayer, Knapsack sprayer, Aerial Sprayer, Rocker Sprayer, and Tractor-mounted sprayer[9].

2.1 Detailed Proposed Method

The ARM7 controller, which is connected to the robotic platform, is used in the proposed scheme. Robot is tended by Bluetooth, and we can organize pesticide application through Bluetooth solely. Wherever we wish to spray, we will give the controller a specific order, and the pump will switch on as a response. By imploring the robot to proceed forward, backward, right, left, or stopping, we can control it. Figure 2 shows the IoT based multipoint pesticide developed by us and Figure 3 shows block diagram of the spraying machine. Table 1 shows technical specifications of hardware used for the present spraying robot.

Fig 2. IoT based multipoint pesticide spraying machine developed by us.

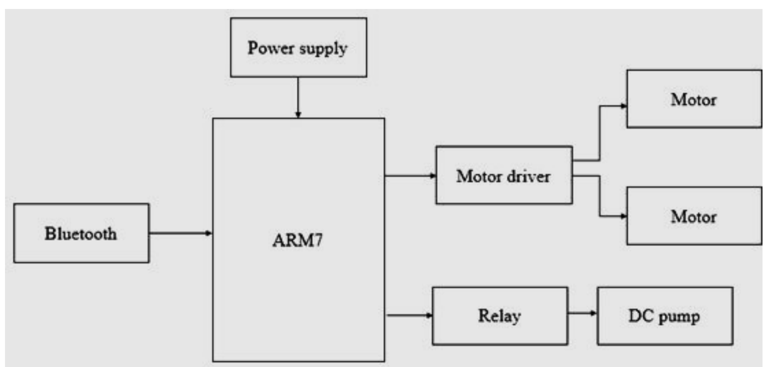

Fig 3. Block diagram of proposed IoT based multi-point pesticide spraying machine

Table 1. Technical specifications of hardware used for the spraying robot

S. No.	Component	Description
1.	ARM 7	The ARM7 LPC2148 is a 32-bit microcontroller based on the ARM7 TDMI-S core. It has a range of integrated peripherals including UART, SPI, I2C, and PWM, making it suitable for a wide range of applications. The LPC2148 also has a maximum clock speed of 60 MHz and up to 512 kB of on-chip flash Memory.
2.	HC-05	The HC-05 is a popular Bluetooth module that can be used to establish a wireless connection between two devices. It is commonly used in hobbyist and DIY projects for its low cost and ease of use. The module supports both master and slave modes of operation and can communicate with other Bluetooth- enabled devices within a range of up to 10 meters.
3.	Motor Driver	The L293D is a popular motor driver IC that can control up to two DC motors or one stepper motor. It provides bidirectional drive currents of up to 600 mA per channel and can handle peak currents of up to 1.2 A per channel. The L293D also includes built-in flyback diodes for protection against back EMF.
4.	DC Motor	A DC motor is an electric motor that operates using direct current (DC) as its power source. It converts electrical energy into mechanical energy through the interaction of magnetic fields. DC motors are widely used in a variety of applications, from small household appliances to large industrial machinery.

Continued on next page

Table 1 continued

5.	DC pump	A DC pump, also known as a direct current pump, is a type of pump that runs on DC power. It is commonly used in applications that require low flow rates and moderate pressure. DC pumps are popular for their efficiency, low power consumption, and compact size.
6.	Relay	A relay is an electrical switch that allows a low-power signal to control a high- power circuit. It works by using an electromagnet to open or close a set of contacts. Relays are commonly used in industrial control systems, automotive electronics, and home automation.
7.	Jumping Wires	Jumping wires, also known as jumpers, are short pieces of electrical wire used to connect two points on a circuit board or other electronic device. They are often used in prototyping and bread boarding to make temporary connections between components. Jumping wires can come in various lengths, gauges, and colors, and can be easily removed and replaced as needed.

2.2 Advantages of Spraying Robots

- **Precision:** Pesticide spraying robots are designed to precisely apply pesticides, herbicides, and other chemicals to crops, which can result in better crop yields and less waste.
- **Efficiency:** Pesticide spraying robots can cover large areas quickly and efficiently. This can save time and money compared to manual spraying methods
- **Data collection:** Some pesticide spraying robots are equipped with sensors and other technologies that can collect data on crop health and pest infestations. This data can be used to make informed decisions about pesticide use and crop management strategies
- **Safety:** Pesticide spraying robots can operate in hazardous or hard-to-reach areas, reducing the need for human exposure to potentially harmful chemicals
- **Sustainability:** Pesticide spraying robots can be programmed to apply pesticides in a targeted manner, reducing the overall amount of pesticides needed and minimizing their impact on the environment.

2.3 Limitations of Spraying Robots

- No specific maintenance is presented to navigation or the proportion of pesticides sprayed.
- The robot's control and navigation are woefully insufficient.
- The robot load capacity for transporting pesticides is lower, and
- Involves extensive equipment and increasing circuit complexity.

Drones have even better features in smart agriculture that they can have enhanced coverage ability, and as a drone flies over crops it can show the precise development of a crop. On the other hand, the biggest constraint of a spraying robot is that as it can move on wheels only like a rover placed on the surface of the moon or any celestial object, it cannot be used to assess the crops' health completely with great accuracy. Barring these constraints, the spraying robot is economically feasible that's why it is being preferred by the farmer community.

2.4 Applications

- **Precision farming:** An IoT-based pesticide spraying robot can be used in precision farming to apply pesticides, herbicides, and fertilizers in a targeted manner. This can result in better crop yields and less wastage of pesticides.
- **Smart agriculture:** In obtaining data on soil moisture, temperature, and other environmental parameters, an IoT- based pesticide spraying robot can be connected to sensors and certain other IoT devices. This data can be utilized to improve the rates and timing of chemical insecticides as well as other elements of crop management
- **Pest control:** An IoT-based pesticide spraying robot can be used for pest control in areas such as greenhouses and orchards. The robot can be programmed to identify and target specific pests, reducing the overall amount of pesticide needed.
- **Autonomous operation:** An IoT-based pesticide spraying robot can operate autonomously, reducing the need for human intervention and improving safety. The robot can be programmed to operate during off-hours, when workers are not present.
- **Remote monitoring and control:** An IoT-based pesticide spraying robot can be monitored and controlled remotely using a smartphone or other device. This can allow farmers and other agricultural workers to monitor the robot's operation from a distance, and make adjustments as needed.
- **Data analysis and decision-making:** An IoT-based pesticide spraying robot can collect and analyze data on crop health, pest infestations, and other factors. This data can be used to make informed decisions about pesticide use, crop

management strategies, and other aspects.

3 Results and Discussion

The following steps are taken into consideration to operate this robot in different environments, which include

- **Stage 1:** The first stage involves identifying the shortcomings of existing methods and proposing solutions by considering the fundamental requirements for the proposed system
- **Stage 2:** The next stage is to consider the hardware requirements for the proposed system. This involves selecting specific components such as a microcontroller, inputs (such as sensors or drivers), and outputs (such as relays or loads)
- **Stage 3:** After finalizing the hardware requirements, the software requirements are taken into account. The chosen microcontroller determines the available software options for coding, compiling, and debugging. The next step involves writing the source code for the system based on the requirements and debugging it using the selected software. After completing all the hardware and software requirements, the source code is burned into the microcontroller.
- Finally, the input and output modules are connected as per the system's needs to bring everything together and make the system operational and efficient to work under different situations.

The top view of the robot can be seen in Figure 4, which we used in a crop field near our college. We have quantitatively compared our robot and the existing models in the following table. Our model is, undoubtedly, superior in several aspects compared to earlier robots, as can be seen from Table 2. Nevertheless, a few researchers have designed better robots than our robot. For example, one that was designed by Hasan et al.[2] has got better features compared to our robot. But, the model proposed by Hasan et al.[2] needs to b revised regarding the cost involved and the weight that carries. Further, it may not be an exaggeration to inform that our robot has almost all optimal characteristics compared to earlier designs. Still, the endurance of our robot is less compared to the robots proposed by[2,10,11].

Table 2. Comparisons of different features between earlier robots and our robot.

Researcher (s) and Reference no	Controller & operating voltage	Economically feasible	Spraying Coverage	Plastic Container capacity	Disadvantages
Hasan et al. 2020[2]	ArduPilot Mega 2.8 & 5V	No	12.2 sq m/ sec	2 litres	Carries less weight
Amaresh et al. 2020[12]	RISC & 5V	Yes, but costlier than the proposed	50 m	2 litres	Lack of upgradation
Edgar et al. 2022[10]	RISC & 5V	Yes, but costlier than the proposed	50 m	5 litres	Lack of upgradation
Sai Viraj, 2019[11]	Atmega AVR controller & 4 V-6V	No	More than 75 m	3 litres	Too conventional
Our sprayer	ARM7 & 3.3 V	Yes and only needed 250 USD	50 m	2 litres	Extensive equipment and, hence, increasing circuit complexity

Fig 4. An IoT Based Pesticide Spraying Robot developed by us (Top View)

4 Conclusion

An IoT-based pesticide spraying robot can benefit agriculture in many ways, including increased precision, effectiveness, and sustainability in applying pesticides. To grab those benefits, we designed a robot for spraying pesticides in this research. The developed robot is superior in several aspects compared to the existing ones. Firstly, it can spread pesticides up to 50 m range, uses less power of 3.3 V only, and can also carry three liters of weight. And importantly, it is economically cheap that it is needed only USD 250 to construct so that poor farmers can afford it.

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