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Research Article

Enhancing agricultural efficiency in India with IoT based smart boats

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ABSTRACT

Around 70% of the people in India depend heavily on agriculture for their survival. However, facts show that it only generates 17% of the economy and creates 58% of jobs, which is an extremely significant percentage, thus it is important to support this sector. There are many technologies available on the market for agricultural use, but the majority of them are expensive or require an expert human operation, are poor, and some of them have negative health effects for a farmer. So, to address these various problems, we created a smart boat that will sail the water. This smart boat was created utilizing less expensive components, and a smartphone is used to control it. We collected some data to determine efficiency in terms of time and plant coverage of the field to determine how this smart boat is more productive than humans and robots can be. This smart boat is tested on a surface irrigation field for that we take some seeds and pesticides to test this smart boat. Consequently, from the result, we observe that in terms of pesticide spraying and seed sowing the smart boat is highly productive as compared to humans and robots. Thus, creating smart farming with several benefits is the idea behind this endeavor. Effective pesticide use, effective seed use, and minimal human labor are all features of smart farming. In the future, we may also provide a fresh function like fertilizer spraying. Thus, we learn that this model has a variety of uses. So, we're confident that this idea will be pitched to the Indian market well.

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INTRODUCTION

India's agricultural sector employs about half of its workforce. Despite having such a large workforce, agriculture only contributes 17% to the economy; hence technology development is required to boost output. According to reports, India produces less rice, cotton, sugarcane, and other crops than other major producers like the United States, China, and other nations. Over the past ten years, the expansion of agriculture has been quite erratic. Such a variation in agricultural growth affects farm earnings as

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well as farmers' capacity to claim investment in their land holdings [1], [2]. Therefore, the agriculture system needs to be improved to lessen the farmers' workload. It's crucial to create effective interventions for agriculture. So, the answer is smart farming. Smart farming has the potential to minimize the wastage of pesticides and fertilizer, save money, save labor and potential to boost farmer income [3]. The proposed research paper uses IoT to solve the problem of farmers; IoT is taken because it provides a high level of flexibility in communication and information. Also, IoT is easy and required very less skill to operate [4]. Smart agriculture has proven many advantages to all human-like it reduces pollution, works 24 hours and saves costs [5]. So, this research aims to build an IoT-based smart boat for smart farming. This smart boat can sow a seed and spray pesticides in rice farming activities and agricultural activities.

This model has been built by studying various research papers, and the various effective, cheap, and easily available components have been selected [6]. By using these components this smart board cost is been reduced. Although there are some robots on the market for applying pesticides and planting seeds, the model presented in this article stands out from them in two ways: first, we are building a boat that is controlled by people via a mobile app using IOT; and second, we employed a smart boat in agriculture as an additional feature, which provides greater accuracy and consistency in applying pesticides and planting seeds, which will boost productivity. This smart boat address various issue which is currently faced by the robot which is available in the market such as some electronic component cannot sustain vibrations and high temperature, the accuracy of the robot reduces due to clod and mud, and various robot cannot work on every type of soil, many robots cannot move easily due to heavy weight and lastly, some prototypes are expensive for a farmer that they may not benefit from it [7]. The proposed model is beneficial not only for Rice farming, and agricultural activities but also for aquaculture.

An IoT smart boat is a boat that is equipped with Internet of Things (IoT) technology and sensors that allow it to collect and transmit data in real-time. These boats can be used in aquaculture, the farming of aquatic organisms such as fish, shellfish, and plants. Today's aquaculture industry faces many problems like safety issues, environmental pollution, the effectiveness of equipment and the cost of operating is high which leads to health issues as well as the impact on production [8], [9].One of the main benefits of using an IoT smart boat in aquaculture is that it allows for more efficient and precise monitoring and management of the aquatic environment. The sensors on the boat can collect data on water quality, temperature, pH levels, and other important parameters, which can then be analyzed to optimize the growth conditions of the aquatic organisms. This can lead to improved yields and reduced costs. Another benefit is that IoT smart boats can be used for tasks such as automated feeding, fertilization, and disease control. This allows farmers to schedule and monitor these tasks remotely, reducing the need for manual labor and increasing the efficiency of the farm. Additionally, the proposed research model is also very beneficial by reducing human presence on-site, which can help to mitigate safety issues and improve the overall efficiency of the farm.

In addition, the smart boat can also be used for mapping and surveying the aquatic environment, which can help farmers identify the best areas for farming and also detect potential issues such as pollution or overfishing. Currently, India's contribution to aquaculture is low compared to other nations, India contributes 7.96% in the world, so by using this model, India will achieve growth in the aquaculture sector [2]. But the present model has been tested only in an agricultural field. In future, it will be beneficial. In contrast to understanding how the proposed model is efficient for sowing and spraying, we compared this model with another autonomous robot and human to understand how our model is more effective than others.

Therefore, our research paper's goal is to create a model that works well while taking up less time. This model can be used for two different tasks, including the application of pesticides and the planting of seeds in agricultural fields. In the surface irrigation field, where we tested this smart boat, we were able to successfully address several problems. Therefore, this strategy will undoubtedly increase farmer productivity and benefit the market as well.

PROTOTYPE OF MODEL

Developing the prototype for the smart boat was an undertaking that required a thoughtful selection of hardware components that would prove effective in transforming theoretical concepts into practical applications. The objective was to create a versatile and cost-effective solution that could fulfill the unique requirements of agricultural tasks like seed sowing and spraying operations. By engaging in a systematic evaluation process, the selected components were identified based on their affordability, compatibility, and performance features, thereby ensuring the prototype's feasibility in practical settings. This section will investigate into the intricate specifications and functionalities of the hardware components utilized in the smart boat prototype, shedding light on their roles in actualizing the envisioned agricultural automation system.

Hardware of Model

The smart boat use Arduino UNO, L293D driver, servo motor and dc motor this various component is explained in detail below.

Arduino UNO

Arduino UNO microcontroller, which is used in this application. An inexpensive, widely accessible microcontroller with sufficient computing capability and application is the Arduino Uno is selected also because of its wide use and because it is easily available [10], [11],. Basically, Arduino is a small brain and functions like a computer. It is an open-source microcontroller which handles the functions of other electronic components which are connected to it with the help of Arduino IDE software. In this proposed paper we use this model for computing and integrating with other electronic components. Lastly, this microcontroller operates between 5 to 12v.

L293D driver

The L293D driver shield operates between 4 to 36V. This board is selected based on a wide range of applications, it is easy to operate and very much suitable for our project [12]. The L293D operates on the principle of the H bridge and amplifies the signal. The function of this driver in our model is to connect 2 servo motors, 2 dc motors, Bluetooth and a power source to it. This board is connected to Arduino or mounted on it.

Servo motor

A servo motor is an electronic component that consists of a motor, a control circuit, and a feedback sensor. The motor is connected to a shaft that allows it to rotate between 0 and 180 degrees. The control circuit is responsible for providing power to the motor and controlling its rotation, while the feedback sensor provides information about the position and speed of the shaft.

In this research paper, the servo motor is used for the movement of a smart boat, specifically for controlling the left and right movement of the boat. Additionally, another servo motor is used to regulate the flow of seeds mechanism, which is responsible for controlling the release of seeds from the boat. The servo motor is a versatile and precise component that allows for precise control of the boat's movement and seed release. This improves the efficiency and accuracy of the seed-sowing process and allows for a more controlled and precise operation of the smart boat.

DC motor

The dc motor is used for controlling our boat speed and another motor is used for spraying operation. dc motor unlike the servo motor rotates 360 degrees. Dc motor is used in this research paper use to two reasons it is highly efficient and second is affordable (Fig. 1)[4]. Unlike other motors, this motor is used for watering purposes so it was very helpful in this research paper. Figure 2 shows the diagram of the submerged dc motor which is used in this proposed research paper.

Bluetooth module

Wireless The objective behind the use of this module is to explore the wide range of operating. The range of Bluetooth is 10 meters within this range our smart boat is operate accurately and efficiently. This type of module is selected because of easy to operative and cost-effective components as it can help us to communicate with this smart boat and operator without any trouble [8]. This Bluetooth module is operated between 5 voltages. Is it the

Figure 1. DC Motor.

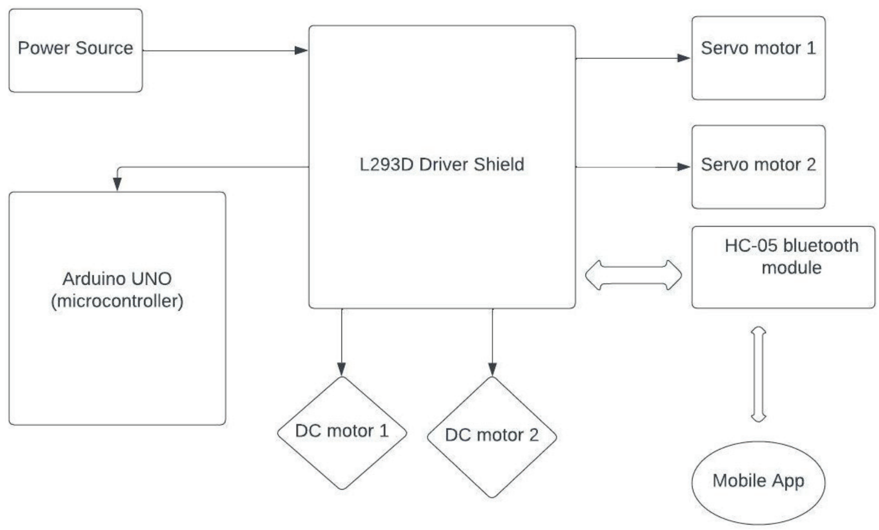

Figure 2. Block diagram of smart boat.

main channel of a communicator as it receives data from the operator via an android mobile phone and sends it back to Arduino.

Block Dıagram of Model

The block diagram consists of Arduino uno, L293D, servo motors, DC motors, hc05 Bluetooth sensor and battery. Firstly, the Arduino is attached to the L293D driver shield and use because of its several uses and ease of operation. L293D board is directly mounted on Arduino as there is no need to connect with wires. We use L293D to amplify the current. We selected this L293D because of its cheaper and easy availability. Then we use two servo motors which are connected to L293D as there we can only use two servo motors. The servo motor was chosen because of its compact size, lightweight, toughness, water resistance, and simplicity of installation. It is simple to move, therefore the servo motor 1 is connected to the DC motor 1. Servo motor 2 is employed to operate the seed-dropping mechanism, and it regulates the flow of seeds following specifications. Last but not least, the HC-05 Bluetooth module is necessary for the boat's wireless navigation. Additionally, we then use two DC motors which is connect to L293D. The DC motor was selected because of easily available in the market and for long-term use purposes. DC motor 1 is used for the movement of a boat that is forward and backwards. DC motor 2 is used as a sprayer that is to spray pests on plants. Moreover, Bluetooth which is used for operating this model wireless connected to L293D. Bluetooth when properly connected to an android mobile phone then with the help of a controller we can operate this smart boat. Lastly, we had to use a 9V battery to power our boat to work according to the operator. This battery provides enough power to operate the smart boat for required operations.

Circuit Diagram

The electronic circuit consists of an Arduino Uno Board, 2 servo motors, 2 DC motors, an L293D driver shield, an HC-05 Bluetooth module & 9V Battery. The logic behind programming this circuit is that as soon as the switch is on and the boat is connected to Bluetooth the boat will start operating. A schematic of the Smart Boat's circuitry is presented in Figure 2. The device is capable of functioning with the computer for changing according to requirements. This Arduino is driven by a chip known as the AT Mega 238. This chip is used because it has a lot of power. To filter the power, this microcontroller is connected to L293D. When everything is finished, use a USB cord to connect the Arduino board to a computer and begin coding. When Bluetooth is ON connect the mobile Bluetooth to Arduino Bluetooth and open software for controlling the Arduino. When the control device is ready then put the boat in the water with the pesticides and seeds/crops for plating purposes we can put this boat in surface irrigation method or rice farming. The operation of planting and spraying pesticides is done by using a mobile.

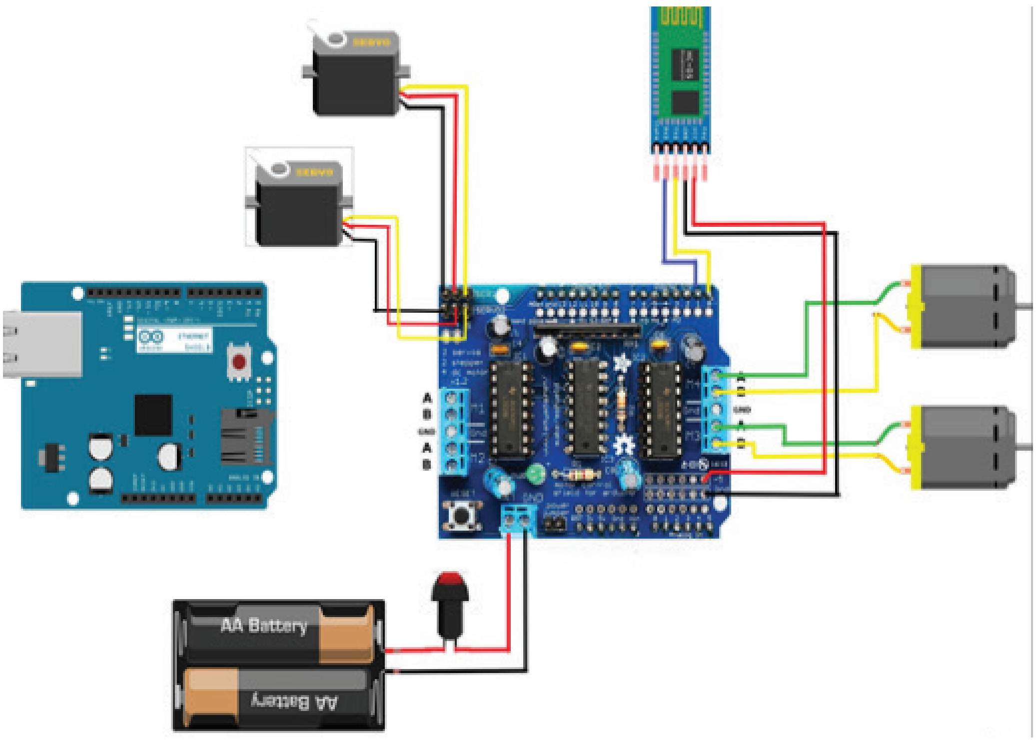

Figure 3. Circuit diagram of smart boat.

Software for Smart Boat

The Arduino UNO work on C++ programing language. Utilizing the Arduino software, it is coded. The smart boat is controlled using an android application. Bluetooth is used to connect an android application to a smart boat. After taking various data for spraying and sowing, the data is added to a Microsoft excel sheet to get the graph of a smart boat.

IMPLEMENTATION OF ALGORITHM

The algorithm for the smart boat that uses Android/ Bluetooth software to spray pesticides and sow seeds is explained by the circuit diagram in Figure 2. This is how the robot's algorithm looks:

Procedure 1: START.

Procedure 2: Energize the smart boat.

Procedure 3: Pair the Bluetooth device and phone.

Procedure 4: The smart boat should wait for the signal from the app in Figure 3.

Procedure 5: If the smart boat receives a signal, it responds appropriately.

Procedure 6: If communication is not received, go to procedure 1.

Procedure 7: To disable, use the global OFF signal.

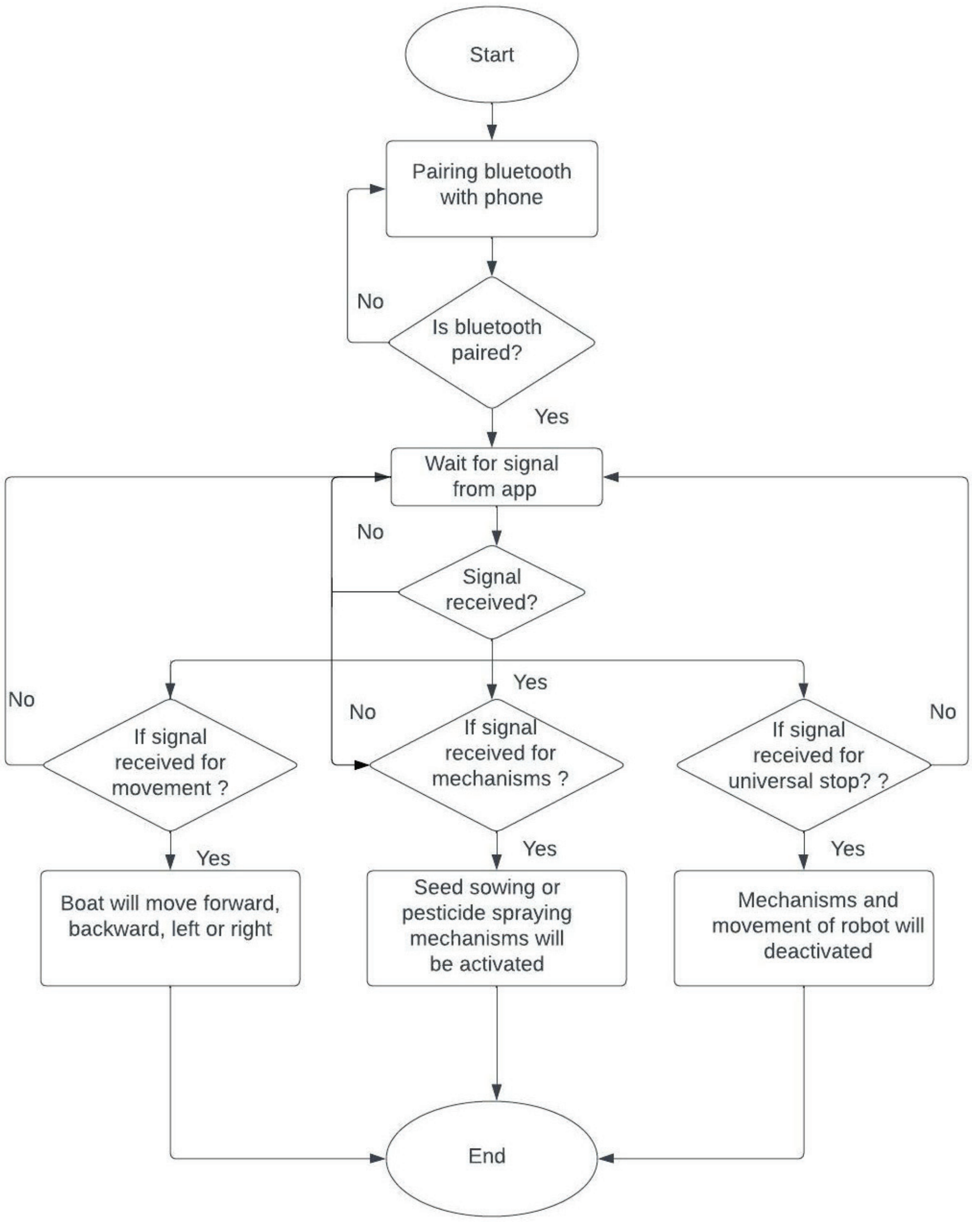

Figure 4. Flowchart of smart boat.

EXPERIMENTAL ANALYSIS

This experiment is conducted on surface irrigation farmland of 9 x 4 m area where a sufficient quantity of water is availed to conduct the experiment. The distance for each path is 10 meters. The proposed model is tested with 120 cotton, wheat, soybeans, sugarcane seeds and 500 milliliters of pesticide liquid use in order to show the result. This experiment is conducted on still water and a boat moving in downstream or along with the water. In order to get a reading of both spraying and sowing we had taken 4 different readings considering time factor and plant coverage. This experiment is conducted in the morning at 10.00 am in clean weather. The cotton, wheat, soybeans, and sugarcane seeds as taken in this experiment and they are dry and low weight as our objective was to keep the low weight as possible on the boat. The reading in this experiment is manually taken our reading are based on time and plant coverage or seed sowing location. Both the operation of sowing and spraying was conducted separately as this both operations can also be operated simultaneously but, in this experiment, we had taken reading separately.

Figure 5 shows the diagram of the path of the smart boat and the procedure of how our smart boat will operate in the surface irrigation field. Different reading is taken on different crops in 4 paths

Path1: It consists of the sowing of cotton seeds on both sides and operation spraying is also done on crops of cotton in this path.

Path 2: It consists of sowing of wheat seeds on both sides and operation spraying is also done on crops of wheat in this path.

Path 3: It consists of the sowing of soybean seeds on both sides of the path and the operation of spraying is also done on crops of soybean in this path.

Path 4: It consists of the sowing of sugarcane seeds on both sides of the path and the operation of spraying also done on the same crop this path we had taken 4 reading are taken on these 4 paths at a time for a total of 2 minutes. After every path, we need to manually reload the 30 seeds each time.

CALCULATIONS

To calculate the time, it takes for a boat to travel 10 meters at a speed of 3.393 km/hr. in still water (downstream),

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$

However, the given speed is in Km/hr. and distance is in meter so we need to convert speed in meter/sec.

1 km = 1000-meter

1 hr. = 3600 sec

so, 3.393 km/hr. = 3.393*1000/3600 m/s = 0.943 m/s

Time = 10 meters / 0.943 m/s = 10.62 sec

Please note that this calculation consider that the boat is lightweight and the water is still, with no external factors affecting the boat's speed, such as wind or currents. The weight of the boat is also not affecting the time calculation as the distance is too small and the speed is average.

Pesticide Spraying Function

The pesticide reading is taken considering time and total plant coverage factors. To reduce the cost of the experiment here water at 500 milliliters is taken in the tank. In this

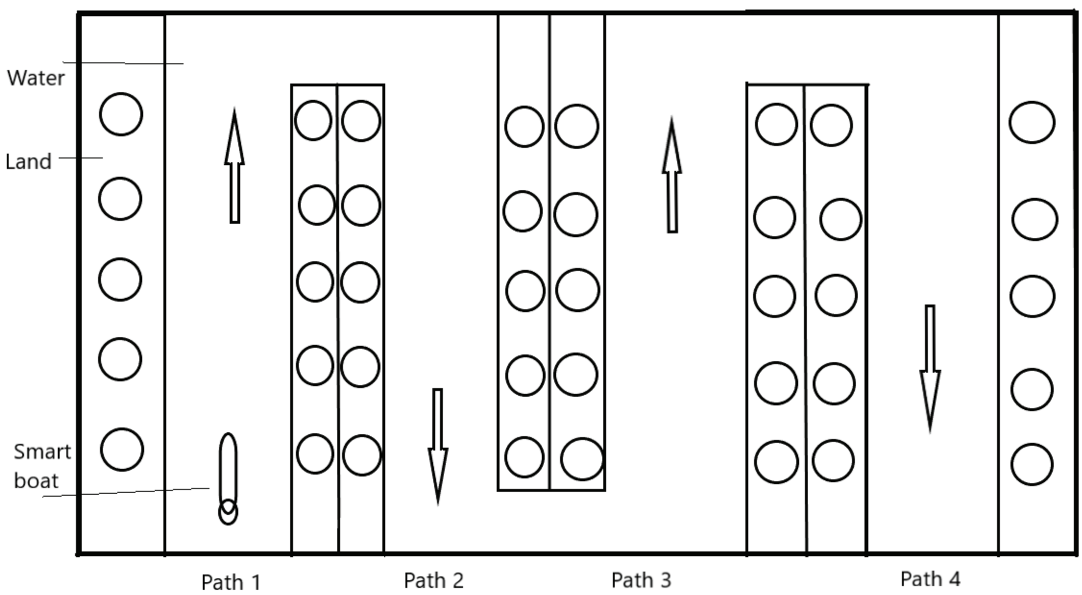

Figure 5. Path of Smart Boat in Agriculture Field.

Table 1. Pesticide spraying specifications

Sr No.	Overview of DC Motor	
	Variable	**Outcome**
1.	Torque of the motor	4 kg/cm
2.	Speed of the boat	3.393 km/hr.
3.	Area covered by model	9 m x 4 m
4.	Distance between one location to second location	1 meter
6.	Flow rate	2 Lpm
7.	Used pesticide	400 ml
8.	Time delay	1 sec

experiment, we had taken a nozzle which will able to spray pests at 2 plants simultaneously and then move forward. The operation of pesticides is conducted using Bluetooth-operated mobile. This operation is carried out by any one because the controller is straightforward with few buttons. Additionally in this experiment, we had given a flow control slider on a mobile app to control the flow of the pest.

Calculations

To calculate the time taken by a boat to spray pesticides in a farm, we can use the following formula:

$$\text{Time} = \frac{(\text{Field Size})}{(\text{Boat Speed x Spray Width})} + \text{ Additional Time}$$

Given:
- Distance: 10 meters
- Field area: 9-meter x 4 meter (36 square meter)
- Speed: 3.393 km/hr. (convert it to m/s = 0.943 m/s)
- Liquid: 500 milliliters
- Spray width: 0.5 meter

Additional time:
- For turning and stopping: 10 sec

$$\text{Time} = \frac{36}{(0.943 \text{ x}0.5)} + 10 = 86.59 \text{ sec.}$$

Therefore, it will take approximately 86.59 seconds for the boat to spray pesticides in the farm.

To calculate time for each path -

To calculate the time taken by a boat to spray pesticides on 20 plants in a 10-meter distance, with a stopping and spraying every 1 meter, we can use the following formula:

$$\text{Time} = \frac{\text{Total Distance}}{(\text{Distance per stop x time per stop })} + \text{ Additional Time}$$

Given:
- Total Distance: 10 meters
- Distance per stop: 1 meter
- Number of plants per stop: 2 plants
- Total number of plants: 20 plants
- Time per stop: x seconds (for spraying 2 plants)

Additional time:
- For turning and stopping: 20 sec

$$\text{Time} = \frac{10}{(1 \text{ x } (\text{x sec})} + 20 \text{ sec}$$

Hence Time = x sec

Therefore, by finding the x time in the experiment we can also find the approximate time for each crop from above equations.

Seed Sowing Function

At the time of the experiment, a total of 120 seeds of cotton, wheat, sugarcane, and soybean are taken and plotted in different locations. While conducting the experiment we had sown 2 seeds per sec with a delay of 1 sec on the left and right sides of the smart boat. The seeds of cotton, wheat, sugarcane, and soybeans are taken to conduct an experiment and drop at a specific location. We had taken all readings manually. To control the flow of seeds we provided a slider on a mobile app which was very useful in this experiment.

The flow of seeds is controlled by a servo motor via a mobile application. When a smart boat is in motion, we had stopped this operation and when a smart boat stops, we then start this sowing operation. The purpose of our use of this servo motor is to stop the wastage of seeds in movement. To measure the time, we had taken stopwatches. Following are paths of smart boats.

Path 1. We had taken a smart boat with 30 seeds in a chamber and then started the boat on this path at the end of the path we stop.

Path 2. We need to again fill the seed chamber with 30 seeds and run this experiment.

At the end of the path again, we conduct this experiment again for 1 min on path 3 and path 4. A total of 2-minute experiments are conducted.

Calculations

To calculate the total time, it takes for a boat to sow 30 seeds of cotton along a distance of 10 meters, stopping every 1 meter to sow 2 seeds at each location, you will need to know the time it takes for the boat to stop and sow the seeds at each location.

we can calculate the time as:

Table 2. Seed sowing specification

Sr No.	Overview of servo motor	
	Variable	**Outcome**
1.	Torque of motor	1.5 kg/cm
2.	RPM of motor	1800
3.	Area covered by model	9 m x 4 m
4.	Distance for each path	10 meters
5.	Number of seeds sowed	120

Time for travelling 1 meter = $\frac{1\text{m}}{0.943\text{ m/s}}$ = 1.06 sec

Time for sowing 2 seeds = (x sec) (assuming it take x sec to sow 2 seeds)

Total time for 1 meter = 1.06 sec + x sec = 1.06 + x sec

As the boat stops every 1 meter to sow 2 seeds, the total time for the 10 meters distance will be:

10 * (1.06 + x) sec = 10.6 + 10x sec

As the boat sows 30 seeds in total, at every stop sowing 2 seeds. But these 30 seed are sows at one time.

So, the total number of stops will be 15/2 = 7.5

So, the total time for sowing 30 seeds along a distance of 10 meters will be:

10.6 + 10x + 7.5*x sec.

Therefore, by finding the x time in the experiment we can also find the approximate time for each crop from above equations.

RESULTS AND DISCUSSION

Cost of Smart Boat

To use cheaper and more effective materials we had analysis different papers to find out which electronic components are suitable and will give us effective results [6]. Our objective was not only to find cheaper material but also, they need to sustain it in long run.

Table 3 shows the specification of the smart boat as we had taken voltage and cost factors to select material. From a survey of different papers, we found out this all-electronic component is cheaper and is easily available in the marker. So, anyone in long run can take this component to increase their productivity [13], [14].

Table 3. Overview of the component's cost

Sr No.	Components Specification		
	Components	**Voltage**	**Cost**
1.	Arduino UNO	5-12	Low
2.	Servo Motor	4.8-6	Low
3.	Dc motor	8-24	Low
4.	L293D Driver	4.5-36	Low
5.	Bluetooth module	3.3	Low

Pesticide Spraying Readings

This experiment is conducted in a surface irrigation field in the morning. Table 2 shows the reading of the smart boat. This reading is taken manually 4 times and readings are taken in seconds and no plant cover in seconds. Below we had discussed the process of results.

Path 1: We take the smart boat with loaded 500-millilitre water and started running on water. When plants are coming in the way of the path, we stop the boat and spray pesticides on the left and right sides and then move forward. While measuring we go to know it takes average 1sec distance between 2 locations of plants. When path 1 is completed then we measure time which was started with boat movement. At the end of the path, we measure 20 cotton crops pesticide was sprayed in 34 seconds.

Path 2: We started again the same process with pesticides. At the end of the path, we measure it took 31 seconds for 20 wheat plants. This was different from path 1.

Table 4. Pesticide spraying reading

Sr No.	Crops	No of plants	Use path no	Time delay(s)	Total Time (sec)
1	Cotton	20	a	20	34
2	Wheat	20	b	20	31
3	Soyabean	20	a	20	27
4	Sugercane	20	b	20	28
Total	4	80	4	80	120

Table 5. Average reading

Sr. No	Human(H)	Robot(R)	Boat(S)	Difference		Time taken(min)
				S-H	S-R	
1	30	20	40	10	20	1
2	60	40	80	20	40	2
3	90	60	120	30	60	3
4	120	80	160	40	80	4
5	150	100	200	50	100	5

Path 3: we start the same process with the stopwatch. For this path, we took spraying on soybean plants and it takes around 27 seconds on 20 plants.

Path 4: we conducted the same process and here we got a different result for sugarcane plants it takes around 28 seconds for spraying on 20 plants.

After the whole process ended then we calculated the result. As we carried the whole process in 2 minutes with a stopwatch. It is also observed that some liquids are wasted near plants but the majority spray on plants. At the end of the whole process, a 400-millilitre pest was utilized and a 100-millilitre pest was saved out of 500 milliliters.

When the experiment was completed, we survey how our model is efficient as compared to others[15], [16].

Table 5 shows the reading of different experiments of humans and robots. In this experiment reading, we compare with others and we found there is a lot of difference in this experiment. From this reading, it was sure that there is a difference between a robot, human and boat operation. The table provided shows that the productivity of the boat increases with time while the productivity of human and robot decrease with time.

Overall, the boat is the most efficient method of pesticide spraying. Thus, this smart boat is beneficial to the farmer.

The Figure 1 shows the graph of the pesticide spraying mechanism. To compare robots and humans we had taken measure time in minutes. The time is measured in a minute as how much plant is covered by a smart boat per minute. The sprayer nozzle is taken in such a way it will spray pesticide on 2 plants in 2 seconds. It is found that the smart boat takes an average of 1 minute to spray 40 plants in 20 different positions as compared to the human takes 1 minute to cover 30 plants and the robot takes 20 plants. Therefore, it is found that smart boat is very efficient and consume less time as compared with robot and human.

Seed Sowing Readings

This experiment is conducted after conducting a pesticide spraying experiment. This experiment is conducted in a surface irrigation field in the morning. Table 6 shows the reading of the smart boat

This reading is taken manually 4 times and readings are taken in a sec and no of plant cover in 30 sec. The experiment is conducted 4 times in paths 1 and 2 and again experiment is conducted in paths 3 and 4 for a total of 2 minutes. The following steps are followed.

Path 1: We take a smart boat with loaded 30 seeds and started running on water. At a specific location, we stop the boat after 1 second and sow seeds on the left and right sides and then move forward. While measuring we go to know it takes average 1sec distance between 2 locations. When path 1 is completed then we measure time which was started with boat movement. At the end of the path, we measure

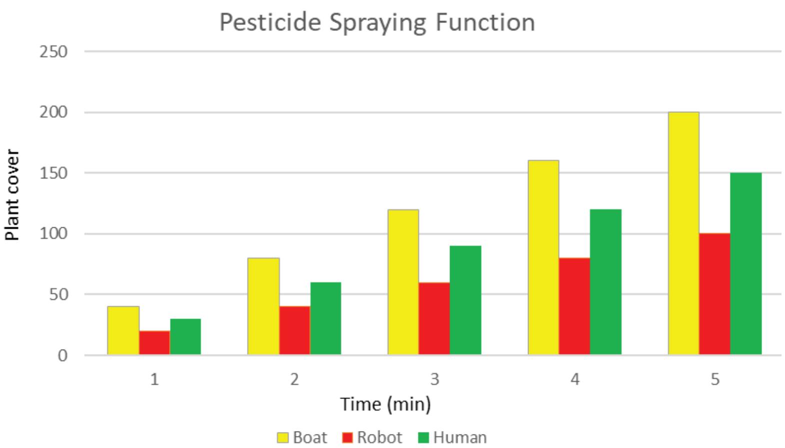

Figure 6. Pesticide spraying.

Table 6. Seed sowing readings

Sr No.	Crops	No of seeds	Use path no	Time delay(s)	Total time (sec)
1.	Cotton	30	a	15	33
2.	wheat	30	b	15	27
3.	soyabean	30	a	15	31
4.	sugercane	30	b	15	29
Total	4	120	4	60	120

Table 7. Seed sowing comparision

Sr No	Human(H)	Robot(R)	Boat (S)	Difference		Time taken (min)
				S-H	S-R	
1	20	30	60	40	30	1
2	40	60	120	80	60	2
3	60	90	180	120	90	3
4	80	120	240	160	120	4
5	100	150	300	200	150	5

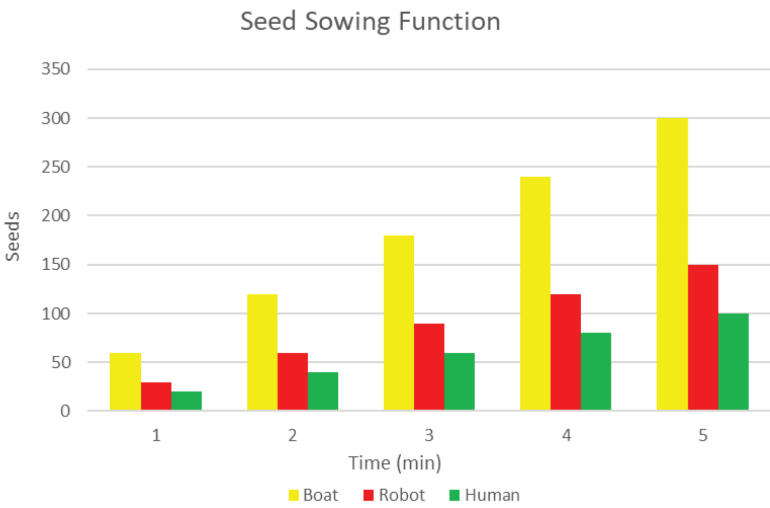

Figure 7. Seed sowing.

30 seeds of cotton that were sown within 33 seconds. When we need to start on path 2, we need to again fill the seed chamber with 30 seeds.

Path 2: We started again the same process with 30 seeds of wheat with a stopwatch. At the end of the path, we measure it takes 27 seconds for 30 plants. This was different from path 1 so it is observed that due to the light weight of wheat seeds, it takes low time as compared with cotton.

Path 3: Again, we repeat the same process with 30 seeds of the soybean. At the end of 3rd path, it was found that it takes 31 seconds to sow the seeds.

Path 4: Again, we fill the seed chamber with 30 seeds of sugarcane now it takes only 20 seconds. It was found that due to the low weight of seeds, it takes less time.

Hence after completing 4 paths in 2 minutes, we measure that it takes an average of 1 minute to sow 60 seeds in different locations both on the right and left sides. It was also found that some seeds are wasted but the majority are sown in an accurate position.

Table 7 shows the reading of different experiments of humans and robots. When the experiment was completed, we survey how our model is efficient as compared to others. For that various data have been taken by studying the number of research papers to compare smart boat efficacy [6, 12,5,11] . The table provided compares the productivity of three different methods of seed sowing: human, robot, and boat. The results show that the boat is the most productive method as it covers the most area in the least amount of time in every instance[17], [18]. The human method is less productive compared to the robot but also less productive compared to the boat. On the other hand, the human is the least productive method as it covers the least area in the most amount of time. The table also shows that the productivity of the boat increases with time while the productivity of the human and boat decreases with time. Overall, it can be concluded that the boat is the most efficient method of seed sowing, while the human and robot are the least efficient method [19], [20].

The Figure 7. shows the graph of the seed-sowing mechanism. To compare robots and humans we had taken measure time in minutes. The time is measured in minutes as how much plant is covered by smart boat per minute. The graph is drawn using an excel sheet. The smart boat takes an average of 1 minute to sow 60 cotton seeds (Left and Right side positions). From the above graph, it is observed that in terms of seed sowing the smart boat is highly efficient as compared to humans and robots [18,21,22]. The smart boat productivity increases due to two factors; the first is it is designed in a way to sow 2 seeds at a single time and the second is this boat run on water as compared to humans and robots which work on soil so the time and power required is reduced with the increase of seed. Also, here we didn't face any problems in the path of the smart boat as in the case of humans and robots facing the issue of obstacles or soil tropology [20,23,24].

From the above two graphs, it is observed that in terms of pesticide spraying and seed sowing the smart boat is highly efficient as compared to humans and robots [25,26]. Thus, creating smart farming with several benefits is the idea behind this endeavor. Effective pesticide use, effective seed use, and minimal human labor are all features of smart farming. Consequently, using this smart boat boosts agricultural yield. In the future, we may also provide a fresh function like fertilizer spraying. Thus, we learn that this model has a variety of uses. So, we're confident that this idea will be pitched to the Indian market well. Automatically spraying and seeding, also boosts farmers' output while lowering their labour requirements.

CONCLUSION

The research work involved the development of an autonomous multipurpose agricultural boat for tasks such as seed sowing and pesticide application.

- Results indicate that the smart boat effectively sows seeds in the correct order, promoting proper germination, and accurately sprays pesticides on legal crops, leading to a doubling of production compared to traditional methods.
- Implementation of the smart boat significantly reduces labor requirements and minimizes wastage of pesticides and seeds, resulting in cost savings and environmental benefits.
- Bluetooth technology is utilized for remote communication with the system, ensuring operator safety and precise task execution.
- While the focus is on agricultural activities, the potential application of the model in aquaculture is recognized, suggesting future opportunities for expansion.
- The proposed model offers numerous advantages, including pollution reduction, increased production, improved human health, and addressing current challenges in agriculture.
- Future advancements could extend the application of the smart boat to other crops and further enhance efficiency and sustainability in agriculture.
- Overall, the research demonstrates the potential of robotic farming technology to revolutionize agricultural practices and promote economic and environmental benefits.
- In conclusion, while there are limitations to be addressed, the study underscores the transformative potential of the smart boat in advancing agricultural productivity and sustainability, paving the way for a more resilient and prosperous agricultural sector.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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