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Design and Operation of Agribot using Four Control Variables

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Abstract

India has a population that is almost entirely reliant on the agricultural sector. The major issues that farmers, particularly those in rural areas, confront are poor levels of production and a lack of access to the right technologies for the agricultural industry. The number of workers in agricultural fields has decreased in modern times. So, more assistance is needed to complete specific activities on agricultural land. Although there are numerous tools and techniques on the market, not all farmers can afford to purchase them. This paper describes the creation of a multifunctional, solar-powered Agribot for agricultural support. There are four ways that this robot can work: 1. Using a plough 2. Planting seeds 3. Monitoring soil moisture; 4. Weeding. These procedures are given to the robot together with information on the dimensions of the entire land surface and the spacing between plants. The user sends the variables as SMS to the GSM Module. The information is delivered to a PIC Microcontroller. The revolving blade and the plough will be turned on for the ploughing activity. The robot starts to drop the seed during the seed-sowing mode by first loosening the soil, covering the seed, and then dropping the seeds and covering the seed with loosening soil. Batteries handle the onboard power management. To recharge these batteries, a solar panel has been provided. A spinning blade removes the undesired plants that grow in between the sowed seeds when the weed-removal mode is active.

Sensors measure the precise moisture content of the soil while in the soil moisture monitoring mode. As a result, it will turn on the water pump that is located in the agricultural field. For broad agricultural holdings and a big number of farmers, this highly affordable robot can be used.

Keywords: Weed Remover, Soil Moisture Monitoring Robot, Weeding Mechanism, Seed Sowing Mechanism.

1. Introduction

The agriculture industry serves as the foundation of the Indian economy. The amount of food produced has always increased. But occasionally enormous areas of cultivated crops are harmed by insufficient oversight, as well as by natural disasters, which results in reduced production and higher selling prices because of increased demand. There need to be enough workers on the field. But as a result of not being able to get labour to complete some repairs, landowners are now beginning to sell their property. In the event that they hire laborers, they pay exceedingly high rates. Many landowners were unable to pay such exorbitant wages.

The traditional approach to agriculture is typically quite labour-intensive and time-consuming. There are numerous contemporary methods for performing some agricultural tasks. However, because they require such a large upfront investment, most farmers are unable to bear the hefty cost. Therefore, some agricultural robots could be deployed in place of human labourers to streamline the farmer's labour. The goal is to create agricultural robots that can carry out labour-intensive tasks including ploughing, sowing, pulling weeds, and watering crops. Consequently, the employment shortage in the agriculture industry might be eased. Worldwide, a sizable population uses mobile phones. A mobile phone is being used in this instance as the human and robot interface. Wireless communication is supported by the GSM (Global System for Mobile

communication). The GSM module, which is installed inside the robot, can receive the proper instructions from the farmer.

In this study, Agribot operates in four different ways: 1. Using a plough 2. Planting seeds 3. measuring soil moisture 4. weeding out. A curved tool is utilised in the ploughing mode. It is capable of both digging and covering the seeds in soil. The input for the seed-sowing mode consists of three control variables. The space between the seeds is crucial. The proper spacing is necessary for proper germination and future growth. A soil moisture sensor is used in the soil moisture monitoring mode to measure the soil's moisture content. The robot will turn on and off the water pump that is kept close by in the agricultural field based on the amount of moisture present. More so than the amount of nutrients present in the soil, soil moisture has a major impact on crop yield. It supports effective crop growth physiologically. Weed growth is another major issue that farmers deal with. In between the sown crops, undesirable plants are known as weeds. This is mostly caused by the agricultural land's higher fertiliser content. In order to cultivate seeded crops, such undesirable crop varieties should be eliminated. To increase the produce from the agricultural area, weeds need to be eradicated at an earlier stage.

The brain of this robot is the microcontroller. An 8-bit PIC microcontroller (PIC16F877A) is used in this application. This robot will function in an open atmosphere. So the agribot is topped with a solar panel. It is employed to replenish the utilised 12V batteries. Many farmers can utilise this highly affordable robot, which can even be deployed on vast agricultural regions. It is user-friendly and simple to use. The yield of the crops can be boosted by using such technology in agriculture.

2. Proposed System

There are four ways that this Agribot can function. The length and number of seed columns to be sowed in the ground are the two agricultural variables for the seed sowing procedure, and the spacing between seeds is a third variable. The proposed robot, after planting each seed in turn till it reaches the end of the intended area, automatically drops the seeds and soil coverings. A smartphone uses GSM and a PIC controller to automate this robot's complete operation. The microcontroller has software that can be programmed, for seed sowing its open the dirt, scatter seeds in it, then close it again for agricultural uses. Additionally, we are programming the PIC to use the GSM module to deliver the report to the distant location. Anywhere in the world, a mobile phone can be used to monitor the report. Therefore, a robot-led workforce may be able to solve the farmers' fundamental challenge of a lack of labour. To gauge the amount of moisture in the soil, a soil moisture sensor is positioned. Turn the water pump located in the agricultural land ON or OFF in accordance with it. Here is a weed-cutting mechanism for use in agricultural area to remove weeds. Unwanted crops are removed using its rotating blade. The goal of the planned study is to improve agricultural outcomes.

3. Methodology

This paper focuses on creating a robot that can perform a variety of agricultural tasks, including weeding, seeding, soil moisture monitoring, and ploughing. The variables are given to the robot via SMS using GSM technology. The PIC microcontroller executes the preprogrammed sequences after receiving the variables from the GSM modules. The GSM can only send SMS (Short Message/Messaging Service) after it has connected to the cellular network. The LCD wording "ENTER THE DISTANCE" can be used to identify it. The activating mechanisms varied depending on the mode of operation. The robot's gear includes a shovel-like ploughing instrument that is used to dig and loosen the dirt. For the seed-sowing mechanism, a wooden plate is used to open the funnel's bottom so that seeds can be dropped into the ground. The seeds

are stored in a funnel-shaped container. The wooden plate's location in this instance is limited by a limit switch. In order to monitor soil moisture, a soil moisture sensor is employed, which sends data about the soil's moisture level to the microcontroller and instructs it to switch on or off the water pump as necessary. When the moisture level is extremely high, the water pump is turned OFF, and vice versa. A fan-shaped blade is positioned beneath the robot to eliminate weeds. After each operation, users are informed of the completion status. Here, the GSM module uses AT (ATtention) commands to transmit and receive data. The farmers might employ this robot to increase the productivity of their labour.

4. Block Diagram

Figure 1 depicts Agribot's block diagram. A PIC 16F877A microcontroller, two sensors—a soil moisture sensor and an inductive proximity sensor—a solar panel with 12V rechargeable batteries, an LCD for displaying user-sent data, a GSM module with an antenna for sending and receiving user-sent data, and a total of five relay drive circuits for seed sowing and watering mechanisms, the weed-cutting, ploughing, and robot-moving mechanisms.

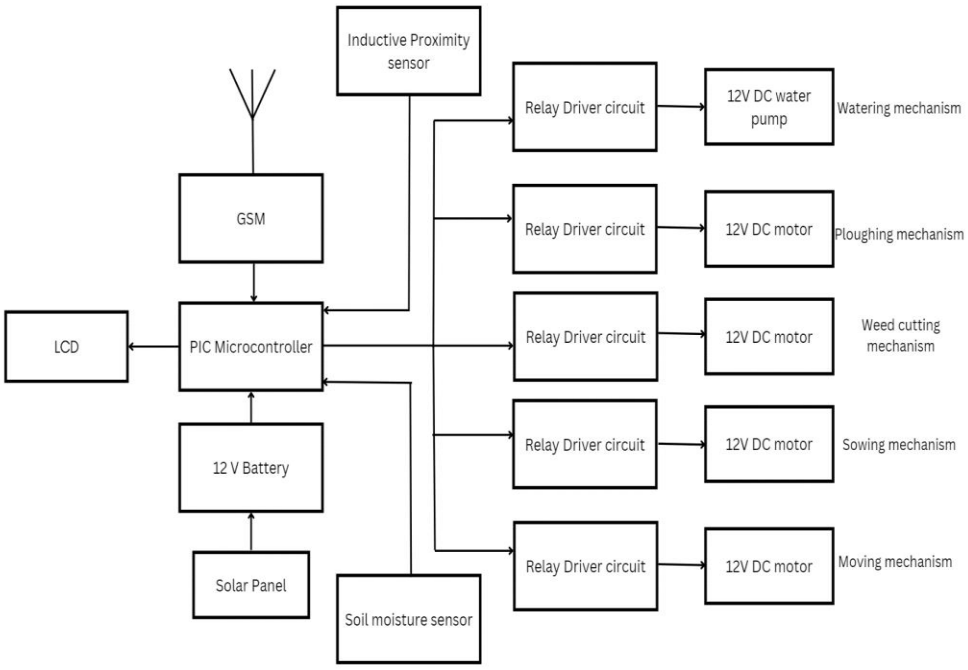

Figure.1. Block Diagram

5. Hardware Implementation

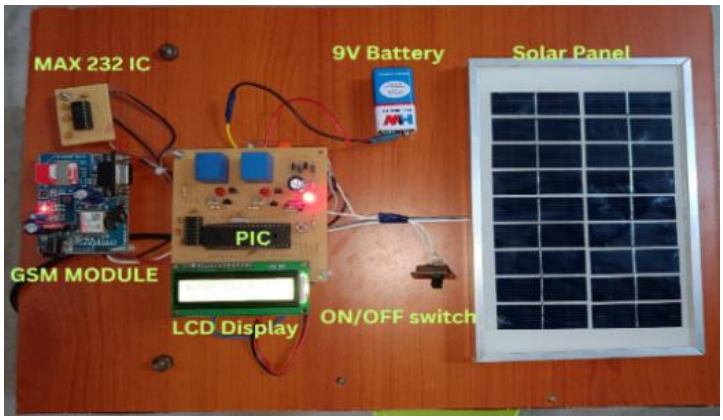

Figure.2. Top view of the Agribot

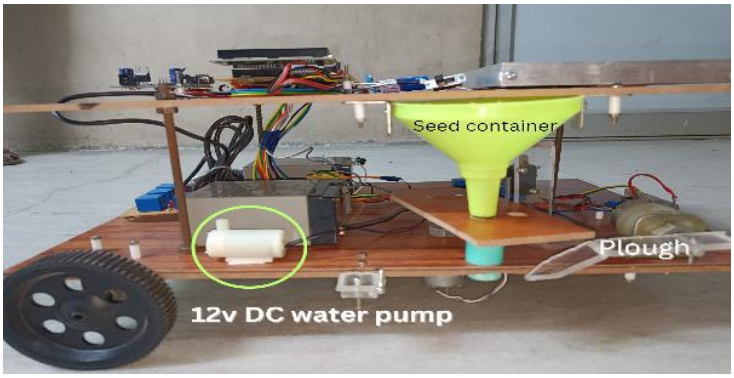

Figure.3. Side view of the Agribot

Figure.4. Bottom view of the Agribot

Figs. 2, 3, and 4 depict the hardware setup's top, side, and bottom views, respectively. A 12V DC power supply is utilised here. The created programme instructs the PIC microcontroller to begin processing the robot as soon as the power supply is turned ON. The programme used in this instance was developed using MP LAB IDE software and was written in Embedded C. The robot's GSM module must first be used to detect the signal. The robot's complete performance is introduced by SMS in the beginning. The Red-LED begins to flicker slowly as soon as the GSM module gets the input signal. It is now prepared to receive SMS messages from the user. The SMS is sent by the user from the mobile phone to activate the robot's operation when the LCD displays "ENTER THE DISTANCE." This SMS is presented as a list of seven-digit numbers. Here, a solar panel is being utilised to charge a 12V battery. This robot uses an inductive proximity sensor to determine its distance from an object. Here, the soil moisture level is also monitored using a soil moisture sensor.

6. Operation Modes

This robot is capable of four tasks: weeding, spreading seeds, assessing the moisture level of the soil, and ploughing.

6.1. Mode 1: Using a plough

Before planting crops, farmers prepare the land. The ground has been properly loosened and prepared for germination. When this mode is chosen, the soil is loosened for efficient germination and the plough structure is brought down. Through the SMS, the land's total dimensions were communicated.

Figure.5. Ploughing mechanism

The configuration of the mechanism employed for this robot is shown in Fig. 5. Here, such a mechanism is managed by a 12 V, 10 RPM motor. Relays with two channels are used to regulate the forward and reverse motions. The structure that resembles plastic will descend to dig the ground whenever it receives a signal from the microcontroller. It operates in accordance with the directions provided in the programme. When the job is done, it will return to its original location.

6.2. Mode 2: Seed Sowing

Figure.6. Seed sowing mechanism

For the dropping of seeds, a 50 mm-diameter wooden disc is offered. Above the wooden disc, a funnel-shaped receptacle holds the seeds. The funnel features a bottom hole through which the seeds fall one by one. A hole with a diameter of 10 mm exists in the hard disc. Until the robot arrives at the spot where the seed must be dropped, the disc rotates. The wooden disc's motion is managed by the limit switch. It's crucial to plant the seed properly on the ground for better germination. This method helps farmers save time and increase productivity.

6.3. Mode 3: Soil moisture checking

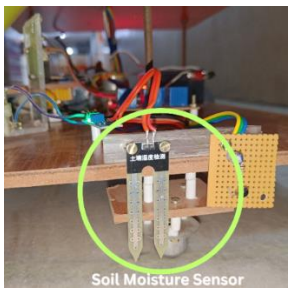

Figure.7. Soil moisture monitoring

As a farmer, it's crucial to continuously monitor the moisture of the soil, provide water when it's needed, and avoid water waste. If the option for soil moisture is chosen, the device will begin to travel about the places where seeds have been planted, check the moisture content, and then send the user the result. The water pump will turn off if the moisture content of the water is high and vice versa.

6.4. Mode 4: Weed removing

Figure.8. Weed removal mechanism

Controlling weeds is crucial in agricultural land. because it hinders harvesting and decreases the crop's ability to grow efficiently. To increase crop output, weed removal should be done right away. Weeding is the procedure of getting rid of weeds from agricultural land.A rotating blade acts as the weed elimination mechanism, chopping down any unintended crops that have been planted there. Here, the blade is driven by a 12V DC motor. For effective weed cutting, the entire mechanism is mounted on the bottom side of the robot.

6.5. Measuring the Distance

Figure.9. Inductive proximity sensor

The robot must be given instructions regarding the distance at which to drop the seeds. To measure the distance, an inductive proximity sensor is employed. The left-rear wheel is where this sensor is mounted. The sensor measures the position of four nuts as the wheel rotates in order to determine the distance. On the left rear wheel's rim, there are four nuts. The controller automatically determines the robot's distance travelled when the sensor detects each nut. Robotic devices can be configured to shut down as necessary. The robot can travel about 15 cm when the wheel completes one full rotation.

7. Results and Discussion

Table.1. Format of SMS

0	**x**	**y**	**z**	**w**	**X**		**X**
Distance between the seed		No. of Columns	Length	Mode of operation	0		0

- The distance between the seeds that are to be sown is indicated by the variable "x."
- The number of columns in the field where the seeds will be sown is indicated by the variable "y."
- The 'z' variable represents the length of the land as a whole in units.
- The mode of operation is indicated by the "w" variable.
- One unit is approximately equal to one robot wheel spin and equals 10 cm.

Table.2. Modes of Operation

SMS variables	Modes of Operation
1	Ploughing
2	Seed Sowing
3	Soil moisture monitoring
4	Weed removal

8. Experimental Methods

8.1. Ploughing

The 2-unit length and 3-unit breadth are used to represent the land's total dimensions. The SMS is therefore delivered with the format 0232100>. The distance between the seeds is therefore represented by the first two digits. The message's Variable 'w' is represented by 1 when the Ploughing option is used.

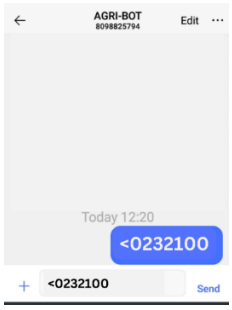

Figure.10. Screenshot of SMS (Ploughing mode)

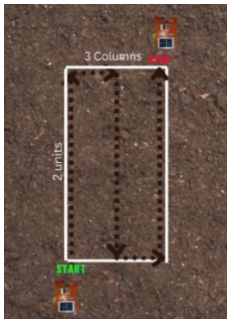

Figure.11. The output of Ploughed land

Figure 10 displays a screenshot of the SMS that the user sent in the format indicated in Table 1 for the ploughing operation. The diagrammatic representation of the land is shown in Figure 11. The area that has been ploughed is indicated in this graphic by the White colour line. Dark brown is used to indicate the robot's path. The stages below outline the complete procedure.

STEP 1: The first action in the pre-programmed process is to receive the user's values via SMS over GSM. After then, the microcontroller receives this.

STEP 2: Based on the user-provided variables, a proximity sensor supports the distance that the robot must move in the first column and permits the wheel to rotate in the forward direction. When it has finished the length specified by the user, it pauses, turns right, and begins ploughing in the following column.

STEP 3: During this step, the ploughing shovel stays in the down position while the revolving blade turns to cut down undesired plants in addition to cleaning them. The robot's basement houses the rotary blade. For this, a 12V DC motor is employed.

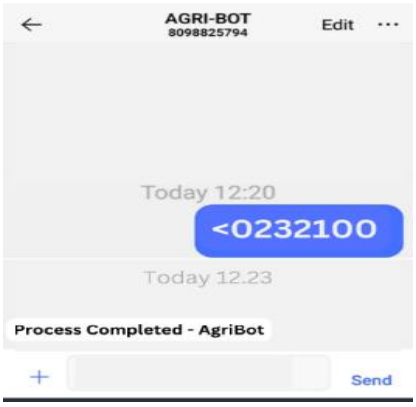

Figure.12. Ploughing completed SMS

STEP 4: Finally, after the procedure is complete, the Agribot will notify the user by sending the message "Process completed - AgriBot" as shown in Figure 12.

Table.3. Sequences of Ploughing

Sequence of tasks	**Task completed Timeline(in s)**
SMS received by Robot	10
Completion of ploughing in 1st column	20
turning right and moving to the next column	23
Completion of ploughing in 2nd column	33
Turning left and moving to the next column	36
Completion of ploughing in 3rd column	46
Robot stops	50

8.2. Seed Sowing

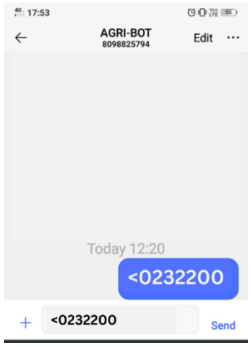

Figure.13. Screenshot of SMS (Seed sowing)

The snapshot of the SMS that the user sent from their phone is seen in Fig. 13. The procedure begins when the microcontroller receives the SMS and transmits it to the GSM module, which then receives the SMS content and transmits it to the GSM module. The steps listed below clarify the process's order.

STEP 1: The Shovel lowers to break up the earth, the wheels turn, and the robot advances.

STEP 2: It comes to a stop after travelling the specified distance (the separation between the dropping of two seeds).

STEP 3: To support the dropping of seeds, a wooden disc (diameter: 50 mm) is provided. Above the wooden disc, a funnel-shaped receptacle holds the seeds. The funnel features a bottom hole through which the seeds fall one by one. A hole with a diameter of 10 mm exists in the hard disc. Until the robot arrives at the spot where the final seed must be dropped, the disc rotates. The wooden disc's limit is managed via the limit switch.

STEP 4: The dug trench is sealed up with the soil-closing shovel as the robot advances, dropping seed after seed.

STEP 5: The robot automatically turns right and stops when it reaches the terminus spanning the complete length specified in the SMS. In the field, the seeds are sown at uniform intervals.

STEP 6: As illustrated in Fig. 14, the robot will automatically stop after completing the entire procedure, display the value 00 00 in the LCD display, and send an SMS.

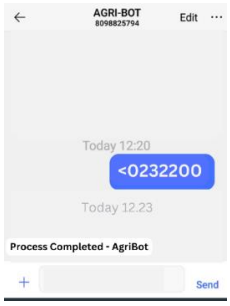

Figure.14. SMS screenshot of Seed sowing (completed)

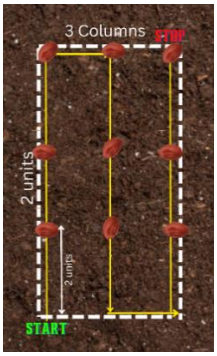

Figure.15. Seed sown land

STEP 7: The shovel finally returns to its initial position. The results of the land with seeds seeded are shown in Fig. 15.

Table.4. Seed sowing sequences

Sequence of Tasks	Task completed Timeline (in s)
SMS received by Robot	10
moving 2 units forward distance	12
sowing 1st seed in 1st col.	14
moving 2 units forward distance	16
sowing 2nd seed in 1st col.	18
moving 2 units forward distance	20
sowing 3rd seed in 1st col.	22
For turning right to the 2nd column	25
sowing 1st seed in 2nd col.	27
moving 2 units forward distance	29
sowing 2nd seed in 2nd col.	31
moving 2 units forward distance	33
sowing 3rd seed in 2nd col.	35
For turning left to the 3rd column	38
sowing 1st seed in 3rd col.	40
moving 2 units forward distance	42
sowing 2nd seed in 3rd col.	44
moving 2 units forward distance	46
sowing 3rd seed in 3rd col.	48

8.3. Monitoring soil moisture

A water pump is utilised in the agricultural sector to hydrate the entire region. The soil's moisture content may occasionally decrease as a result of heat. This issue can be resolved by utilising the soil moisture checking option. The variable 'w' needs to be given the value '3' for this operation to be chosen.

8.3.1. Case 1: Low levels of soil moisture

The water pump in the agricultural field will be turned ON by the microcontroller utilising a relay attached to it when the moisture sensor detects that the soil moisture level is low. This includes a 12V DC water pump that is driven by a 9V battery.

STEP 1: The user sends an SMS containing information about the region of land that needs to be watched.

STEP 2: The GSM transmits to the microcontroller the variable it has received.

STEP 3: The soil moisture sensor advances into the region where the seeds were sowed, continuously monitoring the moisture content of the soil.

STEP 4: The robot turns on the water pump automatically after detecting a low moisture level.

STEP 5: After Agribot completes all of the programmed steps, the message "Process completed-Agribot" is ultimately displayed in the SMS.

Table.5. Soil moisture monitoring sequences

Sequence of tasks	**Task completed Timeline (in s)**
SMS received by Robot	10
soil moisture checking in the first column	20
For turning to the next column	23
2nd column soil moisture checking	33
For turning to the next column	36
3rd column soil moisture checking	46

The sequences of the soil moisture monitoring mode are shown in Table 5. The field's water pump will always be turned ON or OFF depending on the values detected by the soil moisture sensor.

8.3.2. Case ii: Soil Moisture Level Is High

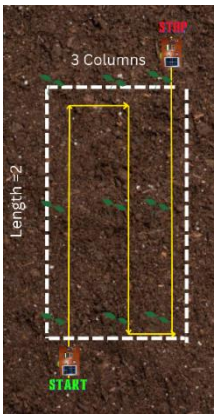

Figure.15. Soil moisture monitored land

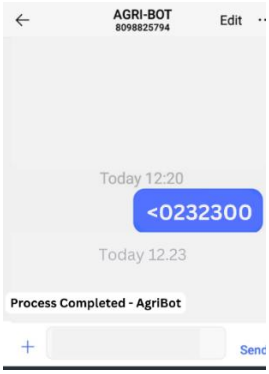

Figure.16. SMS screenshot of Soil moisture monitoring

The SMS is sent using the 0232300 format, as displayed in figure 16. In this case, "02" stands for the distance between the seeds that were sowed, "3" for the number of columns, "2" for the length of the land, and "3" for the soil moisture monitoring mode. When an SMS is received by the GSM, it is delivered to the microcontroller, which then initiates the processes listed below. Due to the high temperatures during the day, the land may readily be dried. Therefore, it is essential to monitor the land at evening.

STEP 1: Tracking the user's SMS messages sent with information about that location

STEP 2: GSM transmitted to the microcontroller the variable it had received.

STEP 3: A soil moisture sensor moves around the seed-sown area, continuously checking the moisture content.

STEP 4: It turns the water pump off automatically after detecting the excessive moisture level.

8.4. Weed removal

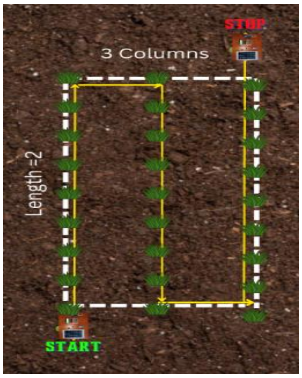

Figure.17. Weed Cutting

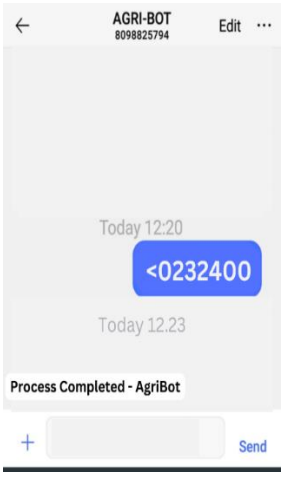

Figure.18. SMS screenshot of Weed cutting

The weed-removing mode can be completed in the following steps:

STEP 1: The user depicted in Fig. 18 sends an SMS with control variables.

STEP 2: After receiving the SMS from the GSM, the PIC microcontroller will receive it.

STEP 3: A rotary blade that turns and cuts down all weeds is fixed in the bottom of the robot. These blades function during ploughing as well.

STEP 4: When the robot has completed all the work, it will halt at the final location depicted in Fig. 17.

STEP 5: After all procedures are finished, Agribot will send the user an SMS.

Table.6. Weed Removing Sequences

Sequence of tasks	Task completed Timeline (in s)
SMS received by Robot	10
For removing weed 1st column	20
For turning to the next column	23
For removing weed 2nd column	33
For turning to the next column	36
For removing weed 3rd column	46

9. Conclusion

In this paper, a robot has been suggested to carry out various agricultural tasks, such as weeding, soil moisture monitoring, seed sowing and ploughing. These tasks are intended to be carried out by the robot using programme sequences. It scatters the seeds evenly spaced out at the user-specified distances without wasting any of them. The GSM module serves as the user's and the robot's interface. The robot is given land measurements using a mobile phone. All tasks are completed in accordance with the user's instructions. The robot has undergone satisfactory testing and completed all tasks. The farmers who cannot afford to pay hefty wages to the labour will find this robot to be of great assistance. As a result, big farming communities can utilise this robot to efficiently manage vast agricultural regions. More agricultural activities could

make this project better. You can add spike wheels for greater mechanical power. Additionally, this project's use of IoT and machine learning techniques can be carried out by a fully autonomous robot. Other features can be added, such as the ability to identify certain weeds and diseases, as well as the percentage of vegetable growth.

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