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Autonomous Agribot

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Abstract: Agriculture plays a vital role in the economic growth of any country. With the increase of population, frequent changes in climatic conditions and limited resources, it becomes a challenging task to fulfill the food requirement of the present population. A manual farming consumes more time and is less efficient. So, smart agriculture techniques have recently seen widespread interest by farmers. This is driven by several factors, which include the widespread availability of economically priced, low-powered Internet of Things (IoT) based wireless sensors to remotely monitor and report conditions of the field, climate, and crops. Furthermore, the boom in IoT technologies have enabled farmers to deploy autonomous farming machinery and make better predictions of the future based on present and past conditions. This helps in decreasing the labor and time required to perform the processes on crops. So, the project is to design and construct a solar powered agricultural robot capable of seeding and watering. The system uses GPS coordinates to measure distance. This helps in planting the seed at equal distances. Geopy libraries in python is used to implement distance measurement algorithm. The same distance measurement algorithm is used to locate the planted seeds and water them. Watering is based on the results of soil moisture sensor. The battery used in this project can be recharged by the solar panel kept above the vehicle. This ensures the use of eco-friendly energy and prevents frequent charging of the vehicle. IoT is the backbone of the control strategy of the project thus, the actual status of the field can be monitored and controlled from any part of world using internet.

I. INTRODUCTION

Agriculture has always been a vital industry in the world, providing food and raw materials for various industries. As per the recent report by the UNESCO World Water Assessment Program (WWAP), the world's population will increase by 33 percentage in 2050, doubling the need for food and water. So Smart Agriculture Techniques have recently seen widespread interest by farmers and researchers alike to meet increased food demands. Smart Agriculture Systems (SAS) are driven by several key factors, which include the adoption of IoT technologies for remote, unmanned monitoring of the agriculture fields and taking corrective actions to make the environment most conducive for crop growth. The traditional methods of farming have been labor-intensive, time-consuming, and not environmentally friendly. The use of technology in agriculture has brought about significant changes and made the industry more efficient, productive, and sustainable. One of the latest developments in the agricultural industry is the use of smart agricultural robots. Smart agricultural robots are autonomous robots that can perform a range of agricultural tasks such as planting, harvesting, weeding, and monitoring crops. The use of smart agricultural robots has the potential to revolutionize the agricultural industry by increasing efficiency, productivity, and sustainability.

One of the most significant advantages of using smart agricultural robots is the increase in efficiency. The use of traditional farming methods involves a lot of manual labor, which is time-consuming and costly. With the use of smart agricultural robots, tasks such as planting, harvesting, and weeding can be done quickly and efficiently, reducing labor costs and increasing productivity. Smart agricultural robots can work for long hours without getting tired, ensuring that tasks are completed on time. They can also operate in adverse weather conditions, making them suitable for use in all seasons. Smart agricultural robots can also help to reduce the amount of water used in farming. These robots can monitor the moisture levels in the soil and apply water only when necessary, reducing waste and conserving water. The use of smart robots can also reduce the amount of energy used in farming, as they can operate autonomously, reducing the need for manual labor and machinery. The use of smart agricultural robots can significantly increase the productivity of the agricultural industry. These robots can perform tasks quickly and accurately, reducing the time and labor required for farming. This increased productivity can help farmers to produce more food and raw materials, meeting the growing demand for these products. The use of smart robots can also increase the yield of crops, as they can identify and treat crops with precision, ensuring optimal growth and harvest.

II. RESEARCH OBJECTIVES

The main objectives of this project are to design and implement an Agriculture Robot, which is capable of doing mainly two functions, seeding and watering. Additionally, the robot has to be made autonomous, which can be controlled by an android application.

III. OVERVIEW ON AUTONOMOUS AGRIBOT

The system is a solar powered robot capable of seeding and watering and to detect soil moisture. The motion of the machine is based on distance measurement by using GPS coordinates. The machine is programmed to work in two modes, either automated or manual mode depending on the decision of the user. These modes are controlled by a PIC microcontroller and the distance detection is controlled by a Raspberry Pi module. The configurations are made in such a way that the device can be controlled easily by any user. Solar panel is provided to charge the battery with maximum efficiency and sustainability.

3.1 Configuration of Agricultural Robot

The robot consists of PIC Microcontroller and Raspberry Pi for interfacing the system with Internet of Things (IoT). The output power from solar panel is used as a power source for the system. A 10W,12V solar panel with 36 cells per module is used. Two DC motors of ratings 12V are used for the movement of the machine. The machine consists of a seed chamber which has an opening at the bottom part, through which the seed is dropped. This opening is covered by a servo motor. The servo motor is configured to rotate by 90^0 When the user command given is seeding, at the vehicle stopping distance, the servo motor rotates by 90^0, thus opening the seed chamber. This ensures that the seed falls through the opening.

Watering depends on the value of soil moisture and a soil moisture sensor is used for the same. The soil moisture sensor is integrated with the microcontroller. When the user command is to water, the vehicle stops at the coordinates where the seed was planted. The soil moisture sensor then detects the moisture level and if the moisture level is below a threshold value, DC motor pump is activated, which waters the area.

Figure 3.1 shows the block schematic of the system.

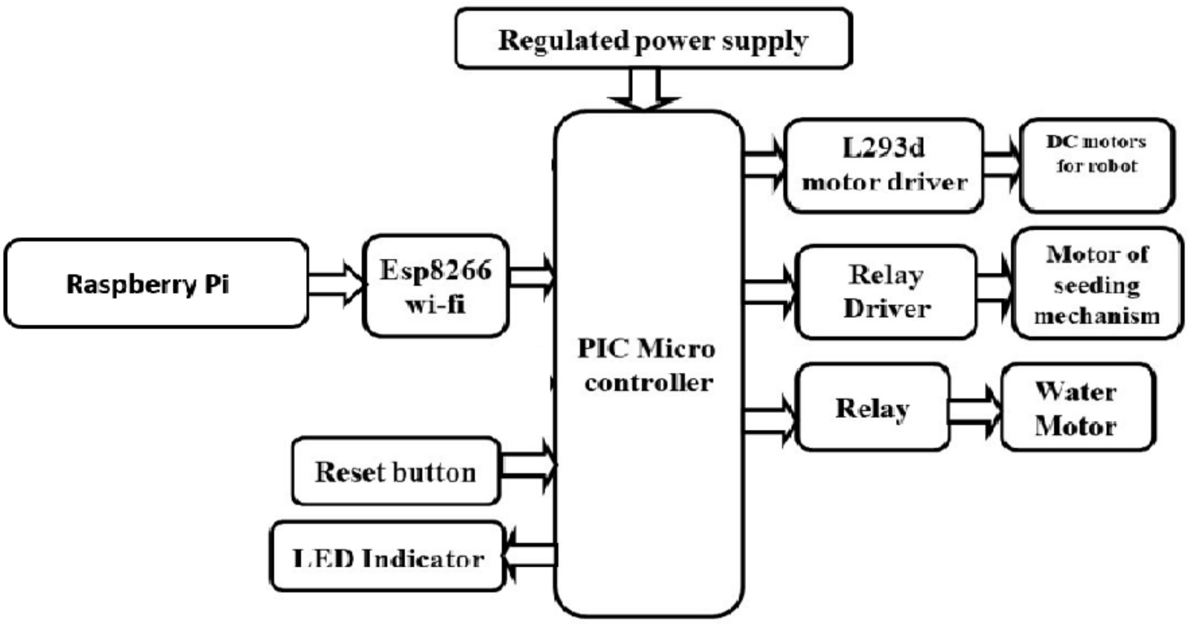

Figure 3.1. Schematic Diagram of Agriculture Robot

Here, L293D is a motor driver used which can drive up to 4 DC motors at a time. The functionalities of the machine is controlled using an android application called JuiceSSH, which works as a platform for IoT devices, like Arduino and Raspberry Pi and uses a protocol known as SSH. The PIC16F72 microcontroller is interfaced with the motors and relays. The PIC microcontroller is programmed to work depending upon the signal or command given by the user, through the android application.

3.2 Solar Panel and Charging Circuit

The specifications of the solar panel used is given in Table 3.1. A 10W, 12V solar panel is used to charge the battery. This solar panel consists of a set of interconnected silicon solar cells, encased in a durable and weather-resistant frame. It is designed to be efficient, lightweight and easy to install, making it ideal for use in remote locations and moving parts which can only carry lightweight mountings.

Table 3.1. Parameters of Solar Cell

PARAMETER	RATING
Power	10W
Number of cells per module	36
Open Circuit Voltage	21.65V
Short Circuit Current	0.69A
Voltage at maximum power	17.85V
Current at maximum power	0.60A

The circuit diagram of the charging circuit used for regulated power supply is shown in Fig 3.2.

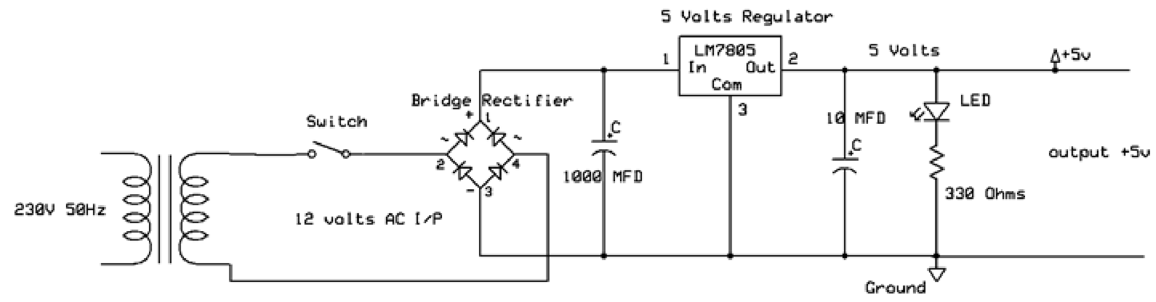

Figure 3.2. Circuit for regulated power supply.

This circuit converts 230V, 50Hz AC to an output of 5V DC. It uses a 240/12V step-down transformer. A rectifier is used to convert the low voltage AC to a pulsating DC. A full wave bridge rectifier is used for this purpose. Here, IC DB107 acts as a full wave rectifier. Then, filter capacitors are used. A voltage regulator LM7805 is used. It a specific voltage regulator which converts any voltage to a value of 5V. A small capacitor is placed at the output of the voltage regulator to filter out any high-frequency noise that may be present.

IV. CONTROL STRATEGIES AND FUNCTIONALITIES

In the proposed work, an optimal approach for design and functioning of the agricultural robot is explained. the motion of the machine with its other functionalities and control strategies are also explained. Here, for the motion control of the system, GPS coordinates are used. These are implemented by interfacing GPS modules with Raspberry Pi. The Raspberry Pi has Geopy library, which helps in converting the GPS coordinates from coordinate for to a metric form, assuming starting point as origin. The algorithm for the motion and stoppage of the vehicle is also explained.

4.1 System Control Strategy

The motion and the functionality of the machine is based on two parameters. First one being distance detection algorithm using GPS coordinates. The flowchart for implementing distance detection algorithm is shown in Fig. 4.1.

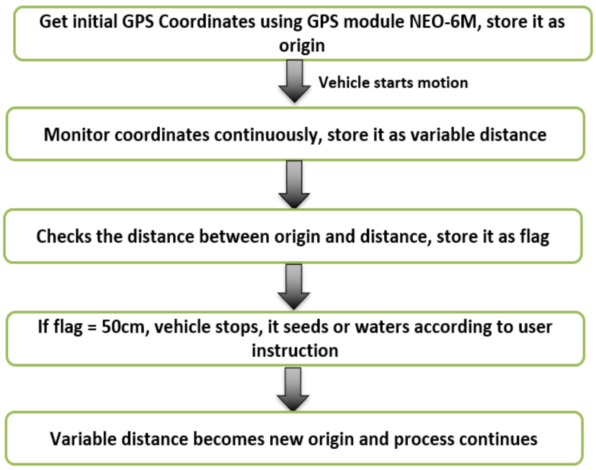

Figure 4.1. Distance Measurement using GPS Coordinates.

Initially, the starting point of the machine is taken as the origin point and is saved as a variable origin. Now the vehicle starts its motion. With each identifiable GPS coordinate, the device compares the distance between the origin and the present coordinate by converting it to centimetre. If the distance between origin and the present point is within a value 45 to 55 centimetres, the machine stops and conducts its task. If the distance is not within the specified limits, the vehicle will move forward. After stoppage, the GPS coordinate at which the vehicle stopped will become the new origin and the motion of the vehicle continues.

Generally, GPS modules are made such that GPS coordinates have an accuracy only around 1.5 metres to 2 metres. It means that the coordinate detected by the GPS module is not accurate. The coordinate is just a part of a 2m radius. Thus, the distance of stoppage may sometimes not be equal. To tackle this, a second method of control strategy is used. Here, the machine stops after every 15 seconds of motion to do the function. The machine is programmed in such a way that the machine will stop either at constant distance or at constant time, whichever comes first.

4.2 Functionalities of Agriculture Robot

The functionalities of the vehicle can be controlled using any of the two android applications JuiceSSH or UDP/TCP Client application. These applications can communicate with the ESP8266 module which is connected to the agribot. The ESP module is interfaced with a Raspberry Pi module and the PIC16F72 microcontroller. The functionalities of the agribot are decided based on the command given by the user through the android application.

The machine has two functionalities, seeding and watering. Specific commands are provided in the android application to activate each functionality.

4.2.1 Seeding

The vehicle consists of a chamber to store seeds. The chamber is a funnel like structure, which has a large opening on the top and a small one on the bottom. Seed is stored at the top opening and the bottom opening is covered using a servo motor, which is programmed to rotates by an angle 90^0 upon receiving signal from the microcontroller. Using the distance detection technique, when the vehicle stops at a particular distance, a signal is sent to the microcontroller which activates the servo motor connected to the seed chamber. On receiving the signal from the microcontroller, the servo motor rotates by 90^0 angles. This in turn makes an opening in the seed chamber through which the seed is dropped. The vehicle is programmed to stop for 7 seconds at a position and after 7 seconds, the vehicle moves forward.

4.2.2 Watering

Another functionality of the vehicle is watering. A plastic vessel is mounted at the front end of the vehicle. This acts as a chamber to carry water. The chamber can carry up to 1 litre of water. The vessel has a hole drilled in it within which a 12V DC motor pump is placed. The pipe connected to the pump is placed at the back end of the vehicle.

The microcontroller is interfaced with two components, first one being the DC motor pump and second interface is a soil moisture sensor. The vehicle travels according to the GPS coordinates and stops at coordinates. When the user given command is watering, initially the microcontroller sends a signal to the soil moisture sensor. The soil moisture sensor is configured with a threshold value of 800. If the sensed value is less than the threshold value, there is no need for watering. If the sensed value goes beyond 800, the microcontroller identifies it as low moisture and a signal is sent to the DC motor pump. The pump then draws water from the chamber and waters the area of seed.

4.3 Controlling the Machine using Android Application

The system uses an android application called JuiceSSH which is interfaced with Raspberry Pi and ESP8266 module over the internet. JuiceSSH is an Android SSH client that allows users to securely connect to remote servers and manage them from their mobile devices. JuiceSSH uses a protocol called Secure Shell Communication which is a method of securely communicating over IP address. The application has a terminal like interface through which different commands can be given. There are specific commands for each motion of the vehicle.

The machine can be worked in two ways. Either in automatic method or in manual method. In automated working, the user only needs to provide the initial command i.e., whether to seed or water and based on the programs in the PIC16F72 microcontroller, the vehicle will move. While, in manual method of working, the user should always provide commands for the motion of the vehicle.

4.3.1 Automated Working of Agribot

In automated working method, there are only three sets of commands: command for Automated Seeding, command for Automated Watering and a common command to stop the vehicle any time. In automated control, the user initially gives an instruction through JuiceSSH, whether to water or seed. The JuiceSSH application then forwards the instruction to the microcontroller. The microcontroller is programmed to detect the signal received via the JuiceSSH application. Here, command 'A' is given for Watering and command D is given for seeding. When the user sends the commands through the JuiceSSH application, the microcontroller receives the signal and if it signals 'A', the device will seed autonomously according to the algorithm and program provided and if the signal is 'D', the device will automatically water.

4.3.2 Manual Working of Agribot

In manual method, the user can give commands whenever he need using the application. There are specific commands for forward, backward and sideways motion as well as commands for watering and seeding whenever necessary. The user can provide the command according to his need. There are several commands like 'f' for forward motion, 'b' for backward motion, 'l' and 'r' for left and right motions.

Seeding can be done using command '1' and watering is done by command '2'. To completely stop all the activities of the vehicle, command 'S' is given. The user should always give the commands for the proper functioning of the machine.

V. HARDWARE MODEL

5.1 Prototype Model

The agribot is programmed to perform two tasks: planting and watering with minimal human intervention. It uses GPS coordinates to navigate the field and stop at equal distances. It also uses soil moisture sensor to sense the moisture level and water according to the threshold value. The system is designed in such a way that it ensures uninterrupted charging services to users, even in the absence of sunlight as it could be charged using an adapter, while in remote areas devoid of electricity, solar energy can be used to charge the battery. The prototype is typically designed with a lightweight and durable frame, making it easy to maneuver and operate in various terrains. It has various attachments, such as seeding mechanism and watering mechanism.

The hardware model of Autonomous Agribot is shown in Fig 5.1, and Fig 5.2. Solar Panel, water chamber and seed chamber are fixed the agribot and whole circuitry is fixed on a thick cardboard. The whole machine is made from an iron frame which is welded according to the required design. At the bottom portion of the frame, space is provided to set up the circuitry. Both the end of the structure has supports for seeding and watering chamber. A higher structure is provided to place the solar panel. The machine consists of a 12V battery, which is obtained by placing six 2V batteries in a series connection.

The system has two modes of charging, i.e., charging from the solar panel or charging from direct supply through an adapter. Depending on the requirement of the user, charging can be done in either way.

Figure 5.1. Prototype model of Autonomous Agribot

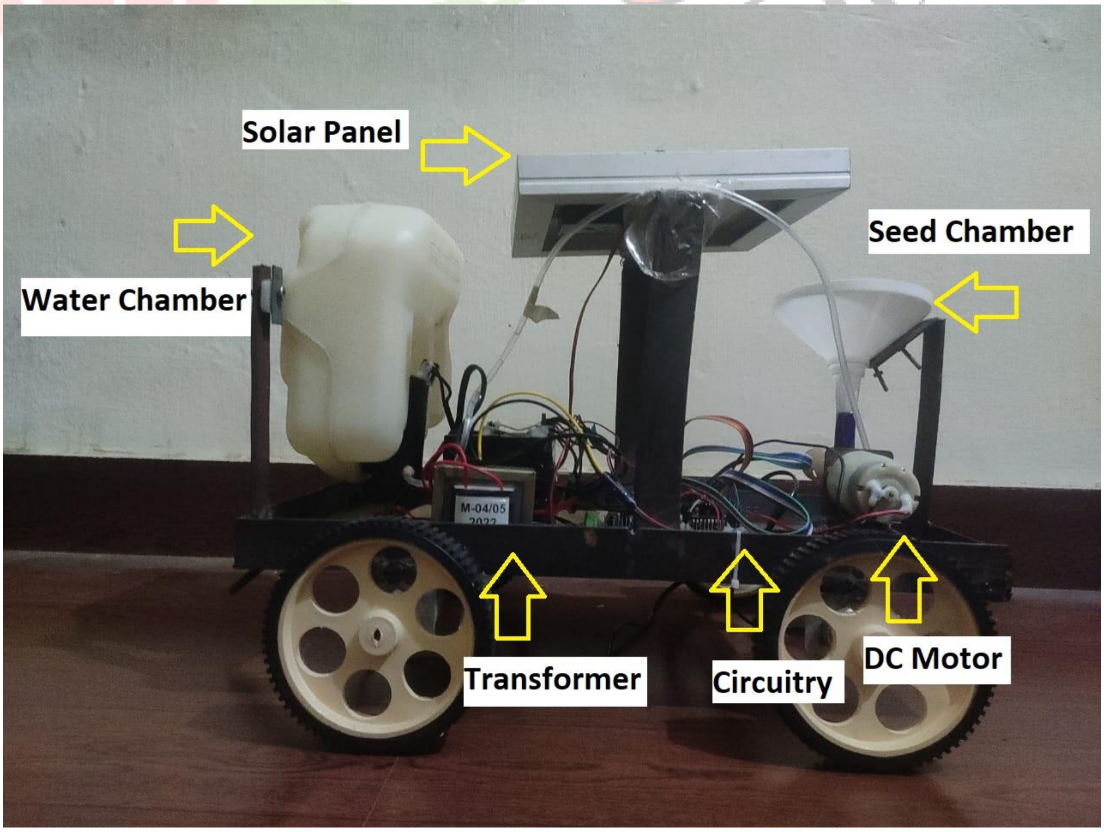

Figure 5.2. Sideview of the agribot

5.2 Software User Interface and Mapping of Commands

Different keys are mapped for different functions. It is shown in Table 5.1.

When the user inputs command ‘f’ in the terminal, forward motion occurs, likewise for other commands ‘b’, ‘l’ and ‘r’, these are used for motion of vehicle. Commands ‘1’ and ‘2’ are used for manual control of the vehicle. The user has to give these commands at regular time for proper functioning of the vehicle. Commands ‘A’ and ‘D’ corresponds to automated working of the vehicle. The user has to initially give the commands and based on the compiled program; the device will work automatically.

Table 5.1. Keys and Mappings for commands used in JuiceSSH

Keys	**Functions**
F	Forward
B	Backward
L	Left
R	Right
1	Manual Seeding
2	Manual Watering
S	Stop
A	Automated Seeding
D	Automated Watering

Figure 5.3 shows the UI of the android application JuiceSSH.

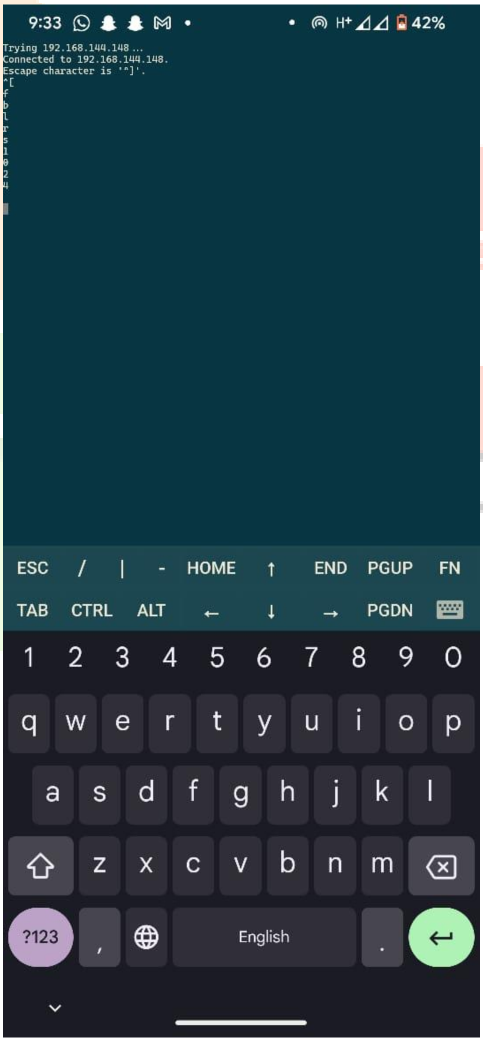

Figure 5.3. UI of JuiceSSH

5.3 Conclusion

The importance of smart agriculture practices is increasing with the growing gaps in global food demand versus current food generation, the growing shortage of arable land for agriculture, stricter regulations by International organizations on the use of toxic pesticides/herbicides, and global shortage of water resources for irrigation purpose. Clearly, all the challenges cannot be met through traditional agricultural practices. The smart agriculture robot's implementation, use-cases, and constraints were examined together with the hardware, software, and wireless communications technologies that are used for the project. A solar-powered autonomous agribot is a robotic machine that is designed to assist in agricultural tasks, such as planting and watering.

The control to the device through the android application JuiceSSH was established. With JuiceSSH, the agribot's performance can be monitored and behavior can be changed by executing commands remotely. This enables the optimization of the agribot's operation and enables real-time adjustments to its behavior, making it a highly efficient and effective tool for farming.

Overall, a solar-powered autonomous agribot controlled by JuiceSSH is a sustainable solution for modern agriculture. By using renewable energy and remote-control capabilities, it can help improve the efficiency and productivity of farming while reducing the environmental impact.

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