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The Solar Powered Farm Assisting Multipurpose Agricultural Machine with Wireless Connectivity

Harshita Mishra¹, Pravin Kumar Singh²

U.G. Student, Department of Mechanical Engineering, Amity University, Lucknow, India¹

Assistant Professor, Department of Mechanical Engineering, Amity University, Lucknow, India²

ABSTRACT: The agriculture sector in India is the main source of income for the vast majority of the population. The agriculture sector is being impacted more by environmental, food safety and quality, and animal welfare norms as well as by the expanding worldwide market. It must overcome new challenges in order to meet the world's growing food demand, maintain its competitiveness, and produce high-quality agricultural products. One of the most common methods to boost farmers' income is the adoption of more cutting-edge agricultural technology, and agricultural robots are one such technology. As an agricultural enthusiast, I have proposed the development of a solar-powered agricultural robot that will have several innovative features to revolutionize the farming industry. This robot will operate through Bluetooth enabled device increasing efficiency in various agricultural operations such as seed sowing, weeds cutting, smart irrigation, ploughing of field, pesticide spray, drain making and levelling of field. The smart irrigation feature allows farmers to optimize water usage and reduce water wastage, resulting in better conservation of this precious resource. The temperature and humidity sensors allow farmers to monitor environmental conditions and make informed decisions about planting, watering, and harvesting crops. The robot's ability to plough, weed, and level the field will improve soil quality, leading to better crop yields, reduced erosion, and improved plant health. The pesticide spray feature will help farmers target specific areas that require treatment, reducing the use of chemicals and minimizing environmental impact. The proposed work on a solar-powered agricultural robot with its multiple features is an innovative solution that has the potential to transform farming practices. It will help farmers increase efficiency, save time and resources, also contribute to the sustainability.

KEYWORDS: ArduinoUNO, IntegratedCircuit(IC), DCMotor, Battery, Bluetooth, Sensor, SolarPower, Servomotor.

I. INTRODUCTION

The vital problem of feeding India's rapidly expanding population falls on the agriculture sector. The industry must consistently use novel strategies to boost yields, utilize inputs effectively, and vary crop patterns towards more valuable and sustainable crops [1]. For the development and use of these knowledge-intensive technologies, qualified farmers and a robust infrastructure for research and extension are crucial. To achieve a win-win information exchange, this calls for improved communication between farmers, researchers, and policymakers. The agricultural industry must use technology if it wants to utilise resources effectively. This involves using cutting-edge methods and equipment to raise output, lower expenses, and enhance sustainability [2]. However, policymakers must commit a sizable amount of funding to and support the adoption of technology in agriculture. It is essential to give farmers the education, tools, and incentives they need to adopt new technology and increase their profitability. Over 50% of India's population relies on the agricultural sector for their livelihoods and the economy [3]. In terms of low and stagnating revenue, poverty, and the need to feed a constantly expanding population, the industry faces considerable problems. To overcome these obstacles and boost the effectiveness of resource utilization in the industry, innovative agricultural technologies must be adopted. To ensure that India's agricultural industry has a sustainable and prosperous future, farmers, academics, and politicians must work together [4].

Producers think that automation is a feasible and occasionally required approach to assure maximum earnings with minimal expenditures, thus they have started to enhance particular automation in several industries in response to rising demand on farmers [5]. Hopkins does, after all, contend that technology makes it possible to grow a farm without

spending more money on workers. Increased sales from a cheaper product may be advantageous to retailers; similarly, customers will gain from a cheaper product of equivalent quality. However, from an ethical or social standpoint, it appears that agricultural labourers are the main beneficiaries. In this project, an autonomous robot that aims to alleviate some of the issues with human health connected to farms is designed and built. This robot is intended to serve as a foundation for the creation of systems that will enable the automation of farming tasks including the application of pesticides, fruit picking, and plant disease management [6]. As many of the various jobs may be developed and/or modified, the system is created to be as flexible as feasible.

II. LITERATURE SURVEY

Ratnadip S. Patil et al [7] proposed a system that combines all the tasks including ploughing, planting, and irrigation, into a single robot and executes them through wireless through remote control. When necessary, the entire arm-supported structure is employed for plough work, sowing, irrigation, and fertilization. In the field, Agro-Bot will move. By using a remote controller, we have the opportunity to select the mode of operation. Farmers will find it easier to work in the way they choose. Additionally, Agro-Bot will be fitted with solar panels that will aid in recharging the batteries using renewable energy. It won't harm the environment and will aid in reducing the usage of non-renewable energy sources. The project's main goal is to create a multifunctional agricultural robot that can be utilized for low-cost and more effective agricultural tasks including soil preparation, seed sowing, irrigation system maintenance, and fertilizing. This robot will be environmentally friendly and energy-efficient since it will be powered by solar panels. Mild steel makes up the robot's foundation frame.

Sanna et al [8] discussed the development of a potential precision mobile application controlling farming system. This system's effective tilling, ploughing, harvesting, spraying, and cutting with video monitoring capabilities are intended to enhance agriculture. They can control robotic vehicles and the Android's ability to control Bluetooth with this little mobile application. In this regard, this project is essential for recharging the battery that powers the motor attached to the robot's vehicles. This project and its predecessors are supported by renewable solar energy. Future labour shortages will be lessened by this system. The robot that is operated by a mobile application or by a program is used for harvesting, ploughing, spraying, and cutting. This mobile application also incorporates a camera monitoring method. A battery that is attached to a solar panel for recharging will power the robot. The difficulty and requirement of constructing and developing robots is to cooperate with nature.

Hans W. Griepentrog et al [9] provide a description of the tiny electric powered robot's design, control, and renewable energy source for use in field monitoring and other outside tasks. Additionally, based on power consumption measurements for the fundamental navigation modes, the energy consumption for the various operational scenarios was calculated. Two distinct charge situations have also been researched. The experiment has demonstrated that a robot may be operated for 11 to 13 hours using only PV cells. When compared to using the public power grid, PV charging methods are more costly. Only when there is no access to the grid are they practical. A pair of situations have been looked into for electrically recharging an agricultural robot. The experiment has demonstrated that a robot can be powered by PV cells. However, as compared to using the power grid, both alternatives are quite expensive. When there is no connection to the public power grid, the solutions are still workable.

Erinle et al [10] highlighted several activities that go into the production of food and fiber. Additionally, it emphasizes how important robot development for agricultural applications is. The finding demonstrated the important contribution that robots may make to agricultural approaches for efficient mechanized farming in the sector. Last but not least, agricultural robots are essential tools for carrying out repetitive operations in farm cultural practices, inspection, and harvesting, as well as post-harvest management, faster, cheaper, and more correctly than people.

Akash Gheoderao et al [11] proposed a system whose primary goal is to increase crop growth while requiring less work from farmers. In this project, a mobile phone may be used to regulate the pump's supply from anywhere in the world. Farmers have recently begun adopting irrigation techniques with manual controls, turning the water pump on and off as needed to irrigate the ground at regular intervals. Sometimes, this procedure uses more water and other times, the water delivery to the field is delayed, which causes the crops to dry up. The Dual Tone Multi-Frequency (DTMF) signal is converted into a binary signal for this using the IC8870. The microcontroller IC89C52, is utilized to link IC8870 and ULN2003.



III. METHODOLOGY

In this prototype, solar energy is captured by a solar panel, which is then turned into electrical energy. This electrical energy is then used to charge a 12V battery, which provides the required power to run a DC motor. The Robot is managed by the Arduino. Here, Arduino serves as the robot's central processing unit and is utilized to manage all of its functions. Internal motors and motor drivers receive the necessary direction in this manner.

- The battery and solar power are used throughout the robot system. The battery is charged using a solar panel that is mounted on top of the frame.
- The system powered by the solar panel needs a 12V battery to run the entire robot and the whole system is controlled by a Bluetooth enabled device for which HC05 Bluetooth module is used.
- The robot's basic structure has four wheels that are attached to a L298 motor driver, which controls the robot's movement and speed.
- Two Arduino uno is used one for seeding, harvesting, light and water pump and other Arduino is used to display temperature, humidity and moisture and to monitor smart irrigation.
- A plastic funnel that is attached to the dug-up dirt and utilized for sowing seeds is used for the seed-sowing process.
- Attachments are made for drain making and levelling which can be attached at the rear end of the robot as per requirement.

IV. SYSTEM MODEL

An agricultural robot that is controlled by an Android app using Bluetooth protocol is the subject of this research. The four buttons on the Android app control the robot's movement. The robot would move in the following directions: forward, backward, right, left. Additionally, it has a list picker for choosing the Bluetooth device that is linked to the robot. The Android app is prepared to control the robot's operations once it has established a secure connection with it. The robot can level the soil, sow seeds, water plants, plough, make drains, pesticide spray and cut the weeds. The movement of soil moisture sensor will be operated by a servo motor to conduct the smart irrigation operation. Pump motor will be used for pesticide spraying. The Flat leveller is used for levelling and drain cutter is used for making drains in the field. All of these operations may be started using a button on the Android app. The robot is equipped with sensors including a temperature, humidity and soil moisture sensor. The app automatically detects and displays the sensor data. The robot's surroundings are measured for temperature and humidity using the temperature and humidity sensor. The soil moisture sensor is used to gauge the soil's moisture level. The robot has two modes of operation. The robot moves while also carrying out tasks including ploughing, seeding, pesticide spraying and levelling the soil, drain making in the first mode. In the second mode, the robot merely waters the soil after detecting its moisture content. The first method of operation is employed during the early phases, while second method is used when robot merely needs to water the field.

V. MATERIALS AND METHODS

• Hardware Requirement

S. No.	Components	Use
1.	ArduinoUNO	TheArduinoUNOisamicrocontrollerboardthatactasasthebrainoftheagricultureRobot.Itreceivesinputfromvarioussensorsandcontrolstheoutputdevices.
2.	L298MotorDriver	TheL298motordriverisamodulethatalloestheArduinotocontrolthespeedand direction ofthe100 RPM motor.
3.	100RPMMotor	The100RPMmotorisused tomovetheAgricultureRobot.
4.	4channelrelay modules	The4-channelrelaymoduleisusedtocontroltheseeding,harvesting,light,andwater motor.TheArduinocontrolstherelaymodule,whichin turncontrolstheoutputdevices.

5.	Servomotor	The Servo Motor is used to control the movement of the Agriculture Robot.
6.	HC05 Bluetooth Module	The HC-05 Bluetooth module is used to control the Agriculture Robot using a mobile phone. The module is paired with mobile phone, and the app is used to control the robot.
7.	DHT11	It is used to detect temperature and humidity.
8.	Soil Moisture Sensor	The Soil Moisture Sensor is used to monitor the soil moisture level of the farm. It activates the water pump when the moisture level is low.
9.	Solar Panel	The Solar Panel is used to charge the battery using solar energy.
10.	Water Pump	The Water Pump is used to supply water to the plants.
11.	Battery	Supply power to the system.
12.	Charger	The Charger is used to charge the battery using solar energy.
13.	7805 & 7809 IC	The 7805 and 7809 ICs are voltage regulators that are used to power these separate sensors and modules.
14.	Jumper Wires	These are used to connect the various components to the Arduino and other modules.
15.	LED	The LED is used to indicate the charging and solar indication features.
16.	16*2 LCD Display	It is used to display temperature, humidity and soil moisture.

Table 1: List of Component Required along with their Specifications

• **Block Diagram**

The block diagram includes an Arduino microcontroller that serves as the overall system's controller shown in Fig 1, a solar panel that stores energy in a battery, and a power supply charging circuitry that supplies +5 V for the Arduino board and +12 V to drive DC motors with L298 motor driver modules. To operate the entire system, Bluetooth HC05 is connected to an Arduino board and wirelessly to an Android smartphone.

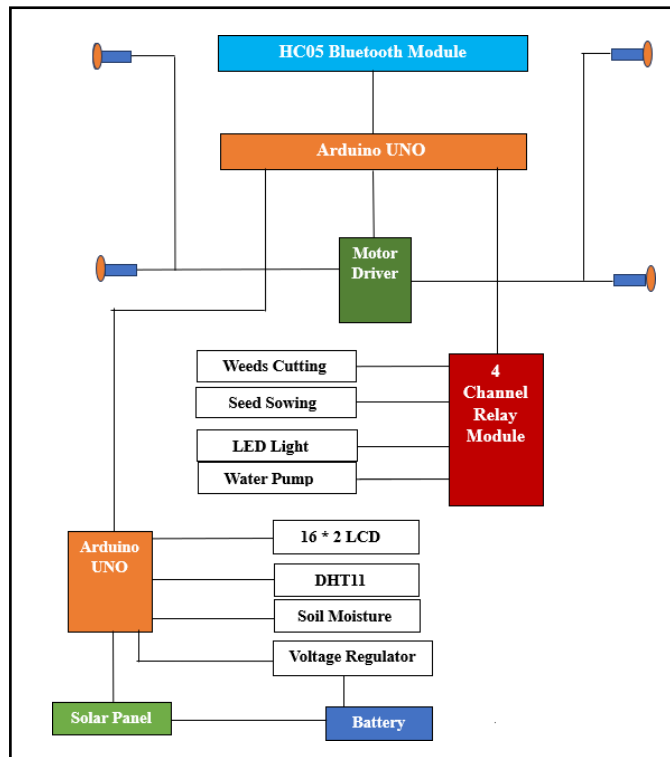


Figure 1: Block Diagram of Agricultural Machine

• **Fabrication of System**

- Two Arduinos will be used in the Agriculture Robot, one to operate it and the other to track temperature, humidity, soil moisture, and water pump.

- The L298 motor driver, which controls the robot's 100RPM motor, will be linked to the Arduino used to operate the robot.
- The digital pins on the Arduino UNO will be used to link the L298 motor driver, and the 7805 and 7809 ICs will be used as a separate power source.
- The robot will be propelled by a motor that is fastened to wheels. The Agriculture Robot's many functions will be controlled by a four-channel relay module.
- Each relay will be connected to a separate activity, such as sowing, harvesting, light, servo motor, or water motor, and will be connected to the digital pins of the Arduino UNO. The 7805 and 7809 ICs will supply power to the relay module.
- The servo motor, which is attached to the Arduino UNO's digital pin and whose movement is controlled by the Servo library, will be used to move the robot's arm.
- The second Arduino will be used to keep an eye on the water pump, soil moisture, temperature, and humidity. The appropriate sensors will be attached to the Arduino, and its readings will be sent over the I2C protocol to the Arduino controlling the robot. Relay module attached to the second Arduino will be used to operate the water pump.
- A 12V 1A battery will be used to power the entire system, and a solar panel will be used to recharge it. The battery's voltage and current will be controlled by a charging circuit that is linked to the solar panel.
- In order to indicate when the battery is being charged, the charging circuit will additionally have a charging indicator LED.
- Mobile control of the robot will be possible thanks to the HC-05 Bluetooth module. The module will be linked to the Arduino UNO's serial pins, and Bluetooth-enabled mobile devices will be used to establish communication between them.

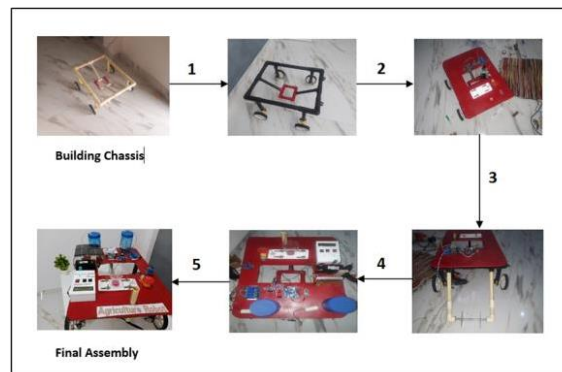


Figure 2: Fabrication process of Agricultural Machine

• **Final Assembly**

The final assembly of an agricultural robot prototype involves bringing together all the different components and subsystems into a fully functional machine that can perform various tasks in the field. The process requires careful attention to detail and testing to ensure that the prototype is reliable and efficient in its intended use. After the wheels and motors are installed, the electrical components such as sensors, controllers, and batteries are connected. Once all the components are assembled, the software is loaded onto the controller. Figure 3 shows the final assembly of the agricultural robot.



Figure 3: Final Assembly of the Prototype

VI. OPERATIONS

- Seed Sowing:** The agricultural robot can be used for seed sowing for which slider crank mechanism has been used. To control the slider crank mechanism, the user can send commands through a Bluetooth-enabled smartphone. These commands can control the speed and direction of the linear motion. The seed sowing mechanism using a slider crank mechanism typically consists of a plastic pet bottle that holds the seeds, a metering mechanism that controls the flow of seeds, and a delivery system that places the seeds into the soil at the correct depth and spacing. This ensures precise seed placement.
- Harvesting:** The agricultural robot can be used for cutting down the weeds. The agriculture robot’s cutting mechanism consists of a blade that is attached to the motor. The blade is mounted on an arm that can be controlled remotely by the user through a Bluetooth enabled device. The blade rotates with high frequency to ensure that the weeds are removed properly.
- Smart Irrigation:** The smart irrigation mechanism in the agricultural robot consists of a network of sensors that measure soil moisture, temperature and humidity. The sensors send the data to the robot’s control system, which analyses the information and determines the appropriate amount of water to be applied to the crop. DHT11 sensor is used to measure the temperature and humidity which is displayed on the LCD screen. When soil moisture sensor is dipped into the soil it measures the soil moisture. Soil moisture sensor measure the soil moisture in terms of resistance. When resistance value is more than 800 then water pump is turned on and water is supplied to the soil and when resistance value is less than 800 than water pump is switch off. The movement of the soil moisture sensor can be controlled by Bluetooth enabled device.
- Ploughing:** This agricultural robot can be used for ploughing application. The ploughing attachment has been provided at base of the robot so that as the robot will move forward it will do the ploughing of the field. It can be controlled by the Bluetooth enabled device.
- Levelling:** The agricultural robot can be used to leveling the land after seed sowing. An attachment has been made which can be attached at the rear end of the robot so as the robot will move forward it will level the field.
- Drain Making:** The agricultural robot can be used to create drains in the agricultural field. An attachment has been made which can be attached at the rear end of the robot so as the robot will move forward it will make the drains.
- Pesticide Sprayer:** The agricultural robot can be used for spraying of the pesticide. The pesticide spraying mechanism consists of a plastic container of 500 ml capacity which has water pump. The pump can be switched on/off by Bluetooth enabled device. The user can control the pesticide spraying mechanism through their smartphones. Figure 7 shows the pesticide spraying mechanism in the agricultural robot. Figures shows the results of text detection from an image and inpainting by using exemplar based Inpainting algorithm. Figs. 2, 3, 4 (a) shows the original image. (b) is the image obtained by applying first set of criteria. All objects whose area greater than 10000 and filled area greater than 8000 are eliminated and major axis lengths are in between 20 to 3000 are considered to be text. Still, some small non-text objects are detected.

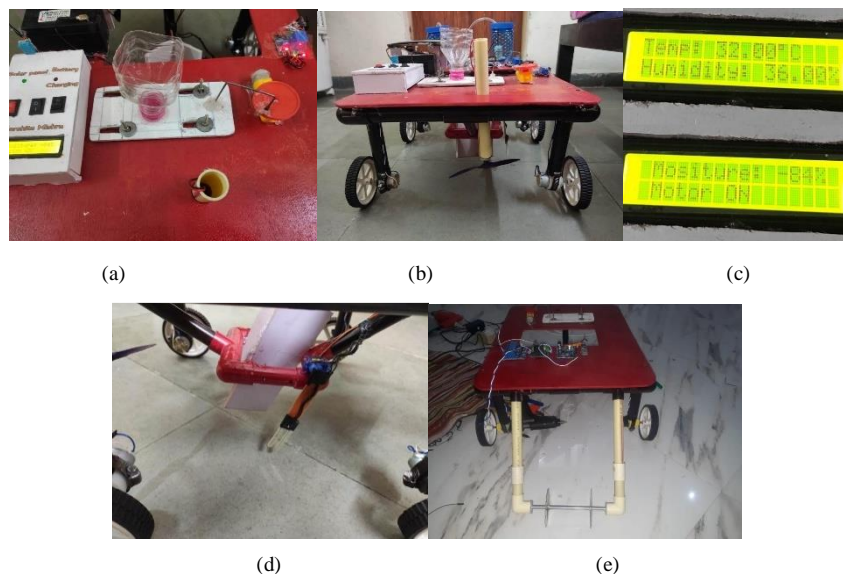


Figure4:Robot Operations (a) Seed Sowing (b) Harvesting (c) LCD Display (d) Soil Moisture Sensor (e) Drain Making

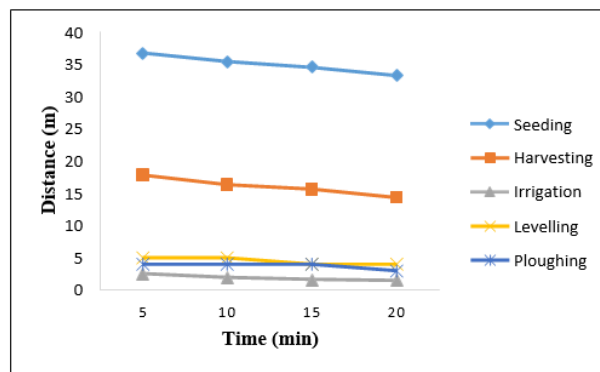


VII. EXPERIMENTAL RESULTS

1. Maximum Reach

Table 2: area covered during activities for plain surface

Time (min)	Max reach covered during seed sowing (m)	Max reach covered during harvesting (m)	Max reach irrigated during irrigation (m)	Max reach during levelling and drain making (m)	Max reach during ploughing (m)
5	36.7	17.8	2.56	5	4
10	72.1	34.1	4.51	10	8
15	106.6	49.7	6.15	14	12
20	139.8	64.0	7.65	18	15
Average	34.95	16	1.91	4.5	3.75

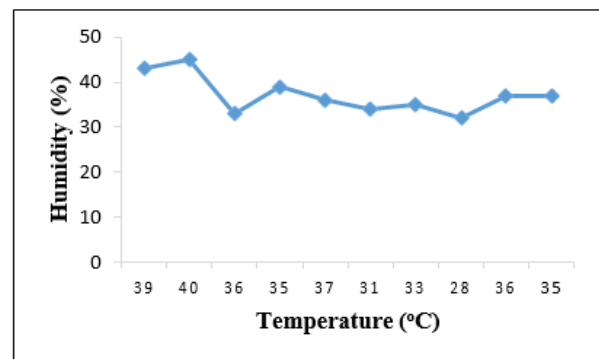


Graph 1: Max. reach covered by the prototype

2. Data Collection of Temperature and Humidity

Table 3: temperature and humidity collected by prototype

S. No.	Temperature (°C)	Humidity (%)
1	39	43
2	40	45
3	36	33
4	35	39
5	37	36
6	31	34
7	33	35
8	28	32
9	36	37

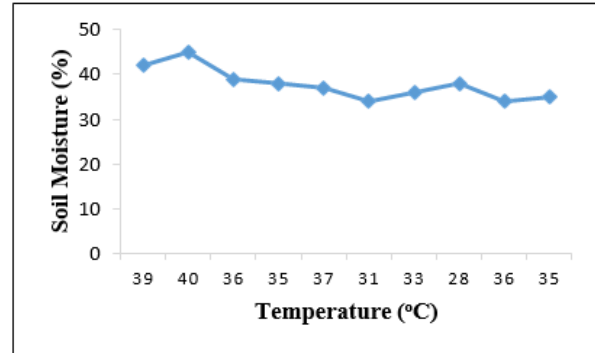


Graph 2: temperature vs humidity

3. Data Collection of Temperature and Soil Moisture

Table 4: temperature and soil moisture collected by prototype

S. No.	Temperature (°C)	Soil Moisture (%)
1	39	42
2	40	45
3	36	39
4	35	38
5	37	37
6	31	34
7	33	36
8	28	38
9	36	34



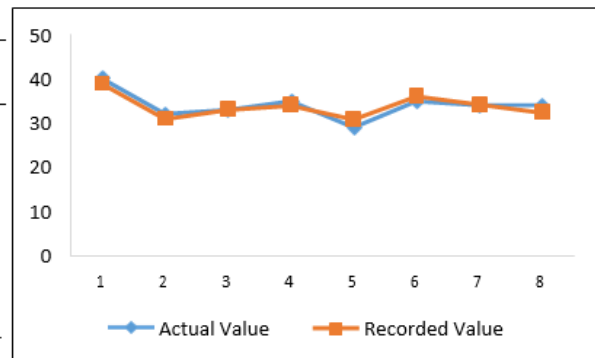
Graph 3: temperature vs soil moisture

4. Data Collection of Actual Temperature and Temperature Recorded by Prototype

The actual temperature is calculated by hygrometer and then recorded the temperature detected by robot prototype.

Table 5: actual temperature and recorded temperature

S. No.	Actual Temperature (°C)	Recorded Temperature (°C)	Error (%)
1	40	38.80	3
2	32	30.89	3.47
3	33	33.01	0
4	35	33.95	3
5	29	30.79	6.17
6	35	36.01	2.89
7	34	34.12	0.35
8	34	32.32	4.94
Average Error			2.38



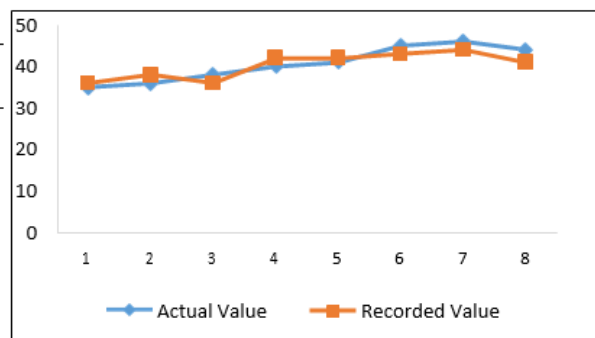
Graph 4: actual temperature vs recorded temperature

5. Data Collection of Actual Humidity and Humidity Recorded by Prototype

The actual humidity is recorded by hygrometer and then recorded the humidity detected by robot prototype.

Table 6: actual humidity and recorded humidity

S. No.	Actual Humidity (%)	Recorded Humidity (%)	Error (%)
1	35	36	2.85
2	36	38	5.55
3	38	36	5.26
4	40	42	5
5	41	42	2.44
6	45	43	4.44
7	46	44	4.35
8	44	41	6.82
Average Error			3.67



Graph 5: actual humidity vs recorded humidity

6. Data Collection of Experimental Soil Moisture and Recorded Soil Moisture

To measure the soil moisture (%) 200 g of soil sample is taken. It is dried with the help of blower so that all the moisture is removed from the soil sample and the soil sample has zero moisture. Then the soil sample is divided into two parts of 100g each and water of 20ml is added is to one part of soil then soil moisture is calculated by using the following formula:

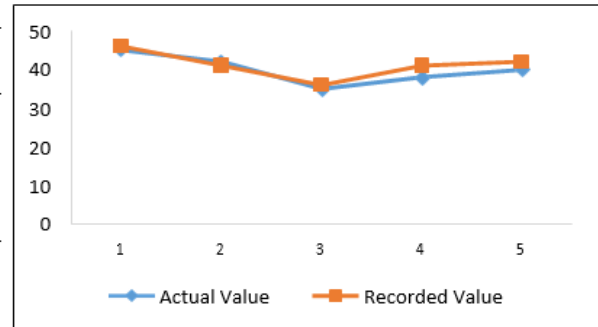


Soil Moisture = ((Wt. of the wet soil – Wt. of the dry soil) / Wt. of the dry soil) * 100

Then recorded the soil moisture detected by the soil moisture sensor of the robot prototype.

Table 7: experimental data and recorded data of soil moisture

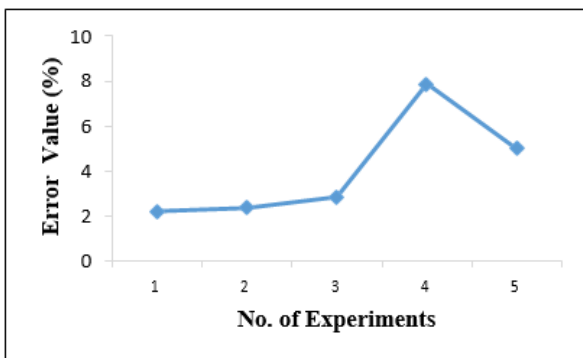
S. No.	Actual Soil Moisture (%)	Recorded Soil Moisture (%)	Error (%)
1	45	46	2.22
2	42	41	2.38
3	35	36	2.86
4	38	41	7.89
5	40	42	5
Average Error			4.07



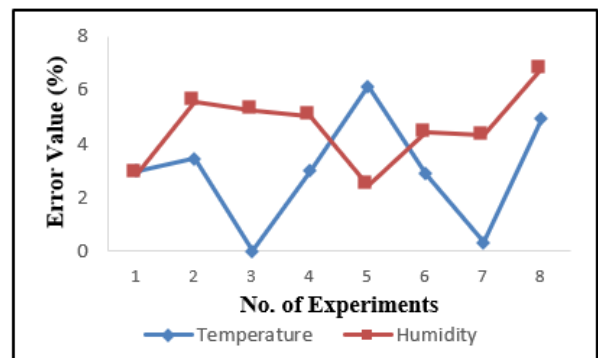
Graph 6: actual soil moisture vs recorded soil moisture

7. Error Analysis

Experiments are conducted to prove the functionality of the sensors and the system. We have also computed the error (%) value for the measurement of parameters such as temperature, humidity and soil moisture.



Graph 7: error calculation in soil moisture readings



Graph 8: error calculation in temperature and humidity

The experiments conducted during the course of this project have demonstrated that our agricultural robots have an accuracy rate of more than 90%. This is a significant achievement and a testament to the effectiveness of the advanced technologies we have incorporated into the design, including sensors and algorithms.

VIII. CONCLUSION

The solar-powered multipurpose agricultural robot is a revolutionary technology that has the potential to transform the agriculture industry. It is a fully autonomous robot that can perform various tasks such as seed sowing, weeding, levelling, irrigation and harvesting crops, reducing the need for human labour. The robot is powered by solar energy, which makes it cost-effective and eco-friendly. The use of renewable energy in agriculture can reduce the carbon footprint of farming and contribute to a more sustainable future. The project has demonstrated the feasibility of the solar-powered multipurpose agricultural robot in real-life scenarios. The robot has been successfully tested in different environments and has proven to be effective in performing various tasks. Its remote-control feature allows farmers to operate the robot from a distance, saving them time and increasing their efficiency. One of the significant advantages of the solar-powered multipurpose agricultural robot is its ability to work in areas with limited access to electricity. In many parts of the world, farmers face challenges in accessing electricity, which hinders their ability to use technology to improve their farming practices. The solar-powered robot can work in these areas and provide farmers with the technology they need to increase their yields and profitability. While the technology is still in its early stages, the results of this project demonstrate the feasibility of the solar-powered multipurpose agricultural robot in real-life scenarios. The development of this technology can significantly benefit farmers worldwide and contribute to food

security and sustainability. Therefore, further research and development are necessary to optimize the robot's performance and make it accessible to small- scale farmers, contributing to a more sustainable future.

IX. FUTURE SCOPE

This project offers plenty of scope in terms of further upgrades:

- Several sensors may be added to this first prototype as an extension to increase the robot's intelligence and ability to recognize impediments.
- It is possible to add sensors to measure the depth of the soil so that seeds may be sown properly.
- The Agricultural robot may be equipped with a camera, and the software can be adjusted to show a 360-degree image of the field as the robot moves.
- Modern technologies may be employed to provide a wide communication range, including Zigbee, Wifi, IOT, and WiSmart.
- Sensors that can sprinkle water can be added to determine the temperature and moisture content.
- A sensor that determines the necessary amount of pesticide can be combined with a pesticide sprinkler.

Based on the design and functionality of the prototype, it is feasible to develop it into a finished product. However, further refinement and testing may be necessary to ensure its effectiveness and efficiency in the agricultural industry.

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