



IOT Based Automatic Ploughing, Seeding And Watering Robot

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Abstract. Agriculture is one of the long-established occupations across the globe. More than half of the population predominantly rely on agriculture as the primary occupation for their livelihood. Despite the advancement of technology farmers still follow traditional methods to carry out the tasks. The development of “IoT BASED AUTOMATIC PLOUGHING SEEDING AND WATERING ROBOT” introduces an innovative approach in the agriculture sector, focusing on reducing the manual labour and increasing efficiency in farming operations. This system leverages modern technologies to automate three crucial processes like ploughing, seeding and watering ensuring precise and consistent execution. This automation system is integrated with ESP32 microcontroller, ESP32-CAM for remote control, servo motors for ploughing and seeding, a soil moisture sensor with a DC water pump to optimize water usage and the entire system is powered using solar panels and lithium-ion batteries, ensuring sustainable and energy-efficient operation. Farmers can remotely control the robot from a web-based interface, enabling real-time monitoring and management of their agricultural fields. By integrating various technologies optimizes the farming process, reduces the time and effort and need for the manual labour.

Keywords: Automation, Ploughing, Seeding, Watering, Servo Motor, Soil Moisture

1. INTRODUCTION

Every sector is experiencing rapid technological advancements. Agriculture is one of the key sectors essential for ensuring human livelihood. The most pressing issue in the world today is the food supply. The demand for food has increased at more than twice the rate of population. By 2050, the global population is expected to reach between 9 and 10 billion, which will significantly increase food demand [1]. Modernizing agriculture is important, to enhance productivity, improve sustainability and meet the rising demands of the population. Innovations like precision farming, automated systems, data analytics and can significantly improve agricultural efficiency. Some of the major challenges that farmers face today is rising of maintenance cost, lack of skilled labours and lack of water resources. Therefore, many advancements are being

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made to address these challenges.

The modern farming incorporates the integration advanced technologies like automation, precision agriculture and data analytics to enhance productivity. Precision agriculture, is a modern farming which uses GPS, IoT [2], [3], [4], [5] robotics [6], [7] and AI [8], [9] to optimize resource utilization, also employs automation, drones and real-time sensors to track the state of soil, crops and weather conditions [10], [11], [12], [13]. This paper presents one of the innovative solutions is “IoT BASED AUTOMATIC PLOUGHING, SEEDING AND WATERING ROBOT which is capable of performing three pivotal agricultural tasks like ploughing, seeding and watering automatically through a web-based interface. Equipped with servo motors, sensors, camera and wireless communication technologies, the robot monitors soil conditions, optimize farming operation. By utilizing IoT, the robot can operate with precision, adjusting its actions based on real-time inputs, and providing farmers with valuable insights to boost crop yield and conserve water and energy. This development attributes the beginning of a new era in agriculture, where robots and IoT work hand in hand to improve the overall farming experience.

2.LITERATURE REVIEW

Agriculture is significantly transforming over generations, the industrial revolution which is begin in 18th century, brought prominent changeover in agriculture. Before this period agriculture was labour-intensive and simple tools, confining efficiency and production. However, agriculture is slowly transforming its shape chronologically resting on technological advancements, economic needs and environmental factors. The transformations often categorized as Agriculture 1.0, Agriculture 2.0, Agriculture 3.0, Agriculture 4.0.

Agriculture 1.0 is the earliest phase of agriculture, where agriculture used to be simple and depicted by traditional farming practices. In this period of time farmers focused on subsistence farming, raising livestock and growing crops to sustain themselves. The practices are quite simple, largely relied on basic hand tools, manual labours and weather patterns [14]. To preserve the soil fertility, farmers used the techniques like diverse cropping, crop rotation and cow dung. There was no chemical fertilizers and pesticides by that time the agriculture was extremely human dependent, low in production wise and vulnerable to climate change. This phase lasted until mechanization and scientific advancements began during the 18th-19th century, leading to Agriculture 2.0.

Agriculture 2.0 is the phase between industrial revolution, which began during the period of 18th-19th centuries, introduced machinery such as tractors, enhanced productivity and reduced reliance on labour. The small-scale agriculture was replaced by large scale agriculture. On the other hand, Chemical fertilizers also introduced during this period which helped the farmers to increase the yield but had a negative impact to

the eco-system and human health. These challenges led to more sustainable agriculture practices, giving rise to agriculture 3.0.

Agriculture 3.0 this period is called as the smart farming or precision agriculture which the modern form of agriculture. During this period GPS technology and remote sensing was integrated which collects the data from various sensors and applied in real-time operations, which optimizes the farming practices. During this period high-yield crop varieties, synthetic fertilizers and pesticides was used, which has huge impact on the eco-system [15], [16].

In current era, Agriculture 4.0 is being practiced, where farmers are adopting emerging technologies like AI, IoT, robotics, machine learning and cloud computing to enhance the productivity reduce the manual labour. It addresses the challenges faced in various phases such as food security, climate change, labour shortage and resource efficiency invoke smart, efficient and sustainable farming. Building upon the advancements of Agriculture 4.0, this project aims to design and implement an IoT-based automatic ploughing, seeding, and watering robot [17], [18], [19]. This system integrates smart sensors, automation, and real-time data collection to improve efficiency and reduce manual labour in primary farming operations. Fig 1 represents the agricultural transformations categorized as agriculture 1.0, 2.0, 3.0 and 4.0.



Fig 1: Transformation of agriculture

3.METHODOLOGY

The Ploughing and Seeding and Watering Robot operates using a structured workflow to execute various agricultural tasks efficiently. The methodology can be broken down into the following steps:

1. Remote Control via Web Server: The robot is controlled remotely using a web-based server hosted on the ESP32 microcontroller. The ESP32-CAM provides live video streaming, allowing farmers to monitor the field and control the robot's movements efficiently. The robot can be maneuvered in forward, backward, left, and right directions with minimal latency with support of DC motors driven by L293D motor driver.

The behaviour of the motor depending on the input conditions such as Inputs and Enables is shown in a table 1 as follows:

Here, Logical 1 is referred to as HIGH and Logical 0 is referred to as LOW.

Table 1: Behaviour of L293D motor based on different input combinations.

Input 1	Input 2	Enable 1,2	Result
0	0	1	Stop
0	1	1	Anti-clockwise rotation
1	0	1	Clockwise rotation
1	1	1	Stop
0	1	50% duty cycle	Anti-clockwise rotation with half speed
1	0	50% duty cycle	Clockwise rotation with half speed

The DC motor working principle is that when a current-carrying conductor is located within the magnetic field, then it experiences a mechanical force. This force direction can be decided through Flemming's left-hand rule as well as its magnitude.

$F = BIL$ Newtons Where:

'B' is the magnetic flux density,

'I' is current

'L' is the conductor's length in the magnetic field.

2. Ploughing Mechanism: The 180-degree servo motor is connected to a ploughing blade that digs into the soil as the robot moves forward. The servo motor's movement ensures controlled ploughing depth and angle, making it suitable for different soil conditions.

3. Seeding Mechanism: A 360-degree continuous rotation servo motor is used to release seeds into the ploughed soil. The seeding mechanism is synchronized with the robot's movement, ensuring even seed distribution.

Servo motor is a closed-loop system where it uses a positive feedback system to control motion and the final position of the shaft. Here the device is controlled by a feedback signal generated by comparing output signal and reference input signal as shown in fig 2.

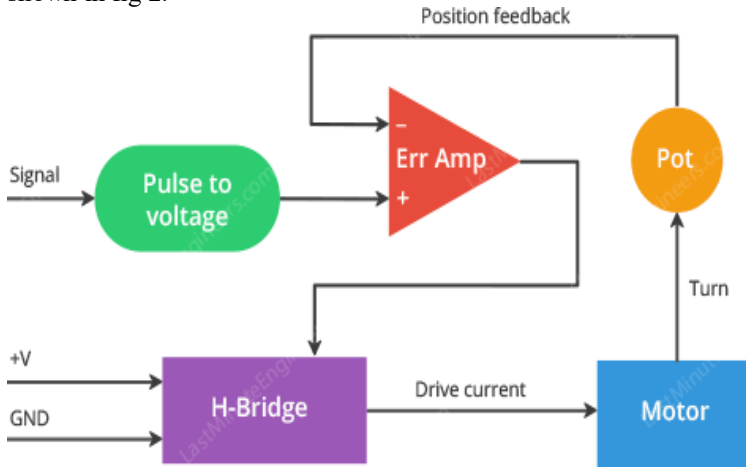


Fig 2: Servo control system

Servo motor is controlled by PWM (Pulse with Modulation) which is provided by the control wires. There is a minimum pulse, a maximum pulse and a repetition rate. Servo motor can turn 90° from either direction from its neutral position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position, such as if pulse is shorter than 1.5ms shaft moves to 0° and if it is longer than 1.5ms than it will turn the servo to 180° . Fig 3 illustrates the principle of PWM to control servo motor.

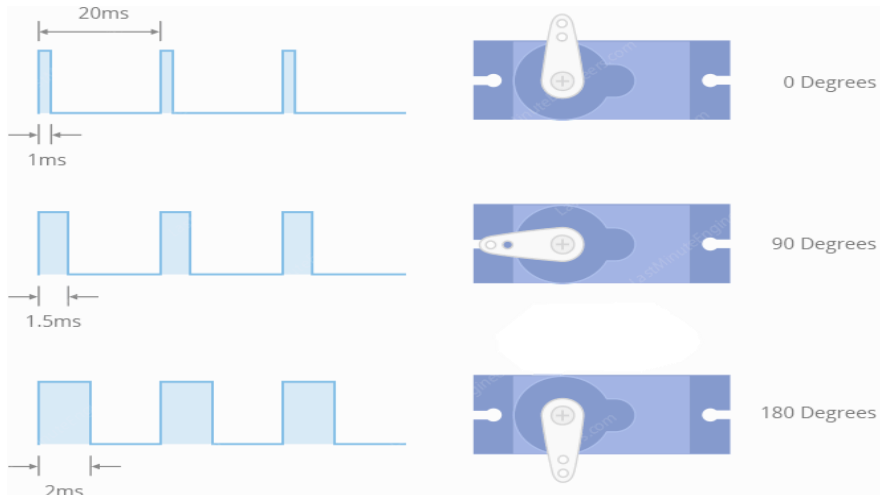


Fig 3: Principle of pulse width modulation

4. Soil Moisture Monitoring and Watering: A soil moisture sensor monitors the moisture levels in the soil. If the soil moisture falls below a set threshold, the DC water pump (controlled via a relay module) is activated to supply the required amount of water. This automated irrigation process helps in water conservation and ensures optimal soil conditions for seed germination.

For a typical resistive soil moisture sensor connected to an ESP32, the moisture level can be calculated as:

$$\text{Moisture (\%)} = \left(\frac{V_{wet} - V_{out}}{V_{wet} - V_{dry}} \right) \times 100$$

Where:

- V_{out} = Analog output voltage from the sensor
- V_{wet} = Sensor output voltage in completely wet soil
- V_{dry} = Sensor output in dry soil

5. Power Management Using Solar Energy: The entire robot is powered using solar panels coupled with lithium-ion batteries to store excess energy. This feature ensures the robot operates sustainably and can function in remote agricultural areas where electrical infrastructure is limited and also conserve energy.

4.Existing System

Current farming systems often rely on manual labour or semi-automated machinery for

ploughing and seeding. Separate machinery is used to carry each one tasks. However, few integrate full automation for all three processes like ploughing, seeding, and watering. Most existing systems also lack precise control mechanisms, resulting in resource wastage and inefficiency.

5.Proposed System

The "Automatic Ploughing, Seeding, and Watering" system introduces a convenient approach to agricultural automation, which reduces the need of manual labour, optimizing resource utilization and increasing efficiency in farming operations. This project utilizes modern technology (IoT) to automate three crucial processes such as ploughing, seeding, and watering, ensuring each task is performed with greater consistency. The system’s core objective is to enhance agricultural productivity by automating these repetitive tasks. By utilizing servo motors, the system assure that each process is carried out with high accuracy and control. Key components of this system include servo motors for ploughing, servo motors for seeding, water pumps for irrigation, and sensors for monitoring soil moisture and entire system is powered by solar panels and lithium batteries. This integration of various technologies optimizes the farming process, reducing the resource wastage, time and effort required for manual labour.

Block Diagram Description

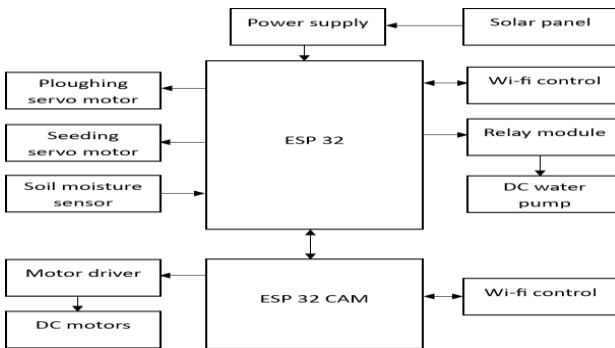


Fig 4: Block diagram for IoT based automatic ploughing seeding and watering robot

5.1 Hardware description

The IoT-based automatic ploughing, seeding, and watering robot is designed using an ESP32 microcontroller, which serves as the central processing unit. The initial processes like ploughing and seeding are executed using a servo motors and these two processes can be performed simultaneously. The watering process is controlled by a DC water pump, activated based on readings from the soil moisture sensor. The robot is powered by the solar panel and lithium-ion batteries. The robot has interfaced with ESP32-CAM which plays a crucial role in controlling robot movement and enables real-time monitoring. Motor driver is used to drive the DC motors that are fixed at four wheels of the robot, these motors assist the robot movement in different directions (forward, backward, left and right). Communication is handled through the built-in Wi-Fi module of the ESP32, allowing remote monitoring and control via a mobile or web-based interface.

5.2 Software Composition

Programming Language: Embedded C++ (Arduino IDE)

5.2.1 Functions:

- Reads data from Soil Moisture Sensor.
- Controls Plough Servo Motor.
- Operates Seeding Servo Motor.
- Manages Relay Module to activate the DC Water Pump on/off based on moisture levels.
- Operate the Motor Driver to control DC Motors for movement.
- Uses Wi-Fi Control for remote operation and monitoring.

5.2.2 Camera Module (ESP32-CAM)

- Captures real-time video support for monitoring.
- Streams video via Wi-Fi for remote viewing.

5.2.3 IoT Communication

- Wi-Fi Connectivity: Connects to a web or mobile app for remote control.

5.2.4 User Interface (Web/Mobile App)

- Developed using web server.
- Displays:

- Live camera.
- Soil moisture levels.
- Robot movement controls.
- Ploughing, seeding, and watering status.
 - Allows manual operation.

6.Results and Discussion

The IoT-based automatic ploughing, seeding, and watering robot demonstrated significant improvements in efficiency, precision, and resource utilization compared to traditional farming methods. The ploughing, seeding and watering is successfully preformed.

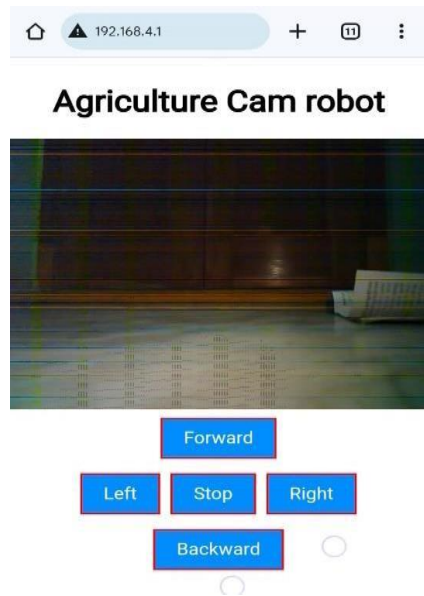
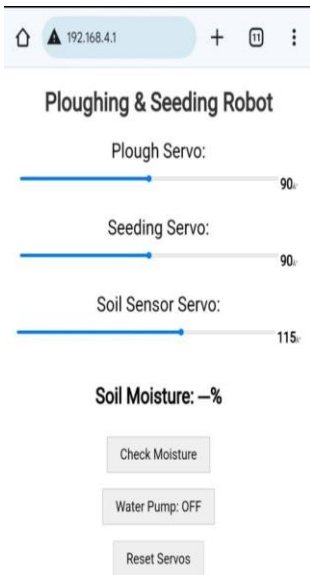


Fig 5: Web server interface for Video streaming ploughing, seeding and watering movement control

Fig 6: Web server for and robot

The IoT-enabled irrigation system effectively adjusted water distribution based on real-time soil moisture data, reducing water consumption. Remote monitoring and control through a mobile interface allowed real-time data transmission with minimal latency, enabling automated decision-making and reducing manual labour [20], [21].

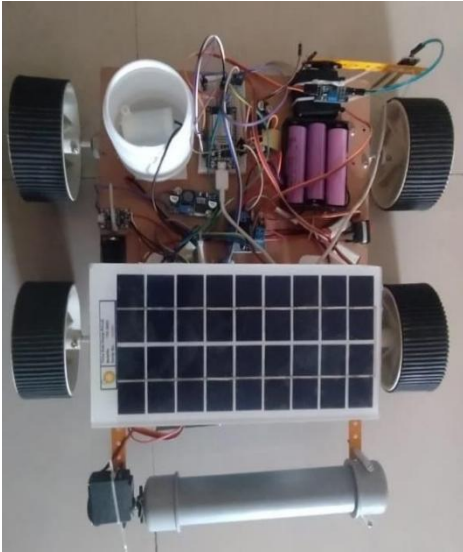


Fig 7: Top view of the robot

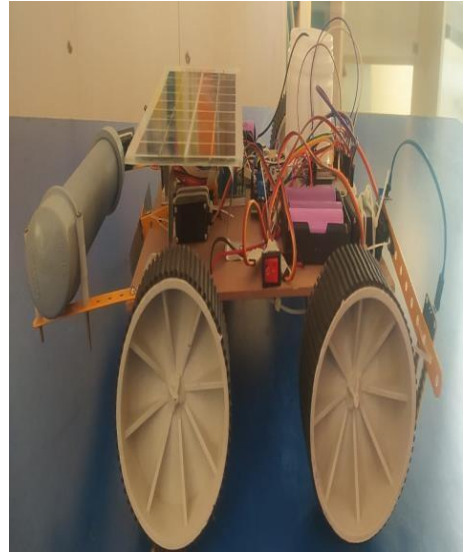


Fig 8: Side view of the

robot

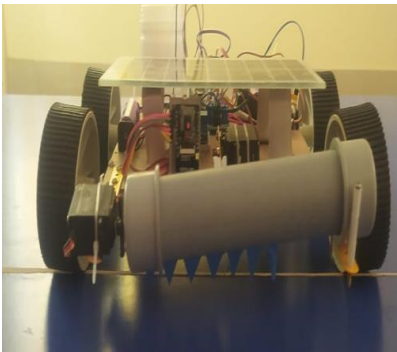


Fig 9: Back view of the robot

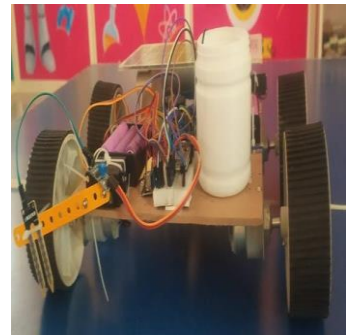


Fig 10: Front view of the robot

The operations are performed by the robot based on the inputs from the web-server provided by the user. Fig 5 depicts the webserver interface for ploughing seeding and watering and fig 6 depicts webserver for interface video streaming and movement control of the robot in desired directions (left, right, forward and backward). The proposed system has reduced the labour dependency and optimizes resource utilization

by increasing efficiency.

7. Conclusion

The Automatic Ploughing, Seeding, and Watering System is an advanced agricultural tool designed to automate essential farming tasks. Utilizing servo motors, a water pump, relay modules, and a motor driver, the system efficiently handles ploughing, seeding, and watering and employing solar panel enhances energy efficiency. Its integration of precision technologies ensures resource optimization and increased crop yields. While current systems are primarily manual or semi-automated, this fully automated solution has the potential to revolutionize farming by increasing efficiency, productivity, and sustainability and paves the way for smart farming technologies.

8. Future Scope

AI and machine learning can make it more effective by analyzing soil conditions, predicting crop growth, and making better farming decisions, helps to collect past data, weather conditions, and soil quality. AI can then study this data to decide when to plough, plant seeds, or water the crops, ensuring efficient farming with minimal waste. Machine learning can also help predict crop growth by analyzing check plant health, detect diseases, and spot pest problems early making it more sustainable and effective.

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