Advanced Smart Agribot

A. Jahnavi[1], M. Chandra Sekhar[2], M. Sunandu[3], P. Rama Krishna[4], Y. Jashuva[5]

[1,2,3,4,5] Internet of Things, Seshadri RaoGudlavalleru, Engineering College, Gudlavalleru, India

ABSTRACT

Agriculture is essential food production worldwide, but conventional farming practices are frequently time-consuming, labor-intensive, and prone to inefficiencies. Higher agricultural productivity while preserving sustainability is required due to the growing global population. To overcome these obstacles, this project presents an Advanced Smart Agribot that uses Arduino to automate a variety of farming tasks, including digging, plowing, spraying water and pesticides, cutting grass, and planting seeds. To ensure ideal farming practices and minimize human intervention, the system incorporates sensors such as soil moisture and DHT11 to monitor environmental conditions. The ThingSpeak cloud stores the gathered data, enabling historical analysis, real-time monitoring, and well-informed decision-making. Farmers can operate the robot efficiently and remotely thanks to its Bluetooth wireless control. This smart agriculture robot increases productivity, decreases human labor, and encourages precision farming by fusing automation with Internet of Things-based management. This ultimately boosts crop yield and sustainability. The system also guarantees the effective use of resources like fertilizer and water, which lowers waste and raises agricultural productivity overall. Large-scale agricultural applications, scalability, and affordability characterize the suggested solution. Future food security is ensured by a more efficient and sustainable agricultural ecosystem made possible by the incorporation of technology into farming.

Keywords: IoT-based Monitoring, Automation, Precision Farming, smart Agriculture, Real-Time Environmental monitoring, Wireless Farming Solutions, and IoT Smart Farming.

INTRODUCTION

The foundation of the world's food production, agriculture sustains billions of people. However, manual labor is a major component of traditional farming methods, which makes them resource-intensive, time-consuming, and inefficient. The need for increased agricultural productivity rises with the world's population, making the use of intelligent and automated solutions imperative. Modern precision farming methods that maximize resource use and boost efficiency have been made possible by technological developments in robotics, the Internet of Things, and automation. To keep an eye on environmental factors like soil moisture, temperature, and humidity, smart agriculture systems combine sensors, wireless communication, and cloud-based data analytics. These developments help farmers increase yield while reducing waste by enabling data-driven decision-making, predictive analysis, and real-time monitoring. By automating processes like plowing, digging, spraying, and seeding, Arduino-based agricultural robots lower labor costs and the need for human intervention. Agriculture can become more productive, sustainable, and capable of overcoming obstacles in the future by embracing automation and the Internet of Things. Farmers can operate the robot remotely using Bluetooth-based wireless control, which improves accessibility and convenience. In the end, this scalable and reasonably priced solution seeks to ensure food security and environmental sustainability by increasing crop yield, reducing resource waste, and advancing precision farming.

METHODOLOGY

Developed with Arduino, the Advanced Smart Agribot combines automation, sensors, and the Internet of Things to efficiently complete a variety of farming tasks. Methodology adheres to these crucial steps: Hardware integration includes an HC-05 Bluetooth module for wireless communication, servo motors for task execution, and DC motors for movements. Environmental data is gathered by sensors such as DHT11 and soil moisture. Software Development: Based on sensor inputs, an Arduino program is created to regulate motor operations. Tasks like plowing, digging, watering, and applying pesticides can be automated by a robot. Seed-sowing sprinkler. IoT-based Monitoring: Informed decision-making is made possible by the transmission of sensor data to the ThingSpeak cloud for real-time monitoring and historical analysis. Wireless Control: A smartphone app is used to control the robot, enabling remote accessibility. Testing and Optimization: The system was tested under various soil conditions to guarantee accuracy, efficiency, and resource optimization, which makes it appropriate for precision farming.

A. System Architecture:

To enable automated farming operations, the Internet of Things-based agricultural robot is designed using a combination of hardware and software components. The required components include an Arduino microcontroller, servo motors for precise mechanical operation control, DC motors for mobility, an HC-05 Bluetooth module for remote communication, and a DHT11 sensor for temperature and humidity monitoring. Other components, such as water pumps, soil moisture sensors, and seed dispensers, ensure that the robot can efficiently carry out a range of agricultural tasks. The system's structural design, which includes a rotating seed dispenser and a chassis with mounted motors, allows it to precisely navigate fields and perform real-time operations.

B. System Integration:

An organized framework for automating important agricultural tasks like plowing, seeding, weeding, digging, and water/pesticide sprinkling is provided by the Advanced Smart Agribot's System Architecture. Fundamentally, the Arduino Uno serves as the central processing unit, handling inputs, processing information, and regulating output devices. While sensors like the DHT11 and soil moisture sensor record temperature, humidity, and soil moisture levels for real-time monitoring, the HC-05 Bluetooth module allows wireless control through a mobile app. The ESP8266 Wi-Fi module is used to send data to ThingSpeak Cloud, enabling remote access and analysis. Sending commands to the robot is made easier by the Serial Bluetooth Terminal App. In addition to operating specialized mechanisms for plowing, seeding, weed cutting, digging, and sprinkling, L298D motor drivers also regulate the movement of the gear motors. Visual system status is provided by LED indicators, and effective decision-making with real-time updates is ensured by IoT integration. The Smart Agribot increases precision, decreases manual labor, and facilitates remote monitoring by automating farming tasks, thereby increasing agriculture's efficiency, automation, and sustainability.
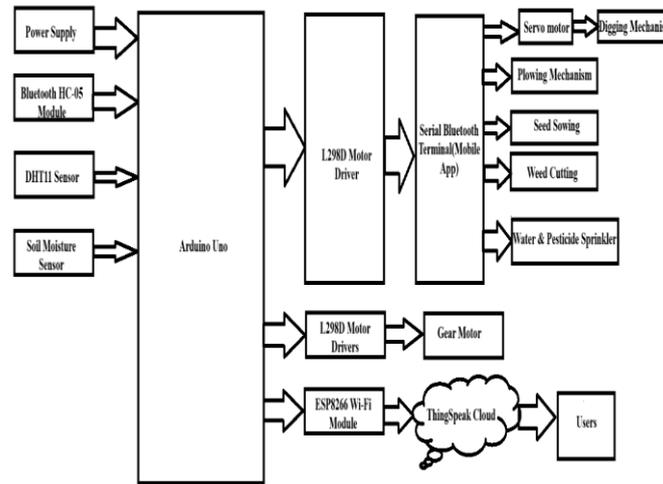

Fig 1: Block Diagram

With the help of cloud-based dashboards and the ESP8266 Wi-Fi module, farmers can remotely access environmental conditions and machine status, enabling real-time data monitoring. This data-driven method increases efficiency and improves decision-making.

All things considered, the Smart Agribot automates agricultural tasks, minimizes manual labor, and maximizes resource utilization. It promotes precision and sustainable farming by combining IoT with intelligent control systems, increasing the productivity and resource efficiency of contemporary agriculture.

C. Operational Framework:

Through Bluetooth communication, the project continuously receives commands from a mobile application, which controls various components in response to user input. After processing these commands, the Arduino turns on the appropriate actuators, like movement motors and servo motors for seeding and plowing. Sensors gather environmental information, such as temperature and soil moisture, and send it to the user so they can make decisions. By reducing manual intervention, the system ensures efficient farming processes by integrating automation with real-time monitoring. The robot is highly adaptable to a variety of agricultural environments because of its step-by-step working structure, which includes sensor data acquisition, motor actuation, and command execution.

IMPLEMENTATION

An intelligent agricultural robot called the Advanced Smart Agribot was created to automate a variety of farming chores, decreasing manual labor and increasing productivity. Fundamentally, the Arduino Uno coordinates all system operations as the central processing unit. A voltage regulator keeps the power supply for the robot's motors and sensors steady, and the rechargeable battery powers the robot's continuous operation. The Agribot's four DC gear motors,

which are managed by an L298D motor driver module, enable smooth field navigation. Through a mobile application, users can remotely control the robot thanks to the HC-05 Bluetooth module's ability to facilitate wireless communication. To carry out necessary farming tasks, the Agribot combines several mechanisms.
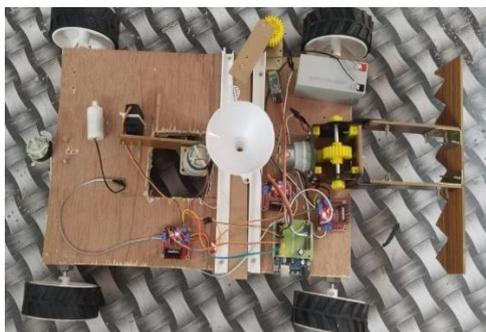

Fig 2: Hardware Design

The soil is efficiently tilled by a ploughing mechanism that uses a rotating blade system driven by a DC motor. To ensure accurate seed placement, the seed-sowing mechanism uses a funnel-based dispenser that is driven by a servo motor. A rotating cutting tool in a weed-cutting system removes unwanted plants, and a servo motor powered digging mechanism enables controlled soil excavation. To maximize irrigation and pest control, a small DC pump also powers the water and pesticide sprinkler system, distributing fluids according to soil moisture levels. The Agribot has sensors that provide real-time data for environmental monitoring. The soil moisture sensor evaluates hydration levels to identify irrigation requirements, while the DHT11 sensor measures temperature and humidity. This information was sent to ThingSpeak Cloud via an ESP8266 Wi-Fi module, allowing for data-driven decision-making and remote monitoring.

Farmers can monitor field conditions in real time and increase productivity and resource use by utilizing IoT-based connectivity. Combining environmental sensing, precision-controlled farming mechanisms, and automated mobility, the Advanced Smart Agribot is a useful tool for contemporary agriculture that supports technologically advanced and sustainable farming methods.

RESULTS

A. Movement of Robot:
When x == "1," the robot advances by turning on motors M1 and M3 but leaving M2 and M4 off. When x == "2," it moves backward, turning on M2 and M4 while leaving M1 and M3 off. Motors M2 and M3 are turned on to turn left (x == "3"), while motors M1 and M4 are deactivated. Likewise, M1 and M4 are powered during a right turn (x == "4"), while M2 and M3 are left off. Since all of the motors are off and the robot cannot move in any direction, it stops when x == "5"

B. The Mechanism of Plowing:
Fig: 3,4,5 shows the working and operation of the plowing mechanism. When x == "6," the plowing mechanism is triggered, turning on pg1 while pg2 stays off. When x == "7," the opposite occurs. Controlled plowing operation is ensured by a brief delay.

Fig:3 Ploughing Upward Movement

Fig: 4 Ploughing Downward Movement

Fig: 5 Ploughing Starts in Forward Movement

C. Cutting Weeds:

Fig: 6,7 shows the working and operation of the Cutting Weeds. When x == "e," the weed-cutting mechanism turns on gs1, and when x == "f," it turns off. When necessary during operation, this mechanism guarantees effective weed removal.

Fig: 6 Weed Cutting Start

Fig: 7 Weed Cutting Stops

D. Movement of Servo Motors

When x == "a," the servo motor moves, adjusting the angle to 140 degrees; when x == "b," the angle is set to 65

degrees. This regulates particular processes like digging and seed distribution.

E. Sprinkler for Water and Pesticides:

Fig: 8 shows the working and operation of the Sprinkler for Water and Pesticides. When x == "c," the water and pesticide sprinkler activate, turning on the pump by activating wp1 and wp2. Both WP1 and WP2 are turned off when x == "d."

Fig: 8 Water Mechanism Stops & Starts

F. Planting Seeds:

Fig: 9 shows the working and operation of ploughing mechanism. When x == "8," the seed- sowing mechanism kicks in, causing sed to start dispensing seeds. When x == "9," it shuts off, ensuring regulated seed distribution throughout the process.

Fig: 9 Seed Sowing Mechanism

G. Mechanism of Digging:

Fig: 10 shows the working and operation of ploughing mechanism. When x == "g," the digging mechanism activates dig while deactivating dig1. In order to ensure controlled soil excavation, it stops when x == "h," turning off dig and dig1.

Fig: 10 Digging Mechanism

H. The temperature:

Fig: 11 shows the working and operation of Temperature. The DHT11 temperature sensor operates continuously. It uses dht.readTemperature() to read the temperature, and it sends the data to the cloud and serial monitor every 25 iterations (cnt > 25).
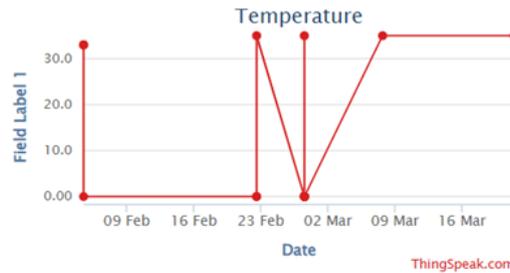
Fig: 11 Real-Time Temperature Data

I. The level of humidity:
Fig: 12 shows the working and operation of Humidity. The DHT11 humidity sensor runs continuously in a loop. It uses dht.readHumidity() to read the humidity, and it sends the data to the cloud and serial monitor for monitoring every 25 iterations (cnt > 25).
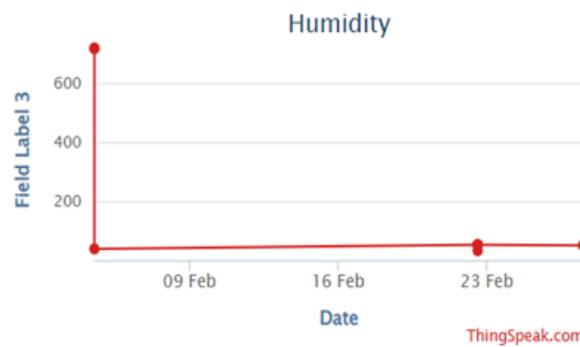

Fig:12 Real-Time Humidity Data

J. Moisture in the Soil:
Fig: 13 shows the working and operation of Moisture in the soil. AnalogRead(sm) is used to read analog input from A4 in order to operate the soil moisture sensor. The moisture value (sval) is sent to the serial monitor and cloud for monitoring every 25 iterations (cnt > 25).
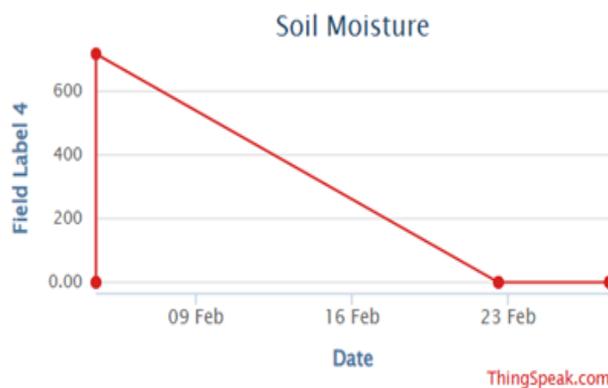

Fig: 13 Real-Time Soil Moisture Data

CONCLUSION

The Advanced Smart Agribot optimizes resource use, lowers labor costs, and increases farming efficiency by combining automation, IoT, and sensor-based monitoring. It makes precision farming possible by automating tasks like plowing, digging, spraying, and seeding, which increases yields and promotes sustainability. Farmers can efficiently operate the robot and make educated decisions thanks to Bluetooth-based wireless control and real-time data monitoring via ThingSpeak Cloud. Both small- and large-scale farmers profit from this scalable and reasonably priced solution, which provides a novel solution to contemporary agricultural problems. Farming is made more productive and ecologically friendly by employing data-driven automation, which reduces resource waste while increasing output. By incorporating technology-driven solutions, the Advanced Smart Agribot essentially transforms conventional farming and opens the door to an intelligent, environmentally conscious, and sustainable agricultural ecosystem.

ACKNOWLEDGMENT

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