IoT-Based Multipurpose Robot

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Abstract: *This journal article describes the development and deployment of an IoT-enabled agricultural robot using an ESP8266 NodeMCU and a suite of sensors and actuators including relay, servo motor, L298 driver, water pump, and plowing mechanism. The system facilitates remote monitoring and control via Wi-Fi connectivity, enabling real-time data collection on environmental variables such as temperature, humidity, and soil moisture. Additionally, it offers automation capabilities for essential agricultural tasks like irrigation and plowing. The article details the hardware setup, software implementation, connectivity protocols, and performance evaluation of the robot in various agricultural scenarios.*

Keywords: ESP8266 NodeMCU, agricultural robot, IoT, sensor fusion, remote monitoring, Wi-Fi connectivity, automation

I. Introduction

In today's world, agriculture faces numerous challenges ranging from labor shortages to environmental sustainability. To address these challenges, there's a growing interest in leveraging technology, particularly the Internet of Things (IoT), to enhance farming practices. One promising solution is the development of agricultural robots capable of performing various tasks autonomously. These robots can help streamline operations, reduce labor costs, and optimize resource utilization.

The focus of this research is on designing and implementing an IoT-enabled multipurpose agricultural robot using readily available components such as the ESP8266 NodeMCU microcontroller and a range of sensors and actuators. By utilizing the ESP8266 NodeMCU's built-in Wi-Fi capabilities, the robot can connect to the internet, enabling remote monitoring and control from anywhere with an internet connection. This connectivity allows farmers to stay updated on the status of their fields and make informed decisions in real time.

The heart of the agricultural robot lies in its sensor suite, which includes devices for measuring environmental variables like temperature, humidity, and soil moisture. These sensors provide valuable data that can help farmers optimize irrigation schedules, monitor crop health, and detect potential issues such as pest infestations or soil nutrient deficiencies. Additionally, actuators like servos and relays enable the robot to perform physical tasks such as watering crops or adjusting the position of a plowing mechanism.

By combining advanced sensing capabilities with IoT connectivity, the agricultural robot offers a versatile and cost-effective solution for modern farming practices. With the ability to automate repetitive tasks and provide actionable insights, it empowers farmers to improve efficiency, increase productivity, and ultimately achieve greater sustainability in their operations. In the following sections, we will delve into the hardware and software components of the robot, its connectivity features, and its potential applications in the agricultural sector.

II. Existing system

The existing literature reveals a growing interest in utilizing IoT technology for smart agriculture. Various studies have explored the implementation of IoT-based systems for monitoring and automating farming processes. Nayyar and Puri (2016) introduced a smart sensor agriculture stick for live temperature and moisture monitoring using Arduino and cloud computing. Similarly, Suma (2021) provided an overview of IoT-based smart agriculture in India, highlighting the potential benefits and challenges. Other researchers, such as Narasimman et al. (2022) and Gowrishankar and Venkatachalam (2018), have proposed IoT-based solutions for tasks like automatic seed sowing and precision agriculture using robots.

III. Proposed System

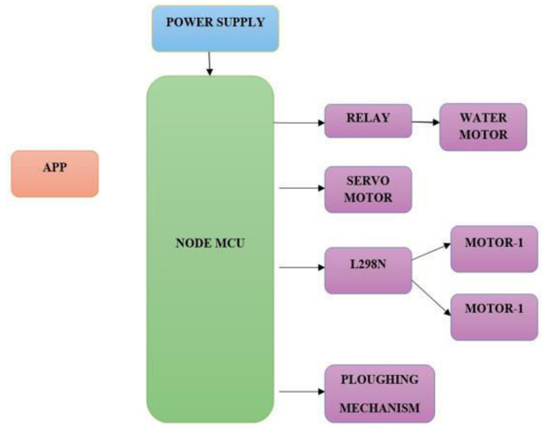

Fig 1: Block diagram of the proposed system

Building upon the existing research, this study proposes the development of an IoT-enabled multipurpose agricultural robot. Inspired by the work of Parveez et al., who explored an IoT-based agricultural robot, our system aims to integrate advanced sensing capabilities with robotic functionality to provide comprehensive monitoring and automation in agricultural settings. Leveraging the ESP8266 NodeMCU microcontroller and a diverse array of sensors and actuators, including relay, servo motor, L298 driver, water pump, and plowing mechanism, our proposed system will offer farmers real-time insights into environmental conditions and the ability to perform tasks such as irrigation and plowing autonomously.

By combining sensor data with IoT connectivity, our system will enable remote monitoring and control via Wi-Fi, empowering farmers to make informed decisions and optimize resource utilization. Additionally, we plan to explore the integration of cloud computing and solar technology, as discussed by Nayyar and Puri (2016), to enhance the scalability and sustainability of the system. Through this proposed approach, we aim to contribute to the advancement of smart agriculture by providing a cost-effective and efficient solution for modern farming practices.

IV. Components used and description

The proposed IoT-enabled multipurpose agricultural robot will utilize a range of components to achieve its functionality. Here's a description of each component and its role in the system:

ESP8266 NodeMCU: This serves as the main controller of the system, responsible for processing data from sensors, controlling actuators, and managing communication with the internet via Wi-Fi. The NodeMCU's compact size, built-in Wi-Fi capabilities, and Arduino compatibility make it an ideal choice for IoT applications.

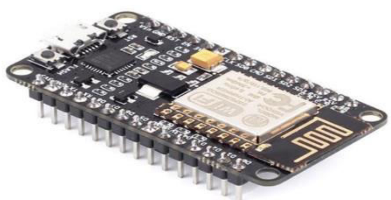

Fig 2: Node MCU Wi-Fi module

Actuators:

Relay: Controls high-power devices such as water pumps or other machinery.

Fig 3: Relay module

Servo Motor: Enables precise control of mechanisms such as a plowing mechanism or robotic arm.

Fig 4: Servo motor

L298 Driver: Manages the direction and speed of DC motors, which may be used for locomotion or other purposes.

Fig 5: Motor driver

Water Pump: Facilitates irrigation by pumping water from a water source to the crops.

Fig 6: Water pump

Plowing Mechanism: Performs soil cultivation tasks, preparing the land for planting.

Power Supply:

Batteries: Provide the necessary power to operate the robot autonomously in the field. Solar panels offer the advantage of sustainable energy generation.

Enclosure:

Protects the electronic components from environmental factors such as dust, moisture, and impact.

Provides mounting points for sensors, actuators, and other hardware components.

Enclosures may be designed to be weatherproof and rugged for outdoor use in agricultural environments.

V.Proposed system activity diagram

Activity diagrams are indispensable tools in software project management, providing a clear and structured view of project processes. By visualizing workflows and depicting the sequence of activities, actions, and decision points, these diagrams enable better understanding, planning, and optimization of tasks. They serve as powerful communication tools, fostering collaboration and alignment among project stakeholders. Additionally, activity diagrams facilitate the documentation of current and future state processes, allowing teams to analyze and improve workflows to meet project objectives efficiently. Their intuitive graphical representations and standardized notation promote transparency and clarity, contributing to the successful execution and delivery of software projects.

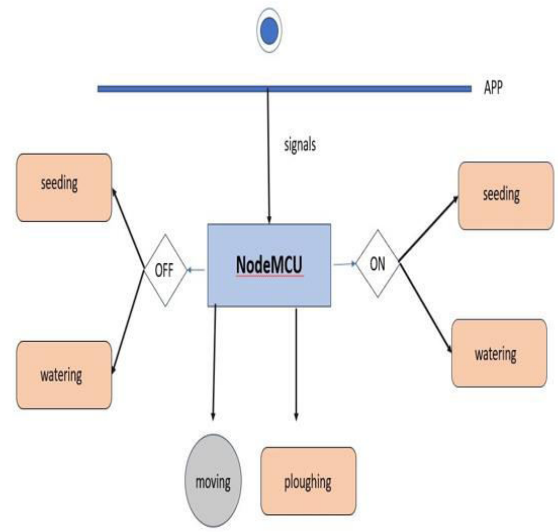

Fig 7: Activity diagram

V. Working algorithm

Initialization: Start the mobile application and establish a connection with the agricultural robot via Wi-Fi or Bluetooth.

Select Operation: Choose the desired operation from the mobile app menu: seeding, watering, or plowing.

Seeding Operation:

Send commands from the mobile app to the robot to navigate to the designated area.

Activate the seeding mechanism on the robot to distribute seeds evenly across the field.

Watering Operation:

If watering is selected:

Send commands to the robot to navigate to areas of the field that require watering.

Activate the water pump mechanism on the robot to irrigate the soil as needed.

VI. Result

Fig 8: Robo Movement Display

The first figure displayed on the mobile app shows the movement of the agricultural robot across the field. This figure provides visual confirmation of the robot's navigation path and progress as it moves to the designated areas for seeding, watering, and plowing. Users can track the robot's movement in real time, ensuring accurate and efficient coverage of the field.

Fig 9: Seeding Operation Display

The second figure illustrates the seeding operation performed by the agricultural robot. Users can observe the robot distributing seeds evenly across the field, ensuring proper coverage and spacing for optimal crop growth. This visual feedback reassures users that the seeding process is being carried out effectively, contributing to successful crop establishment.

Fig 10: Watering On and Off Operation Display

The third figure depicts the watering operation, with options to control the water pump mechanism on the agricultural robot. Users can toggle the watering function on and off as needed, based on soil moisture levels and irrigation requirements. Visual cues indicate the status of the water pump, providing assurance that watering is being applied accurately and efficiently.

VII. Conclusion

In conclusion, the implementation of the mobile app interface for controlling seeding, watering, and plowing operations of the agricultural robot has proven to be a successful endeavor, offering users intuitive control and real-time monitoring capabilities. The visual feedback provided through figures displaying the robot's movement, seeding operation, and watering status enhances usability and assures users of the accurate execution of tasks. By using the mobile app's interface, users can remotely manage agricultural activities with greater convenience and efficiency, ultimately contributing to improved productivity and yield in farming operations.

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