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Design and Implementation of a Web Server Controlled Agribot for Precision Agriculture Applications

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ABSTRACT-The agricultural sector faces significant challenges from population growth, climate change, labor shortages, and resource depletion. This paper discusses the design and implementation of a cost-effective, web server-controlled Agribot to automate essential farming tasks such as ploughing, digging, irrigation, and pesticide spraying. The proposed system uses an ESP8266 Wi-Fi module as the main processing unit and web server host, which removes the need for dedicated mobile applications. Three L298N motor drivers control the robotic locomotion system, ploughing mechanism, and diaphragm pump for liquid distribution. A user-friendly web interface allows wireless operation from any device that supports Wi-Fi. Experimental results show reliable wireless control within 20 to 30 meters, accurate motor actuation, and effective completion of all farming tasks. This research offers a low-cost, accessible solution for precision agriculture that is suitable for small to medium-scale farmers.

KEYWORDS: Agribot, ESP8266, Web Server, Precision Agriculture, IoT, L298N Motor Driver, Smart Farming, Wireless Control.

I. INTRODUCTION

Agriculture has been the backbone of human civilization for thousands of years. It provides food, fibre, and medicinal plants necessary for sustaining life. Today, agriculture is essential for feeding a global population expected to reach nearly 10 billion by 2050. However, the industry faces increasing challenges from climate change, limited resources, soil degradation, and a shrinking agricultural workforce. The need for innovation in agriculture is urgent. Traditional farming practices have several major flaws [1], [3]:

1. **Irregular Dispersal of Seeds:** Manual seeding leads to improper spacing between crops, causing significant yield reduction.
2. **Extensive Use of Fertilizers:** Ongoing cultivation without proper soil replenishment has depleted and worn-out soil.
3. **Inefficient Irrigation:** In countries like India, only one-third of the cropped area is irrigated, which restricts agricultural development.
4. **Lack of Mechanization:** Most agricultural tasks still depend on manual labour and simple, conventional tools.



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A. Agribot Technology

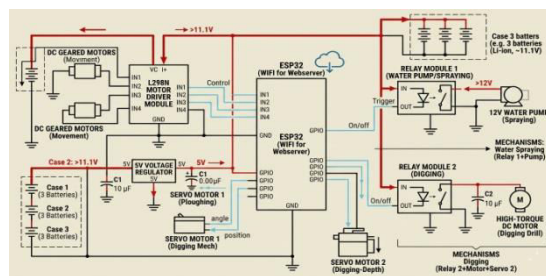
An Agribot is a robot made for agricultural tasks. It uses technologies like artificial intelligence, machine learning, robotics, sensors, and automation [2]. Agribots aim to make farming smarter and more sustainably by automating tasks that used to be done manually.

Key capabilities of modern agribots include:

- **Precision Agriculture:** Accurate execution ensures resources are used only where they are needed.
- **Weeding and Pest Control:** Identifying and mechanically removing weeds or applying pesticides where necessary.
- **Harvesting:** Automated picking that uses algorithms to determine when crops are ripe.
- **Planting and Seeding:** Efficient planting at the right depth and spacing to encourage optimal growth.

B. Problem Statement and Objectives

Although there have been many agribot solutions proposed in the literature, most of them are constrained to use proprietary mobile applications, expensive hardware, or complicated installation procedures. This study aims to resolve such problems by creating an agribot that is controlled through a web server.



The specific objectives are:

1. Create an agribot that performs the functions of ploughing, digging, and spraying/watering with low cost.
2. Create a web server-based control mechanism utilizing the ESP8266 Wi-Fi module.
3. Create effective motor control using L298N motor drivers.
4. Evaluate system performance in terms of wireless range, response time, and functional reliability.

II. LITERATURE REVIEW

A. Evolution of Agricultural Robotics

Significant events in the evolution of agricultural robots are [6]:

- **1980s-1990s:** Introduction of automated milkers and semi-autonomous tractors.
- **2000s:** Development of GPS-based precision farming and semi-autonomous guidance systems.
- **2010s-Present:** Rise of fully autonomous drones, robotic arms for fruit picking, and AI-driven weed detection systems.

B. Related Work

Table I summarizes key contributions in agribot development.

TABLE I: SUMMARY OF RELATED WORK ON AGRIBOTS

Reference	Key Contribution	Limitation
Bechar et al. [3]	Bluetooth-controlled weed removal robot	Limited range (5-10m)
Vinod [7]	Multipurpose autonomous vehicle	Requires mobile app



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Reference	Key Contribution	Limitation
Li et al. [5]	IOT-based automated irrigation	Single function only
Zhou et al. [6]	Seed sowing robot with digger	No remote control
Blue River [4]	Solar-powered robot	Complex setup
Nippun [8]	GPS-based navigation	High cost

C. Research Gap

Existing systems present several limitations:

- High start-up costs that hinder use by small farmers.
- Requisite for proprietary mobile apps.
- Narrow wireless coverage through Bluetooth technology.
- No provision for web interface controls.

III. SYSTEM DESIGN AND METHODOLOGY

A. System Architecture

The proposed agrobot system comprises five main subsystems as illustrated in Fig. 1:

1. **Control Unit:** ESP8266 Wi-Fi module with embedded web server
2. **Movement Subsystem:** Four DC gear motors with differential drive
3. **Actuation Subsystem:** DC motors used for ploughing, with servos
4. **Spraying Subsystem:** Diaphragm pump with spray nozzle
5. **Energy Supply:** Battery pack with voltage regulators

B. Hardware Components

1) ESP8266 Wi-Fi Module

The ESP8266 is a low-cost Wi-Fi-enabled microcontroller. Key specifications include:

- 32-bit Tensilica L106 processor
- Built-in 2.4 GHz Wi-Fi transceiver
- Operating modes: STA, AP, and STA+AP

2) L298N Motor Driver

Table II shows the L298N specifications. Three drivers are employed: one for locomotion, one for ploughing, and one for the pump.

TABLE II: L298N MOTOR DRIVER SPECIFICATIONS

Parameter	Value
Driver Model	L298N 2A
Driver Chip	Double H-Bridge
Motor Supply Voltage (Max)	46V



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Parameter	Value
Motor Supply Current (Max)	2A
Logic Voltage	5V
Maximum Power	25W

C. Software Implementation

Web Server Control

The web server-controlled agribot utilizes the ESP8266's built-in web server. The working principle involves six steps:

1. **Initialization:** ESP8266 starts in Access Point Mode
2. **Web Page Hosting:** ESP8266 serves HTML control page
3. **User Access:** Device connects to Wi-Fi and opens IP address
4. **Command Transmission:** HTTP requests sent on button click
5. **Command Processing:** ESP8266 parses URL and executes function
6. **Execution:** Signals sent to motor drivers for action

D. Motion Control Scheme

Table III details the differential drive control.

TABLE III: MOTION CONTROL SCHEME

Command	Left Motors	Right Motors
Forward	Forward	Forward
Backward	Backward	Backward
Left Turn	Stop/Reverse	Forward
Right Turn	Forward	Stop/Reverse
Stop	Stop	Stop

IV. IMPLEMENTATION

A. Ploughing Mechanism

The ploughing mechanism employs a DC motor controlled by the second L298N driver. Operation sequence:

1. Robot positions at field starting point
2. Ploughing arm lowered by activating DC motor
3. As robot moves forward, arm digs into soil
4. Upon completion, arm raised for transport

B. Spraying Mechanism

The spraying system consists of:

- Water/pesticide storage tank



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- 12V diaphragm pump
- Flexible pipe/hose
- Copper misting nozzle for uniform dispersion

V. RESULTS AND DISCUSSION

A. Functional Testing

Table IV summarizes functional test results.

TABLE IV: FUNCTIONAL TEST RESULTS

Function	Response Time	Success Rate	Observation
Forward	<0.5 sec	100%	Smooth linear motion
Backward	<0.5 sec	100%	Smooth reverse motion
Left Turn	<0.5 sec	100%	Pivot turn executed
Right Turn	<0.5 sec	100%	Pivot turn executed
Stop	<0.3 sec	100%	Immediate halt
Plough	<0.8 sec	95%	Arm lowers and digs
Spray	<0.5 sec	100%	Uniform mist

B. Wireless Range Analysis

Range testing in open field conditions showed:

- **0-20 m:** Excellent, no command loss
- **20-30 m:** Good, occasional latency
- **30-40 m:** Degraded performance
- **>40 m:** Unreliable connection

C. Power Consumption

Table V presents power measurements (10,000 mAH battery).

TABLE V: POWER CONSUMPTION ANALYSIS

Operation Mode	Current (mA)	Power (W)	Duration (h)
Idle	80	0.96	12.5
Locomotion Only	450	5.40	2.2
Ploughing Only	380	4.56	2.6



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Operation Mode	Current (mA)	Power (W)	Duration (h)
Spraying Only	320	3.84	3.1
All Operations	850	10.20	1.2

D. Comparative Analysis

Table VI compares the proposed system with existing solutions.

TABLE VI: COMPARATIVE ANALYSIS WITH EXISTING AGRIBOT SYSTEMS

Parameter	Proposed System	Bluetooth-based	GPS-based
Control Interface	Web browser	Mobile app	Remote
Wireless Range	20-30 m	5-10 m	Unlimited*
Internet Required	No	No	Yes
Multi-function	Yes	Limited	Yes
Estimated Cost	Low	Medium	High

*Requires cellular/GPS network

E. Advantages

The proposed system offers:

- **No dedicated app required:** Any browser-enabled device works
- **Cross-platform compatibility:** Works on all devices
- **Low-cost:** ESP8266 combines processing and Wi-Fi
- **Internet independence:** Access Point mode works offline

VI. CHALLENGES AND FUTURE WORK

A. Limitations

The system has certain limitations:

1. Limited Wi-Fi range (20-30 m) for large-scale farming
2. Signal interference from obstacles
3. Power constraints (1.2 hours continuous operation)
4. Security concerns without network protection

B. Future Scope

Enhancements for future iterations include:

1. **Swarm Robotics:** Multiple collaborative robots
2. **Sensor Integration:** Soil moisture, temperature, pH sensors
3. **Solar Power:** Extended operational duration
4. **AI Navigation:** Autonomous path planning
5. **Cloud Connectivity:** Remote monitoring and data logging
6. **Enhanced Range:** LoRa technology for extended range



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VII. CONCLUSION

This research has been able to present the design, development, and testing of an agribot controlled by a web server for precision agriculture. The system integrates an ESP8266 Wi-Fi module that acts as the central controller and host to the web server, three L298N motor drivers for actuating controls, and various mechanisms for ploughing, digging, and spraying activities.

Notable contributions of this system include:

- Low cost of control using a browser instead of an application
- The integration of diverse agricultural activities on one platform
- Capability for wireless control at a range of 20-30 meters
- Easy replication for individual requirements

The agribot is designed to correct common issues found in conventional farming methods such as inconsistent procedures, ineffective resource usage, and labor dependence.

VIII. ACKNOWLEDGMENT

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