iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** V **Month of publication:** May 2026

DOI: https://doi.org/10.22214/ijraset.2026.82867

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

AI-Based Agricultural Robot for Real-Time Crop Monitoring: A Comprehensive Review

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Abstract: Agriculture is evolving toward intelligent automation due to increasing demand for food production, environmental challenges, and labor shortages. Artificial Intelligence (AI), Internet of Things (IoT), and robotic technologies enable precision farming through continuous monitoring and automated decision-making. This review paper presents a detailed analysis of an AI-based agricultural robot designed for real-time crop monitoring, autonomous navigation, and smart irrigation management. The system integrates environmental sensors, wireless communication, cloud analytics, and automated treatment mechanisms to optimize agricultural productivity while reducing resource wastage. Existing research on agricultural robots, intelligent pesticide spraying systems, and precision farming technologies is critically reviewed. The study highlights the effectiveness of sensor-driven automation in improving crop yield, conserving water, and minimizing chemical usage. Future developments involving computer vision, predictive analytics, and swarm robotics are also discussed.
Keywords: Precision Agriculture, Agricultural Robotics, IoT Farming, Smart Irrigation, Autonomous Robot.

I. INTRODUCTION

Agriculture remains the backbone of many economies, yet traditional farming techniques suffer from inefficiencies such as excessive irrigation, delayed disease detection, and dependence on manual labor. Modern agriculture increasingly adopts automation technologies to overcome these limitations.AI-based agricultural robots provide continuous monitoring of environmental conditions and enable automated responses based on real-time data. The reviewed system collects soil moisture, temperature, humidity, and light intensity data and transmits them to cloud platforms for analysis and intelligent decision-makingPrecision agriculture shifts farming practices from generalized treatment toward plant-specific management, improving sustainability and productivity.

II. LITERATURE SURVEY

Research in agricultural robotics demonstrates steady progress toward intelligent farming systems.

Sumithra and Gayathiri proposed an agricultural robot capable of detecting plant diseases using image processing and automatically spraying pesticides only on affected regions, reducing chemical wastage [1].

Sammons et al. developed an autonomous greenhouse spraying robot that minimized human exposure to toxic chemicals while ensuring uniform pesticide application [2].

Xu et al. introduced an intelligent control simulation system using embedded wireless networks to improve pesticide spraying accuracy and operational reliability [3].

Gengaje and Deshmukh designed an ARM-based pesticide spraying robot with wireless monitoring capability, reducing labor risks and improving efficiency [4].

Raval et al. developed an automated agricultural robot capable of navigating farm rows and applying pesticides remotely [5].

Zhang et al. provided a global overview of precision agriculture technologies emphasizing sensors, remote monitoring, and data analytics for sustainable farming [6].

Vision-based navigation research by Jinlinlin and Tony improved robot guidance accuracy using image processing techniques [7].

Husin et al. demonstrated crop disease detection using digital image processing and MATLAB-based analysis [8].

These studies confirm that combining robotics, sensing, and AI significantly enhances agricultural efficiency but requires affordable integrated solutions for practical deployment.

III. SYSTEM ARCHITECTURE

The AI agricultural robot functions as a cyber-physical system integrating sensing, processing, communication, and actuation.

Operational Modes

- Manual wireless control
- Fully autonomous navigation

Core Functions
- Environmental monitoring
- Smart irrigation
- Precision spraying
- Cloud analytics

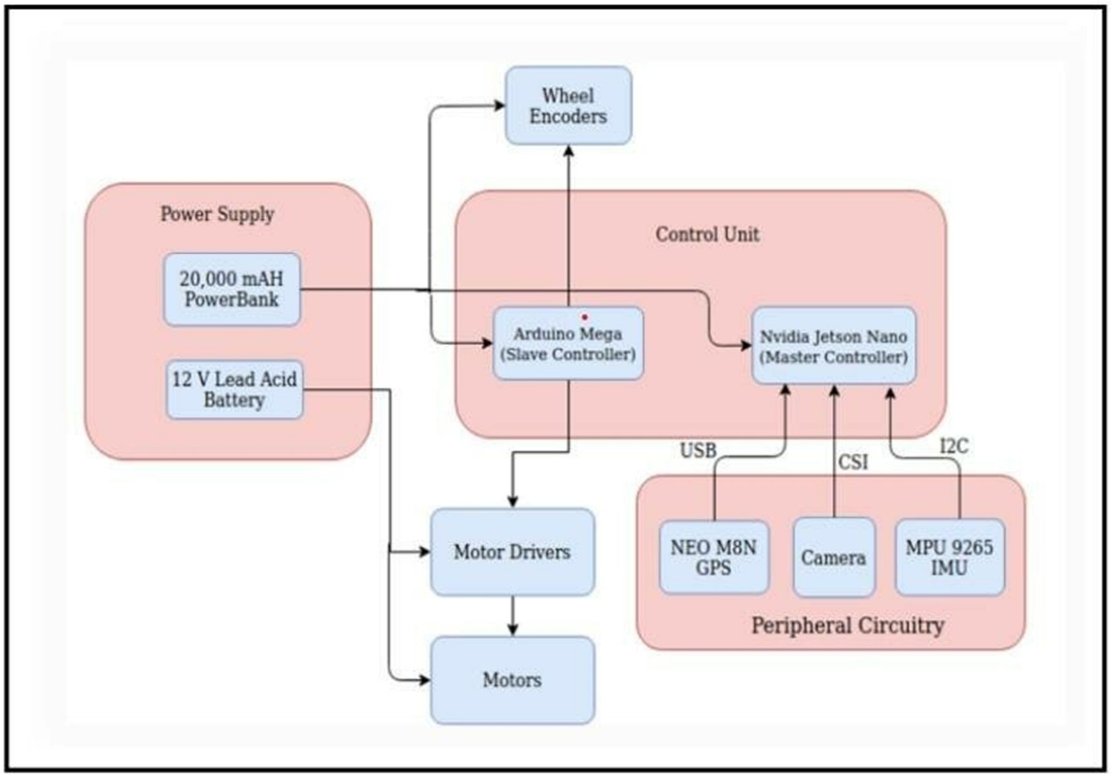

Fig.1 illustrates the architecture of the AI-based Architectural Robot.

Working Flow:
Sensors → ESP32 Controller → Cloud → Decision → Actuators

IV. HARDWARE COMPONENTS

A. *ESP32 Microcontroller*

ESP32 serves as the main controller providing:
- Wi-Fi & Bluetooth connectivity
- Dual-core processing
- Low power consumption suitable for IoT farming
- AI BASED AGRI ROBOT

B. *Sensor Modules*

Sensor	Function
Soil Moisture Sensor	Irrigation control
DHT11	Temperature & humidity Monitoring
Ultrasonic Sensor	Obstacle detection
Light Sensor	Growth analysis

C. Actuation System
- DC motors for mobility
- L298N motor driver
- Water pump for irrigation
- Sprayer mechanism

D. Power Supply
Solar panels and Li-ion batteries ensure sustainable operation.

V. IOT ARCHITECTURE

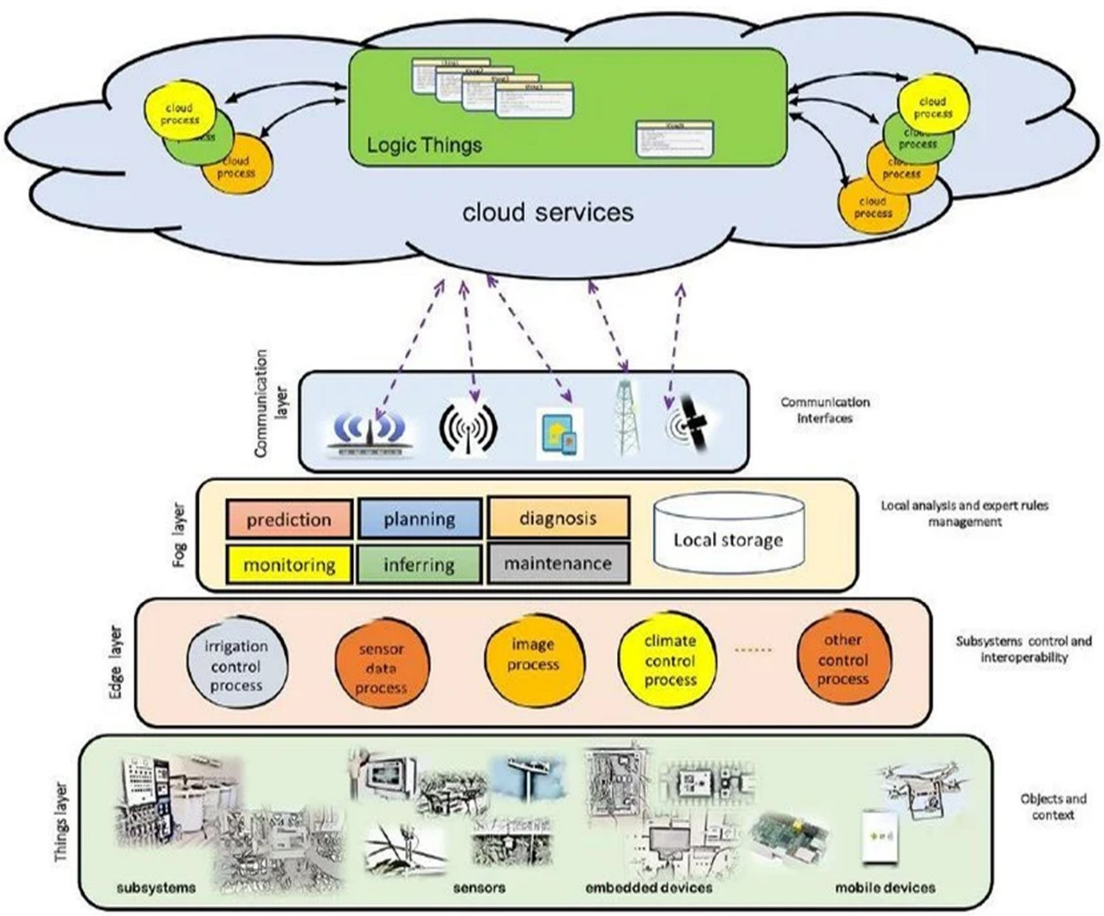

Fig.2 This architecture enables real-time analytics and decision

VI. WORKING METHODOLOGY

Step-wise Operation
1) Sensors collect environmental data.
2) ESP32 processes sensor readings.
3) Data uploaded to a cloud platform.
4) AI logic analyzes conditions.
5) Irrigation or spraying is activated automatically.
6) The user monitors the system through a mobile app.

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VII. SMART IRRIGATION TECHNIQUES

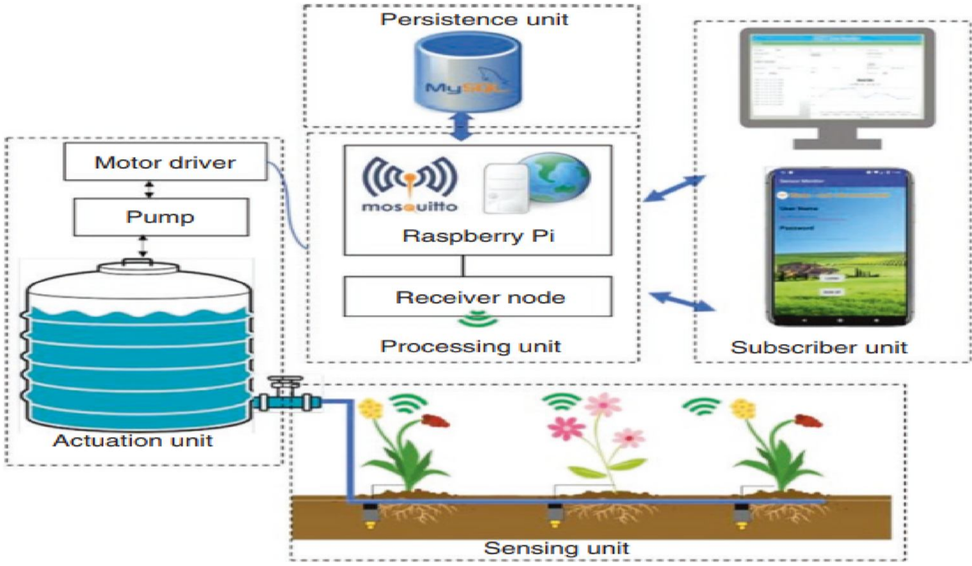


Fig 3 Smart irrigation techniquesWater pump activates when soil moisture falls below threshold levels, enabling precision irrigation and reducing water usage by nearly 40%.

VIII. SOFTWARE AND CLOUD DESCRIPTION

A. Embedded Software
- Arduino C++ firmware
- Sensor data processing
- Navigation algorithms

B. Cloud Platforms
- Firebase database
- ThingSpeak analytics

C. Mobile Application
- Real-time monitoring dashboard
- Manual control interface
- Alerts and historical analysis

IoT integration converts the robot into an intelligent decision-support system

IX. APPLICATIONS

A. Precision Farming
- Optimized irrigation
- Reduced pesticide usage
- Yield improvement

B. Greenhouse Automation
- Continuous environmental monitoring

C. Sustainable Agriculture
- Water conservation
- Reduced environmental pollution

D. Education & Research
- Robotics learning platform
- Agricultural experimentation

X. ADVANTAGE AND LIMITATIONS

A. *Advantages*

1) Real-time monitoring
2) Automated operation
3) Resource optimization
4) Reduced labor dependency

B. *Limitations*

1) Battery constraints
2) Weather dependency
3) Initial setup cost

XI. FUTURE SCOPE

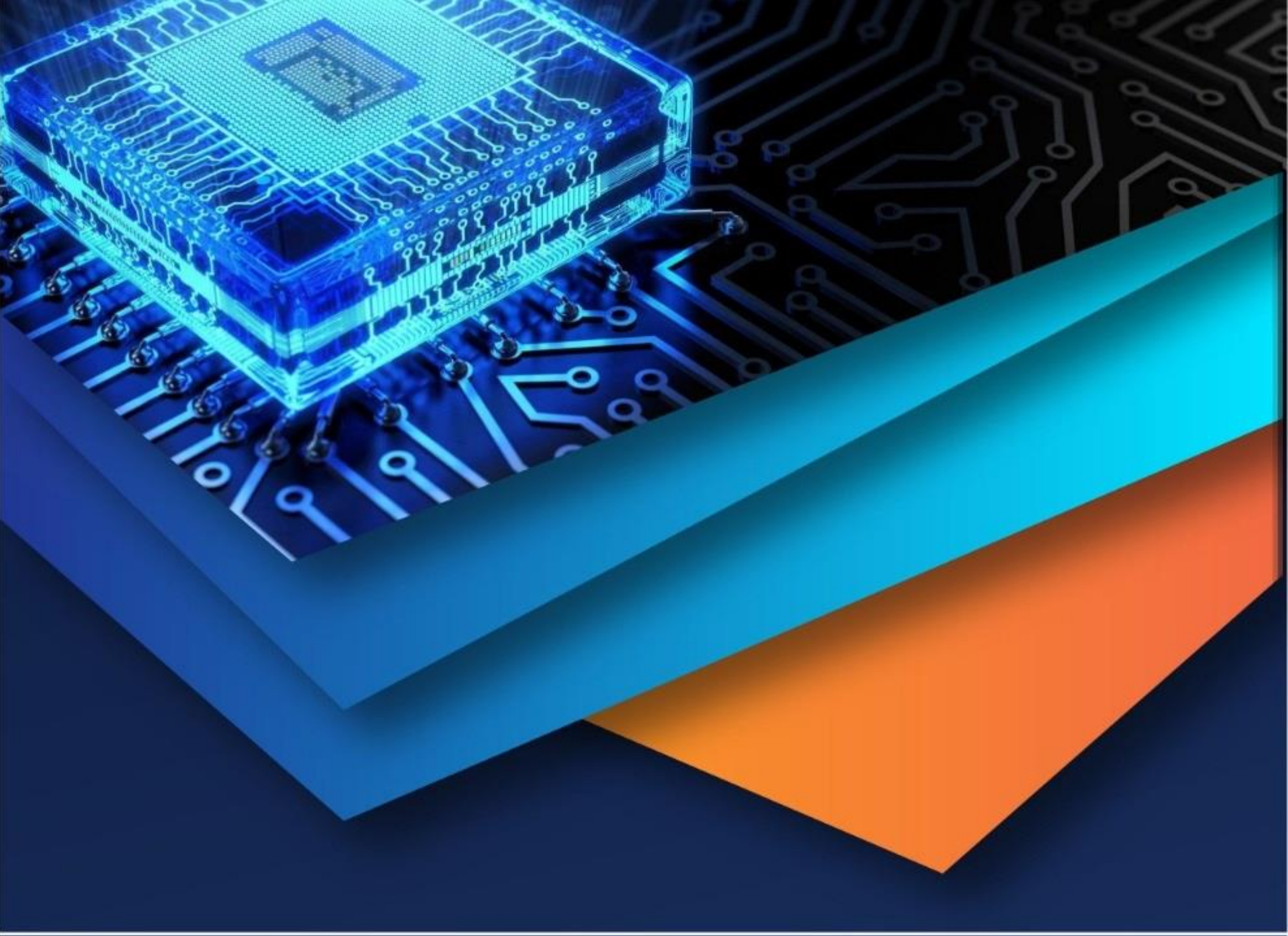
1) Computer vision disease detection
2) GPS navigation
3) Swarm robotics
4) Predictive yield analytics
5) Fully autonomous farm ecosystems

XII. CONCLUSION

AI-based agricultural robots represent a transformative advancement in precision agriculture. The integration of IoT sensors, autonomous mobility, and cloud-based intelligence enables efficient monitoring and automated crop management. The reviewed system demonstrates significant improvements in water conservation, productivity, and sustainability. Continued research in AI and robotics will enable scalable autonomous farming solutions capable of addressing global food security challenges.

REFERENCES

[1] M.G. Sumithra and G.R. Gayathiri, Agricultural Robot for Leaf Disease Detection
[2] P.J. Sammons et al., Autonomous Pesticide Spraying Robot for Greenhouses
[3] C. Xu et al., Intelligent Control in Pesticide Spraying Simulation
[4] S.R. Gengaje and S.M. Deshmukh, ARM-Based Agricultural Robot
[5] M. Raval et al., Automation of Agricultural Spraying Robot
[6] N. Zhang et al., Precision Farming Worldwide Overview
[7] Jinlinlin & Tony, Vision-Guided Agricultural Robot Navigation
[8] Z.B. Husin et al., Image Processing for Plant Health Monitoring
[9] AI Agricultural Robot for Real-time Crop Monitoring Documentation



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10.22214/IJRASET

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