



iJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** X **Month of publication:** October 2026

DOI: <https://doi.org/10.22214/ijraset.2026.85108>

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IoT-Enabled Autonomous Agriculture Monitoring Rover for Smart Farming: A Comprehensive Literature Review

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Abstract: *The rapid development of the Internet of Things (IoT), autonomous robotics, artificial intelligence (AI), embedded systems, wireless communication, and precision agriculture has created new opportunities for improving agricultural productivity and resource utilization. Conventional agricultural monitoring relies extensively on manual field inspection, which is time-consuming, labor-intensive, and often unable to provide continuous information about crop and soil conditions. Autonomous agricultural rovers provide an alternative approach by enabling mobile sensing, real-time environmental monitoring, crop observation, navigation, and precision agricultural operations. This paper presents a comprehensive literature review of IoT-enabled autonomous agricultural rovers for smart farming, with particular emphasis on recent developments reported in IEEE literature. Existing research is analyzed according to rover architecture, sensing technologies, navigation techniques, communication technologies, IoT platforms, agricultural applications, AI integration, and autonomy levels. Recent studies have demonstrated the feasibility of ESP32-based IoT rovers, ROS-based agricultural monitoring robots, autonomous navigation systems, precision irrigation platforms, soil-monitoring robots, and AI-enabled agricultural rovers. However, several limitations remain, including restricted autonomous navigation in unstructured environments, limited multi-parameter sensing, communication reliability in rural areas, high computational requirements for AI, energy limitations, and insufficient integration of monitoring with autonomous decision-making. Based on the reviewed literature, a research gap is identified for a low-cost, modular, IoT-enabled autonomous agricultural monitoring rover capable of simultaneously performing soil and environmental sensing, crop monitoring, obstacle avoidance, real-time wireless communication, location-aware operation, and intelligent decision support.*

Keywords: *Internet of Things, autonomous agricultural rover, smart farming, precision agriculture, agricultural robotics, IoT monitoring, soil monitoring, crop monitoring, autonomous navigation, ESP32, artificial intelligence.*

I. INTRODUCTION

Agriculture is undergoing a significant transformation from conventional farming practices toward data-driven and automated farming systems. Increasing population, climate variability, water scarcity, shortage of agricultural labor, and the need for improved crop productivity have created a strong requirement for intelligent agricultural technologies [13]–[15]. Traditional crop monitoring primarily depends on human observation and manually operated machinery. Although human observation remains important, manual monitoring has several limitations. Large fields require significant time and labor, while variations in soil moisture, temperature, humidity, nutrient conditions, crop growth, and disease symptoms may not be detected at an early stage. The emergence of precision agriculture provides an opportunity to overcome these limitations by collecting spatially and temporally distributed agricultural data. IoT technology enables sensors deployed throughout agricultural environments to collect information and transmit it to cloud or edge platforms for analysis [13], [14]. However, conventional stationary IoT sensor networks have an inherent limitation: sensors are normally installed at fixed locations and therefore provide information only from their immediate sensing region. An autonomous mobile rover can overcome this limitation by physically moving through different areas of a field and collecting measurements at multiple locations. Recent research demonstrates increasing interest in agricultural mobile robots and autonomous rovers. Recent IEEE work has explored ESP32/Blynk-based autonomous agricultural rovers, ROS/STM32 monitoring robots, autonomous navigation, precision watering, IoT connectivity, and AI-enabled low-cost agricultural robotics [1]–[5]. These developments indicate a transition from single-purpose agricultural robots toward multifunctional intelligent platforms. The proposed research direction therefore focuses on an IoT-enabled autonomous agriculture monitoring rover capable of combining autonomous movement, environmental sensing, soil monitoring, crop monitoring, obstacle detection, wireless communication, real-time IoT visualization, location-based data collection, and intelligent agricultural decision support.

II. EVOLUTION OF SMART AGRICULTURE TECHNOLOGIES

The development of agricultural automation can broadly be divided into four stages [11], [12], [18].

- 1) **Conventional Agriculture:** Traditional farming depends primarily on human observation and manually operated machinery. Crop health, irrigation requirements, and soil conditions are generally determined through periodic field inspection.
- 2) **Sensor-Based Agriculture:** Electronic sensors enabled measurement of soil moisture, temperature, humidity, pH, light intensity, rainfall, and other environmental parameters. However, most systems remained stationary.
- 3) **IoT-Based Smart Agriculture:** IoT technology enabled sensor information to be transmitted wirelessly to cloud platforms and mobile applications, allowing farmers to monitor field conditions remotely [13], [19].
- 4) **Autonomous Robotic Agriculture:** Integration of IoT with robotics allows sensing systems to become mobile. Autonomous rovers can travel through fields, collect measurements at multiple locations, identify obstacles and transmit information to remote users [18].

III. LITERATURE REVIEW

A. Rover for Small-Scale Precision Farming

Small-scale farms need affordable and compact robotic platforms that can operate with limited infrastructure. Sanal et al. presented “IoT-Enabled Autonomous Rover for Small-Scale Precision Farming” at the 2025 IEEE International Conference on Power, Instrumentation, Control, and Computing (PICC). The work is closely related to the proposed direction because it brings together IoT, autonomous rover technology, and precision agriculture. The system is built around an ESP32 microcontroller and the Blynk IoT platform, and is aimed at field operations such as soil digging, seed sowing, and fertilization, for which high precision is reported [1]. Its main limitation is its focus on agricultural operations rather than comprehensive crop-health monitoring. The platform could be extended with multi-parameter sensing, crop imaging, disease detection, and intelligent decision support.

B. Agricultural Monitoring Robot Based on ROS

Xu et al. proposed an Agricultural Monitoring Robot Based on Robot Operating System (ROS) [20] at the 2025 IEEE 3rd International Conference on Electrical, Automation and Computer Engineering. The robot uses an STM32 development board and ROS-based control architecture. It integrates sound-source localization, automatic obstacle avoidance, multi-point navigation, temperature monitoring, humidity monitoring, and light-intensity monitoring [2]. The work demonstrates the importance of combining autonomous navigation with agricultural sensing. However, advanced crop monitoring, disease recognition, soil nutrient estimation and intelligent decision-making remain opportunities.

C. Intelligent Autonomous and Manually Operated Agricultural Rover

At the 2025 IEEE SILCON conference, Saravanan et al. presented “Design of an Intelligent Autonomous and Manually Operated Agricultural Rover with Automated Navigation, Precision Watering, and Real-Time Monitoring.” The system brings together autonomous navigation, manual control, precision watering, and real-time monitoring [3]. Having both autonomous and manual modes is useful because agricultural environments are unstructured, and manual override can act as a safety mechanism. Integrating soil, environmental, and visual crop information would further strengthen the system.

D. AGROBOT: IoT-Enabled Autonomous Agricultural Robot

Landge et al. proposed “AGROBOT: An IoT-Enabled Autonomous Agricultural Robot for Precision Farming” at the 2025 IEEE Pune Section International Conference. The work demonstrates the growing emphasis on combining IoT and autonomous robotic systems for precision agriculture [4]. The study is relevant to autonomous agricultural operation, IoT connectivity, and precision farming. A remaining opportunity is development of a more comprehensive monitoring platform with multi-modal sensing and intelligent analysis.

E. Low-Cost AI-Enabled Autonomous Agricultural Rover

Andrei and Dorin presented “Low-Cost Agricultural Robotics: An AI-Enabled Autonomous Rover” at the 2025 IEEE International Symposium for Design and Technology of Electronics Packages. The work addresses the challenge of high agricultural robotics cost and explores affordable autonomous robotics for agricultural monitoring and early disease detection [5]. This direction is important for developing regions and small-scale farmers. Future development can focus on modular hardware, edge AI, scalable sensing and long-duration field validation.

IV. COMPARATIVE ANALYSIS OF EXISTING RESEARCH

The reviewed studies demonstrate a clear movement toward multifunctional agricultural robots. Table I compares recent representative works according to their principal technology and research emphasis.

Ref.	Year	Research Work	Technology	Main Application	Major Limitation
[1]	2025	IoT-Enabled Autonomous Rover for Small-Scale Precision Farming	ESP32 + Blynk	Digging, sowing, fertilization	Limited crop-health monitoring
[2]	2025	Agricultural Monitoring Robot Based on ROS	ROS + STM32	Environmental monitoring	Limited AI/crop analysis
[3]	2025	Intelligent Autonomous and Manually Operated Agricultural Rover	Autonomous navigation + IoT	Watering + monitoring	Needs broader sensing integration
[4]	2025	AGROBOT: IoT-Enabled Autonomous Agricultural Robot	IoT + autonomous robotics	Precision farming	Limited multifunctional monitoring
Ref.	Year	Research Work	Technology	Main Application	Major Limitation
[5]	2025	Low-Cost AI-Enabled Autonomous Rover	AI + robotics	Crop monitoring / disease detection	Requires further field validation
[6]	2024	Autonomous Driving Strategy for Agricultural Rover	Autonomous navigation	Field navigation	Navigation-focused
[7]	2025	Co-Simulation Model of Autonomous Driving Rover	Simulation + autonomous driving	Agricultural mobility	Simulation-oriented

TABLE I. COMPARISON OF RECENT AGRICULTURAL ROVER RESEARCH

V. TECHNOLOGIES USED IN AUTONOMOUS AGRICULTURAL ROVERS

A. Microcontrollers

Common embedded controllers include ESP32, STM32, Arduino, Raspberry Pi and NVIDIA Jetson platforms. ESP32 is attractive for low-cost systems because it combines embedded processing with Wi-Fi/Bluetooth connectivity.

B. Soil Sensors

A monitoring rover can incorporate soil moisture, soil temperature, pH, electrical conductivity and NPK sensors. Measurements can be associated with geographical position to create spatial soil-condition maps.

C. Environmental Sensors

Typical sensors include DHT22, BME280, light sensors, rain sensors, atmospheric pressure sensors and CO₂ sensors.

D. Crop Monitoring

Cameras mounted on the rover can support plant detection, crop-growth monitoring, leaf analysis, disease detection, weed detection and fruit counting. AI models can process images locally using edge computing or remotely through cloud platforms [16], [17]. In-field optical detection of crop compounds by a rover prototype has also been demonstrated [8].

VI. AUTONOMOUS NAVIGATION

Autonomous navigation is one of the most important components of an agricultural rover.

- 1) GPS: Provides global positioning and is useful for outdoor field navigation.
- 2) RTK-GPS: Provides substantially improved positioning accuracy for precision agricultural navigation.
- 3) Ultrasonic Sensors: Provide low-cost obstacle detection.
- 4) LiDAR: Provides three-dimensional information for mapping and obstacle avoidance.
- 5) Computer Vision: Cameras can identify crop rows, obstacles, plants, weeds and field boundaries.

Recent research on autonomous agricultural vehicles emphasizes motion strategies involving path planning and path following [6], [7]. Agricultural terrain presents additional challenges such as mud, uneven surfaces, vegetation and changing field conditions [9].

VII. IOT ARCHITECTURE FOR AGRICULTURAL ROVER

A typical architecture follows the sequence: Sensors > Microcontroller > Wireless Communication > IoT Platform > Cloud Database > Farmer Application [10], [13], [19].

- 1) Sensing Layer: Soil moisture, temperature, humidity, pH, light and crop images are collected.
- 2) Processing Layer: ESP32/STM32/Raspberry Pi processes sensor information and controls the rover.
- 3) Communication Layer: Wi-Fi, LoRa, GSM/4G and Bluetooth can be considered depending on range and infrastructure.
- 4) Cloud/IoT Layer: Blynk, ThingSpeak, MQTT, Firebase or a custom cloud platform can be used.
- 5) Application Layer: Farmers can monitor rover location, soil conditions, environmental conditions, crop condition, battery status and alerts.

VIII. ARTIFICIAL INTELLIGENCE IN AGRICULTURAL ROVERS

AI significantly expands agricultural rover capabilities. A camera can capture plant images and a CNN-based model can classify crop conditions [16], [17]. The processing pipeline can be represented as Image > Pre-processing > CNN > Feature Extraction > Classification > Decision.

Potential AI applications include plant disease detection, weed identification, crop classification, growth-stage estimation, fruit detection, nutrient-deficiency detection and yield estimation. Recent research increasingly identifies AI, IoT, robotics and edge computing as complementary technologies for smart agriculture [16], [18], [19].

IX. RESEARCH GAP ANALYSIS

Based on the reviewed literature, the following gaps are identified [14], [18], [19]:

- 1) Limited Integration: Many existing systems concentrate on irrigation, sowing, fertilization or monitoring rather than integrating multiple capabilities.
- 2) Limited Mobile Sensing: Conventional IoT agriculture often uses stationary sensors. Autonomous rovers can provide spatially distributed measurements.
- 3) Limited Intelligent Decision-Making: Many systems collect sensor data without automatically interpreting it to generate actionable recommendations.
- 4) Navigation Challenges: Agricultural environments contain uneven terrain, mud, plants, stones, irrigation pipes, people and farm equipment.
- 5) Communication Reliability: Wi-Fi availability can be limited in rural agricultural environments; long-range communication such as LoRa can be useful.
- 6) Energy Management: Rovers require energy for motors, sensors, processors, cameras and communication. Efficient power management is therefore important.
- 7) High Cost: Commercial agricultural robots may be inaccessible to small-scale farmers. Low-cost modular architectures remain important.

X. PROPOSED RESEARCH FRAMEWORK

The proposed IoT-enabled autonomous agriculture monitoring rover can combine mobile sensing, navigation, communication and decision support. Core modules include:

- 1) Soil and environmental sensing unit
- 2) Crop imaging unit
- 3) ESP32/STM32 processing controller
- 4) Motor driver and geared motors
- 5) GPS/RTK-GPS navigation
- 6) Ultrasonic/LiDAR obstacle detection
- 7) Wi-Fi/LoRa/4G communication
- 8) IoT cloud dashboard

- 9) AI-based crop analysis
- 10) Battery monitoring and power management

The rover can periodically navigate predefined field paths, collect geo-tagged measurements, transmit information to the IoT platform and generate alerts when soil or crop conditions cross predefined thresholds.

XI. EXPECTED CONTRIBUTIONS OF THE PROPOSED SYSTEM

- 1) Real-Time Monitoring: Continuous collection of agricultural parameters.
- 2) Mobile Sensing: Measurements can be collected from multiple locations instead of fixed sensor positions.
- 3) Autonomous Operation: The rover can navigate predefined agricultural paths with minimal human intervention.
- 4) IoT Connectivity: Farmers can remotely access real-time field information.
- 5) Intelligent Analysis: AI algorithms can identify abnormal crop or soil conditions.
- 6) Resource Optimization: The system can support optimized irrigation, fertilization and other agricultural inputs.
- 7) Low-Cost Implementation: An ESP32-based architecture can improve accessibility for small and medium-scale farms.

XII. FUTURE RESEARCH DIRECTIONS

- 1) Edge AI: Moving AI processing closer to the rover can reduce cloud latency.
- 2) Digital Twin Agriculture: A digital representation of the agricultural field can be continuously updated using rover-generated sensor data.
- 3) Swarm Agricultural Robots: Multiple low-cost rovers can cooperate to cover larger fields.
- 4) 5G/6G Connectivity: High-speed communication can support real-time video and AI-assisted remote control.
- 5) Solar-Powered Operation: Solar charging can extend operating time and improve sustainability.
- 6) Multispectral Imaging: Multispectral cameras can enable advanced crop-health analysis.
- 7) Autonomous Decision-Making: Future systems can progress from Sense > Communicate to Sense > Analyze > Decide > Act.

XIII. CONCLUSION

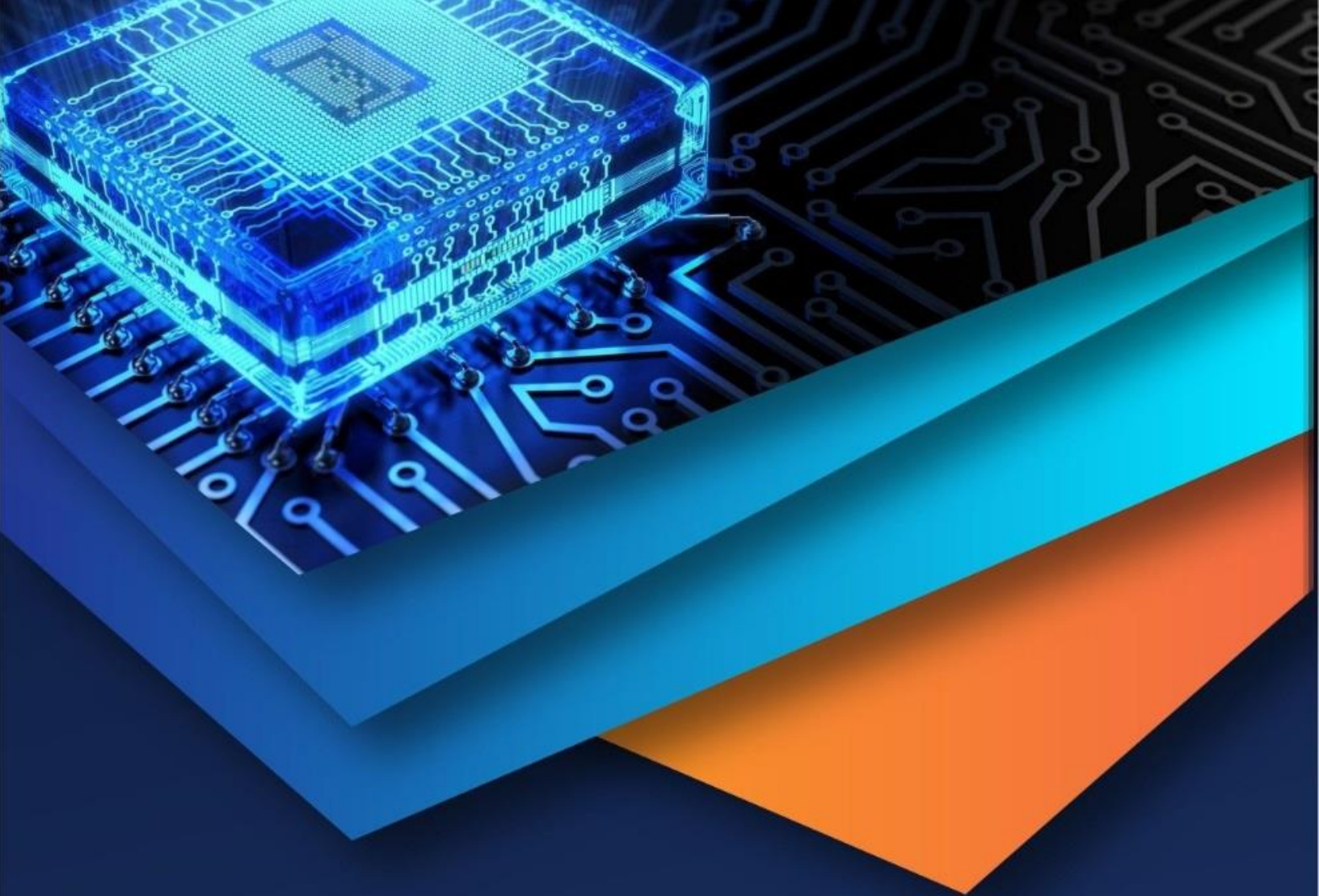
This literature review investigated recent developments in IoT-enabled autonomous agricultural rovers for smart farming, with emphasis on recent IEEE research. The reviewed studies demonstrate substantial progress in autonomous navigation, IoT connectivity, environmental sensing, precision irrigation, agricultural operations, soil monitoring and AI-enabled crop monitoring. Recent work demonstrates the feasibility of affordable autonomous agricultural platforms, while other studies demonstrate ROS-based navigation, environmental monitoring, precision watering and AI-enabled low-cost robotics. Nevertheless, significant opportunities remain in integrating mobile sensing, autonomous navigation, IoT communication, AI-based crop analysis, spatial soil monitoring and intelligent decision-making within a single low-cost platform. An IoT-enabled autonomous agriculture monitoring rover is therefore a promising research direction for small- and medium-scale farms. Such a system can reduce dependence on manual monitoring, improve resource utilization, provide continuous agricultural intelligence and contribute to sustainable precision agriculture.

REFERENCES

- [1] A. K. Sanal, A. P. R., A. Chandran, J. Anoj, and A. Francis, "IoT-Enabled Autonomous Rover for Small-Scale Precision Farming," in Proc. 2025 Int. Conf. Power, Instrumentation, Control and Computing (PICC), 2025, doi: 10.1109/PICC67314.2025.11291327.
- [2] F. Xu, X. Yin, L. Wang, and Y. Shen, "Agricultural Monitoring Robot Based on Robot Operating System," in Proc. 2025 IEEE 3rd Int. Conf. Electrical, Automation and Computer Engineering (ICEACE), 2025, pp. 1770–1775, doi: 10.1109/ICEACE67491.2025.11439057.
- [3] S. Saravanan et al., "Design of an Intelligent Autonomous and Manually Operated Agricultural Rover with Automated Navigation, Precision Watering, and Real-Time Monitoring," in Proc. 2025 IEEE Silchar Subsection Conf. (SILCON), 2025, doi: 10.1109/SILCON67893.2025.11327010.
- [4] A. Landge, P. Patil, S. Jadhav, S. Jadhav, and D. A. Jakkan, "AGROBOT: An IoT-Enabled Autonomous Agricultural Robot for Precision Farming," in Proc. 2025 IEEE Pune Section Int. Conf. (PuneCon), 2025, doi: 10.1109/PuneCon67554.2025.11378815.
- [5] C. D. Andrei and S. Dorin, "Low-Cost Agricultural Robotics: An AI-Enabled Autonomous Rover," in Proc. 2025 IEEE Int. Symp. Design and Technology of Electronics Packages (SIITME), 2025, pp. 269–272, doi: 10.1109/SIITME67657.2025.11293697.
- [6] A. M. Ruzic et al., "Autonomous Driving Strategy for a Specialized Four-Wheel Differential-Drive Agricultural Rover," *AgriEngineering*, 2024.
- [7] S. Martelli, V. Martini, F. Mocera, and A. Soma, "Co-Simulation Model of an Autonomous Driving Rover for Agricultural Applications," *Robotics*, vol. 14, no. 9, 2025.
- [8] F. Micheletti, G. Agati, S. Cremasco, F. Visentin, and R. Muradore, "In-field autonomous UV-B irradiation and phenolic compounds optical detection of lettuce crops by an agricultural rover prototype," in Proc. 2025 IEEE Int. Workshop Metrology for Agriculture and Forestry (MetroAgriFor), 2025, pp. 378–382, doi: 10.1109/MetroAgriFor66923.2025.11512400.
- [9] J. L. Cleetus et al., "Enhancing the Farmland Rover for Muddy Terrain with IoT," 2025.



- [10] L. Joseph, S. Joseph, S. H. Abraham, and A. George, "An Autonomous Agriculture Robot Using IoT," *Int. J. Computer Sciences and Engineering*, vol. 8, no. 7.
- [11] A. Bechar and C. Vigneault, "Agricultural robots for field operations: Concepts and components," *Biosyst. Eng.*, vol. 149, pp. 94–111, 2016.
- [12] A. Bechar and C. Vigneault, "Agricultural robots for field operations. Part 2: Operations and systems," *Biosyst. Eng.*, vol. 153, pp. 110–128, 2017.
- [13] M. Ayaz, M. Ammad-Uddin, Z. Sharif, A. Mansour, and E. M. Aggoune, "Internet-of-Things (IoT)-based smart agriculture: Toward making the fields talk," *IEEE Access*, vol. 7, pp. 129551–129583, 2019.
- [14] O. Elijah, T. A. Rahman, I. Orikumhi, C. Y. Leow, and M. N. Hindia, "An overview of Internet of Things (IoT) and data analytics in agriculture: Benefits and challenges," *IEEE Internet Things J.*, vol. 5, no. 5, pp. 3758–3773, Oct. 2018.
- [15] S. Wolfert, L. Ge, C. Verdouw, and M.-J. Bogaardt, "Big data in smart farming – A review," *Agric. Syst.*, vol. 153, pp. 69–80, 2017.
- [16] A. Kamilaris and F. X. Prenafeta-Boldu, "Deep learning in agriculture: A survey," *Comput. Electron. Agric.*, vol. 147, pp. 70–90, 2018.
- [17] S. P. Mohanty, D. P. Hughes, and M. Salathe, "Using deep learning for image-based plant disease detection," *Front. Plant Sci.*, vol. 7, Art. no. 1419, 2016.
- [18] L. F. P. Oliveira, A. P. Moreira, and M. F. Silva, "Advances in agriculture robotics: A state-of-the-art review and challenges ahead," *Robotics*, vol. 10, no. 2, Art. no. 52, 2021.
- [19] B. S. Sinha and R. Dhanalakshmi, "Recent advancements and challenges of Internet of Things in smart agriculture: A survey," *Future Gener. Comput. Syst.*, vol. 126, pp. 169–184, 2022.
- [20] M. Quigley et al., "ROS: An open-source Robot Operating System," in *Proc. ICRA Workshop Open Source Softw.*, Kobe, Japan, 2009.



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