International Journal on Engineering Technologies and Informatics

Internet Of Things (Iot) and Plant Health Monitoring: A Short Comment

Short Communication

Volume 6 Issue 1- 2025

Author Details

*Seyed Mohamad Javidan**

Biosystems Engineering, Tarbiat Modares University, Iran

*Corresponding author

Seyed Mohamad Javidan, PhD in Biosystems Engineering, Tarbiat Modares University, Tehran, Iran

Article History

Received: May 21, 2025 Accepted: June 02, 2025 Published: June 03, 2025

Abstract

The integration of Internet of Things (IoT) technologies within agriculture has ushered in a new era of plant health monitoring, providing unprecedented opportunities for real-time data acquisition and comprehensive analysis. By leveraging diverse sensor technologies, IoT systems continuously track vital parameters such as soil moisture, temperature, humidity, and indicators of plant stress. This capability enables early disease detection, efficient pest management, and optimized irrigation practices, which collectively enhance crop productivity and sustainability. This review synthesizes recent advances in IoT-enabled plant health monitoring, emphasizing critical technological components including wireless communication protocols and data analytics. It also examines the principal challenges such as sensor durability, connectivity constraints, cost factors, and data security concerns that impede broader adoption. Finally, emerging trends involving edge computing, artificial intelligence, and multi-sensor fusion are explored, underscoring the transformative potential of IoT for precision agriculture and sustainable crop management.

Keywords : Internet of Things (IoT), Plant Health Monitoring, Precision Agriculture, Sensor Networks, Wireless Communication, Early Disease Detection, Pest Management, Soil Moisture Sensing, Data Analytics, Sustainable Agriculture

Introduction

The Internet of Things (IoT) paradigm has fundamentally transformed numerous industries by enabling the interconnection of physical devices embedded with sensors, software, and communication capabilities to collect and exchange data seamlessly [1]. Agriculture, traditionally reliant on labor-intensive and subjective monitoring practices, stands to benefit significantly from IoT's ability to provide smart, automated, and real-time monitoring solutions. By equipping farms with networks of sensors that continuously capture environmental and plant-specific data, IoT empowers farmers to make informed decisions that improve crop health and productivity while reducing resource wastage [2]. The capacity for continuous and remote sensing not only accelerates the identification of plant stressors, diseases, and pest outbreaks but also facilitates precise interventions tailored to the specific needs of crops. This review focuses on recent advancements in IoT technologies applied to plant health monitoring, detailing the types of sensors employed, communication frameworks, and data processing methodologies. Additionally, it discusses current limitations including technological, environmental, and economic barriers and contemplates future innovations that may overcome these challenges to support sustainable agriculture on a global scale.

Importance Of Plant Health Monitoring

Effective plant health monitoring is a cornerstone of modern agriculture, integral to early detection of diseases, efficient pest management, and optimal utilization of water and nutrients. Historically, assessment of plant health has depended heavily on manual field inspections, which are time-consuming, subjective, and often insufficient to detect subtle physiological changes preceding visible symptoms [3]. The adoption of IoT-based monitoring introduces objectivity and temporal continuity to this process by deploying various sensors that capture parameters such as soil moisture, temperature, humidity, and light intensity in real time [4]. This objective and continuous data collection not only enhances the accuracy of health assessments but also enables proactive interventions that minimize crop losses and support sustainable resource management.

Iot Sensors For Plant Health

A variety of sensor technologies underpin IoT systems for plant health monitoring. Soil moisture sensors provide critical data for irrigation scheduling, ensuring plants receive adequate water without waste [5]. Temperature and humidity sensors monitor the microclimatic conditions around plants, which directly influence pathogen development and plant stress [6]. Advanced optical sensors, including multispectral and hyperspectral imaging devices, capture detailed information on plant coloration and reflectance, revealing signs of nutrient deficiencies or stress that are not visible to the naked eye [7]. The integration of these heterogeneous sensors into wireless networks forms the backbone of comprehensive monitoring platforms capable of delivering granular insights into crop conditions.

Wireless Communication Technologies

Transmitting the vast amounts of sensor data collected requires reliable wireless communication technologies. Protocols such as ZigBee, LoRa WAN, and Narrowband IoT (NB-IoT) are commonly employed depending on application requirements related to range, power consumption, and data rate [8]. For instance, LoRa WAN is favoured in agricultural settings for its long-range communication and low power usage, making it well-suited to expansive fields [9]. The selection of an appropriate communication protocol is critical to maintaining continuous data flow, which underpins timely decision-making and effective management of plant health.

Data Processing and Analytics

Collected sensor data necessitates robust processing capabilities. Cloud computing platforms offer scalable storage and computational power necessary for handling large datasets and running complex analytics [10]. Machine learning and artificial intelligence algorithms have become instrumental in interpreting sensor data by classifying plant diseases, predicting stress conditions, and suggesting corrective actions [11]. These intelligent analytical tools transform raw data into actionable insights, enabling precision agriculture where interventions are tailored to real-time crop needs, thus enhancing yield and reducing environmental impact.

Applications In Plant Health Monitoring

Early Disease Detection

One of the most impactful applications of IoT in agriculture is the early detection of diseases. Many plant diseases induce physiological changes well before visible symptoms appear, providing a crucial window for intervention [12]. IoT systems augmented with image processing and pattern recognition can detect subtle variations in leaf colour, shape, and texture, enabling prompt responses that reduce yield losses and the need for extensive pesticide application [13].

Pest Management

Pest infestations pose a significant threat to crop health. IoT facilitates pest management through sensors that detect plant stress associated with pest attacks and traps equipped with cameras that monitor pest populations directly [14]. Instant alerts allow farmers to implement targeted control measures, reducing the indiscriminate use of pesticides, curbing pest resistance, and preserving beneficial insect populations [15].

Irrigation Management

Water management is vital for maintaining plant health, especially in water-scarce regions. IoT-driven soil moisture sensing enables dynamic irrigation scheduling, preventing both water stress and excess watering [16]. Automated irrigation systems integrated with IoT platforms respond in real time to sensor feedback, optimizing water usage, conserving resources, and enhancing crop health [17].

Current Iot Systems And Innovations

Recent years have witnessed the development of numerous IoT-based plant health monitoring solutions ranging from simple sensor arrays with mobile applications to sophisticated platforms combining drones, multispectral imaging, and AI analytics [18]. For example, drones equipped with advanced sensors can rapidly survey large agricultural areas, feeding high-resolution data into IoT networks for detailed crop health assessments [19]. These innovations contribute to improved scalability, efficiency, and precision in monitoring efforts.

Challenges In Iot Adoption

Despite its promise, IoT adoption in agriculture faces several challenges. Sensor durability and accuracy under extreme environmental conditions remain pressing issues, as sensor degradation can compromise data quality and system reliability [20]. Connectivity limitations, especially in remote or vast agricultural areas, hinder real-time data transmission and necessitate hybrid or localized data processing solutions [21]. Furthermore, data security and privacy concerns arise due to the sensitive nature of agricultural data, requiring robust measures to ensure secure transmission, storage, and ownership control [22]. Economic factors also play a significant role; the cost of IoT infrastructure and maintenance can be prohibitive for smallholder farmers, highlighting the need for affordable, user-friendly solutions.

Conclusion and Future Perspectives

The integration of IoT technologies into plant health monitoring systems represents a pivotal advancement in agricultural science, offering unprecedented opportunities for enhancing crop management through precise, timely, and data-driven interventions. By enabling continuous, objective monitoring of environmental and physiological plant parameters, IoT facilitates early disease detection, effective pest control, and efficient resource management, thereby contributing to improved productivity and sustainability. Nonetheless, challenges related to sensor reliability, connectivity, data security, and economic accessibility continue to impede widespread implementation. Addressing these issues requires coordinated efforts among researchers, industry stakeholders, policymakers, and farmers to develop resilient, scalable, and cost-effective IoT solutions. Future directions are promising, with emerging trends such as edge computing, which allows data processing at the sensor level to reduce latency and bandwidth demands, artificial intelligence for enhanced data interpretation, and the integration of multiple sensor modalities offering holistic insights into plant health. As these technologies mature, they will foster the evolution of smart, sustainable farms capable of meeting global food demands while minimizing environmental impact, thus heralding a new era of precision agriculture.

References

1. Ansarimovahed A, Banakar A, Li G, Javidan SM (2025) Separating Chickens' Heads and Legs in Thermal Images via Object Detection and Machine Learning Models to Predict Avian Influenza and Newcastle Disease. Animals 15(8): 1114.

2. Javidan SM, Banakar A, Rahnama K, Vakilian K A, Ampatzidis Y (2024) Feature engineering to identify plant diseases using image processing and artificial intelligence: A comprehensive review. In Smart Agricultural Technology 8: 100480.

3. Movhed A, Banakar A, Javidan SM, Mehrabadi M (2023) Using image processing to detect the tartan mite on strawberry plant leaves, 15th National Congress and 1st International Congress of Biosystem Mech- anics and Mechanization Agriculture, Tehran.

4. Asefpour Vakilian K, Massah J (2017) A farmer-assistant robot for nitrogen fertilizing management of greenhouse crops. Computers and Electronics in Agriculture 139: 153-163.

5. Mohamad zamani D, Sajadian S, Javidan SM (2020) Detection of Callosobruchus maculatus F. with image processing and artificial neural network. Applied Entomology and Phytopathology 88(1): 103-112.

6. Mohammadzamani D, Javidan SM, Zand M, Rasouli M (2023) Detection of Cucumber Fruit on Plant Image Using Artificial

Neural Network. Journal of Agricultural Machinery 13(1): 27-39.

7. Vakilian KA, Moreau M, Javidan SM (2024) An IoT-based smart biosensor for the measurement of nitrate concentration in liquid samples. In 2024 20th CSI International Symposium on Artificial Intelligence and Signal Processing (AISP) 177: 1-5.

8. Javidan SM, Banakar A, Asefpour Vakilian K, Ampatzidis Y, Rahnama K (2024) Early detection and spectral signature identification of tomato fungal diseases (Alternaria alternata, Alternaria solani, Botrytis cinerea, and Fusarium oxysporum) by RGB and hyperspectral image analysis and machine learning. Heliyon 10(9): e38017.

9. Javidan SM, Banakar A, Asefpour Vakilian K, Ampatzidis Y (2022) A feature selection method using slime mould optimization algorithm in order to diagnose plant leaf diseases. In 2022 8th Iranian Conference on Signal Processing and Intelligent Systems (ICSPIS) 1-5.

10. Javidan SM, Banakar A, Asefpour Vakilian K, Ampatzidis Y (2023) Diagnosis of grape leaf diseases using automatic K-means clustering and machine learning. In Smart Agricultural Technology 3: 100081.

11. Javidan SM, Ampatzidis Y, Asefpor Vakilian K, Mohammadzamani D (2024) A novel approach for automated strawberry fruit varieties classification using image processing and machine learning. In 2024 10th International Conference on Artificial Intelligence and Robotics (QICAR). IEEE.

12. Javidan SM, Banakar A, Asefpour Vakilian K, Ampatzidis Y (2023) Tomato leaf diseases classification using image processing and weighted ensemble learning. In Agronomy Journal (In Press) 116(3): 1029-1049.

13. Javidan SM, Mohamadzamani D (2021) Design, Construction, and Evaluation of Automated Seeder with Ultrasonic Sensors for Row Detection. J Biosyst Eng 46: 365-374.

14. Javidan SM, Banakar A, Vakilian KA, Ampatzidis Y, Rahnama K (2024b) Diagnosing the spores of tomato fungal diseases using microscopic image processing and machine learning. In Multimedia Tools and Applications. Springer Science and Business Media LLC 83: 67283-67301.

15. Javidan SM (2023) Identifying plant pests and diseases with artificial intelligence: A short comment. Int J Eng Tech & Inf 4(4): 1-2.

16. Javidan SM, Ampatzidis Y, Banakar A, Asefpour Vakilian K, Rahnama K (2024) Tomato Fungal Disease Diagnosis Using Few-Shot Learning Based on Deep Feature Extraction and Cosine Similarity. In AgriEngineering 6(4): 4233-4247.

17. Javidan S, Mohammadzamani D (2019) Design, construction and evaluation of semi-automatic vegetable transplanter with conical distributor cup. SN Appl Sci 1: 999.

18. Khakrangin R, Mohamad Zamani D, Javidan SM (2021) Recognition of Fill and Empty Walnuts Using Acoustic Analysis and Fuzzy Logic. Journal of Nuts 12(1): 17-30.

19. Javidan SM (2025) Improving Plant Health Monitoring Through Advanced Image Analysis and Artificial Intelligence: A Short Comment. Int J Eng Tech & Inf 6(1): 1-3.

20. Javidan SM, Ampatzidis Y, Banakar A, Asefpour Vakilian K (2025) An Intelligent Group Learning Framework for Detecting Common Tomato Diseases Using Simple and Weighted Majority Voting with Deep Learning Models. AgriEngineering 7(2): 31.

21. Soltani Nezhad F, Rahnama K, Javidan SM, Asefpour Vakilian K (2024) Application of microscopic image processing and artificial intelligence detecting and classifying the spores of three novel species of Trichoderma. Discover Applied Sciences 6(12): 1-12.

22. Samadi SM, Asefpour Vakilian K, Javidan SM (2025) Combining miRNA concentrations and optimized machine-learning techniques: An effort for the tomato storage quality assessment in the agriculture 4.0 framework. Journal of Agriculture and Food Research 19: 101605.

Citation: Javidan SM. Internet Of Things (Iot) and Plant Health Monitoring: A Short Comment. *Int J Eng Tech & Inf*. 2025; 6(1):1-3.
DOI: 10.51626/ijeti.2025.06.00090