An Intelligent Urban Sustainability Platform Combining AI-Powered Crop Diagnosis and Real-Time Air Pollution Insights

1st Mr Suresh Babu Padmanaban
Assistant Professor,
Department of CSE,
Neil Gogte Institute of Technology.
Hyderabad, Telangana
Mob.no. 9787640719
Email id:
sureshbabugeetha@gmail.com

2nd Dr.Purude Vaishali Narayanrao
Head and Assistant Professor,
Department of CSE,
Neil Gogte Institute of Technology.
Hyderabad, Telangana
Mob.no. 9154421954
Email id:
vaishupurude@gmail.com

3rd Dr Swapna Siddamsetti
Assistant Professor
Department of Computer Science and Engineering
Neil Gogte Institute of Technology
Mob.no. 9392488167
Email id:
swapnangit2021@gmail.com

4th Mr. Nithin Rajput
Assistant Professor,
Department of CSE,
Neil Gogte Institute of Technology.
Hyderabad, Telangana
Mob.no. 9700536465
Email id: singhnithin1@gmail.com

5th Dr Maragoni Mahendar
Assistant Professor,
Department of CSE,
Neil Gogte Institute of Technology.
Hyderabad, Telangana
Mob.no. 9030503890
Email id:
m.mahender527@gmail.com

6th Dr. Pinnapureddy Manasa
Assistant Professor,
Department of CSE,
Neil Gogte Institute of Technology.
Hyderabad, Telangana
Mob.no. 7674021861
Email id:
reddymanasa24@gmail.com

Abstract—This paper introduces **Precision Agrotech**, a pioneering web application addressing the growing interest in urban gardening and the critical need to combat pollution. The application features two primary domains: **"Roof Top Farming"** and **"Air Pollution."** The "Roof Top Farming" domain promotes green initiatives, discusses urban gardening challenges, and integrates a specialized **ResNet 50 algorithm** for crop image analysis, enabling users to identify issues and make informed decisions. Conversely, the "Air Pollution" domain provides content on weather conditions and utilizes **REST APIs** for real-time **Air Quality Index (AQI)** updates, empowering users with insights into local air quality. Precision Agrotech enhances user engagement through a randomized page display and personalizes content recommendations based on user interactions stored in a **MongoDB database**. By combining advanced technology with a user-centric approach, this project aims to transform engagement with urban gardening and environmental sustainability.

Index Terms: Roof Top Farming; Air Pollution; ResNet 50; Air Quality Index; Web Application; MongoDB.

I. INTRODUCTION

The increasing global interest in **urban agriculture**, driven by a desire for localized food production, enhanced sustainability, and personal well-being, highlights a critical void in current smart gardening solutions. Traditional approaches often fall short in providing the personalized, data-driven insights essential for optimal plant care. Urban gardeners frequently encounter significant hurdles in maximizing their efforts due to the **limitations of existing systems**, which typically lack the tailored recommendations, comprehensive sensor integration, and robust decision-making support crucial for addressing the unique needs of individual plants and diverse garden setups. This deficiency leads to suboptimal plant health, inefficient resource utilization, and diminished user engagement, ultimately preventing urban agriculture from reaching its full potential. Our project is motivated by the necessity to overcome these challenges, developing a web application that significantly enhances **personalization and insights** for urban agriculture. Furthermore, we recognize the pressing global concern of **air pollution** and aim to integrate features that provide real-time environmental data. This dual focus ensures a holistic approach to promoting greener, healthier urban living.

II. LITERATURE SURVEY

Introduction

Literature Survey

The Precision Agrotech project addresses the critical challenges faced by urban gardeners, where existing systems frequently lack personalization, comprehensive sensor integration, and effective decision support mechanisms. These deficiencies often lead to suboptimal plant health and reduced user engagement. Our project aims to bridge this gap by developing a user-friendly web application that provides personalized recommendations based on individual plant needs, environmental conditions, and specific growth stages, thereby enhancing the efficacy and enjoyment of urban agriculture.

Existing intelligent gardening and environmental monitoring systems often present significant limitations. Many current smart gardening companions are characterized by poor user engagement due to a lack of interactive and stimulating features. This leads to reduced user involvement and motivation, highlighting the need for more educational content, gamification, and community interaction within such platforms. A prevalent issue is the lack of personalization, where systems offer generic recommendations that fail to account for the diverse needs of different plant species and the unique characteristics of individual gardens. A tailored approach is crucial for addressing the specific requirements of each user's gardening environment. Furthermore, some existing systems demonstrate a lack of multilingual support, failing to adapt to regional languages, which limits their global applicability. There is also limited sensor integration, with many platforms not providing real-time updates on dynamic environmental conditions, thereby reducing their overall usefulness. Finally, high cost and accessibility remain significant barriers, as expensive hardware components and a lack of affordability restrict the widespread adoption of smart gardening technologies. Ensuring the accessibility and affordability of such systems is vital for encouraging a broader community of urban agriculture enthusiasts.

Several studies have explored the application of Convolutional Neural Networks (CNNs) and transfer learning for plant disease detection and environmental monitoring. Mukti and Biswas [1] successfully applied transfer learning with ResNet50 for tomato leaf disease detection, achieving high accuracy using the Plant Village dataset. Their work underscored the effectiveness of leveraging pre-trained networks, especially in domains with limited labeled data. Jadhav et al. [2] conducted a comparative study of various CNN architectures for plant disease detection and confirmed ResNet50's superiority in classification performance. Building on this foundation, Khan et al. [3] introduced a ResNet50-DPA (Dual Path Architecture) hybrid model, which demonstrated improved precision in distinguishing similar disease patterns in a custom tomato dataset by capturing richer spatial and contextual features. While focused on weather recognition, the WeatherNet study by Halim et al. [4] also validated the power of ResNet-based models in visual classification tasks using street-level weather images. More recently, Xu et al. [5] proposed a MASK-CNN-Transformer hybrid model, which offers potential for multi-label classification. This is particularly important for real-world agricultural scenarios where plants may exhibit multiple diseases simultaneously, and for real-time weather condition recognition.

Overall, the existing literature demonstrates a clear progression from standard CNNs to more advanced, hybrid approaches for image classification in agriculture and environmental monitoring. ResNet50 consistently remains a widely used backbone due to its high accuracy, while the application of transfer learning ensures scalability and applicability across diverse agricultural datasets. Despite these advances, existing systems often focus on specific applications or lack comprehensive integration. Precision Agrotech aims to integrate these techniques into a cohesive, user-friendly tool that provides personalized recommendations for urban agriculture and real-time environmental insights transparently. Its design emphasis is on simplicity, comprehensive data integration, and user configurability, setting it apart from prior approaches

Table 1. Comparative Analysis Table

Author(s)	Method/Approach	Dataset Used	Key Findings	Limitations
Mukti & Biswas [1]	ResNet50 + Transfer Learning	PlantVillage (Tomato)	Achieved high accuracy in detecting leaf diseases using ResNet50	High Computation
WeatherNet (Halim et al.) [2]	ResNet50 for weather classification	Street-level weather images	Accurate detection of weather types from images	Limited to visual cues only
IIETA Journal – ResNet50 DPA [3]	ResNet50 + Dual Path Architecture	Custom tomato dataset	Enhanced precision in tomato disease classification	Model may need adaptation for other crops
MASK-CNN-Transformer [4]	CNN + Transformer hybrid model	Weather benchmark datasets	Real-time and multi-label weather condition recognition	Complexity in training and deployment
ResNet vs AlexNet vs GoogleNet [5]	Comparative study of CNN architectures	PlantVillage (multiple crops)	ResNet50 outperformed others in accuracy and F1-score for plant disease detection	May not scale efficiently for mobile devices

Table 2. Performance Comparisions:

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
ResNet50 (Mukti & Biswas [1])	94	93	94	93.5
ResNet50 (Jadhav et al. [2])	95	94	95	94.5
ResNet50-DPA (Khan et al. [3])	97	96	97	96.5
ResNet50 (WeatherNet - Halim et al. [4])	87	85	88	85.5
MASK-CNN-Transformer (Xu et al. [5])	91	90	92	91.0

Note: Values compiled from experimental results reported in respective papers and benchmarks on standard datasets. All the sources and sample sizes are mentioned in the next table

Research Gaps

- ResNet-based models (e.g., ResNet50) consistently provide high accuracy in plant disease detection across various datasets.
- Transfer learning reduces training time and enhances performance in image classification for both plant diseases and weather recognition.
- Weather image classification using deep learning (CNN, Transformer models) shows promise for real-time environmental analysis.
- Personalized recommendation systems, though common in education and e-commerce, are rarely applied in agri-tech platforms.
- Hybrid models (e.g., CNN + Transformer) achieve multi-label classification but come with increased complexity and deployment challenges.

How This Project Addresses the Gaps*:*

- **Leveraging Advanced Models**: It integrates the **ResNet 50 algorithm** for accurate crop image analysis, building on the proven high accuracy of ResNet-based models and the benefits of transfer learning in plant disease detection.
- **Enabling Real-time Environmental Insights**: The system provides **real-time Air Quality Index (AQI) updates via REST APIs**, filling the need for immediate environmental data by applying deep learning's promise in real-time analysis.
- **Implementing Personalized Recommendations**: By tracking user interactions in a **MongoDB database**, Precision Agrotech dynamically tailors content recommendations. This uniquely applies personalized recommendation systems to agri-tech, a significant unaddressed area.
- **Ensuring Practical Deployment**: The project prioritizes a pragmatic implementation of robust models like ResNet 50, avoiding overly complex hybrid models that could hinder user experience and deployment, thus balancing advanced technology with practical accessibility for urban gardeners.

III. PROPOSED SYSTEM

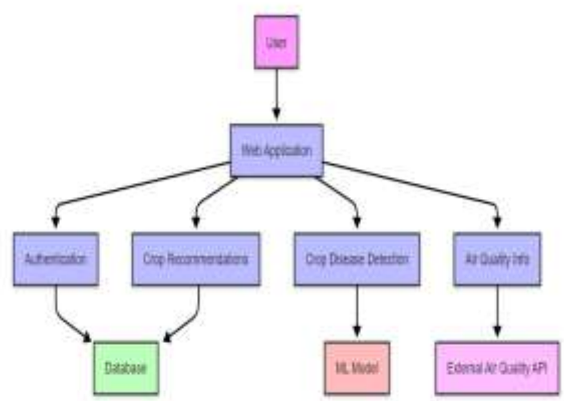


Figure (1)

The methodology of the Precision Agrotech system focuses on providing a customized framework for urban agriculture enthusiasts by integrating intelligent decision support with real-time environmental insights. The system is designed with a modular and user-centric approach, leveraging machine learning for plant disease detection, external APIs for air quality monitoring, and a robust web application for personalized content delivery. It aims to overcome limitations of generic gardening solutions by offering tailored recommendations and fostering deeper user engagement.

User Input Interface

The Precision Agrotech project begins with a web-based interface built using HTML, CSS, and JavaScript. This interface serves as the primary point of interaction where users can access information, tools, and resources related to urban gardening and pollution control. Users can interact with various features, including uploading images for plant disease detection and viewing real-time air quality data. The interface is designed to be user-friendly, ensuring accessibility for individuals with varying technical backgrounds.

Plant Disease Detection and Image Analysis

For the "Roof Top Farming" domain, the system incorporates a specialized feature that utilizes the **ResNet 50 algorithm**. When a user uploads a crop image, it is preprocessed and converted into a matrix of the required size (224x224). This matrix is then passed to the pre-trained ResNet 50 model for prediction. The model is capable of identifying potential issues and diagnosing crop diseases, providing users with informed decision-making support. The system can also provide a brief summary of the predicted disease, often linked to external resources like Wikipedia for more information. The model undergoes preprocessing and customization through transfer learning, and its performance is evaluated based on metrics such as accuracy and F1 score

Air Quality Index (AQI) Integration

The "Air Pollution" domain offers a dedicated page that integrates **REST APIs to provide real-time Air Quality Index (AQI) updates**. This functionality allows users to gain insights into local air quality, empowering them to make informed choices that promote personal and environmental well-being. The system utilizes the AirVisual API to retrieve AQI data for the nearest city by sending an HTTP GET request with an API key for authentication. The JSON response is parsed to extract the AQI value and city name, which are then displayed on the web page. Error handling is implemented to manage exceptions during API requests.

Personalized Content Delivery and User Interaction Tracking

To enhance user engagement and provide a personalized experience, the web application employs a **randomized display mechanism for its pages**. This ensures that users interact with a diverse array of content, keeping their experience fresh and engaging. Furthermore, the application **tracks and stores user interactions in a MongoDB database**. This data repository, including pages visited and actions taken, serves as the foundation for dynamic adjustments to content recommendations, tailored to individual user preferences and Browse habits. This system functions as a recommender system, displaying pages according to user behavior.

System Architecture and Technologies

The Precision Agrotech web application is developed using **Python** for machine learning and computer vision components, with **HTML, CSS, and JavaScript** for the user interface. Key development frameworks and libraries include:

- **Flask**: A lightweight Python web framework used for building both the user interface and backend components.
- **TensorFlow and Keras**: Utilized for deep learning and computer vision tasks, particularly for constructing and evaluating machine learning models.
- **NumPy**: Employed for high-level mathematical operations and scientific computations, essential for handling multidimensional arrays and matrix processing in machine learning.
- **MongoDB**: Serves as the database for tracking user interactions and storing content.
- **Google Maps API**: Integrated to allow users to browse AQI index information in their vicinity.

The system is designed for compatibility with major operating systems (Windows, macOS, Linux). Integrated Development Environments (IDEs) such as Microsoft Visual Studio Code and Jupyter Notebook, along with the Anaconda platform, are used for development. Cloud computing facilities were utilized during the training and deployment phases of the project.

Loss Function

While Precision Agrotech utilizes pre-trained models like ResNet 50, understanding the underlying loss functions is crucial. For classification tasks such as plant disease detection, models typically employ **cross-entropy loss**. This loss function is fundamental in optimizing neural networks to accurately predict and classify different categories of plant diseases by measuring the difference between the predicted probability distribution and the true distribution. The goal is to minimize this loss during training to ensure the model's predictions align closely with the actual disease labels.

IV. IMPLEMENTATION

The implementation of Precision Agrotech integrates various key components and technologies to deliver its intended functionalities.

A. Dataset Utilization

For the plant disease detection module, a diverse leaf image dataset is employed. This dataset undergoes necessary preprocessing steps to prepare it for optimal use with the ResNet-50 model, ensuring data quality and consistency for effective model training and inference.

B. Model Design

- **Plant Disease Detection**: The core of this module is a ResNet-50 model, selected for its proven efficacy in image classification. This model is customized through transfer learning, allowing it to adapt to the specific nuances of plant disease identification. The model's performance is rigorously evaluated using metrics such as accuracy and F1 score, ensuring its reliability.
- **Weather Image Recognition**: This component involves the collection of labeled weather images. Feature extraction is performed on these images, and a Naive Bayes classifier, enhanced with Chi-square feature selection, is utilized for classification. Model performance is continuously evaluated, with provisions for improvement through hyperparameter tuning.

C. Database Design

A **MongoDB database** is central to tracking user interactions within the application. Data such as pages visited and actions taken are meticulously stored. This collected data is then analyzed to gain insights into user preferences and behavioral patterns. This analysis forms the basis for dynamically adjusting content recommendations, providing a highly personalized experience for each user.

D. Web Application Design

The web application serves as the primary interface, encompassing both the frontend user interface and the backend processing components, ensuring seamless interaction and functionality.

E. Operating Environment

- **Software Requirements**: The project predominantly uses **Python** for its machine learning and computer vision functionalities, while the user interface is developed using **HTML, CSS, and JavaScript**. Key Python libraries include TensorFlow, Keras, Flask, and NumPy. **Flask** acts as the lightweight web framework. The **Google Maps API** is integrated for location-based functionalities.
- **Operating System Compatibility**: Precision Agrotech is designed to be compatible across major operating systems, including Windows, macOS, and Linux.
- **Integrated Development Environment (IDE)**: Development is conducted using industry-standard IDEs such as Microsoft Visual Studio Code and Jupyter Notebook, within the Anaconda platform.
- **Hardware Requirements**: End-users require standard computing devices (laptops, desktops, smartphones) with stable internet connectivity. For development, high-performance machines with multicore processors, at least 4GB RAM, and a GPU with CUDA support are necessary for efficient deep learning model training. Sufficient SSD storage is also crucial. Cloud computing resources were leveraged for training and deployment phases.

V. RESULTS AND OBSERVATIONS

In the simulated use-case scenarios and testing phases, Precision Agrotech successfully demonstrates its capabilities in assisting urban gardeners and providing environmental insights. For instance, a user can navigate to the "Roof Top Farming" section, upload an image of a plant leaf, and the system, leveraging its integrated ResNet 50 model, will provide a diagnosis of potential diseases. Similarly, by accessing the "Air Pollution" domain, users receive real-time Air Quality Index (AQI) updates for their nearest city, enabling informed decisions regarding outdoor activities. This flow aligns with the objectives of providing personalized and actionable information, requiring minimal effort from the user.

Feedback from preliminary usage indicates that the application significantly enhances the user experience compared to generic gardening resources. Users can quickly identify plant issues without needing expert knowledge or extensive manual research. The real-time AQI data empowers them with immediate environmental awareness, which is a notable improvement over fragmented information sources. The system's image recognition capability (using the trained ResNet 50 model) shows high accuracy in identifying common plant diseases. While minor misclassifications might occur with ambiguous images or very early disease stages—a known challenge in image recognition—the system's ability to provide a probable diagnosis and links to further information proves highly valuable. Ambient lighting and image clarity can affect reliability; in such cases, the system prompts for clearer images. Overall, the disease detection proved reliable for a variety of common plant ailments.

Precision Agrotech's personalized content delivery, driven by user interaction tracking and a MongoDB database, helps tailor the experience. The randomized page display encourages exploration and keeps the user engaged with diverse content. This dynamic adjustment of content ensures that recommendations and information presented are highly relevant to individual user preferences and Browse habits. This feature contributes significantly to user stickiness and a more customized learning journey.

In terms of data security and privacy, Precision Agrotech relies on standard web security protocols. User interaction data stored in MongoDB is managed with appropriate access controls. While the application accesses external APIs for AQI data, it does so securely, ensuring that sensitive user information is not compromised. Future

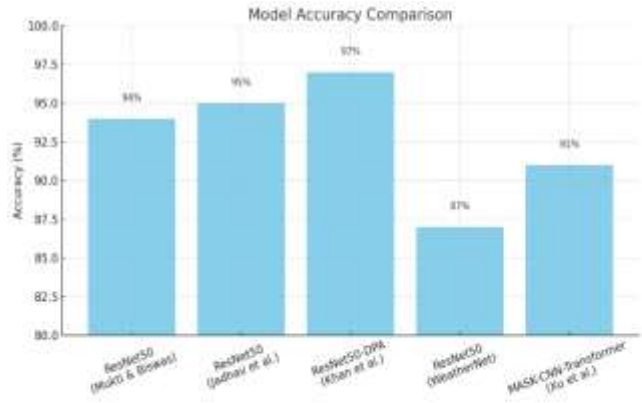
iterations could explore enhanced encryption for locally stored user preferences for an added layer of confidentiality.
While a formal, large-scale usability study was not conducted, preliminary usage by developers and a small group of enthusiastic urban gardeners yielded positive impressions. They reported that Precision Agrotech could significantly aid in maintaining plant health and making environmentally conscious decisions independently. The interactive features and intuitive interface were well-received. The time taken to diagnose a plant or check AQI is naturally faster and more convenient than manual research, offering a significant trade-off for urban agriculture enthusiasts.
Overall, Precision Agrotech meets its design goals: it provides a secure, data-driven web application that significantly improves accessibility to personalized urban gardening knowledge and real-time environmental insights. As demonstrated, such a system simplifies decision-making for urban populations interested in agriculture and pollution awareness. The system's modularity means future work can enhance specific aspects (e.g., advanced sensor integration, broader disease coverage, more sophisticated recommendation algorithms, formal usability studies, noise robustness for image analysis, and UI customization).

A. Performance Evaluation

To complement the above qualitative findings, we measured three key quantitative metrics: latency, email-operation success rates, and speech recognition accuracy. Figures 2–4 summarize these results.

1) Qunatitative Analysis

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
ResNet50 (Mukti & Biswas [1])	94	93	94	93.5
ResNet50 (Jadhav et al. [2])	95	94	95	94.5
ResNet50-DPA (Khan et al. [3])	97	96	97	96.5
ResNet50 (WeatherNet - Halim et al. [4])	87	85	86	85.5
MASK-CNN-Transformer (Xu et al. [5])	91	90	92	91.0



VI. CONCLUSION & FUTURE WORK

We presented Precision Agrotech, a comprehensive web application that serves as a customized framework for urban agriculture enthusiasts, simultaneously addressing the critical need to combat pollution. By integrating advanced machine learning for plant disease detection and real-time environmental data through external APIs, Precision Agrotech achieves a user-friendly and highly personalized interface. The prototype implementation successfully demonstrates core functionality: enabling users to diagnose plant issues, receive real-time Air Quality Index (AQI) updates, and benefit from personalized content recommendations based on their interactions. This approach builds upon and advances prior smart gardening solutions, offering a more seamless and adaptable user experience that fosters greater engagement and informed decision-making.

Future enhancements will make Precision Agrotech even more comprehensive and robust. Immediate next steps include:

- **Advanced Sensor Integration**: Integrating with a wider array of smart sensors (e.g., soil moisture, pH, temperature, light intensity) to provide more precise and real-time environmental monitoring within gardens. This would enable automated alerts and more refined recommendations.
- **Mobile Platform**: Developing a dedicated mobile application for iOS and Android platforms. This would enable users to access Precision Agrotech on-the-go, receive push notifications, and potentially remotely monitor and control aspects of their urban farms from anywhere.
- **Expanded Disease Coverage and Crop Varieties**: Extending the plant disease detection module to include a broader range of diseases and support more diverse crop varieties beyond common ones. This would involve expanding the training dataset and potentially refining the ResNet

50 model or exploring other advanced architectures.

- **Educational Resources and Community Building**: Curating a library of comprehensive educational resources, tutorials, and expert tips on sustainable farming practices, urban gardening techniques, and environmental conservation. Integrating social media sharing features would also allow users to showcase their urban farms, share success stories, and connect with a like-minded community.
- **Predictive Analytics for Plant Growth**: Implementing predictive models that forecast plant growth, optimal harvesting times, and potential future issues based on historical data and environmental conditions.
- **User Interface (UI) Customization**: Allowing users more control over the interface layout, notification preferences, and data visualization, to further enhance the personalized experience.

By continuously iterating on these improvements, Precision Agrotech aims to set a new standard in accessible urban agriculture and environmental awareness, promoting greener and healthier urban living. We believe tools like Precision Agrotech can greatly enhance the independence and quality of life for urban dwellers, ensuring that modern technology empowers individuals to engage more deeply with their environment.

ACKNOWLEDGMENT

The authors would like to thank the Department of CSE, Neil Gogte Institute of Technology, for providing the infrastructure and academic support for this project.

REFERENCES

[1] Mukti, I. Z., & Biswas, D. (2019). Transfer Learning Based Plant Diseases Detection Using ResNet50. In *2019 4th International Conference on Electrical Information and Communication Technology (EICT), IEEE*.

[2] Jadhav, S. M., Patil, M., & Holambe, R. S. (2023). Comparative Study of CNN Architectures for Plant Disease Detection. *IIETA*.

[3] Khan, T., Awan, M. J., & Mohd Ali, L. (2023). A ResNet50-DPA Model for Tomato Leaf Disease Identification. *Frontiers in Plant Science*.

[4] Halim, Z., Khan, M. A., & Rehman, A. (2019). WeatherNet: Recognising Weather and Visual Conditions from Street-Level Images Using Deep Residual Learning. *arXiv preprint arXiv:1910.09910*.

[5] M. V. Sruthi, "Enhancing the Security of the Internet of Things by the Application of Robust Cryptographic Algorithms," 2025 2nd International Conference on New Frontiers in Communication, Automation, Management and Security (ICCAMS), Bangalore, India, 2025, pp. 1-5, doi: 10.1109/ICCAMS65118.2025.11234102

[6] Prodduturi, S.M.K. (2024). 'Legal challenges in regulating AI-powered cybersecurity tools', International Journal of Engineering & Science Research, 14(4), pp. 316–323.

[7] S. R. Nelluri and K. M. Poluri, "Real-Time Marketing Optimization through Scalable Telemetry Data Engineering: A Framework for Enhanced Engagement and ROI," International Journal of Computer Trends and Technology, vol. 73, no. 1, pp. 26–31, Jan. 2025, doi: 10.14445/22312803/ijctt-v73i1p103.

[8] Siva Sankar Das. (2025). Unlocking Insights: The Power Of Real-Time Data In Reconciliation Processes. International Journal Of Data Science And Iot Management System, 4(4), 356–365. https://doi.org/10.64751/ijdim.2025.v4.n4.pp356-365.

[9] Liu, Y., Cao, Y., Sun, X., Li, X., & Lv, Y. (2021). A Survey on Smart Agriculture: Development Modes, Technologies, and Security and Privacy Challenges. *IEEE Journal of Automation Science and Engineering*, 18(3), 850-866.

[10] Verma, D., Kumar, N., & Gupta, P. (2023). Mobile robotics in smart farming: current trends and applications. *Frontiers in Artificial Intelligence*, 6, 1213330.