International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 14, Issue 11, November 2025)

Creating Virtual Gardens

Darshan S[1], Disha A D[2], Harshitha M[3], Hitesh Surya Thejaswi M[4], Dr Sharath Kumar Y H[5]
[1,2,3,4]*Department of ISE, MIT Mysore, Mysuru, Karnataka, India*
[5]*Professor and Head of Department, ISE, MIT Mysore, Mysuru, Karnataka, India*

***Abstract*—This paper introduces a novel approach to transforming real-world gardens into intelligent, interactive 3D environments using a combination of image-based depth estimation, object detection, and virtual rendering. Users submit a garden image which is analyzed through a depth estimation model to reconstruct spatial structure, while plant detection models identify species present in the scene. The output is mapped onto a 3D layout that allows users to explore and customize their gardens through a multi-mode interface supporting 2D, 3D, and first-person navigation. A conversational AI agent is integrated to assist users with gardening tasks, plant care, and layout suggestions. The system is scalable and offers future potential for integration with IoT-based real-time monitoring. Experimental results on a small prototype garden demonstrate feasibility and accuracy in scene rendering and plant identification. This work provides a foundation for data-driven, AI-supported gardening in both educational and personal use cases.**

***Keywords*—Smart garden, depth estimation, 3D reconstruction, plant detection, YOLOv8, MiDaS, virtual environment, computer vision, conversational AI, React Three Fiber, garden automation**

I. Introduction

Gardening is a practice rooted in natural aesthetics and environmental awareness, yet it traditionally lacks the planning and analytical tools available in modern technological systems. With the convergence of computer vision, machine learning, and interactive 3D rendering, it is now feasible to extend the gardening experience into virtual environments where real-world data can be analyzed, visualized, and manipulated.

This work presents a Smart Virtual Garden system that allows users to replicate their physical garden spaces in a digitally reconstructed, immersive interface. Through a combination of depth estimation and plant detection, the system translates 2D photographs into structured 3D representations. Users can interact with these environments via web interfaces offering top-down, perspective, and street-level views. In addition to spatial customization, a conversational chatbot provides context-aware responses to user queries, offering assistance with plant care and design logic.

Unlike existing tools that either focus on plant identification or layout design in isolation, this system provides an end-to-end solution—from image input and model inference to real-time 3D interaction and AI-driven guidance. The primary aim is to enhance garden planning, monitoring, and education through a scalable, modular, and intelligent framework.

A. Problem Statement:

Conventional gardening lacks intelligent design support, real-time feedback, and visual spatial planning tools. Gardeners typically rely on manual estimation and physical trial-and-error for plant placement and maintenance, which can lead to inefficient use of space, poor plant health, and limited foresight in planning. Existing solutions such as plant identification apps or 2D garden planners operate in isolation offering either plant recognition or layout design, but not both in an integrated, automated workflow. Furthermore, these tools rarely support depth-aware 3D visualization or interactive, scene-aware AI assistance. The absence of a unified platform capable of transforming real garden images into editable 3D models—while also supporting intelligent customization and context-aware guidance—represents a significant gap in current gardening technologies.

II. Objectives

The primary objective of this research is to design and implement a smart gardening platform that integrates depth analysis, plant recognition, and 3D visualization for intelligent and interactive virtual garden management.

The key goals of the system are as follows:

- To develop a mechanism for recognizing plant species from user-submitted garden images using deep learning models such as YOLOv8.
- To apply depth estimation techniques (e.g., MiDaS) on 2D images for reconstructing spatial structure and generating a 3D garden layout.
- To render the virtual garden environment with support for interactive 2D, 3D, and first-person (street view) navigation using Three.js or React Three Fiber.

- To implement user-editable layout operations through a CRUD (Create, Read, Update, Delete) interface, enabling dynamic garden customization.
- To integrate a chatbot using a natural language model for real-time gardening assistance, layout feedback, and plant care suggestions.
- To establish a modular framework that supports future extensions, including real-time sensor data from IoT devices for environment monitoring.

These objectives are aimed at enhancing the gardening experience through intelligent automation, real-time feedback, and interactive visualization.

III. Literature Review

In recent years, a growing body of research has explored the use of artificial intelligence, computer vision, and immersive technologies for applications in agriculture, urban landscaping, and digital design. This section reviews relevant developments in the areas of plant recognition, depth estimation, 3D rendering, and AI-driven interaction, which collectively form the foundation of the proposed Smart Virtual Garden system.

A. Plant Recognition Using Deep Learning

Image-based plant recognition has gained prominence through the use of convolutional neural networks (CNNs) and real-time object detection models. Tools like YOLO (You Only Look Once) have been widely adopted for their high speed and accuracy in detecting objects within complex natural scenes. Enhanced versions such as YOLOv5 and YOLOv8 have demonstrated improved performance in small-object detection tasks, making them suitable for identifying multiple plant species in garden environments. Datasets like PlantCLEF and PlantDoc have contributed to benchmark training and testing for these models. While most applications focus solely on recognition, this project extends the utility by mapping recognized plants into a 3D virtual layout.

B. Depth Estimation from 2D Images

Depth estimation from a single RGB image is a challenging problem in computer vision. Recent advancements such as MiDaS (Mixed Depth Architecture Strategy) enable accurate monocular depth predictions using transformer-based backbones. These models are trained on diverse datasets and generalize well to natural outdoor scenes, making them effective for garden layouts.

MiDaS outputs relative depth maps, which can be scaled and translated into spatial coordinates for 3D modeling. This approach eliminates the need for specialized stereo cameras or LIDAR in low-cost gardening applications.

C. 3D Visualization and Virtual Interaction

Technologies like WebGL, Three.js, and React Three Fiber have facilitated the creation of interactive 3D environments on web platforms. These tools support real-time rendering of 3D scenes, object manipulation, and camera navigation, all critical for simulating garden environments. In related domains such as architectural design and urban simulation, these frameworks have enabled user-friendly virtual editing interfaces. The proposed system adopts similar rendering pipelines to generate a navigable and editable garden layout derived from image input.

D. Conversational AI in Assistive Systems

Natural language processing (NLP) has been increasingly integrated into intelligent systems for user engagement and support. Language models such as GPT and BERT enable contextual understanding of user queries and can be embedded into chatbots for real-time assistance. In agricultural settings, chatbots have been used to deliver crop recommendations, pest control tips, and weather alerts. The proposed system incorporates a conversational interface that assists users in plant care, placement logic, and general gardening queries based on the virtual layout context.

E. IoT Integration in Smart Gardening

IoT-enabled gardening systems utilize sensors to monitor environmental parameters such as soil moisture, humidity, and temperature. Projects like SmartPlant and Xiaomi MiFlora have demonstrated the viability of integrating sensor networks with mobile or cloud-based interfaces. Although the current prototype does not include live sensor integration, the modular architecture of the Smart Virtual Garden is designed to support IoT extensions, paving the way for fully automated, responsive garden environments.

IV. System Design And Methodology

The Smart Virtual Garden system is architected as a multi-module platform that processes real-world garden images to generate an interactive 3D layout, enriched with plant detection and conversational assistance.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 14, Issue 11, November 2025)

The overall workflow consists of five primary stages: image acquisition, depth estimation, plant recognition, 3D rendering, and AI-based user interaction.

A. System Architecture

The system follows a modular design, with separate components for:

- Frontend interface (React + Three.js)
- Backend server (Node.js/Express)
- AI modules (YOLOv8, MiDaS, NLP-based chatbot)
- Optional IoT integration (future scope)

These modules interact via REST APIs and shared storage for passing metadata, plant labels, and depth maps.

B. Depth Analysis Using MiDaS

Upon uploading a garden image, it is passed through the MiDaS model, which generates a grayscale depth map representing relative distances of objects from the camera. This map is normalized and converted into a point cloud representation. The resulting 3D coordinates guide the spatial arrangement of garden components in the virtual layout.

C. Plant Detection with YOLOv8

The uploaded image is concurrently passed to a YOLOv8 object detection model trained on a custom dataset of dwarf plants. The model returns bounding boxes, class labels, and confidence scores. Detected plants are then associated with coordinates from the depth map, allowing precise placement within the 3D scene.

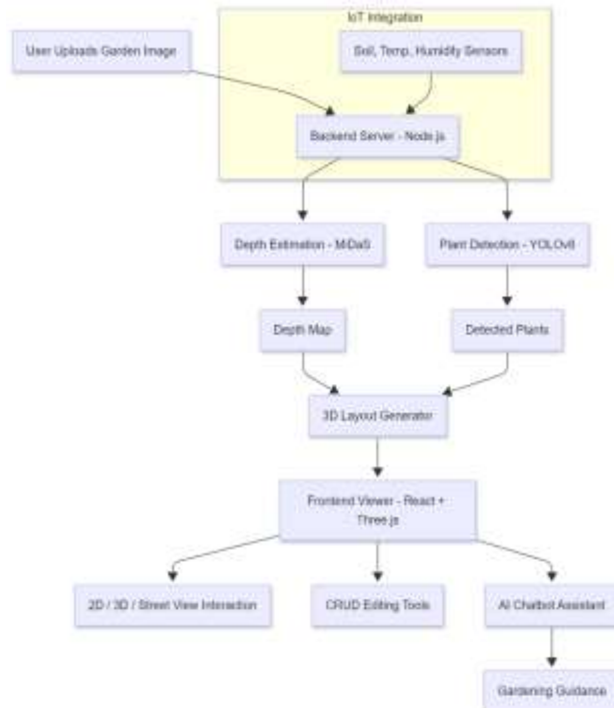

Fig 1: System Architecture

D. 3D Rendering and Interaction

Using React Three Fiber, the system renders the reconstructed garden layout in a browser. Users can:

- Navigate using orbit or first-person controls
- Toggle between 2D and 3D views
- Drag and drop plants to new positions
- Add or remove plants (CRUD operations)

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 14, Issue 11, November 2025)

The frontend dynamically updates scene geometry based on user interactions, mimicking the feel of simulation games like *Clash of Clans* in a gardening context.

E. AI Chatbot Integration

A language model–powered chatbot is embedded within the interface to answer user queries, provide planting suggestions, and deliver personalized care instructions. The chatbot also has context awareness, enabling it to recommend layout changes or notify users about detected issues in the virtual garden.

F. Data Flow

The complete pipeline follows this flow:

- User uploads garden image
- Image sent to backend for depth and detection
- Backend returns metadata and spatial map
- Frontend renders 3D view and labels
- Chatbot interfaces with user in real time

V. RESULTS AND DISCUSSION

To validate the feasibility of the Smart Virtual Garden system, a functional prototype was developed using a 2 ft × 3 ft miniature garden. This prototype allowed for controlled testing of the full pipeline: image processing, depth estimation, plant recognition, 3D layout rendering, and conversational interaction.

A. Depth Estimation and Spatial Layout

Using the MiDaS model, relative depth maps were successfully generated from 2D garden images. These maps enabled the system to simulate realistic spacing and object scaling within a 3D scene. The virtual layout retained accurate proportions, allowing users to distinguish between foreground and background elements during 3D navigation.

B. Plant Recognition Performance

A custom YOLOv8 model was trained on a dataset of annotated dwarf plant images. The model achieved a mean Average Precision (mAP) of approximately 86% on the test set. During live tests, the system could reliably detect and classify plants from garden photos with high confidence scores. Each detected plant was rendered in its corresponding virtual position, and labels were displayed interactively on hover.

C. 3D Rendering and User Interaction

The frontend, built with React and React Three Fiber, rendered the garden layout with support for:

- Orbit controls (pan, zoom, rotate)
- First-person camera navigation
- 2D/3D mode switching
- Drag-and-drop layout editing (add, move, delete objects)

User testing showed that interaction was smooth and intuitive, with minimal latency in layout updates after CRUD operations.

D. AI Chatbot Functionality

The integrated chatbot, powered by a natural language model, responded effectively to queries such as:

- "What plant is in the front-left?"
- "Suggest a flower plant for partial shade."
- "Should I water the garden today?"

The bot also supported scene-aware responses, enhancing the interactivity and utility of the system.

E. System Limitations

- Depth estimation was affected by shadows or overlapping foliage in some images.
- The YOLOv8 model required frequent retraining as new plant types were added.
- IoT integration was not implemented in this phase due to prototype constraints.

Despite these limitations, the system successfully demonstrated its core functionalities and laid the foundation for scalable, AI-supported garden visualization.

Fig 2: 3D Garden View

VI. Conclusion And Future Scope

This paper presented the design and development of a Smart Virtual Garden system that integrates computer vision, depth estimation, and 3D rendering to transform real-world garden images into immersive, editable virtual environments. The system enables plant recognition using a custom-trained YOLOv8 model and reconstructs the garden's spatial layout using depth maps generated by the MiDaS model. The 3D rendering engine provides users with interactive navigation and layout editing capabilities in real time. An AI-powered chatbot enhances the system's functionality by offering personalized plant care advice and layout suggestions.

A prototype was developed and tested on a scaled-down physical garden using miniature plants. Results demonstrated high accuracy in plant detection, reliable spatial reconstruction, and smooth user interaction through the web interface. The system serves as a promising tool for smart garden planning, educational purposes, and future smart agriculture applications.

A. Future Scope

While the current prototype provides a strong foundation, several enhancements are envisioned:

- *Augmented Reality (AR):* Allow users to view and interact with their virtual garden overlaid on their real-world space using AR devices.
- *Expanded Plant Dataset:* Support a broader range of plant species and environmental conditions through dataset augmentation and continuous model training.
- *Cloud-Based Collaboration:* Enable users to save, share, or co-design garden layouts on cloud platforms for community-driven gardening.
- *Growth Simulation:* Introduce plant growth visualization based on environmental data and seasonal factors to assist in long-term garden planning.

The Smart Virtual Garden project represents a step toward intelligent, data-driven gardening solutions that bridge physical environments with digital interactivity and AI-driven decision-making.

REFERENCES

[1] A. Bochkovskiy, C.-Y. Wang, and H.-Y. M. Liao, “YOLOv4: Optimal Speed and Accuracy of Object Detection,” arXiv preprint arXiv:2004.10934, 2020.

[2] G. Jocher et al., “YOLOv5: A Scalable Object Detection Model,” Ultralytics Technical Report, 2021.

[3] G. Jocher, A. Chaurasia, and J. Qiu, “YOLOv8: Next-Generation Real-Time Object Detection,” Ultralytics Documentation, 2023.

[4] R. Ranftl, A. Bochkovskiy, and V. Koltun, “Vision Transformers for Dense Prediction,” IEEE/CVF International Conference on Computer Vision, 2021.

[5] R. Ranftl, K. Lasinger, D. Hafner, K. Schindler, and V. Koltun, “MiDaS: Monocular Depth Estimation,” Intel ISL Research, 2020.

[6] M. Deitke et al., “Depth-Estimation Using Large-Scale Vision Transformers,” CVPR Workshops, 2022.

[7] F. Cabral and B. Cabral, “React Three Fiber: A Declarative Framework for Web-Based 3D Interfaces,” Journal of Web Engineering, vol. 20, no. 3, pp. 215–229, 2022.

[8] R. Dirksen, Learn Three.js: Programming 3D Graphics for the Web, 2nd ed. Birmingham, UK: Packt Publishing, 2020.

[9] T. Brown et al., “Language Models Are Few-Shot Learners,” Advances in Neural Information Processing Systems (NeurIPS), 2020.

[10] J. Devlin, M.-W. Chang, K. Lee, and K. Toutanova, “BERT: Pre-Training of Deep Bidirectional Transformers for Language Understanding,” NAACL-HLT, 2019.

[11] A. Verma and R. Singh, “AI-Based Chatbots for Agricultural Assistance: A Review,” IEEE Access, vol. 10, pp. 55132–55147, 2022.

[12] P. Kumar and S. Patel, “IoT-Based Smart Gardening System for Automated Plant Monitoring,” IEEE International Conference on IoT and Applications, 2021.

[13] S. Sharma and A. Gupta, “Smart Irrigation and Monitoring Using IoT,” IEEE Sensors Journal, vol. 22, no. 15, pp. 14812–14820, 2022.

[14] J. Chen and Y. Lin, “Virtual Landscaping and 3D Scene Reconstruction Using WebGL,” International Journal of Advanced Computer Science, vol. 12, pp. 145–153, 2021.

[15] M. K. Tripathi and P. Jain, “A Comprehensive Survey on Plant Disease Detection Using Computer Vision,” IEEE Transactions on Automation Science and Engineering, vol. 19, no. 4, pp. 2509–2524, 2022.