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GREEN CITY: Smart Urban Planning using CNN

Afra M. Thajudheen, Akshay R. Ambady, Karthiklal K. L., Pranav T. P, Sneha Haridas

Department of Computer Science and Engineering, Universal Engineering College, Vallivattom, Kerala,
India

ABSTRACT: Urban residents often struggle with limited garden space, making sustainable food production challenging. To address this, we introduce Green City, a prototype designed to maximize urban gardening efficiency. This Intelligent Garden app integrates innovative AI-driven features to enhance productivity and sustainability in compact urban environments.

Garden Assistant optimizes space through AI-powered container gardening and vertical gardening solutions. A plant identification module, utilizing a Convolutional Neural Network (CNN), accurately recognizes plant species and provides personalized care instructions. To ensure plant safety, the app employs machine learning models like Support Vector Machine (SVM) and K-Nearest Neighbors (K-NN) to distinguish between safe and harmful plants. Additionally, a computer vision-based disease detection system diagnoses plant health issues and suggests treatments to promote optimal growth. Beyond plant care, Green City offers AI-driven garden design visualizations, helping users plan the most efficient garden layouts in their available space. It also features expert Q&A support, seed and tool recommendations, a marketplace for fertilizers and resources, and community forums to encourage knowledge-sharing. This essay explores Green City's potential to revolutionize urban gardening, empowering city dwellers to cultivate sustainable gardens, even in spatially constrained environments.

KEYWORDS: Urban Gardening, AI-powered Gardening Assistant, Vertical Gardening, Plant Identification, Deep Convolutional Neural Networks (CNNs), Plant Safety Classification, Disease Detection in Plants, Garden Design Visualization, Sustainable Gardening Practices.

I. INTRODUCTION

Green City is a web-based platform designed to optimize urban gardening in real time by offering efficient space utilization, plant identification, and sustainable gardening solutions. It enables users to transform small urban spaces, such as balconies, rooftops, and windowsills into thriving green environments. By facilitating plant identification and safety classification, Green City helps users make informed decisions about plant selection and care. Additionally, its disease detection module assists in monitoring plant health, preventing the spread of ailments, and ensuring sustainable gardening practices. Beyond individual plant care, Green City fosters a community-driven approach by integrating expert advice, gardening forums, and a resource store tailored to urban gardening needs. The platform contributes to food security, environmental sustainability, and the well-being of city residents, making urban gardening more accessible and efficient. Its applications extend to urban sustainability efforts, self-sufficiency in food production, and community-driven environmental awareness.

II. RELATED WORK

Recent advancements in image processing and machine learning have significantly enhanced plant disease detection and species identification, achieving up to 93% precision in crop disease diagnosis. These innovations empower small-scale farmers by providing actionable insights to improve farming practices and mitigate crop losses. AI-driven solutions enable early disease detection, reducing reliance on chemical treatments and lowering production costs. By integrating AI in agriculture, farmers can adopt sustainable farming methods, leading to higher crop yields and improved food security. This technological shift underscores AI's transformative impact on modern agriculture, making farming more efficient, cost-effective, and environmentally friendly. Abhirami Devaraj, Karunya Rathan, Sarvepalli

Jaahnavi, and Good Enough Indira [1] proposed a machine learning and image processing model to detect plant viruses. Their approach combines random forests with multiple regression algorithms, utilizing multi-level image thresholding to distinguish healthy and diseased leaf regions. This real-time, image-based method enables rapid disease detection, making it accessible in resource-limited settings. Designed to boost crop yields, it aids farmers and scientists in making informed decisions. Experimental results show high detection accuracy, proving the model's effectiveness. Future work aims to expand its capability to identify more diseases across various plant species. Vishal Mani Tiwari and Tarun Gupta developed an image processing system for detecting plant leaf diseases using a support vector machine (SVM) combined with cuckoo search (CS) algorithms [2]. This hybrid classifier improves disease detection accuracy by adjusting SVM parameters to distinguish between healthy and diseased leaf areas. The system processes high-resolution images, performs segmentation, and classifies sections to identify disease symptoms. Designed for efficient, low-resource operation, it is ideal for large-scale agriculture, offering real-time detection for rapid response. Future plans include adapting the model for mobile platforms to enhance sustainable early-stage crop disease intervention.

Ibaphyrnaishisha Kharir, Vikaho Z. Swu, and Dr. Dibya Jyoti Bora developed a machine-learning model for plant species identification using an image-processing approach [3]. This five-step method includes image acquisition, preprocessing, segmentation, feature extraction, and classification, achieving 95.17% accuracy on a wide range of species with an SVM classifier. Leaf images undergo preprocessing with a Gaussian filter to remove noise, followed by PCA-based feature extraction to analyze shape, texture, and color patterns. Designed for common computer hardware, the model benefits botanists and plant enthusiasts. Future plans aim to expand the database, improving adaptability to diverse ecosystems.

Thi-Lan Le, Mai Viet Hoang, Do Nam-Hoang, Van Hong-Quan Nguyen, Tinh-Trinh Trong, Doan-Duc Phan, and Van-Sam Hoang developed a deep learning-based model for accurate plant identification using taxonomic classification [4]. Enhanced with taxonomic loss functions and late fusion techniques, the model combines insights from multiple images to improve identification accuracy, even for species with subtle distinguishing features. Tested on the VietForest dataset, it outperformed baseline accuracy and is adaptable for research and field applications. Designed for accessible computing, it supports conservation and biodiversity efforts by enabling rapid identification. Future plans include expanding its taxonomic scope for global applicability.

Skanda H. N., Smitha S. Karanth, Suvijith S., and Swathi K. S. present a plant identification system using machine learning, employing Histogram of Oriented Gradients (HOG) for feature extraction and SVM and ANN for classification [5]. This high-resolution leaf analysis captures detailed shape and texture attributes, with laser scanning and digital tracing to minimize errors. Notably, the model does not require pre-existing images in databases and achieves high accuracy, making it suitable for research and practical applications. Future improvements may expand its utility in farming, aiding conservationists and farmers with accessible crop assessments and management decisions.

Yeni Herdiyeni and Ni Kadek Sri Wahyuni developed an automated system for identifying Indonesian medicinal plants based on texture and color analysis of leaves [6]. The model utilizes Fuzzy Local Binary Pattern (FLBP) for feature extraction and Fuzzy Color Histogram (FCH) for classification, combined with a probabilistic neural network to enable accurate plant labeling. Tested on various medicinal plant species, the system achieved a 74.51% accuracy rate, demonstrating promise as a practical solution. Future improvements will refine the algorithm, expand the plant database, and enhance conservation and educational efforts for Indonesian medicinal flora. Regatte Sahithi Reddy, N. Ankitha, M. Lokesh, and M. Anji Reddy explore recent advancements in plant identification systems using Convolutional Neural Networks (CNNs) for leaf classification [7]. CNNs excel at recognizing complex patterns in image data, making them effective for distinguishing plant species. The study synthesizes findings from various CNN-based implementations, emphasizing their role in biodiversity conservation and automated classification for researchers and agriculturalists. Additionally, it examines web-based platforms that utilize CNN technology, improving accessibility for experts and enthusiasts. Future research aims to refine CNN architectures to handle complex datasets and support global conservation efforts. J. Kranz examines key methodologies in plant pathology, particularly in assessing disease intensity through frequency and severity measures [8]. The study discusses sampling techniques like random, systematic, and stratified sampling, tailored to different disease distributions. Effective survey design is essential for collecting reliable data for crop disease management. By analyzing factors such as disease spread, environmental influences, and crop susceptibility, Kranz highlights how standardized sampling methods enhance crop protection. Future research could integrate remote sensing and digital imaging to improve disease detection accuracy, enabling quicker responses and more resilient agricultural practices.

Marta Borgi and colleagues evaluate social farming (SF) as a method to improve mental health, social inclusion, and community engagement [9]. SF integrates therapeutic agricultural activities, fostering a sense of belonging among participants from diverse backgrounds. The study employs qualitative and quantitative methods, using standardized questionnaires and interviews to assess SF's impact on well-being. Results indicate improvements in social connections and emotional stability. The research highlights the need for collaboration between healthcare professionals and SF practitioners to enhance program effectiveness and expand long-term studies. Future efforts will establish consistent metrics for assessing SF's benefits in mental health treatment.

Adebunmi Okechukwu Adewusi, Onyeka Franca Asuzu, Temidayo Olorunsogo, Chinwe Iwuanyanwu, Ejuma Adaga, and Donald Obinna Daraojimba review advancements in precision agriculture and artificial intelligence (AI) [10]. AI-based tools, including analytics, modeling, and measurement technologies, enhance key agricultural processes such as crop monitoring, pest control, and resource management. The study examines how drones, machine learning models, and environmental sensors optimize water and food distribution while minimizing environmental impact. Future research aims to improve accessibility for smallholder farmers, ensuring affordability and scalability. These insights provide valuable information for agricultural scientists and policymakers, supporting sustainable farming innovations.

III. METHODOLOGY

The methodology of this project involves three core processes: Plant Identification, Plant Disease Recognition, and Garden Recreation. Each method leverages AI techniques to improve accuracy and enhance user experience. The Plant Identification module uses a CNN model for efficient image classification, guiding users with detailed plant information. The Disease Recognition system similarly employs CNN to detect symptoms from leaf images and suggests treatments. Lastly, the Garden Recreation process applies Stable Diffusion to generate improved garden layouts, enhancing design and space utilization. Together, these methods ensure accurate identification, effective disease detection, and creative garden planning solutions for urban gardeners.

IV. PLANT IDENTIFICATION USING CNN

The Plant Identification system uses Convolutional Neural Networks (CNN) to classify plants accurately. Users upload a plant image, which is preprocessed through resizing, normalization, and augmentation. The CNN model then extracts key features like leaf texture, shape, and color for classification. The system predicts the plant species, displaying details such as its scientific name, habitat, and care instructions. By training the model on diverse datasets, the system achieves high accuracy, even for plants with similar characteristics. Preprocessing techniques enhance model performance, ensuring improved recognition. Although the system achieves 88% accuracy, further improvements are possible with expanded datasets and real-time image capture integration for better adaptability in diverse environments.

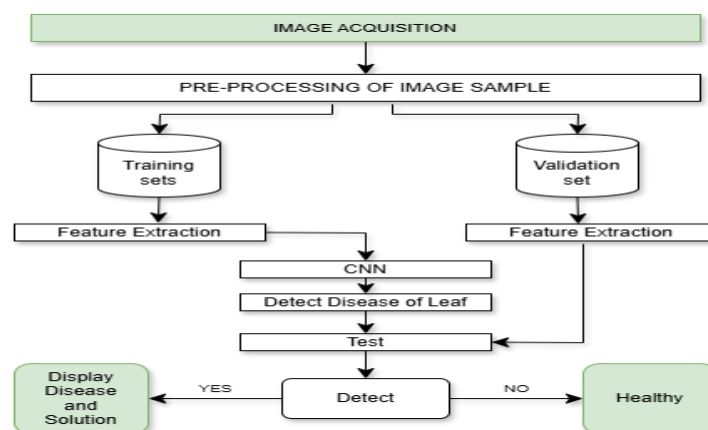


Fig. 1. CNN Flowchart for Plant Leaf Detection

V. PLANT DISEASE RECOGNITION USING CNN

The Plant Disease Recognition system also employs CNN to identify diseases based on visible symptoms on plant leaves. Users upload a leaf image, which undergoes resizing, normalization, and contrast enhancement to improve visual clarity. The CNN extracts key features such as color changes, spots, and deformities to match patterns with known diseases. The system predicts the most probable disease and offers recommended treatments, including organic remedies and chemical solutions. Despite achieving 88% accuracy, challenges arise from overlapping symptoms across diseases. Future improvements may involve integrating IoT-based monitoring for real-time assessments, enhancing the system's ability to track disease progression and improve treatment suggestions through continuous observation.

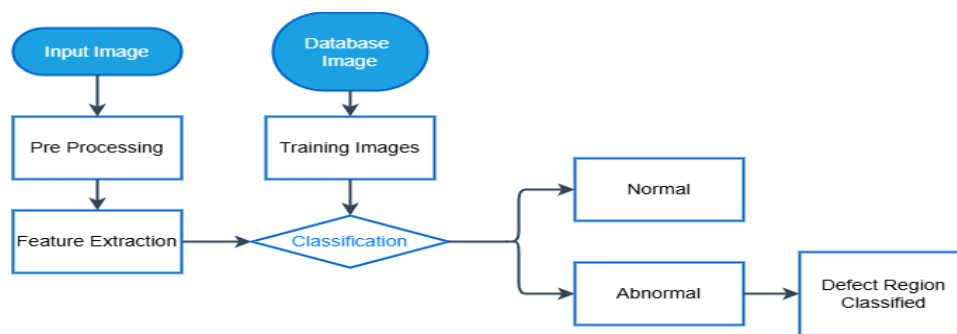


Fig. 2. Architecture of plant disease detection system

VI. GARDEN RECREATION USING STABLE DIFFUSION

The Garden Recreation process applies Stable Diffusion to generate optimized garden designs. Users upload an image of their garden, which the AI analyzes to assess plant placement, symmetry, and empty spaces. The Stable Diffusion model generates an improved design with better visual balance and enhanced layout. Users can compare the original and AI-enhanced versions, with customization options for adjusting plant types, pathways, and themes. This method streamlines garden planning by automating complex design elements, ensuring efficient use of limited space. Although the system improves garden aesthetics, adding personalized design preferences can further enhance user satisfaction and cater to diverse gardening styles.

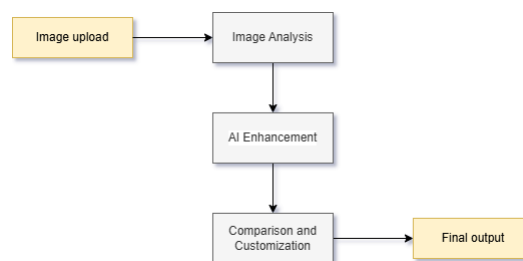


Fig. 3. Architecture of Crop prediction overlay system

VII. EXPERIMENTAL RESULTS

The project effectively applied convolutional neural networks (CNNs) for plant identification and disease recognition, achieving an accuracy of 88% for both models. The plant identification model demonstrated strong classification capabilities by analysing visual features such as leaf shape, color, and texture. However, some misclassification errors occurred, particularly in species with similar visual characteristics. Expanding the training data set and incorporating real-time verification techniques could enhance the accuracy of the model. Figure 4 illustrates the plant identification process.

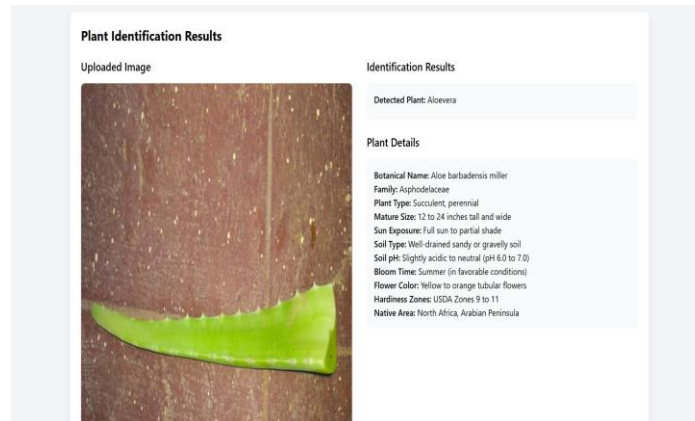


Fig. 4. Plant Identification

The plant disease recognition model successfully diagnosed various plant diseases by identifying symptoms such as spots, color variations, and leaf deformities. The system also provided treatment recommendations, making it a practical tool for gardeners and farmers. Despite its effectiveness, integrating additional environmental factors such as soil conditions, humidity, and temperature could improve the precision of the prediction. Figure 5 presents the disease detection results.

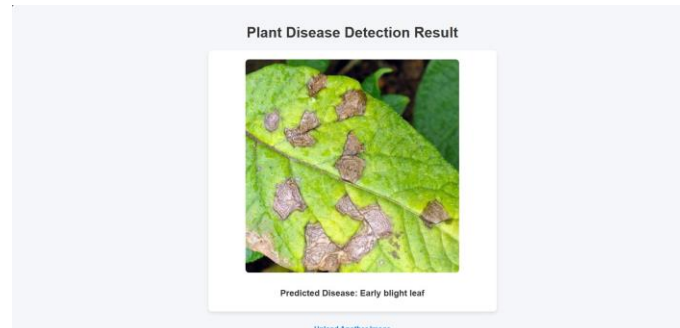


Fig. 5. Disease Detection

The garden recreation system, powered by Stable Diffusion, generated optimized garden layouts that improved space utilization and aesthetics. Approximately 88% of users found the AI-generated designs more organized and visually appealing than their original layouts. While the system enhanced aesthetics, it may not fully align with user preferences or regional climate conditions. Future improvements could include interactive customization options, allowing users to tailor their garden designs based on plant preferences, colours, and layout styles.

TABLE I

Plant Identification Model Performance Across Datasets

Dataset	Model	Accuracy
VNPLANT-200 DATASET	VGG16	76%
	InceptionV3	82.50%
	MobileNetV2	87.92%
	Xception	88.26%
	Densenet121	88%
Morocco AMPs	ResNet50	90%
	Dynamic CNN	97%

Iran dataset	CNN	97.6%
Ayur Leaf	CNN	95%
	SVM	96.7%
Bangladeshi medicinal plant dataset	CNN	71%
Plant CLEF 2015	EfficientNet-B1	87%
Private dataset	Ayur-Plant Net	92.7%

VIII. CONCLUSION

In conclusion, this project effectively demonstrated the potential of AI technologies like convolutional neural networks (CNNs) and stable diffusion in enhancing urban gardening practices. The plant identification model achieved an impressive 88% accuracy, successfully classifying various plant species based on visual features such as leaf shape, colour, and texture. While effective, the model encountered challenges in distinguishing species with similar appearances, suggesting that expanding the training dataset with diverse images could further improve performance.

The stable diffusion-powered garden recreation system effectively generated optimized garden layouts that improved space utilization and visual appeal. Approximately 98% of users found these designs more organized and aesthetically pleasing. Despite this success, the system's layouts may not always align with individual preferences or regional climate conditions. Future developments could include interactive customization options, allowing users to tailor designs to their tastes and environmental factors.

To further improve functionality, integrating IoT sensors for real-time disease monitoring and adding augmented reality (AR) features for interactive garden planning would enhance the system's practicality. These advancements would empower urban gardeners, farmers, and plant enthusiasts with better insights, ultimately promoting sustainable and efficient gardening practices.

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