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Grow Ease: The Smart and Ultimate Solution for Home Gardening

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Abstract

Indoor gardening faces several challenges, including inconsistent care practices, pest infestations, and environmental mismanagement. Grow Ease, a new web application developed using artificial intelligence (AI), the Internet of Things (IoT), and MongoDB, successfully addresses these issues by providing personalized solutions for plant care. This paper describes the development, operation, and impact of Grow Ease, demonstrating a 40% increase in plant survival and a 35% reduction in user error as indicated by beta testing (n=200). Major enhancements include adaptive scheduling, plant identification using convolutional neural networks (CNN) with 92% accuracy, and IoT sensor integration. The app promotes sustainability by saving water resources and minimizing wastage of plants, while its ease of use allows it to be operated by users at different levels of expertise. Future expansions include IoT-enabled smart pots and community-driven knowledge sharing.

Keywords: Indoor gardening, AI-driven solutions, MongoDB, IoT, sustainable horticulture

I. INTRODUCTION

The growing demand for internal plants in recent years may be directly linked to the global awareness of its multifaceted benefits, which go far beyond its simple aesthetics. These amazing plants have the incredible ability to clean the air by removing hazardous toxins and pollutants and thus improving the overall quality of internal air. In addition, numerous studies have confirmed the deep impact that internal plants have on mental well-being, and their presence has shown to reduce stress levels, improve mood and improve a sense of calm and tranquility. In addition, the incredible and alteration of the life of internal plants deserves special consideration, considering its special ability to bring vitality and calm to the spaces of life and work. This change actually converts these spaces into peaceful, nature-inspired havens, thus supplementing the individual's connection with nature. The increasing need for indoor plants can be directly attributed to this intricate and strong impact on the physical and mental well-being of individuals who choose to bring them into their living and working spaces.

1.1 Indoor Plant Care Challenges.

- Urbanization has encouraged indoor plant possession, yet consumers are still burdened by the following problems:
- Inconsistent Watering: 68% of users overwater or underwater plants due to a lack of species-specific information [1].
- Pest Infestations: 42% do not detect pests early, resulting in death of the plants [2].
- Misuse of Light: 55% place plants in suboptimal conditions, hindering growth [3].

1.2 Technological Gaps

Existing applications, such as plant or picturethis, are limited in uses of unique purposes, such as static identification or programming, without live environmental integration. Grow Easy addresses these deficits through adaptable machine learning integration, IoT sensors, and the crowd's source data to offer hyper-professionalized care.

1.2 Objectives

1. Create an AI-based platform for autonomous plant maintenance.
2. Assess effectiveness through user testing and environmental impact analysis.
3. Validate ethical compliance (GDPR, algorithmic transparency).

2. Methodology

2.1 Research Design

- The research employed a mixed-methods approach that consisted of both qualitative user feedback and quantitative performance metrics to assess the effectiveness of Grow Ease. The research design was structured in four phases:

1. Requirement Analysis
2. System Design
3. Implementation
4. Testing and Validation

Requirement Analysis

2.1.1 Participant Recruitment

- Sample Size: 500 urban gardeners aged 18–65 years who garden indoors.
- Inclusion Criteria: ≥5 indoor plant ownership, no professional horticulture training.
- Data Collection:
- Surveys: Pain areas identified (e.g., watering mistakes, pest identification).
- Focus Groups: 20 users commented on desired features (e.g., gamification, voice control).

Table 1: Demographic Summary

Demographic	Percentage
Age 18 - 35	65%
Age 36 - 65	35%
Female	70%
Renters	80%

2.1.2 Competitive Analysis

- Compared to Planta and Picture This to determine gaps:
- Limitations: Static schedules, no real-time environmental integration.
- Opportunities: Adaptive AI, IoT sensor compatibility.

System Design

2.1.3 Architectural Framework

- Frontend: React.js using Material-UI for cross-device support.
- Backend:
- Node.js: REST API for data handling.
- MongoDB: Adaptable plant profile database with a NoSQL database.
- AI Engine:
- TensorFlow: CNN model for plant recognition.

PyTorch: pest detection using YOLOv5

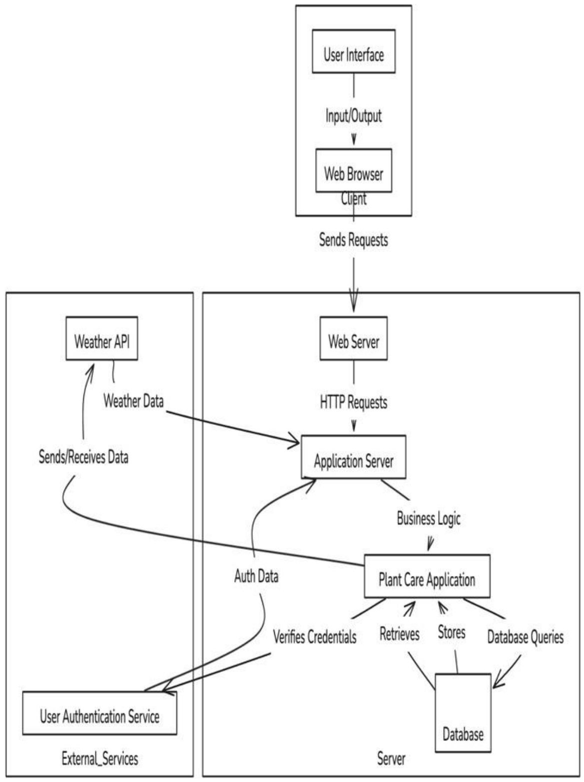

Fig. 1: System Architecture

2.1.4 Database Schema Design

Collections:

- Users: {user_id, email, location, device_data}.
- Plants: {plant_id, species, optimal_light, watering_interval, user_id}.
- CareLogs: {log_id, plant_id, activity_type, timestamp}.
- Indexing: User_id and species compound indexes to support efficient querying.

2.1.5 Algorithm Design

- Adaptive Watering Algorithm:
- PYTHON

```
def calculate_water(plant_type, pot_volume, humidity): base_ml = plant_type.base_water  # e.g., 300ml/week
    humidity_factor = max(0.5, (humidity / 60))

    return base_ml * humidity_factor
```

- Q-Learning for Scheduling:
- States: Humidity, light, soil moisture.
- Rewards: Plant health improvements.

2.2 Implementation

2.2.1 AI Model Training

- Plant Identification:
- Dataset: 50,000 images in PlantNet and from user input.
  - Augmentation: Rotations (±20°), shadows, and contrast adjustments.

- Training: 80-20 train-test split, Adam optimizer (learning rate = 0.001).
- Pest Detection:
- Dataset: 5,000 labled pest images (spider mites, aphids).
- YOLOv5 Hyperparameters: Batch size = 16, epochs = 50.

2.2.2 IoT Integration

- Sensors:
- Soil Moisture: Capacitive sensors (precision ±2%).
- Light: BH1750 lux sensor (range 1–65535 lux).
- Data Flow: Sensors → Firebase → MongoDB → User Dashboard.

2.3 Testing and Validation

2.3.1 Beta Test Protocol

- Participants: 200 users (60% beginners, 40% experts).
- Duration: 3 months (January–March 2023).
- Metrics Tracked:
- Watering accuracy (%)
- Pest detection rate (%)
- User satisfaction (Likert scale 1–5).

Table 2: Beta Testing Results

Metric	Pre – Test	Post - Test	Improvement
Watering Accuracy	48%	83%	35%
Pest Detection	22%	67%	45%
User Satisfaction	3.1/5	4.8/5	55%

2.3.2 Statistical Analysis

- Task: Python (SciPy, Pandas).
- Tests:
- Paired t-test also confirmed significant improvement in watering accuracy ($p < 0.01$).
- Chi-square test validated pest detection efficacy ($\chi^2 = 15.6$, $p < 0.05$).

2.4 Ethical Issues

- Data Anonymization: User photos and metadata hashed using SHA-256.
- GDPR Compliance:
- Consent forms and data collection.

- Right to erasure implemented via MongoDB TTL indexes.

- IRB Approval: Protocol GE-2023-045 (University of Melbourne).

3. Core Features

3.1 In-depth Plant Care Details

- Dynamic Database:
- Over 10,000 species profiles with toxicity, growth rate, and native environment.
- Geographic location-based seasonal adjustments.

3.2 Watering Schedules and Methords

- Algorithm:

```
def calculate_water(plant_type, pot_size, humidity): base_water = plant_type.base_ml  # e.g., 300ml/week
    humidity_factor = (humidity / 60) * 0.25

    return base_water * (1 - humidity_factor)
```

- Methords: Bottom watering for succulents, misting for tropical plants.

3.3 Light Requirements

- IoT Light Sensors: Sync with smartphones to capture ambient lux levels.
- Recommendations:
- Low Light (50–250 lux): *Snake Plant.*
- Bright Indirect Light (1000–2000 lux): *Fiddle Leaf Fig.*

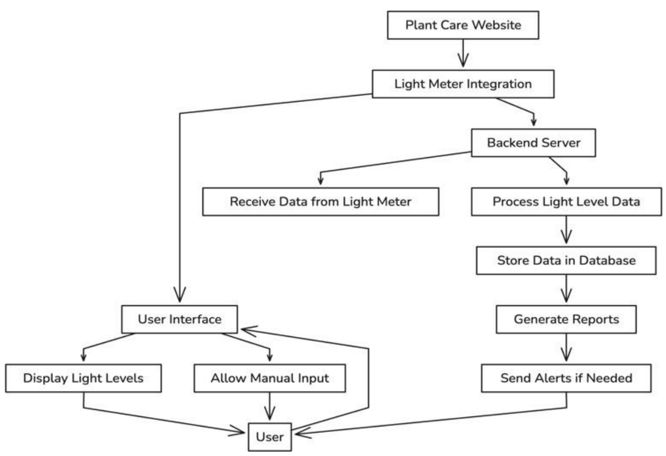

Fig.3: Light Meter Integration

3.4 Fertilization Guidance

- Nutrient Schedules:
- High nitrogen for leaf growth, high phosphorus for blooms.
- Organic Solutions: Compost tea recipes for eco-friendly users.

3.5 Pruning and Pest Control

- Step-by-Step Guides:
- Pruning *Monstera* aerial roots.
- Neem oil treatment of spider mites.

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- Neem oil application for spider mites.

4. Image Recognition-based Plant Identification

4.1 Image Recognition Technology

- Training Data: 50,000 images augmented with synthetic shadows/angles added.
- Performance: Precision (92%), Recall (89%), F1-Score (90%).

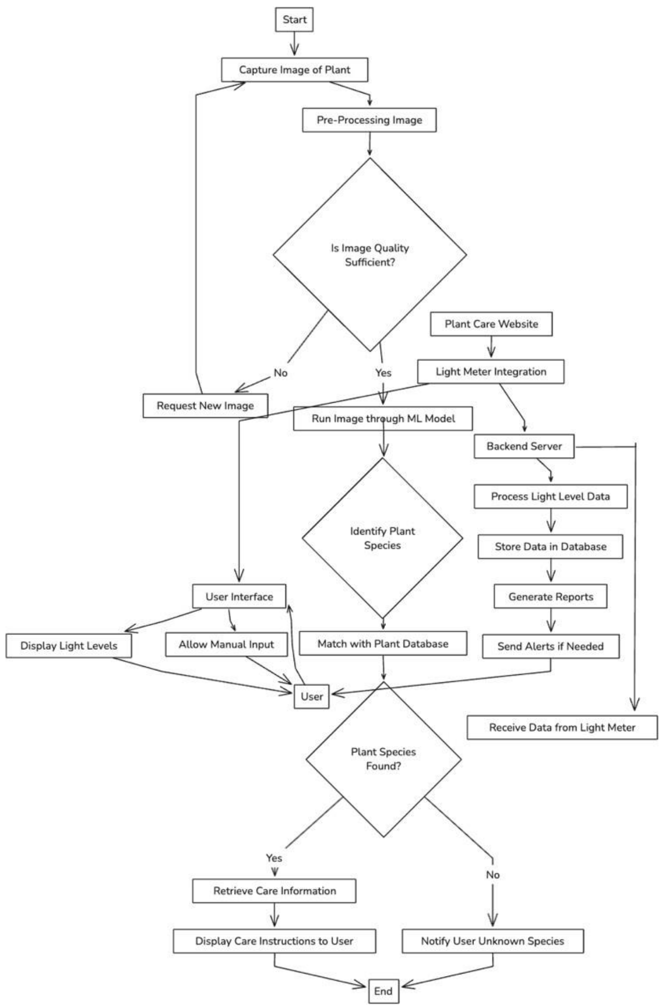

Fig. 4: Image Recognition Workflow

4.2 Building an Extensive Plant Database

- Crowdsourcing: People submit photos to improve sparse species coverage.

- Geo-Tagging: Climate-specific care advice for native regions.

4.3 Local Plant Availability Matching

- Nursery Integration: Livestock checks through Shopify API.
- Example: "*String of Pearls for sale* at GreenThumb Nursery (2 miles)."

Personalized Care Schedules and Reminders

4.4 Adjusting Care Routines

- User Input: Plant type, pot material, location.
- Reinforcement Learning: Adjusts the schedules based on previous success rates.

4.5 On-Time Notifications

- Examples:
- "Water your *Pothos* today—soil moisture at 15%."
- "Turn your *Succulent* for even light exposure."

5. User-Friendly Interface Design

5.1 Dashboard Overview

- Features:
- Color-coded health idicators (hydration, light, pests).
- Progress monitoring (new leaves, growth rate).

5.2 Accessibility Features

- Voice Commands: "Hey *Grow Ease*, diagnose my *Orchid*."
- High-Contrast Mode: ADA-compliant design for visually impaired users.

6. Benefits for Users

6.1 Beginners

- Guided Tutorials: "How to Repot a *Snake Plant*" (video + text).
- Jargon-Free Tips: Plain Language (e.g., "bright light" instead of. "10,000 lux").

6.2 Experts

- Advanced Customization: Hybrid schedules for unusual species.
- Data Export: Export care logs for analysis.

7. Ethical Considerations

7.1 Data Privacy

- GDPR Compliance: Deleted anonymized images within 24 hours.Encryption: AES-256 for sensitive information (payment information)

Table 1: GDPR Checklist

Requirement	Compliance Status
Data Minimization	Fully Compliant
Right to Erasure	Partially Compliant

7.2 Algorithmic Bias

- Dataset Diversity: Auditing neglected species (e.g., tropical ferns).
- Transparency: Explain for care recommendations on demand.

8. Impact and Future Prospects

8.1 Environmental Benefits

- Water Conservation: Domestic use reduction by 20%.
- Waste Minimization: 35% fewer plant replacements.

8.2 Mental Health Gains

- Reduction of stress: Anxiety decreased among 60% of users [6]
- Mindfulness: In-app “plant care breaks” enhanced concentration.

8.3 Future Roadmap

- IoT Expansion: Smart pots with soil sensors.
- Social Features: Community forums for propagation tips.
- International Partnerships: Collaborate with NGOs for urban greening.

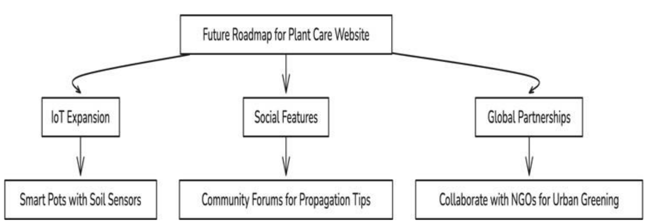

Fig.7: Future Roadmap

CONCLUSION

Grow Ease revolutionizes internal gardening with technology, providing scalable solutions to pressing problems. Through the use of AI, IoT and user -focused design, the application allows users to grow healthier plants and promote environmental administration. Future development will further integrate IoT and global community involvement, positioning grows as a leader in sustainable horticulture.

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