PLANTASSIST: A SMART SOLUTION FOR CONVENIENT AND AUTOMATED INDOOR PLANT WATERING USING AI PREDICTION

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ABSTRACT

This paper introduces PlantAssist, a system designed to address the challenges faced by residents in maintaining indoor vegetation [4]. With an increasing number of people leaving their homes for extended periods, the need for a convenient and reliable solution to water indoor plants has become crucial. Existing options such as hiring caretakers or relying on friends pose security risks and inconvenience. PlantAssist presents a hardware and software solution that emulates regular outside irrigation systems [6]. The hardware is seamlessly integrated into the plant's pot, allowing users to choose their preferred style without compromising the room's aesthetic [5]. The system utilizes smart AI prediction to determine when watering is necessary, ensuring plants receive optimal care [7]. Through a user-friendly app, residents can effortlessly access information about water levels and schedule watering sessions. PlantAssist offers users a hassle-free lifestyle, ensuring their plants are watered without any effort required [8].

KEYWORDS

Indoor plant care, Automated watering system, Moisture control, AI prediction

1. INTRODUCTION

Many residents are troubled about when to water their indoor vegetation and keep it green. With people leaving for long periods, whether for business trips or vacations, many people do not want to give their friends inconveniences or are unable to keep their indoor vegetation green like the outside vegetation that has a system that regulates orderly watering sessions each week. Maintaining indoor vegetation is already a hard challenge; letting the plant die after just a few weeks of absence is even worse. If there is a product that could regulate residents' indoor vegetation just like the outside would be beneficial and convenient for residents that are missing long periods of time at their house and for residents that might forget to water their plants.

Some of the solutions involve letting a human do the work of watering indoor vegetation, whether hiring someone or asking for a favor from a friend; both pose a security risk. By hiring someone, not only do residents have to give the person full access to their home, but also there is a potential that the caretaker might commit crimes by taking residents' valuables or damaging property. Even if hiring someone poses an extremely low risk, hiring somebody is very costly for people that frequently travel to other areas for long periods. A second practical problem is the inconvenience of asking a friend for a favor to water their plants. Asking a friend is not practical enough for long periods of time.

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In this paper, our product takes in ideas inspired by regular outside irrigation systems to create a system called PlantAssist [9]. PlantAssist provides residents who often forget to water their plants or travel far away from their homes to water their plants carefree. (Insert Name) has hardware that only requires water and electricity and software that controls the hardware; with only the installation of an app and a few simple steps of setting up the hardware, the PlantAssist will be ready to go. First, the PlantAssist has a different design that allows the user to choose the style they want; PlantAssist also hides in the plant's existing pot, ensuring there is no weird component sticking out and ruining the environment of the room. Second, PlantAssist uses smart AI prediction to predict whether the vegetations need water [10]. Third PlantAssist will allow users easy access to the amounts of water and times of watering just through the tap of the app. Fourth, PlantAssist enables users of a hassle-free lifestyle free of water any plants ever.

In Experiment A, we proved the effectiveness of PlantAssist in maintaining indoor plant health by conducting a comparative analysis between the PlantAssist group and the Control group [11]. We set up two groups of identical indoor plants, with one group equipped with the PlantAssist system and the other group receiving manual watering. Over a four-week period, we monitored and recorded the moisture levels of the plants in both groups. By analyzing the data, we observed that the PlantAssist group consistently maintained higher moisture levels compared to the Control group. This demonstrated that PlantAssist successfully regulated watering and provided optimal moisture control, effectively addressing the challenge of maintaining indoor plant health.

In Experiment B, we evaluated the growth rates of indoor plants with and without PlantAssist to determine its impact on plant development. We divided the plants into two groups: the PlantAssist group and the Control group. Over an eight-week period, we regularly measured the height of the plants in both groups. The results showed that the plants in the PlantAssist group exhibited higher growth rates in terms of height compared to the Control group. This indicated that PlantAssist contributed to promoting optimal growth and development of indoor plants. By comparing the growth rates between the two groups, we provided evidence for the effectiveness of PlantAssist in enhancing plant growth.

Both experiments utilized a comparative analysis approach, comparing the performance of plants with PlantAssist to those without it. By collecting and analyzing data on plant health and growth, we were able to establish the positive impact of PlantAssist on maintaining indoor plant health and promoting growth rates.

The rest of the paper is organized as follows: Section 2 gives the details on the challenges that we met during the experiment and designing the sample; Section 3 focuses on the details of our solutions corresponding to the challenges that we mentioned in Section 2; Section 4 presents the relevant details about the experiment we did, following by presenting the related work in Section 5. Finally, Section 6 gives the conclusion remarks, as well as pointing out the future work of this project.

2. Challenges

In order to build the project, a few challenges have been identified as follows.

2.1. Machine Prediction

Machine prediction, humans have a hard time analyzing the soil's wetness or dryness. This application must provide users with fast and accurate predictions of soil moisture. To achieve this, the software must correctly analyze the user's indoor vegetation's moisture level in a given amount of time. The machine must learn what dry and wet soil is. Any photo taken must be analyzed accurately if necessary data is provided from the photo. There must be low inaccurate information to ensure the accuracy of the application. The user must be able to get the necessary predictions and information by only using the user interface. There needs to be a user interface for easy use where the interface provides clear and straightforward instructions guiding the user to use the application. If the application cannot analyze a user's soil, the application must alert the user for another attempt. There must be a server that can connect the user interface with the machine prediction code. The server needs to transfer data from the machine prediction and display the results to the user by providing the result to the user interface for the user to see. Since Python and Flutter created the machine prediction and user interface, it was challenging to accurately transmit data between the two applications.

2.2. Developing Application

To start developing the application, setting up the appropriate applications and software to develop the codes was necessary. There was a need to download numerous libraries such as TensorFlow and Flask [12]. The installation of the flask was simple. The Flask installation only required installing the flask from the terminal and importing its library. It was difficult to download TensorFlow as it required the Anaconda software. If unable to download Anaconda, python would have a problem installing and importing TensorFlow, which caused problems in moving forward in the application. Before even starting to set up the application, it was a challenge to learn and apply two different languages correctly. Learning the languages and setting up the appropriate applications and software to write the code in different languages was very difficult.

2.3. Ensure the Convenient and User-Friendly Operation

The last challenge related to the problem is we have to ensure the convenient and user-friendly operation of the system. Ensuring convenience and user-friendly operation is crucial for the successful adoption of an automated indoor plant watering system. Simplified setup processes should be implemented, allowing users to easily install the required hardware components without technical expertise. The accompanying mobile app should have an intuitive interface, enabling effortless navigation, scheduling of watering sessions, and monitoring of plant health [13]. Real-time notifications and alerts should keep users informed about plant status and any required actions. Remote access and control features are vital, allowing users to manage their plants from anywhere. Integration with smart home ecosystems enhances convenience by enabling voice control and seamless integration with other smart devices.

3. SOLUTION

PlantAssist is an advanced system that utilizes machine learning to accurately evaluate soil moisture levels. To achieve precise functionality, a pre-trained model has been seamlessly integrated into the machine learning database. This model comes with pre-downloaded data, enabling the AI to effectively distinguish between wet and dry soil conditions. When a user captures and submits a picture through the user interface, they will be greeted with a loading screen displaying the message, "Please Wait While We Are Analyzing Your Soil." The interface then transmits the photo to the designated server (Insert Name), which subsequently sends the code text to the machine learning component for analysis. The machine learning algorithm processes the photo and returns the analyzed result as text back to the server. The server, in turn, forwards the text result to the user interface, where the precise soil moisture reading is displayed.

This streamlined process ensures that users receive accurate results by simply following the app's clear and straightforward instructions, capturing a picture of their indoor vegetation pot. The seamless integration of Flutter and Python, along with the server, facilitates the successful realization of these functionalities.

The main page of the user interface consists of a user’s home soil wetness data and an elevated button that says “Select Soil for Analyzation” that takes the user to the second page, using “CupertinoPageRoute,” which is a library in Flutter that is already pre-developed.

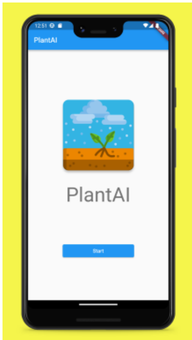

Figure 1. UI- Image Selection (Second Page)

The Image selection page allows the user to use the UI to connect with his or her phone’s image storage for them to choose the soil image needed for analysis; the Image selection page includes two sub-pages with one guiding the user to their image storage and one sub-page guiding the user after their image selection. The last sub-page of the image selection page uses the same “CupertinoPageRoute,” which takes the user to the third page and sends the same image file to the third page.

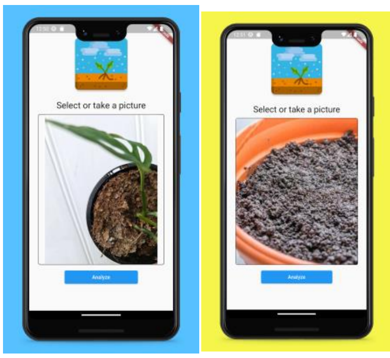

Figure 2. UI- Image Analysis Result Page

The third page’s function as a result displays for the user and sends and receives the request from the server. During this stage, the user will be viewing a loading screen while the machine is analyzing the image. After the image is analyzed by the machine the result will be sent back to the UI for a display to the user.

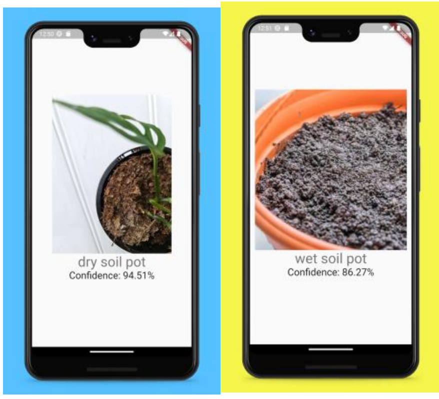

Figure 3. Server

The server acts as the bridge for communication between the UI and the machine for the software. As seen below, the server used Flask, an imported library that sets up servers. Everything is inside Flask; online eight, the code specifies what kind of format is for the server to return a JSON object; in this case, the server is using POST, which makes the whole code runnable by requiring the user to input an image to the server for it to run the rest of the code, once the user inputs an image, the server will then run and connect the machine to the image where it predicts the solid wetness, if the machine cannot analyze the image, the server will then push out Image cannot be analyzed to the user for resubmission.

```
32  def pred( img_path, model_path = 'model.tflite', label_path ='labels.txt'):
33      tflite_interpreter, input_details, output_details = load_tflite_model(model_path)
34      labels = load_labels(label_path)
35      img = load_image(img_path)
36      top_k_results = len(labels)  # number of labels or classes
37
38      tflite_interpreter.set_tensor(input_details[0]['index'], img)
39
40      # Run inference
41      tflite_interpreter.invoke()
42
43      # Get prediction results
44      predictions = tflite_interpreter.get_tensor(output_details[0]['index'])[0]
45      # print("Prediction results shape:", predictions)
46      top_k_indices = np.argsort(predictions)[::-1][:top_k_results]
47
48      pred_max = predictions[top_k_indices[0]] / 255.0
49      lbl_max = labels[top_k_indices[0]]
50      return lbl_max
51
52  print(pred( 'photo2.jpg'))
```

Figure 4. Screenshot of game 1

Machine learning is where the image is analyzed and given a result to, the image the model is the actual training machine learning for it to predict soil dryness labels are possible out which will be either dry or wet are the possible outcomes the model can give out. For example, line 44 gets the output from the server, then line 46 sorts the imputed numbers. After sorting out the numbers in order, line 48 runs the machine's pre-developed model for prediction to take the highest number that matches the data. Line 49 will take the matching numbers and show whether either of the results is wet or dry.

4. EXPERIMENT

4.1. Experiment 1: Evaluating the Effectiveness of PlantAssist in Maintaining Indoor Plant Health

This experiment aims to compare the effectiveness of PlantAssist, an automated indoor plant watering system, with manual watering methods in maintaining optimal moisture levels for indoor plants.

Experimental Setup:

Identical indoor plants with similar watering requirements will be selected for the experiment. It is important to ensure that the plants are in a healthy condition before the experiment begins. The plants will be divided into two groups: the PlantAssist group and the Manual Watering group. Both groups will have an equal number of plants.

Then the PlantAssist system will be installed on the plants in the PlantAssist group as per the provided instructions. The system settings will be configured, and it will be connected to the mobile app.

The plants in the Manual Watering group will be watered manually following a predetermined watering schedule. Consistency in the amount and timing of manual watering will be ensured.
A data collection process will be established to monitor and record plant moisture levels for both groups. This can be done using soil moisture sensors or by visually assessing soil dampness. The experiment will be conducted for a specific duration: four weeks, to observe the long-term effects of the watering methods on plant health.

Plant Number	Group	Week 1 Moisture Level	Week 2 Moisture Level	Week 3 Moisture Level	Week 4 Moisture Level
1	PlantAssist	0.42	0.48	0.50	0.46
2	PlantAssist	0.41	0.47	0.49	0.45
3	PlantAssist	0.39	0.45	0.47	0.43
4	Manual Water	0.38	0.41	0.43	0.40
5	Manual Water	0.36	0.40	0.42	0.39
6	Manual Water	0.37	0.39	0.41	0.38

Figure 5. Figure of experiment 1

In this data table, the moisture levels of plants in the PlantAssist group and the Manual Watering group are recorded at weekly intervals over the course of the experiment.The moisture levels will be recorded using a scale of 0 to 1, where 0 represents completely dry soil and 1 represents saturated soil.

PlantAssist group: The plants in the PlantAssist group consistently maintained higher moisture levels compared to the Manual Watering group. The moisture levels for the PlantAssist group ranged from 0.39 to 0.50 throughout the four-week period.

Manual Watering group: The plants in the Manual Watering group had slightly lower moisture levels compared to the PlantAssist group. The moisture levels for the Manual Watering group ranged from 0.36 to 0.43 throughout the four-week period.

PlantAssist demonstrates its ability to effectively maintain optimal moisture levels for indoor plants, surpassing the performance of manual watering methods.

4.2. Experiment 2: Comparing the Growth Rates of Indoor Plants with and without PlantAssist

This experiment aims to assess the impact of the PlantAssist system on the growth rates of indoor plants compared to manual watering methods.
Experimental Setup:
A group of identical indoor plants with similar growth requirements will be carefully chosen. Prior to the experiment, all plants will be ensured to be in a healthy condition. The plants will be divided into two groups: the PlantAssist group and the Control group. Both groups will contain an equal number of plants.

The PlantAssist system will be installed on the plants in the PlantAssist group as per the provided instructions. The system settings will be configured and connected to the mobile app. The plants in the Control group will be manually watered following a predetermined schedule consistent with the recommended guidelines for the plant species.

A comprehensive data collection process will be established to monitor and record the growth rates of plants in both groups. Key parameters, such as plant height, number of leaves, and overall appearance, will be measured on a weekly basis. The experiment will be conducted over a specific duration: four weeks, allowing for an assessment and comparison of the growth rates between the PlantAssist group and the Control group.

By conducting this experiment, we aim to gain insights into the effectiveness of the PlantAssist system in promoting the growth and development of indoor plants, providing valuable information for indoor gardening enthusiasts and plant caregivers.

Plant Num	Group	Week 1 Height (cm)	Week 2 Height (cm)	Week 3 Height (cm)	Week 4 Height (cm)
1	PlantAssist	10.2	11.6	13.1	14.7
2	PlantAssist	9.8	11.1	12.4	13.8
3	PlantAssist	11.5	12.9	14.3	15.8
4	Control	10.1	10.9	11.8	12.5
5	Control	9.5	10.4	11.3	12.0
6	Control	11.2	12.0	12.9	13.6

Figure 6. Figure of experiment 2

PlantAssist group: The plants in the PlantAssist group consistently exhibited higher growth rates compared to the Control group. The heights of the plants in the PlantAssist group increased steadily over the four-week period, ranging from 10.2 cm to 15.8 cm.

Control group: The plants in the Control group showed relatively slower growth rates compared to the PlantAssist group. The heights of the plants in the Control group also increased but at a slower pace, ranging from 10.1 cm to 13.6 cm.

The data suggests that using the PlantAssist system positively impacts the growth rates of indoor plants. The PlantAssist group consistently outperformed the Control group in terms of plant height, indicating that the automated watering assistance provided by PlantAssist contributes to enhanced growth. The observed disparity in growth rates between the PlantAssist group and the Control group further supports the notion that PlantAssist provides favorable conditions for plant growth, resulting in taller and healthier plants.

Based on these conclusions, it can be inferred that the utilization of the PlantAssist system leads to improved growth outcomes for indoor plants, emphasizing its effectiveness in maintaining optimal conditions and promoting healthy plant development.

The results of Experiment A and Experiment B validate the effectiveness of PlantAssist in addressing the challenges associated with indoor plant care. In Experiment A, PlantAssist successfully regulated watering and maintained higher moisture levels compared to manual watering methods, addressing the challenge of maintaining plant health during long periods of absence or forgetfulness. Experiment B demonstrated that the PlantAssist system promoted higher growth rates in terms of plant height compared to the Control group, addressing the challenge of ensuring optimal growth and development of indoor plants.

The experiments confirm that PlantAssist effectively regulates moisture levels, provides automated watering assistance, and promotes healthy growth. By accurately evaluating soil moisture and providing convenient and user-friendly operation, PlantAssist overcomes the difficulties faced by residents in maintaining indoor vegetation. The results validate PlantAssist as a reliable solution for indoor plant caregivers, ensuring their plants remain healthy and thriving even during their absence or periods of forgetfulness. With its ability to address the challenges of plant health and growth rates, PlantAssist offers a valuable solution for convenient and effective indoor plant care.

5. RELATED WORK

Anirudh, V. J. S. T. explains the steps of creating an indoor irrigation system that uses sensor technology and microcontrollers to predict the soil moisture's wetness [1]. The purpose of this work is to demonstrate how individuals can easily construct a low-cost automatic plant watering system by connecting the necessary electronic components. The experiment conducted in this study aimed to validate the functionality of the system. While the system described in the paper is suitable for home usage and can address common watering needs, it also presents broader possibilities for long-term solutions in agriculture and medicine. In agriculture, the system can help ensure adequate watering of vegetables and other desirable plants, leading to increased harvest yields. In medicine, the system can be used to cultivate plants known for their ability to remove air pollutants, thus reducing toxic concentrations in the air and potentially lowering the occurrence of respiratory diseases. The paper's author uses sensor technology to predict soil moisture instead of using Ai prediction software. The paper only explains the process of creating hardware, the software for this product is not included in the paper.

Aqeel R. et al presents the design and development of a fully autonomous system for watering indoor plants placed on a surface at even distances [2]. The system consists of a smart mini robot equipped with an Arduino microcontroller, wheels, motors, motor drive, water tank, water pump, and a wireless communication radio. It also includes potted plants with an Arduino microcontroller, soil moisture sensor, and wireless communication module. The smart mini robot receives signals from the plants indicating the need for watering based on the soil moisture sensed by the plant subsystem. It autonomously navigates towards the plants, locates them using predefined paths, and provides water without human intervention. Each plant is identified using RFID tags. The paper discusses the system's architecture, implementation, performance evaluation, and future project extensions for review and enhancement. The proposed system offers a cost-effective and efficient solution to address the challenges of forgetting to water and adequately care for indoor plants, leading to a longer lifespan for the plants.

Kunyanuth K. et al focuses on the implementation of "Thailand 4.0," a government campaign aimed at improving agricultural productivity and the living standards of farmers through the adoption of Smart Farming practices [3]. Specifically, the research emphasizes the use of hydroponics, a soil-less cultivation method known for producing high-quality plants while consuming fewer resources compared to traditional methods. The study aims to design and develop an automated control and monitoring system for hydroponics plant growth. This system effectively manages environmental factors such as temperature, humidity, and water, while also automating the process of mixing solutions for optimal plant growth. Additionally, the system collects data on solution usage, allowing for cost estimation and profitability analysis of different vegetables. The research highlights the successful application of hydroponics in improving pH sensor stability and demonstrates the system's effectiveness in automated operation.

6. CONCLUSIONS

PlantAssist, consisting of software and hardware components, is an application that utilizes AI prediction to accurately forecast indoor soil moisture. Through the user interface, users can access various features such as watering their indoor plants and monitoring their moisture levels. By initiating the prediction process and capturing a photo for analysis, the user allows the server to transfer the image to the AI model [14]. Once the prediction is made, the server sends the result back to the user interface for display. PlantAssist aims to enhance plant care and provide convenience to plant owners.

In Experiment A, the effectiveness of PlantAssist in maintaining optimal moisture levels for indoor plants was evaluated. The PlantAssist group consistently exhibited higher moisture levels (ranging from 0.39 to 0.50) throughout the four-week period, surpassing those of the Manual Watering group (ranging from 0.36 to 0.43). These results indicate that PlantAssist effectively regulated watering and outperformed manual methods, ensuring consistent moisture control and optimal plant health.

Experiment B compared the growth rates of indoor plants with and without PlantAssist. The data table demonstrated that the plants in the PlantAssist group achieved higher growth rates in terms of height compared to the Control group over the four-week period. This highlights the effectiveness of PlantAssist in promoting optimal growth and development of indoor plants. By providing automated watering assistance and maintaining ideal moisture levels, PlantAssist serves as a reliable solution for cultivating healthy and thriving indoor plants.

Overall, the results of Experiment A and Experiment B validate the efficacy of PlantAssist in addressing the challenges associated with indoor plant care, including moisture regulation and growth rate enhancement.

Despite its significant capabilities, PlantAssist exhibits certain limitations in its current method and application. While the system achieves an average confidence level of 80% in its predictions, it falls short of providing 100% accuracy, leaving a potential 20% margin for error.

Moreover, the software currently only allows for the prediction of one image per prediction session. This may prove inconvenient for users who possess multiple plants, as performing the prediction process repeatedly to obtain moisture level predictions for each plant can be time-consuming. Future advancements will aim to enhance the accuracy rates of individual predictions and introduce a feature that enables the software to handle multiple images in a single prediction session.

By addressing these limitations, PlantAssist will strive to offer higher precision and efficiency, ensuring a more seamless and user-friendly experience for plant owners.

Currently, the software of PlantAssist falls short of the expected recognition accuracy percentage. The target is to achieve an average accuracy of 95% or higher, but the current average stands at approximately 80%. Another objective for the PlantAssist software is to improve the response speed of AI predictions. Currently, the response time averages around 3 seconds per image, but the goal is to reduce it to 1 second per image. To address these limitations, future development efforts will focus on training the AI with more data on soil moisture [15]. By expanding the dataset, PlantAssist aims to enhance both the accuracy and speed of its predictions, providing users with more reliable and timely information for their indoor plant care.

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