SMART MANGO – SMART SYSTEM FOR MANGO PLANTATION MANAGEMENT

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B.Sc. Special (Honors) in Information Technology Specialize in Computer Systems and Network Engineering

Department of Computer Systems Engineering

Sri Lanka Institute of Information Technology
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DECLARATION

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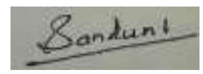
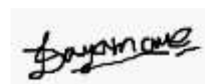
Withanaarachchi S. P.	IT20466008	
Jayamanne B.D.N.	IT20276928	
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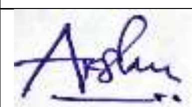
Aksham M.Z.M	IT20280260	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

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Ms. Hansika Mahaadikara – Supervisor Date

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Ms. Shashika Lokuliyana – Co-Supervisor Date

ABSTRACT

Mango (Mangifera indica) cultivation is of immense economic importance worldwide, necessitating enhanced practices to optimize productivity, quality, and disease management. This introduces a pioneering approach that harnesses machine learning to revolutionize multifaceted mango management. Traditional grading methods relying on subjective human assessments prove inefficient and prone to inconsistencies. To address these challenges, our research proposes fourfold objectives: (1) developing an automated mango grading system based on weight and color using machine learning, (2) accurately predicting mango yield through historical data and weather patterns, (3) forecasting optimal water requirements for mango trees at different growth stages, and (4) implementing a disease detection system for early identification of mango diseases. The research utilizes transfer learning with VGG16 and ResNet50 models for image-based tasks, SVM for grade prediction, and linear regression for yield and water level prediction. This research showcases the potential of machine learning to transform mango cultivation, benefiting farmers and consumers by streamlining processes and promoting data-driven, sustainable agriculture.

ACKNOWLEDGEMENT

The completion of this research would not have been possible without the contribution and dedication of many people. We would like to sincerely thank everyone who has helped us to continue 4th year research project. First, we would like to express our sincere gratitude to our project supervisor Ms. Hansika Mahaadikara, who guide us with knowledge and informative commentary to continue this project successfully. We would like to thank our co-supervisor Ms. Shashika Lokuliyana for her valuable advice and encouragement. We would also like to thank the AIMS panel for giving us valuable advice on our project.

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LIST OF ABBREVIATIONS

IoT	Internet of Things
AWS	Amazon Web Services
ML	Machine Learning
SVM	Support Vector Machine
GBM	Gradient Boosting Machine
MSE	Mean Squared Error
pH	Potential Hydrogen
NGO	Non-Government Organization
RN50	Rest Net 50

1. INTRODUCTION

Mango (Mangifera indica) stands as one of the most economically significant and widely cultivated fruits globally, revered for its delectable taste, enticing aroma, and exceptional nutritional value. The growing demand for mangoes has prompted agriculturalists to explore advanced practices that optimize productivity, maintain fruit quality, and curtail losses caused by diseases and suboptimal water management. Addressing these challenges head-on, this research delves into a pioneering approach that harnesses the potential of machine learning and Internet of Things (IoT) systems to revolutionize multifaceted mango management. Traditional methods of mango cultivation have long relied on subjective human assessments for grading mangoes based on weight and color. Unfortunately, such practices prove laborious, time-consuming, and susceptible to inconsistencies, leading to subpar grading decisions and potential financial setbacks for both farmers and consumers. Furthermore, the precise prediction of mango yield, appropriate water levels, and early detection of diseases persist as complex obstacles, significantly influencing productivity and profitability in the mango industry. However, the advent of machine learning has opened the gateway to data-driven solutions in various domains, including agriculture. Machine learning algorithms have demonstrated their prowess in processing vast amounts of data, recognizing patterns, and making accurate predictions, thus paving the way for transformative advancements in mango management, harvesting, and disease prevention. When coupled with IoT systems, this combination enables the seamless collection and streaming of real-time data from mango orchards, empowering the machine learning application with up-to-date information crucial for decision-making. With machine learning and IoT at its core, this research aspires to enhance efficiency, reduce resource wastage, and foster informed decision-making throughout the realm of mango cultivation.

The objectives of this research are fourfold:

1. **Grading mangoes based on weight and color using machine learning:** By leveraging sophisticated machine learning algorithms and IoT data, we endeavor to develop an objective and automated grading system capable of precisely assessing mangoes based on weight and color. Such a system will not only streamline the grading process but also elevate fruit quality consistency and market value.

2. **Predicting the Mango yield:** Drawing insights from historical data, weather patterns, and real-time data from IoT devices, we strive to construct a robust machine learning model that accurately predicts mango yield. Armed with this foresight, farmers can optimize resource allocation, plan harvests, and facilitate post-harvest activities with unrivaled precision.

3. **Predicting the required mango water level**: Employing cutting-edge machine learning techniques and leveraging data from IoT sensors, our aim is to forecast the optimal water requirements for mango trees at various stages of growth. Armed with this understanding, farmers can adopt sustainable irrigation practices, curbing water wastage and promoting the health of the orchard.

4. **Predicting mango diseases**: Integrating advanced image recognition and pattern detection algorithms with real-time data from IoT systems, we seek to develop a disease detection system capable of identifying early signs of illnesses in mango trees. Timely disease detection empowers swift intervention, averting disease spread, and minimizing crop losses.

Embracing the capabilities of machine learning and IoT systems, this will utilize diverse algorithms, such as support vector machines, random forests, and neural networks, to efficaciously achieve its objectives. The paramount importance of this research lies in its potential to transform mango cultivation practices, benefiting farmers and consumers alike. By replacing laborious manual processes with automated machine learning systems and integrating IoT data, mango grading can achieve newfound objectivity, consistency, and efficiency. Furthermore, accurate yield prediction and water management stand to optimize resource allocation, reduce costs, and mitigate environmental impact. In the context of mango orchard health, the timely detection of diseases can curtail losses and bolster the well-being of the orchard. As machine learning converges with mango management practices and IoT systems provide real-time data insights, a pivotal step towards sustainable, data-driven agriculture unfolds. This research aspires to contribute critical insights to the agricultural community, equipping farmers with innovative tools to elevate productivity and quality in the dynamic realm of mango cultivation. Armed with the promise of machine learning and IoT, the multifaceted mango management journey commences, marking a transformative chapter in the annals of agricultural advancement.

1.1 Background Literature

Smith et al. (2018) used the machine learning method Random Forests to precisely predict mango fruit production under various irrigation regimes. Their model successfully captured complex interactions impacting mango production by taking important environmental aspects into account, and as a result, it provided insightful information for resource optimization and higher productivity [1].

A Multilayer Convolution Neural Network (MCNN) was introduced by Gupta et al. (2019) for the categorization of anthracnose disease in mango leaves. Their model displayed great sensitivity and accuracy, highlighting its potential to revolutionize plant disease diagnoses and help sustainable agriculture by reducing the need for pesticides and intervening quickly [2].

Fuzzy image analysis was investigated by Rahman et al. (2017) as an automated alternative to manual, traditional methods for grading mangoes. Despite obstacles, this research is an important step toward improving the effectiveness and consistency of mango supply networks [3]. For mango grading, Chen et al. (2018) suggested a vision- based volume estimation approach. This non-destructive method provided quicker throughput and lower post-harvest losses while precisely estimating mango volume [4].

The grading of mangoes is a critical process that determines their market value and suitability for different applications, such as fresh consumption or processing. Traditional grading methods often involve destructive sampling, leading to wastage and reduced shelf life. To address these challenges, researchers have explored non-destructive grading methods that preserve fruit quality while providing accurate assessments. In a significant research contribution, Jain et al. (2019) introduced a novel nondestructive grading method for mangoes using a fuzzy expert system. The proposed grading system combines the principles of fuzzy logic with domain expertise from experienced graders to classify mangoes based on various quality attributes. Fuzzy logic allows for the representation of uncertainty and imprecision, mimicking human reasoning and decision-making processes. The system incorporates multiple sensory inputs, including color, size, firmness, and sugar content, to determine the fruit's grade. The study by Jain et al. (2019) demonstrated the effectiveness of the nondestructive grading method, showcasing accurate and consistent results comparable to traditional grading approaches [5].

In a study, Patel et al. (2018) aimed to scientifically classify the ripening period of Indian mangoes (Mangifera indica L.) and develop a color grade chart for informed decision-making by growers and traders. They utilized multivariate cluster analysis to categorize mangoes into distinct ripening stages based on color and physicochemical parameters. With data collected from multiple regions and seasons, the researchers built a comprehensive dataset for robust statistical analysis. The resulting color grade chart provided a visual representation of the mango's ripening stage, aiding in determining the optimal harvest time. The study also explored changes in biochemical and physiological characteristics during ripening, offering insights into post-harvest behavior and potential shelf life. These findings have significant implications for mango cultivation, providing a scientific basis for ripening classification and practical tools for better post-harvest management. The multivariate cluster analysis approach could be extended to other fruit species, offering a generalizable method for ripening characterization. Future research could explore non-destructive techniques and environmental factors to further improve accuracy and predictive capabilities [6].

Wong et al. (2020) proposed an intelligent mango canopies yield estimation system using machine vision techniques to overcome the labor-intensive and time-consuming nature of traditional methods. The researchers developed a specialized camera system and advanced imaging setup to capture high-resolution images of mango canopies. These images were processed using image segmentation and feature extraction algorithms to detect and quantify individual fruits. By integrating machine learning, such as Support Vector Regression (SVR), the system accurately estimated fruit yield. The results demonstrated the potential of machine vision-based yield estimation, offering reliable and non-destructive measurements compared to manual sampling. The intelligent system significantly reduced the time and effort required for yield estimation, enabling informed decisions for harvest timing and resource allocation. Challenges in complex environments remain, such as lighting variations and canopy structure, prompting the need for robust methods like deep learning.

Wong et al.'s (2020) research represents a significant advancement in intelligent mango yield estimation, providing a practical and efficient solution to improve mango cultivation's accuracy and sustainability through automation and advanced technologies [7]. An innovative study on mango fruit detection, localisation, and yield calculation was carried out by Chen et al. (2019). Their creative strategy entailed carefully positioning cameras inside mango orchards to take overlapping canopy photos from different perspectives. They recreated the 3D structure of the mango canopy using multiple view geometry techniques, making it possible to pinpoint the location of specific fruits. The researchers produced extremely precise estimations of mango fruit output by combining this spatial data with machine learning methods like Random Forests. This non-destructive and effective image-based method automates fruit localization and detection, providing encouraging prospects for efficient and sustainable mango growing methods [8].

Silva et al. (2020) carried out a thorough life cycle evaluation to estimate the water and carbon footprints of semi-arid Brazilian mango cultivation. Taking into account diverse mango cultivating techniques and mango types, their research quantified greenhouse gas emissions and water usage at various stages of mango production. The study showed that conventional and sustainable production strategies have quite different effects on the environment. It has been discovered that environmentally friendly techniques reduce water use and carbon emissions, such as effective irrigation and fertilizer utilization. The research by Silva et al. sheds important light on how to encourage environmentally friendly mango production and informs prospective legislative changes and actions to lessen the industry's environmental impact. To increase the accuracy of footprint estimates and help wise decision-making in sustainable mango production, the study also highlighted the need for enhanced data collecting and assessment procedures [9].

In northeast Brazil, Souza et al. (2017) carried out field studies in irrigated mango orchards using cutting-edge measurement methods including sap flow sensors to track water requirements all through the growing season. In order to maximize water use efficiency and reduce losses, their research showed that water demand rose during the flowering and fruit development stages. This emphasizes the significance of matching irrigation schedules with tree water demand. This study offers helpful recommendations for mango orchard irrigation management practices, especially in areas with limited water resources. It also emphasizes how important it is to manage water resources responsibly while maintaining crop yield, which could help other areas that are experiencing water scarcity [10].

Khan et al. (2018) also explored the water needs of mature mango trees and provided recommendations for customized irrigation management to enable long-term mango farming, particularly in water-scarce areas. Collectively, these investigations support ethical resource management and environmentally friendly farming methods in mango orchards [11].

In order to identify and predict plant diseases, Gupta et al. (2019) created a collaborative platform utilizing cloudbased technology and artificial intelligence. To assess photos of samples of damaged plants, our platform blends cuttingedge machine learning methods like deep learning and convolutional neural networks. With a cloud-based architecture that enables real-time data storage and dissemination, it continuously improves accuracy by using crowdsourced data from farmers and researchers. The platform enables early warning systems and preventative disease control strategies by combining meteorological data and environmental characteristics. The study demonstrates how well the platform works to improve disease detection and forecasting, underlining the importance of user participation and data protection for the platform's widespread adoption in the agricultural sector [12].

The research conducted by Khan et al. (2018) dramatically improves automated disease detection in mango crops, providing a promising means of assisting farmers with prompt disease management and intervention [13]. A feedforward neural network and a hybrid metaheuristic feature selection were suggested by Patel et al. (2019) as a novel approach for the early disease categorization of mango leaves. Even with little data, their method—which uses a combination of genetic algorithms and particle swarm optimization to maximize feature selection—improved classification performance. This study offers a useful tool for precise and prompt disease identification to promote sustainable agricultural practices, marking an important advancement in automated disease recognition for mango growing. Future research could examine its effectiveness against different mango illnesses and regional differences to increase its usefulness [14].

A ground-breaking deep grading system for mangoes was created by Li et al. (2019) using computer vision and convolutional neural networks (CNN). The algorithm correctly classified mangoes into various categories based on appearance after being trained with a wide dataset of mango photos. This novel method reduces the need for manual labor and reduces human error while providing consistent and effective grading outcomes. The study emphasizes the value of both large and high-quality data sets when developing deep learning models, and it establishes the CNN-based grading system as an efficient and precise method for automating mango grading. This innovation encourages effective marketing and use of fruit [15].

1.2 Research Gap

It is essential to create smart mango plantation management systems that make use of technological advancements and data analysis to address these issues. Such systems could help farmers monitor and manage their mango plantations in real time, making informed decisions based on data-driven insights. However, the implementation of smart mango plantation management systems in Sri Lanka is still in its primary stage, and there is a significant gap in the research and development of such systems. This presents an opportunity to address this research gap by developing innovative and effective smart mango plantation management systems that are tailored to the specific needs of Sri Lankan farmers and the challenges they face in the mango plantation sector.

1.3 Research Problem

Mango cultivation is a vital agricultural sector in numerous regions in Sri Lanka, facing challenges such as unpredictable weather patterns, recurring disease outbreaks, and inefficient resource utilization. To enhance mango cultivation while mitigating these challenges, a critical research problem emerges: How can a comprehensive 'Smart Mango Plantation Management System' be conceptualized, developed, and optimized to augment mango cultivation in diverse agricultural contexts? This system incorporates cutting-edge technologies such as IoT-enabled watering systems, mango grading solutions, disease detection mechanisms, and yield prediction models, all meticulously tailored to the unique nuances of local agricultural landscapes. The research problem further branches into intricate sub-problems, encompassing seamless integration of system components, adaptation to diverse local conditions, assessment of economic viability, scalability across various plantation sizes, examination of cultural and social factors influencing technology adoption, and the practical implementation intricacies in harmony with existing mango farming practices. Addressing these challenges is fundamental to the sustainable enhancement of mango cultivation, thereby ensuring improved yields, better crop quality, and environmentally conscious agricultural practices.

1.4 Research Objectives

1.4.1 Main Objectives

- To implement an integrated solution to increase the production of the mango plantation and help the management to monitor the plants.

The main objective of the research is to implement a system that covers all the aspects of mango plantation. This system will help the mango planters to use their resources in a more efficient and effective way. Our system has covered the main four areas in mango plantation management such as grading, watering, disease detection and yield prediction. This will help to produce more quality mangoes using less resources.

1.4.2 Sub Objectives

- To implement a IoT – based Mango Grading System

The mango grading system is mainly consisting of IoT and machine learning model. This will help to identify the grades more accurately. And this will avoid the confusions made my humans. The quality of the mangoes is categorized into three grades. This system will help to avoid the wastage of resources. And do the task more efficiently.

- To implement a mango leaf disease identification system

The disease identification system helps to identify the diseases in the mango leaves. When the disease is identified by the system, it will provide a suggestion to the user to what to do next. This will help to save the time of the workers. And by identifying the diseases in the early stage it will help to increase the yield in the mango plantation.

- To implement a IoT - based Smart Watering System

This system will help to water the plantation at the correct time in the correct amount. This will help to manage the resources effectively. As most of the mango plantations in Sri Lanka has located in dry area saving of water usage is a challenging problem. Therefore, this system will help to achieve the business goals more sustainably.

- To implement a yield prediction system

The yield prediction system will help to analyze the past data and predict the mango production. The system will use the data like age of the mango tree. water usage, fertilizer usage, soil conditions, environmental conditions, and diseases affected. This will help the mango planters to achieve their goals more effectively.

2. METHODOLOGY

In this research, we have employed several machine learning technologies to address the different objectives of grading mangoes based on weight and color, predicting mango yield, determining the required mango water level, and predicting mango diseases as depicted in Fig. 1. Each technology was chosen based on its suitability for the specific task and the nature of the data available. Below, we elaborate on the technologies used and the reasons behind their selection: Transfer Learning with VGG16 and ResNet50 Models. Transfer learning is a popular technique in the field of deep learning that involves leveraging pre-trained models on large datasets to address specific tasks. In our research, we used transfer learning with both the VGG16 and ResNet50 models for different purposes.

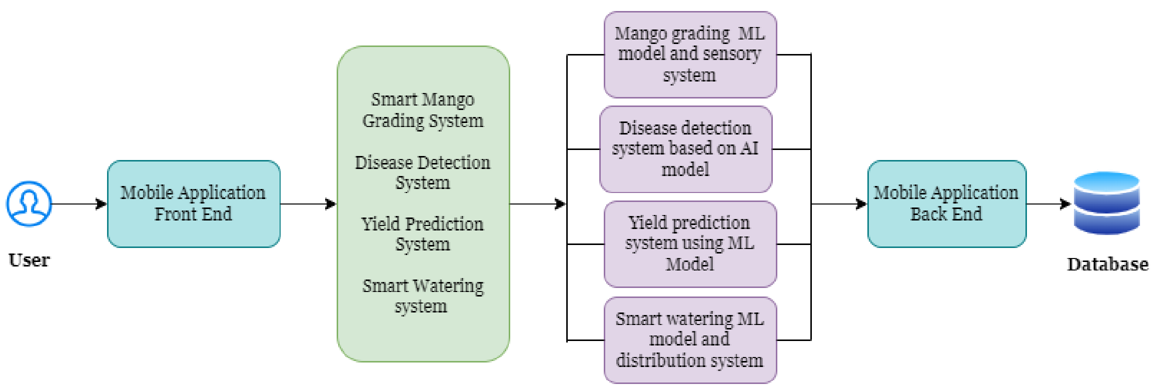

Figure 2:1 System Diagram

VGG16 Model for Mango Grading: The VGG16 model was chosen for mango grading based on visual appearance (colour and texture). By using transfer learning with VGG16, we were able to utilize the model's ability to extract features from images and classify them and this approach significantly reduced the need for a large mango specific dataset and improved the accuracy of mango grade classification. The model was trained with 1000 of images for each grade where 80% of data were used for training and 20% of data were used for validation. The model is trained to classify images into three classes which are grade 1, grade 2, and grade 3.

Support Vector Machine (SVM) for Mango Grading: After obtaining the classification results from the VGG16 model, we needed a method to combine the image-based classification with the mango weight information for the final grade prediction as the weight is an important parameter for grading decision. SVM, a supervised learning algorithm, was trained for this task. SVM is particularly well-suited for this since the classification is based on multi-dimensional features. A Dataset was created with VGG16 model probability scores for 1000 of images. Weights of that each mango and ground truth class is also included to the dataset. By using SVM, we integrated the visual information from the VGG16 model and the mango weight to make accurate predictions for mango grading. In training process 80% of data were used for training and 20% of data were used for validation.

ResNet50 Model for Mango Disease Prediction: A ResNet50 model, another deep CNN architecture, was used for detecting mango diseases from images. Mango diseases often exhibit specific patterns and visual cues that can be difficult to capture with traditional image processing techniques. Transfer learning with ResNet50 allowed us to benefit from the model's understanding of general image features and patterns, which helped in accurate disease prediction. Fine-tuning the ResNet50 model on our mango disease dataset made it proficient at identifying disease related patterns and distinguishing healthy from infected mangoes. The dataset included 1000 of images belongs to two classes which are Anthracnose, Bacterial Canker. 80% of data were used for training and 20% of data were used for validation.

Required Mango Water Level Prediction: Linear regression was used to predict the required mango water level based on environmental parameters (Humidity Level, Moisture Level in the soil, Temperature). The model is trained using 100000 data points of water supplied to a mango plantation along with environmental parameters. 80% of data points were used for training and 20% of data points were used for validation. By employing linear regression model, we could make accurate predictions for the water level needed to maintain optimal growing conditions for mangoes.

IoT model for Watering System: ESP32 DEV module is used as the microcontroller in this IoT device. The microcontroller is programed to take the input readings and send the data to the cloud database. The other equipment's used are temperature sensor, humidity sensor, soil moisture sensor, relay module, solenoid valve, voltage sensor, motor, and ultra-sonic sensor. The ultrasonic sensor is used to measure the level of water in the water tank. The data to the system is obtained from the temperature, humidity, and soil moisture sensor installed in the mango plantation. The data obtained from the sensors are send to the cloud server using Wi-Fi. The water needed to the plantation will be released through the pipelines. The water is given to the root of the plant using sprinklers in drip irrigation method. Device Ids are used to identify the crops uniquely.

Mango Yield Prediction: Linear regression was chosen for mango yield prediction because it allowed us to model the relationship between the input environmental and agricultural factors (Soil pH, Soil Moisture, Temperature, Humidity, Rainfall, Light Exposure, Life Span, pesticide, Disease) and the output (mango yield). Linear regression model allows us to estimate the expected yield based on the given conditions. The model is trained using 100000 data points of historical yield data along with environmental and agricultural factors. 80% of data points were used for training and 20% of data points were used for validation.

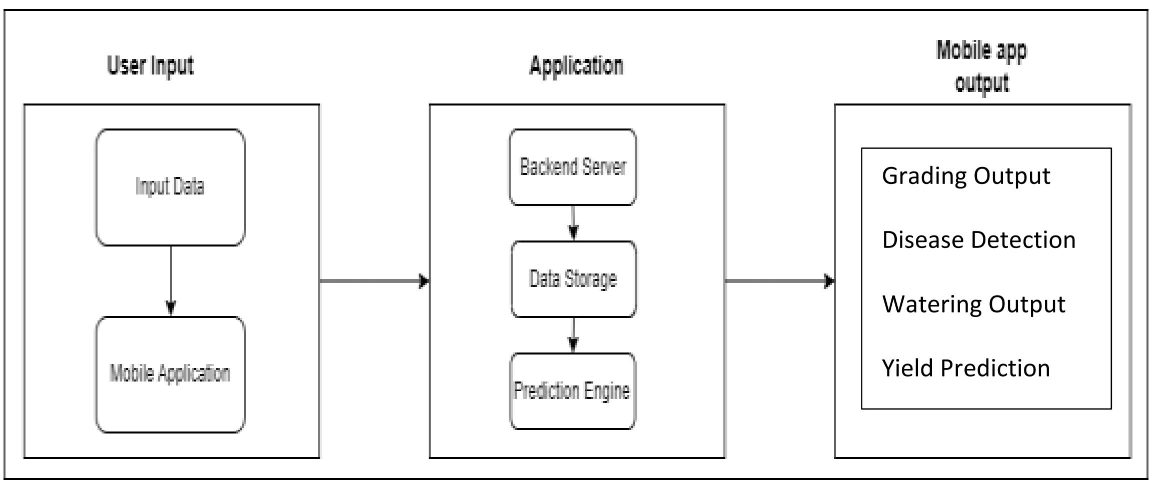

Figure 2:2 Application Overview

2.1 Commercialization of the product

2.1.1 Target Audience

The target audience of the product is mango farmers specifically in Sri Lanka. But our future plan is to make this system to be used by mango farmers worldwide.

2.1.2 Demand

The demand for this product is very high as there is a lack of management systems for the mango plantation is Sri Lanka. As we have discussed with few mango planters in Sri Lanka, they are always willing to find a method decrease their expense and increase their income. By using a smart mango plantation management system made by using ML and IoT the resources can be used in a more efficiently. Therefore, this system will have a high demand among the mango planters in Sri Lanka.

2.1.3 Marketing Strategy

We plan to sell this system as a product through the Agriculture Department in Sri Lanka. The new buyers will have a free trial period and if they are not satisfied with the system, they can return the product within the given time period. The small-scale farmers who cannot afford the system are given a monthly based paying method. The people who cannot afford the system are distributed through the NGO’s.

2.1.4 Social Media Marketing

The social media marketing is the most current trend in marketing. Even though you do not have a customer base still, you can make people aware of the product through the social media marketing like Instagram, Facebook, YouTube etc.

2.2 Testing & Implementation

This system is tested throughout the development lifecycle. All the modules were tested separately before and after the integration with the main system. The testing of the entire system was done to ensure the proper functioning of the system.

Table 2:1 Summary of testing of the system

Test ID	Test Description	Status
001	Testing the ML models by varying the input values	Pass
002	Testing the sensors individually	Pass
003	Testing the IoT modules	Pass
004	Testing the disease identification system	Pass
005	Testing the watering system	Pass
006	Testing the yield prediction system	Pass
007	Testing the mango grading system	Pass
008	Testing the Database	Pass
009	Testing the mobile application	Pass

2.3 Budget and Budget Justification

Table 2:2 Budget and budget justification

Component	USD (per year)	LKR (per year)
ESP 32 Dev Module	11	3300
Soil Moisture Sensor	1	200
Load Cell Sensor	1	380
DHT11 Sensor	2	490
Ultra-sonic sensor	2	595
Solenoid Valve	5	1485
Relay Module	2	450
Mongo DB	10	3227
AWS	15	4840
Total	49	14,967

*Used 1 USD to LKR conversion rate of 322 Rs. on 9/10/2023

3. RESULTS AND DISCUSSION

3.1 Results and Discussions of the System

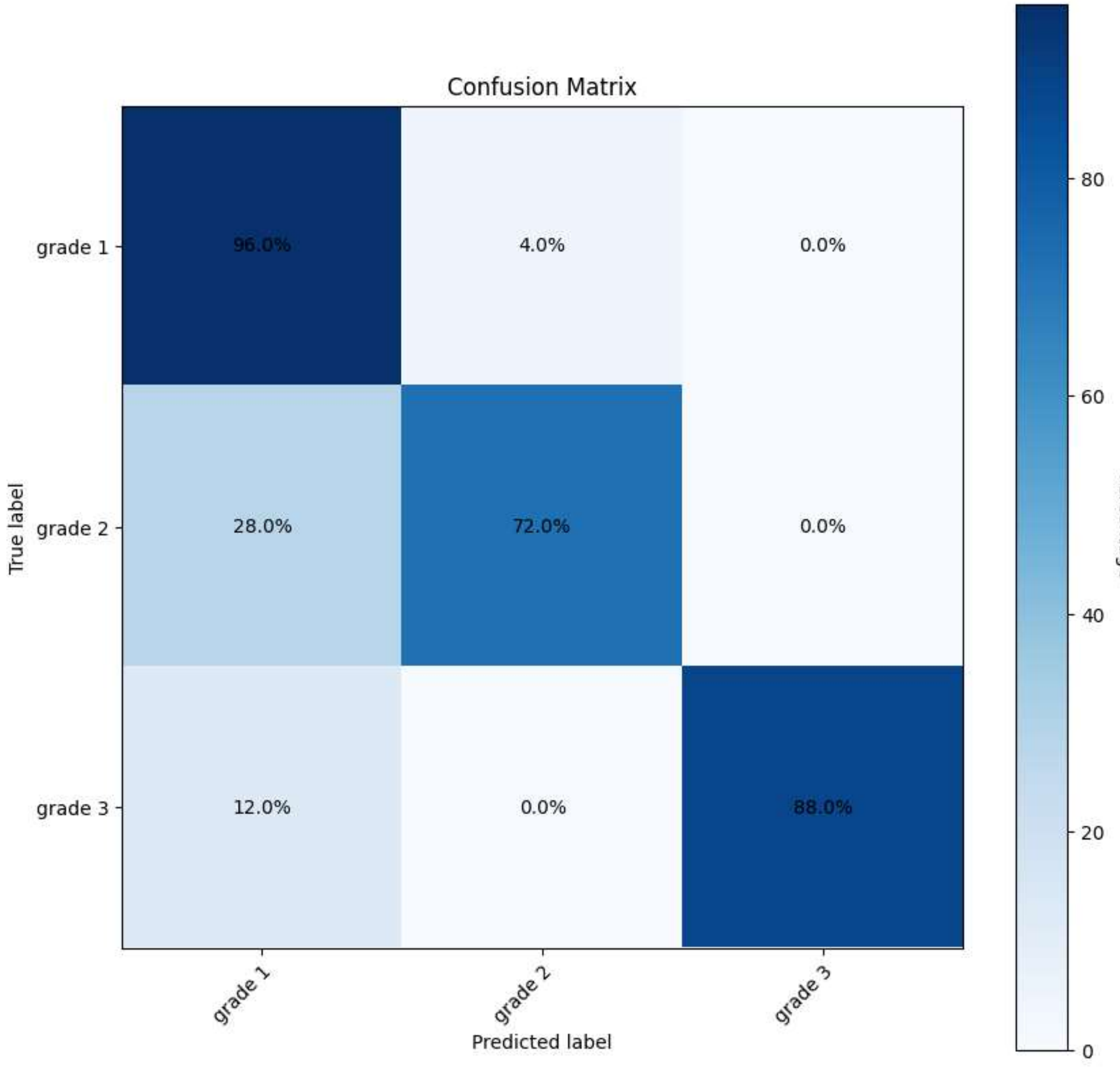

Figure 3:1 Mango Grade Prediction Confusion Matrix

The confusion matrix in Fig. 3.1 shows the accuracy breakdown of color grading prediction system. The model has an average precision score of 88% and recall average of 85% and an average f1 score of 85%. This gives an accuracy of 85%. The model has a comparatively good accuracy and further training would yield higher accuracy scores.

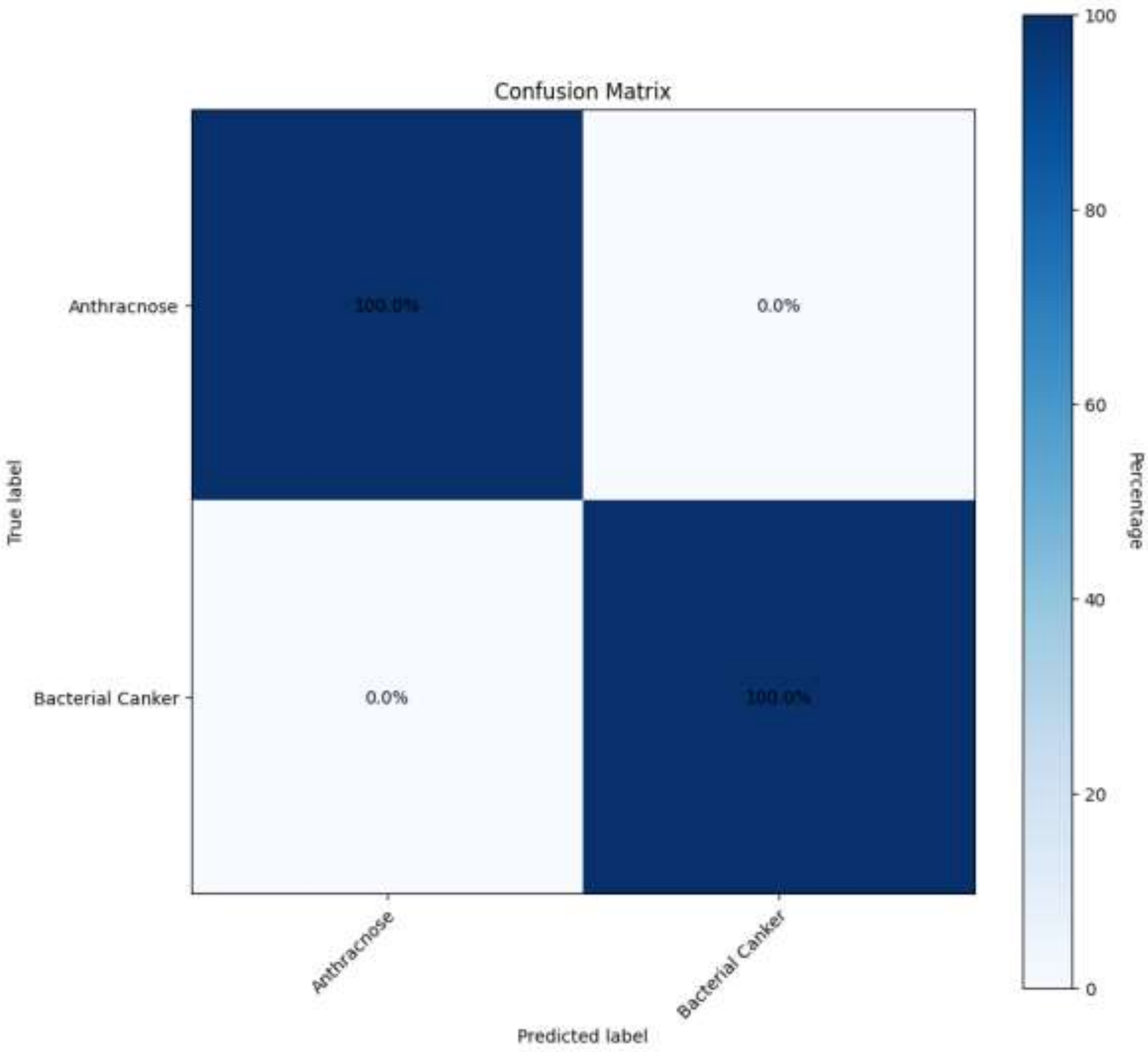

Figure 3:2 Disease Detection confusion matrix

The confusion matrix in Fig. 3.2 shows the percentage of cases of bacterial canker and anthracnose that were correctly or incorrectly classified by a machine learning algorithm. The model has an average precision of 100% and an average recall value of 100%. This gives an average accuracy of 100%. This model gives a prefect accuracy due to the high training data availability.

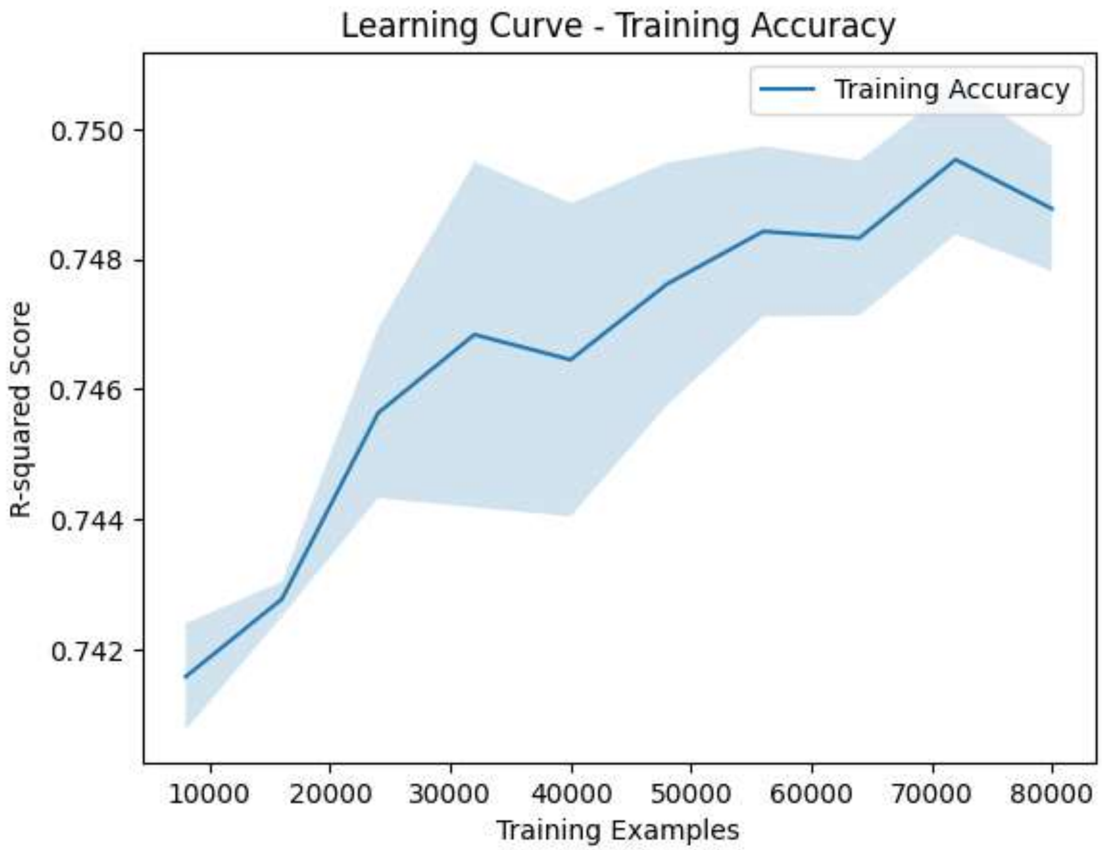

Figure 3:3 R-Squared Score of Watering System

The linear regression model of the smart mango watering system is trained using a dataset of 100,000. The dataset is divided as 80% (80,000) data for training and 20% (20,000) for testing. The training accuracy of the dataset has reached its maximum value 0.7495 when the training examples are 70,000. The R-squared score of the module is 0.74621.

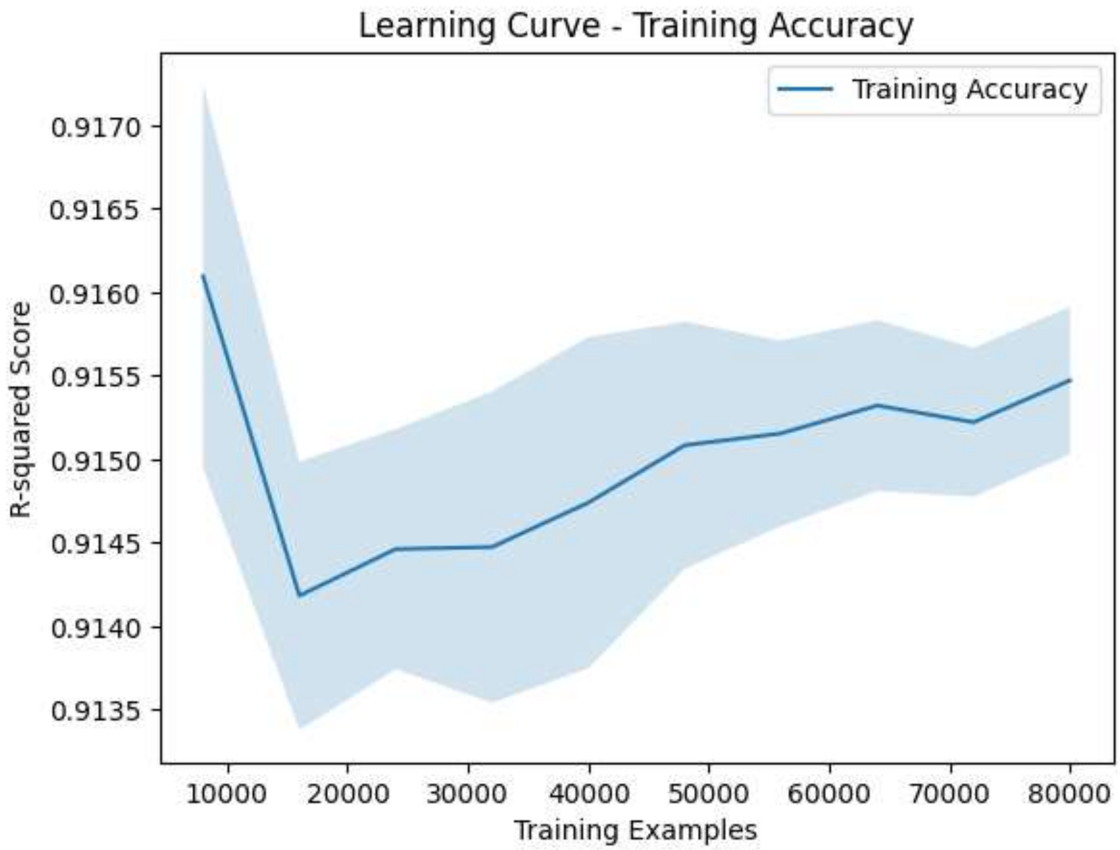

Figure 3:4 R-Squared Score of Yield Prediction

The mango yield prediction done with linear regression maxes out at a r-square accuracy of 74.9%. Further training with a larger data set should yield better results. The model was able to achieve considerably higher accuracy value compared to the yield prediction model. Further training with a larger dataset would increase the accuracy of the model.

3.2 Summary of Each Student’s contribution

Table 3:1 Summary of each student's contribution

Member	Task	Contribution
Withanaarachchi S.P. (IT20466008)	Implementation of the Smart Watering System	• Implementation the IoT device used to gather data from the plantation. • Designing of the pipe system used to distribute water in the plantation. • Deployment of the ML model used to decide the water required to the plantation based on the data collected from the IoT device. • Implementation of the mobile application.
Jayamanne B.D.N (IT20276928)	Implementation of the IoT Based Mango Grading Model	• Designing of the weighting model used to measure the weight of mangoes. • Implementation of the ML model for mango grading. • Creating of the mobile app.
Niroshani A. (IT20103354)	Implementation of the Mango Yield Prediction Model	• Implementation of the ML model of the yield prediction. • Implementation of the mobile application. • Designing the UI/UX of the mobile application.
Aksham M.Z.M. (IT20280260)	Implementation of the Mango leaf disease identification system	• Implementation of the ML model used for disease detection. • Designing of the mobile application

		• Creating the Mongo DB database and host the server on cloud and creating Virtual Machine

4. CONCLUSION

This study aims to develop a smart system for a mango planation management using Internet of Things (IoT), Machine Learning, and AI. Technology developments are now crucial in the present business environment, and plantation management and its applications may be improved to deliver the maximum degree of operational efficiency while achieving the desired performance goals. Farmers have used sensory systems to get a better understanding of their crops, minimize their influence on the environment, and preserve resources, while the Internet of Things has been linked to the automation of all agricultural practices and elements to make the whole process much more effective and efficient. Businesses have been looking for strategies to protect the resource while also improving the efficiency of their operations due to the major challenge of a resource’s shortage. In order to achieve their performance goals, smart plantation management systems are now required, and recommendations for implementing to identify the current inefficiencies in procedures and methods and develop a better strategy for improved results.

The environmental effects of the system should be taken into consideration and appropriately integrated with the Sustainable Development Goals in order to optimize the advantages of the three pillars (environment, social, and economic). Additionally, it must be made sure that operating costs do not exceed desired outcomes in order to preserve sustainability. Companies may find it easier to fulfill their goals if they have an inclination toward green activities and functions.

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6. APPENDICES

6.1 Interface of the mobile application

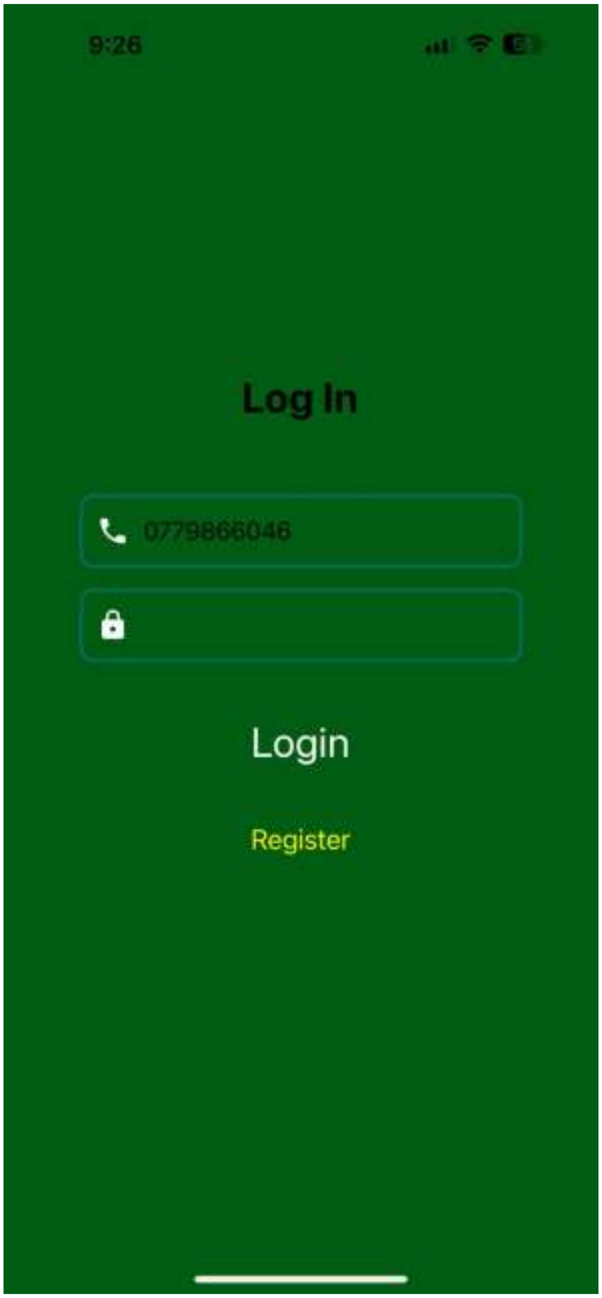

Figure 6:1Interface 1

Figure 6:2 Interface 2

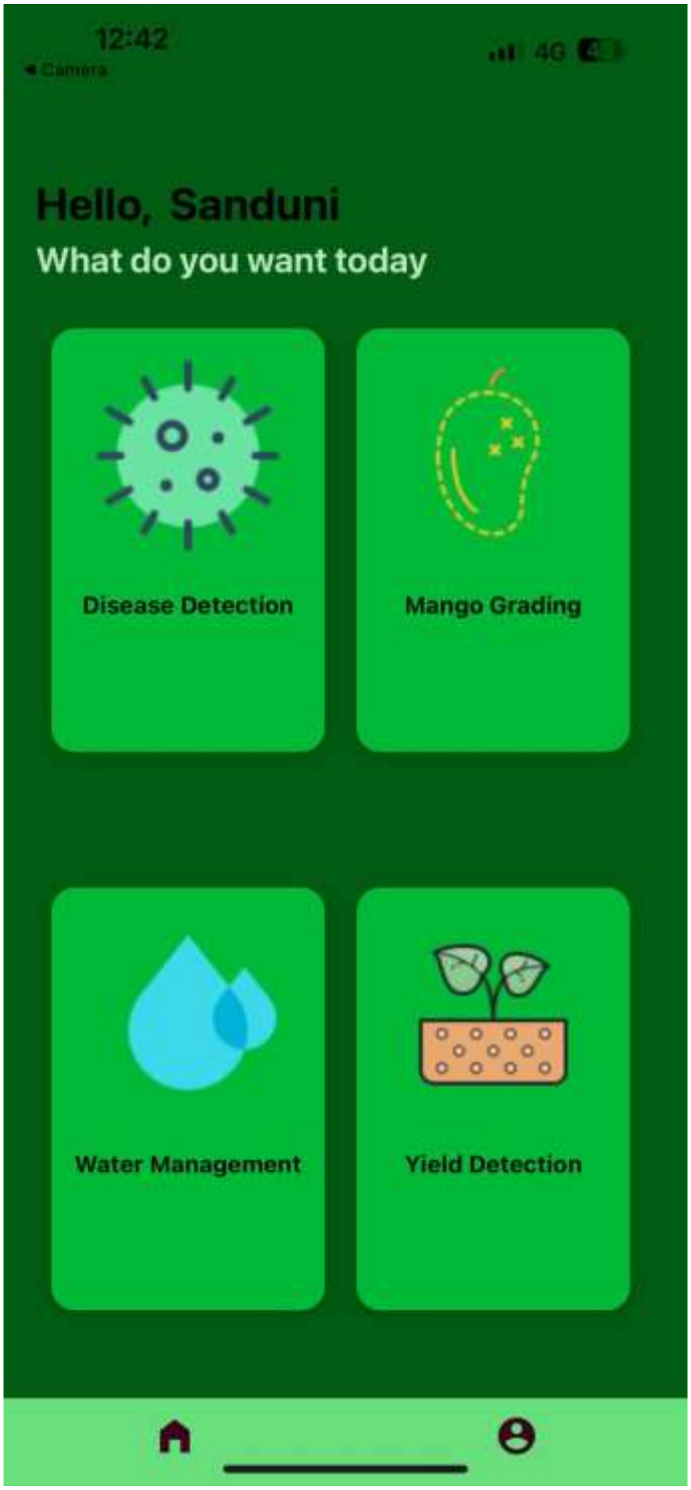

Figure 6:3 Interface 3

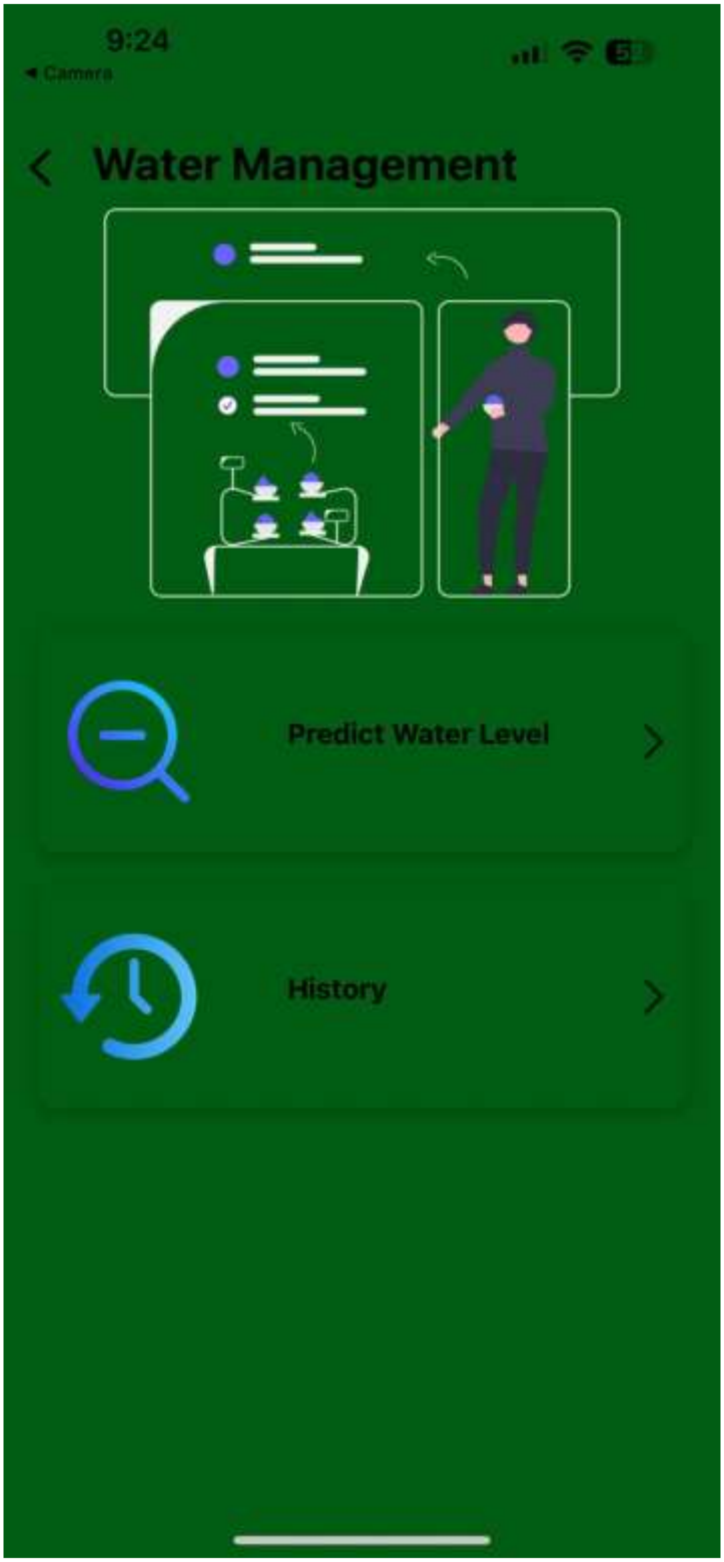

Figure 6:4 Watering System Interface

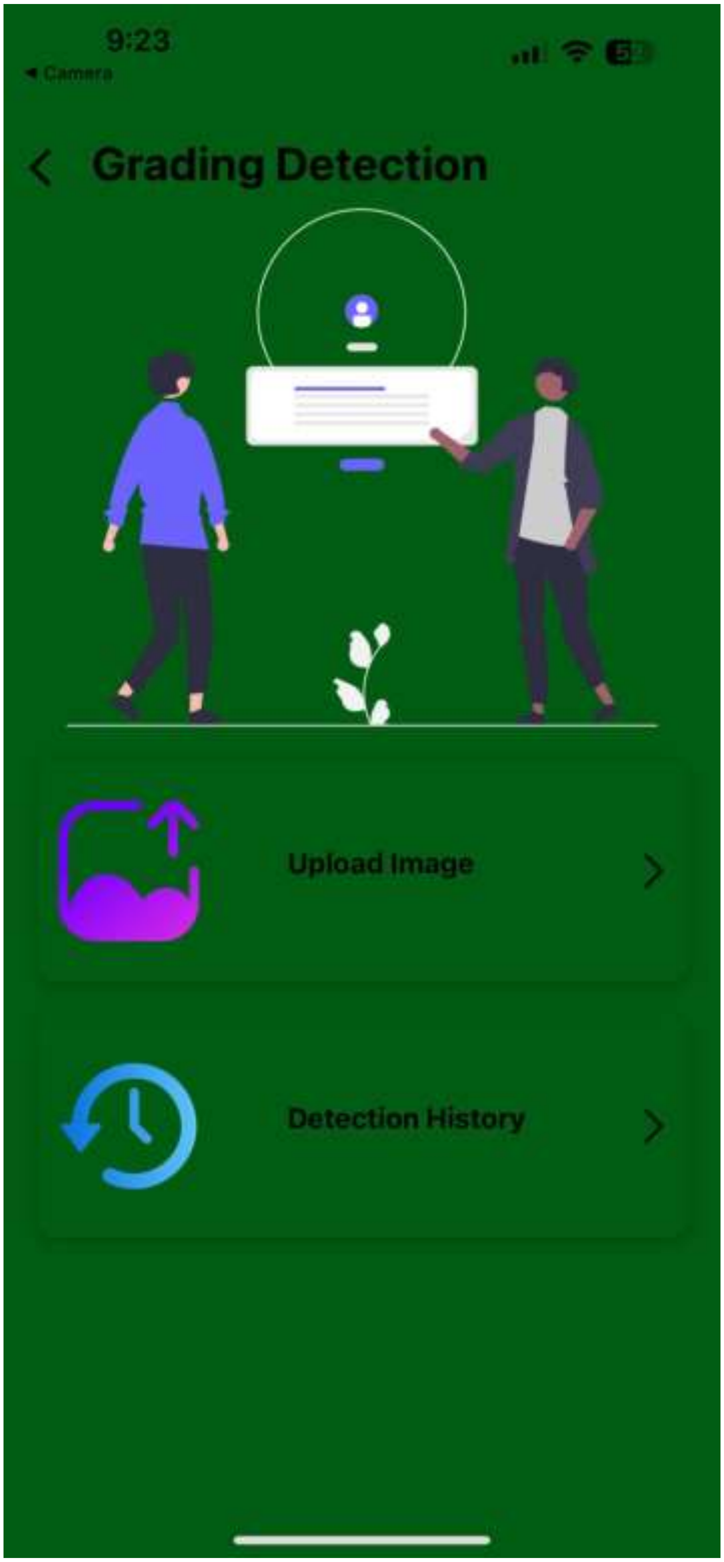

Figure 6:5 Grading System Interface

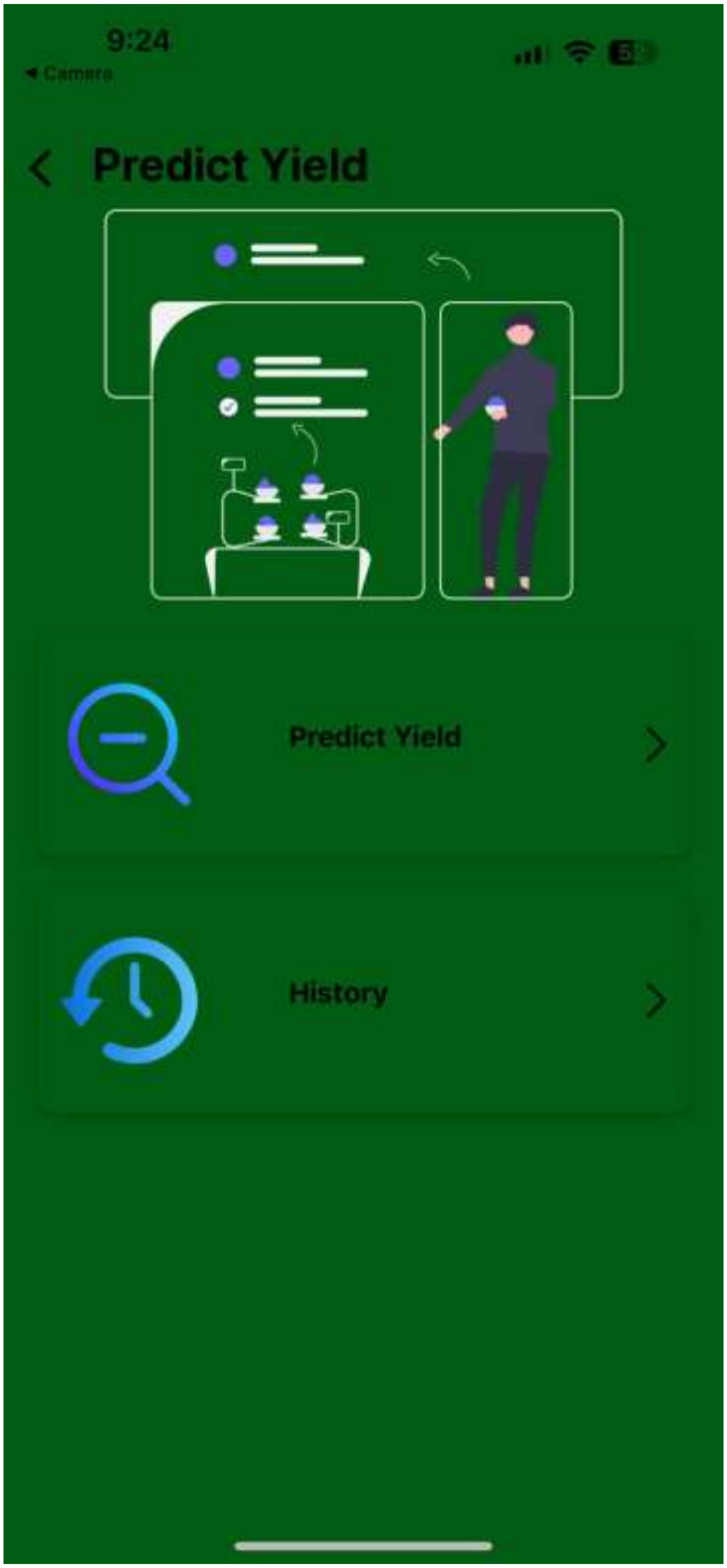

Figure 6:6 Yield Prediction Interface

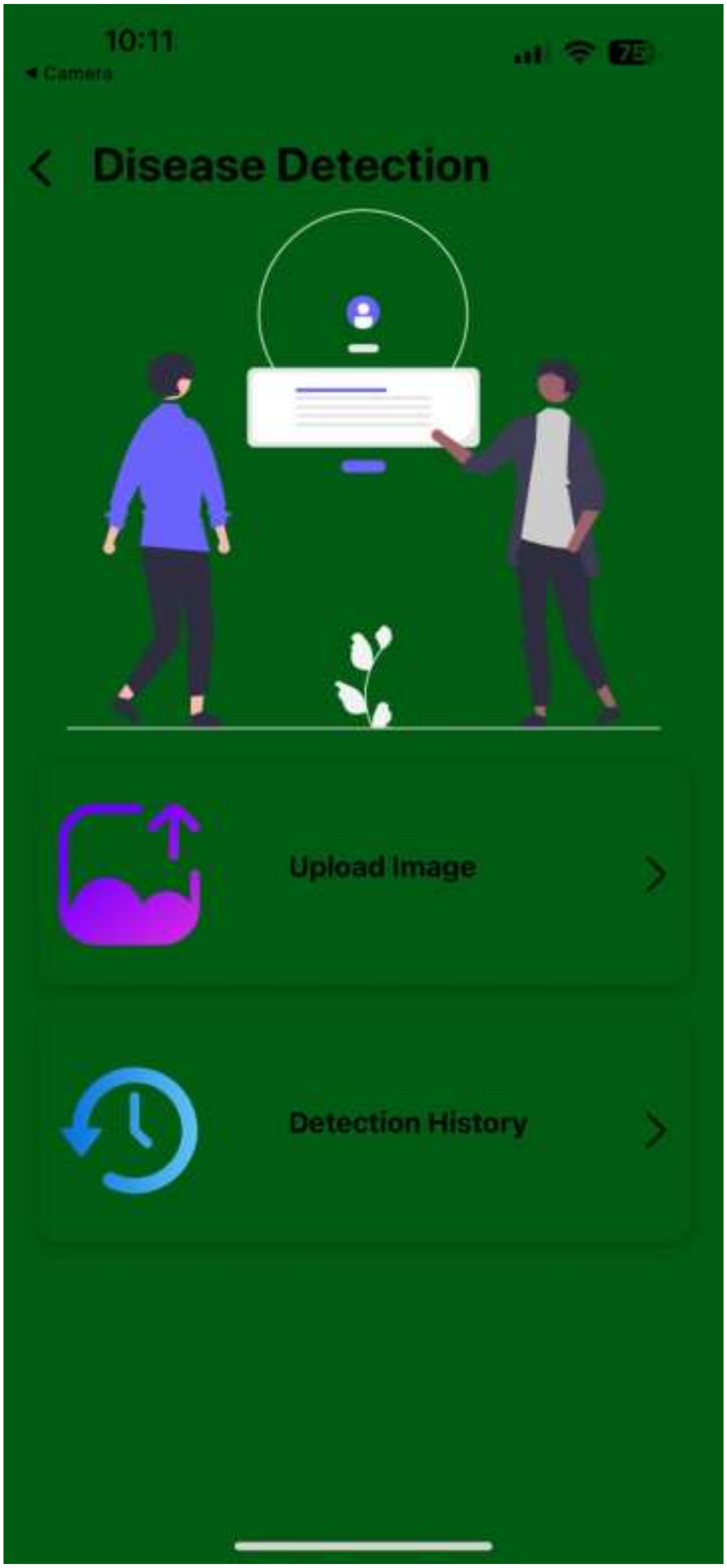

Figure 6:7 Disease Detection Interface

Figure 6:8 User Account Interface