Applied Information Technology And Computer Science Vol. 3 No. 2 (2022) 1257-1270
© Universiti Tun Hussein Onn Malaysia Publisher's Office

AITCS

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/aitcs
e-ISSN :2773-5141

Design and Development of IoT Based Smart Farming for Plant Disease Detection

Muhammad Adli Danial Rahmat[1], Suziyanti Marjudi[1]*, Raja Mohd Tariqi Raja Lope Ahmad[2]

[1] Faculty of Computer Science and Information Technology,
Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA
[2] Salonika Systems Sdn. Bhd,

DOI: https://doi.org/10.30880/aitcs.2022.03.02.077
Received 10 October 2020; Accepted 02 November 2022; Available online 30 November 2022

Abstract: Plant disease identification is an important factor that farmers should emphasis while planting in the garden. If the garden area is too vast, the process of diagnosing plant diseases takes a long time. Arduino cameras were used to interact with a Smart Farming system following the emergence of new technologies like the Internet of Things (IoT). The goals are to investigate plant disease detection using an object-oriented approach, design a system that incorporates plant disease categorization using machine learning techniques, and evaluate the system. Planning, Designing, Developing, Testing, Release, and Feedback are all steps of the Agile process for software development. Modeling through categorization with deep learning approach will be used to detect plant disease. As a result, this approach may more precisely increase the efficacy and efficiency of evaluation.

Keywords: Internet of Things, Plant Disease Detection, Agile, Smart Farming

1. Introduction

Several countries have focused the agricultural industry as a new technology to society especially farmers. Malaysia is a country in Southeast Asia that relies heavily on agriculture to alleviate poverty and maintain peace. The World Bank estimates that 78 percent of the world's poor live in rural regions and rely on agriculture for a living [1]. Furthermore, the industry is under increasing pressure to fulfil the rising population's consumer demand. The efficiency, productivity, and optimization of agricultural practises are critical for these two reasons. In Malaysia, IoT-based smart agriculture aims to enhance the agricultural industry while also reducing poverty.

Technology that has been acquired in terms of aspects of planting, watering, harvesting up to crop health. The presence of Smart Farming when developing Internet of Thing (IoT) connected devices applications or websites in agriculture. The development of IoT can also improve in terms of aspects of agricultural practices to grow more advanced. In agriculture, like in other industries, the Internet of

*Corresponding author: suziyanti@uthm.edu.my

Things promises hitherto unattainable efficiency, resource and expense savings, automation, and data-driven operations. However, in agriculture, these advantages aren't enhancements; they're remedies for a whole industry grappling with a slew of severe issues. Farmers can monitor their product and conditions in real time thanks to IoT-enabled agriculture. With excelled efficiency, they have quick insights, can foresee problems before they occur, and make well-informed judgements on how to prevent them. IoT solutions in agriculture also provide automation, such as demand-based irrigation, fertilisation, and robot harvesting. 77% of the Malaysia's population will live in cities by the time we reach 32.37 million people [2]. Short food supply chains are possible with IoT-based greenhouses and hydroponic systems, and they should be able to feed the masses. Food can be grown in supermarkets, on the walls and rooftops of buildings, in shipping containers, and, of course, in the comfort of everyone's home, thanks to smart closed-cycle agricultural systems. In agriculture, IoT refers to the improved agility of operations. Farmers can immediately respond to any significant change in weather, humidity, air quality, or the health of each crop or soil in the field thanks to real-time monitoring and forecast systems. New capabilities aid agriculture experts in saving crops in the face of harsh weather fluctuations.

Farmers and agricultural specialists must be able to detect illnesses in plants at all times. The suggested system's main goal is to use IoT to identify plant illnesses. The illness starts on the plant leaves in the majority of cases. As a result, we have considered detection of plant disease on leaves in the proposed study. Images are a valuable source of data and information in the agricultural sciences. In recent years, photography has been the only tool utilised to replicate and publish such data [3]. However, mathematically processing or quantifying photographic data is challenging. Because of improvements in computers and microelectronics linked with conventional photography, digital image analysis and image processing technologies assist to bypass these issues. These technologies help in the enhancement of pictures from the microscopic to the telescopic visual range, as well as the analysis of such images. Several image-processing applications for agricultural operations have been created. In order to enter the photos, these apps employ camera-based hardware devices or colour scanners. With ever-changing computing systems, computer-based image processing is experiencing fast innovation. The specialised imaging systems on the market, which need the user to press a few keys to obtain results, are not particularly adaptable and, more significantly, come at a premium price.

However, utilising scientific knowledge and experience, it is important to build a highly efficient approach for detecting illness signs. Initially, datasets are used to collect the acquired crops leaf pictures of fruits and vegetables. A normal digital camera or a high-resolution mobile phone camera may be used to capture the photos. The gathered leaves of fruits and vegetables are then subjected to image processing. For identifying plant illnesses, several image processing techniques such as capture, pre-processing, restoration, segmentation, augmentation, feature extraction, and classification are used [4]. The pre-processing approach converts raw input leaf image datasets into suitable process datasets format in order to improve leaf image quality and remove unwanted sections from the pictures. To properly diagnose leaf illness, image augmentation is used to change and facilitate the leaf picture representation. As a result, the training and testing leaf image datasets are supplemented to reduce the risk of overfitting and to improve the model's simplicity [5]. The augmentation approach is used to enlarge the original leaf image collection using flipping, cropping, and rotating techniques, as well as convert the leaf pictures to RGB using colour transformation. The enhanced leaf pictures, on the other hand, are generated to keep the image quality and size in the healthy and unhealthy leaf databases balanced. Additionally, the classification method may be used to detect diseases in colour images. Convolutional neural network (CNN) models are used as a classification technique in this article. Many present agricultural systems can detect some plant leaf diseases but do not give a strategy for preventing them. As a result, utilising a graphical user interface, to offer a system that can identify illnesses and also suggest a preventative action.

2. Related Work

2.1 Overview of Paddy and Chilli in Malaysia

In this section to introduce the definition, type of disease, symptoms and control of paddy and chilli in Malaysia. Paddy or rice paddy is flat, small that can locate in southern and eastern of Asia. Wet-rice farming is the most common agricultural practise in the Far East, where it takes up a tiny percentage of total area yet feeds the bulk of the rural people. Malaysia continues to implement tough and progressive measures throughout the Eleventh Malaysian Plan (2016–2020) and National Agro-Food Policy (2011–2020) steps to encourage the growth of the paddy and rice sectors [6]. Rice is a major crop in the globe, with over half of the world's population relying on it for survival. Rice is a staple cuisine for many people across the world, including Malaysians. Chilli is a called to 'Capsicum annuum and capsicum frutecens'. Capsicum or "Kapsimo" is derived from the Greek word meaning "to bite". However, many decades ago, they adapted to Malaysian Tropical Climate. In Malaysia, Chilli (Capsicum annum L.) plant is a high-value vegetable is grown in soilless culture pots [7]. Lack of care of rice and chilli crops can cause the disease to spread to the whole plant over a long period of time. Therefore, control for both crops should be taken care of to prevent disease.

2.2 Comparison with Existing Systems

As the explanation for each existing system that related and compared to the features of the proposed system. This includes the features contained in Plant Disease Detection by using IoT. The comparison results are shown in Table 1.

Table 1 System's Comparison

Features \ System	Plant Leaf Diseases Identification using Convolutional Neural Network with Treatment Handling System	Brown Spot Disease Severity Level Detection using Binary-RGB Image Masking	Paddy Disease Detection System Using Image Processing	IoT Based Smart Farming for Plant Disease Detection
System Platform	Web-Based	Web-Based	Web-Based	Web-Based
Login / Registration	No	No	No	Yes
Administrator login	No	No	No	Yes
Software Development	MATLAB R2019a	-	MATLAB 7.0	Jupyter Notebook, Visual Studio Code
Data Mining Technique	Classification, Clustering	Classification	Classification	Classification
Database	No	No	No	Yes

Live-Chat	No	No	No	Yes
Dashboard	No	No	No	Yes
Type of Disease	Bacteria Disease, Septoria Leaf Spot, Alternaria (Early Blight)	Brown Spot (BS)	Brown Spot Disease, Narrow Brown Spot Disease, Blast Disease	Paddy: Brown Spot, Hispa, Leaf Blast Chilli: Leaf Curl, Leaf Spot, Whitefly, Yellowish

3. Methodology/Framework

The choose of methodology for project development was using agile model. This model necessitates ongoing meeting with stakeholders as well as continual development at each level. This lifecycle model started with several ways to expedite development in order to bring a new software to market more quickly. Figure 1 below show the agile model as a project development methodology.

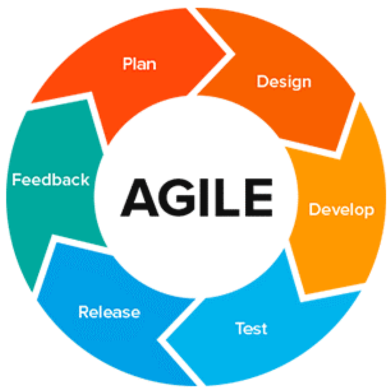


Figure 1 Agile Methodology Model [8]

3.1 Planning Phase

The system and IoT hardware are integrated in this project. IoT devices should be able to identify plant disease and the system should be able to monitor plant disease detection via a dashboard. The crop of plant illness should be upgraded or extracted some relevant information from it using an image processing technology.

3.2 Designing Phase

Draw.io, an online app that allows you to simply draw diagrams, was utilised to kick off the design phase. It is a free source with several benefits, such as numerous solid collaboration capabilities and a user-friendly layout that makes it easier to grasp, particularly for beginners.

3.3 Developing Phase

The use of Visual Studio Code as a code editor for the development of web systems. It's a free application that supports as many programming language. MySQL is a free-to-use relational database that meets all application development needs. For a training and testing model that requires the use of a Jupyter Notebook and the Anaconda environment. The IoT hardware will be connected to the web system through a Wi-Fi signal, allowing the system to display the camera via the Arduino camera.

3.4 Testing Phase

Rather of waiting for development to finish before testing, new features are introduced as they are developed. In order for all stakeholders to work closely together throughout the testing phase, questions and responses are crucial. The system should be ready for the next step after the stakeholders are pleased with it.

3.5 Release Phase

The deployment phase will begin, and end-users will be the ones to use it. It's crucial to keep a watch on these early stages for any defects or errors that were missed during testing. There should be a transfer with adequate training between the production and support teams. The system's engineers should maintain it functioning smoothly and demonstrate how to utilise it to consumers. This phase will focus on finishing the documentation for end users and production employees who will be directed through the system.

3.6 Feedback Phase

Finally, when the system has been released to end users, there is a feedback phase. This online system will be assessed in this phase to identify some user input so that it can be improved. During this phase, the developers also learn how the web system will effect the goals.

4. Results and Discussion

4.1 System architecture

System architecture is a form of software that offers fundamental operations and automation and is used to define the structural design of systems. Figure 2 show the system architecture of IoT Based Smart Farming for Plant Disease Detection.

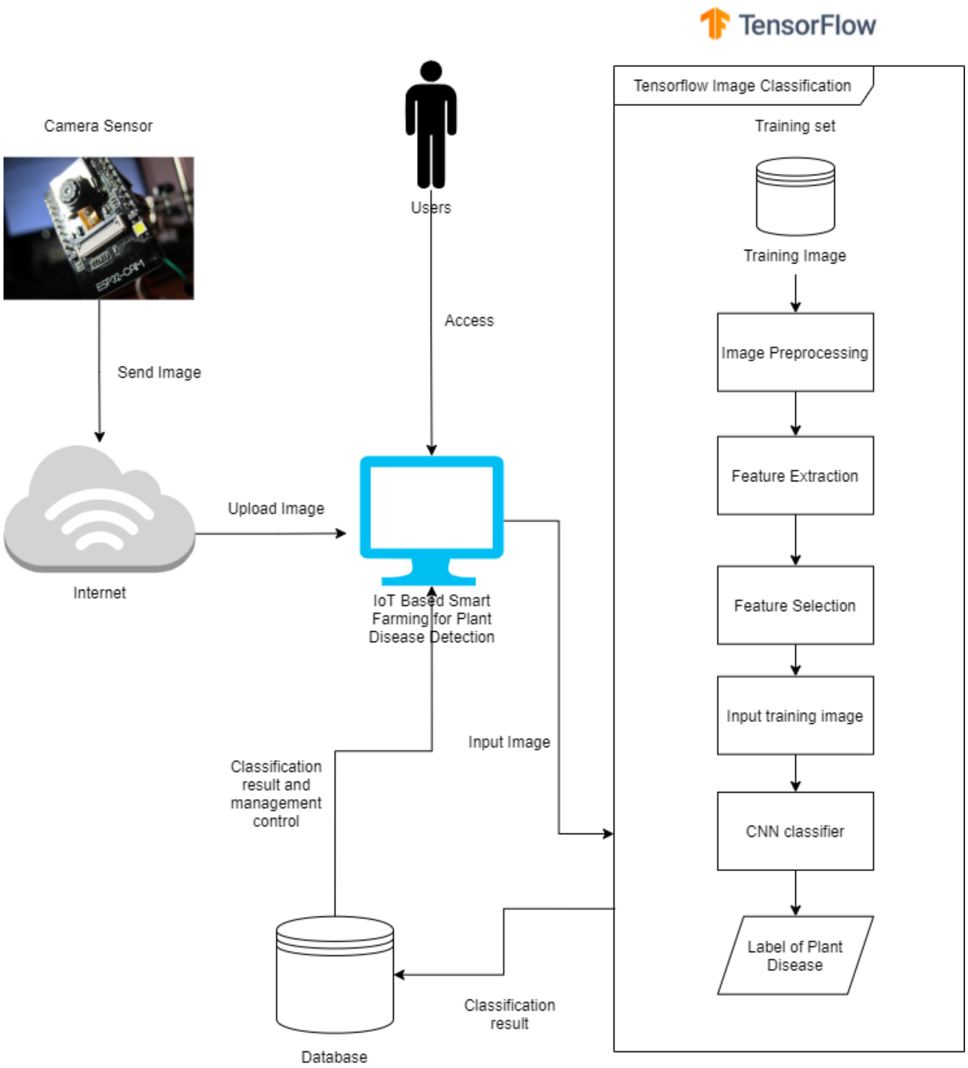


Figure 2 System architecture of IoT Based Smart Farming for Plant Disease Detection

4.2 Main Flowchart

In a system design shows overall of flowchart of the IoT Based Smart Farming for Plant Disease Detection. Flowchart is a way of displaying how data flows in the system. Figure 3 show the illustration of flowchart with including all modules and operations.

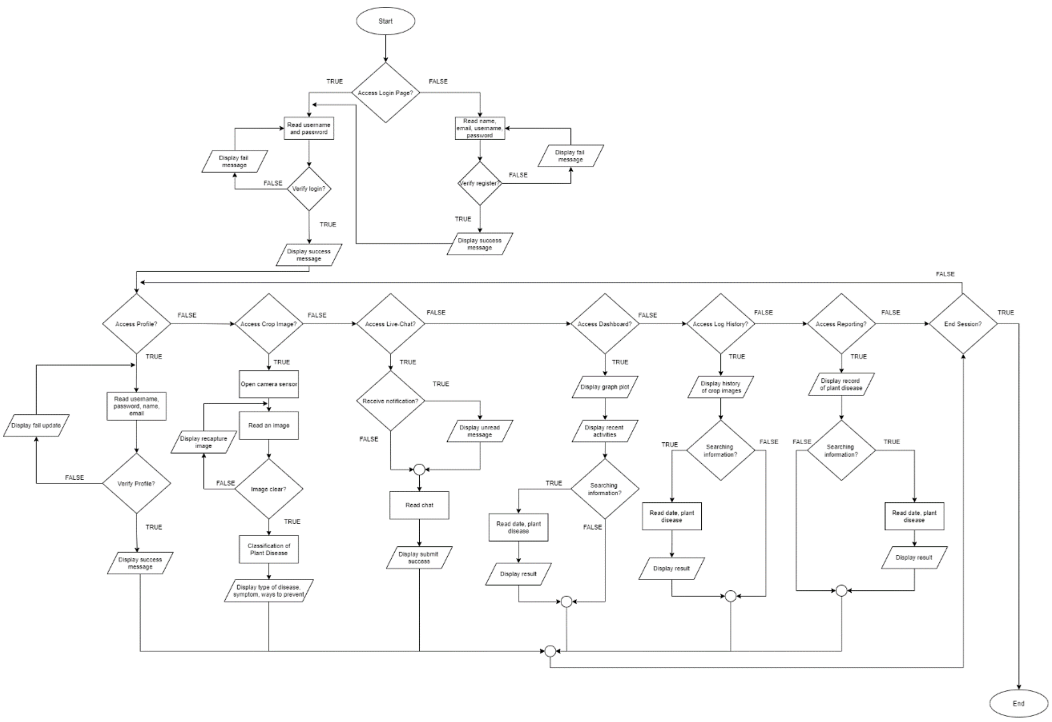


Figure 3 User Flowchart for IoT Based Smart Farming for Plant Disease Detection

4.3 Main Use Case

Figure 4 below show use case diagram of the development system that represents a scenario in which the system interacts with people, external systems or organizations.

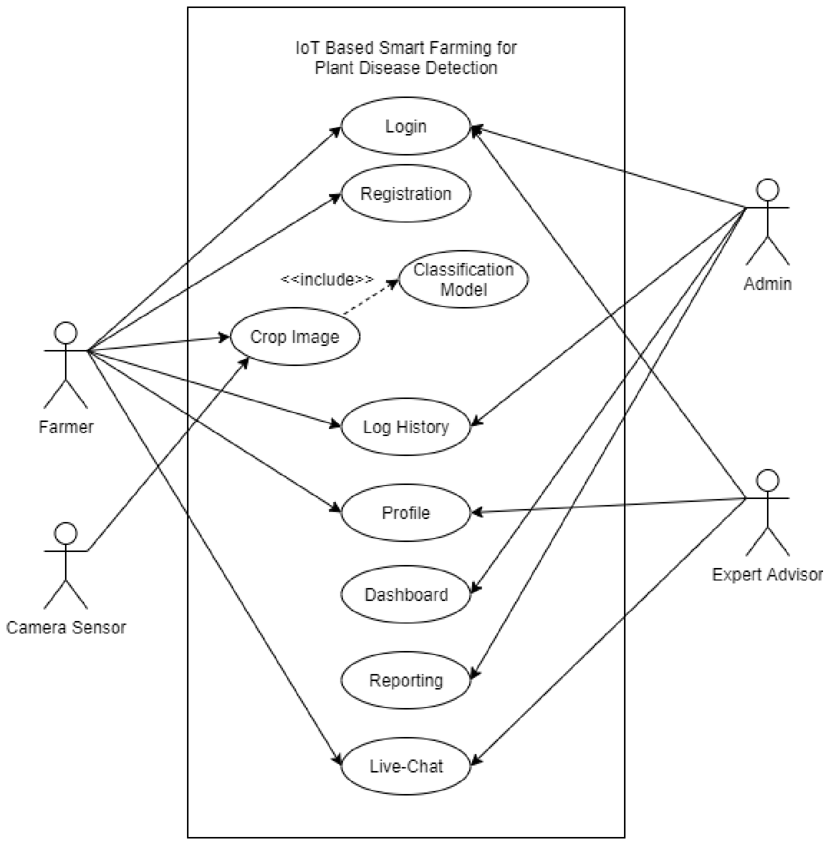


Figure 4 Use Case Diagram for IoT Based Smart Farming for Plant Disease Detection

4.4 Main Menu

Figure 5 below show home interface after the user success login into the system. In this page, the system will show the name of user at the top right. If the user did not login yet, the crop disease menu will not appear.

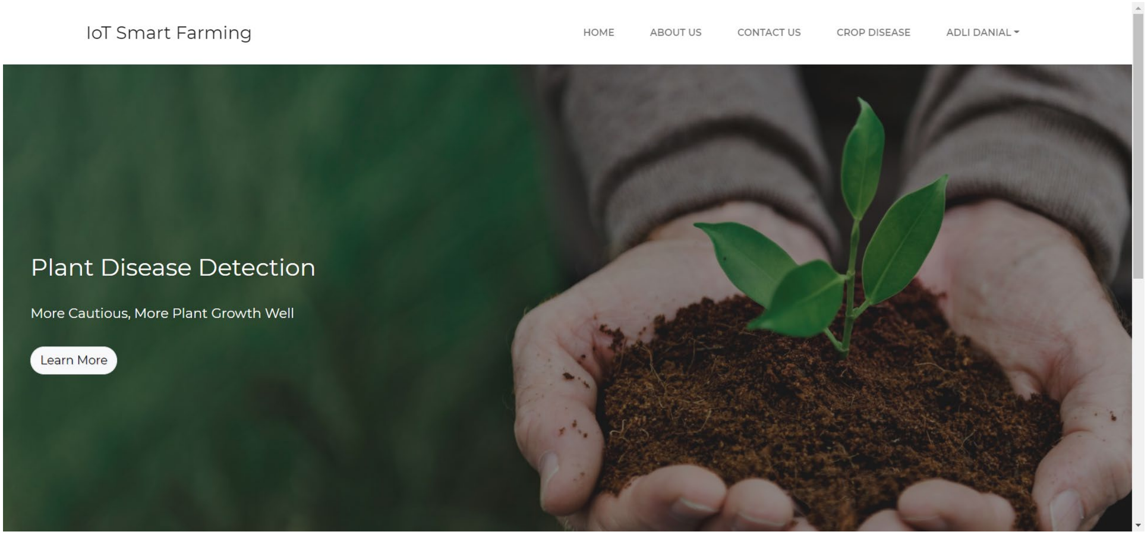


Figure 5 Home Interface

4.5 Crop Disease

Figure 6 below show crop disease interface that allow user to capture image by using IoT hardware or upload the image to identify the category of plant disease. After that, the result will shows a disease of plant, symptom and prevention of disease.

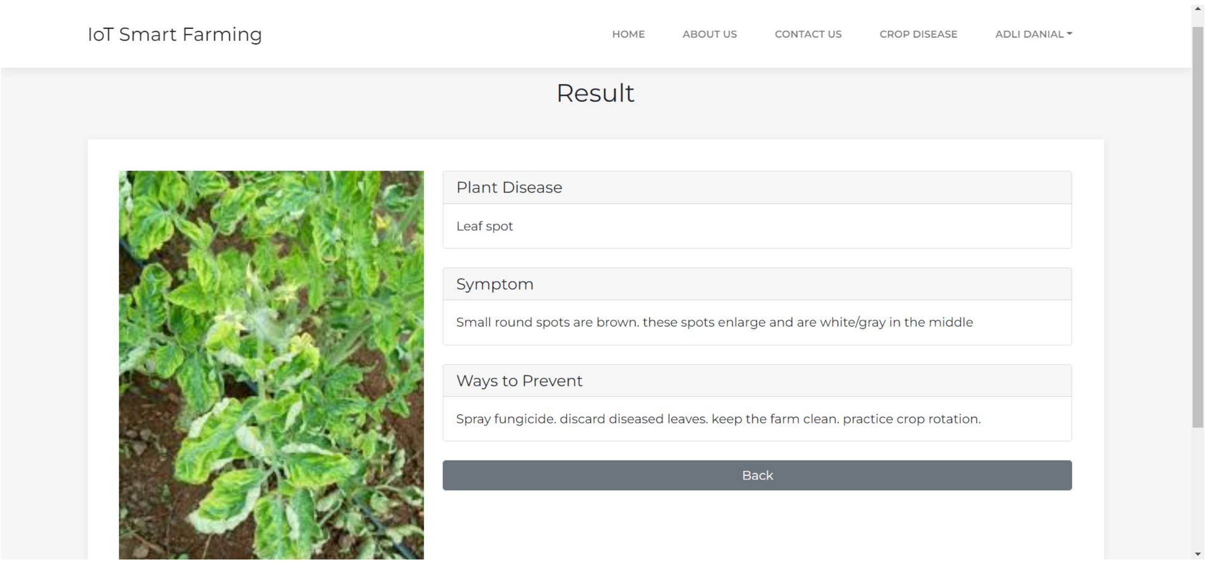


Figure 6 Crop Disease Interface

4.6 Accuracy Prediction Result

Figure 7 below shows the accuracy prediction result from the CNN model by using Tensorflow. This deep learning is processing the image recognition to identify the classification of plant disease. During the training of model, the final result shows the accuracy prediction is 0.60 or 60%

```
#model = load_model('../output/kaggle/working/model.h5')
final_loss, final_accuracy = model.evaluate(X_val, Y_val)
print('Final Loss: {}, Final Accuracy: {}'.format(final_loss, final_accuracy))

5/5 [==============================] - 1s 156ms/step - loss: 1.5008 - accuracy: 0.6042
Final Loss: 1.5007842779159546, Final Accuracy: 0.6041666865348816
```

Figure 7 Accuracy Prediction Result

4.7 User Acceptance System

User acceptance should do after the phase of development system. This user acceptance to determine the functionality of this system whether the error exist from the system. Table 2 below show the user acceptance system for the IoT Based Smart Farming for Plant Disease Detection.

Table 2: User Acceptance System

	Functionality	Expected Result	Testing Result
1	**Login Module** The users allow to login into the system by using email and password. The users allow to input a valid email and password to be logged in as user. The system should alert to the users for any invalid input. The system should redirect user to respective pages according to the roles of user once successful login.	The user's success to login the system by using email and password. The user's success allow to input a valid email and password to be logged in as user. The system success showing alert to the users for any invalid input. The system success showing redirect user to respective pages according to the roles of user once successful login.	PASS
2	**Registration Module** The system should allow the new user to register before login. The system should show any error includes empty field, invalid email or existing email.	The system success that allows the new user to register before login. The system success showing any error includes empty field, invalid email or existing email.	PASS
3	**Crop Capture Module** The users allow to capture the image of crop disease from camera sensor hardware. The system should show result types of plant disease. The system should show briefing the effect of plant disease.	The user's success to capture the image of crop disease from camera sensor hardware. The system success shows result types of plant disease. The system success show briefing the effect of plant disease.	PASS

	The system should show information or tips on how prevent the plant disease.	The system success shows information or tips on how prevent the plant disease.	
4	**User's Information Module** The system should show their personal user's information. The system should allow users update their personal information.	The system should show their personal user's information. The system should allow users update their personal information.	PASS
5	**Live-chat Module** The system should users allow to ask with experts in a live-chat box.	The system success shows users allow to ask with experts in a live-chat box.	PASS
6	**Dashboard Module** The system should show the data analytic in visualization to the users especially the administrator.	The system success shows the data analytic in visualization to the users especially the administrator.	PASS
7	**Reporting Module** The system should allow users to show the record log. The system should allow users to search, update and delete the specific information. The system should allow users to generate the report based on the information.	The system success allows users to show the record log. The system success allows users to search, update and delete the specific information. The system success allows users to generate the report based on the information.	PASS
8	**History Log Module** The system should allow store information of crop disease into history log. The system should allow users to search, update and delete the history log.	The system success allows store information of crop disease into history log. The system success allows users to search, update and delete the history log.	PASS

Based on the expecting results, all the modules have been successfully achieved and meet the requirement of the target users. These modules have met the objectives and solved the problem statement of this project.

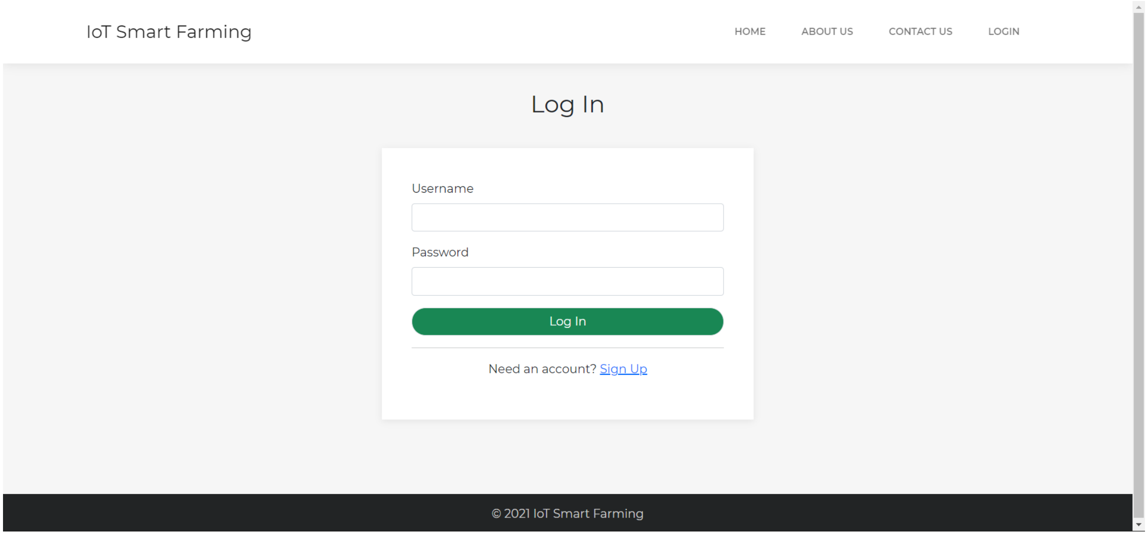
5. Conclusion

Through modern technology, IoT Based Smart Farming for Plant Disease Detection may assist farmers in identifying plant illnesses more easily. The benefits of this technique include exposing the farmer to plant care procedures based on disease category and stressing the pattern that covers disease regions on the leaves. With new capabilities like live-chat, communication exchanges around plants are becoming more linked. This system will be easier to use, with rapid access to popular features and actions.

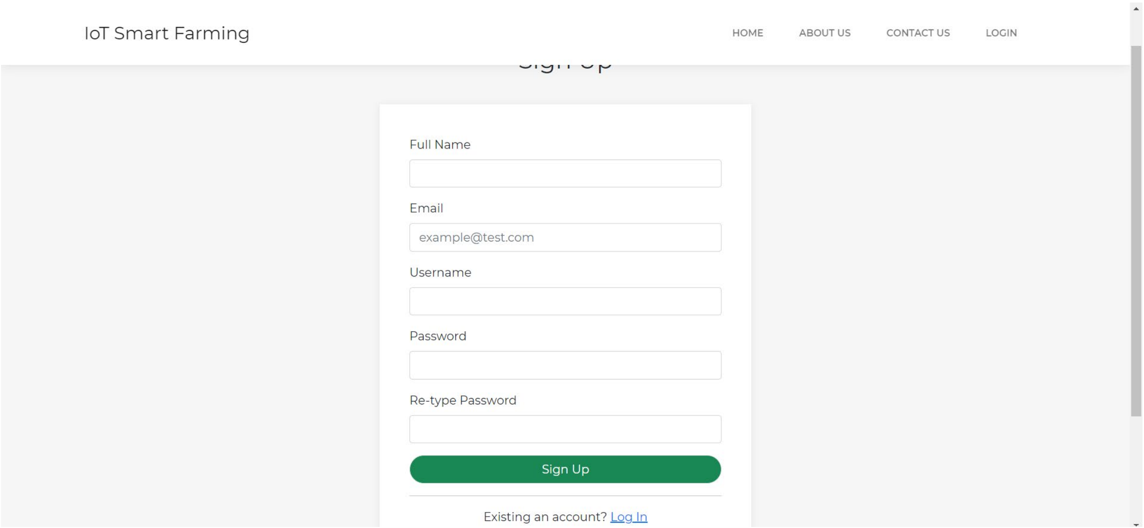
Acknowledgment

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM) through Grant SEPADAN RE-SIP (M075).

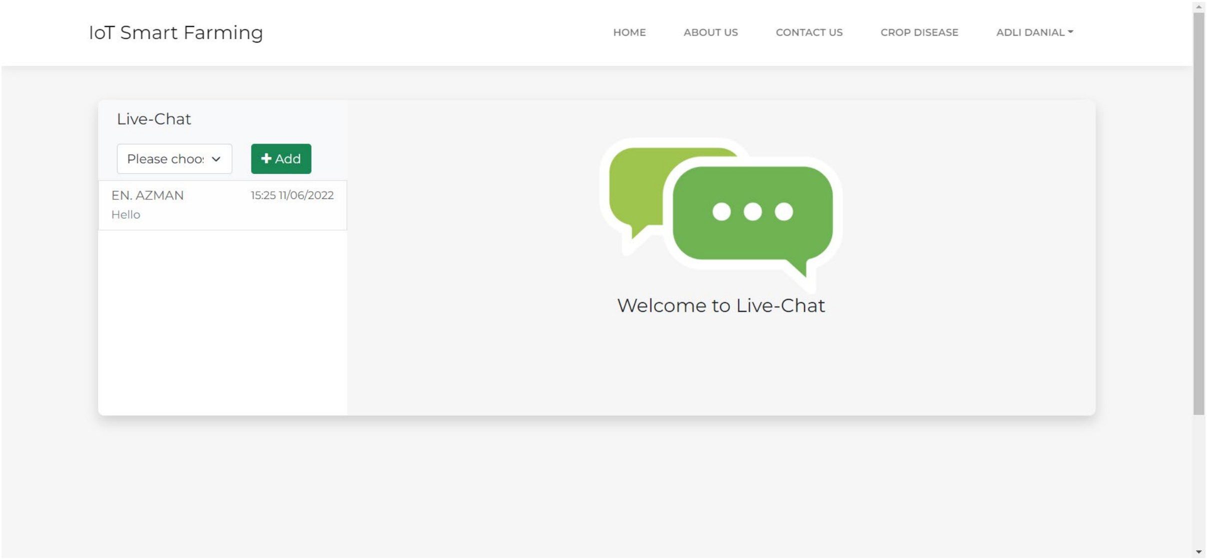
Appendix A



Log In Interface



Register Interface



Live-chat Interface

References

[1] World Bank Group. (4 October, 2021). Agriculture and Food. Retrieved from World Bank: https://www.worldbank.org/en/topic/agriculture/overview

[2] Urban population (% of total population) - Malaysia. (2018). Retrieved from The World Bank: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=MY&name_desc=true

[3] Rosenblum, N. ,. (3 December, 2020). history of photography. Retrieved from Encyclopedia Britannica: https://www.britannica.com/technology/photography

[4] Wanjale, C. G. (2017). A Modern Approach for Plant Leaf Disease Classification which Depends on Leaf Image Processing. ICCCI-2017, Coimbatore, INDIA.

[5] Shorten, C. K. (6 July, 2019). Journal of Big Data. Retrieved from A survey on Image Data Augmentation for Deep Learning: https://doi.org/10.1186/s40537-019-0197-0

[6] Firdaus, R. B. R., Leong Tan, M., Rahmat, S. R., & Senevi Gunaratne, M. (2020). Paddy, rice and food security in Malaysia: A review of climate change impacts. Cogent Social Sciences, 6(1). https://doi.org/10.1080/23311886.2020.1818373

[7] Zakaria, N. I., Ismail, M. R., Awang, Y., Megat Wahab, P. E., & Berahim, Z. (2020). Effect of Root Restriction on the Growth, Photosynthesis Rate, and Source and Sink Relationship of Chilli (Capsicum annuum L.) Grown in Soilless Culture. BioMed Research International, 2020. https://doi.org/10.1155/2020/2706937

[8] “What's the agile methodology and how can it benefit your enterprise?,” The Agile Methodology and Its Benefits | WAM. [Online]. Available: https://www.wearemarketing.com/blog/what-is-the-agile-methodology-and-what-benefits-does-it-have-for-your-company.html. [Accessed: 29-Dec-2021].