UNIVERSITI TEKNIKAL MALAYSIA, MELAKA
FAKULTI TEKNOLOGI MAKLUMAT DAN KOMUNIKASI

WORKSHOP 2

SYMBIOTE , AN INTELLIGENT ASSISTANT
(SMART AND PRECISION AGRICULTURE ASSISTANT)
(FINAL REPORT)

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ACKNOWLEDGEMENT

First of all, we would like to thank our supervisor, Ts. Dr. Sek Yong Wee for guiding us with the project, providing ideas and suggestions to us, and helping us to complete our task.Not to forget, we would also like to recognize our university, **Universiti Teknikal Malaysia Melaka (UTeM)** for providing us a chance to test ourselves abilities and skills, and providing us such a good opportunity to show ourselves.

ABSTRACT

The agricultural sector in Malaysia accounts for about 8.4% of the GDP and employs 14.5% of the total labor force (CIA, 2007). Malaysian agricultural production consists of tree crops (mainly for export), rice and livestock (mainly for domestic consumption), and fruits and vegetables (both export and domestic consumption). Main export crops include oil palm, rubber, cocoa, pineapple and pepper and cover over 75% of cultivated land. The government is encouraging a shift of production to higher value crops. Thus, farmers are now focusing more on the supply chain of cash crops such as chili and cucumber. The aim of this project is to create an all-in-one platform for farmers to automate the traditional agriculture practice into precision farming practice and also to create a higher chance for farmers to bring their productions straight to the end consumer without the involvement of middlemen factor.

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1.0 CHAPTER I : INTRODUCTION

1.1 Introduction

Smart farming refers to managing crops using technologies like IoT, robotics, drones, and AI to improve the quality and quantity of crops, thus reducing the human labor needed for agricultural production and generating high agricultural revenue. In this project, we will be focusing on the use of IoT and AI in the smart farming system. The goal of this project is to develop a smart farming system to monitor the crops in real-time with the recommendation system for the precise level of Electrical Conductivity Level (EC) of stock fertilizer solution that should be mixed and given to the crops as most farmers dwellings are they have no idea how much EC level their stock fertilizer solution should be in order for the crops to give out increased yields. Data like pH, temperature, and soil moisture level will be collected using IoT with the aid of precise sensors. The data collected will be used to examine the conditions of the crops in real time and also to create high accuracy Machine Learning models for EC recommendation system using the interactive website and mobile application. Moreover, we will be also focusing on forecasting the fluctuations of cash crops prices in daily manner as many factors are now influencing the fluctuations of cash crops' prices nowadays. This forecasting could actually provide a clear insight for farmers in two elements which are :

- When does a certain crop's market is bullish and bearish.

- When is the perfect season to plant and harvest.

1.2 Problem Statement

- Expanding population growth causes an increased demand for crop yields. There is a need to create a smart farming system to ensure agricultural productivity.
- Farmers are unable to monitor the condition of their crops in real-time. Farmers need to do a lot of labor work to deliver the high quality and quantity of crops.
- The changing climate and weather in Malaysia often result in crop waste and thus less profitability. Crops real-time sensors are required to control the pH, temperature, soil moisture level, etc. allowing farming to be more profitable, efficient, safe, and environmentally friendly.

- Many farmers face issue when it comes to identifying price fluctuations of crops in global market for import and export purposes. By creating this system farmers can identify which crops can be planted at which season to be more profitable

1.3 Objectives

- To develop a database module using Arduino electrical conductivity fertilizer sensor, pH level sensor and temperature sensor.
- To integrate the price fluctuation of the crops using machine learning models for prediction.
- To design mobile and web apps that connect with the data collected to help the farmers control and manage the agricultural activity.

1.4 Project Scope

1.4.1 Module to be developed

i) Data collection using IoT, electrical conductivity fertiliser, pH level, temperature sensor and crops price fluctuation. The data is collected using the Arduino sensors and connected to the implemented application.

ii) Web application with interactive GUI to display the data analysis and interpretation.

iii) Data for the stock market price of crops will be collected in the FAMA website to do the prediction of price fluctuation by using Machine Learning Models.

iv) Mobile application will be implemented using flutter to connect with the data analysis and display all the functions to the users.

v) AI Module – receive data from EC Sensor and provides the best fertilizer value to use

vi) Database Module – All the sensor data will be kept in database as for the future improvement

1.4.2 Target User

- Farmers
- Agriculture development Agency

1.5 Software and Hardware Requirement

SOFTWARE	HARDWARE
System and Server: SQLite 3 Firebase python 3.8 Web: Bootstrap Node.js PHP 5.5 or above Apps: Android Studio	Computer Laptop Arduino NodeMCU Arduino Uno Rev 3 Keyestudi TDS Sensor DHT22 Sensor Flying Fish Sensor Jumper Wires

1.6 PROJECT SIGNIFICANCE

1.6.1 Motivation and inspiration for the project.

Farmers frequently face issues with plant quality and a lack of staff to care for their operations. Furthermore, there aren't many young people in society nowadays who want to work in agriculture because they believe it's difficult to be a farmer because there are so many other things to do. They're more interested in internet technology and business. Plant data such as environmental temperature, soil moisture level, and light intensity level can be collected in real time by the Smart Agricultural System. The data is then extracted from the localhost database which uses A.I technique and analyzed using the interactive website and mobile apps. After conducting this proper management, the number of good quality harvests will grow. As a result, we believe that this agricultural artificial intelligence system can assist farmers in resolving their issues.

1.7 SUMMARY

In summary, one of the most crucial duties in any farming or agriculture-based environment is plant monitoring. With the inception of Smart agricultural system , there are many type smart agricultural system is growing rapidly where it help farming easier, our proposal discussion is based on the smart agricultural system where it help to diagnose the accurate health of a plant in a productive way, The given implementation works along with a cloud based server and a mobile based devices and also we have included with IOT devices which helps the user to control and see the status of the plant which is being monitored by the hardware device , in our system we have Fertilizer EC,PH level , Ambient temperature that will help to improvise the accuracy in plant monitoring beside we also include several A.I technique such machine learning that to be precise on our system development . By continuously monitoring and recording from remote areas, information about the plant's health and growth will be delivered to the user live. It enables a better knowledge of how each parameter of the area influences plant growth. The arduino controller interfaces with all the sensors has been utilized in this project. This information about the garden can be directly watched and controlled by the garden owner using an IoT device on his or her smartphone. By sensing and managing the characteristics of the garden without the user's physical presence, this smart agricultural system will bring ease and comfort to the user. To install the smart agriculture system or access the website, any Android device can be used. And finally all information is saved in a database and can be accessed at any time. Last but no least, farmers face a lot of problems in selling off their crop yields to the end user. Why does this happens? Because the price of crops changes according to seasons in a year respectively. If farmers have the domain information of the fluctuations of crop prices they could easily know which crop to plant at which time in the season. This eventually will increase the profitability of farmers widely.

2.0 CHAPTER II : METHODOLOGY

2.1 Intelligent System Development Methodology

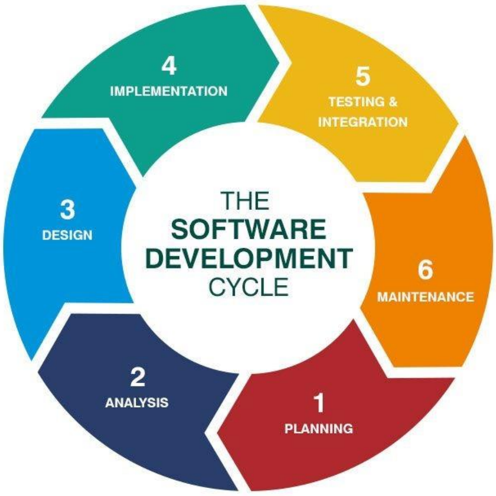


Figure 1Diagram 1 : The SDLC flow

We are using software development life cycle (SDLC) as our methodology to process our project to ensure that our progress is in control.

2.2 Intelligent System Development Technique

2.2.1 Characterize the type of Crop

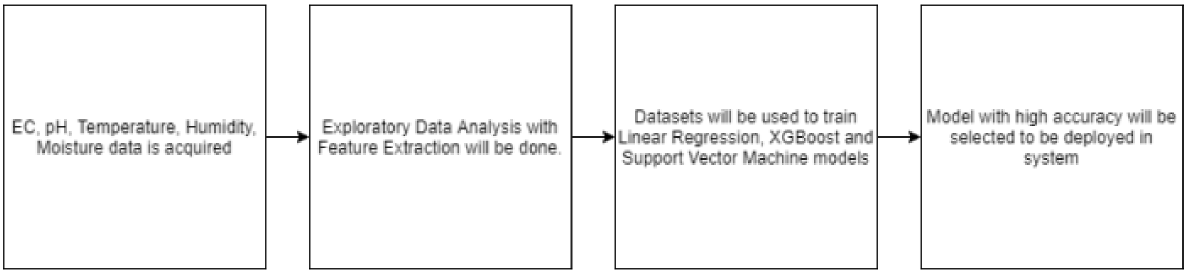
Although all the crops are considered as a food product but when it comes to planting it requires certain set of knowledge. For example, we cannot use the same fertilizer that is used for annuals in biennials. Plants fall under annuals category complete their life cycle in one single season whereas plants fall under the biennials category takes one or two years to complete their life cycle. Thus, characterization of crops is a pre-requisite. Even though, the type of fertilizer given to each type of plants is different, but we are keeping the limitation where EC plays a dominant role in determining how much fertilizer level should be given to each plant

2.2.2 Acquiring the Real time data of EC, pH, Temperature, Humidity and Soil Moisture

The main idea of collecting these data is to know how much EC is consumed by the plant in a pre-determined period. A buffer EC will be set for each iteration and will be given to the crop. Then, the moisture, pH, temperature, and humidity will be monitored in the period to know whether the given liquid fertilizer has already dried up from the soil. Moreover, the temperature and humidity data will tell us under which temperature and humidity does the plant absorbs the fertilizer efficiently.

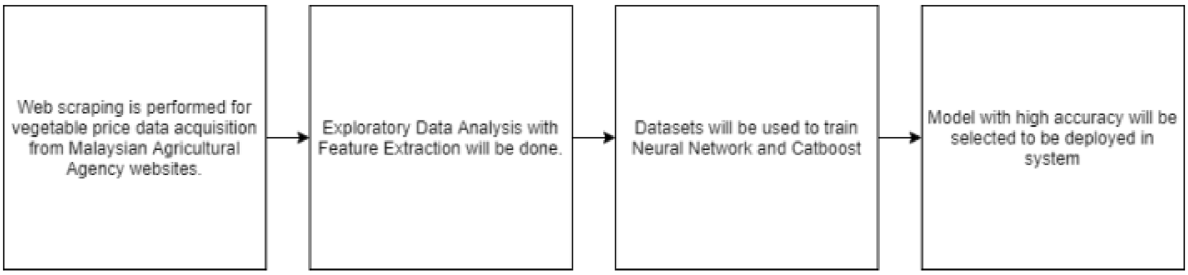
2.2.3 Creating Machine Learning Models

Linear regression, XGBoost, and Support Vector Machine works like a charm for recommendation systems. So, an Exploratory Data Analysis will be performed in order to sort the dataset and then the sorted datasets will be used to train and evaluate the respective models. Using the evaluation accuracy, the model with high accuracy will be handpicked to be deployed in the system. So, we decided to pick Ridge Classifier under L2 Regularization Technique and Random Forest Model as their R^2 score is very high.



2.2.4 Acquiring Vegetable Price Datasets

The datasets acquired through web scraping as usually will be put up to Exploratory Data Analysis with Feature Extraction to be sorted. Then, the sorted datasets will be used to train a neural network model and also certain Machine Learning models such as Catboost which works the best for forecasting models.



At the end, we decided to use the same model which is the ridge Classifier and Random Forest for price prediction as well since catboost is not possible for multilinear regression.

3.0 CHAPTER III : ANALYSIS

3.1 Analysis of Current Application

Farmers frequently face issues with plant quality and a lack of staff to care for their operations. Furthermore, there aren't many young people in society nowadays who want to work in agriculture because they believe it's difficult to be a farmer because there are so many other things to do. They're more interested in internet technology and business. Plant data such as environmental temperature, soil moisture level, and light intensity level can be collected in real time by the Smart agricultural System. The data is then extracted from the localhost database which uses A.I technique and analysed using the interactive website and mobile apps. After conducting this proper management, the number of good quality harvests will grow. As a result, we believe that this agricultural artificial intelligence system can assist farmers in resolving their issues.

The machine learning is playing an important role in this task, below are some of the researches which focus on smart agriculture management using Machine Learning :

Resource example:

1. Sharma, A., Jain, A., Gupta, P., & Chowdary, V. (2021). Machine Learning Applications for Precision Agriculture: A Comprehensive Review. IEEE Access, 9, 4843–4873.
   https://doi.org/10.1109/access.2020.3048415

   This research explains the use of linear regression model to predict the water level that has to be poured to the crops in a day. The supplement of dependent variables which affects the water level that has to be poured to the crops defines the end variable that is intended to be predicted. The dependent variables are crop age, soil moisture level and also the time of the day.

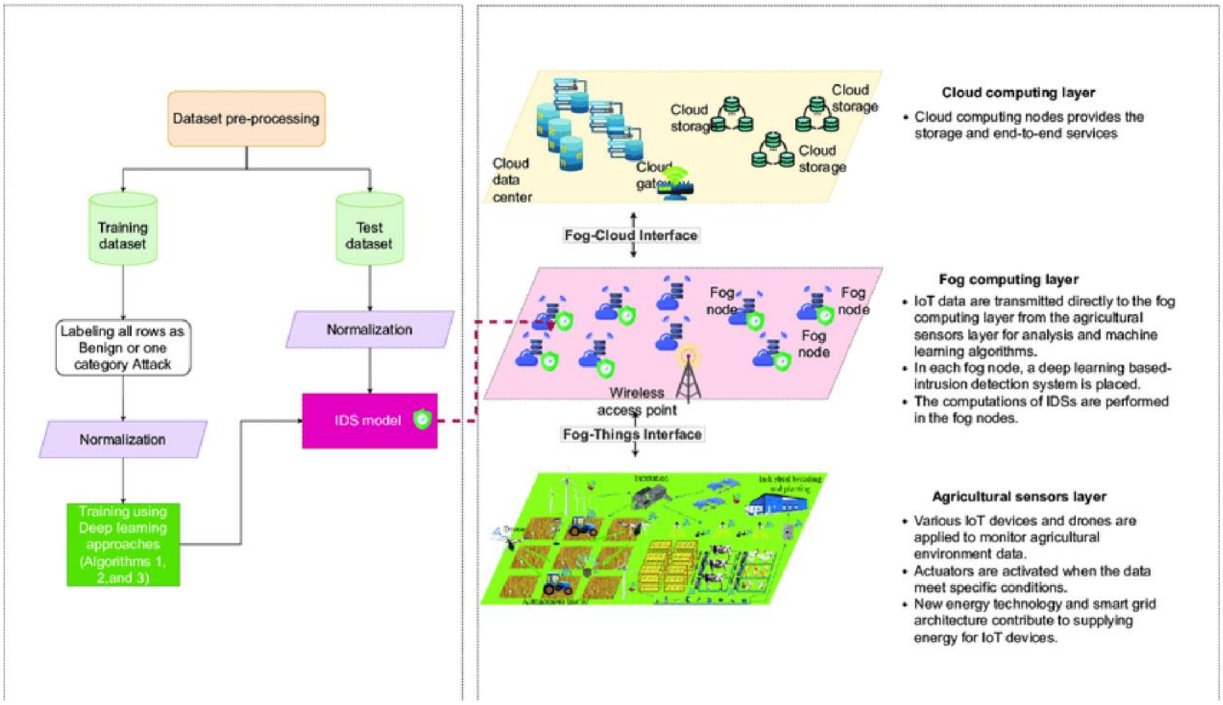


Diagram 1: The ML network

2. Bu, F., & Wang, X. (2019). A smart agriculture IoT system based on deep reinforcement learning. Future Generation Computer Systems, 99, 500–507. https://doi.org/10.1016/j.future.2J019.04.041

The smart agriculture system proposed in the research paper employs deep reinforcement learning. The system comprises four major layers: the agricultural data collection layer, the edge computing layer, the agricultural data transmission layer, and the cloud computing layer. To adapt the environment to crop growth, a series of parameters are required like the air temperature and humidity, carbon dioxide concentration, soil moisture and temperature, and light intensity, etc. After extracting data from raw sensor data and constructing Q-learning features, the combination of deep reinforcement learning powerful data learning capabilities and the cloud layer can make immediate smart decisions based on the given data. As a result, the precision of agricultural environment control can be easily improved.

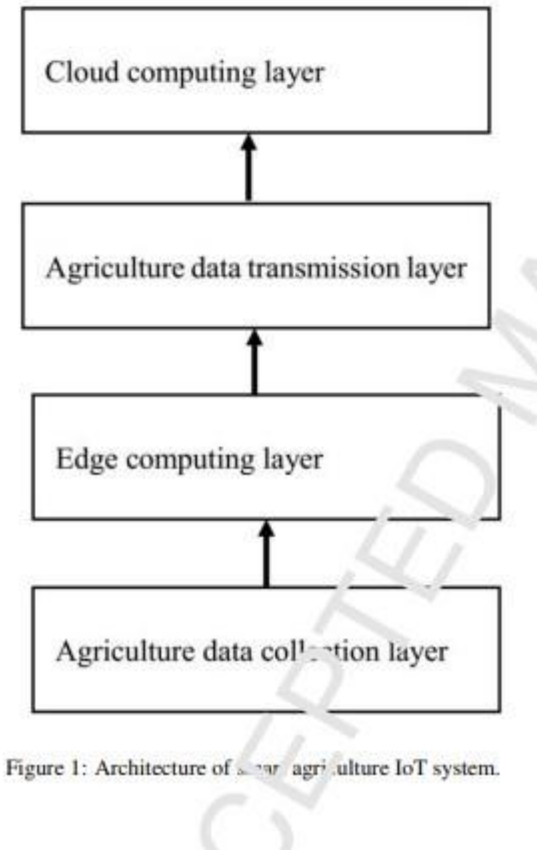


Diagram 2: Architecture of smart agriculture IoT system.

3. Jha, K., Doshi, A., Patel, P., & Shah, M. (2019). A comprehensive review on automation in agriculture using artificial intelligence. *Artificial Intelligence in Agriculture*, *2*, 1–12. https://doi.org/10.1016/j.aiia.2019.05.004

This article discusses several automation techniques such as Internet of Things, Wireless Communications, Machine Learning and Artificial Intelligence, and Deep Learning.
Crop diseases, lack of storage management, pesticide control, weed management, lack of irrigation and water management are some of the issues that plague the agriculture field, and all of these issues can be remedied utilising the approaches stated above.moreover this paper also specifies It is critical to comprehend concerns such as the use of dangerous pesticides, controlled irrigation, pollution management, and environmental repercussions in agricultural activity. Automation of farming processes has been shown to increase soil gain while also strengthening soil fertility. This study examines the work of a number of researchers in order to provide a quick summary of the present state of automation in agriculture.The report also addresses a potential system for flower and leaf identification and watering that may be implemented in a botanical farm utilising IOT.

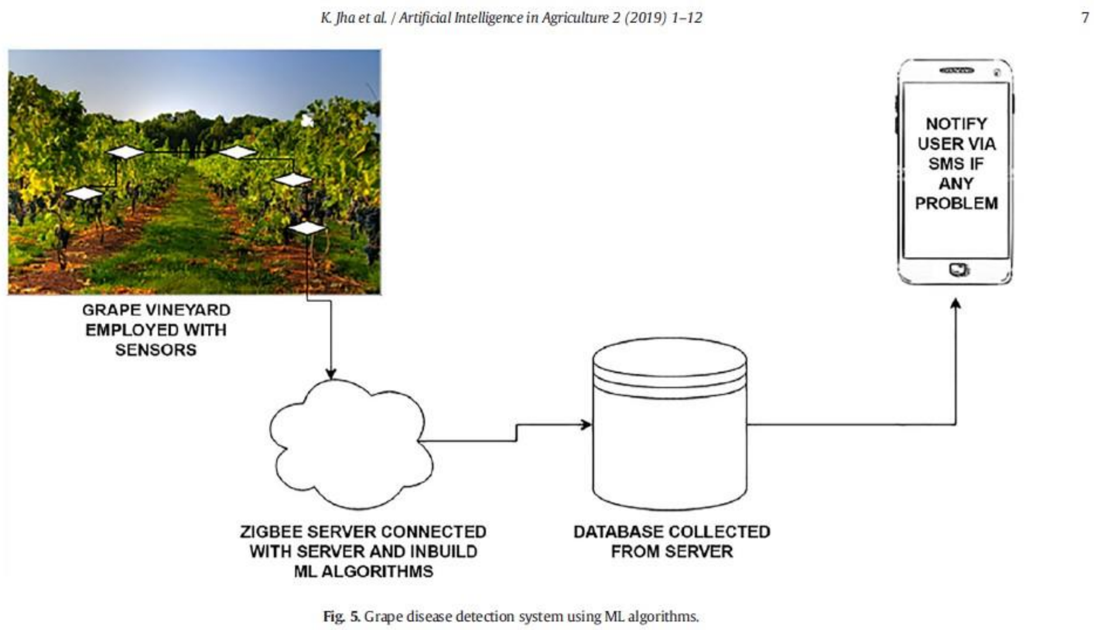


Diagram 3: Grape disease detection system using ML algorithms.

3.2 Analysis of Current Application

Smart Agriculture System is a system that is formed for the farmers to monitor the farmland with the help of sensors, which senses components such as pH, temperature, soil moisture and electrical conductivity fertiliser (EC). In this project, we will include machine learning and deep reinforcement learning in building the interactive website and smartphone application to monitor good quality harvests based on the real time database using the Arduino sensors. In the proposed algorithm, 0 degree Celsius to 60 ℃ for temperature and 0-16 dS/m for the EC value. Furthermore, we will analyze and predict the price fluctuation of crops using machine learning models. After we extract the data from the raw sensor data and construct Q-learning features, the combination of machine learning and the cloud layer will make immediate smart decisions based on the given data. The result would assist farmers to improve the effectiveness and productivity in farming. This intelligent system will be developed using VS Code, Android Studio, Flutter, Firebase and Python.

3.3 Structure Chart of Proposed Intelligent System

The initial design of price prediction system will be like:

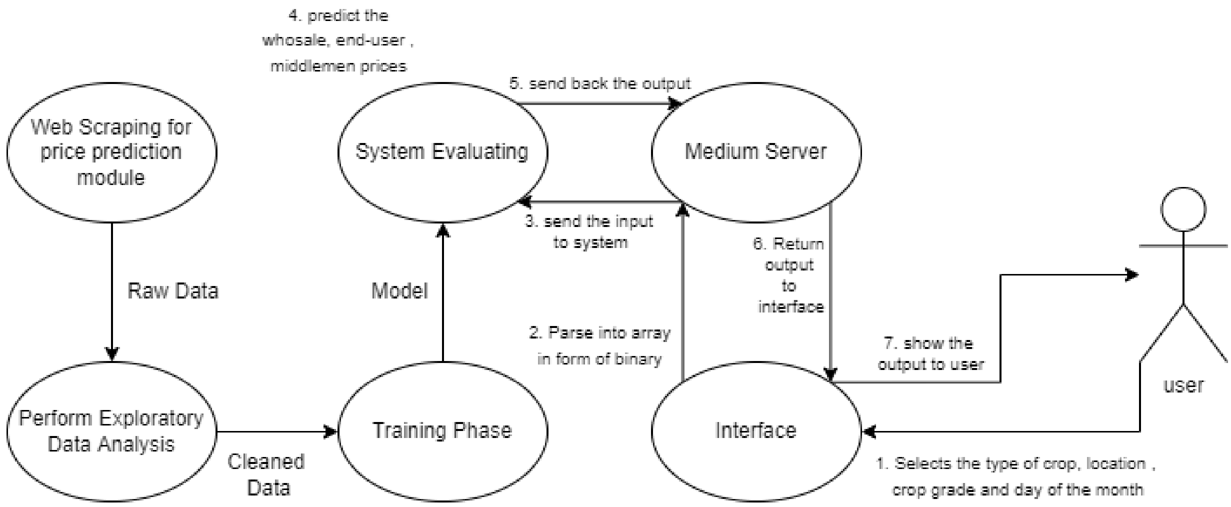


Diagram 5: The conceptual design of Price Prediction workflow

The initial design of EC and N-P-K prediction system will be like:

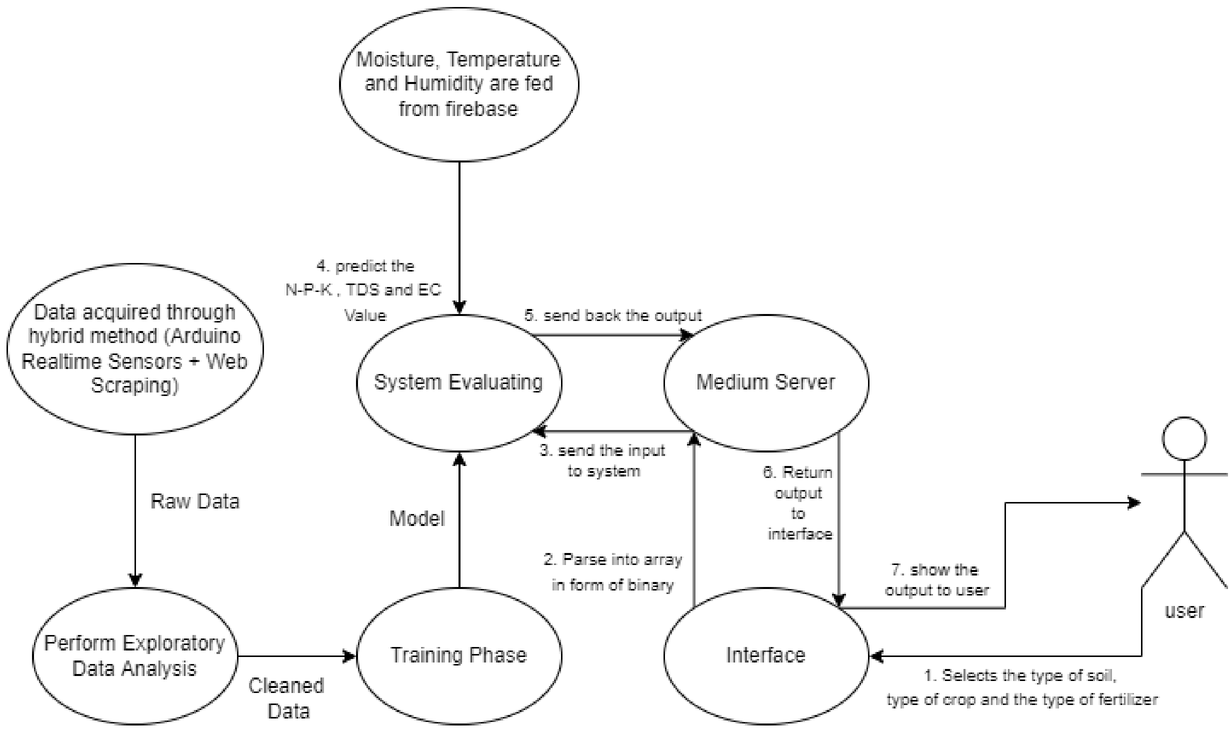


Diagram 6: The conceptual design of Fertilizer and N-P-K Prediction workflow

The initial design of Symbot Intelligent Chatbot:

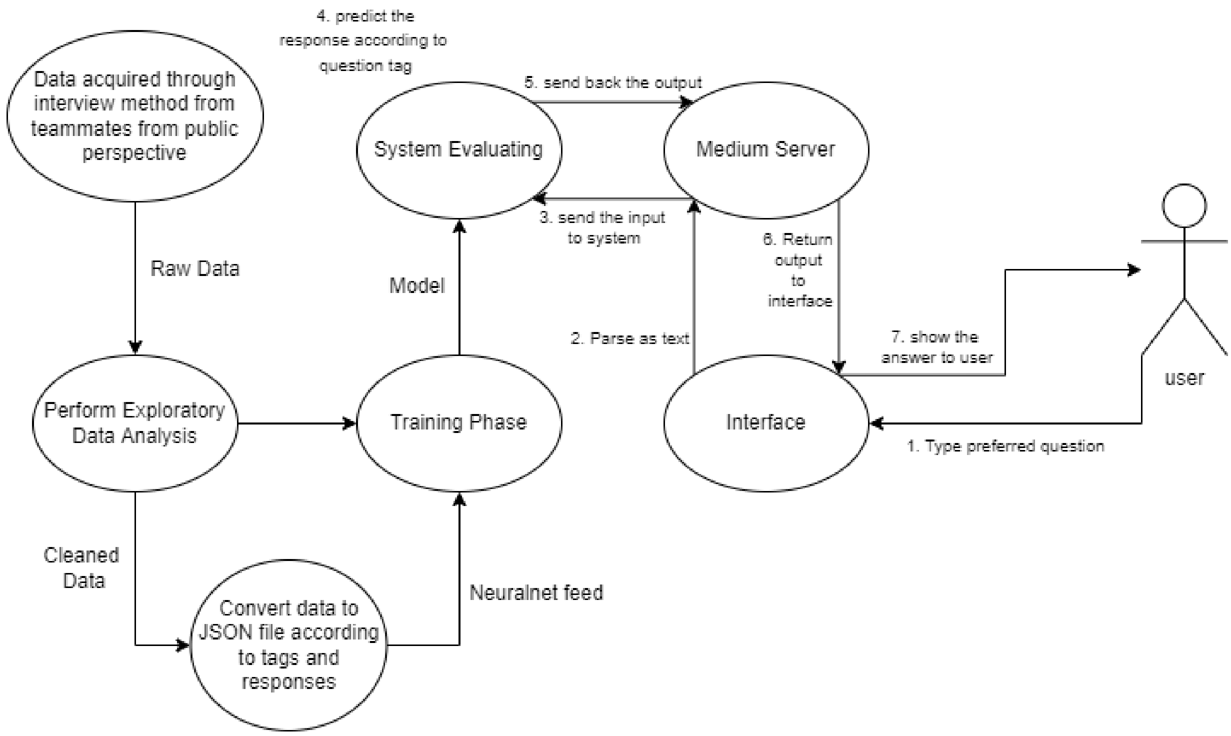


Diagram 7: The conceptual design of Chatbot workflow

3.4 Work Breakdown Gantt Chart:

No	Task	Week													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Discussion of project background	■													
2	Methodology Analysis		■												
3	Characterize the Type of Crops			■											
4	Acquiring Real-time Data				■	■									
5	Creating ML Models						■								
6	Acquiring Vegetable Price Datasets						■								
7	Creating Price Forecasting System							■	■						
8	Testing on system										■	■			
9	Further Improvement of System												■		
10	System Demonstration													■	
11	Final Report														■

Table 1: Gantt Chart

<u>Work Allocation:</u>

Work	Name
Module 1: Artificial Intelligence system	KRISHNAR RAM MURUGAN & AZFAR RAHMAN & DING XUE WING & RECA SENG
Module 2: Server & database	KRISHNAR RAM MURUGAN
Module 3: Mobile Interface	RECA SENG & DING XUE WING
Module 4: Web Interface	KRISHNAR RAM & AZFAR RAHMAN

Table 2: Work Allocation

Work Breakdown:

KRISHNAR RAM MURUGAN - K

AZFAR RAHMAN - A

DING XUE WING - D

RECA SENG - R

No	Task	Name
Planning	Discuss on the workshop title, work distribution and what needs to be done.	All
	Proposal is submitted via ULearn.	All
Analysis	Identify and discuss the requirements of the system.	All
	Define the project goals.	All
	Identify the risks and limitations of the system.	All
	Discuss and choose which AI techniques are going to be implemented into the system.	All
Design	1. Structured chart 2. System Methodology	A, D , R
	3. Use case diagram	D
	1. Flowchart	R
	Sequence diagram ERD	A, R

	Design and program Database	K
Implementation	Developing the back-end part of the web application	K, R
	Developing the front-end part of web application	K, R
	Developing the back-end part of mobile application	A, D
	Developing the back-end part of mobile application	A, D
	Implement AI techniques into the system.	K
Testing and integration	Testing the system by running it.	All
Maintenance	Identify and fix errors.	All
	Improve the system performance.	All
Evaluation	Presentation of the system to the committees.	All

Table 3: Work Breakdown

3.5 Summary

In summary for this chapter, we are making the preparation phase for the whole project and making the direction of work. We have analyzed how others do the system and develop our own. It is the milestone for our project starting and showing the concept. Also it has shown the initial planning of our team including the time distribution and work for every member.

4.0 CHAPTER IV: DESIGN

4.1 Introduction

During the Design Phase, the system is designed to satisfy the requirements that have been identified in the previous phases. The requirements identified in the Requirements Analysis Phase are transformed into a System Design Document that describes about the design of the system and that can be used as an input to system integration in the next phase.

4.2 Intelligent System Architecture

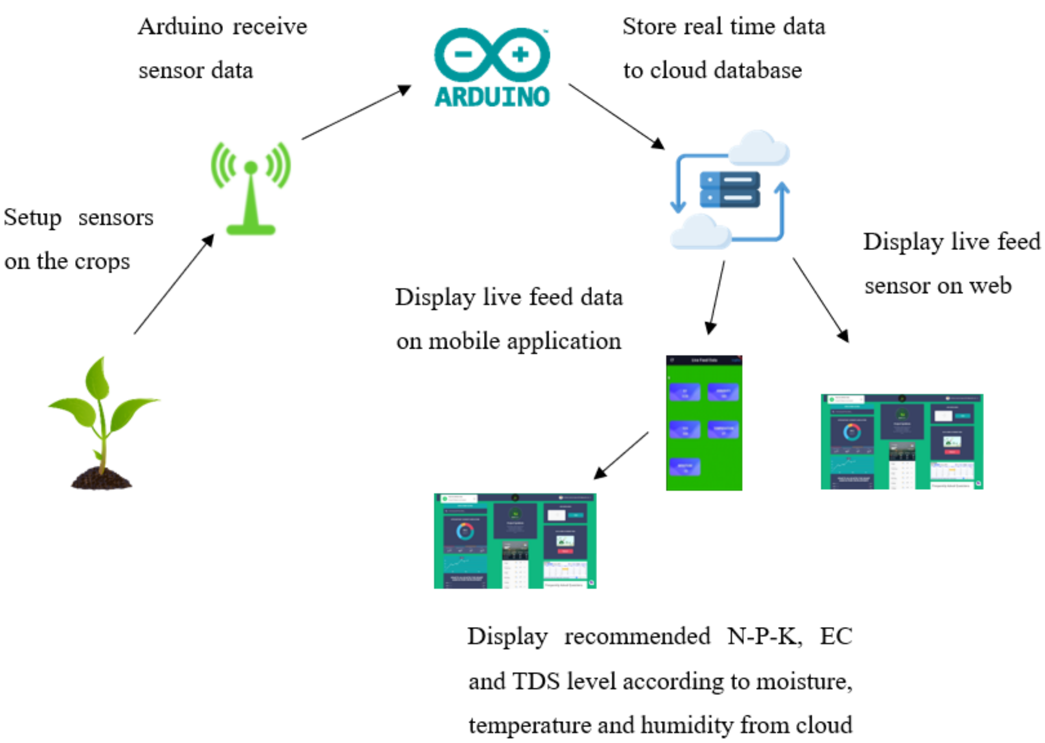


Diagram 8: Display the flow of the Intelligent System Architecture

Diagram 8 above shows the intelligent system architecture. There are four modules that need to be developed. The first module is artificial intelligence system part include the Machine Learning model training, data scraping, chatbot and etc. This module need to be completed by training the Machine Learning model and doing data scraping which will be used further in the system. The second module is sensor and database. This module is completed by assembling all the hardware which include the sensors and the Arduino board and connect it to the PC, then all the data will be updated in the real time database in the firebase. The third module is web application. This module is completed using flask, which is the python framework for displaying live feed data from the database, price prediction, N-

P-K and TDS level prediction and chatbot. While for the fourth module is mobile application part. This module will be completed using flutter and database to display the live feed data.

4.3 Module 1: Artificial Intelligence System

To complete this module, Machine Learning model training, data scraping, chatbot will be processed and will be used for price, N-P-K, TDS level prediction in the system. After completed for data scraping for the dataset, Machine Learning model will be trained by doing some programming and the models which include ridge classifier and random forest will be used in predict the price forecast, N-P-K and TDS level which this two ML models have high accuracy compared with other ML models. Other than that, the intelligent chatbot, which is Symbot is completed with all the data acquired through the interview method from the members from public perspectives, all the data will be processed and trained, after that will be evaluated into the system. So, user can input for the questions and the input will be sent to the system then the output will be returned to the interface and shown to the user.

4.4 Module 2: Sensor and Database

To complete the second module, all the required hardware is needed to be assembled correctly to collect the temperature, moisture, humidity, EC and TDS then connect to the PC to send and store the live feed data into the real-time database in the Firebase. The hardware consists of the main board, which is the Arduino Uno, the temperature, moisture and humidity EC and TDS sensors. There is also some several components that might be required to assemble all the parts like jumper cables and breadboard for the connection of the parts.

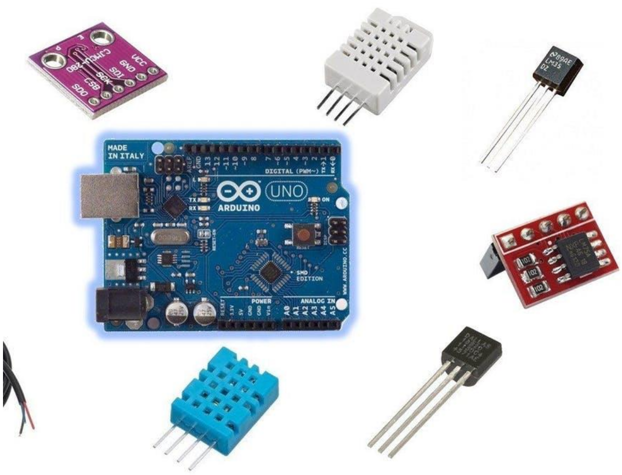


Diagram 9: The Arduino board and the sensors

Diagram 9 shows the main components of this module. All the components will be connected using the jumper cables. The Arduino Uno is connected to the PC via USB cable for sending the data to the PC. The cable also used to upload the program from the PC to the Arduino Uno for it to read and collect the sensors data. All the data that collected by the Arduino and the sensors from the crops will be uploaded in live to the Realtime Database in Firebase. The live feed data will be updated in every 30 seconds in the Firebase which shown in Diagram 10 below and will be shown in the web and mobile application.

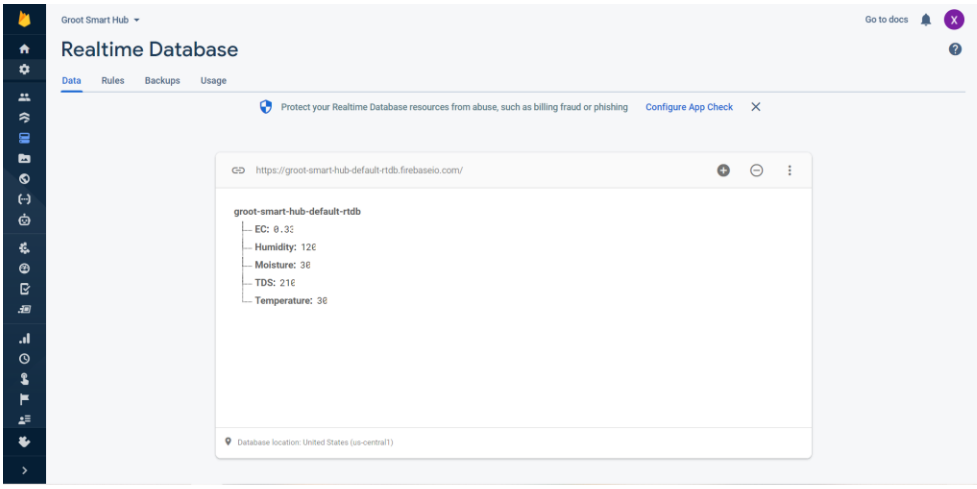


Diagram 10: The Realtime Database that updated from the Arduino Uno

4.5 Module 3: Web Application Interface

In this module, web application interface is created for the system. We use flask which is the python framework to create the interface which suits our needs. In web application, we first create the user authentication page which can register and login the account and the user data will be store in the cloud database. Then it must relate the database to be able to display the live data in the web. In our system, we have connected with the Realtime Database in the Firebase to reach our data stored, this allows us to display the live data in live graph in our system. The interface for price prediction, N-P-K and TDS level prediction also be created. For the price prediction, the user can select the type of crop, location, crop grade, day of the month and the preferred models, then the input will be sent to the system, after the system evaluated, the output which is the price prediction will be returned to the interface to be shown to the user. And also for the N-P-K and TDS level prediction, the user can select the type of soil, the type of crop, the type of fertilizer and the preferred model. Then the input also will be sent to the system. Then after the system predict the N-P-K and TDS value, it will be shown to the user in the interface.

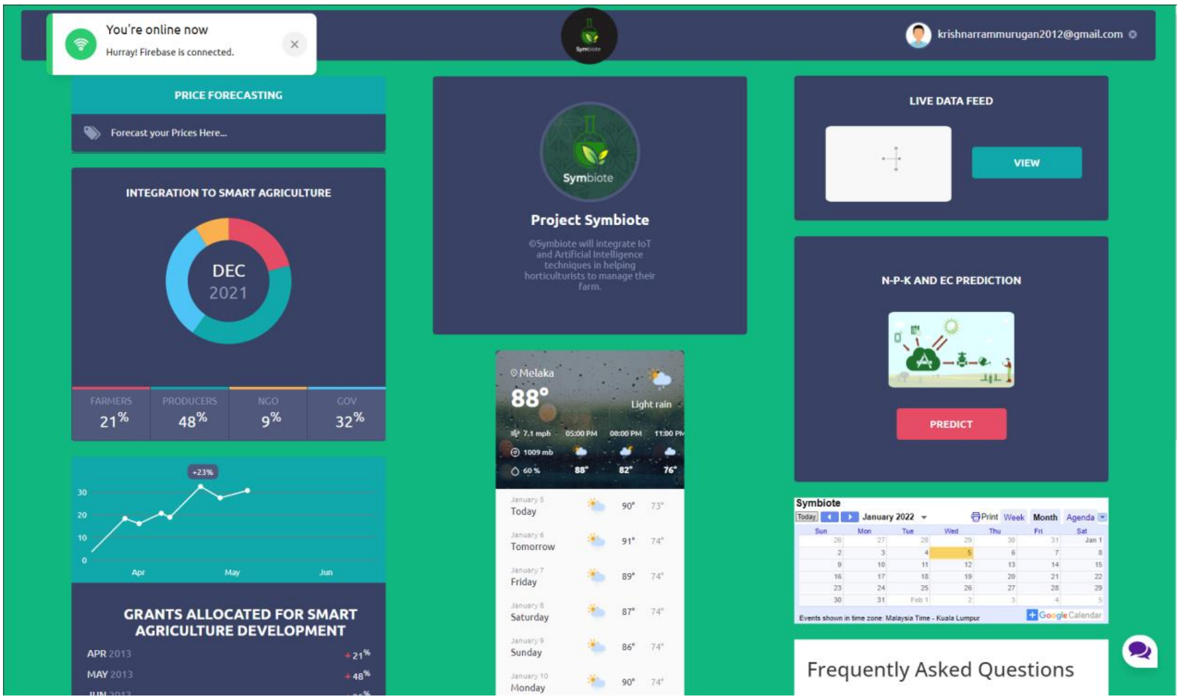


Diagram 11: Display the interface for the web application

4.6 Module 4: Mobile Application Interface

In this module, a simple mobile application is developed for the system. Storyboarding of the mobile app layout was completed prior to coding the mobile app. The layout such as background image, as well as the button images, were all created using Adobe Illustrator. We began coding the mobile interface using the Dart programming language and Flutter as UI toolkit to build a mobile application after the mobile layout was completed. Flutter is a framework to generate an interface on android which have been written in Dart programming language. While Dart is a programming language that optimized for building user interfaces with different features. The advantages by using flutter and dart include we manage to customize and use a collection of plugins provided based on our system criteria. Because the Android Mobile app is the focal point of our mobile interface, we select the Google Pixel 5 as our Android Virtual Device (AVD) or emulator to ensure it matches the design layout for the app, and these changes can be made in Android Studio. Please keep in mind that the design layout may not be suitable for other phone types. Furthermore, the API level is set to 28 (Pie) as shown in the figure below as it's more stable.

In this module, we will connect our mobile application to the Firebase database which work efficiently with flutter that provide Firebase plugin. The user authentication such as register and login for the mobile application will be stored under Authentication in Firebase, while user also can request for password forgotten function and the password reset email will be sent to the user's email that have been registered, then user also can leave some message which the information will be stored in Firestore Database in the Firebase. The live feed data from the Arduino sensors also will be updated in the mobile apps with the clicked refresh button which have been connect with the Realtime Database in the Firebase.

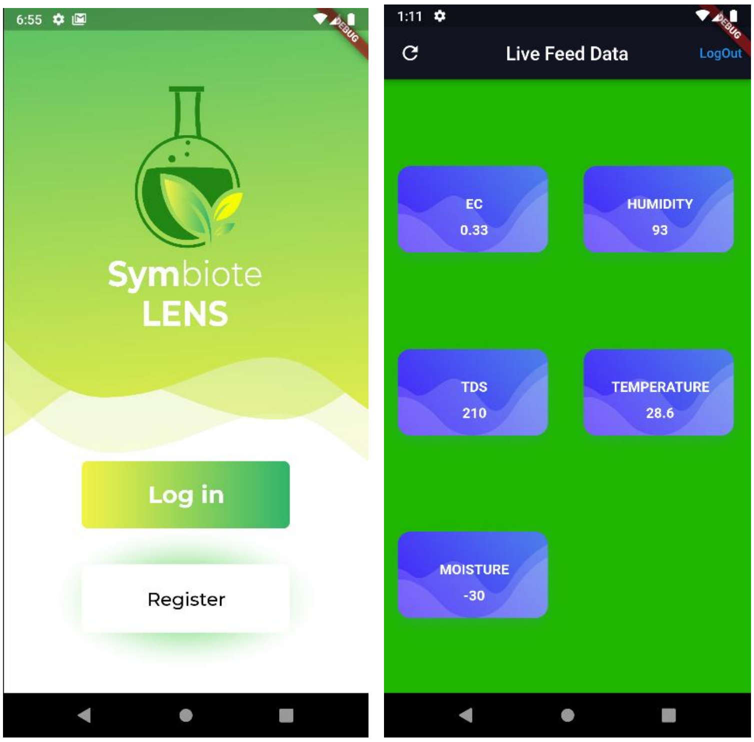


Diagram 12: Part of interfaces for the mobile application

4.7 Summary

In short, we have successfully completed the design phase for our system. All the design is in our expectation. Then, all the function for the interfaces will be implemented in the next phase.

5.0 CHAPTER V: IMPLEMENTATION

5.1 Introduction

This chapter will be about how we are going to implement our system including the 3 modules. It will cover the runtime environment for the system and detail of the environment.

5.2 Intelligent System Development Environment

The system is running on Python 3.8.11 environment with the following library packages: sklearn==0.24, pandas==1.3.5, numpy==1.18.5, pytorch, NeuralNet, Flask, PIL, werkzeug, pyrebase, sqlalchemy, WTForms, LSTM, nltk, pickle

And also we need to install DB Browser to view our local database so that the result can be returned correctly by following the virtual IP address. For connecting the SQLite3 database, the PHP version in apache is at least 5.5 because the required library for connecting SQLite3 does not exist in the earlier version. The newest version of DB Browser can be installed from https://sqlitebrowser.org

For Sqlite3 the database is created locally using SQLAlchemy Library.

5.3 Intelligent System Configuration Management Identification :

The system is currently being tested on linux Ubuntu, window 7 and window 10 with pip installed. For running the whole system, it’s suggested to have at least 8GB RAM in order to make it process well without corruption. The training phase may need a GPU device especially for the chatbot because the training on natural language processing JSON context will need a quite huge computing power.

Baseline :

As we have used PHP and SQLite3 inside our programme, it should have DB Browser with PHP version higher than 5.5 and SQLite to be accessible to the database. If you want to run the mobile app on the computer, some extra software like Android Studio and Bluestack may be required for it to run. For the AI part, Python with version 3.8 is required. The required libraries for Python code to run are listed in the requirements text file and new users should install them on themselves.

Version Control :

As we have only one completed product here, no option on choosing another version other than the final version.

Auditing :

As it is a workshop in one semester and there are no github for it open to the public, any updating on the code will be just based on the one who wants to try it.

5.4 Completing Task via Intelligence

We are using the Python library Ridge, RandomForestRegressor and Neuralnet to develop our system. And after a long period of web scraping for about more than a month for data acquisition while the model training happening simultaneously, it is now able to fit the 2.5k training sets for price , 5k training sets for different combination of N-P-K,EC and TDS for fertilizer and 150 tags and responses set for chatbot dataset, our system is now able to analyse the price forecasting, Fertilizer Level Prediction based on N-P-K, EC and TDS and chatbot pretty good.

5.5 Summary

In short, we are successfully developing an AI system with Ridge Classifier under L2 Regularization Technique, Random Forest Regressor and NeuralNet under Pytorch Module as the core and performing Price Forecasting, Fertilizer Level Prediction and Symbot Chatbot and finishing training on it. And now we have successfully linked it to the interfaces by the server playing the role of medium.

6.0 CHAPTER VI : TESTING

6.1 Testing Method

For this chapter, we will validate the result of the implementation of the three Intelligence Modules that has hit the requirements specification of the project. Since this project is not a body in development phase, we will need to cover the individual tasks and make sure all of them work well then only we can do testing on the next step. Hence, in our testing phase it will involve 3 parts, they are unit, integration and system testing. These testing helps us to ensure the system is bugless and proof of the tested scenario of the entire system from its beginning towards end.

a) Unit Testing

In this section, we will do testing on every task separately. It is on purpose to make sure that the individual parts can work well, if simply combined all together it will be hard to do checking and testing when bugs are happening or intend to make some change. So in this phase we will do testing on the AI backend system, frontend interface including apps and web page and also the medium server.

AI backend : After finishing training, the accuracy in training will be collected and used for recording, some parameters will be updated to improve the performance of the system. A graph will be plotted out easier for us to observe the result and become part of our report. After that when the model is trained, the AI system will be simplified into one or few functions so that we can call it from another file easily, then the program will be executed again to find out the bug and mistake until it works perfectly.

Server medium : Set up a basic server and web page for testing the ability of sending request and return results, there will be no AI function inside but instead using a hard code function inside it, then check on whether the backend and frontend are connected successfully. After connecting, the database will be involved and tested on whether it can insert a new row of information into it.

Interface frontend : Build up the design and implement it then testing to post requests to an inexistent server, then observe whether it can post requests to somewhere. After the interface outlook is completed, do checking on the JAVASCRIPT part to make sure it's working. Then try to connect the database and get the information to display it.

b) Integration Testing

When integration testing, the different parts will be integrated with another related part.

Backend System and Server : To involve the forecasting, predicting and answering into the server part and executing in hard code, it's on purpose to observe whether the system can be applied when run through the medium program.

Server and Frontend interface : Send request from interface to the server to see whether the request reaches the selected target, then return the same output for three of the modules from the server to ensure that the interface can receive output from the server and response for it.

c) System Testing

System testing will be involved in the end of the testing. The testing will be like can the system provide the workflow exactly like the workflow diagram. For example, can the system get user interaction then perform until the end of the system also does not occur any unexpected fault.

6.2 Test Result Analysis

As only the AI system have result, the record in training will be shown at below:

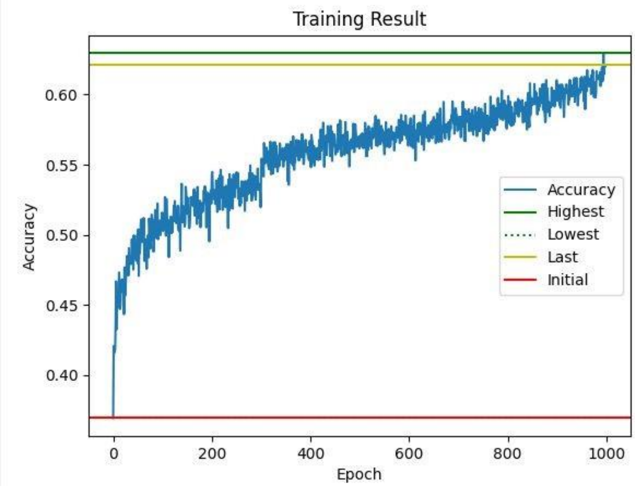


Diagram 7 : Accuracy over period for Chatbot Tags and Response Context

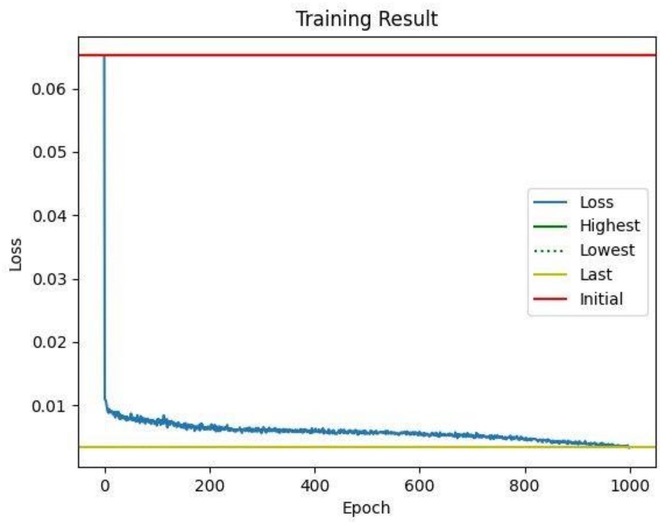


Diagram 8 : Loss over period for Chatbot Tags and Response Context

Price Forecasting System and N-P-K, EC and TDS Prediction System

Num. of Dataset Pipeline / Combinations	**Price Forecasting System**		**N-P-K, EC and TDS Prediction System**	
	R-squared Score (Ridge) (3 D.P)	R-squared Score (Random Forest) (3 D.P)	R-squared Score (Ridge) (3 D.P)	R-squared Score (Random Forest) (3 D.P)
100	0.734	0.478	0.878	0.602 (overfitting)
1000	0.726	0.533	0.647	0.543
1500	0.723	0.498 (underfitting)	0.665	0.522
1700	0.820	0.655	0.785	0.742
1800	0.825	0.670	0.731	0.702
2200	0.883	0.702	0.753	0.892
2500	0.890	0.773	0.889	0.893

Table 4 : Accuracy Scores when the dataset pipelines are enlarged

Result for interfaces:

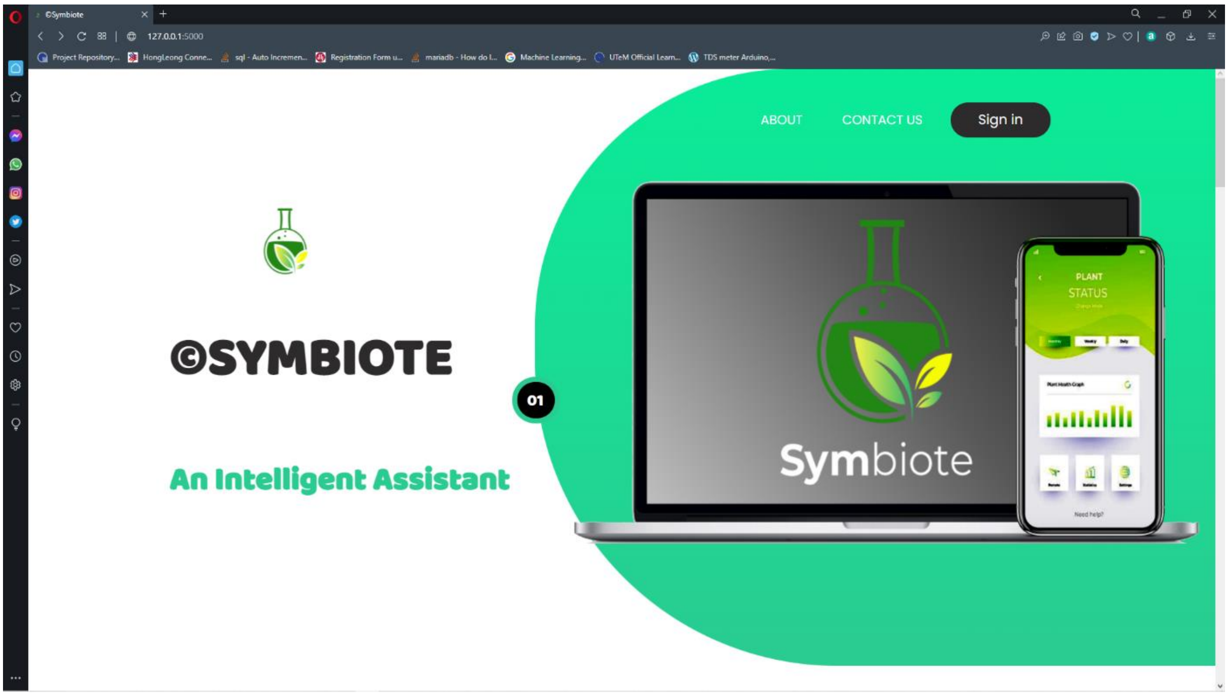


Diagram 9 : The web application design(landing page)

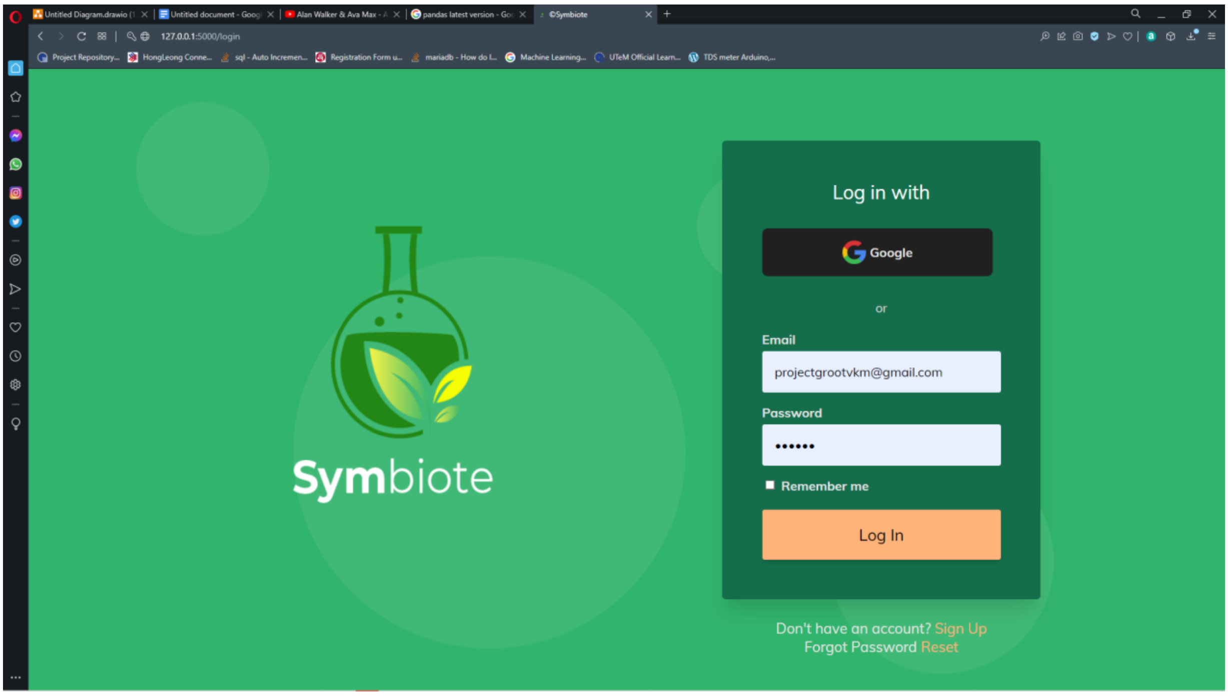


Diagram 10 : The web application design(login page)

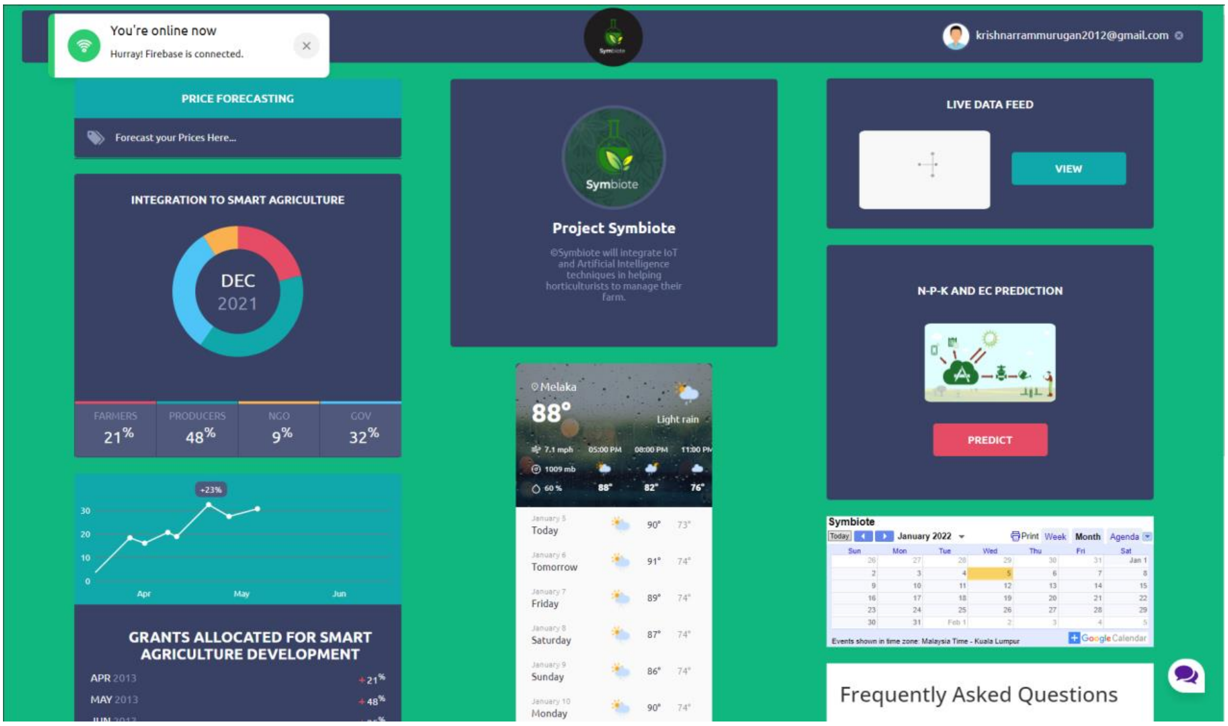


Diagram 11 : The web application design(dashboard)

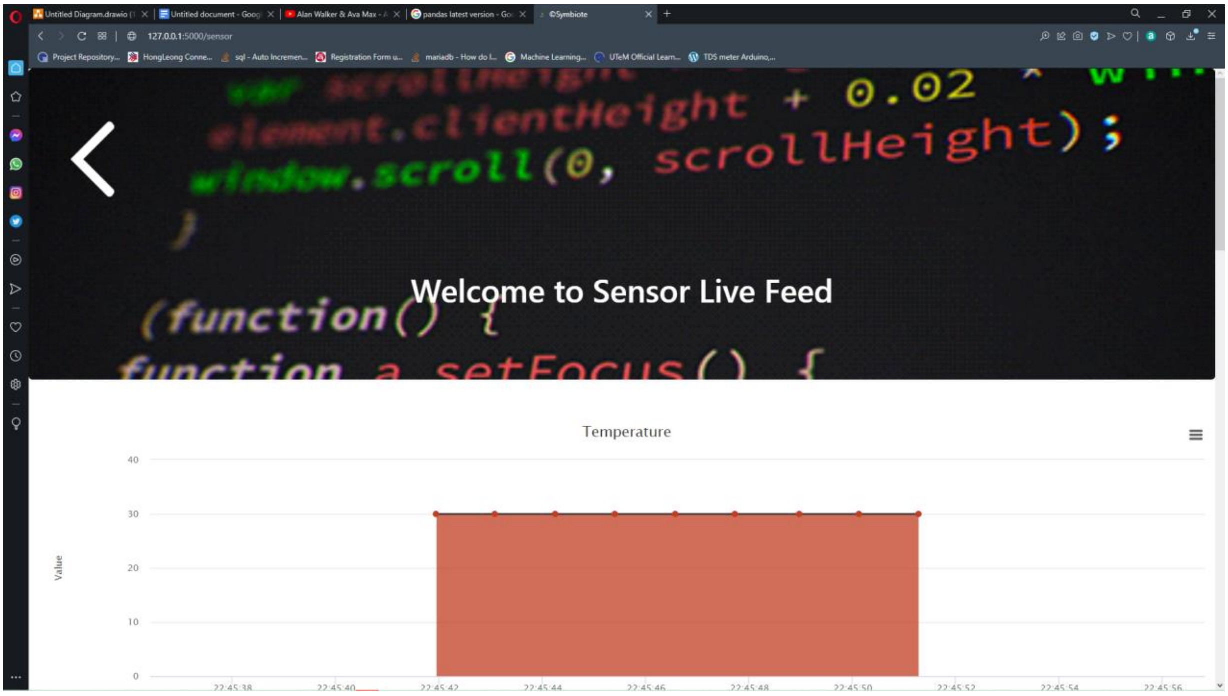


Diagram 12 : The web application design(live sensor feed)

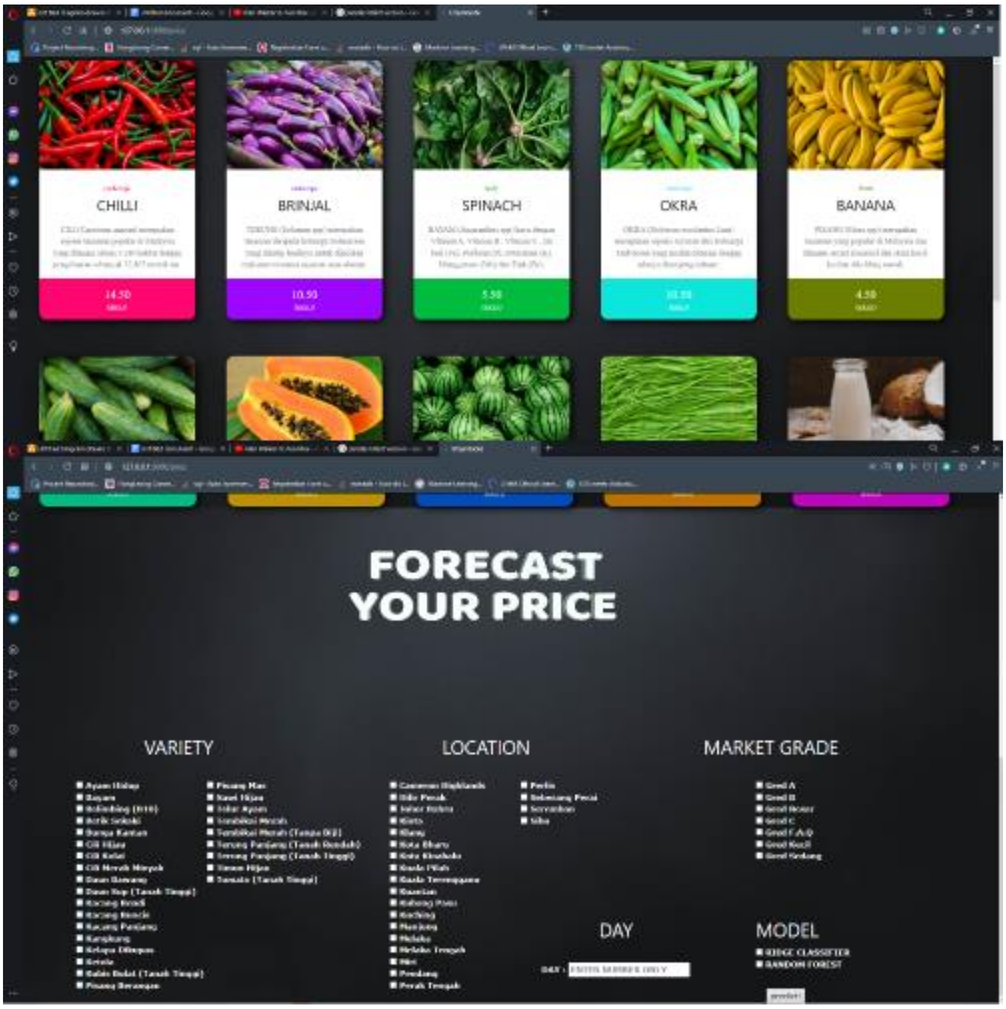


Diagram 13 : The web application design(Price Forecasting System)

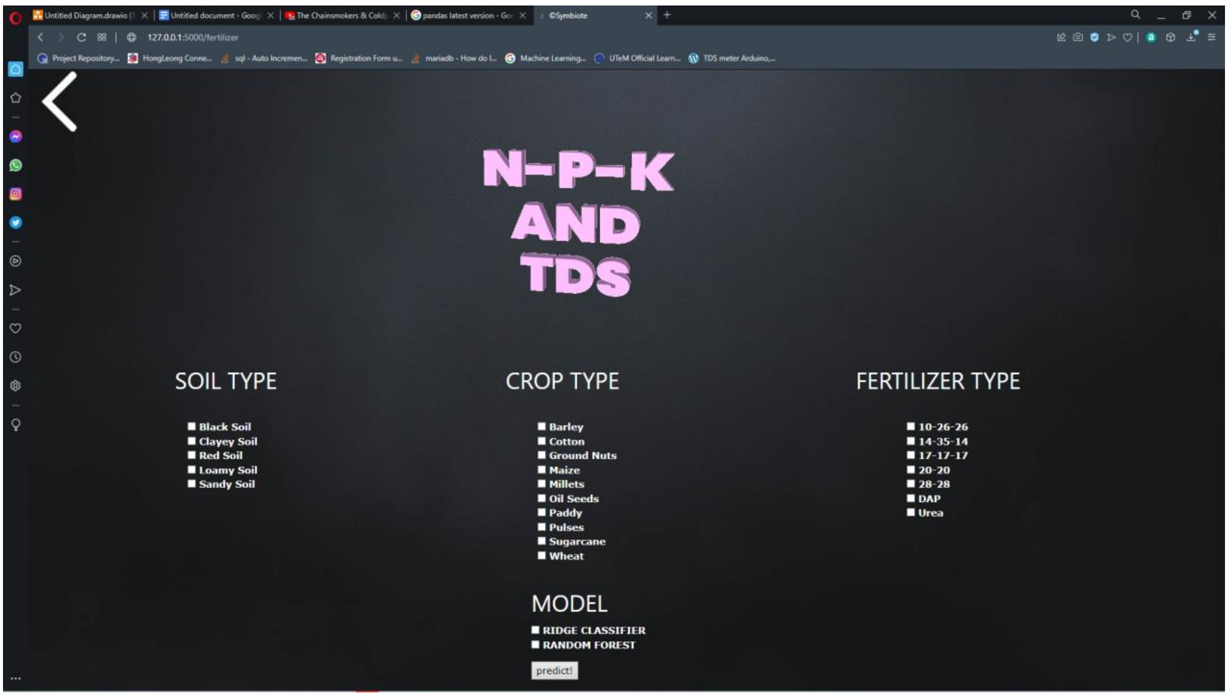


Diagram 14 : The web application design(N-P-K, EC and TDS Prediction System)

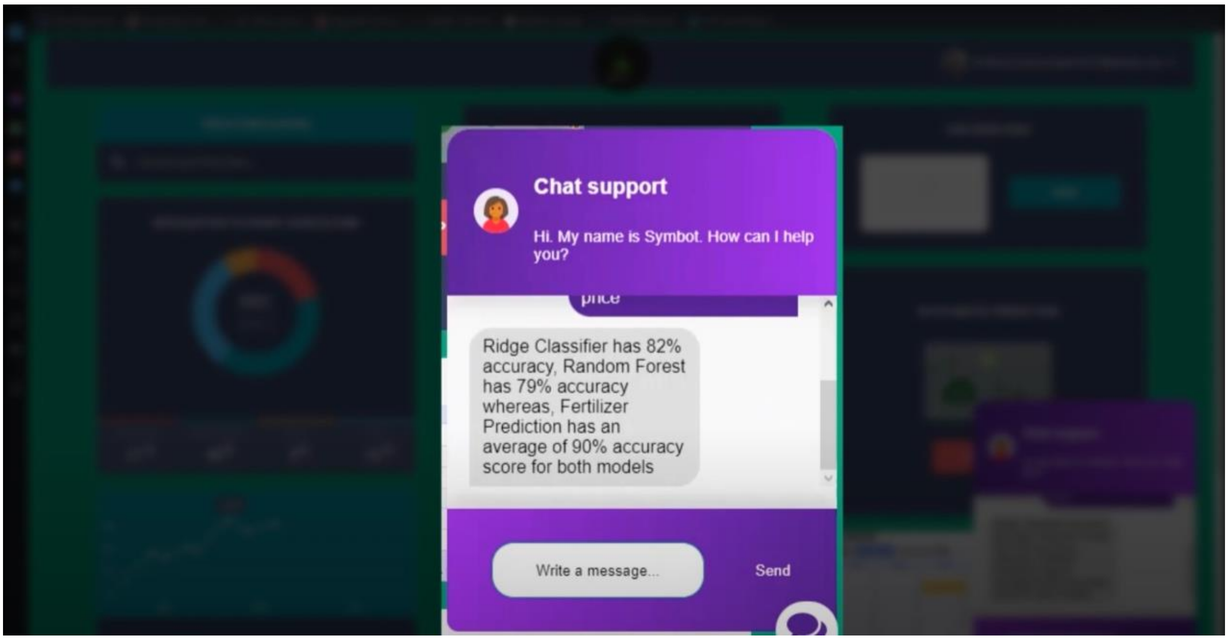
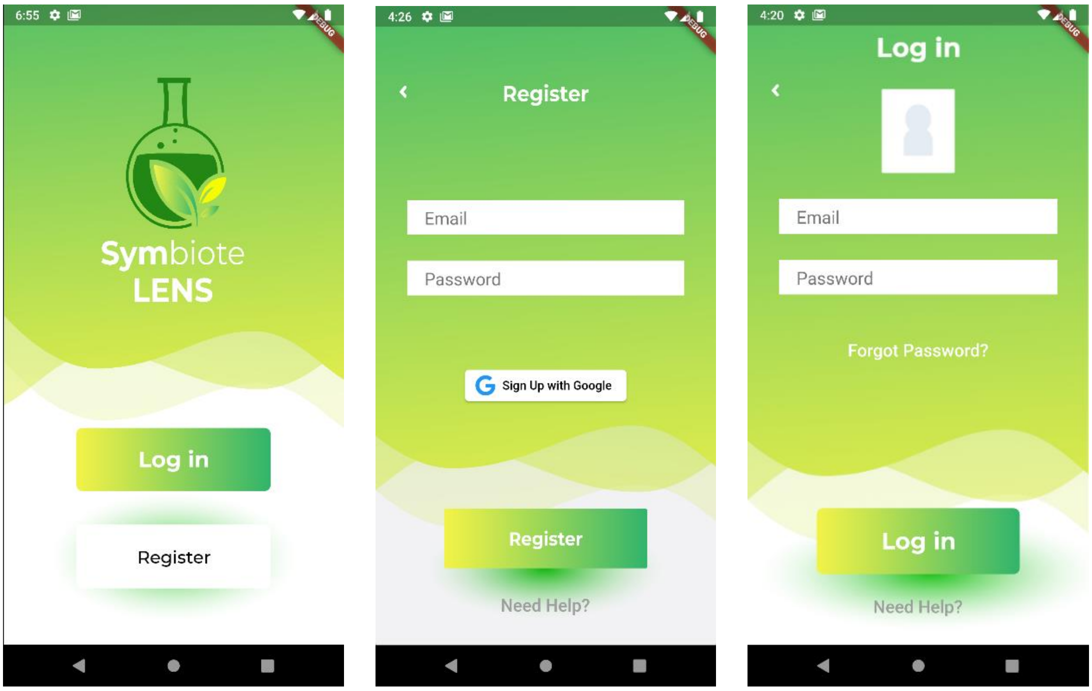


Diagram 15 : The web application design(Symbot Chatbot)



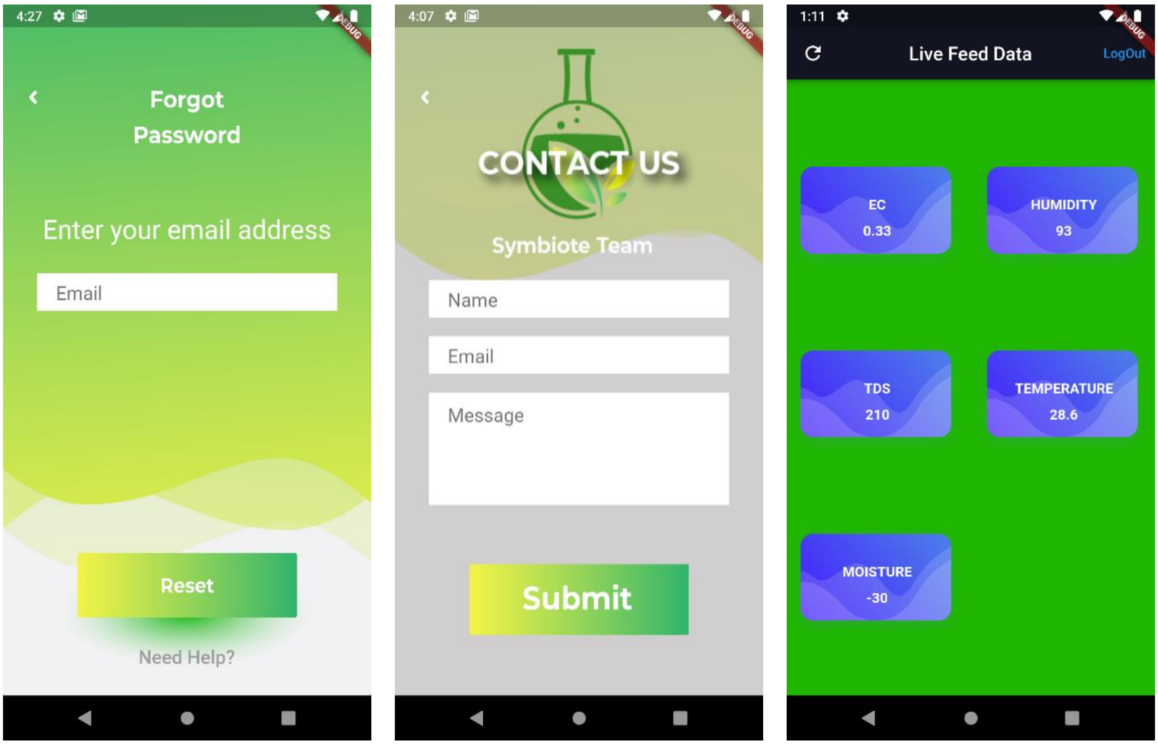


Diagram 16: The interfaces of Symbiote Lens Mobile Interfaces which consists of Landing page, Login page, Contact us page, Forgot Password page and the Live Data Sensor Feed page.

6.3 System Constraints

As this system is only local only, so that others will not be able to access this system through the internet. It's because if making it online there will be a lot of trouble for example the online server cost and the environment, it will be hard to handle if it's not in localhost.

Other than that, actually this system is very limited when it comes to the types of crop varieties and the locations all over nation that can be selected for Price Forecasting System. Moreover, it is also very limited when it comes types of crops and types of fertilizer for N-P-K, EC and TDS Prediction System.

6.4 Summary

After completing the testing task, all tasks are workable even after merging together, the testing and checking will be repeated if the code is updated to ensure everything is working well. This also benefits us in controlling the performance of the system.

7.0 CHAPTER VII: CONCLUSION

7.1 Intelligent System Advantages and Commercial Values

It was a staple of traditional farming methods for the farmer to be out in the field, constantly monitoring the land and crop condition. However, as farms have grown in size, it has become more difficult for farmers to monitor everything everywhere. This is especially true in microfarming, where many remote plots of land may be farmed for different crops, each requiring different conditions and precise soil and water control.

Presently, the integration of smart irrigation and control connected to local sensors, along with sensor for soil moisture, temperature and other environmental conditions can prevent many problems that were previously encountered by farmers who need to always be in the field to monitor crops. Remote monitoring via Symbiote increases production yields since farmers have extra time to attend to their farm's real issues such as solving pest problems, watering in any location, and adjusting soil conditions – all through use of automation and sensors.

In terms of commercial value, Symbiote assists in managing land supply and, based on its condition, setting it forth in the right growing parameters such as moisture, fertiliser, or material content to provide production for the right crop that is in demand in the current market. With Symbiote, crop production costs can be easily managed, too. Symbiote precision farming systems, for instance, concern precision soil conditions and surroundings with automated sensors to reduce seed loss and optimise plant spacing to produce the highest possible yield per acre.

Another example of Symbiote increases the commercial value is the ability to manage precision water delivery of the crops by reducing evaporation and improve soil moisture content, delivering water only when needed via sensors and automation. Thus, Symbiote's ability to forecast crop prices and predict the N-P-K, EC, and TDS puts it ahead of the other smart farming systems on the market, allowing it to deliver controlled quality and quantity of goods to market on time, reducing waste.

7.2 Intelligent System Weaknesses

The drawback of our system is that the user is required to click on the refresh button on the top as in the Live Data Sensor Feed page as in Diagram 16. The mobile interface unable to load the live feed data automatically from the Firebase. Besides, Symbiote needs availability of internet continuously to load the live feed data and sending data queries to both Firebase and Firestore. Most of the internet connection in rural area has not fulfil this requirement. Moreover, the management of the equipment like the Arduino and accessing the webpage and mobile interface of Symbiote may require farmers to understand and learn the use of technology.

Aside from that, farmers should always use the Symbiote website or mobile apps to check the status of their crops. If the farmers did not check in at the time, they may have missed a sudden change in weather, resulting in a missed the timing to control the water duration of the water pumps.

7.3 Suggestions for System Improvements

The improvements that can be made on Symbiote is to include the Crops' Price Forecasting and N-P-K, EC and TDS Prediction features in the mobile app. A well-integrated mobile app can perform actions much quicker than a webpage. Mobile app typically store data locally on mobile devices, as opposed to websites, which typically use web servers. As a result, data retrieval in mobile apps is much quicker than the webpage.

Another point for improvement is to include notifications alert when there is sudden change in the threshold of the Live Feed data in the mobile apps or monitor dashboard to the farmers. With this, the farmers can be easily notified about the sudden changes and control and manage the soil content and water control of the crops in anytime.

7.4 Summary

To sum up, Symbiote has successfully fulfilling all of its objectives in designing a database for storing the physical readings of Electrical Conductivity Sensor, pH Level, Sensor, Moisture Sensor and Temperature Sensor, developing a web-based system and mobile application for facilitating the horticulturists to manage the crops, and integrating the prediction of the crops price fluctuation module using machine learning techniques.

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APPENDICES

Figure 2 The SDLC flow

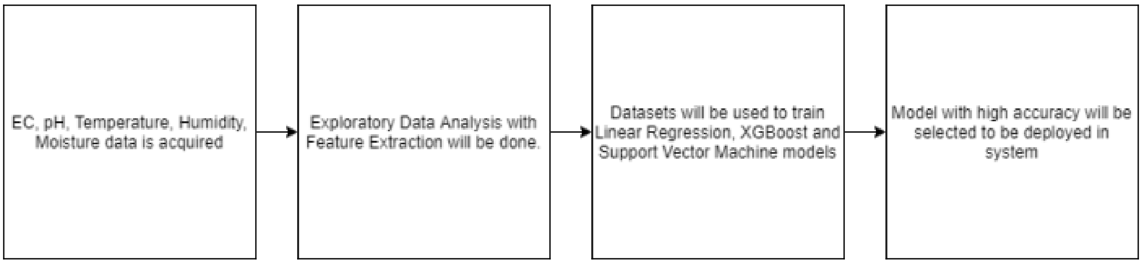

Figure 3 The Flow of Creating Machine Learning Models

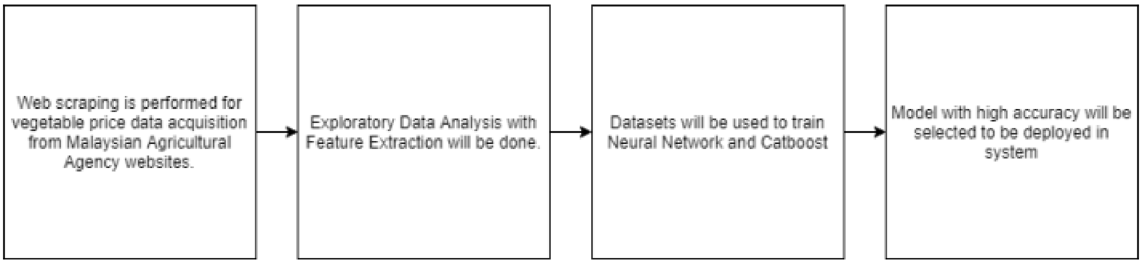

Figure 4 The Flow of Acquiring Vegetable Price Datasets

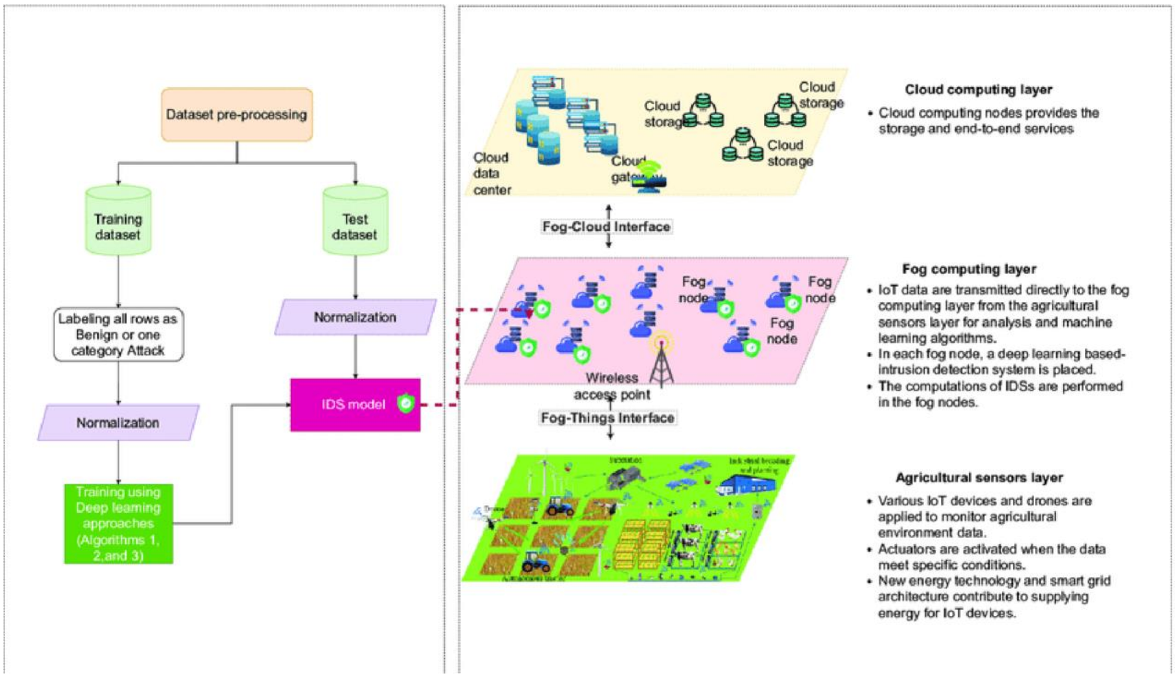

Figure 5 The Machine Learning Network

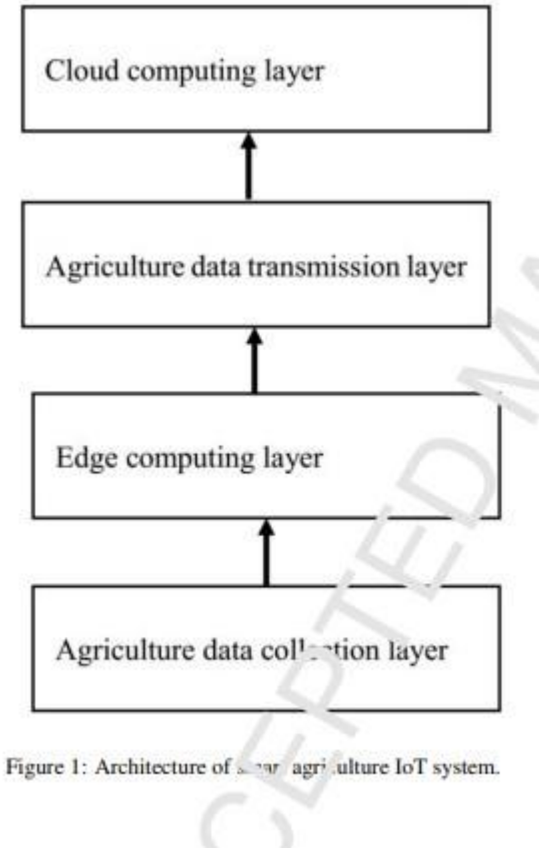

Figure 6 Architecture of Smart Agriculture IoT System

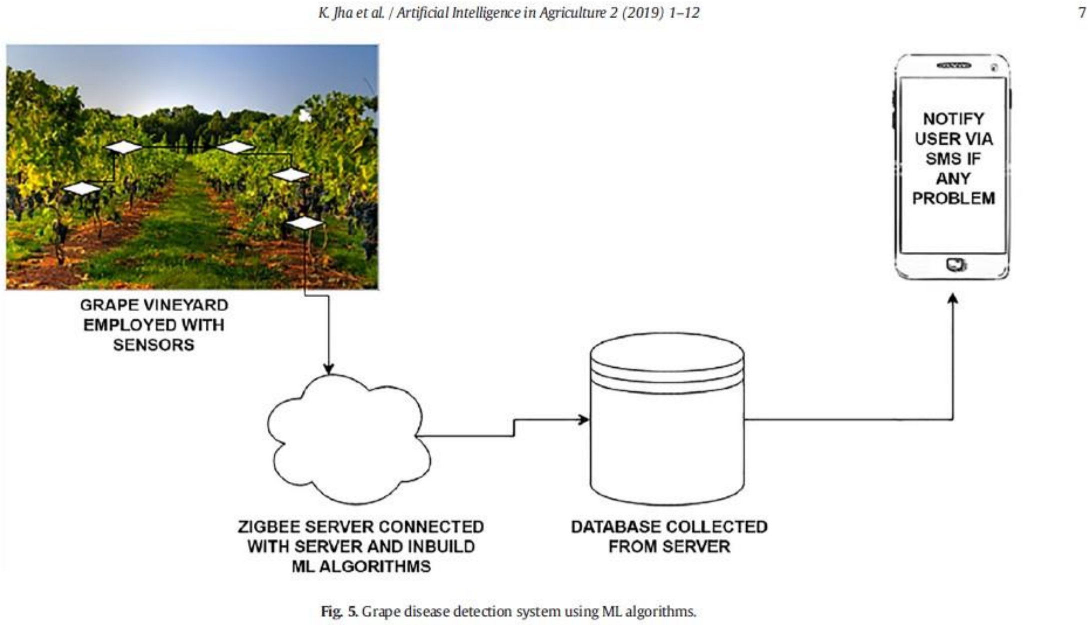

Figure 7 Grape Disease Detection System using ML Algorithms.

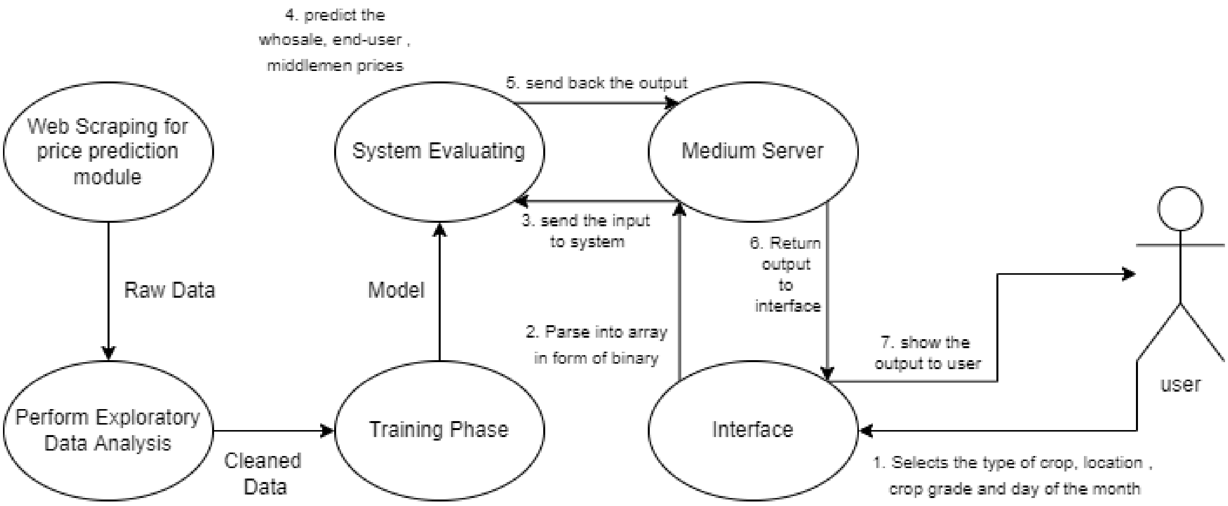

Figure 8 The Conceptual Design of Price Prediction Workflow

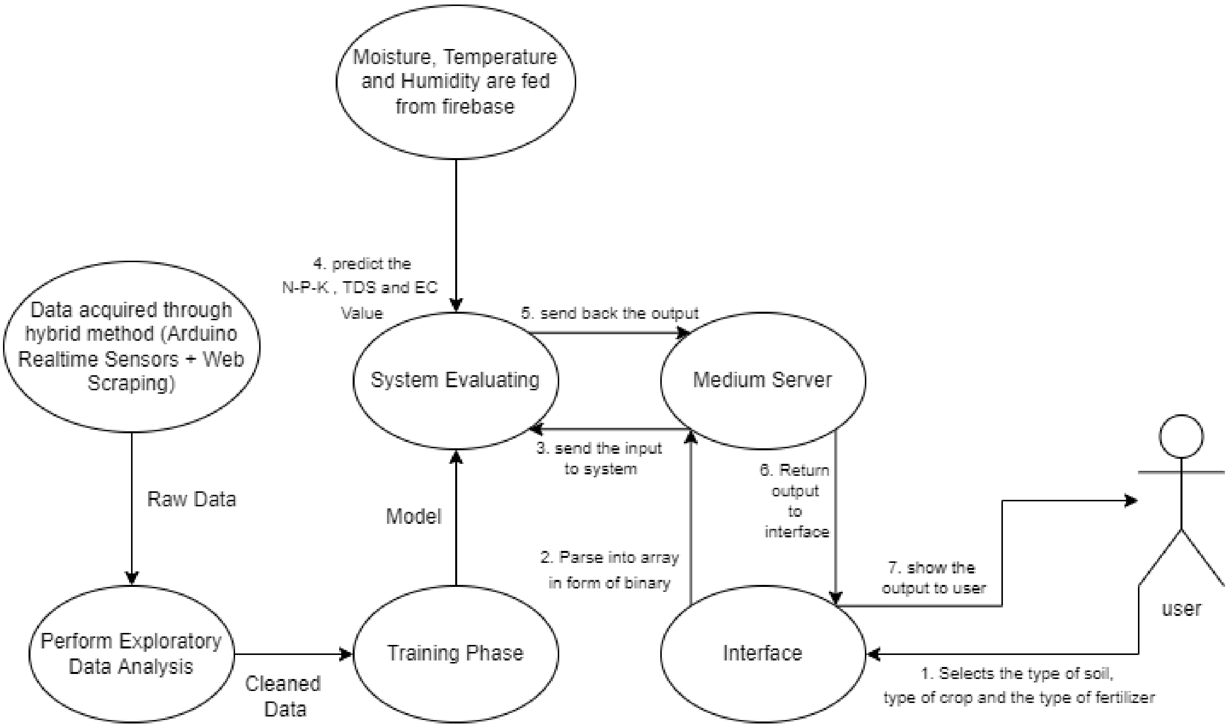

Figure 9 The Conceptual Design of Fertilizer and N-P-K Prediction Workflow

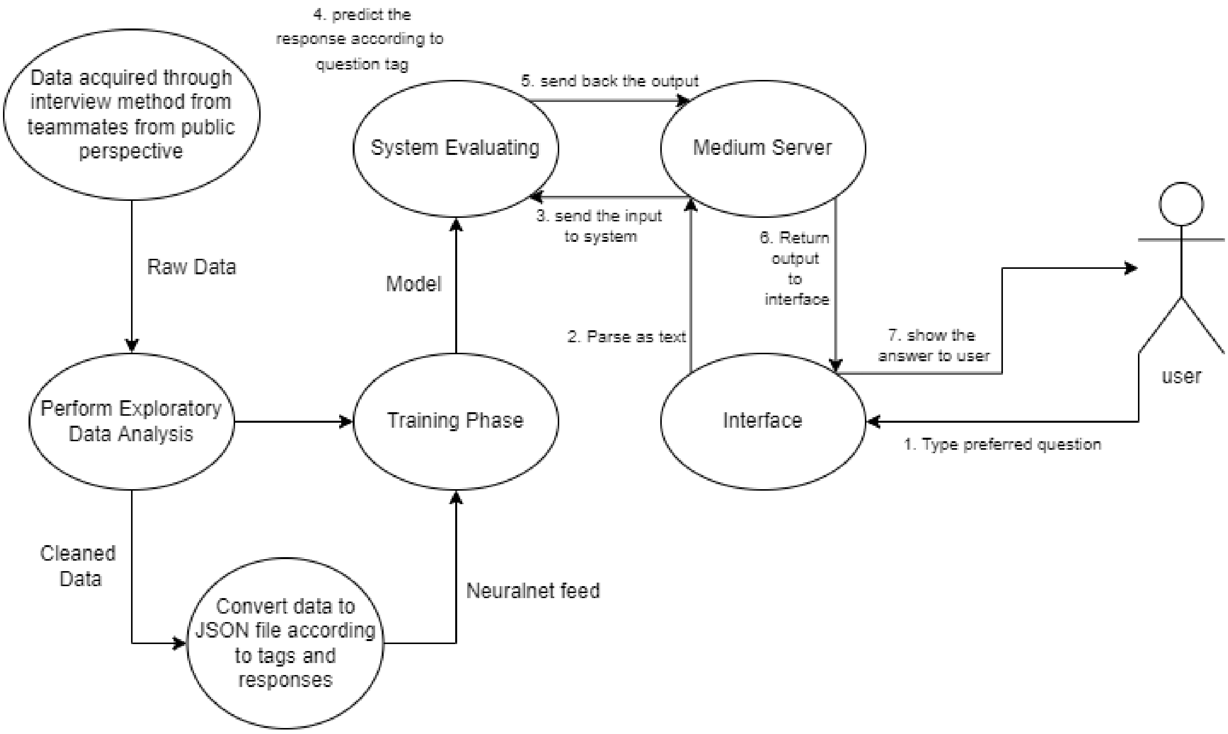

Figure 10 The Conceptual Design of Chatbot Workflow

No	Task	Week													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Discussion of project background	■													
2	Methodology Analysis		■												
3	Characterize the Type of Crops			■											
4	Acquiring Real-time Data				■	■									
5	Creating ML Models						■								
6	Acquiring Vegetable Price Datasets						■								
7	Creating Price Forecasting System							■	■						
8	Testing on system										■	■			
9	Further Improvement of System												■		
10	System Demonstration													■	
11	Final Report														■

Table 1: Gantt Chart

<u>Work Allocation:</u>

Work	Name
Module 1: Artificial Intelligence system	KRISHNAR RAM MURUGAN & AZFAR RAHMAN & DING XUE WING & RECA SENG
Module 2: Server & database	KRISHNAR RAM MURUGAN
Module 3: Mobile Interface	RECA SENG & DING XUE WING
Module 4: Web Interface	KRISHNAR RAM & AZFAR RAHMAN

Table 2: Work Allocation

No	Task	Name
Planning	Discuss on the workshop title, work distribution and what needs to be done.	All
	Proposal is submitted via ULearn.	All .
Analysis	Identify and discuss the requirements of the system.	All
	Define the project goals.	All
	Identify the risks and limitations of the system.	All
	Discuss and choose which AI techniques are going to be implemented into the system.	All
Design	1. Structured chart 2. System Methodology	A, D , R
	3. Use case diagram	D
	1. Flowchart	R
	Sequence diagram ERD	A, R
	Design and program Database	K
Implementation	Developing the back-end part of the web application	K, R
	Developing the front-end part of web application	K, R

	Developing the back-end part of mobile application	A, D
	Developing the back-end part of mobile application	A, D
	Implement AI techniques into the system.	K
Testing and integration	Testing the system by running it.	All
Maintenance	Identify and fix errors.	All
	Improve the system performance.	All
Evaluation	Presentation of the system to the committees.	All

Table 3: Work Breakdown

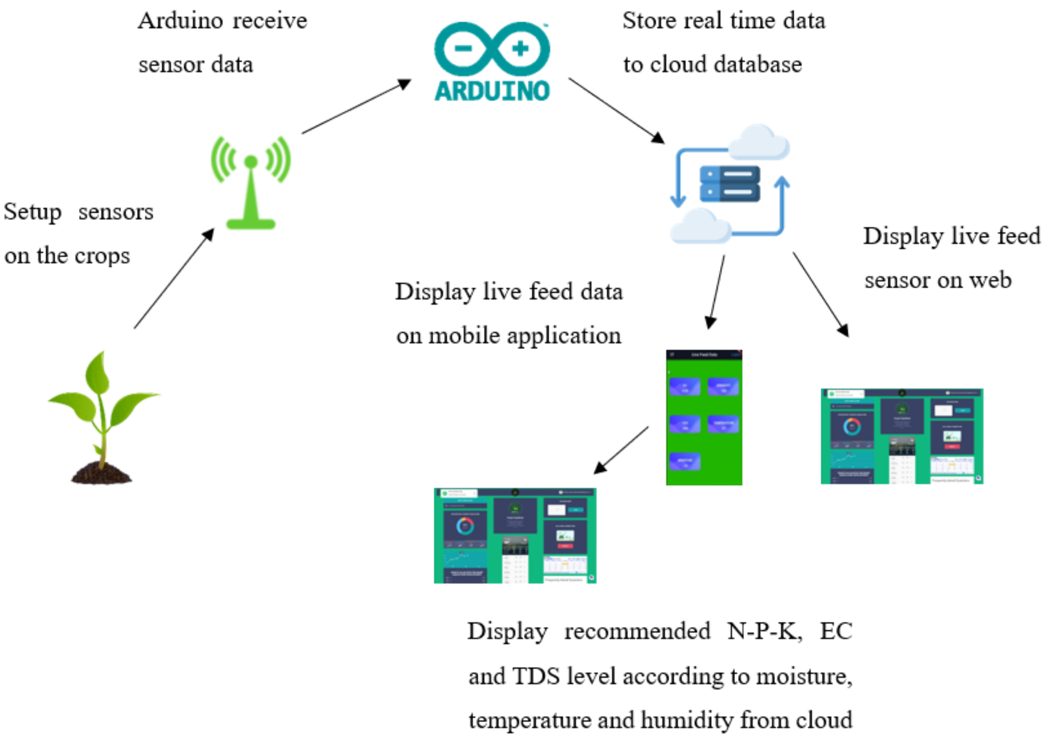

Figure 11 Display the flow of the Intelligent System Architecture

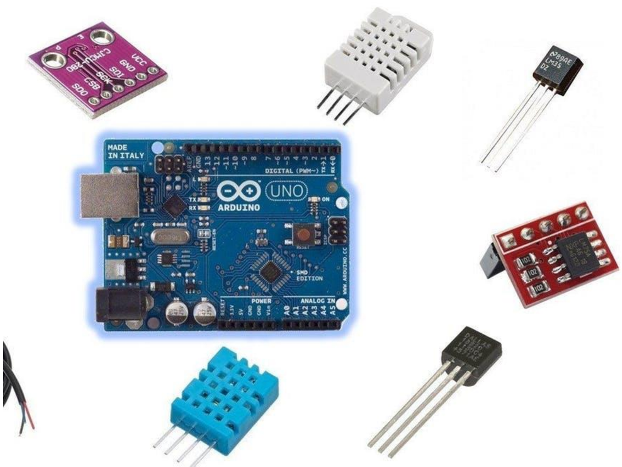

Figure 12 The Arduino Board and the Sensors

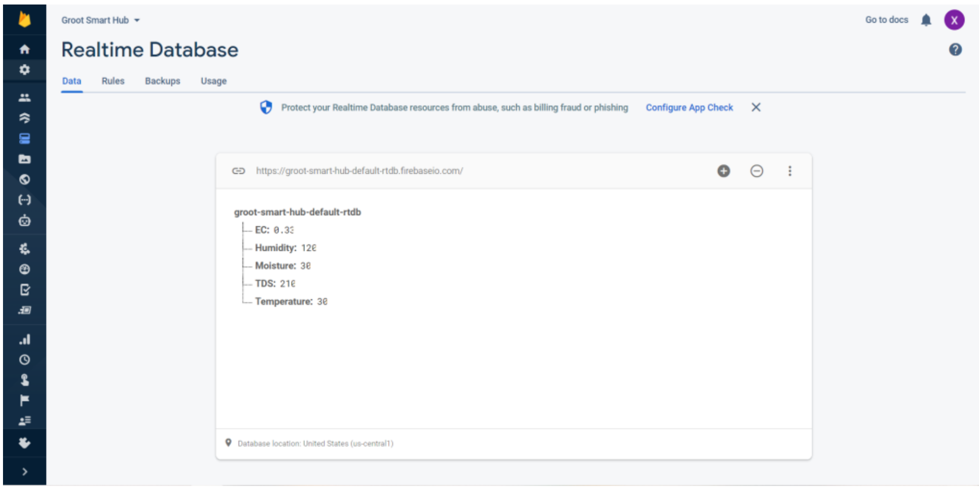

Figure 13 The Realtime Database that Updated from the Arduino Uno

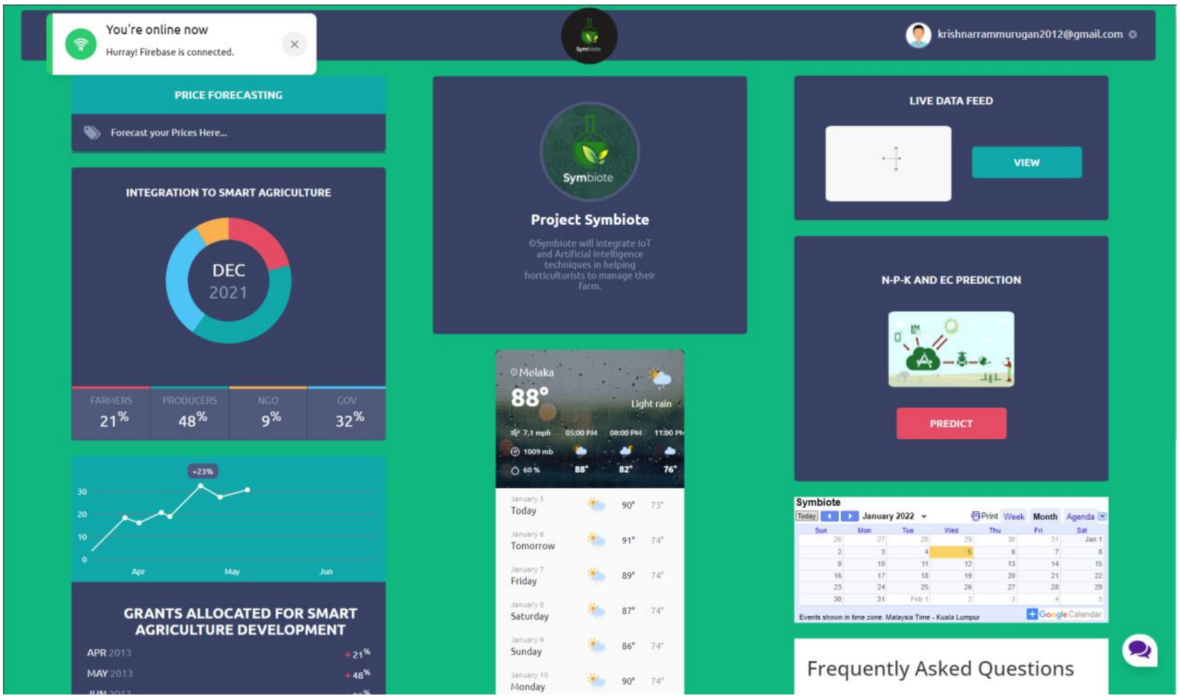

Figure 14 Display the Interface for the Web Application

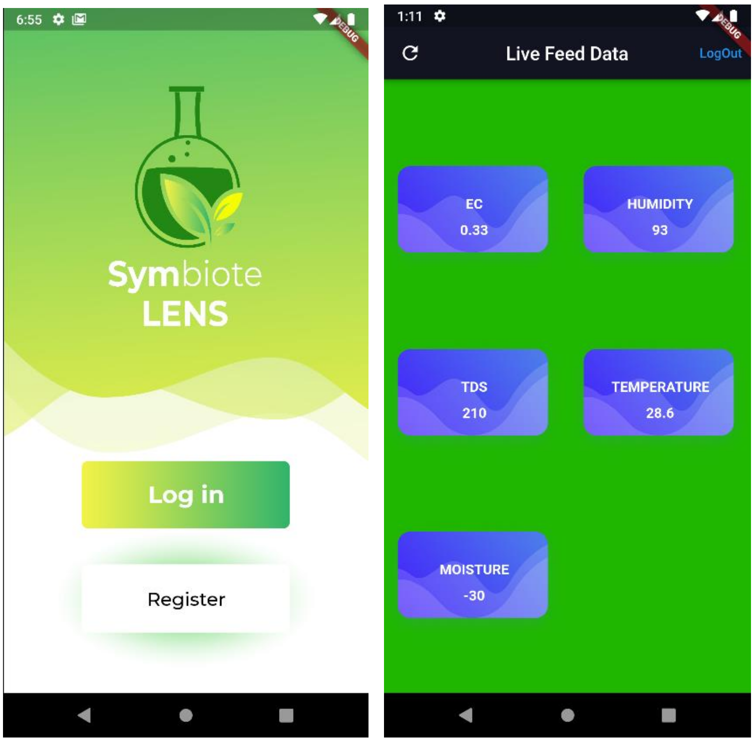

Figure 15 Part of interfaces for the Mobile Application

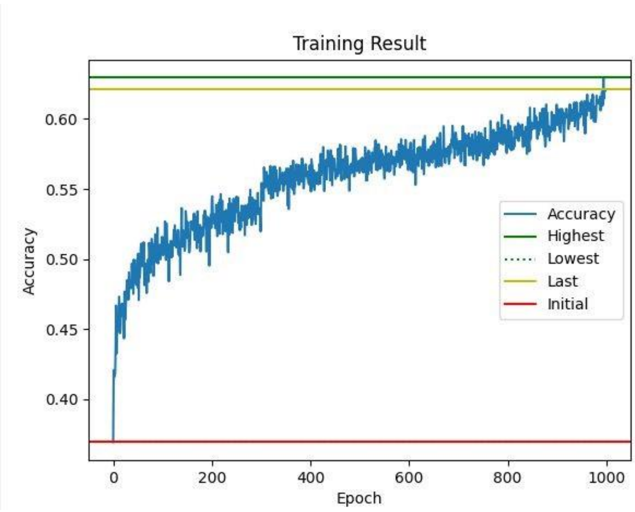

Figure 16 Accuracy Over Period for Chatbot Tags and Response Context

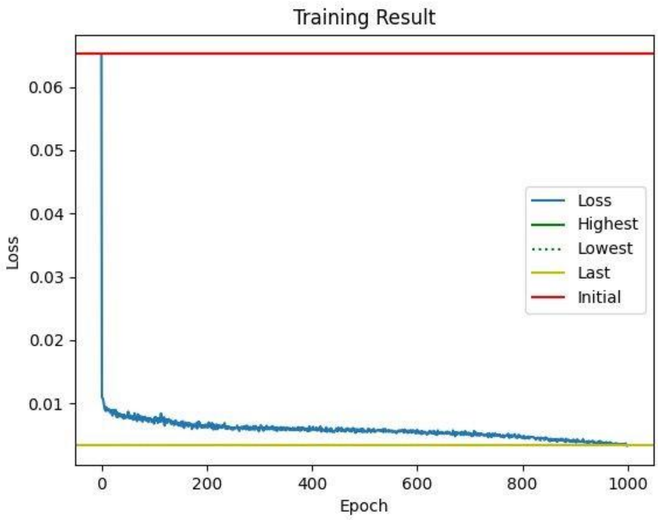

Figure 17 Loss over period for Chatbot Tags and Response Context

Num. of Dataset Pipeline / Combinations	**Price Forecasting System**		**N-P-K, EC and TDS Prediction System**	
	R-squared Score (Ridge) (3 D.P)	R-squared Score (Random Forest) (3 D.P)	R-squared Score (Ridge) (3 D.P)	R-squared Score (Random Forest) (3 D.P)
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1000	0.726	0.533	0.647	0.543
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1700	0.820	0.655	0.785	0.742
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Table 4 : Accuracy Scores when the dataset pipelines are enlarged

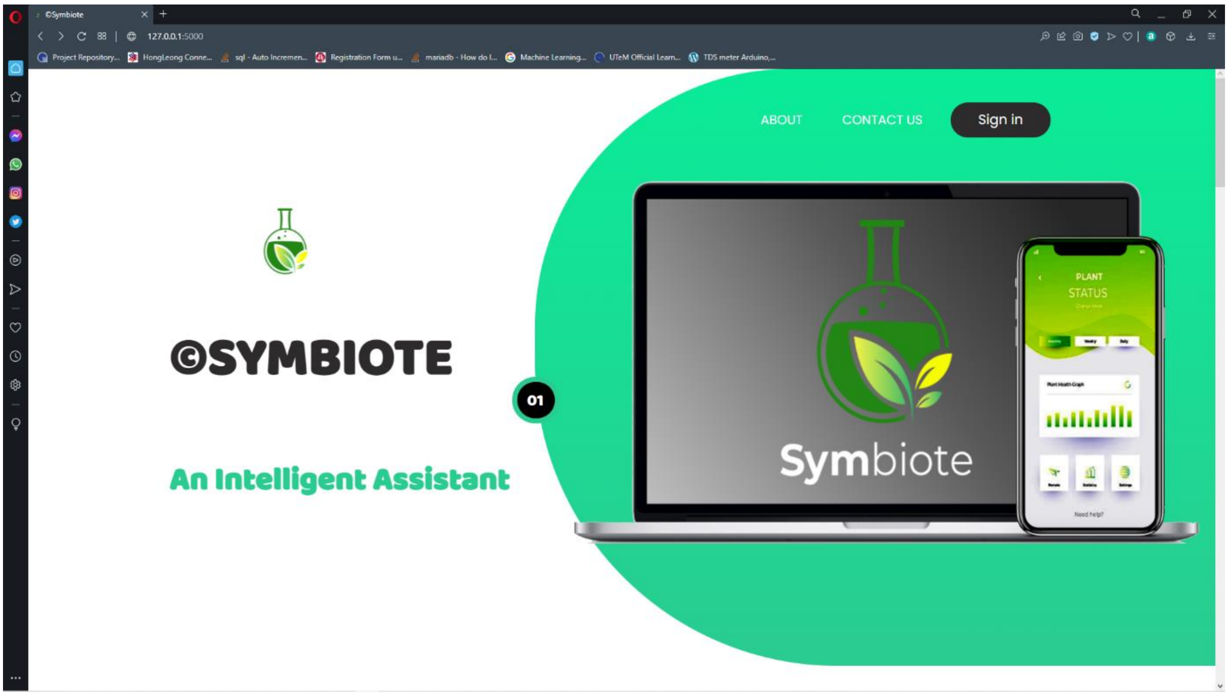

Figure 18 The Web Application Design (Landing Page)

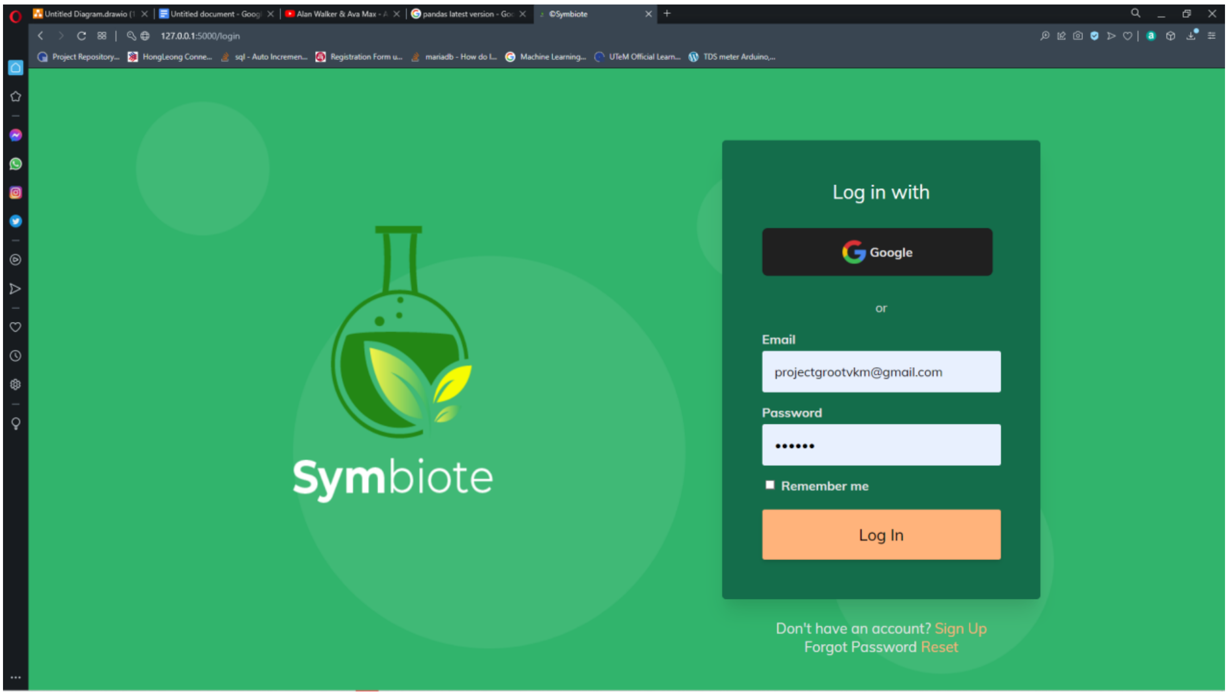

Figure 19 The Web Application Design (Login Page)

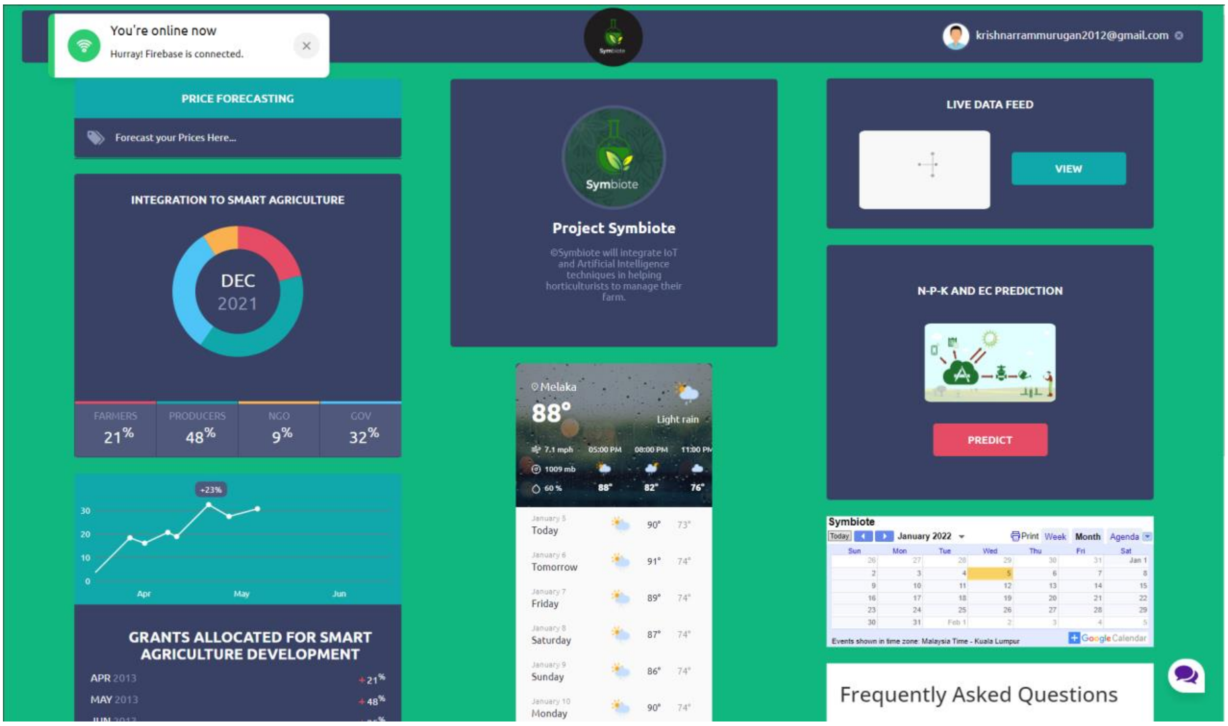

Figure 20 The Web Application Design (Dashboard)

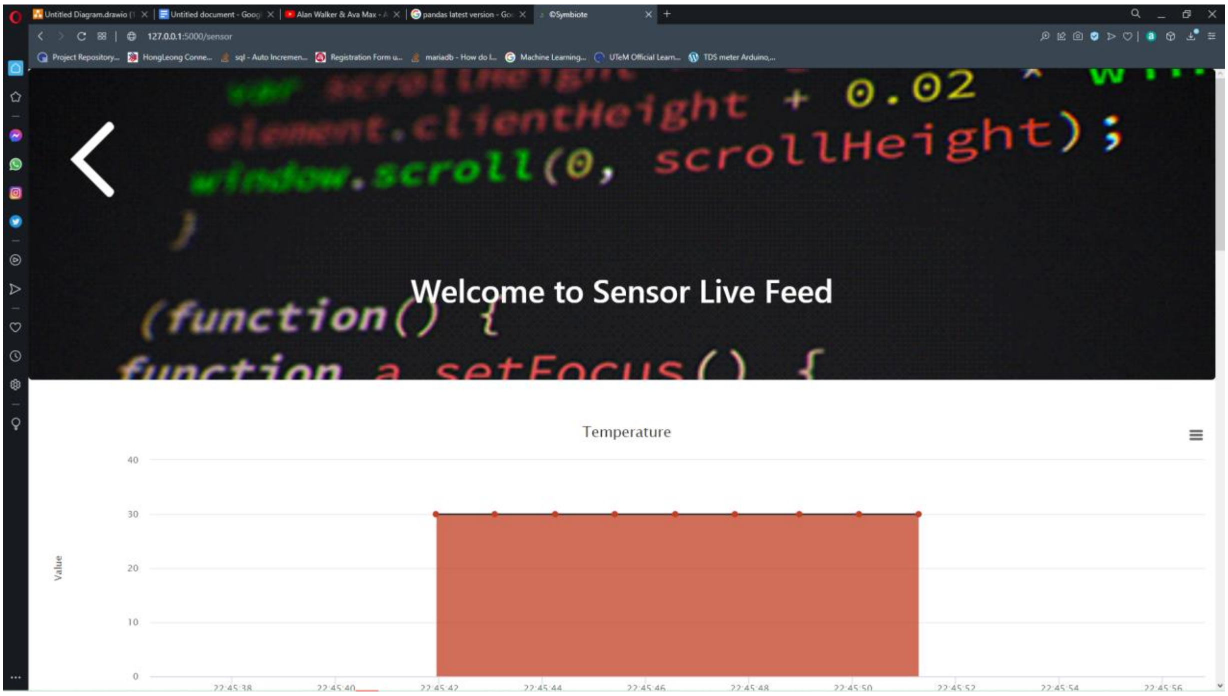

Figure 21 The Web Application Design (Live Sensor Feed)

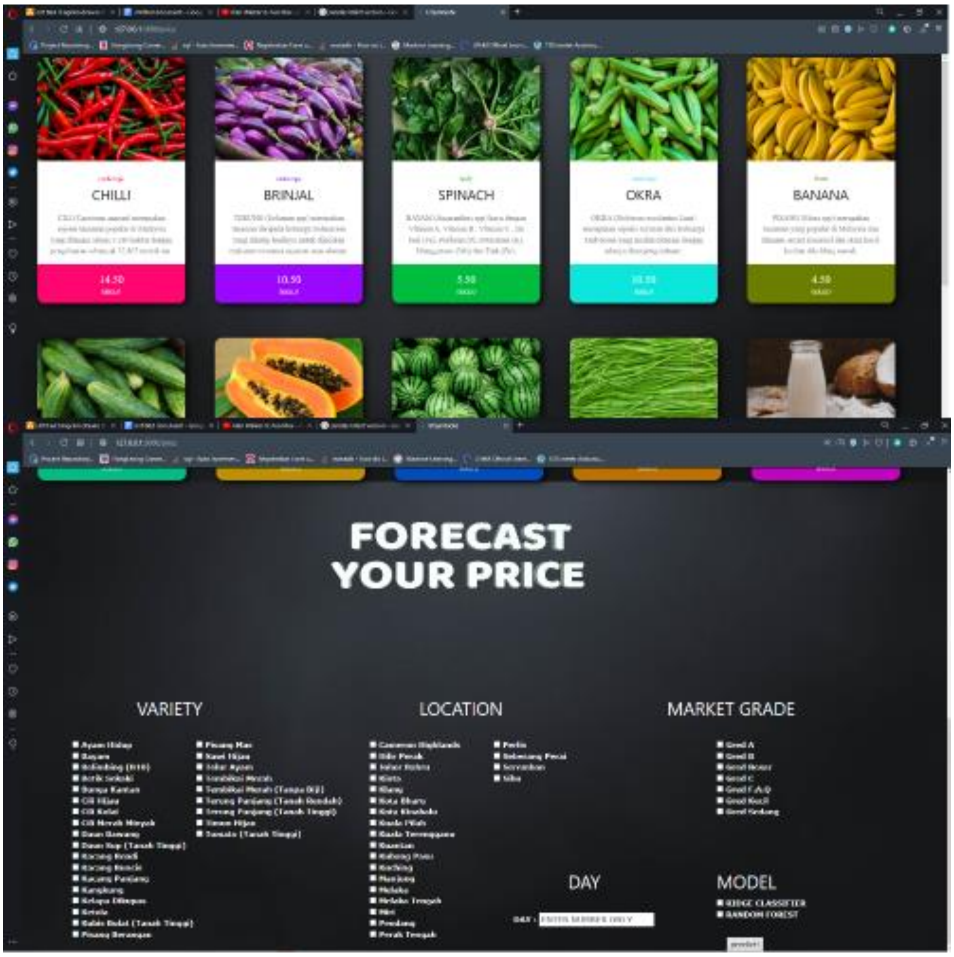

Figure 22 The Web Application Design (Price Forecasting System)

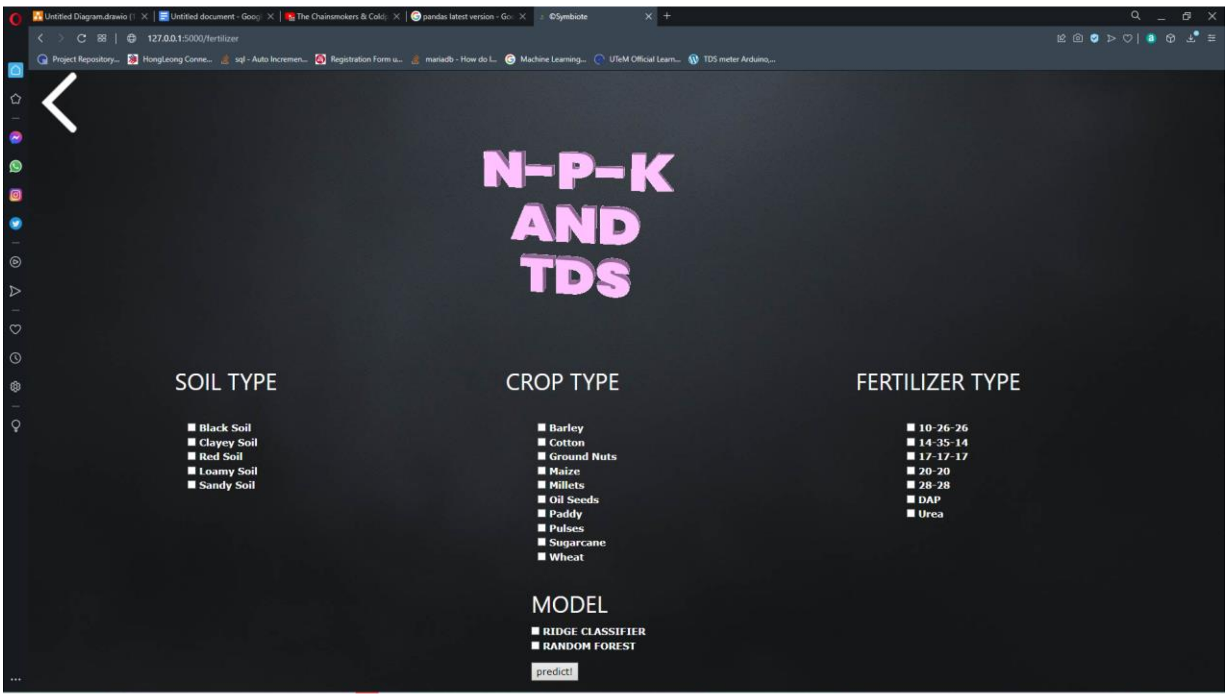

Figure 23 The Web Application Design (N-P-K, EC and TDS Prediction System)

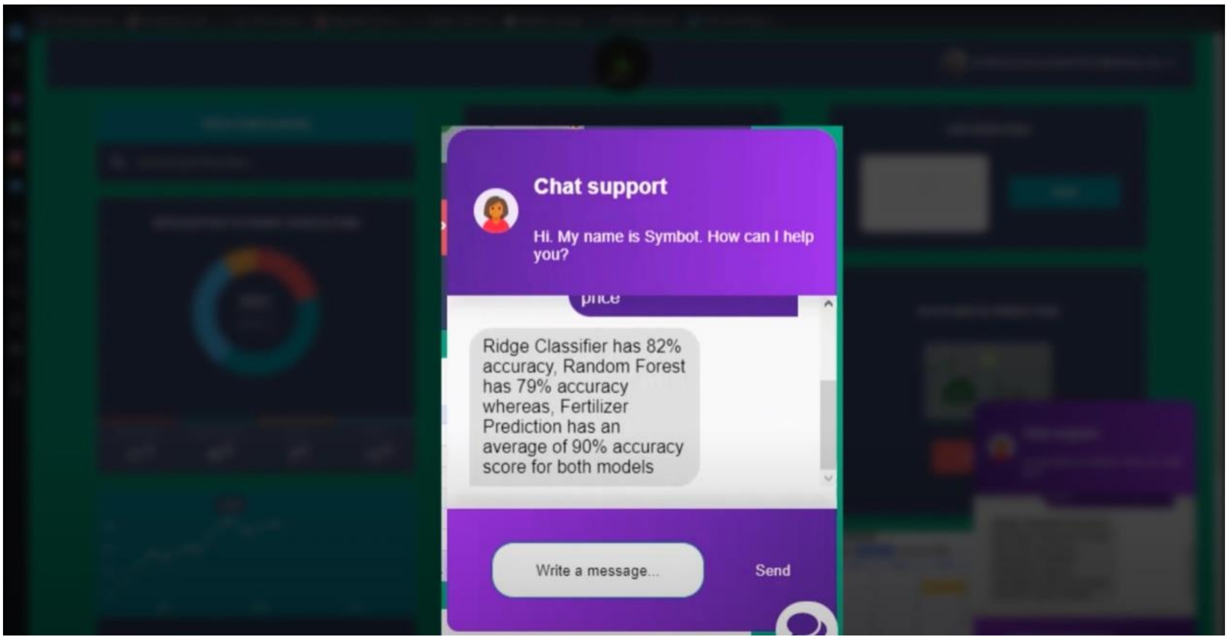

Figure 24 The Web Application Design (Symbot Chatbot)

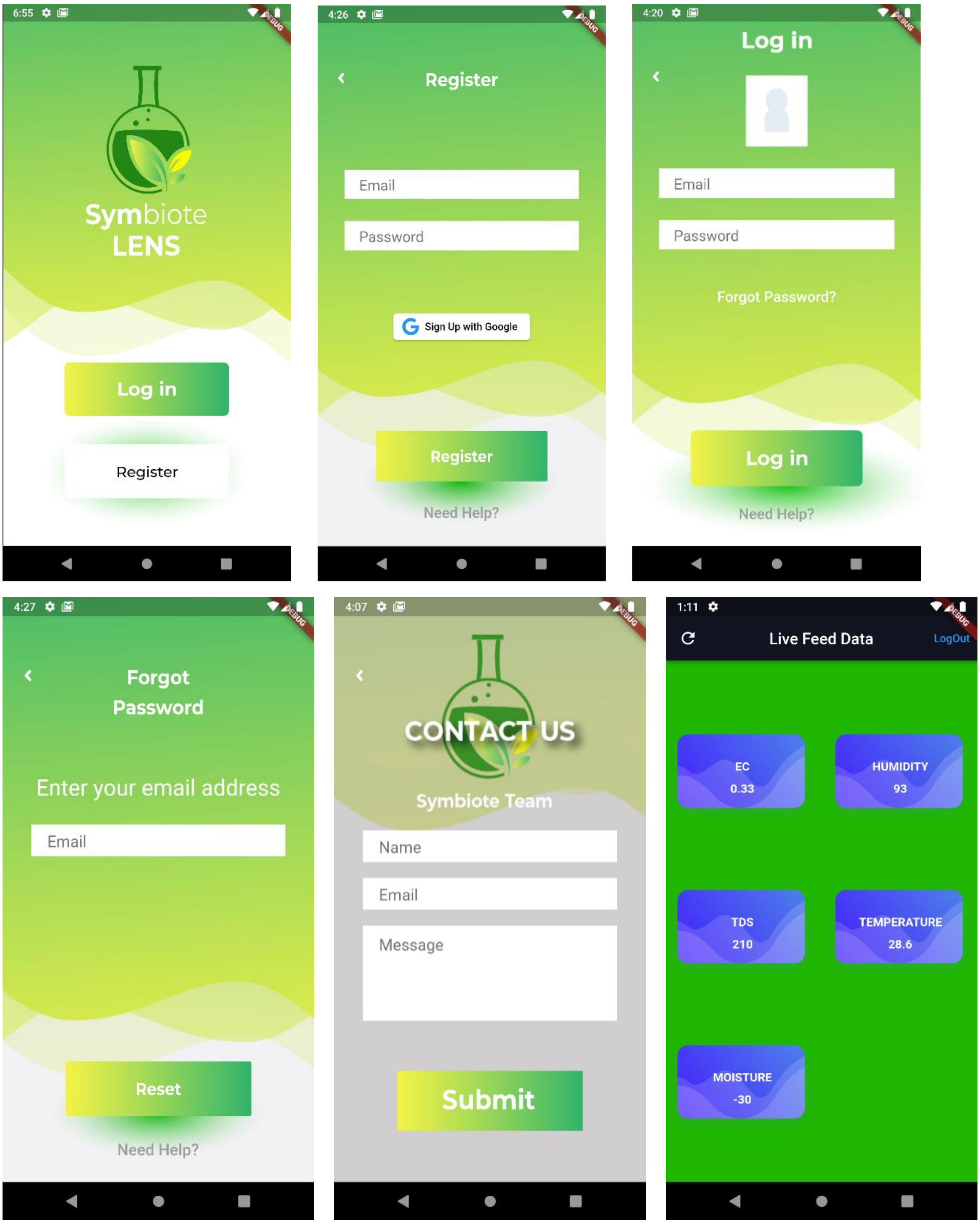

Figure 25 The interfaces of Symbiote Lens Mobile Interfaces which consists of Landing page, Login page, Contact us page, Forgot Password page and the Live Data Sensor Feed page.