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Web Based Plantation Information System with IoT for iGrow Organization

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Abstract: The Malaysian economy has always been focused mostly on agriculture and agro-related sectors. Nevertheless, despite its benefits, modern technology is still not extensively utilized. The information on agricultural soil types is the study's focus. This includes the manual land classification that is still carried out with the assistance of human experts. The importance of soil type in achieving the best yields in agriculture is well known. As a result, it's critical to have a database that has information on soil type to facilitate classification and aid in choosing the right crop type for the soil. Therefore, in this project, a centralised database and online information system have been designed to address the centralised information challenges outlined above. Scrum is an agile methodology that is employed. Databases include PhpMyAdmin and Firebase, and the programming language used is Python. The technology aids the community of trainees in gathering soil data and doing agricultural analyses based on district and plant types using rule-based algorithms. By assessing the soil's suitability for growing crops, the developed system assists people who want to start farming.

Keywords: Plantation, Soil Classification, Web-based, IoT

1. Introduction

Malaysian agriculture is influenced by several factors, namely the basic status of natural resources, land structure and soil quality, climate change, advances in science and technology, and others. These factors will affect the development of agriculture in the country holistically [1]. Soil quality is the capacity of soil to function for a particular land use or within the boundaries of an ecosystem [2]. Better soil quality leads to better production performance including reduced input costs for herbicides, pesticides and fuels, less wear on machinery and more efficient use of water and nutrients [3]. This abundant agricultural information is very important to help the survival of the agricultural industry. Therefore, knowledge of agricultural practices must be available and can be channeled to the community in a simple way so that it can be utilized to those in need.

Soil is a mineral-rich and organic-rich component of the earth's surface [4][5]. Soil is a critical component in the cultivation of a variety of plants, whether for food, industry, or animals [6]. Because

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soil sustains the life cycle in which plants give food and oxygen while also absorbing carbon dioxide and nitrogen, it is critical for all life on Earth [7]. The composition of soil varies from one location to the next. It goes back millions of years and is the result of the weathering process. The variety of soil types is linked to the sort of crop that can be grown there. Soil classification, soil and crop suitability classification, and crop suitability assessment are all significant variables to consider when developing an agricultural operation [8][9]. This fundamental knowledge is critical for agronomic activities, as well as land and agricultural management.

The case study in this project is conducted at Institut Agro Usahawan, or iGrow which is private learning centers. This center offers agricultural training to those interested in opening an agricultural farm. Farmers trained under the course program at iGrow are called trainees. The trainees at iGrow come from a variety of professions and backgrounds. However, each trainee land is not in the same condition as determined by the institution. Many trainees find it difficult to learn about the agricultural areas in their district and the types of crops that are suitable to be planted when they start farming. It is also difficult for new farmers to receive knowledge from other farmers in the same district, even if they are close. It is also challenging for new farmers to know what types of crops to grow on their farms. Due to the lack of information on the type and condition of the soil at their location, it is difficult for them to assess what types of crops are suitable for planting.

iGrow's courses cover a wide range of topics and include a diverse range of trainees with a variety of backgrounds and planting techniques. Most of their trainees would use their previous experience to begin planting. The only issue they have is that each district has its own set of conditions and plants that are best for planting. The condition of the soil in the highlands, for example, differs from that in the lowlands. Temperature, weather, and situations are frequently incompatible. The methods of planting and tree kinds vary widely depending on the suitability of the soil. Because the data is not stored in any software or hardware, trainees have a difficult time determining the best circumstances, weather, and temperature for the crop they intend to plant. The trainee will be trained in the workshop and will then be required to scribble down or memorize all the material given to them to recall it.

Therefore, a web-based information system which keep plantation information is proposed. The proposed system will assist the iGrow trainee community in gathering soil data and conducting farming analyses based on district and plant types utilizing a rule-based algorithm. The proposed system will aid trainees who wish to start farming by examining the land's condition to cultivate a crop. Trainees will be able to register their sensor for soil analysis and view the results via the channel module. Based on trainee analysis and graph output, each channel is unique. The system also allows trainees to log in from many online systems within the same company.

There are five sections in this article. The project's introduction and the organization's history are described in Section 1. An overview of the literature review and comparative studies is provided in Section 2. System development process is discussed in Section 3. The project's results and debate are explained in Section 4. The conclusion is in Section 5.

2. Related Work

With a growing population, the agricultural industry needs to increase to meet demand regardless of environmental challenges such as bad weather and climate change [10]. In another effort for the industry to thrive in the challenge, the agricultural industry needs to adopt new technologies to gain more advantages such as smart farming and precision farming through IoT that can increase productivity as well as reduce costs and reduce waste [11]. Smart farms are systems built to monitor crop farms with the help of sensors and automate irrigation systems [12]. With intelligent farming the farmer can monitor the condition of the farm with the help of IoT devices which are highly efficient as compared to traditional methods [13]. The project uses an IoT system because it can integrate with a web -based information system that allows sensors to output to the system. IoT sensors allow trainees to make analysis based on sensor output from web -based information.

Generally, web-based information system methods have information management facilities, can be easily accessed from a variety of device tools and are easy to maintain. With the advantages offered by this method, and the requirements of the proposed system, then the new system will use this method. Furthermore, in its age of digital technology, the importance of accessing information quickly is essential to many business operations or other information management. Web-based information systems are easily accessible even if each user has a different device if there is an internet connection. Finally, web-based information systems can improve the efficiency of information management processes and information transactions. This can help achieve better work productivity. Data storage in a centralized database facilitates the process of managing this data for various purposes related to business operations. Users can access their data and users can share their data to other users for them to access it. With the right level of security, all sensitive data is restricted to specific users through the login function.

The proposed system allows for a smooth work process for trainees as they do not have to rely on third party organizations such as the Department of Agriculture for land information. This is because iGrow trainees will conduct their own research as they use IoT sensors to measure soil moisture as well as other requirements for growing crops such as temperature. Trainees do not have to rely on global information from other countries because not all countries have the same climate as our country. The system will focus on local data solely because the location will be captured during information collection. The new system needs to work with IoT sensors for the system to function properly. The goal will be to generate an API key for each channel that the trainer has created, and the key will be used for the IoT sensor in the Arduino to register to the server. After that, the sensor output will be saved into the database and will be displayed in the channel via graph. The IoT will allow trainees to collect soil data to do their own research based on soil and crop data suitable for cultivation.

For the comparative case study three related systems were selected. Every function in the system is examined, namely ThingSpeak for IOT Projects, Dynatrace and IOT Analytics Market Insights for The Internet of Things. ThingSpeak was built by The Mathworks, Inc to provide free service usage of IoT platform service for any kind of users to build IoT-based projects. This system used web programming language including HTML, CSS, and JavaScript as user interface design as well as MATLAB for analysis and visualization and another plugin. This system offers student, teacher, farmers, and other user a platform to start their own IoT project either for research or study. The website is available for 24 hours thanks to cloud-based server and user can easily access it. To visualize their analysis, user must create a channel to display their analysis which user can choose the form of visualization. From bar chart to pie chart users have a variety of form to visualize their analysis and they can choose whether to display it publicly or keep it to themselves.

Dynatrace is a service provided by Dynatrace LLC that monitors the performance of IoT devices. This web system can be accesses through https://www.dynatrace.com/. The user interface design web language was HTML and CSS, while the DBMs were cloud-based servers. This online system is powered by Artificial Intelligence (AI), which is a trusted partner for IoT performance and unparalleled user experience. Users must pay a price to gain access to the platform, but before they must pay, they can get a 30-day free trial to see how Dynatrace works with IoT sensors.

IoT Analytics GmbH (https://iot-analytics.com/), a business that specialises in industry, developed IoT Analytics. Because it concentrates on industry power and is accessible from anywhere in the world, this website gives the impression that it is professional. The fundamental objective of this system is to embrace Industry 4.0, making it a leading source of IoT market intelligence. The system keeps tabs on the overall business environment for technology as well as broad trends in digital transformation, with an emphasis on IoT markets and IoT firms. As they conduct additional research and delve into different IoT segments, IOT Analytics, which covers several IoT segments and marketplaces, continually add new focal subjects. This system's goals are to provide information to improve knowledge of IoT markets and to keep track of global trends.

Django is the framework of choice for the new system. All iGrow trainees get access to the created IoT Web-Based Farm Information System without having to install anything on their computer or smartphone. Two main users, including the administrator who handles user accounts, are present in this system. trainee who uses the system most frequently. Comparing the three current systems and the newly designed system is summarized in **Table 1**.

Table 1: Comparison analysis among similar systems

Features / System	ThingSpeak for IoT Projects	Dynatrace	IOT Analytics Market	Web Based Plantation Information System
Module	Create Channel and register sensor devices	Monitor the performance and health of IoT devices	IoT Market insights	Create Channel and register sensor devices
Login and Registration	Email required	Email required	Email required	Email required
User	Student, teacher and IoT users	Business organization	Business organization	iGrow Trainee
Security	Provide authorization access	Provide authorization access	Provide authorization access	Provide authorization access
Platform	Web-based	Web-based	Web-based	Web-based

Table 2: Software development activities and their task

Sprint	Task	Output
Sprint 1: Planning	□ Proposed the project. □ Determine the project schedule, activities, and output	□ Project proposal □ Gantt chart
Sprint 2: Analysis	□ Analyse gathered information	□ Requirement □ UML Diagram □ Class Diagram □ Flowchart
Sprint 3: Design	□ Interface design □ Navigation structure design □ Database design	□ System architecture □ Database design □ System's interface design
Sprint 4: Implementation	□ Implement interface design. □ Coding □ Implement database design to system	□ Complete system with interface and database □ Test cases
Sprint 5: System Testing	□ Test on site	□ Test report

3. Methodology

The agile Scrum methodology will be used to handle this project. Scrum is a sprint-based technique that shows how continuous work moves. As a result, the development team may have a better understanding of their project's scope and the tasks that must be completed. Scrum procedures can solve complex customization issues while producing high-value commodities in a timely and innovative manner. **Table 2** shows software development activities and their task. There are total of five sprints that need to be done in SCRUM Agile methodology.

3.1 Sprint 1: Planning

In this phase, early planning of the project has been undertaken to ensure the flow of the system development is well executed and managed. Proposal and Gantt chart of the project has proceeded which shows the activities that will be taken throughout the process system development. Information collected from the iGrow organization includes current processes used, data, and technologies used. The discussion session was online with representatives from iGrow.

3.2 Sprint 2: Analysis

All the data from the previous sprint will be examined based on the previously obtained information to determine the issue that the iGrow organization is presently experiencing. The activities that establish the requirements or conditions for a new or upgraded product are the focus of requirement analysis. This is accomplished by considering the conditions or demands of diverse stakeholders. To ensure that the product is well-developed, this analysis is crucial. **Table 3** lists the functional requirements, whereas **Table 4** lists the non-functional requirements. The user requirements are listed in **Table 5**.

Table 3: Functional Requirement

Module	Description
Registration and Login	• The system should allow the user to login into the system using registered username and password. • The system should only allow a user to log in as a user with a valid username and password. • The system should alert the user of any invalid input. • The system should redirect user to that respective main menu upon successful login.
Plantation Module	• The system should store plantation data (type of soil, plants, and other related information) • The system should provide Rule based Analysis to identify suitable plants for a type of soil
Channel	• The system should allow the user to create a channel, delete and view. • The system should allow users to create a channel based on the data they captured. The channel name will be based on the user create. • The system should allow trainee to visualize their sensor input into type of graph.
Sensor Register and Management	• The system should allow users to register their sensor, add sensor and delete sensor. • The system should allow users to also add a new sensor to capture new data. Users also can delete their sensor if they don't use it anymore.
Report	• The system should generate a report after capturing data through sensor. • The system should allow users to view their data on the channel based on the graph.
Forum	• The system should allow users to share their data to other users to help them make an analysis.

Table 4: Non-Functional Requirement

No	Requirements	Explanation
1.	Operation	• The system must be user-friendly. • The system can easily update.
2.	Implementation	• The system can be use from laptop or computer that run Window OS.
3.	Security	• Only administrator can update the system. • Administrators need to update user's username and password to login the system.

Table 5: User requirements

No.	User Requirements
1.	Trainee should be able to input username and password for login purpose respectively.
2.	Trainee should be able to create channel for connecting sensor and display sensor's output.
3.	Trainee should be able to edit and delete channel for changing purposes.
4.	Trainee should be able get API key for connecting IoT sensor to the system server.
5.	Trainee should be able to display the result of sensor in the system.
6.	Trainee should be able to keep the record of the results for future purposes.
7.	Trainee should be able to discuss among each other for research purposes.
8.	Trainee should be able to log out from the system.
9.	Administrator should be able to monitor all channel create by trainee in the system.
10.	Administrator should be able to input admin username and password to login to the system.
11.	Administrator should be able to edit and delete all trainee accounts in the system.
12.	Administrator should be able check the report from the system
13.	Administrator should be able to logout from the system.

On the other hand, system analysis for the project is developed using and object-oriented approach and involves the construction of a Unified Modelling Language (UML) and a class diagram. **Figure 1** provides the use case of the system.

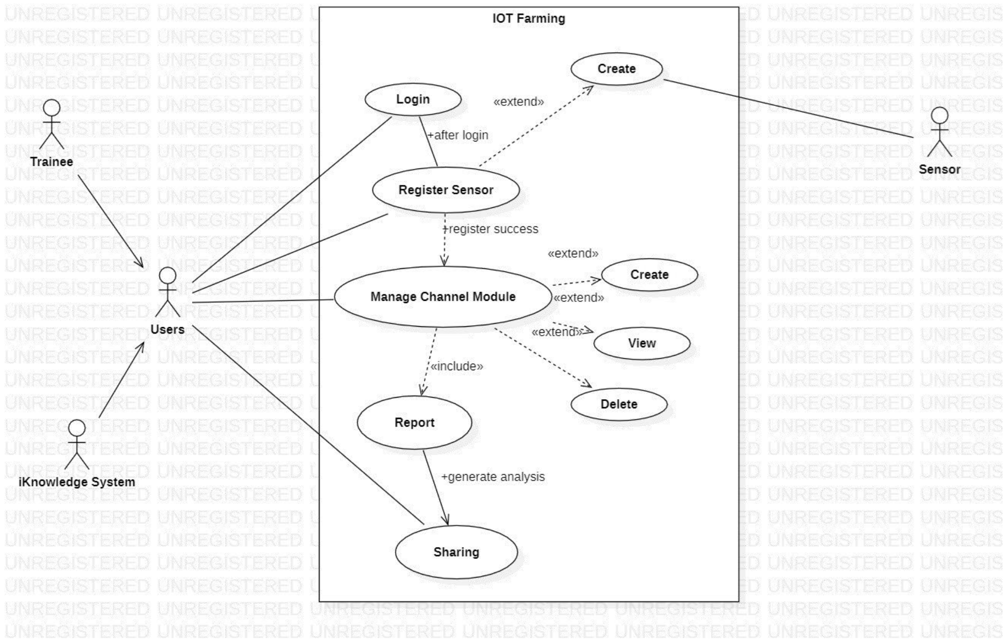

Figure 1: Use case diagram

The class diagram in **Figure 2** shows six classes: Forum, Login, Channel, Plantation, Field, and Sensor.

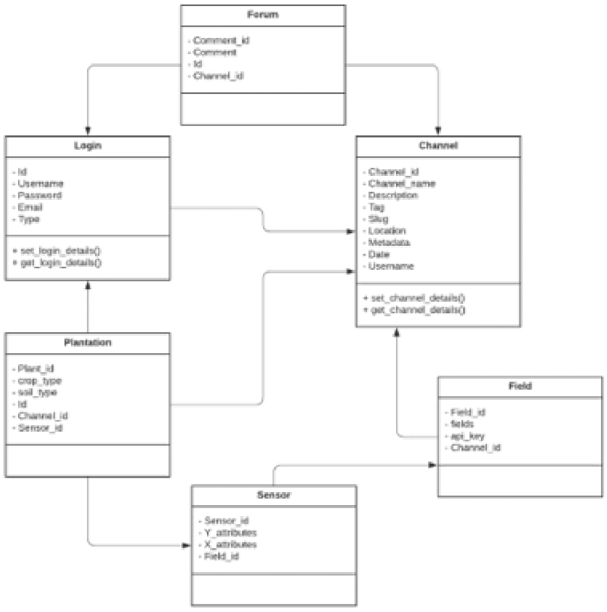

Figure 2: Class Diagram

System design involves the construction of a flow chart for the proposed application system. **Figure 3** shows the flow chart for channel registration and **Figure 4** shows the flowchart for generating API key for sensor registration to Arduino.

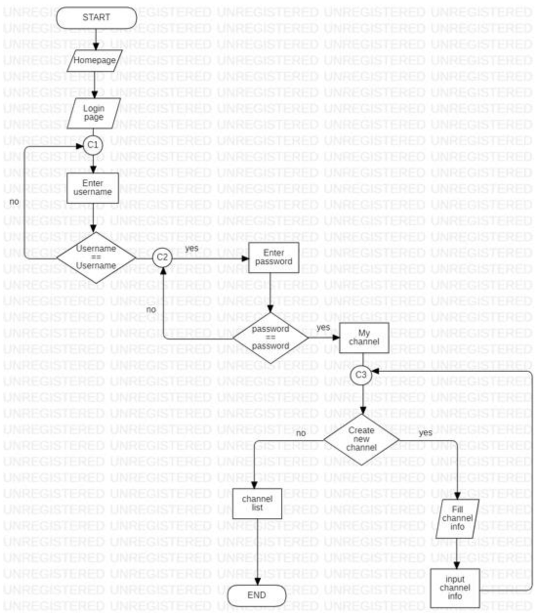

Figure 3: Flow chart for creating new channel

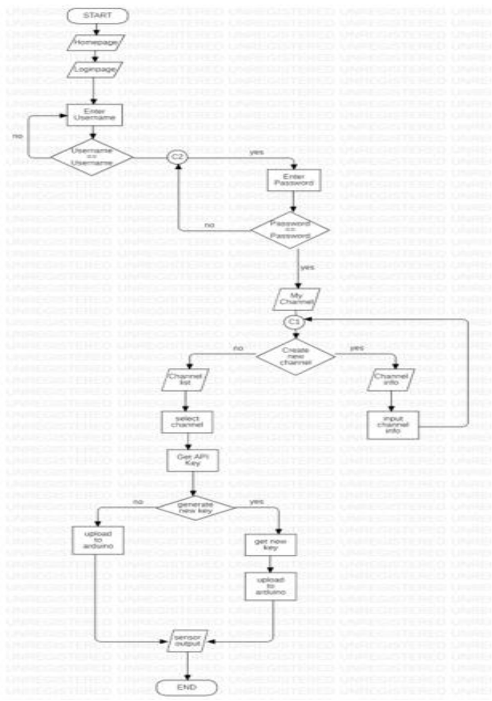

Figure 4: Flow chart for generating API key for sensor registration

3.3 Sprint 3: Design

In this current sprint, system will be design based on the system requirement that have been identified. Database design involves the preparation of a data dictionary and database scheme. The scheme for the developed database is as follows:

i. Login (Id, Username, Password, Email, Type)
ii. Channel (Channel_id, Channel_name, Description, Tag, Slug, Location, Metadata, Date, Username)
iii. Field (Field_id, fields, api_key, Channel_id)
iv. Sensor (Sensor_id, Y_attribute, X_attribute, Field_id)
v. Forum (Comment_id, Comment, Id, Channel_id)
vi. Plantation (Plant_id, Type, Id, Channel_id, Sensor_id)

The Graphical User Interface (GUI) design is a blueprint for the system as what the system will look like when the project start. Interface design should be easy to understand and have a suitable appearance according to the project. **Figure 5** to **Figure 8** show the design interfaces for the system.

Figure 5: Login page of the system

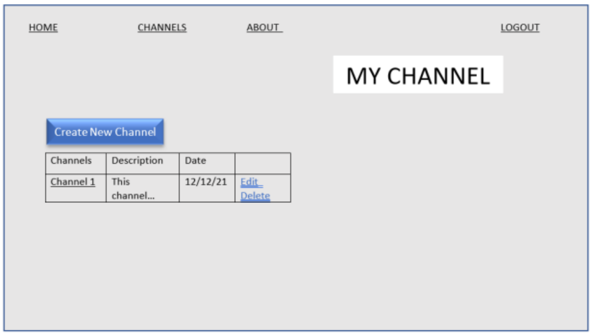

Figure 6: My Channel page of the system

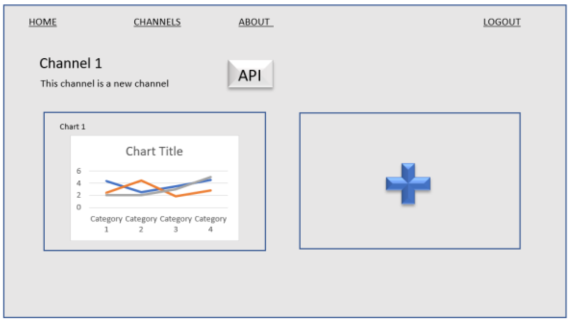

Figure 7: Channel info page of the system

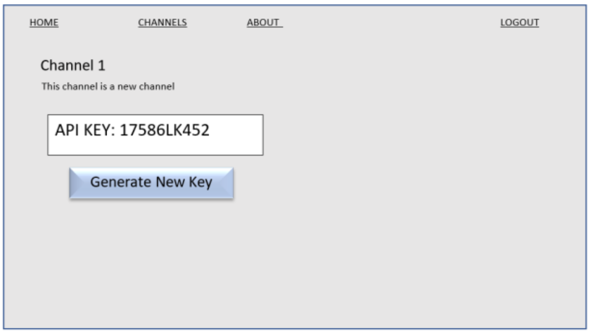

Figure 8: API key section page of the system

3.4 Sprint 4: Implementation

Based on the designs that have been done previously, the system will be developed for the iGrow organization. All the material that has been gathered will be integrated one by one to connect IoT sensor to the system. An API key will be given to the Arduino IDE for Arduino programming to connect IoT sensor to the system server. Firebase software will act as the database to collect all output from the sensor and then transmit the data to the system in channel module as an output result from the sensor.

Figure 9 shows the homepage for the system. Most of the users for the system are iGROW trainees that are registered to iKnowledge Management System or new trainees that just receive their training from iGROW. Homepage allows people to navigate their way in the system. There is a navbar that allow them to navigate which are Channels for them to see other trainee channels and research, PH soil graph for them to measure soil PH using IoT sensor, which is connected to the system, and about which is a section to teach them how to use the system. In homepage, there is also a section where it takes iGROW trainee to where they can register an account to use the system.

Figure 10 depicts the login page, which is for the user (iGROW trainee). The login class name in both figures is 'login view,' and the user will submit their username and password there. The code will first seek token authentication from another system, the iKnowledge Management System, in this function.

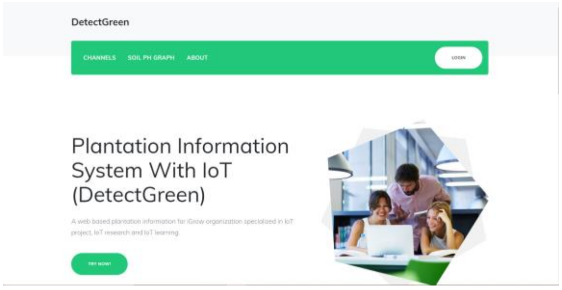

Figure 9: Homepage

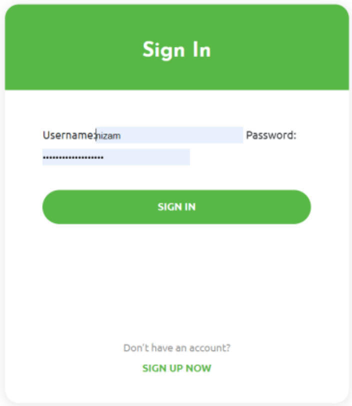

Figure 10: Login form

Figure 11 shows My Channel page after successfully logging in with iKnowledge account. iGROW trainee can create their own channel for their own research after successfully login and can oversee their own channel in this page. Users can either delete or edit their channel accordingly as well as search their channel through here. In this page, there are channel name, channel description as well as last updated.

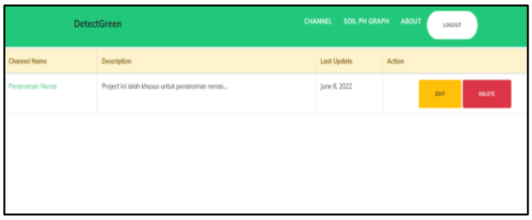

Figure 11: My Channel interface

```
@login_required(login_url="/accounts/login/")
def my_channel(request):
    channel = Channel.objects.filter(author=request.user)
    return render(request, 'channel/my_channel.html', {'channel': channel})
```

Figure 12: My Channel code snippet

Figure 12 shows the snippet of my channel code. The code shows that before a user can access the page it needs to login first which is required to access. After that, it will get data from the database and will filter according to the author of the channel. `Channel.object.filter` is a code to filter out what data it will fetch from the database and filter it from foreign key in the table; in this case it filters author. Lastly, it will redirect the user to My Channel page.

Figure 13 shows channel list interface and **Figure 14** shows snippet of Channel list. In this page, user can see what type of research their fellow trainee did without login to the system. It can be accessed publicly for everyone to see their research. This page shows the name of the channel, description, and the author of the channel. The code `Channel.objects.all().order_by(date)` is to fetch all the data from channel table from the database and order it by date created.

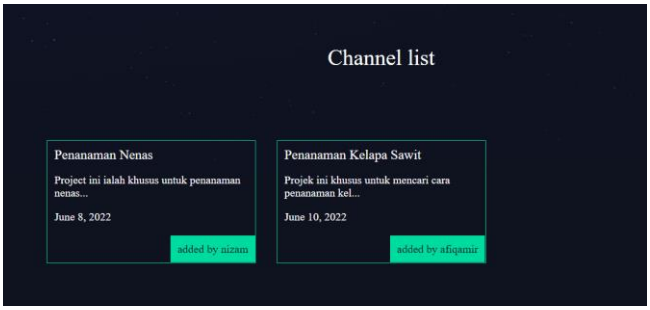

Figure 13: Channel list interface

```
def channel_list(request):
    channel = Channel.objects.all().order_by('date')
    return render(request, 'channel/channel_list.html', {'channel': channe
```

Figure 14: Channel list code snippet

Figure 15 shows the detail of each channel created by trainee and **Figure 16** shows the snippet code. In this page, the details of the channel posted by trainee will be shown in this page. This page is for their research on how to handle the type of plantation they did, and a comment section acts as a forum for them to discuss among each other. The details that are shown on this page are Channel name, description, date created type of soil they used and their data from IoT sensor.

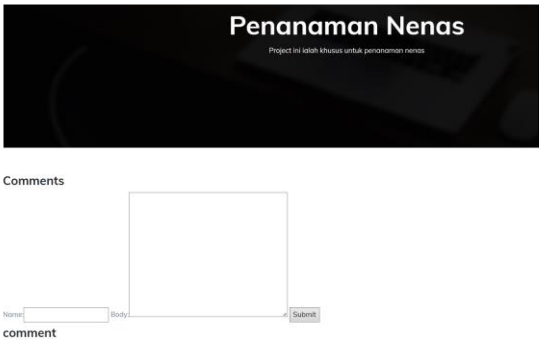

Figure 15: Channel page

Figure 16 Soil PH Graph

Figure 12 shows the interface of soil PH graph. The graph shown on the page is for PH soil measurement from IoT sensor. The graph used WebSocket framework acting as a third party to connect IoT sensor and system. The data which is gathered from the sensor will then be saved in the database.

3.5 Sprint 5: Testing

Once the system development is complete, a test will be conducted to find out whether the system met the functional and non-functional requirements. The test will be conducted with the working IoT sensor and the system to monitor whether the system is integrated with the system or not and to make sure the result is accurate. Comments and suggestions will be collected to provide further updates for the system.

4. Result and Discussion

The web-based plantation information system with IoT for iGrow Organization is a web-based information system which allow IoT sensor to connect with the system using Websocket framework and store information to the database. Python Django, HTML, CSS, Javascript and SQL programming language will also be implemented as back-end and front-end code. The tools for this system development are PyCharm for web development and phpmyadmin for database development.

Once the web-based plantation information system with IoT is completed, the next phase is the testing phase. In this phase, a User Acceptance Test (UAT) is performed to test whether the functionality for each module works or does not work. All five modules were tested with different test cases based on function.

Table 6 shows the test case for registration and login module. There are 2 test cases for this module namely test case M1-1 and M1-2. The purpose of the test case is to check the login module is functional or malfunction. Based on **Table 7**, the actual performance of this module is successful where the users can login to the system. The result of the test case is passed.

Table 6: Test Case for Registration and Login

Module: Registration and Login

Test Case ID	Description	Expected Result	Actual	Result
M1-1	To check whether the connection to iKnowledge Management system is establish	The system able to connect to iKnowledge Management system	User's data is saved in the database	Pass
M1-2	To check whether the user able or unable to login to the system	The user should be able to login to the system	The user login is successful	Pass

Table 7 shows the test case for sensor register and management module. There are 2 test case for this module namely test case M2-1 and M2-2. The purpose of this test case is to check the connection using dummy data as a test and check whether the system able to read the data. Based on Table 72, the actual performance of this module was successful where the connection is established, and the system can read the dummy data.

Table 7: Test Case for Sensor Register and Management

Module: Sensor Register and Management

Test Case ID	Description	Expected Result	Actual	Result
M2-1	To check whether there is connection between the system and dummy using Anaconda	The Anaconda should be able to establish a connection	The Anaconda is successfully establishing a connection	Pass
M2-2	To check whether the system able to read and save the dummy data from Anaconda	The system should be able to read and save the dummy data	The system is successfully read the dummy data and saved it	Pass

Table 8 shows the test case for channel module. There are 4 test case for this module which are test case M3-1, M3-2, M3-3 and M3-4. The purpose of the test case is to check whether the channel is function or malfunction. Based on the **Table 8**, the actual performance of this module is successful which the system can allow user to user create, delete, edit, search channel. The result of the test case is passed.

Table 8: Test Case for Channel

Module: Channel

Test Case ID	Description	Expected Result	Actual	Result
M3-1	To check whether the user can create a channel	The user is able to create a channel	The user successfully creates a channel	Pass

M3-2	To check whether the user can delete a channel	The user is able to delete a channel	The user successfully deletes a channel	Pass
M3-3	To check whether the user can edit a channel	The user is able to edit a channel	The user successfully edits a channel	Pass
M3-4	To check whether the user can view a channel	The user is able to view a channel	The user is successfully viewing a channel	Pass

Table 9 shows the test case for forum module. There are 1 test case for this module which are test case M4-1. The purpose of the test case is to check the forum module is functional or malfunction. The actual performance of this module is successful which the system is able to make a comment on the channel. The result of the test case is passed.

Table 9: Test Forum

Module: Forum

Test Case ID	Description	Expected Result	Actual	Result
M4-1	To check whether user can comment a single channel	The user is able to comment on a single channel	The user successfully comments a channel	Pass

Table 10 shows the test cases for the report module. There is 1 test case for this module which is the M5-1 test case. The purpose of the test case is to check that the report module is working or not working. The actual performance of this module was a failure. Test case results passed.

Table 10: Test Case for Reporting

Module: Reporting

Test Case ID	Description	Expected Result	Actual	Result
M5-1	To check whether the system is able to generate a report based on stored data	The system should be able to generate a report based on stored data from the measurement taken	The system can generate a report based on stored data	Pass

5. Conclusion

In conclusion, a web-based plantation information system for iGrow organization is expected to be well-developed with working sensors and other components. As mentioned, this proposed system is for trainees to register their soil sensor to the web system and show the output as graph for analysis and other trainees to make their own analysis. For the suggestion for future research, this project can be expend not only for agriculture but the other industries as well.

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