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AgreeKultura: An IoT-Driven Smart Carrot Farming Solution with Mobile Application using MIT App Inventor

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Abstract*— The main objective of this study is to develop an IoT-Driven Smart Carrot Farming Solution with Mobile Application using MIT App Inventor. The study used the ISO 25010:2011 software quality model and was evaluated by functional suitability, maintainability, performance efficiency, reliability, and usability. Evaluation was done using the 4-point Likert scale to measure agreement levels. Also, the developers used the Agile methodology in the project's process, wherein the project management will break into phases. This methodology is flexible and effective in developing this project. A total of 50 individuals responded to the survey questionnaire. Functional suitability received an average rating of 3.69, maintainability has a mean of 3.57, performance efficiency achieved a mean score of 3.6, usability obtained an average mean of 3.56, and reliability gained a mean rating of 3.58. Results show that respondents have given positive evaluations across all categories.

Index Terms*— Carrots, Fertilizer, Irrigation, Microcontroller, Mobile Application, Sensors, Monitor, Farming, Crops.

I. INTRODUCTION

(a) Background of Study

Carrot (*daucus carota var. Sativus*) is from the family of the *umbelliferae*. Celery, parsnip, parsley, dill, caraway, anise, coriander, and fennel are other vegetable crops and herbs in this family. *Umbelliferae* comes from the word umbel which means flower form. Carrots come in Asia particularly around Northwest India. It became popular because it was used for medicinal purposes because it is a source of vitamin a in the diets of many cultures and a good source of other vitamins, minerals, and fiber. It is usually used for stomach ulcers, abscesses, bladder, liver, and kidney problems, to aid in childbirth and even as aphrodisiacs.

Carrots are not drought tolerant plant that is why it crucial to maintain a right amount of supply of moisture during the growing season which is it is planted in high areas in the Philippines particularly in the region of Benguet and Mountain Province. According to Antolin et. al (2024), the total area planted to carrots in the Philippines was 4,822.49 hectares with total production of 59,979.07 MT in 2023. Cordillera Administrative Region contributes 87.7 percent of the total production wherein Benguet served as major producing province of Carrot with 82 percent of the total production in the country [1]. Carrot is an important contributor to the country's growth and development, that is why having a modern approach for increasing productivity and ensuring food security is vital.

(b) Statement of the Problem

a. How to develop a smart carrot farming solution with mobile application?

b. How to implement a fertilizer that is set up to automatically distribute the right amount of nutrients to the crop?

c. How to incorporate temperature sensors for maintaining crop's environment?

(c) Objectives of the Study

a. To develop a smart carrot farming solution with mobile application that guarantees real-time soil moisture monitoring.

b. To implement a button, feature that automatically distributes fertilizer to the plant.

c. To incorporate a temperature sensor and cooling mechanism that maintains the crop's environment.

II. METHODS AND METHODOLOGY

(a) Instrument Used

Research Evaluation

Table 1. Rating Scales for Interpreting the Evaluation Results

RANGE	VERBAL INTERPRETATION
0.50 – 1.49	Very Unsatisfied
1.50 – 2.49	Unsatisfied
2.50 – 3.49	Satisfied
3.50 – 4.49	Very Satisfied

This study will make use of the ISO 25010:2011 software quality model. ISO 25010:2011 is a software quality standard that classifies its attributes into eight main characteristics: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. These criteria sorted the features of the application and

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pinpointed all areas requiring verification prior to release.

This study will evaluate the Smart Carrot planting solution in the following categories:

Functional Suitability. The Smart Carrot planting solution features can meet both stated and unstated requirements under specific circumstances.

Maintainability. The Smart Carrot planting solution was created with a focus on easy maintenance, guaranteeing durability and user-friendly operation.

Performance Efficiency. The performance of the Smart Carrot planting solution depends on the level of resources utilized in specific circumstances.

Reliability. The Smart Carrot planting solution is essential for consistently and accurately dispensing food to fish at specific times without any issues.

Usability. The user can utilize the Smart Carrot planting solution to meet specified goals effectively, efficiently, and satisfactorily within a defined context of use.

The evaluation results will be interpreted using the following numerical scale.

(b) System Design

Theoretical Framework

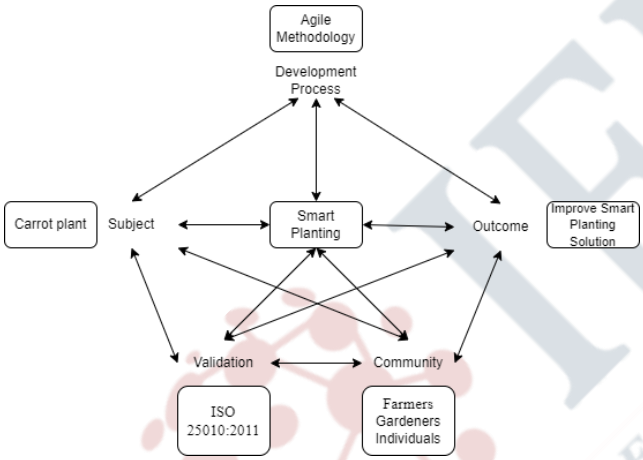

Figure 1. Theoretical Framework of AgreeKultura

Figure 1 shows how each section is interconnected to each other to achieve the project's goal. Inconsistency and the difficulty in maintaining precise soil moisture and regulated irrigation in carrot farming to address the problem. Developers come up with the development of smart carrot farming driven by internet of things (IOT) equipped with monitoring sensor mechanisms. The Agile methodology was used in the project's process, wherein the project management will break into phases. This methodology is flexible and effective in developing this project. For the outcome, it leads to the development of the AgreeKultura: An IoT-Driven Smart Carrot Farming Solution with Mobile Application using MIT App Inventor. Lastly, the researchers will be using ISO 25010-2011 to evaluate and improve the software product quality.

Conceptual Framework

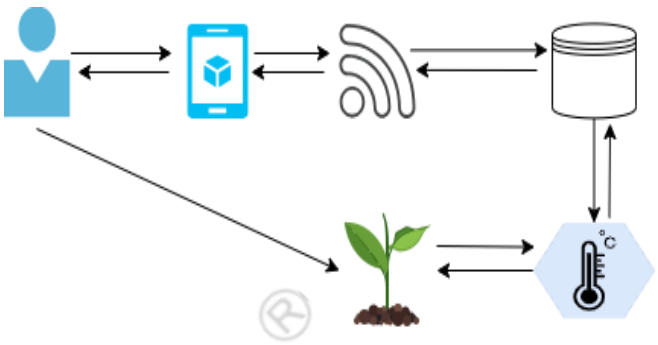

Figure 2. Conceptual Framework of AgreeKultura

In Figure 2, it illustrates the conceptual framework of the AgreeKultura. The AgreeKultura: An IoT-Driven Smart Farming Solution with Mobile Integration Using MIT App Inventor is a sophisticated system designed to help vegetable farmers particularly Carrots farmers to easily manage crops, minimizing the risk of overwatering, and monitor weather condition and soil moisture. To provide an effective and efficient smart farming solution with mobile applications, it is composed of several interconnected parts. Included in the conceptual framework are the user, a smart farming with mobile application, automated watering and fertilization, soil moisture sensor, temperature sensor, and humidity sensor. Through system architecture implementation, each feature of smart farming solution was developed. Adjustments were performed until every feature and functionality was achieved. The smart carrot farming solution with mobile application is the main prototype which is responsible for dispensing water and fertilizer for the plants depending upon how the users control the prototype. Moreover, the development of an application is done with the use of Arduino hardware, C++ Programming Language, and Arduino IDE. The user is the one who will interact or control the prototype of smart carrot farming, and the user can operate it via a mobile application. After opening the mobile application, the AgreeKultura prototype will send data to the database which is reflected in the application. The user can then manage, monitor, and operate the system.

Schematic Diagram

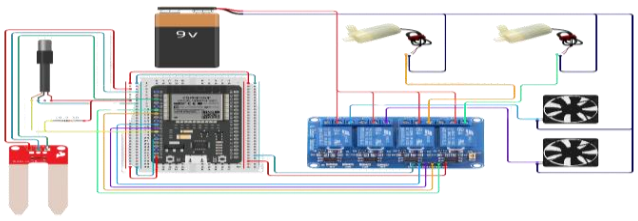

Figure 3. Schematic Diagram of AgreeKultura

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Actual Prototype & Mobile Application

Figure 4. Sideview image of AgreeKultura

Figure 5. Top view image of AgreeKultura

Figure 6. Homepage of AgreeKultura application

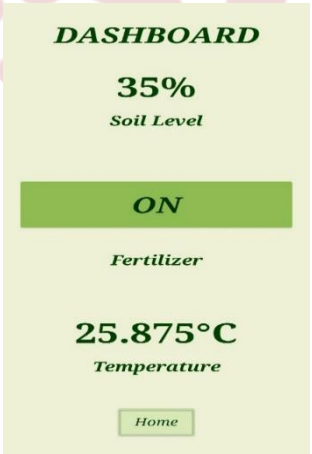

Figure 7. Dashboard of AgreeKultura application

III. RESULT AND DISCUSSION

The researchers conducted an evaluation through mean surveys. All the questions in the survey form and evaluation form can be seen on the appendices. The application was evaluated by the following criteria: Functional Suitability, Maintainability, Performance Efficiency, Reliability, and Usability.

Table 2. Overall Mean Rating of Watering Feature

CRITERIA	MEAN	INTERPRETATION
Functional Suitability	3.60	SATISFIED
Maintainability	3.57	SATISFIED
Performance Efficiency	3.57	SATISFIED
Reliability	3.58	SATISFIED
Usability	3.56	SATISFIED
OVERALL MEAN	**3.567**	**SATISFIED**

Table 2 shows the overall mean results of the AgreeKultura watering system and mobile application based on the evaluation answered by the respondents. First, the results show an average of 3.60 for the Functional Suitability of the AgreeKultura that is classified as “Satisfied.” This indicates that the functions of the AgreeKultura have met the needs when used under specified conditions. Second, Maintainability has a mean of 3.57 which is classified as “Satisfied.” This means that the AgreeKultura is durable and easy to maintain. Third, Performance Efficiency has a mean of 3.57 which is classified as “Satisfied.” This means that the AgreeKultura performs its feature with little lapses. Fourth, Reliability has a mean of 3.58 which is classified as “Satisfied.” This means that the AgreeKultura performs well relative to the number of resources used. Lastly, Usability has an average mean of 3.56 which is classified as “Satisfied.” This shows that the systemhas met a certain degree by which the users can use it to achieve a specific goal. Overall, the AgreeKultura watering system and mobile application acquired a rating of 3.567 which is also classified as “Satisfied,” indicating a good performance across evaluated criteria.

Table 3. Overall Mean Rating of Fertilizer Feature

CRITERIA	MEAN	INTERPRETATION
Functional Suitability	3.69	SATISFIED
Maintainability	3.53	SATISFIED
Performance Efficiency	3.60	SATISFIED
Reliability	3.51	SATISFIED
Usability	3.56	SATISFIED
OVERALL MEAN	**3.578**	**SATISFIED**

Table 3 shows the overall mean results of the fertilizer feature based on the evaluation answered by the respondents. First, the results show an average of 3.69 for the Functional Suitability of the fertilizer feature that is classified as “Satisfied.” This indicates that the functions of the fertilizer

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feature have met the needs when used under specified conditions. Second, Maintainability has a mean of 3.53 which is classified as "Satisfied." This means that the fertilizer feature is durable and easy to maintain. Third, Performance Efficiency has a mean of 3.60 which is classified as "Satisfied." This means that the fertilizer feature performs its feature with little lapses. Fourth, Reliability has a mean of 3.51 which is classified as "Satisfied." This means that the fertilizer feature performs well relative to the number of resources used. Lastly, Usability has an average mean of 3.56 which is classified as "Satisfied." This shows that the fertilizer feature has met a certain degree by which the users can use it to achieve a specific goal. Overall, the fertilizer feature acquired a rating of 3.578 which is also classified as "Satisfied," indicating a good performance across evaluated criteria.

Table 4. Overall Mean Rating of Temperature Level Monitoring and Cooling Mechanism

CRITERIA	MEAN	INTERPRETATION
Functional Suitability	3.58	SATISFIED
Maintainability	3.55	SATISFIED
Performance Efficiency	3.59	SATISFIED
Reliability	3.55	SATISFIED
Usability	3.56	SATISFIED
OVERALL MEAN	**3.566**	**SATISFIED**

Table 4 shows the overall mean results of the temperature sensor and cooling mechanism based on the evaluation answered by the respondents. First, the results show an average of 3.58 for the Functional Suitability of the temperature sensor and cooling mechanism that is classified as "Satisfied." This indicates that the functions of the temperature sensor and cooling mechanism have met the needs when used under specified conditions. Second, Maintainability has a mean of 3.55 which is classified as "Satisfied." This means that the temperature sensor and cooling mechanism is durable and easy to maintain. Third, Performance Efficiency has a mean of 3.59 which is classified as "Satisfied." This means that the temperature sensor and cooling mechanism performs its feature with little lapses. Fourth, Reliability has a mean of 3.55 which is classified as "Satisfied." This means that the temperature sensor and cooling mechanism performs well relative to the number of resources used. Lastly, Usability has an average mean of 3.56 which is classified as "Satisfied." This shows that the temperature sensor and cooling mechanism has met a certain degree by which the users can use it to achieve a specific goal. Overall, the temperature sensor and cooling mechanism acquired a rating of 3.566 which is also classified as "Satisfied," indicating a good performance across evaluated criteria.

Table 5. Overall Mean Rating of All the Objectives

OBJECTIVES	MEAN	INTERPRETATION
Watering System and Mobile Application	3.576	SATISFIED
Fertilizer Feature	3.578	SATISFIED
Temperature Level Monitoring and Cooling Mechanism	3.566	SATISFIED
OVERALL MEAN	**3.573**	**SATISFIED**

Table 5 shows the overall mean results of all the objectives and features combined. First, the result shows an average of 3.576 for the Watering System and Mobile Application that is classified as "Satisfied." Second, Fertilizer Feature has a mean of 3.578 which is classified as "Satisfied." Lastly, Temperature Sensor and Cooling Mechanism has a mean of 3.566, which is also classified as "Satisfied." Overall, it has a Grand Mean of 3.573, which is also classified as "Satisfied." Indicating that the smart carrot farming solution along with the mobile application, fertilizer button, and temperature sensor with cooling mechanism has a good performance across evaluated criteria.

IV. DISCUSSION

To verify the adherence of the AgreeKultura to its specified requirements, the researchers conducted as assessment, categorized according to the criteria outlined in ISO 25010:2011. Evaluation was done using the 4-point Likert Scale to measure agreement levels. A total of 50 individuals responded to the survey questionnaire. Results show that respondents have given positive evaluations across all categories.

Functional Suitability received an average rating of 3.69; most agree that the AgreeKultura: An IoT-Driven Smart Carrot Farming Solution with Mobile Application using MIT App Inventor can dispense water automatically and monitors the soil moisture through the mobile application. Maintainability has a mean of 3.57, which means respondents agree it is easy to maintain. Performance Efficiency achieved a mean score of 3.6, satisfied with the AgreeKultura use of relevant technology which operates and processes commands in a fast and efficient manner. Usability obtained an average mean of 3.56, and most respondents believe that the AgreeKultura looks pleasant, and the mobile application is easy to learn and access for the dispensing water and fertilizer, as well as checking real-time temperature level.

Lastly, Reliability gained a mean rating of 3.58; the AgreeKultura: An IoT-Driven Smart Carrot Farming Solution with Mobile Application using MIT App Inventor can bring convenience to the plantitos and farmers out there, and the mobile application can be installed or uninstalled on Android.

V. CONCLUSION

In consideration of the objectives of the study, the following conclusions were drawn:

1. The successful implementation of a watering system and soil moisture sensor has been achieved by researchers. This system avoids over- or under- water, preventing compaction and soil erosion as well as helping to maintain soil's health.
2. The implementation of the fertilizer feature, along with the mobile based informative application, proved to be successful in providing a feature that automatically dispenses the right amount of fertilizer to the plants.
3. The integration of the temperature sensor and cooling mechanism provided a real-time temperature as well as maintaining the crop's environment that will result in disease prevention and improved higher-quality crops.

The three (3) objectives were accomplished; therefore, the study is successful.

Limitations

This study will primarily concentrate on small to medium-sized farms. In line with this, fulfilling the objective of this research entails attending to important aspects that are essential to the system's functionality. It is necessary to consider practical issues pertaining to the system's continuous maintenance and operation. Smart carrot farming employed a direct current as a power source. In accordance, only four home grown carrots will be used for testing. Furthermore, because it is only a mobile application with no web interface, it requires a consistent internet connection for accurate monitoring. Lastly, fish amino acids will be used as fertilizer.

Future Work and Recommendations

Following the findings, testing, and evaluation procedures conducted by the researchers, the following recommendations were proposed:

1. To enhance the user interface (UI) and user experience (UX) of the mobile application especially for older people, by doing so, the users can experience greater convenience and flexibility, thereby significantly improving overall usability and satisfaction.
2. Consider integrating solar panels to make the system more efficient and sustainable, as well as to be able to run it continuously. This improvement will optimize performance and streamline the overall process.
3. To improve the system's availability and adaptability to other plants, so that other plantitos and plantitas can use it as an innovative way of smart farming.

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