
Using Microcontroller Based Digital Portable Soil Testing Device (“Matir Pran”) for Agricultural Sector Development

Abdullah Al Araf¹, Rahat Uddin² Rezaul Khan³, Foysal Ahammed⁴,

^{2,4}Presidency University, Bangladesh

^{1,3}Southeast University, Bangladesh

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ABSTRACT: *The major economic sector in Bangladesh is agriculture, which contributes 19.6% of the nation's GDP and employs 63% of the residents. The agricultural products feature like growth, quality dependent on the soil condition. Now a day's most of the farmer's family in Bangladesh uses smart phone. Based on this availability of smart devices and huge potentiality of uses of the devices, this project and study have been done for finding the common most useful two features of soil like measuring the pH level and testing the moisture of soil instantly, which usually reported after a long-time traditional process of analysis. These android-based apps incorporated in the smart device, which help the farmer to plant crops based on the testing parameters - pH level and moisture displayed in the screen of the devices. After testing android apps suggests the farmers- which types crops they can plant in this field, it can also suggest the way of increasing and decreasing the pH level. Arduino Nano, OLED display, pH sensor, moisture sensor are the main hardware and XML, material design (for front end) and JAVA, SQLite database, (for back end) are the software uses in the project.*

KEYWORDS: Microcontroller, Agricultural sector, Electronic, Soil, Testing device

INTRODUCTION

Farmer's Friendly Portable Soil Testing System for measuring the pH and Moisture of Soil is a prototype device which is named as “Matir Pran”. “Matir Pran” is a Bangla name of the prototype device. “Matir Pran” is a Smart Portable Soil Testing System or innovative smart device for rural people. It can measure soil pH and moisture. This device is reducing soil testing time, that's why it is profitable for farmer. This device is very user friendly for farmer [1]. Using application farmers get the proper guideline to plant their crops. After take care of field with proper guideline farmer can improve their plant production.

World 75% of people live rural area their main earning source is Agriculture. In this modern world many technologies come in Agriculture sector but rural people don't get that benefit. For this reason, they follow the traditional way for farming. That's why they don't earn enough money, they don't know how can take care field soil, so that they loss their productivity because good soil is main part of Agriculture [2]. So, proposed a smart soil testing device to use this device that can measurement PH and moisture.. After collecting the data that can see the suggestion form this app. By using this device people can be testing the soil on time. And they

can also know the status about the soil by using the App. The application automatically suggests what type of fertilizer and how much they can use. And it also Suggest which types of crops they can grow in this field.

Objective of the project are mentioned bellow:

- To make a smart device for soil testing.
- Measurement pH and Moisture by Using 2 sensor.
- Get data from pH sensor and Moisture sensor.
- An Android App Suggest what type of fertilizer and how much can use.
- Also suggest which type of crops can grow in the field.
- Increase and decrease pH

“Matir Pran: Farmer’s Friendly Portable Soil Testing System” is an innovative smart device and android based application that is developed to easily test soil condition and get solution of soil problem. The final outcome of this app is to get the proper solution for critical problems. Farmers know the soil condition (pH and moisture).Using this application proper guideline will help the farmer to get more production.

BACKGROUND

“Matir Pran: Farmer’s Friendly Portable Soil Testing System” is basically microcontroller based portable soil testing device with android application. For developing this project, that choose C language for Arduino mega and JAVA for android development. For designing that are using XML, MATERIAL DESIGN [2]. Using SQLite and Firebase for real time database, which is very popular in the world right now. Java is the most popular object-oriented programming language for android development. After getting the data from device, in this app has two input field. One is for pH measurement and another is for moisture measurement. After checking the data by this app suggest user, which crops they can grow in this field. If user want to increase or decrease pH level, they also get suggestion from this app [3]. Using SQLite database application show pH and moisture history. Hopefully users can easily use this system without facing any kind of obstacles

Related Works

After deciding to build this project is looked through online and found no such site or app. However, there are some system and apps which have some similar features but not a complete one. There are some website and system with lab facility but not a portable device with android application.

Soil Tester

This equipment is a small handy multifunctional electronic digital soil analyzer, which can test soil environmental conditions, soil moisture content, soil temperature, soil acidity, and alkalinity. The weight of the equipment is about 50 grams. The cost is around 50\$. To run the device one small 9V battery is required. On one side, there is a display box and on the other side, there is a stick, one end tied with the display box, and another end is coated. In the display box, there is an off-on switch. For soil testing, the coated end of the stick is pushed into the soil; the display board will automatically show the result. There is an off/on button to operate the device.

This instrument is a multifunctional electronic digital soil analyzer, and is professional soil quality measurement equipment. It mainly tests soil environmental illumination, environmental humidity, soil moisture content, soil temperature, and soil pH [5]. The instrument uses one 6F229V battery with a low power display reminder. With backlight LCD Display parameters, simple and clear. The 18cm aluminum alloy probe adapts to the test of the sushi soil environment. The product is small in structure, suitable for ergonomics, simple in operation, easy to carry, and improves the testing efficiency, it is applied to flowers, plants, and flowers, garden greening.

Figure 1: Soil Survey Instrument

Product model: MST9917/9918

*Product size: 77*77*33mm/290mm*

Working temperature: +5 °C~+40 °C

Power Supply: 9V battery



Function

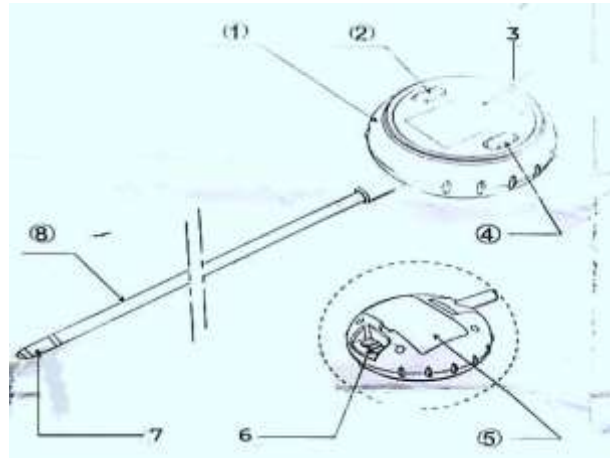


Figure 2: Working Function of Soil Survey Instrument

1. Reporting main body of product. Product function integrated mainframe
2. Parliamentary function key 1 function parameter conversion/reading
3. Press display- function reading function
4. Automation function key 2
5. Transaction battery cover- replace 9V battery power supply
6. PH / 6 conversion button reads the push button
7. Slash sensor probe
8. Probe

Direct Soil Measurement pH Portable Meter - HI99121



Figure3: Direct Soil Measurement pH Portable Meter - HI99121

Rapid and reliable reaction are unaffected by humidity-induced electrical noise. Depending on its pH, soil can be acidic, neutral, or alkaline. Although some species require more acidic or alkaline soil, most plants prefer a pH range of 5.5 to 7.5 [6]. But for optimum growth, all plants require a specific pH range.

The pH has a significant impact on the soil's nutrient availability, microbial population, and plant growth. For instance, fungi prefer acidic environments, whereas most bacteria prefer slightly acidic or slightly alkaline soil, especially those that give plants with nutrients [7]. There is less residual mineralization. Plants take up nutrients that are dissolved in groundwater, and the pH level has a significant impact on the nutrients' solubility.

Each plant needs a specific pH range to promote optimal growth because each one has varied requirements for the element. For instance, in an alkaline atmosphere, iron, copper, and manganese do not dissolve. Therefore, in theory, plants that need these nutrients should be in an acidic soil type [8]. In contrast, the pH range for nitrogen, phosphorus, potassium, and sulfur must be very neutral. Readily attainable additionally, plants have more harmful substances present when the pH is off. For instance, a plant may not be able to survive an excess of aluminum ions in an acidic environment [8]. When the pH value deviates too far from neutral, adverse consequences can also be seen on the chemical and physical structure.

The HI99121 meter includes a sizable multi-level LCD display that shows pH and temperature readings simultaneously. The pH resolution is 0.01 and the pH accuracy is 0.02 on this display. Indicators for calibration stability and status are also present on the LCD panel, along with tutorial messages [9]. The HI99121 is equipped with a number of cutting-edge functions typically found in more expensive portable electronics, including automatic calibration, buffer identification, and temperature adjustment [9]. At startup, the battery percentage level is shown to alert the user to remaining battery life. For measuring soil pH, the accompanying HI12923 is a reinforced glass pH electrode with an integrated temperature sensor.

Soil N-P-K Tester

The soil NPK testing includes an autonomous shut-off option. After about 15 seconds, the meter will shut off automatically without any button presses. Used: It makes use of specifically created, bespoke stainless-steel materials as sensors to quickly determine the amount of N, P, and K nutrients that are available in the soil [10].

- MOQ: One PC
- The RS-*-SC-1 model
- Price: \$30; and estimated delivery time: 24 hours;

The shape of the soil tester is hand-held and easy to carry. The probe uses a four-pin probe design and is made of stainless steel with good corrosion resistance and toughness. The battery of this soil N-P-k meter is replaceable [11]. The operation is simple and the using life is long.



Figure 4: Soil N-P-K Meter Testing

Insert the metal probe into the earth slowly and vertically, about 4-5 cm down. Make sure the metal probe is in contact with the ground all the way around. Within two seconds of pressing the power button, the tester will display the measurement's outcome [13]. The results of the measurement will be impacted by how compacted the soil is. For this project, multiple tests should be run simultaneously at various times, with the average number serving as the final output [14]. Clean the exterior of the stainless steel probe after the measurement. Many other sectors, such as farming, soil research, horticulture, tree planting, pot planting, greenhouse and orchard planting, regularly employ it.

Comparative Studies

There are some devices like moisture testing or pH testing; those are different part not a complete device. And also search some application of the related work, but all of them are information-based application. There is no application related with soil. But everybody knows good soil is the main part of agriculture. This device which is combining with an application all the features like soil testing, how to increase or decrease pH value and after measurement of pH of this application will suggest which crops can be plant in this field.

Scope of the Problem

- It is an open stage for provincial individuals, so anybody can utilize it
- This Device is very user friendly for any kinds of farmer.
- This device reduces soil testing time that's why it's very profitable for farmer.

- Farmer can know his filed soil condition on time.
- Using this app farmer can get suggestion how much fertilizer they need to user their field.

Challenges

- Collect soil form field
- Give proper suggestion to plant crops according to field pH value.
- Make application easier and efficient for rural farmer.

METHODOLOGY

Business Process Modeling

Business process modeling (BPM) is a modern process and methodology. BPM represented the activity of an enterprise of a system engineering to improve or analysts the current process. In this process one can easily represent their workflow of a system. Data flow diagram is one of the most usable diagrams to show the work flow of a system. It's easy and understands to any workflow.

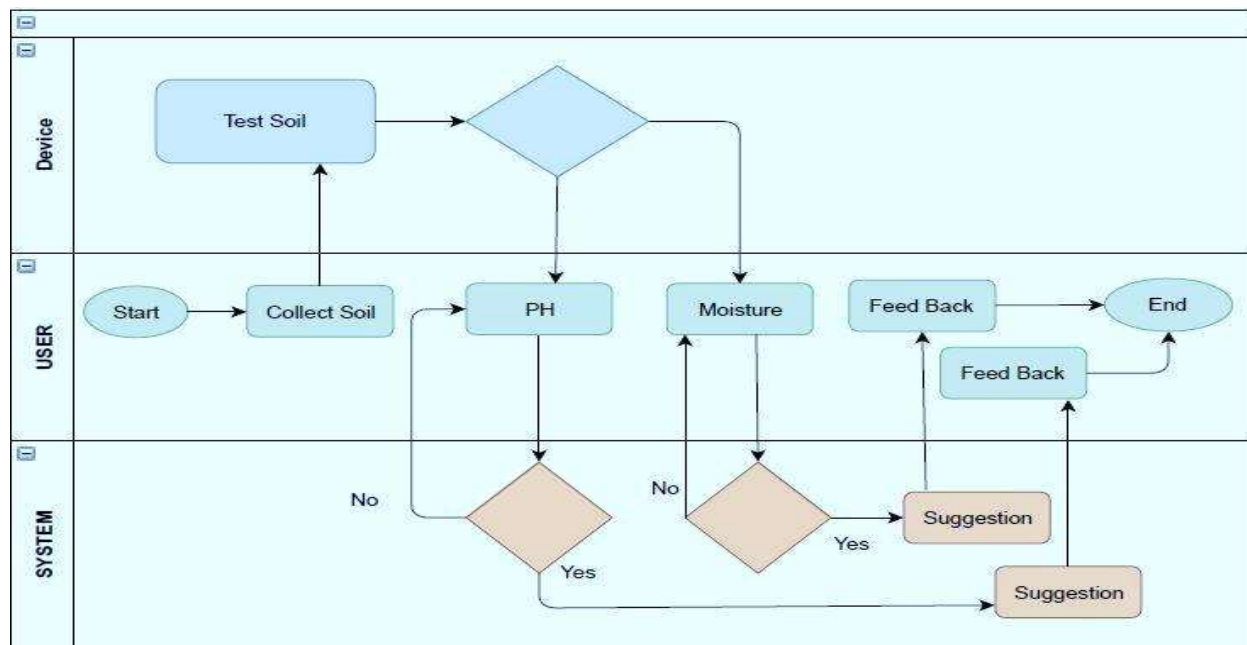


Figure 5: Data Flow Diagram of system

Business Process Model represents the value of that project. In this project, the most of the part show scheduling, collect soil, pH check and Moisture check. This Data flow diagram describes

the “Matir Pran”: Farmer’s Friendly Portable Soil Testing System”. This Data flow diagram fulfill to system activity.

Requirement Collection & Analysis

Requirement collection and analysis are the initial steps of use improvement process. For sending, there are two sorts of prerequisites, one is the utilitarian necessity and the other is nonfunctional necessity. Practical necessities are interior exercises that are the application programming can perform. Then again, Nonfunctional necessities characterize the conduct of an application. It characterizes how much the application is effective, execution issue of the application and some more

Functional Requirement

Functional requirements like, pH value check, moisture value check like Increase or decrease pH value suggestion by this application. User can easily access all of this. Navigation drawer also contains more other option like credits, about, information about pH. User also gets the working procedure video in navigation drawer.

Non-functional Requirement

Non-functional necessities are help to being more proficient; streamline execution, memory devouring, smoother activity, and load on rapidly as conceivable to the application. Application UI ought to be easy to understand and ravishing for astounding client encounter.

Feasibility Study

A system feasibility study analyzes the suggested system and assesses whether or not the system is viable for deployment. Prior to development, feasibility is crucial. In order to maximize its potential, it does some study. This study precisely satisfies the criteria for creating the application. Numerous feasibility studies of various kinds were conducted for the project. An effective survey gives historical context for a company or project, including descriptions of products or services, financial reports, operational and management information, marketing studies and policies, financial data, legal needs, tax duties, etc. Such studies typically come before technology development and project implementation.

Modeling and Description

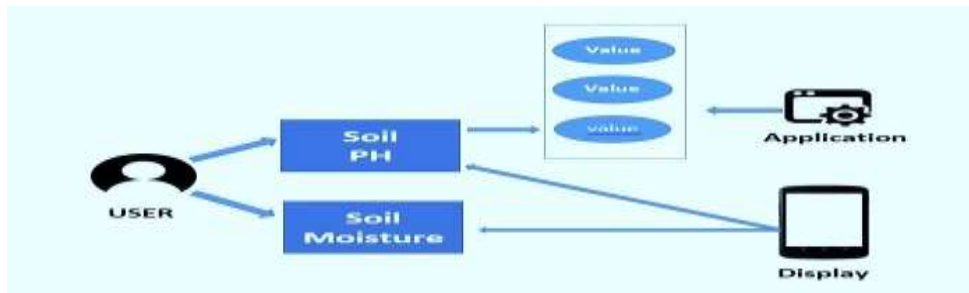


Figure 6: Model of "Matir Pran".

This is Use case model of the application, in this Use case Diagram that is specified for the application functionality. In use case diagram, there discuss about this system, user and application. Actually, here user in the system can check soil pH value and Moisture value. So, user can input pH value in application and get suggestion. After fulfill the input field user can see the suggestion in the display. And, also user get feedback from the android application.

Logical Data Model

Use SQLite in a database.

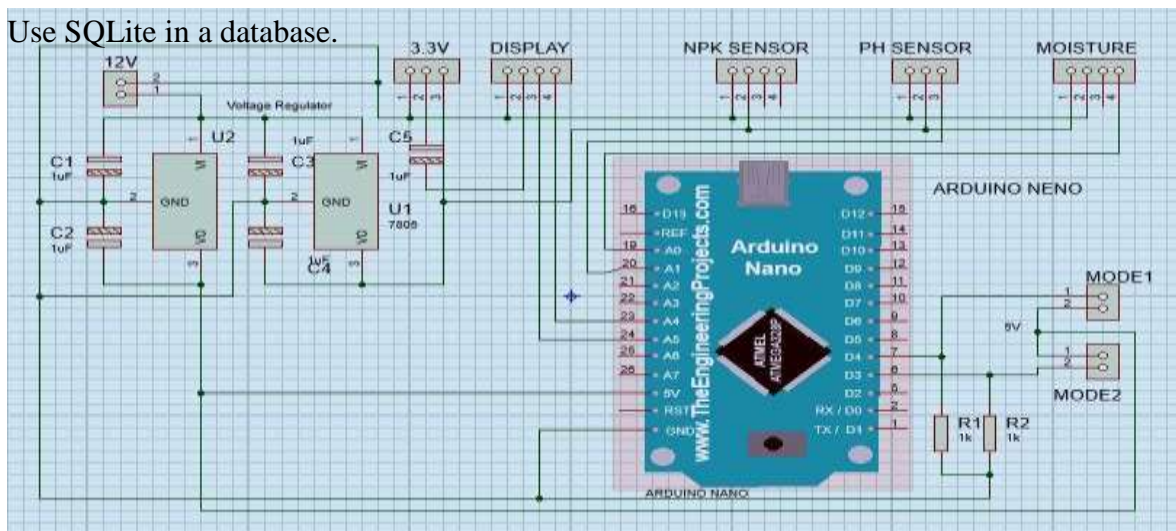


Figure 7: Logical Data Model

The process of defining and analyzing the requirements necessary to enable business operations in the proper information systems in an organization is known as logical data modeling. A logical data model that includes entities, characteristics, tables, and relationships is known as an entity relationship model or entity relationship diagram.

Design Requirements

- In the system, that has a device with application for soil testing. So user can testing soil and design of the application for user.
- In the application after getting the data from device user can input of pH value.
- In the application after getting the data from device user can input of moisture value.
- After input of pH value in the application, user can see the suggestion from the application. And also can see that what types of crops he can plant on this condition.
- After input of moisture value in the application, user can see the suggestion from the application. And also can see that what types of crops he can plant on this condition.
- User also can see the suggestion in the application, How to increase or decrease of pH value.
- In the system is allowing the user to see their recent history.
- In the application user can see working procedure video of the system

REAL IMPLEMENTATION

Back-end Design

Back-end design means the power behind the project. The user is unaware or can't see the back-end of a project. The logical part of a software happened in the back-end. It is the most crucial part of software. Back-end technology usually consists of language like JAVA, PHP and Python etc. Actually frond-end design is only way to interact with the user. Back-end does everything that happens on the behind the application.

Back-end Design of the application

There are many factors need to handle in the back-end like database management, security, data parsing, data validating, and data backups and so on. In the application are used JAVA, SQLite database and Firebase as real time database to develop and maintain the back-end section.

Back-end Design of the Device

In the device need to handle in the back-end like coding site and Arduino setup with sensor that have used C language for coding and Eagle PCB Design software for the device design

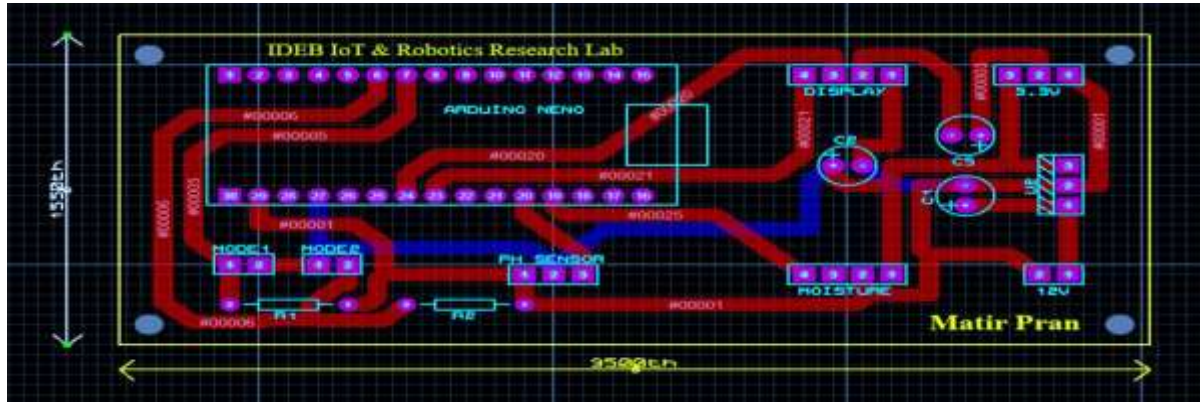


Figure 8: Device Circuit Diagram

Front-end Design of the Device

This project looks attractive and strong. So first make a device casing using 3D printer, for 3D printing Design use Autodesk Fusion 360 Software. This project has an OLED Display for showing result. It have Two push button switch for changing mode and also have on/off button switch for device active and shutdown. This device has two ports for input the sensors, one port for pH sensor and another port for moisture sensor.



Figure 10: Front-end Design of the Device

Device 3D design Model

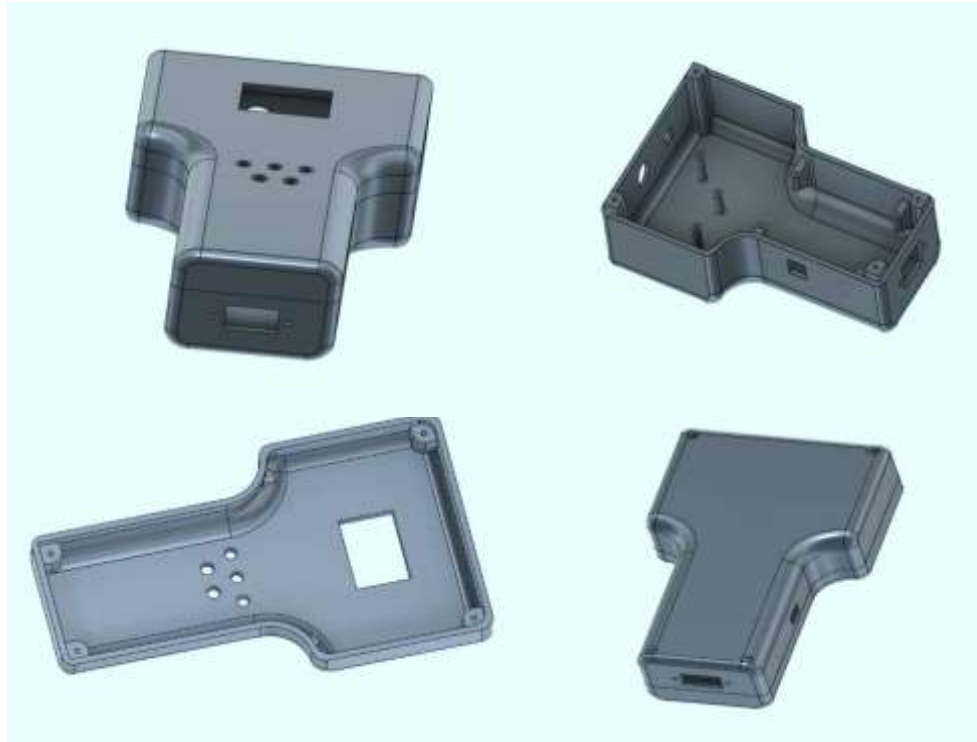


Figure 11: Device 3D design Model

Implementation of Requirements

This project will be developed successfully with the use of several sorts of tools, components, and platforms. All the platforms and tools needed to create the application are covered in the Implementation Requirements section.

- To develop the front-end of the web application use XML, Material design.
- To develop the back-end use JAVA as an object oriented language.
- Using SQLite Database for saving history in the application.
- For real time Database we use Firebase.
- Form validation needed using java-script before server site validation.
- Invalid data input should display with error message.

XML

Extensible Markup Language is known as XML. It is a language that specifies a set of guidelines for document encoding in a way that both machines and people can understand. Like Hyper Text

Markup Language, it (HTML). The page or file's contents are described with markup symbols that are present in both.

Components identified by labels are a crucial XML record construction ingredient. Start and end tags are present on every component. The root component, which surrounds all other components in an XML record, contains all of them [4].

MATERIAL DESIGN

Material Design is a planning valve created by Google in 2014. Material Design expands on the "card" theme that appeared on Google Now, making use of more free-flowing network-based formats, responsive motion and change, padding, and depth effects such as lighting and shadows. Material Design is available in API level 21 (Android 5.0) and can be updated with the appcompat v7 library used by all Android gadgets built since 2009. [5].

SQLite

An open source SQL database called SQLite is used to store data in content documents on mobile devices. A built-in SQLite database is used by Android. All features of social databases are supported by SQLite. Building associations like JDBC, ODBC, etc. is not necessary to achieve the final purpose of obtaining this database. The advantages of SQLite include independence, server essences, zero design, and value based [6].

RESULT

Implementation of Database

The database management system processes requests made through the SQLite interface and sends or modifies information based on these requests. It includes a multi-level readiness framework. On Android there are multiple answers for information persisting between client sessions. One setting is to have the ability to follow information using social databases and then research this information effectively. By default, the Android SDK involves using SQLite. The biggest advantage of SQLite integration for Android OS is that there is no compelling reason to set up a database.

The developer's only task is to specify the tables and SQL statements that will be used to add and edit data access to the file system as well as SQLite databases. It may be slow as a result. Database operations should be carried out asynchronously to prevent ANR (Application Not Responding) problems.

Classes specific to SQLite are included in the SQLite Database Android package. Two key classes make up the SQLite API: the SQLite Open Helper, a helper class you can alter to control database operations. The Android platform's fundamental class is using SQLite databases.

There are two tables and five columns in the database which are

pH Table: Information like as id, date, month, year, value of pH is stored in this table.

Moisture Table: Information like as id, date, month, year, value of moisture is stored in this table. Now that can store in the application information in each time when user input this entire above table.

Implementation of Interactions

The architecture of a software system defines that system in terms of components and interactions among those components. In real world, interaction can have found almost everywhere. Interaction is the key to make a system dynamic and attractive to user. It's very necessary to make a system interactive and try to maintain this. In the application has unique feature, when user input field condition in the application. Its show user what's the condition of the field. And what need to do like a agriculture officer instruction. The application is successfully implemented and the interaction of the application with the users is quite impressive.

Testing Implementation

When it test the features are prepared then it is implemented and is called test implementation. Several times like input of pH value and Moisture value by this project. The input data in the databases and in case of that got the success on that. So, that has tested the followings:

Install Application.

- Activity Check.
- Compile.
- PH Check.
- Moisture Check.

Test Case	Test	Expected	Obtained	Result	Tested on
Install Application	Tested On Various- <ul style="list-style-type: none"> • Kitkat (4.4) • Lollipop (5.5-5.0.2) • Marshmallow (6.0) • Nougat (7.0-7.1) 	Successfully install all those versions	Install successful	Passed	30/10/2018
Activity Check	Activity open with validation and proper information	Show result according to input value	Activity open successfully	Passed	30/10/2018
Compile	Compile Successfully all code	Show the actual result	Showed the actual output	Passed	30/10/2018
pH check	Tested On Various- <ul style="list-style-type: none"> • 4.5 • 5.0 • 6.5 • 7.0 	To see user field condition and crops planting list	Showed the actual output	passed	30/10/2018
Moisture check	Tested On Various- <ul style="list-style-type: none"> • 27% • 45% • 63% • 95% 	To see user field condition and crops planting list	Showed the actual output	passed	30/10/2018

Table 1: Test case for “Matir Pran: Farmer’s Friendly Portable Soil Testing System”

Test Results and Reports

Test outcomes should be reflected in test reports, as per expectation. This gives you the chance to assess your test findings fast. It is a report that relates and documents the data gleaned from the decision analysis, naturally outlines the framework, and exhibits the test results validation with targets, which is crucial for any kind of application.

Table 1 displays the application's test cases, test inputs, predicted results, actual results, and predicted outcomes. The test findings were successfully silent. The application is being used by users satisfactorily. Users should find it simpler to use and comprehend the application with an improved user interface.

CONCLUSION

The reason and target of “Matir Pran: Farmer’s Friendly Portable Soil Testing System” venture is accomplished. By giving to a great degree rich graphical UI, application planning is very simple and in a tasteful shape. Adaptability in structuring influences client to investigate their creative energy and in this way, even a learner client can dream and achieve their desire of utilization and framework planning. After the long travel of thinking, discussion, designing, implementation that is in the last session and point that instead of completion. This project (smart device with application) system provides the capability to minimize the gap between rural area agriculture

and technology. It will help to both rural farmer and agriculture officer to reduce time. Sometimes it face difficulties like in developing Use Case the first technical challenge encountered was that the selection of technical indicators and the Regression model. This project also faced some difficulties trying to making a portable device that could defeat this cross correspondence between various route by unadulterated diligent work, collaboration and constancy.

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