Crop recommendation system and crop monitoring using IoT

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Abstract. The Internet of Things (IoT) has enabled automation in every other field and is one of the emerging technologies. It facilitates communication between devices and the cloud and between the devices themselves. In the current world, many modern techniques are evolved in promoting effective and smart agriculture. Even though early and traditional farming techniques are being used in most parts of the nation, these techniques can't guarantee the efficient yield of crops. Smart agriculture is helpful in many ways to obtain a high crop yield. The proposed work utilizes sensors and data analytics to monitor crop growth and provide recommendations on optimal farming practices. The system collects data on factors such as soil moisture, temperature, and nutrient levels to provide real-time updates on the health of the crops. The application made by Kodular can be used for monitoring the real-time conditions of the crops. It also recommends the crop to be grown based on conditions like soil type and farming season. This system can help farmers improve crop yields and reduce the need for manual labour, leading to increased efficiency and profitability in the agricultural domain.

1 Introduction

Agriculture is a major economic activity in India, with about 58% of the population dependent on it for their livelihood. India is one of the globe's largest manufacturers of agricultural products, including rice, wheat, sugarcane, cotton, tea, and tobacco. Traditional farming methods in India often rely on manual labour and simple tools, which can be time-consuming and inefficient compared to modern farming methods. The growing demand for food in the face of limited resources has led to the need for a more efficient and sustainable approach to agriculture. Traditional methods of farming are often resource-intensive and can

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cause negative impacts on the environment, such as soil erosion and water pollution. Additionally, the unpredictability of weather patterns and market conditions can make it challenging for farmers to consistently produce high-quality crops. Internet of things is the latest automation which connects everyday things embedded with sensors, network, software and electronics to allow exchange of data among them. Things refer to the objects which can be accessed through the internet. These things have an in-built sensor in it to collect and transfer data. IoT connects all the objects to the internet and allows them to be in touch through the internet. This helps devices learn from the observations of other devices. IoT extends the internet connectivity between objects. Smart farming, also known as precision agriculture, is a modern approach to farming that uses technology to increase efficiency and productivity while reducing the environmental impact of agriculture. At the heart of smart farming is the use of IoT (Internet of Things) devices, such as sensors, to collect and analyze data on everything from soil moisture and temperature to crop growth and disease. For example, a sensor embedded in the soil can measure the moisture content, temperature, and nutrient levels.

IoT technology also enables farmers to monitor their crops in real-time, which allows them to detect and address issues early on. Drones can be used to take high-resolution images of fields, allowing farmers to identify problem areas and take action quickly. Smart farming and crop recommendation using IoT can also help farmers to save costs. By providing precise data about when and how to fertilize and irrigate, IoT devices can help farmers avoid over-fertilizing and over-watering, which can be costly. Overall, the use of IoT in smart farming has the potential to greatly improve the efficiency and sustainability of agriculture, while also helping to increase crop yields and reduce costs. However, it's important to note that the key to the success of smart agriculture is the ability to gather accurate, real-time data and process it in a meaningful way. Having a proper IoT infrastructure, device selection, and data management is important.

2 Existing Methods

Growing crops is a tedious process. To produce crops healthily, farmers need to visit the growing area regularly to measure the many environmental characteristics such as humidity, temperature, soil moisture, and light intensity. Although this traditional farming technique has been practiced for many years, it is labour-intensive and inefficient as farmers find it difficult to accurately assess all variables at all times. The Arduino microcontroller is used in this system, suggested by Vinoth and team, to manage and control soil temperature and humidity through sensors and activate cooling fans, light bulbs, and motors to pump water when needed. In the event of unusual circumstances, the information is transmitted to the gardener via an Android application. This system is expensive and complex to maintain. Inaccurate results of the system is a major issue [1].

As an agrarian nation, agriculture in India is largely dependent on rainfall, soil, moisture, and environmental issues. Our farmers have switched to the most advanced agricultural technologies available today. Now Indian farmers need to implement intelligent farming systems to increase crop productivity. Authors from [2] suggested a system such that farmers can monitor the productivity of agricultural fields by collecting data from modern sensors, actuators, and electronic devices. Using sensors connected to the Arduino UNO processing module, smart farming can predict weather data by turning on the pump motor and detecting soil moisture from moisture content. Using network technology, the Smart Agriculture system can be managed from anywhere. This system is difficult to implement and expensive to maintain [2].

The goal of the implementation by [3] is to generate a sophisticated system called "Smart Garden" that can assist beginners, like home gardeners, in farming operations. The objectives of this research are to develop a support system for the Smart Garden that can 1) display visual instructions for farming activities using Computer Graphics (CGs) and superimpose them on the field where the user is working, and 2) track the user's positions and perspectives as they perform their tasks. The usage of AR is not feasible and the system can't be used easily by farmers. Usage of AR makes the system expensive [3].

The goal of the system proposed by Bandara and team is to build a conceptual and theoretical framework for a recommendation system that uses combination of models of data collection from surrounding factors using Arduino microcontrollers, efficient machine learning methods like Support Vector Machine (SVM) and Naive Bayes, and Artificial Intelligence to suggest a crop for the chosen plot of land with a site-specific parameter. Choosing what to grow has proven to be a significant challenge, as every man has enough room on the owner's property. Because of these issues, this recommendation system's solution estimates for the user which type of crop would be best suited for the chosen location by gathering environmental elements that affect growth of plant and combining them with the main system's trained sub-models. Temperature can vary from time to time, so recommendation using temperature alone is not sustainable [4].

Hydroponics is a way of growing plants using nutrient-rich water instead of soil. This method can be useful in situations where soil is not available or not suitable for plant growth, such as in urban environments or in space. It can also allow plants to be grown more efficiently, using less water and other resources. In hydroponics, plants are typically grown in a soilless medium, and their roots are suspended in a nutrient-rich solution. This solution provides the plants with all the necessary nutrients for growth, including nitrogen, phosphorus, and potassium. Because the plants are grown in a controlled environment, hydroponics can be used to grow a wide variety of plants, including fruits, vegetables, and herbs. The crops may get affected by waterborne diseases. This system is not feasible to set up on large scale. This system requires high maintenance and constant monitoring [5].

3 Proposed Method

3.1 Problem Statement

Agriculture and industries related to it are a major source of income in India, particularly in rural regions. It involves cultivating plants for various purposes and adopting sustainable practices, such as protecting biodiversity, preserving soil, and managing natural resources, which are vital for rural development, employment, and food security. The use of IoT (Internet of Things) in agriculture, also known as smart agriculture or precision farming, involves the use of sensors and other IoT devices to collect data from various parts of the farming process, such as soil moisture, temperature, and crop growth. This data can then be analysed and used to optimize farming practices, such as watering and fertilizing, to improve crop yields and reduce waste. The problem facing the agriculture industry is the need to adopt and effectively utilize smart agriculture technologies and practices to improve efficiency, reduce environmental impact, and ensure the long-term sustainability of the food supply. Farmers may not have the knowledge of the crops to be grown in particular situations. The accuracy of the existing systems in recommending crops is taken on the basis of the accuracy given in [6], [7], [8], [9], and [10].

Farmers may water insufficiently or over-sufficiently using traditional watering methods. When the farmer leaves the farm, the maintenance of the crops is halted for the time being.

It may cause damage to the crops as they are kept unwatered. As the weather changes, the temperature and humidity of the crop area change. Sometimes, due to drastic weather changes like becoming too hot or too cold, crops' health may be affected. This work aims to provide an easy way of watering the crops using IoT modules. It also focuses on providing the real-time weather conditions of the crop area to the farmer so that he can monitor his crop from any place. The work also assists the farmer about the crops to be grown based on the soil type and season.

3.2 Objectives

The aim of the proposed work is to provide a user-friendly interface which displays real-time environment conditions residing crop and soil moisture levels of the farmland. This interface also consists of a crop recommendation system which suggests the crop to be grown based on the provided soil type and the farming season, to help farmers obtain better yield. The proposed system helps in maintaining a healthy crop by timely monitoring and producing high yield by farming relevant crops. The goals of the proposed work are as follows:

- To enhance the efficiency of the farming system to be more reliable and easier to monitor.
- To detect the real-time environment conditions surrounding crops using BMP280 sensor
- To detect the soil moisture of the crop land using a soil moisture sensor and know whether to turn the motor on.
- To update the information in a real-time database in firebase which in turn updates in the mobile app.
- To enhance the system further such that the process can be done without human intervention by automating the motor switch.

3.3 Architecture Diagram

Figure 1 shows the Architecture diagram. The work uses Arduino IDE where the code is written to implement the detection of soil moisture levels, temperature and humidity of the surrounding environment. The GISMO-VI board is connected to the computer where the code is written in Arduino IDE. The code is now compiled and uploaded to the connected board. The work contains a BMP280 sensor which is connected to the GISMO-VI board and detects the temperature and humidity levels of the environment and updates to the GISMO-VI board. It consists of a soil moisture sensor which is connected to the GISMO-VI board and detects moisture levels of the soil and updates to the GISMO-VI board. The GISMO-VI board updates the information to the computer which has Arduino IDE set-up, through a USB cable. The information drawn through the GISMO-VI board is thereby updated to the real-time database setup in the google firebase environment.

3.4 Modules-Connectivity Diagram

Figure 2 shows the connectivity diagram of the modules. The sensors employed in the crop monitoring and recommendation system are used to gather the information that will be used by the farmer to identify real-time environmental conditions. To measure the soil moisture of the farmland, the soil moisture sensor is placed in the soil. The BMP280 sensor helps in monitoring the real-time temperature in the field.

The Arduino board is connected to the soil moisture sensor and BMP280 sensor in this system. Real-time data like soil moisture and temperature are collected by both sensors. The data is then updated to the Google Firebase, which in turn is accessed by the Kodular

application. The application displays the real-time values to the user. The ESP32 module can be turned off by the farmer if he wants to stop monitoring. The "plants database" is stored in Airtable and passed to the application. When the user inputs the farming season and soil type, the app matches the values in Airtable and recommends suitable crops to be grown for the given conditions.

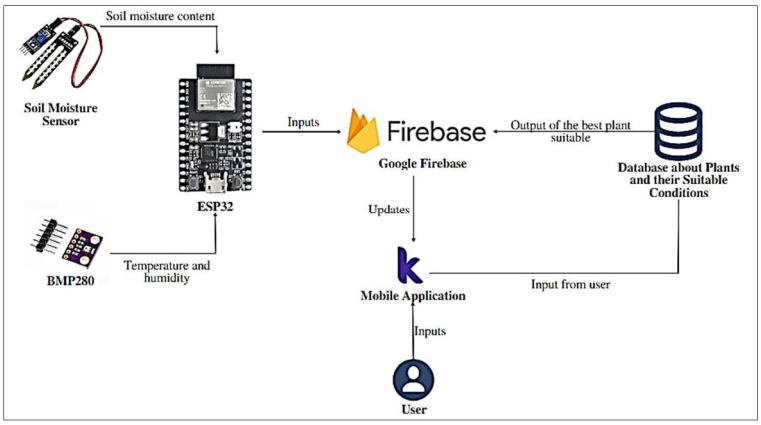

Fig. 1. Architecture diagram.

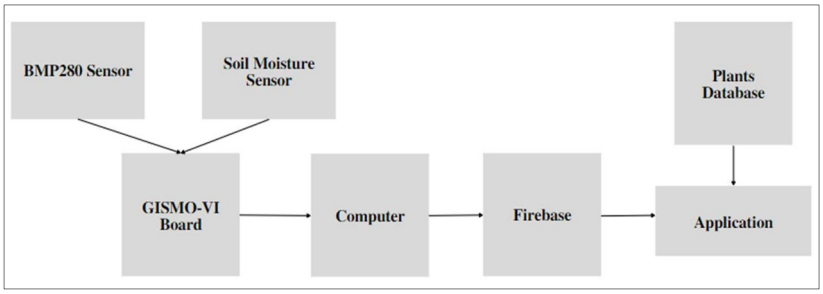

Fig. 2. Connectivity diagram of the proposed system.

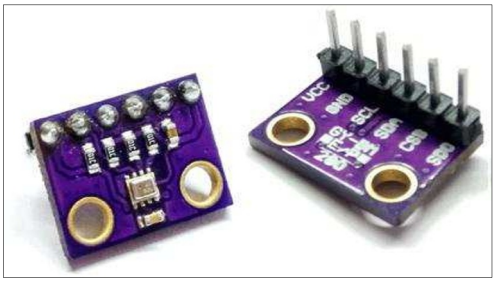

Fig. 3. BMP280 sensor.

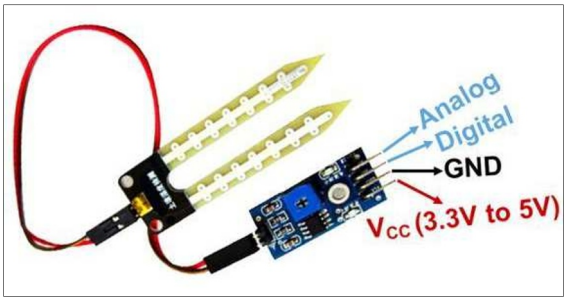

Fig. 4. Soil moisture sensor.

The BMP280 sensor is a preferred choice for environmental monitoring applications due to its high accuracy, low power consumption, small size, wide operating range, I2C and SPI interface support, and cost-effectiveness. Its precision in temperature and pressure readings, combined with its versatility, make it a popular choice for weather stations, drones, and other portable devices. Additionally, its wide temperature range and compatibility with microcontrollers and digital devices make it suitable for a broad range of applications, making it a widely used and reliable sensor in the field of environmental monitoring. Figures 3 and 4 show the BMP280 and soil moisture sensors.

3.5 Modules and its Description

3.5.1 Module 1: Implementation of Sensor Modules

The BMP280, soil moisture sensor, and OLED display are connected to the GISMO-VI board along with ESP32 as shown in Figure 5(a). After connecting the board to the power supply via a USB cable, the code is run and uploaded to the board. The sensors sense the information and update the information to the GISMO-VI board (ESP32). The board then updates the values to the Arduino IDE where we can see the values in the serial monitor present in the IDE. The real-time data of soil moisture levels are measured by the soil moisture sensor. The environment conditions like humidity and temperature are provided by the BMP280 sensor. These values are displayed in the serial monitor as depicted in Figure 5(b).

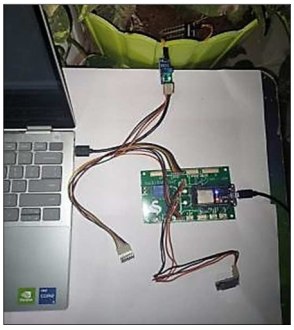

Fig. 5(A). Real-time prototype.

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Temperature = 28.05 deg C
Temperature = 82.49 deg F
Pressure = 945.31 hPa
Altitude = 581.66 m

Temperature = 28.05 deg C
Temperature = 82.49 deg F
Pressure = 945.30 hPa
Altitude = 581.71 m

Temperature = 28.05 deg C
Temperature = 82.49 deg F
Pressure = 945.30 hPa
Altitude = 581.74 m
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Fig. 5(B). Output displayed on serial monitor.

3.5.2 Module 2: Connection to the Firebase

A real-time database in Google Firebase is created and connected to the Arduino environment. The values that are received from the sensors are updated in the real-time database at the respective key positions mentioned in the code. The real-time values are updated and shown in the data tab of the real-time database as shown in Figures 6(a) and 6(b).

3.5.3 Module 3: Incorporation to the Mobile App

A mobile application is created using Kodular app creator where the user can easily operate the application. The app is connected to the real-time database created in Google Firebase so as to read the values of the data stored in the database. It retrieves the real-time data from the connected firebase. It also displays the information received from the database as per the user's request as illustrated in Figures 7(a) and 7(b).

Fig. 6(A). Screenshot of the Firebase database while updating data from BMP280 sensor.

Fig. 6(B). Screenshot of the Firebase database while updating data from Soil Moisture sensor.

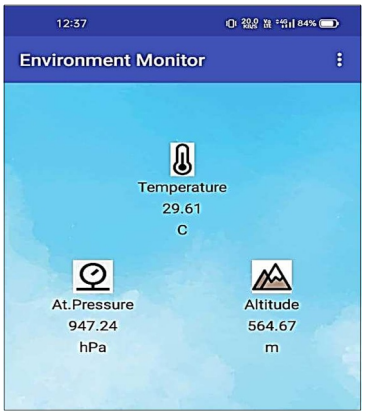

Fig. 7(A). Application displaying the real-time atmospheric conditions.

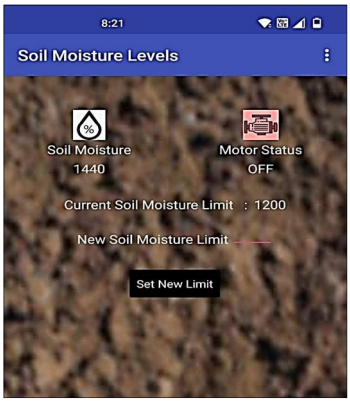

Fig. 7(B). Application displaying the real-time soil moisture levels.

3.5.4 Module 4: Crop Recommendation System

As a further extension of the work,, the app provides a feature to suggest to the user about the suitable crops to be grown for the given conditions. The application is connected to a dataset consisting of crops suitable for a particular soil type and farming season. This dataset is stored in an air table for easy access to data by the application. The app interface is simple to use where the user is asked to choose the type of soil along with the season to recommend suitable crops which aim for high yield and are sustainable for the provided conditions. After the conditions are chosen by the user, the application matches the inputs from the user to the data in the respective labels of the dataset in the Airtable. When the match is found, the suitable crops for provided inputs are fetched from the dataset and displayed in the application.

4 Experimental Results and Discussions

4.1 Description about Dataset

The dataset used in the work gives us the list of crops that are suitable for given conditions like soil type and farming season. The dataset contains three columns: Soil Type, Season and Crop. The data is collected from Kaggle. The dataset contains 7 different soil types and 3 different farming seasons and all suitable crops to be grown for each soil type and farming season are mentioned. This dataset can be further improved to having more plants with more effective and accurate conditions. The given data is now applicable only for Indian climate but can be improved to the region of operation in future.

Fig. 8. Proposed Crop Recommendation System.

4.2 Results

The soil moisture levels are monitored using a capacitive soil moisture sensor and atmospheric conditions using the BMP280 sensor. The sensors were integrated with an IoT platform to collect and analyse data. The results showed that the system was able to accurately measure soil moisture levels and atmospheric conditions, enabling farmers to optimize irrigation schedules, resulting in water conservation and improved crop yields as

depicted in the Figure 8. For crop recommendation, the inputs like farming season and soil type are taken from the user via the application, and the respective outputs are generated by matching values with the database in Airtable.

Input

- Input of farming season and soil type, provided by the user.

Output

- The crops suitable for the given inputs are displayed on the application.
- Real-time weather conditions and soil moisture levels are displayed on the application.

4.3 Significance of Proposed Work

The proposed method is a very effective way to remotely monitor plants. It provides users with information about the specific plants to be grown, based on the conditions like soil type and farming season. With the assistance of this application, users can easily adjust and modify the conditions for their plants like soil moisture limit. The monitoring process is easy and can be done by anyone, anywhere, and at any time. By continuously monitoring the plants, users can ensure that their crops are healthy and growing properly. In addition, the system stores important plant data, such as temperature, humidity, and soil moisture, in a real-time database. This cropping system is a relaxing and enjoyable way to farm, and using the smart cropping feature makes it even more convenient. Additionally, the system can help save water that is often used in traditional farming methods.

5 Conclusion

The proposed system offers a cheaper, smarter, and better way to monitor a crop. It introduces a smart farming system that can sense the needs of crops and automatically provide water when the soil moisture is low. The system uses soil moisture sensor to detect the moisture content of the soil and a BMP280 sensor to measure temperature and humidity. This information is used to provide real-time feedback to the user about when to water the plants. The system is based on GISMO-VI board technology, mobile technology, and the Internet of Things. The OLED screen on the device displays the results, and a mobile app can also be used to access this information. This allows local farmers to easily monitor and care for their plants by providing real-time data on environmental factors such as temperature, soil moisture, and relative humidity. The goal of the work is to enhance the time and effort required to monitor a crop field and provide a hassle-free solution. Additionally, the work aims to provide information about the best crops suitable for the specific soil type and farming season. This approach can address cropping challenges in urban areas where there is a shortage of experienced farmers.

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