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Enhancements in Smart Application for Tracking Farm Land Using Cloud Computing

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Abstract: Smart farming is a renovation in the agriculture sector that focuses on information and communication technologies employed in machinery, equipment, and network-based sensors. Invasive pests are estimated to cost at least $70 billion per year and contribute to the loss of biodiversity, which is reported by the Food and Agriculture Organization of the United Nations (FAO). In this proposed study, a prototype of device was developed with a smart application to help farmers by monitoring their farmland's temperature, air humidity, soil wetness, and lighting. The user can utilize the options provided by the application to decide what has to be done on the field, such as providing water or pesticides, while keeping a watch on the real-time data for soil moisture, temperature, humidity, and plant height (to determine the harvest time). Additionally, the automatic motor on and off control has been included in this prototype, which helps to water the fields at the right time. The Open Weather API, JSON, XML, HTML, and relay modules are the methods utilized to develop smart applications. Mechanisms such as cloud computing and the IoT (Internet of Things) were used to develop this proposed method. Moreover, the sensors, mobile applications, and big data analytics were also utilized to support the enhancements in smart farming. This strategy yields advanced monitoring and increased agricultural productivity.

Keywords: *Agriculture; Internet of Things; Smart application; Smart farming*

1. Introduction

The entire world is nourished by agriculture because it is vital to the economy of the country. It connects and communicates with all pertinent businesses across the country. A nation is seen as socially and economically successful if it has substantial agricultural support. Agriculture is the primary sector in many countries that involved in the improvement of gross domestic product. According to the survey, food production will need to expand by almost 60% by 2050. This will be challenging for utilizing conventional farming and agricultural practices. Large farms often need to engage more staff to assist with planting and animal care. The mainstream of these huge farms have handling facilities in nearby where their products are produced and finished [1]. Sensors are an essential part of collecting data about plants, animals, and the environment, but they also cause a technological challenge to the development of the Internet of Things (IoT). Over the years, sensor technology has led to rapid development with the emergence of innovative resources and techniques [2]. Protected agriculture has made extensive use of the additional well-known traditional environment sensors, such as temperature, light intensity, heat, humidity, and gas. Approximately 6000 research and manufacturing groups from over 40 countries, including well-known industries such as Honeywell, Foxboro, ENDEVCO, Bell & Howell, and Solartron enterprises, are currently involved in sensor research. The majority used agricultural sensors are three main types including biosensors, physical property type sensors, and micro electro mechanical system sensors (MEMS). Even though the principles and manufacturing processes of sensor technology have advanced significantly, several problems remain unresolved [3]. Research and development of soil sensors and vital sign information sensors of plants and animals is one such example of an open issue that has to be resolved quickly. Literatures that were focused the sensor based data collection from the farm land used various approaches. Apurva et al. [4] propounded a method that utilized wireless sensor networks to keep an eye on green fields. Numerous other features, including soil sensors, water level, temperature, wind direction in the field, humidity, and climate, were included for monitoring agricultural fields. Agricultural production has increased in multiple countries and universal organizations have employed smart farming technologies [5,6].

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Thombare et al. [7] propounded a method using big data research to predict the crop production. K-means clustering and Apriori algorithm were used for analyzing the data with similar instances to support smart farming. Gholap et al. [8] focused the decision tree method to forecast soil fertility. The dataset has been retrieved from Pune private soil testing facility. The decision tree algorithm (J48) was used to improve the efficiency hence it has a tree hierarchy for decisions. Another literature was based on the methods of neural networks for supervised learning and back propagation algorithm for analyzing soil properties [9]. The impact of soil attributes such as organic matter, vital plant nutrients, and micronutrients on crop development as well as the computation of their percentages using the aforementioned method served as the main motivating factors [10]. An integrated soil analyzer was recommended by Sivachandran et al. [11] to measure the pH values included in the soil. The analyzer output depends on the various values of soil nutrients. The combinational embedded system has included the display, signal conditioning, and the processing controlling unit to achieve improved results. This technique measures the nutrients such as potassium, phosphorus, and nitrogen also used to forecast the soil composition from the ground. Smart sticks are a new invention that may be used to analyze various parameter values while monitoring live events in green fields [12]. The soil's moisture content and temperature measurements are part of this parameter analysis. The main issue with this model is the difficulty with mobile authentication [13]. The flow of the water and its management techniques are covered. Additionally, a DHT11 sensor was used to measure the humidity and temperature of the data. The mobile application includes a single-click switch control for the motor pump. Meanwhile, this method describes a green field irrigation method that is economical [14].

Several related works were used for smart farming using various techniques that promoted the early adoption [15]. A browser platform called Akkerweb serves as a portal to several data sources, including unit borders, satellite imagery, meteorological data, and data from commercial agriculture management software. This browser stored georeferenced data, including soil data and aerial photos [16]. Sinwar et al. [17] presented a hybrid smart irrigation system that blends solar and cloud power. Even if one or more of the sensor nodes malfunction, the irrigation procedure is still carried out by the Arduino and Raspberry Pi devices' sensors.Sivaganesan et al. [18] predicted the amount of moisture in the soil, the crop's growth, the likelihood of a pestilence assault, temperature, humidity, changes in the climate, and when the field would be harvested. Apart from crop rotation, water management, harvesting time, optimal planting, and crop production, Kumar et al. [19] developed irrigation system by using sensors and machine learning algorithms to forecast past behaviours.

The aforementioned literature explained the methods for smart farming which include monitoring, yielding, irrigation and harvesting separately. So in this proposed study, prototype of a processor-based device is developed and connected to an Android application along with cloud for soil moisturizing, temperature, and humidity monitoring, additionally motor on and off management. It is important to maximize the crop yield and maintain soil richness. Most of the literature focused only on monitoring the parameters, this proposed study highlighted providing suggestions, planning events, and adequate water supply to the farmland with the automated motor on and off control. The remaining work organized as follows, section 2 portrays the methods used in this study, section 3 discusses the results in detail, and section 4 describes the conclusion of this study.

2. Materials and Methods

Climate change and weather condition are the major terms in agriculture, if it is discovered promptly which offers great advantages to the farmers. In this proposed method, different sensors have been utilized in smart farming to observe the light intensity, humidity, soil moisture, and temperature. Meanwhile, a device prototype is used which typically comprises various components such as actuators, sensors, wired or wireless connections, memory, input-output connections, and an embedded system with a central processing unit, communication modules, and a battery with a dataset of 10000 values. The implementation of smart farming technology has become an increasingly popular solution for optimizing agricultural processes. The proposed method includes the intelligent farming system that employs an application and different sensors such as DHT11, and YL-69 to collect various parameters such as temperature, humidity, and soil moisture. The collected data is then sent to the cloud and firebase, where it is stored and processed for further analysis.

2.1. Application Programming Interface

API (Application Programming Interface) seems to be the major feature in this study, which is used to gather climate conditions in a specific area. The observed data was combined with the data from sensors and used to deliver a complete status of the environmental conditions around the farm. This feature is particularly important for commercial farms where sensitive data such as crop yield, quality, and inventory information are stored [20]. Adding to the security measures of the system, it is worth noting that Cloud and Firebase provide enterprise-level security for the data. Both services provide encryption tools and secure communication protocols to safeguard data while it is in transit and at rest. The functional requirement for the proposed system is represented in Table 1.

Table 1. Functional requirements for smart farming

	Functional Requirement	Sub Requirement
1	User Registration	Registration using Gmail
2	User Confirmation	Confirmation Via Email Confirmation Via OTP
3	User Login	Login with EmailId and Password
4	Forgot Password	Login with Email Confirmation of OTP
5	Query Form	It contains the form that stores the problems and issues faced by the user while using the application
6	Weather	To inform the weather related information such as, cloudy, rainy and temperature level
7	AgroNote	List that carries the information related farming such as, how to plant, and how much of water needed
8	Sensors	Sensors for collecting different data such as temperature, humidity, and Soil moisture
9	Database Management	Provide the different data stored for farming
10	Exit	After user checked every information, user can exit the application

2.2. Cloud Storage

The developed application includes the feature of controlling the motor for irrigation purposes. Farmers can remotely control the motor using both the application and the website. The system is equipped with a timer feature, which allows the motor to run for a limited time of 30 minutes. After 30 minutes, the motor automatically turns off, ensuring the efficient use of water resources [21]. Farmers can set the motor to run for less than or more than 30 minutes, depending on their needs, according to the adjustable timer feature. Farmers who forget to turn off the motor and waste valuable water resources will find this function to be of special use.

Moreover, the ability to control the motor remotely saves farmers valuable time and effort, as they no longer need to physically go to the field to turn the motor on or off. They can do it easily from their smart phone or computer. The timer feature ensures efficient use of water resources and flexibility.

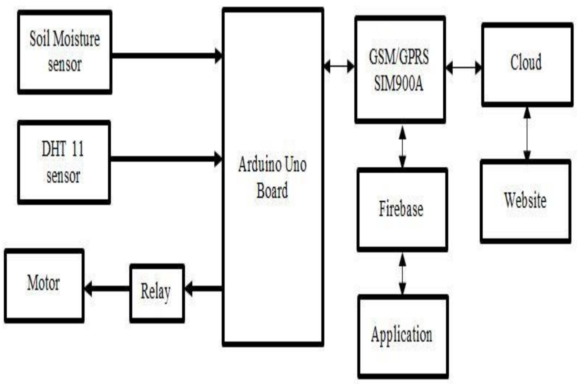


Fig. 1 Block diagram for monitoring the farm land

The system utilizes sim900A to establish an internet connection, enabling seamless data transfer without the need for a stable internet connection. The presence of a SIM card option eliminates the struggle for internet connectivity, ensuring reliable and uninterrupted data transmission [22]. Overall, the customized Arduino Uno board plays a crucial role in collecting, processing, and analyzing data for effective farm management. The complete architecture of the proposed system is presented in Fig. 1, logical structure is represented in Fig. 2, and the workflow demonstrated in Fig. 3.

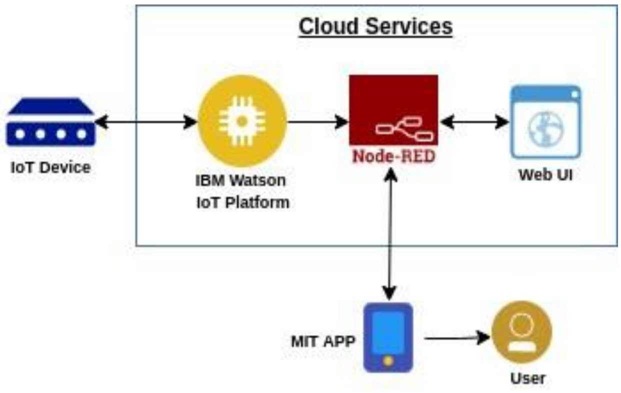


Fig. 2 Logical structure of the proposed system

2.3. Relay Module

A relay module is an electronic device that allows low-voltage circuits to control high-voltage circuits. The data obtained is processed by the Arduino Uno and sent to the SIM 900A module for transmission to the cloud and Firebase [23]. The system is capable of executing commands if any are received.

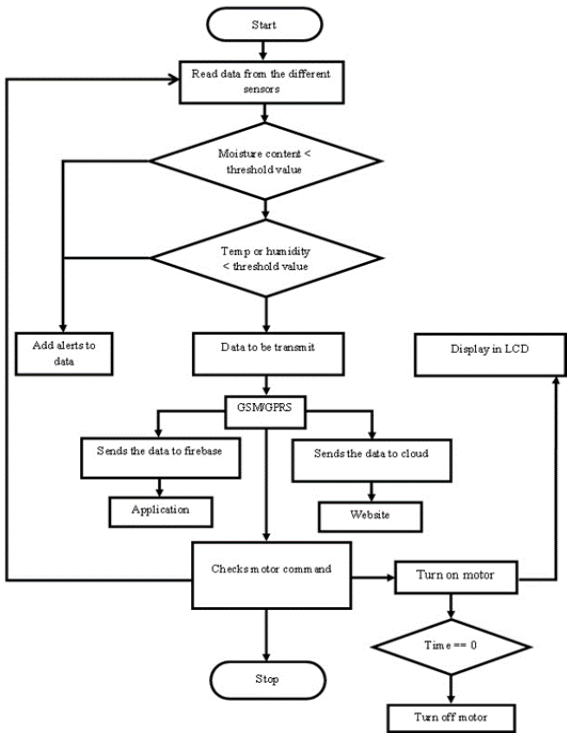


Fig. 3 Workflow of the developed model

2.4. Web User interface

At first, the web user interface (WUI) is configured to support simply HTTP (Hypertext Transfer Protocol). The CICSPlex® SM is a user-friendly web user interface it can be employed to finish all of the operational and administrative tasks needed for CICS® resource management and monitoring [24].The menus and displays that the user can see can be listed with the aid of the CICSPlex SM Web User Interface. These appear to be simple, uncomplicated viewpoints such as organize the user interface by application, user task, or resource category, identify the relationships among the views, and define the purposes of the buttons that will be displayed on a display as examples of task-oriented data structuring.

The WUI can limit entry fields to display-only or predetermined values, boost security by presenting a confirmation panel that asks the user to confirm an action is to be conducted, and more. It can also provide notifications prior to opening views that would generate a large number of records. Performance is enhanced by minimizing unwanted waiting [25]. Every menu item and view has the option to link to an external server that hosts an existing web-based procedure manual, or the help files can be housed on the CICS system, which has been designated as the Web User Interface server. These abovementioned methods were used in this proposed study.

2.5. OpenWeatherMap API

Academics and developers of mobile applications and web-based services can access forecasts and current analysis data for weather by using the OpenWeatherMap API, it is an online meteorological service. It makes use of meteorological broadcast services and official weather stations, namely utilizing raw data from radar stations, airport weather stations, and other official weather stations [26]. Specifically, machine learning is used by the OpenWeatherMap API to assess all the data and enhance the numerical weather forecast models provided by different data providers. It also provides an unlimited free JSON API with endpoints that may be used to retrieve the most recent values for hourly weather indicators and three-hourly forecast values for a maximum of five days.

Overall, the system efficiently manages and controls the irrigation of crops, monitors environmental conditions, and aids in the decision-making process of farmers. In this study, using developed device farmers can control their motor in three ways one is motor on, motor off, motor for 30 minutes where they can run motor for 30 minutes and motor will automatically off. The technical description of the proposed study is depicted in Fig. 4.

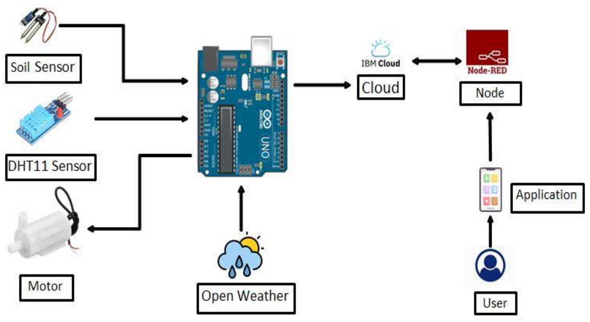
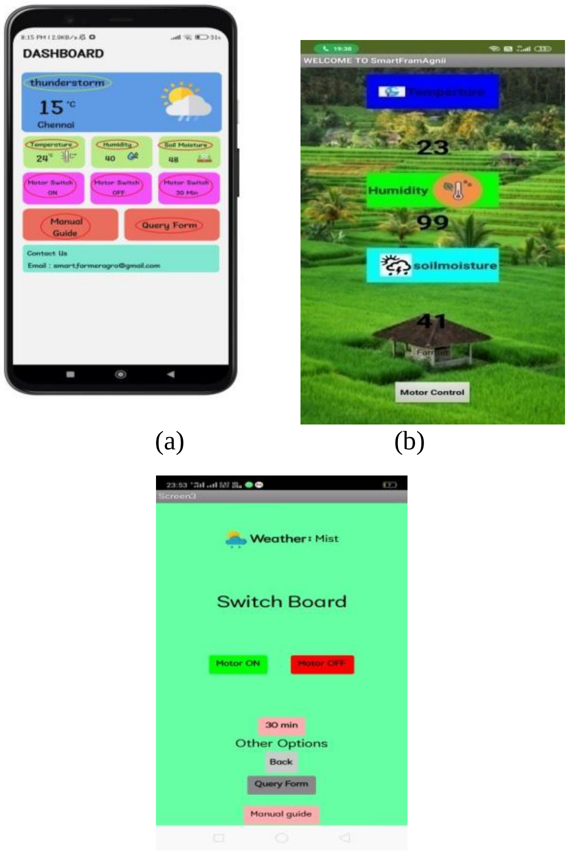


Fig. 4 Technical description of proposed system

3. Results and Discussion

Multiple similar applications were previously that specifically focused on individual parameters. SourceTrace is a smart application which was based on cloud and that has been developed and offers the relationship between markets and farmland [27]. Another cloud-based open application was built with AgJunction which is used for gathering and disseminating the data in terms of various agriculture controllers which effectively reduces the expense and ecological impacts [28]. Fujitsu developed a cloud “Akisai” for focusing on agricultural industries and food and food industries to increase the productivity of food for upcoming years. Martínez-Fernández et al. [29] propounded a method to measure the soil water deficit index using soil moisture level 2 (SMOS L2).

Vagen et al. [30] measured the different soil properties using the moderate-resolution imaging spectroradiometer sensor. This is specifically utilized for the measurement of different maps with soil functional properties to evaluate the land degradation risk. The prediction models were decided by the field survey data and soil maps for monitoring the major climate zones on the continent [31]. The proposed system is a smart irrigation system for agriculturalists to observe and change the various parameters around the farm using intelligent technology with IoT. The system consists of various sensors such as DHT11, and YL-69, to collect data related to temperature, humidity, and soil moisture. The SIM900A model is used to process the observed data from the farmland via the cloud and Firebase. The proposed device is a setup of a website and mobile application that has been built up based on the React Native framework accessible from anywhere. The website is hosted on Watson IoT and Firebase serves as the database for the application. Fig. 5(a), (b), and (c) show the various screens of developed application, Smartfram Agnii. By using the developed application, farmers can obtain many profits such as reducing the level of water usage and costs, the ability to monitor and control their farm remotely, and collective crop yield [32].



(a) (b)

(c)

Fig. 5 (a) Dashboard of developed smart application, (b). Application home page, (c) Other option screen

Additionally, the system uses a timer feature model to control the motor in the farmland and make certain that it only runs for a specified amount of time. This technique will help the farmers to prevent overuse of water in farms which can harm crops [33,34]. The device prototype model has been displayed in Fig. 6. The comparison between the existing literatures is represented in Table 2.

Table 2. Comparison with existing literature

Author	Application Name	Dataset	Specifications
Camacho and Arguello [23]	AgroTIC	20 Hyperspectral real-time images	Assist Colombian farmers' productivity
Hariharr et al. [31]	Smart Warehouse	-	Deploy a smart GPS-based remote-controlled vehicle used for monitoring fields to deter thefts, frightening wildlife, measuring soil moisture

			content, spraying fertilizers and pesticides, weeding, and measuring soil moisture
Phasinam et al. [9]	IoT Based Framework	500 Mango Leaf images	A sophisticated agricultural tracking and monitoring system was developed.
Raut et al. [34]	IoT for Agricultural Application	-	Autonomous irrigation to measure the soil's levels of the three main macronutrients, nitrogen (N), phosphorus (P), and potassium (K), To save the farmer time, money, and working hours.
Proposed Work	**SmartframAgnii**	**10000**	**Application with device setup for smart farming**

The bulk of individuals can profit from advanced technologies. IoT has just recently originated to ensure a substantial impact on daily life, expanding our senses and enabling us to change the environment around us. IoT are especially used in the agro-industrial and environmental industries for both control and diagnostic purposes. It can also inform the customer about the history and features of the product [35]. Therefore, the goal of this effort is to use IoT for computer-aided optimization in agriculture. In this kind of agricultural optimization, farmers are now more effective and efficient thanks to the use of IoT in the field. It can help evaluate field variables like weather, biomass from plants or animals, and soil condition. Furthermore, it can be employed to oversee and control aspects like as temperature, humidity, shocks, and vibrations during a product's transportation. Variables that impact crop development and productivity can also be monitored and managed with WSN. Aside from managing machinery, they can also be used to determine the ideal farmer for a certain circumstance, determine when to harvest, and much more [36]. An effective system requires user interactions, data storage, system development, and a way to extract knowledge from a body of data.

Taking into consideration the past experiences of farmers, Suma [12] gives an overview of forecasting research, IoT designs with cloud presidency, and security liabilities for multi-breeding on the farm land. In order to haphazardly monitor paddy fields. Sethy et al. [37] suggested a technique that combined deep learning with IoT. Utilizing the VGG16 built network, nitrogen rank belief and paddy leaf disease detection are being observed. Kaushik et al. [38] stated that farmers can significantly increase productivity with the help of an intelligent agriculture technology that monitors the land. Because of their affordability, versatility, ease of use, and adaptability, fluorescence-based optical sensors are seen to be a great choice. The proposed device prototype has shown to be highly effective in reducing water usage and increasing crop yield. The proposed system's ease of use has been a significant advantage for farmers. The website and mobile application are straightforward to use, making it easy for farmers to monitor and control their farm parameters remotely. The timer feature has been highly effective in reducing water usage, and farmers have reported significant cost savings as a result. The security features of the system have also been highly effective in protecting the data and securing the farm.

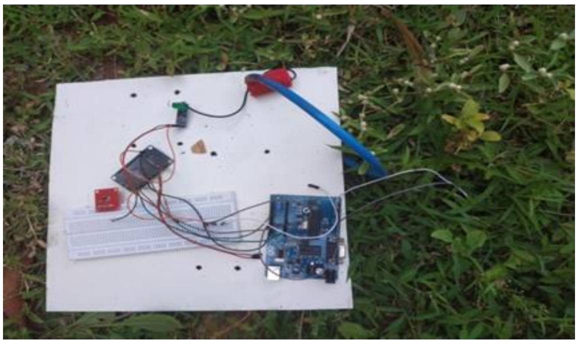


Fig. 6 Device prototype for smart farming

4. Conclusion

In conclusion, the proposed system is a highly effective and efficient smart irrigation system for farmers. The system utilizes IoT technology to monitor and control the parameters of the farm, reducing water usage and increasing crop yield. The developed device prototype is easy to use, highly secure, and provides many benefits to farmers. Meanwhile, this device prototype has to be tested in real-world scenarios and shown tbe highly effective; resulting in significant cost savings and increased profits for farmers.

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Author contributions

Rajeswari J, Josh Kumar J P, Shanmugam B: Resources, Conceptualization, Methodology, Investigation, Writing – Original.

Saranya Nair M, Ratheesh R, Navaneethan S, Elaiyarani A: Resources, Writing – Review & Editing, Visualization.

Conflicts of interest

The authors declare no conflicts of interest.

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