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Machine learning for IoT-based smart farming

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Abstract— Agriculture balances food requirements for mankind, and the supply of essential raw materials for many industries is the fundamental occupation in India. Smart farming allows analyzing the growth of crops and the parameters which influence crop growth and supports farmers in their activities, it is more profitable and reduces irrigation wastages. The proposed model is a smart farming system that analyzes the influence of parameters on crop growth and predicts the soil condition using a machine learning algorithm. Temperature, Ph, humidity, gas, and water level are the few most essential parameters to determine the quantity of water required and to find hazardous gas in any agriculture field. This system comprises temperature, pH, humidity, smoke detector, and water level sensor, deployed in an agricultural field, sends data through a microprocessor, developing an IoT device with cloud. In this study, we present a model that predicts soil series with regard to land type and, in accordance with the prediction, suggests appropriate crops. For soil land classification and crop prediction application is developed using KNN algorithms. Three steps are necessary for its implementation: the first is data collecting using sensors placed in an agricultural field, the second is data cleaning and storage, and the third is predictive processing utilizing the ML technique. The results obtained through the algorithms are sent to the cloud, which helps in decision-making in advance**.**

Keywords—Smart Farming, Precision agriculture, IoT, Machine Learning

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I. INTRODUCTION

Agriculture uses more than 85% of freshwater resources present on this planet and this percentage is gradually reducing because of population growth and an increase in food requirements. Therefore, there is a quick need for an increase in crop growth by developing new strategies based on science and technology. One of the most important factors for a crop's growth is the soil. Rainfall, temperature, soil type, fertilizers, and pH are all taken into account while making agricultural decisions. Crop cultivation is greatly influenced by the weather and the nutrients in the soil, which promote crop growth. For a crop to grow, soil is a key component. Nutrients found in soil are utilized by plants to grow. Various soil kinds are available, with each possessing various characteristics. The type of soil has a significant impact on the production of crops. We can increase production by selecting the proper crop for the correct sort of land. This can be accomplished by first studying the soil and then grouping it into several soil types. From previous decades, the success of theoretical research contribution, nowadays the need of using IoT in agriculture applications becomes a reality. IoT with the adoption of information technology solutions in crop fields with the help of smart agriculture contributes to minimal usage of water, and protection of fields from dangerous gases, including technical agronomic, managerial, and so on. For achieving water saving, several research studies were conducted on irrigation systems on various crops from basic ones to more technologically advanced ones. The framework has been proposed based on various techniques such as direct soil water measurements, thermal imaging, crop water stress index, etc. Precision agriculture is a principle that aims to optimize irrigation wastage and investments while looking for better take into account the unpredictability of the environmental conditions. Precision agriculture is essential to meet the challenges of agricultural production as there is a sustainable rise in the world' s population in terms of food security, production, and environmental impact and an increase in food production must be achieved for providing high nutritional quality worldwide. Sustainability in food production is the ability to meet present and future food demands while minimizing negative environmental impacts, conserving natural resources, and ensuring social and economic well-being. It encompasses various aspects, including agricultural practices, resource management, and food distribution systems. India is indeed a nation renowned for its agricultural sector. As the yields continue to increase, it becomes crucial to address the water requirements of the agricultural system. Proper irrigation plays a vital role in supporting the healthy growth of crops. To ensure successful crop growth, it is important to implement an effective irrigation system that provides water to crops at appropriate intervals. Timely and adequate irrigation helps meet the crops' water needs during different growth stages, promoting optimal yield and quality. Considering the agricultural significance of India, it becomes essential to focus on water management and irrigation practices. The goal of the project is to develop a model that effectively categorizes soil occurrences and maps the soil type to crop data to produce better predictions with higher accuracy. Crop classifications and geographic characteristics play a role in soil prediction. In order to predict crops more accurately, it also seeks to develop a system that analyses real-time soil data. There are two phases to the model: the training phase and the testing phase. Soil and crop databases are the two utilized datasets. The list of the proper classes is obtained after comparing the expected and actual classes. These systems can help ensure water distribution, reduce wastage, provide soil fertility, saves crops from dangerous gases, and enhance the overall productivity of the agricultural sector [7].

II. Related Works

In [1], the authors propose an irrigation system that aims to reduce water wastage and automate the irrigation process for large agricultural areas. The system determines the water requirements of the crops based on the atmospheric temperature, humidity, and soil moisture conditions. To achieve this, the system utilizes a machine learning technique. It collects data from various sensors that measure the environmental conditions, considers predefined threshold values, and performs further analysis. It cross-checks the obtained outcomes with the weather forecast and makes a decision regarding whether water should be initiated or not. By incorporating machine learning and real-time data analysis, this smart irrigation system aims to optimize water usage by providing irrigation only when it is necessary based on the analyzed conditions. This approach can help reduce water wastage and automate the irrigation process for large agricultural areas.

In paper [4], the authors discuss the implementation of an automated irrigation system using an Android operating system smartphone as a remote control. The system utilizes a soil moisture sensor that measures the moisture level in the soil and sends a voltage signal. The voltage signal is then analyzed by comparing it to a constant threshold number that is determined based on different soil compositions. This analysis helps determine the moisture level in the soil, indicating whether irrigation is required or not. The data from the soil moisture sensor is transmitted to a Raspberry Pi device through an HC05 module. The Raspberry Pi acts as a central hub for processing and controlling the irrigation system. The data is then forwarded to a mobile phone as a user interface. The user interface, developed specifically for the Android smartphone, allows the user to remotely control the irrigation system. It provides real-time information about the moisture level in the soil and enables the user to manage the irrigation system by switching it on or off based on the displayed data. The authors consider this automated irrigation system as feasible and suitable for real-time applications. It provides a convenient way for farmers or users to monitor and control irrigation remotely using their smartphones, improving water efficiency and optimizing irrigation practices.

In [5], the authors introduce the use of IoT (Internet of Things) for detecting physical data and transmitting it to the user. They emphasize methodologies that can be employed to address various issues, such as the detection of rodents and the identification of risks of crops. The authors describe the development of an IoT device using Python scripts, which can send notifications without the need for human intervention. The IoT device mentioned in the paper likely comprises sensors or detectors that gather physical data related to the agricultural environment. This data can include information on rodent activity, temperature, humidity or other relevant parameters. The Python scripts developed for the IoT device enable the processing and analysis of the collected data. Based on the predefined criteria or algorithms, the device can identify and recognize rodents and potential risks to crops. When such events or conditions are detected, the IoT device automatically sends notifications or alerts to the user or farmer. By leveraging IoT technology and Python programming, the system described in the paper offers a solution for real-time monitoring and early detection of agricultural issues. The ability to send notifications without human intervention allows for timely response to potential threats or problems, improving the overall efficiency and effectiveness of agricultural operations.

In [6], the authors explore the concepts of web services and the Internet of Things (IoT) and highlight their potential in managing vast amounts of data related to the cultivation field. The integration of IoT and web services enable the collection, processing, and analysis of agricultural data efficiently. By leveraging IoT devices and sensors, data from various aspects of agriculture, such as soil moisture, temperature, humidity, and crop growth, can be gathered and transmitted to cloud services. Web services play a crucial role in handling and processing this data, enabling real-time monitoring and analysis. The combination of cloud services and IoT has rapidly advanced and has contributed significantly to the development of smart solutions for various agricultural challenges. These solutions aim to address problems faced by farmers, enhance productivity and optimize agricultural operations.

III. Implementation

In supervised machine learning techniques, the model is given a labeled dataset with previously known labels or solutions. Using this labeled data, the model learns and discovers correlations between the input features and the appropriate output labels.

The model analyses the incoming data and their related labels in the first phase, known as training, where it discovers underlying patterns and relationships. The model tweaks its internal parameters or weights based on the observed results to increase its capacity for making precise predictions.

The quantity and caliber of the training dataset frequently determine how well-supervised machine-learning models perform. As the model can learn from a greater variety of samples and catch complicated patterns, a larger and more varied dataset typically yields findings that are more accurate.

The data flow diagram represents the direction of the flow of data is shown in the below figure, it provides the required inputs and corresponding outputs present in the system.

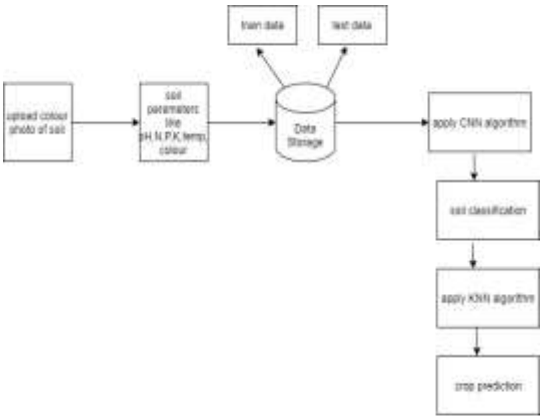


Fig 1: Data flow diagram for smart farming

A. *Algorithm*

- KNN is a straightforward yet powerful machine-learning method used for both regression and classification tasks. With the use of a non-parametric algorithm, predictions are made based on how closely incoming data points resemble labeled training samples.

Here is how KNN functions:

- Training: The algorithm memorizes the feature vectors and matching class labels of the training samples during the training phase.
- KNN measures the similarity of feature vectors using a distance metric, such as the Manhattan distance or the Euclidean distance. The type of data and the issue at hand determine which distance measure should be used
- Prediction: KNN looks for the k closest labeled samples based on the selected similarity measure when a new unlabeled data point is presented. It gives the new data point the majority class label among the k nearest neighbors.

KNN can be used to categorize fresh samples or predict soil attributes based on the values of nearby samples. The algorithm can use the similarity of soil samples (based on their features) to do this.

B. *Architecture*

- The main components of the smart farming system architecture are water level, temperature, humidity, fire detection sensors, and Raspberry Pi.
- Raspberry Pi is essential to the system because it houses a web server and stores the datasets.
- The water level, temperature, humidity, and fire detection sensors are connected to the figure as shown below.
- These sensors send their collected data to the Raspberry Pi, where it is stored and processed.
- In order to forecast correct results, the CNN &KNN algorithms are used for the datasets.
- The website's results are updated regularly with reference to all of the sensors' relevant graphs and tables.
- For later usage, every bit of information transmitted from the sensors to the Raspberry Pi is stored in a cloud database.
- Logging in, registering as a farmer, classifying the soil, and crop prediction modules are some of the functional parts of this system. using our website, a farmer.
- Before choosing a crop, the farmer must first log into the system, upload a colour image of the soil, and then wait for the output to show the appropriate crop.
- It is necessary for the user to log out of the system after the successful completion of actions.

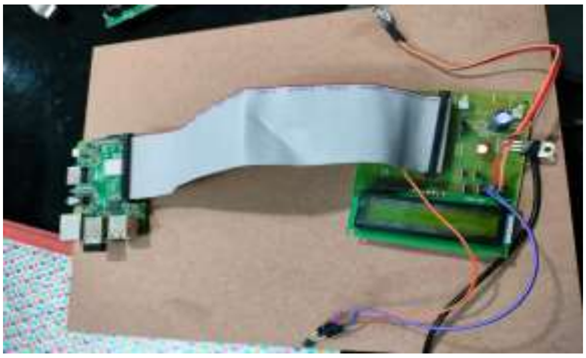


Fig 2: Hardware Setup

C. *Dataset*

- Apply the KNN algorithm to the soil classification soil photo. If a photo does not match any of the photos in the dataset, it is assumed that it is not a soil photo, and the system notifies the farmer to upload a soil photo by comparing soil parameters with the dataset's existing values.
- To determine the pH value for a fresh soil sample, we first take an image of the soil, and then we use the soil pH factor formula to determine the new factor for the fresh image.

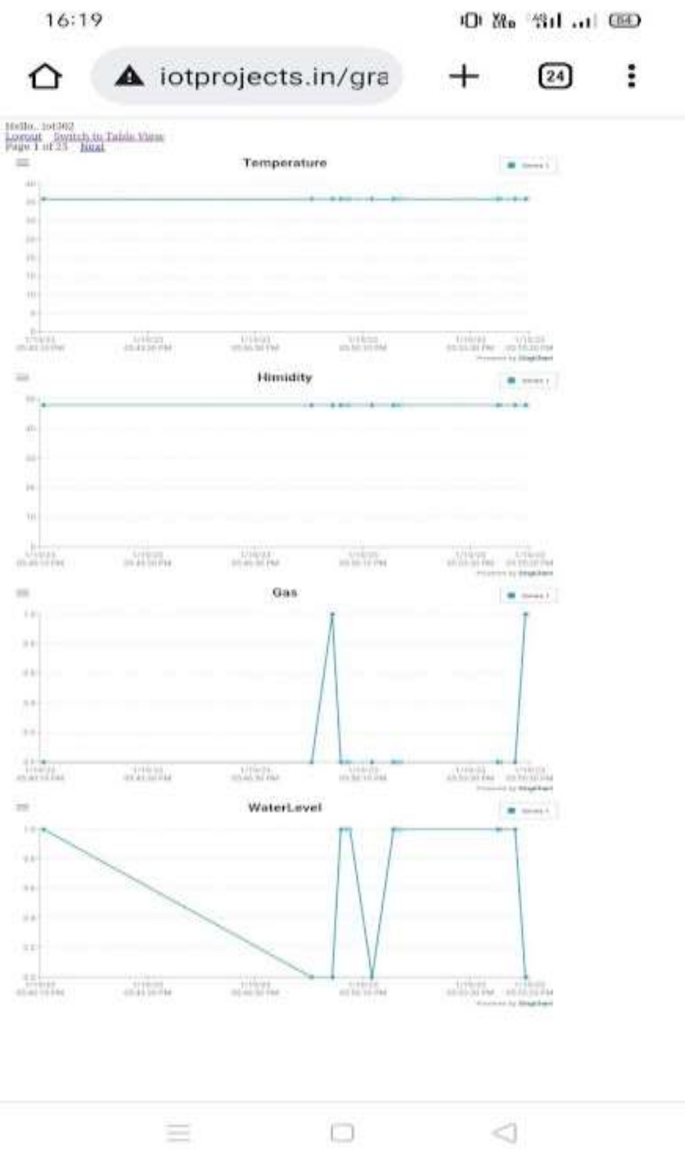
- The system's image capture can be thought of as a matrix of pixels linked to different combinations of red, green, and blue values. To determine the single soil pH factor value for each image, take the average of each sector.

IV. Results

The output shown in the figure contains the values of pH, temperature, humidity, gas, and water level at various intervals of time day to day.

Fig 3: LCD showing pH, Water level, Temperature, Humidity

The sensor values are uploaded to the cloud and are



represented in table form and graphical form as shown in below figures.

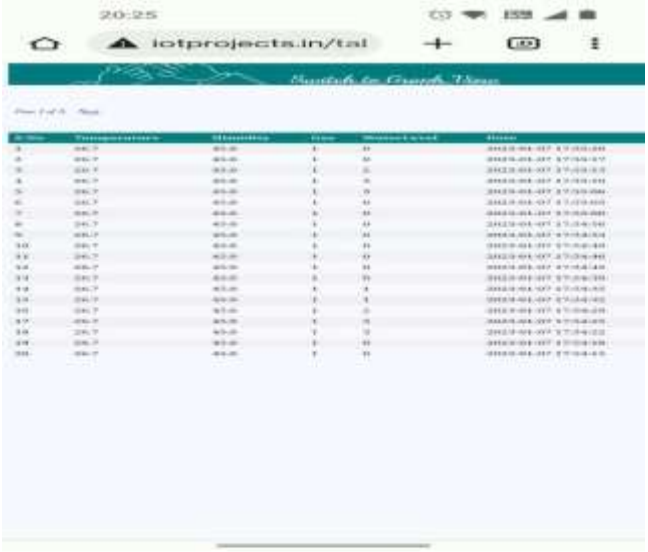


Fig: Table showing sensor values.

Fig: Graphs showing sensor values.

- After uploading an image we can check the soil values and the crop classification and crop prediction values with predicted crop data description as shown in the below figures.

Fig 4: After uploading the image we get to know soil values.

Fig 5: Shows the crop prediction values.

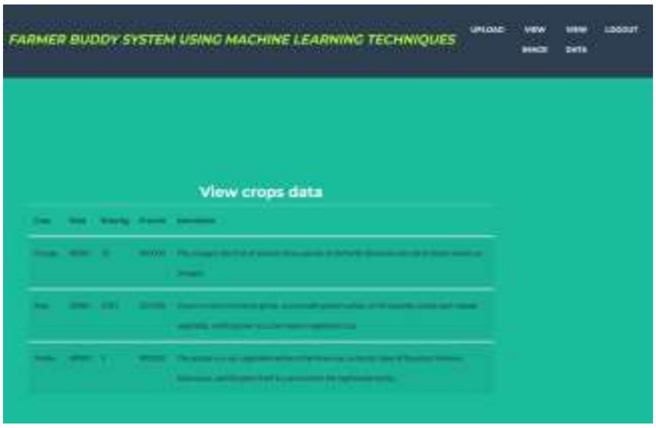


Fig 6: Shows the crop data description.

v) CONCLUSION

The use of a machine learning algorithm to construct an IoT-based smart farming system was proven to be economically viable for precision agriculture and low water resource utilization. This model's goals are to know the soil quality and increase agricultural yield. Using the provided dataset and all detected data from temperature, pH, humidity, water level, and smoke detector sensors, this system is trained and programmed. The KNN algorithm, a member of the family of supervised machine learning algorithms, is used to process data and produce an output of the soil's general health and nutrient level. Prediction also aids in determining how much he can produce in a given soil. This might assist the farmer in producing a range of crops throughout the year. If we want to grow a specific crop, we can improve the soil by incorporating the nutrients the crop needs and convey the decision to the farmer. Using this decision, the farmer can decide his farming activities like a waste of water, crop prediction, and so on.

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