Development of Effective Crop Monitoring and Management System with Weather Reporting

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Abstract – *Hill station agriculture is a place where sudden climatic changes and crop related issues happen. Since farmers owning these hill-station farmlands are often located in down-hills which makes them more inconvenient to reach the farmland on time during a natural calamity resulting in poor crop management and thus affecting production. This paper focuses on developing a virtual environment integrated with real-time components those serve as an input/output devices and as processing device. This proposed method uses machine learning algorithms to solve the inconveniences faced mainly by the hill station farmers. This model also has a weather prediction algorithm added to the crop recommendation algorithm which is used for the precise calculation of crop recommendation that is for the unskilled new person to cultivation field. Agri rating is an additional feature for better understanding of the land.*

Key Words: Crop Recommendation, Weather Prediction, Agri Rating, KNN algorithm, LSTM algorithm.

1. INTRODUCTION

In India, agriculture plays a crucial part in the economy. Of about 330 million hectares of geographical land in India, almost 33 percent of the lands are practicing agriculture. 40+ percent of these agriculture lands are in hill stations. One of the major issues facing by farmers of these hill station farming is the lack of proper maintenance of crops due to their farmlands and homes are separated by a longer distance. This separation between farmlands and homes makes farmers not easier to reach the farmland during a heavy rain or other natural calamities that are constantly changing over time in hill stations. The main motive of this project is to eliminate the communication delay and thus providing an efficient management system.

In this project, we proposed a machine learning model using data mining that can help the farmer to know what happens in the farmland periodically and keep them alert of the changes happening up the hill. K-Nearest Neighbor (KNN), Random Forest and Long Short-Term Memory (LSTM) are the Machine Learning Algorithms used for different purposes of the proposed model. These algorithms are discussed in brief in the upcoming sections.

2. METHODS AND MATERIALS

2.1 Algorithms

A. K – Nearest Neighbor

A machine learning algorithm, that is the simplest and supervised learning technique. It is the most efficient algorithm that can process a very large dataset with numerous classes (that are defined to output) and provides the new data point or provide most similar class possible from the various classes of the stored data. As KNN approach is a non-parametric algorithm, it accepts no assumptions regarding data.

The dataset that is imported has various classes of crops which are based on the respective parameters of the land and environment. If when a crop is seeded, this system gathers the daily data of the land and keep the farmer advised by the final report. This approach facilitates both crop maintenance and crop prediction inside a single model.

B. Random Forest

This is a decision tree algorithm which is non-linear and also non-parametric supervised classification type. It can be used for comparing values between a larger dataset except it can only provide the output from only two classes. As for this project, to predict the weather, the output is set to either "Possibility of Rain" or "No possibility of Rain", hence Random Forest Algorithm is more effective as it performs well for smaller classes of output.

C. Long Short-Term Memory

Long Short-Term Memory, a model of RNN (Recurrent Neural Network) series that has the capacity of learning long-term dependencies. RNN is useful for short-term dependencies where as LSTM is more effective when comes to long-term. Whatsoever, LSTM uses similar structure of chains of neural network as RNN, it has its each part of the chain that are multiple layer which can interact with the other. This method is used for Agri-rating where the system can compare the land parameters and provide how good the land is, thru a rating scale.

D. Datasets

For this model to achieve the goal, three datasets are taken. The processes involved in this project are, Crop Recommendation, Rainfall Prediction and Agri-rating. For each of the model to provide best results, the amount of data given should be valid, higher in numbers and should be comparative to one another.

For Crop Recommendation, a dataset with 8 columns where 7 are parameters of the land and environment and 1 is crop that is appropriate to the values. These parameters are nitrogen, potassium, phosphorus, temperature, humidity, pH and rainfall. Totally there are 22 crops taken and for each crop, the parameter values are taken in number of 200

For Weather/Rainfall Prediction, parameters such as month, date, average temperature, average humidity, sun visibility, average wind speed and rainfall are taken. The rainfall column is the target class that has either 0(no possibility of rain) or 1(possibility of rain).

For Argi-rating, the dataset is created which holds the values of land parameter. These parameters are helpful in determining how well the land is performing according to which the land is rated by the system and provides tips to maintain the system. This dataset is more similar to the crop recommendation dataset, in addition to previous values, air quality and moisture parameters are also added.

These datasets are fed into each of the respective models and trained accordingly. For training the model, each model is provided with the test size of 0.2 (20% from dataset) respectively. The outcome accuracy is discussed later in this paper.

3. METHODOLOGY

To solve the delayed communication issues facing by the hill-station farmers, this model is designed in a way to form a local area network wirelessly which can be achieved by transmitting the data over LoRa. LoRa is a Long-Range communication device that can create or form a network around it without any internet connectivity. This approach will eliminate the need of internet, whereas internet infrastructure is very much lesser in the hill-station areas. LoRa can cover up to 3 to 15 miles theoretically and can be communicated without internet. This gives the advantage of transmitting the real-time sensors data from the farmland to a certain distance where the farmers might able to access and process it even if there isn't no internet connectivity. The general model for the communication between farmland and farmer accessible area is illustrated in the Fig -1.

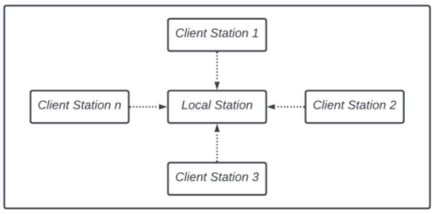

Fig -1: General Model

Client station is the farmland where sensors like pH sensor, moisture sensor, temperature or humidity sensor and a LoRa transmitter are present. Local station is the place where data processing takes place for which the input is taken from the client station thru LoRa receiver. The proposed system architecture is shown in the Fig -2.

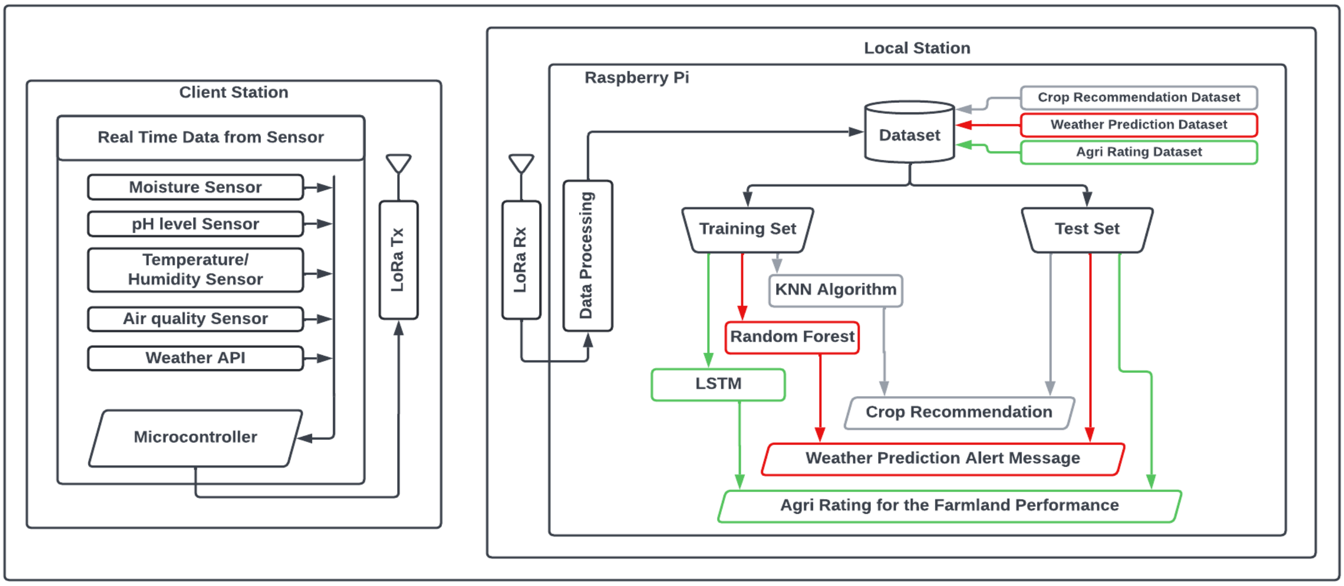

Fig -2: Architecture of the proposed model

4. RESULTS AND DISCUSSIONS

For Machine Learning, confusion matrix is the key parameter to know how the model is performing. The confusion matrix that is obtained should be NxN matrix (N is the number of target classes). When the model is performing well, the diagonal elements of the matrix will be filled with integers whereas the other elements will be zero. If the model is not performing as required, the elements other than diagonal elements will be having some integer values, means these are the errors/miscalculations that are occurred in the model. Below are the figures that represent the confusion matrix of each method.

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Confusion Matrix is:
 [[17  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0]
 [ 0 14  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0]
 [ 0  0 19  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  1  0  0  0]
 [ 0  0  0 22  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0]
 [ 0  0  0  0 26  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0]
 [ 0  0  0  0  0 25  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0]
 [ 0  0  0  0  0  0 17  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0]
 [ 0  0  0  0  0  0  0 24  0  0  0  0  0  0  0  0  0  0  0  0  0  0]
 [ 0  0  0  0  0  0  0  0 17  0  0  0  0  0  0  0  0  0  0  0  7  0]
 [ 0  0  0  0  0  0  0  0  0 21  0  0  0  0  0  0  0  0  1  0  0  0]
 [ 0  0  0  0  0  0  0  0  0  0 19  0  0  1  0  0  0  0  0  0  0  0]
 [ 0  0  0  0  0  0  0  0  0  0  0 18  0  0  0  0  0  0  0  0  0  0]
 [ 0  0  0  0  0  0  0  0  0  0  0  0 21  0  0  0  0  0  0  0  0  0]
 [ 0  0  0  0  0  0  0  0  0  0  0  0  0 16  0  0  0  0  0  0  0  0]
 [ 0  0  0  0  0  0  0  0  0  0  0  0  0  0 16  0  0  0  0  0  0  0]
 [ 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 23  0  0  0  0  0  0]
 [ 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 21  0  0  0  0  0]
 [ 0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0 17  0  0  0  0]
 [ 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 19  0  0  0]
 [ 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 18  0  0]
 [ 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 16  0]
 [ 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 21]]
```

Fig -3: Crop Prediction Confusion Matrix

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Confusion Matrix :
 [[323  59]
 [ 22  69]]
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Confusion Matrix :
 [[ 0  0  0  0  0  0]
 [46  0 13 31  1  0]
 [50  0 14 18  3  0]
 [55  0  8 27  4  0]
 [45  0 11 26  5  0]
 [41  0 15 26  1  0]]
```

Fig -4: Rainfall Prediction & Agri Rating Confusion Matrix

From the confusion matrix, we can calculate the accuracy, specificity and sensitivity by the formulas. The obtained values are shown in table -1

Table -1: Results Obtained

Model	Algorithm	Accuracy	Specificity	Sensitivity
Crop Recommendation	KNN	97%	-	-
Rainfall Prediction	Random Forest	85%	75%	88%
Agri-rating	LSTM	81%	-	-

The performance of the LoRa transmitter is quite convincing. Data that are extracted from the sensors can be sent through LoRa but with efficiency lesser than theoretical value. Also, while transmitting data, some data gets lost, this issue can be solved by resending the data multiple times and making the receiver side system to wait for all the required data to be received. This may slow down the process but the outcome will be accurate.

5. CONCLUSIONS

The aim of this project is to solve the communication delay that happens when the farmers are not nearer to the farmlands and to provide a maintenance system that monitors the farmlands and keeps the farmer updated. Even though the communication problem needed to be taken care, the monitoring and weather prediction systems have done their functions accurately. Crop recommendation system provided the best results.

FUTURE SCOPE

1. Enhancing the communication system with a high-level technology will help both open area and hill-side farmers/farming not to worry about their lands.
2. A sustainable development in the monitoring and maintenance system will escalate the production of crops to a newer level

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