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Smart Agriculture using IoT and Machine Learning

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Abstract – *Agriculture is one of the most important factors for economic growth for any country. Agriculture plays a very crucial role in increasing the economy of many developing countries. India, being one of the major countries in the world for producing vast amounts of different crops, still uses traditional techniques in the field of agriculture. Farmers not only face problems in coping with the changing climatic conditions but also need to meet up the rising demands of higher food production with good quality. As a matter of fact, Farmers need to be aware of the changing climatic conditions in order for them to yield quality crops. IoT and Machine Learning based Smart Agriculture would not only help farmers monitor their crops in real time but also would help in recommendations regarding crops and fertilizers. This paper focuses on proposing an IoT based Smart Agriculture system, which would help farmers, get recommendations based on various factors like humidity, temperature, pH, moisture and rainfall. The system would also focus on suggesting fertilizers to farmers as well based on factors such as nitrogen, phosphorus and potassium levels of the soil.*

***Key Words*: Crop Prediction, Fertilizer Prediction, Internet of Things, Machine Learning, Smart Farming.**

1. INTRODUCTION

The development and usage of Smart Agriculture systems based on IoT and Machine Learning is changing the field of agriculture sector by not only improving the crop production but also making it cost effective. The agriculture sector has gone through a constructional transformation in recent years, demonstrated by hikes in prices and guided by population growth and urbanisation. There is no hesitation that the government needs to invest in the agriculture sector in order for it to bloom. The world seems to be making advancements in the field of technology and it is necessary to make reasonable advancements in the field of agriculture as well. According to the World Bank, the food consumption would increase by 50% by 2050 if the global population continues to rise at its current pace [1]. As a matter of fact, the effects of drastic changes in climatic conditions have seen crops yield falling by more than a quarter. There needs to be a focus on the implementation of smart technologies in the field of agriculture to yield quality and bulk production of crops. The combination of IoT and Machine Learning can certainly help in lowering the cost and also help in increasing the scale of production through the collection of time series data from sensors. There are certain factors, which play a vital role in the production of crops. Nearly 51% of the crop yield is dependent on the influence of these factors. These factors include precipitation, temperature, humidity, and moisture and pH concentration.

1.1 Precipitation

Precipitation refers to all the water that falls from the atmosphere in the form of rain, dew, and snow. Rain is one of the most important factors, which affects the vegetation of a location. Crops like rice, tea and coffee are grown in the areas, which have heavy and equally distributed rainfall whereas crops like millet, sorghum are grown in locations with less rainfall.

1.2 Temperature

The optimal range for temperature, which would yield maximum production for most of the crops range from 15 degree Celsius to 40 degree Celsius. The temperature of a location is highly dependent on the distance of the location from the equator. The growth production of the crops is highly related to the temperature.

1.3 Humidity

Humidity is also one of the most important factors affecting the crop production. Humidity refers to the water content present in the form of vapors. As a matter of fact, around 45-60% of relative humidity is preferred for production of most crops whereas only a few number of crops are able to perform well when the humidity is 75% and above. Humidity also increases the possibility of pests and diseases.

1.4 pH Concentration

pH concentration of the soil plays an important role in the high quality production of the crops. Soils with pH ranging from 6.5-7 are optimal for growth of various crops. Low pH soils tend to be harmful for plants because of the high concentration of iron and aluminum whereas it also interferes with the other nutrients available to the plant

2. LITERATURE REVIEW

According to the Climate-Change-Crop-Yield Report in [9], the crop production is projected to decrease, with a large decline in developing countries like India and South Asia [10]. The contrast in various losses across various regions can be explained by the various reasons such as infrastructure, industrial challenges, inefficient harvesting, climate and not being able to predict the appropriate crops to farm in a particular climate.

Rushika G, Juliee K, Pooja M, Sache N, Priya R in [1] have used various machine-learning algorithms like KS Organising Maps, and BP Networks. The model was trained by teaching the network to classify the type of soil whether it is organic or inorganic. They also compared various other learning methods and the most accurate model was used as the final model. The application also checks the quality of the soil and predicts the crop according to the quality of the soil.

Radhika N in [2] determined the real-time sampling of the various soil properties using MSVM, The application she proposed was divided into four modules, one being the sensor interfacing to an IoT device, second the cloud, third analysing the real time data and lastly the User Interface. As a matter of fact, this system will help the farmers to find the appropriate type of crop to grow depending on the properties of the soil of their region.

Shridhar M, Chinmay P, Piyush W, Aniket P, Vaishali D in [3] developed an ARIMA model, which predicts the temperature, pH and the moisture. Time series forecasting is done based on the historical data. The predicted values are then sent to another K-means model, which classifies the crops in terms of their pH value. The KNN model is used to predict the group of crops, which are most suitable for the farmer.

Raghav K, Bhagavatula A, Aashish S, Drishti J, Natesh B, Varshini S in [4] developed a KNN model which calculates the features and suggests the crop which is appropriate for growing in that particular region. A dataset, which is standardized, is maintained to hold all the minimum requirements for a crop. Various sensors are added to the region for which crop prediction is required which sends real-time data to the cloud.

Akash R, Balaji S, Deepit A, Sarath J, Vinith K in [5] developed a system, which evaluates the quality of the crop based on weather conditions and the type of soil. They used various machine-learning algorithms in order to find the optimum one. Various measures were taken in picture to predict the appropriate period of harvesting and sowing to improve crop yield.

3. METHODOLOGY

In the proposed system, the main concept implemented is the Internet of Things (IOT). There will be a low-level hardware device that will measure different variables of the surroundings like temperature, humidity, soil moisture, pH of the soil, UV radiation, etc. The measured values will then be transferred to AWS S3 database, which will later be pulled back to a NodeJS web application for further processing.

On the other hand, there will be an option to connect the device to a React Native phone application with the help of a Bluetooth module. The data will then be pushed to the database server using the phone.

The major part of the proposed system will be a hardware device that constitutes of different kinds of sensors such as Soil Moisture Sensor (EK1361), Humidity and Temperature Sensor (DHT22), pH Sensor (SKU: SEN0161) and UV Radiation Sensor (ML-8511). The device collects the surroundings attributes (soil moisture, temperature, pH, radiation intensity) independently and processes it with the help of its microcontroller ATMega328p. The microcontroller will then send the received data immediately to the AWS S3 database.

On the other hand, a Bluetooth module will be connected to the microcontroller so that the user gets to connect to the device locally, and send the data manually through a React Native application. The received data will be utilized to process necessary requirements that a farmer needs to take care of, for maximum yield of the crops.

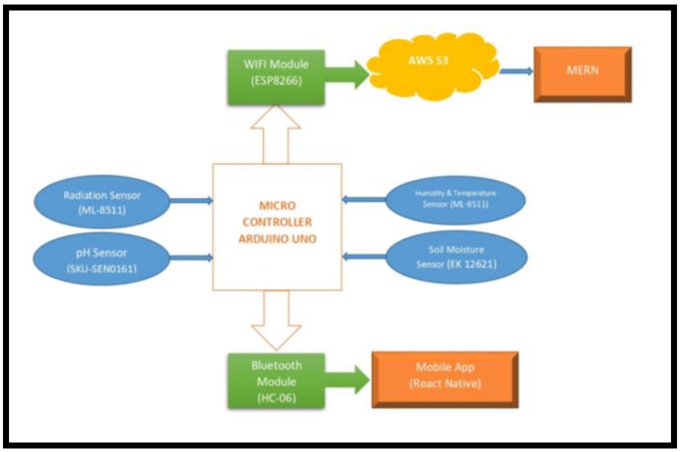

Fig - 1: Architecture

To interface the user with the device's data, a web application will be developed using ReactJS, NodeJS and ExpressJS framework. The data received from the hardware device will be analyzed using different machine learning algorithms and researched agricultural datasets in the past. According to the results from different backend machine learning algorithms, a suggestion template will be developed in the web application so that the farmer knows what to do next.

The main challenge will be to collect different agricultural datasets that will be used to analyze the data received from the hardware device. The web application will be fully focused on the data visualization and helpful suggestions of each user.

4. RESULT AND DISCUSSION

The training dataset used for the training of crop prediction model contains features like nitrogen, potassium, phosphorus, temperature, humidity, pH, and rainfall whereas the fertilizer recommendation model contains features like nitrogen, phosphorus, potassium, pH and soil moisture.

Various Machine learning algorithms were applied against the training dataset - Decision Tree, Naive Bayes, Support Vector Machine, Logistic Regression, Random Forest and XGBoost, and were compared based on the model's accuracy. XGBoost showed the highest accuracy and thus was used for the prediction model.

The user, which is a Farmer, will be able to use our platform to get accurate recommendations regarding which crop to grow based on different features like humidity, pH, and rainfall. Besides that, the user will be able to get fertilizer recommendations based on different features like moisture, nitrogen, phosphorus and potassium.

N	P	K	temperature	humidity	ph	rainfall	label
90	42	43	20.8797437	82.00274	6.502985	202.9355	rice
85	58	41	21.7704617	80.31964	7.038096	226.6555	rice
60	55	44	23.0044592	82.32076	7.840207	263.9642	rice
74	35	40	26.4910964	80.15836	6.980401	242.864	rice
78	42	42	20.1301748	81.60487	7.628473	262.7173	rice
69	37	42	23.0580487	83.37012	7.073454	251.055	rice
69	55	38	22.708838	82.63941	5.700806	271.3249	rice
94	53	40	20.2777436	82.89409	5.718627	241.9742	rice
89	54	38	24.5158807	83.53522	6.685346	230.4462	rice
68	58	38	23.2239739	83.03323	6.336254	221.2092	rice
91	53	40	26.5272351	81.41754	5.386168	264.6149	rice
90	46	42	23.9789822	81.45062	7.502834	250.0832	rice
78	58	44	26.800796	80.88685	5.108682	284.4365	rice

Fig - 2: Dataset Features for Crop Recommendation

Crop	N	P	K	pH	soil_moisture
rice	80	40	40	5.5	30
maize	80	40	20	5.5	50
chickpea	40	60	80	5.5	60
kidneybea	20	60	20	5.5	45
pigeonpea	20	60	20	5.5	45
mothbean	20	40	20	5.5	30
mungbean	20	40	20	5.5	80
blackgram	40	60	20	5	60
lentil	20	60	20	5.5	90
pomegran	20	10	40	5.5	30
banana	100	75	50	6.5	40
mango	20	20	30	5	15
grapes	20	125	200	4	60

Fig - 3: Dataset Features for Fertilizer Recommendation

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Decision Tree --> 0.9
Naive Bayes --> 0.990909090909091
SVM --> 0.10681818181818181
Logistic Regression --> 0.9522727272727273
RF --> 0.990909090909091
XGBoost --> 0.9931818181818182
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Fig - 4: Prediction Accuracy of Different Models

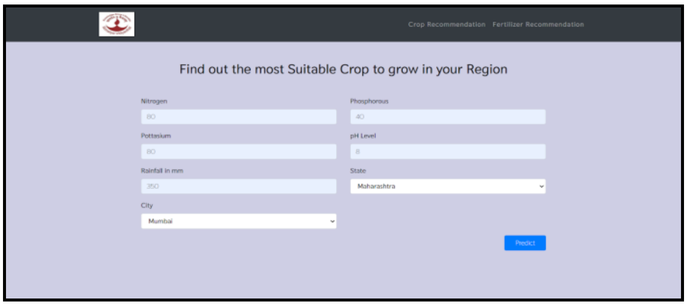

Fig - 5: Input from User for Crop Recommendation

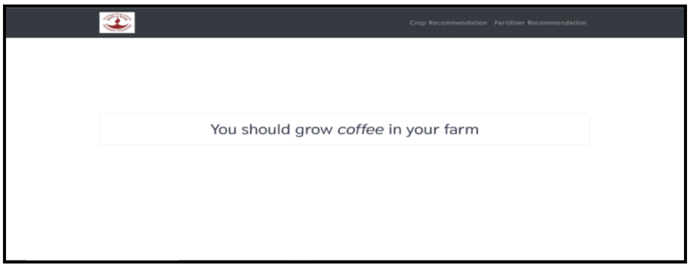

Fig - 6: Crop Recommendation based on Input

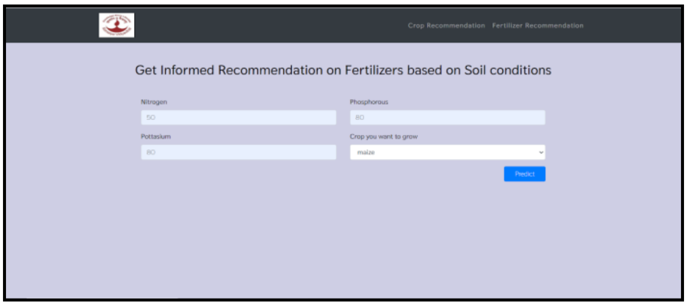

Fig - 7: Input from User for Fertilizer Recommendation

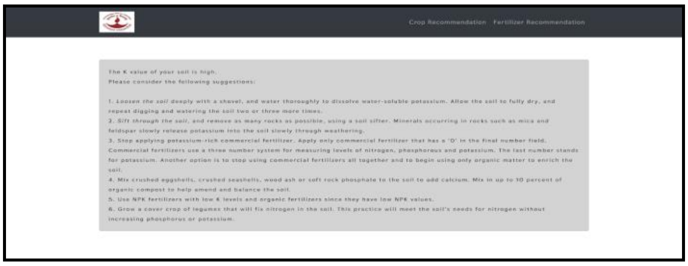

Fig - 8: Fertilizer Recommendation based on Input

7. CONCLUSION AND FUTURE SCOPE

Agriculture is one of the major sectors for the economic development of India. The traditional agricultural sector, which include farmers, seem to suffer from various problems like inadequate crop growth, and inadequate climatic conditions. The real time readings coming from the sensors along with the application of Machine Learning Algorithms will not only help farmers make informed decisions on which crop to grow in a particular region but also recommend fertilizers based on various factors like soil condition, climatic conditions etc. In addition, from the various machine-learning algorithms implemented, XGBoost seems to give the best results with 99.31% accuracy on the recommendations.

These IoT and ML based recommendations will surely help the farmer understand more about the various factors, which help them in minimizing their costs, and make strategic decisions. This leads to a scalable and reliable solution, which will affect millions of people in India.

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