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An IoT Based Gradient Descent Approach and ML for Precision Smart Crop Prediction

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Abstract - **Agriculture is the backbone for a developing economy like India and there is an enormous need to maintain the agricultural sustainability. Hence it is a significant contribution towards the economic and agricultural welfare of the countries across the world. Effective utilization of agricultural land is crucial for ensuring food safety and security of a country. The aim of this paper is to propose an IoT and ML based Agriculture system that can assist farmers or agriculturist in crop prediction based on Metrological Agriculture theory by getting live Metrological data from the crop field using IoT technology and M.L for prediction which will enable smart farming and increase their overall yield and quality of products.**

Key Words: **Agricultural Meteorology; Crop Prediction; Internet of Things; Machine Learning; Smart Farming;**

1. INTRODUCTION

The development of Intelligent Smart Farming devices based on Internet of things and Artificial Intelligence is day by day turning the face of agriculture production by not only enhancing it but also making it cost-effective and reducing wastage. Agriculture and the food system had undergone a structural transformation in recent years, manifested by price hikes and driven by income and population growth, migration and urbanization, as well as speculation. There is no doubt that the world needs to invest in agriculture. As the world is trending into new technologies and implementations it is a necessary goal to trend up in agriculture also. The World Bank says we'll need to produce 50% more food by 2050 if the global population continues to rise at its current pace [1]. But the effects of climate change could see crop yields falling by more than a quarter. The implementation of smart technology in agriculture practices needs to be focused on for better land productivity. Such studies are conducted in natural outdoor environmental conditions and locations where crops are growing, by varying metrological and physical conditions. Internet of Things (IoT) and A.I technologies combinedly can lower the cost and increase the scale of such studies via the collection of related time series data from sensor networks and labs observations recorded by testing them chemically. The Agriculture system proposed in this paper is an integration of the concepts of Machine learning and IOT using IoT boards and various sensors, through which live data feed can be obtained and processed.

1.1 Agricultural Meteorology

Agricultural Meteorology [2] is a branch of applied meteorology which investigates the physical conditions of the environment of growing plant organisms and deals with the relationship between weather/climatic conditions and agricultural production. A science concerned with the application of meteorology to the measurement and analysis of the physical environment in agricultural systems. The word ‘Agro Meteorology’ is the abbreviated form of agricultural meteorology which is a study of interaction between meteorological and hydrological factors on the one hand and agriculture in the widest sense.

1.2 Meteorological Factors affecting Crop Production

Meteorological factors play a vital role in Crop Production. Nearly 50 % of yield is attributed to the influence of climatic/Meteorological factors. The following are the major atmospheric weather variables which influences the crop production.

1. Precipitation
2. Temperature
3. Humidity
4. Solar Light Intensity (/Radiation)

1.2.1 Precipitation

Precipitation includes all water which falls from atmosphere such as rainfall, snow, dew etc. Rainfall one of the most important factor influences the vegetation of a place. Total precipitation in amount and distribution greatly affects the choice of a cultivated species in a place. In heavy and evenly distributed rainfall areas, crops like rice in plains and tea, coffee and rubber in Western Ghats are grown. Low and uneven distribution of rainfall is common in dryland farming where drought resistance crops like pearl millet, sorghum and minor millets are grown. In desert areas grasses and shrubs are common where hot desert climate exists Though the rainfall has major influence on yield of crops, yields are not always directly proportional to the amount of Precipitation as excess above optimum reduces the yields Distribution of rainfall is more important than total rainfall to have longer growing period especially in drylands. Many Farmers in the developing countries like India depend on the annual rainfall for Irrigation Purpose.

1.2.2 Temperature

Temperature is a measure of intensity of heat energy. The range of temperature for maximum growth of most of the agricultural plants is between 15 and 40ºC. The temperature of a place is largely determined by its distance from the equator (latitude) and altitude. It influences distribution of crop plants and vegetation. Germination, growth and development of crops are highly influenced by temperature. Affects leaf production, expansion and flowering. Physical and chemical processes within the plants are governed by air temperature. Diffusion rates of gases and liquids changes with temperature. Solubility of different substances in plant is dependent on temperature. The minimum, maximum (above which crop growth ceases) and optimum temperature of individual's plant is called as cardinal temperature. Some of the sample data is shown in Table-1.

Crops	Min. Temp (in ºC)	Optimum Temp (in ºC)	Max Temp (in ºC)
Rice	10	32	36-38
Wheat	4.5	20	30-32
Maize	8-10	20	40-43
Sorghum	12-13	25	40
Tobacco	12-14	29	35

Table -1: Sample Crop's Temp Favorable Conditions

1.2.3 Relative Humidity

Water is present in the atmosphere in the form of invisible water vapour, normally known as humidity. Relative humidity is ratio between the amounts of moisture present in the air to the saturation capacity of the air at a particular temperature. If relative humidity is 100% it means that the entire space is filled with water and there is no soil evaporation and plant transpiration. Relative humidity influences the water requirement of crops. Relative humidity of 40-60% is suitable for most of the crop plants. Very few crops can perform well when relative humidity is 80% and above. When relative humidity is high there is chance for the outbreak of pest and disease.

1.2.4 Solar Light Intensity

From germination to harvest and even post-harvest crops are affected by solar radiation. Biomass production by photosynthetic processes requires light. All physical process taking place in the soil, plant and environment are dependent on light. Solar radiation controls distribution of temperature and there by distribution of crops in a region. Visible radiation is very important in photosynthetic mechanism of plants. Photosynthetically Active Radiation (PAR - 0.4 – 0.7μ) is essential for production of carbohydrates and ultimately biomass.

Some of the Edaphic factors considered for the proposal are:

1. Soil moisture
2. Soil mineral matter
3. Soil organic matter
4. Soil pH

1.2.5 Soil Moisture

Water is a principal constituent of growing plant which it extracts from soil. Water is essential for photosynthesis. The moisture range between field capacity and permanent wilting point is available to plants. Available moisture will be more in clay soil than sandy soil. Soil water helps in chemical and biological activities of soil including mineralization. It influences the soil environment E.g. it moderates the soil temperature from extremes. Nutrient availability and mobility increase with increase in soil moisture content.

1.2.6 Soil Mineral and Organic Matter

The mineral content of soil is derived from the weathering of rocks and minerals as particles of different sizes. These are the sources of plant nutrients E.g.: Ca, Mg, S, Mn, Fe, K etc It supplies all the major, minor and micro nutrients to crops. It improves the texture of the soil. It increases the water holding capacity of the soil, it is a source of food for most microorganisms. Organic acids released during decomposition of organic matter enables mineralisation process thus releasing unavailable plant nutrients. The chemical analysis of soils and is well recognized as a scientific means for quick characterization of the fertility status of soils and predicting the nutrient requirement of crops. Although plants absorb a large number of elements, all of them are not essential for the growth of crops. The elements are absorbed became they happen to be in the soil solution and those taking active part in the growth and developmental processes are called the essential ones. Some of these are required in large amounts and some in traces.

1.2.7 Soil pH Concentration (/Soil Reaction)

Soil reaction is the pH (hydrogen ion concentration) of the soil. Soil pH affects crop growth and neutral soils with pH 7.0 are best for growth of most of the crops. Soils may be acidic (<7.0), neutral (=7.0), saline and alkaline (>7.0). Soils with low pH is injurious to plants due high toxicity of Fe and Al. Low pH also interferes with availability of other plant nutrients. Soils formed under low rainfall conditions tend to be basic with soil pH readings around 7.0.

Intensive farming over a number of years with nitrogen fertilizers or manures can result in soil acidification. For example, which have soil pH of 5.0 and below, aluminum toxicity in wheat and good response to liming have been documented in recent years.

II. LITERATURE REVIEW

As per Climate Change Crop Yield Assumptions report in [9], Crop Yields are projected to decline, with the larger declines to be expected in several developing economies which includes Southeast Asia (-5 percent) and India (-5 percent). [10] The variation in on-farm losses across regions may be partly explained by the range of reasons which include infrastructure and marketing challenges, unsuitable harvest timing, unexpected harsh climatic conditions and unable to predict suitable crops for farming in such climates. The following comparison is show below:

Rushika Ghadge, Juilee Kulkarni, Pooja More, Sachee Nene, Priya R L in [1] uses unsupervised and supervised learning algorithms like Kohonen Self Organizing Map and Back Propagation Network. Dataset is trained by learning networks to classify it into organic, inorganic and real estate for predicting the type of soil. It compares the accuracy obtained by different network learning techniques and the most accurate result is delivered to the end user. System will check soil quality and predict the crop yield accordingly along with it provide fertilizer recommendation if needed depending upon the quality of soil.

Reference Paper [2] determines real time sampling of soil properties using MODIFIED SUPPORT VECTOR REGRESSION, a popular machine learning algorithm and four modules. The Modules include Sensor interfaced to IoT device, Agri cloud, Analyzing the real time sensor data and Agri user interface (AUI). The first module is portable IoT device (NodeMCU) with soil moisture sensor and pH sensor, environmental sensors. Agri cloud module consists of storage. Analyzing the real time data module is processing of types of crops and small plants suggested using modified support vector machine algorithm. Agri-user interface is a basic web interface. Thus, with the help of soil properties farmer will be able to get types of crops and small plants is grown in farmland with help of Modified support vector machine algorithm.

[3] predicts temperature, moisture and pH value for crop prediction using the ARIMA model. The model takes the values from database as input and then predicts what will be the value of that particular parameter after 1 month. The predicted values are then sent to K means algorithm for classification based on pH value thus creating k cluster s of crops having similar pH value. KNN algorithm is used to predict top N suitable crops which are displayed to user.

In [4], Machine Learning Algorithm (KNN) calculates the parameter to suggest the crop which is best to grow in the particular field based on the values received at real time. A standardized dataset containing the minimum requirements for a particular crop is maintained and is used for the prediction of the crop. The sensors are added to the field for which the readings are needed to be cal culated. The DHT11, MQ2, Soil Moisture Sensor, Light Intensity Sensor sends the readings in real time to the cloud server.

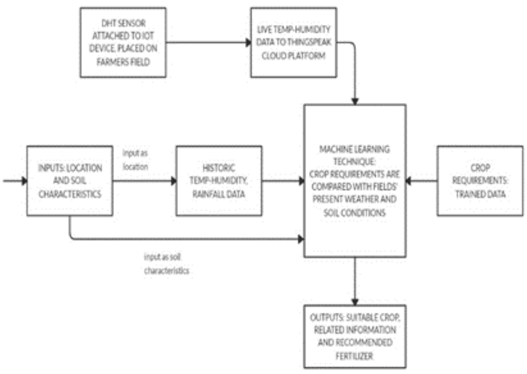
[5] evaluates the crop quality factor based on pre-established weather conditions and nature of soil using the trained set of data and implementing Supervised and Reinforcement models of machine learning. If any unfavorable conditions are perceived ahead of time, the alternative and precautious measures are adopted so as to ensure the wellbeing of the planted crops and agricultural land. Specific measures are also taken to predict the right period of sowing, reaping and harvesting for the overall enhancement of the production which can also be foreseen as a part of the modern agricultural revolution.

III. PROPOSED SYSTEM

The system aims to help farmers for smart decision while predicting the crops. To increase the accuracy along with live data, historic data for temperature and humidity from government website is also collected and stored. Also historic rainfall data is collected and stored. To be definite and accurate in crop prediction, the project analyzes the temperature and humidity of the field – live data collected using DHT -22 sensor and historic data collected from government website and/or google weather API, type of the soil – used by the farmer and the historic rainfall data. It can be achieved using unsupervised or supervised machine learning algorithm. By learning networks, dataset is trained. The accuracy obtained by different machine learning techniques are compared to get the most accurate result which in turn will be delivered to the end user. Along with the most suitable crop, the system also recommends the fertilizer for that crop. Responsive, Multilingual website is used by farmer to communicate with the system.

Hardware Components:

Digital Temperature & Humidity Sensor: DHT22 sensor is preferred to monitor live temperature and humidity. This sensor is proved to be more precise and accurate. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin to Arduino Uno port pin. The range of DHT22 is 0 to-100 % RH for humidity and - 40 to 80 degree Celsius for temperature.



The functionality of the architecture (Figure 1) is as follows:

temperature	humidity	ph	rainfall	crop
45.6374671	11.19524988	7.341612619	36.522037	5
31.76167796	57.72743864	6.198411713	82.10434989	2
29.17510907	79.21985592	6.658683067	131.0297066	14
24.39736241	79.26861738	7.014063944	164.2697011	8
23.17124551	52.97841162	6.766184468	153.1201644	9
23.89271875	61.78779413	6.658605362	52.55730112	7
29.70143197	95.65754365	6.078807239	215.1968037	16
24.388717	62.50453062	6.711341147	47.26052494	7
24.32719167	55.84027641	4.956920312	202.281286	4
20.27514686	23.2353604	5.877347515	139.7521543	15

Fig 2 Training 3 different type Machine Learning Algorithms applied Decision Tree, KNN, SVM

In the website, Farmer logins and enters the Location of the field and the type of soil available at the field for farming as input, both the input are processed further.

Location is used as an input to collect the historic data of specified location i.e. the field. The historic data is collected us ing government websites or third-party applications like APIs for weather and temperature, amount of rainfall in the region.

The live data is collected by placing the IoT device on the field. IoT device consist of DHT 22 sensor – Temperature and Humidity connected to Arduino UNO along with ESP8266 Wi -Fi module. The live data is collected every hour and the stored-on Thing Speak Cloud platform.

The live and historic data is collected. The VAR (Vector autoregression) model is applied on this collected data to forecast the rainfall, temperature - humidity for a period of time when farmer is supposed to cultivate the crop. Now, this forecasted temperature, humidity and rainfall along with Soil characteristic entered by farmer are supplied to three different ML algorithms:- Decision Tree, K-NN, Support Vector Machine wherein the combination of the above results and the predefined data set i.e. actual requirements of the crops present in the crop data store is compared. Finally, by comparing the accuracy obtained by different machine learning techniques, the most accurate result i.e. the most suitable crop is presented to user.

On the website, farmer gets the most suitable crop as an output. Along with this, the end user is provided with all the information about the crop and the best suitable fertilizer.

IV. RESULTS

Training dataset used, contains information about temperature, humidity, rainfall parameters, and the crop pH corresponding to these parameters.

(SVM), and they are compared with respect to their accuracy. Decision Tree has the highest accuracy of all, and is thus used finally to predict the crop.

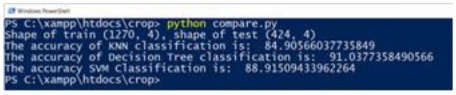


Figure 3. Comparison of the accuracy of the three algorithms

As Decision Tree has highest accuracy, Decision Tree for predicting the crop is used.

Farmer uses the "Smart Crop Prediction" website, to enter the soil pH, locality and the expected month to begin farming.

Figure 4. GUI of Smart Crop Prediction Website

For this, he registers himself, and then logs in to enter the parameters.

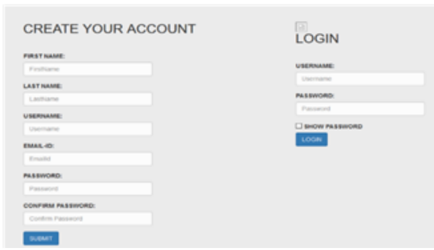


Figure 5. Register and Login page

As per parameters, corresponding historic and live data is retrieved, and Decision Tree algorithm is applied on it.

Figure 6. Page where the farmer is redirected, once he logs in

On clicking Submit, the suitable crop is displayed on the screen.

Figure 7. Suitable crop as displayed

Using Google language translator, the farmer can switch to any language, and the website translated into the selected language.

V. CONCLUSION

In this paper we have proposed an innovative approach for smart agriculture using two emerging technologies: Internet of Things and Machine Learning. With the use of both live and historical data helps to increase the accuracy of the result. Also comparing multiple ML algorithms enhances the accuracy of the system. Thus system will be used to reduce the difficulties faced by the farmers and will increase the quantity and quality of work done by them.

VI. FUTURE SCOPE

The system can be enhanced further to add following functionality: Use of soil moisture sensors, environment sensors, pH sensors to increase the accuracy while predicting the crop. Location's market requirements can be consider, and neighbor farmer's crop while suggesting the suitable crop.

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