Applications of Machine Learning and IoT Devices in Smart Farming

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Abstract: The increasing difficulty for farmers to keep up with the production of food crops to meet the demands of the huge population of our country is a cause for concern. The methods used by farmers are not only old and , but also unyielding Inefficient farming techniques lead to added cost, wastage of land, financial losses due to crop failure. Here comes the need for smart farming which is the use of technologies like IoT devices and cloud networks to increase efficiency and productivity of the farming techniques along with monitoring the growth and state of the crop by the weather, temperature, humidity etc with the help of sensors and maintaining the parameters at optimum levels. Apart from the farming techniques, market price management for farmers in rural areas leads to adverse conditions financially. The need for awareness about the market prices keeping in mind the current conditions using is imminent. Using Machine Learning techniques to predict prices for every crop so that the farmer can plan it accordingly. The paper mentions different methods used under smart farming, issues faced by farmers, and use of IoT and cloud services to enhance the efficiency of yields.

Index Terms: Internet of Things (IoT), Machine Learning, Smart Farming, Agriculture, Crop Price Prediction, Cloud, Management of Crops

I. Introduction

Monoculture, erosion, pollution and silt, pesticide resistance, water depletion, fertilizers and eutrophication, urban sprawl together with soil salinization come hand in hand with the conventional farming techniques. Smart farming has assumed control over the world of agriculture centred on application of Internet of things and various other technologies that have managed to help farmers with the best possible net results by suppressing the severity of these problems. The ever scaling advancement of Internet of Things based technical solutions remodelled this industry and it has blossomed into distinction by dint of technical automation and advanced mechanization. Ingenious sensors, software, heavy machinery accompanied with data filtering techniques and networking of various other components cumulate together to define, 'Internet of Things'. Today, it is the IoT driven precision agriculture that helps feed the mass exodus of people. Precision agriculture dwells in the complete site specific crop governance and through the medium of IoT devices, it is nearly possible to achieve accuracy. To enhance the efficiency of farming maintenance the paper proposes an application which involves three parts: perception (data acquisition), network communication (data connectivity), and application (supervisory control). In a rather straightforward and simpler architecture, the IoT sensors are made to collect Agri-related information like temperature, humidity, soil Ph, soil nutritional levels, water level etc, send this over the Wi-Fi network to the server, where the server can take actions depending on the information and the farmers can remotely keep an eye on their crop and equipment through computers and mobile phones. This approach can forge a simple yet an efficient and accurate application of IoT devices without the need of human intervention. On account of the increasing population, it was the need of the hour to reinforce crop yields and preserve resources. Diverse fields of IoT and cloud computing came in handy and made farming effortless and efficient.

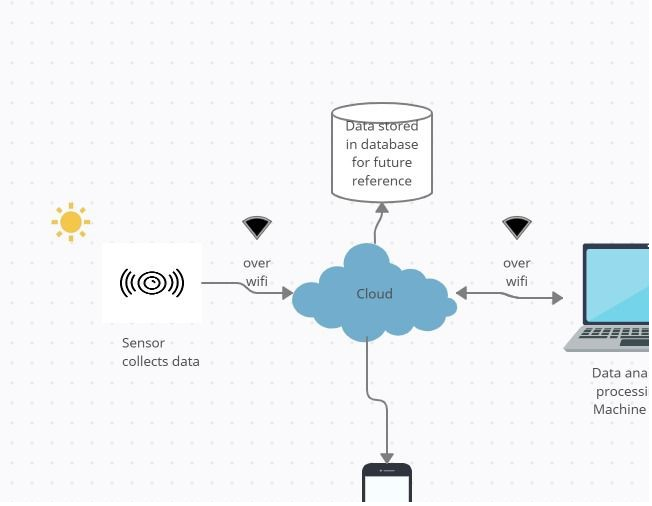

Fig. 1. Proposed usage of IoT and Machine Learning in Smart Farming

II. Literature Survey

Developing an Agriculture Internet of Things (IoT) Application.[4] The following paper describes the IoT researches from the years 2015- 2019 by gathering data and analysing key issues and proposes a maintenance and controlling system. It describes that in agriculture IoT is required to maintain the product, equipment and environment without any -constraints of time and location without human intervention. The paper also sheds light upon a new cloud computing service namely (AaAS) Agriculture as service. IoT along with AaAS seeks to provide efficient technologies for effective farming. The paper further demonstrates how to apply cloud computing in agriculture IoT for the plant's humidity preventive maintenance. It aims to achieve real-time PM for enabling timely decision making through web service applications

A Life Cycle Framework of Green IoT-Based Agriculture and Its Finance, Operation, and Management Issues.[5] The mentioned paper Summarizes the applications of IoT techniques in agriculture in 4 categories: controlled environment planting, open-field planting, livestock breeding, and aquaculture and aquaponics. The paper introduces green IoT and issues regarding management, finance, supply chain, big data financing are addressed along with other common issues such as, as per the increasing population, the need to maximize crop yield as well as preserving resources. Paper suggests monitoring growth of crops and make an optimal environment Some issues addressed are 1) The IoT based devices have to be viewed from the view of the product lifecycle too since it also affects the yield in case of wear-out. 2) Financing and management issues of huge fields. Hence the paper proposes: to formulate a life cycle framework of green IoT-based agriculture, including ingredient supply, growth, processing and packaging, distribution and storage, and consumption.

Crop price prediction using supervised machine learning algorithms.[8] Taking into account the fact that the GDP of our country primarily depends on the agricultural sector, the paper focuses on prediction of the accurate market prices of the crops using machine learning algorithms to ensure the deserved income for farmers. The model used for the paper is a decision tree regressor. The paper provides a thorough guide to performing the entire process with detailed insights into data cleaning, pre-processing and the model.

III. Hardware Requirements

1) **ESP32s Node MCU-** This is an open LUA-based source dynamic RAR and can perform as a complete standalone system or as a slave device reducing communication load on the main application system.
2) **Breadboard-**This piece is used to build and test circuits before establishing any circuit blueprint.
3) **DHT11 Temperature and Humidity Sensor-** This is yet another economical digitized sensor manoeuvring capacitive humidity sensor and a thermistor to measure the encircling air and splutters a digital signal on the data pin.
4) **Soil Moisture Sensor-** These are used to approximate the moisture and the amount of water stored in the soil horizon.
5) **SI1145 sensor for UV/ IR and visible light index -** Sensor with gauged light sensing algorithm that can calculate UV index.
6) **KY-006 passive buzzer-** The KY-006 passive piezo buzzer is a 3-pin module that creates an audible sound of varying frequencies using pulse width modulation (PWM). It can produce a range of tones and sounds depending on the input. Due to this, it is commonly used to create sound effects or simple musical notes for short songs.

7) Power Supply-Power Bank and LEDs

IV. Role of Weather Prediction in Smart Farming

Weather forecasting is mainly apprehensive of the forecast of weather conditions in the given future time. There are a plethora of approaches concerned with weather forecasting, from relatively simple observation of the sky to highly complex computerized mathematical models. Some of the various applications of weather forecasting include climate monitoring, drought detection, severe weather prediction, agriculture and production, planning in energy industry, aviation industry, communication and pollution dispersal. The weather condition at any given point of time may be represented by some variables. Out of them the most significant variable is selected for further studies. The selection of variables is location-specific since the variables and their range always vary from place to place. The weather condition of any day has some connection to the weather conditions that prevailed in the same tenure of previous year and previous week. Here variation touches on the difference between previous day's parameter and present day's parameter. Also there exists a dependency between the weather conditions persisting in current week in consideration and those of previous years. Apropos to this, a methodological analysis is being put forward that could numerically model these two types of dependency and avail itself to predict the future's weather conditions. Now in order to model the aforesaid dependencies the current year's variation throughout the week is being toned with those of previous years by making use of a sliding window algorithm. The best- matched window is picked up to coerce the prediction. The selected window and the current year's weekly variations are jointly used to foresee the weather condition. The reason for applying sliding window matching is that the weather conditions prevailing in a year may not lie or fall on exactly the same date as they might have existed in previous years, that is why seven previous days and seven ongoing days are being considered. Hence a total period of fortnight is checked in previous condition to find the similar one. Sliding window is quite apt as an approach to record the disparity that could compeer the current year's disparity.

i) Window Sliding Algorithm

The Sliding Window Algorithm is essentially applied to the problems trading in linear data structures like Arrays, Lists, Strings etc. These problems can simply be deciphered using Brute Force techniques which develop in quadratic or exponential time complexity. This approach presents how a nested for loop can be permuted to a single for loop to reduce the time complexity.[1]

Here is a basic problem for illustrating how we can apply this technique- Suppose you are given an array of length 'n'. And our goal is to find out the maximum sum of 'x' consecutive elements in the given array.
Example 1 : Input : array[]={1,2,3,4} and assuming, x = 2 , then the output should be 7.

Example 2 : Input: array[]={1,5,3,11,24,4,2,1,21} and now assuming x = 4, then our output should be 43.

We get the maximum output by adding the elements of the subarray {5,3,11,24} from the given array. Now to begin with, let's look over the problem with Brute Force Approach. We go ahead with the first index and find the sum till the x-th element. Further we follow the same step for all attainable consecutive blocks or groups of x elements. Hence we see that a nested for loop is called for, for this approach where in the outer loop commences at the starting element of the group of x elements and the inner loop will add up until the x-th element. It is predicted that the time complexity of the above approach will be O(x*n) as it will need nested loops. It is now when the Window sliding technique comes into picture.

Example: array[6,3,0,1,4] , value of x=3 and n=5. Now applying window sliding technique:
Step 1: We calculate the sum of first x elements out of n terms using a linear loop and cache the sum in the variable wsum.

Step 2: We then browse linearly through the array until it reaches the other end and concurrently also keep track of maximum sum.

Step 3: Next step is to get the present sum of group of x elements, and for this we subtract the first element from the preceding group and add the last element of the present block.[3]

i.i) Window Sliding for Weather Prediction

This work puts forward to predict a day's weather conditions. To work this through a detailed analysis is done to carry out the weather predictions of previous seven days. There is seldom a minute difference between the weather conditions of the previous day and the weather forecast of the present day. The chances that the weather conditions of the day bearing in mind will exact the same day in the previous year is not as much as the probability that it will match within the period of the adjacent fortnight of the previous year. Hence, for the fortnight examined for previous year a sliding window of size equivalent to a week is selected. The current year's week in consideration is then matched with every week of the sliding window. The window that is best matched is made to engage in the prediction.[2]

V. Comparison of Machine Learning Algorithms in crop Price Prediction

Predicting the value of a crop is an extremely crucial step for a farmer before deciding the plantation. By predicting prices for various crops, the farmer knows which crops have to be encouraged further for maximising profit. Fluctuations in multiple areas determining the crop price owing to the lack of previous designing and data leads to the crops being extremely priced with huge drawbacks for the farmer. In this type of country of affairs, it is difficult for a farmer to create an knowledgeable opportunity of crop to develop in his land or to estimate the yield and really well worth to anticipate from it. The purpose of this undertaking is to help the farmer construct better selections, through analysing historic yield and really well worth understanding victimisation system learning. Machine Learning is an software of Artificial Intelligence that has confirmed to provide correct prediction fashions in diverse components together with inventory market, weather, final results of decisions, crop, and in our case crop yield and price Prediction of crop yield requires important parameters like weather, soil, and patterns in previous datasets and previous yield of the crop. (Most accurate prediction is given by Random Forest which in one of the most powerful algorithms.)Price and Profit each can be predicted using Naive Bayes, Random Forest and KNN respectively.[7] Data pre-processing steps are performed like data cleaning and data transformation before analysing. By performing Exploratory Data Analysis, trends in data are recovered along with finding the most important feature. Different commands can be used to find out correlation between different features. Next we train the model and tune the hyperparameters according to our needs. Minimum and maximum number of nodes required are determined using data visualization (minimum being 3, maximum e=being 20 for the given paper). We need to be cautious to avoid overfitting by tuning all the hyperparameters repeatedly.

A. Using Naïve Bayes for crop price prediction

What is Naive Bayes: It is a probabilistic algorithm which uses independent parameters .It comes under supervised learning and under that it comes under classification algorithm. Parameters considered: 1. Minimum support price which is pre decided by the government to ensure at least minimum profit for the farmers. 2. Rainfall 3. Yield The dataset will be divided into two sections namely testing and training and it will contain the previous prices to train our model. The formula used:

$$P(A|B) = \frac{P(B|A).P(A)}{P(B)}$$

P(A) is the probability of A occurring independently. P(B) is the probability of B occurring independently. P(A|B) is the probability that A occurs given B. P(B|A) is the probability of B occurring, given A.

B. Using Decision Trees

What is a Decision Tree? It is a non-parametric model which comes under supervised learning algorithm. It predicts the value of the dependent variable by learning from the decisions made from the dataset features. It works by dividing the dataset into smaller subsets that is smaller trees with leaves and nodes. After data pre-processing and cleaning, the dataset is

split into testing and training. The x_train and y_train variables are fit into the decision tree classifier model. Inputs given :

i. Rainfall
ii. Training Dataset
iii. Formula

Where y1 and y2 are the dependant variables -price to be predicted s1and s2 are the groups receiving different amounts of rainfall. It will recursively divide the dataset into smaller subsets. The cycle stops when the example size of the split gathering falls beneath certain limit. Steps to be performed: Input the dataset containing information about wholesale index price and rainfall. Fit the dependent and independent variable's datasets (x and y) into the tree regress model. Perform data visualization on the predicted values to check the accuracy of the model. After trying and testing the accuracy of multiple algorithms, we conclude that Decision Tree Classifier turns out to be the most effective algorithm in predicting market prices for the crops with a root mean square error of just 3.8 * which is low with respect to other algorithms.

VI. Conclusion

Increasing difficulty to keep up with the efficient production of crops and attain the needs of the farmers calls for a strong step in the direction of introduction of newer technologies in agriculture. The rapidly evolving fields of IoT, Machine Learning to predict the weather, and market prices of crops have immense potential in increasing the productivity of the agricultural sector and hence contribute to the country's GDP. Therefore the paper proposes efficient ways to counter problems related to prediction of weather for the farmer for accurate planning of production of crops which covers thorough details of Window Sliding Algorithm which is one of the most accurate algorithms for prediction of weather data, compares algorithms for prediction of market price of crops and suggests the most effective one with least mean squared error. For future enhancements, the data and proposed algorithms could be further clubbed into a working system capable of smart farming along with other systems, which uses the most effective algorithms and components. The models can be further trained on larger datasets to increase the accuracy and recall and the systems could be made crop specific indigenous to a particular region for an even higher accuracy.

VII. References

1) "Weather Prediction through Sliding Window Algorithm and Deep Learning", Shubham Billus, Shivam Billus, Rishab Behl
2) "Weather Forecasting Using Sliding Window Algorithm", Piyush Kapoor and Sarabjeet Singh Bedi
3) "Prognostication of Climate Using Sliding Window Algorithm", D.V.N.Koteswara Rao, M.Anusha, P. Nagendra Babu, M. Divya Sri, N.Rajesh, K. Sandeep Kumar
4) "Developing an Agriculture Internet of Things (IoT) Application", Yu-Hsin Hung
5) "A Life Cycle Framework of Green IoT-Based Agriculture and Its Finance, Operation, and Management Issues", Junhu Ruan, Yuxuan Wang, Felix Tung Sun Chan, Xiangpei Hu, Minjuan Zhao, Fangwei Zhu, Baofeng Shi, Yan Shi, and Fan Lin
6) "A Survey : Smart Agriculture IoT with Cloud Computing", Mahammad Shareef Mekala, Dr P. Viswanathan
7) "Crop Price Prediction and Forecasting System using Supervised Machine Learning Algorithms", Rohith , Vishnu , Kishore , Deeban Chakkarawarth
8) "Crop Price Prediction System using Machine learning Algorithms", Pandit Samuel, B.Sahithi , T.Saheli , D.Ramanika , N.Anil Kumar
9) "Crop price prediction using supervised machine learning algorithms", Ranjani Dhanapal 1 , A AjanRaj 1 , S Balavinayagapragathish 1 , J Balaji
10) "Crop Price Forecasting system using supervised Machine Learning Algorithms",Rachana P, Rashmi, Shravani , Shruthi , Seema Kousar