SMART CROP PREDICTION AND IRRIGATION MANAGEMENT SYSTEM

Ms R Divya [1], Dr C V Pavithra [2], Ms A Jeyashree [3], Ms K Bavithra [4]
[1,2,3,4] Assistant Professor, Department of EEE, PSG Institute of Technology and Applied Research, India
divya@psgitech.ac.in, pavithra@psgitech.ac.in, jeyashreea@psgitech.ac.in, bavithra@psgitech.ac.in

Abstract –

The agricultural land is decreasing day by day choosing a particular crop for an area and optimal use of water is highly demanded in the agricultural sector to get more yield and to minimize fertilizer cost. The goal of this project is to accurately predict the crop for the particular area and to water the crops based on the climatic conditions. Elaborating a functional and efficient prediction system is a very complex task due to the high number of factors that the technician considers when managing prediction in an optimal way. Automatic learning systems propose an alternative to traditional ways by means of the automatic elaboration of predictions based on the learning of an agronomist. The aim of this project is the study of several learning techniques in order to determine the goodness and error relative to expert decision. LightGBM, XGBoost and CatBoost as engines of the prediction. Certain parameters are considered and evaluated like pH of the soil, temperature, the amount of water required, humidity, and rainfall are obtained and these data are processed using machine learning concepts develop prediction systems and parameter like humidity, rainfall and soil moisture are used to develop irrigation management systems.

Keywords- Light GBM, XG Boost, Cat Boost
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I. Introduction

The scarcity of unpolluted and water resources round the globe has generated a requirement for his or her optimum utilization and assumption. Internet of Things (IoT) solutions, supported the appliance specific sensors' data acquisition and intelligent processing, are bridging the gaps between the cyber and physical world. Smart Farming grow exponentially as data became the key element in modern agriculture to assist the producers with critical deciding. Valuable advantages appear with objective information acquired through sensors with the aim of maximizing productivity and sustainability. this type of data-based managed farms believe data which will increase efficiency by avoiding the misuse of resources and pollution of the environment and therefore the society. this technique is employed to predict the irrigation requirements of a field using the sensing and analysis of the bottom parameters of the soil like moisture, temperature in that region, and environmental conditions alongside the weather outlook data from the web. The intelligence of the proposed system is predicated on a sensible algorithm, which considers the sensed data alongside the weather outlook parameters like precipitation, pH of the soil and UV for the near future. For irrigation management system soil moisture data from farmer, weather data is fed into the machine learning model which tells whether to irrigate the field or not. The knowledge that crops offer is became profitable decisions only it's efficiently managed. Machine learning algorithms like XGBoost, LightGBM and CatBoost are used and their accuracy is compared to settle on the acceptable algorithm.

Crop prediction is one among the challenging problems in precision agriculture. This problem requires the use of several datasets since crop yield depends on various factors such as climate, weather, soil, use of fertilizers, and other seed variety. Machine learning predictive algorithms is highly optimized estimation which is likely outcome based on the trained data. Predictive analytics is that the use of knowledge, statistical algorithms and machine learning techniques which is employed to spot the likelihood of future outcomes supported historical data. The goal is to travel beyond the knowing what went on within the past and to supply the simplest assessment of what is going to happen within the future. In our system we have used supervised machine learning algorithm having subcategories as classification and regression. Classification algorithm are going to be best suited for our system. In general, agriculture is that the backbone of India and also plays a crucial role within the Indian economy by providing a particular percentage of domestic product to make sure the food security. But now-a-days, food production and prediction are getting depleted thanks to unnatural climatic changes, which can adversely affect the economy of farmers by getting a poor yield and also help the farmers to stay less familiar in forecasting the long-term crops. This research work helps the beginner farmer in such how to guide them for sowing the reasonable crops by deploying machine learning, one among the advanced technologies in crop prediction. The seed data of the crops are collected here, with the acceptable parameters like temperature, humidity and moisture content, which helps the crops to realize a successful growth.

Aim is to develop smart irrigation system automatic for the plants which help in saving water and money. Appropriate soil water level may be a necessary pre-requisite for optimum plant growth. Also, water being an important element for all times sustenance, there's the need to avoid its undue usage. Irrigation may be a dominant consumer of water. This involves the necessity to manage water system for irrigation purposes. Fields should neither be over-irrigated nor under-irrigated. The target is to style a simple easy to put in a methodology to watch and to indicate the extent of the moisture of the soil that's continuously controlled so as to realize maximum plant growth and simultaneously optimize the available irrigation resources on monitoring the sensor data which will be seen on Internet.

For irrigation management system soil moisture data from farmer, weather data is fed into machine learning model which tells whether to irrigate the sector or not. the knowledge that crops offer is became profitable decisions only efficiently managed Machine learning algorithms like XGBoost, LightGBM and CatBoost are used and accuracy is compared to settle on the acceptable algorithm.

II. Literature Survey

AmarendraGoapa, Deepak Sharmab, A.K. Shuklab, C. Rama Krishna(2018) has proposed an IoT based smart irrigation architecture alongside a hybrid machine learning based approach to predict the soil moisture[1]. The proposed algorithm uses sensors' data of recent past and therefore the weather forecasted data for prediction of soil moisture of upcoming days. the anticipated value of the soil moisture is best in terms of their accuracy and error rate. Further, the prediction approach is integrated into a standalone system prototype. The system prototype is cost effective because it is predicated on the open standard technologies. The auto mode makes it a sensible system and it are often further customized for application specific scenarios. In future we are getting to conduct the water saving analysis to support the proposed algorithm with all the required multiple nodes alongside minimizing the system cost.

AnnekethVij, Singh Vijendra, Abhishek Jain, Shivam Bajaj, AashimaBassi, Aarushi Sharma(2019), Bavithra K et al., (2022) has proposed asolution which is based on the Internet of Things (IoT), which would be a cheaper and more precise solution to the farm needs[2]. A Monitoring system whose main purpose is to unravel the over irrigation, erosion and crop-specific irrigation problem are going to be developed to ease and efficiently manage Irrigation problems. The proposed solution is going to be developed by establishing a distributed wireless sensor network (WSN), wherein each region of the farm would be covered by various sensor modules which can be transmitting data on a common server. Machine learning (ML) algorithms will support predictions for irrigation patterns based transmitting data on a common server.

Janani M and Jebakumar R (2019) did a survey which measures the impact of applied techniques and how to improve the productivity using those techniques and it helps the farmers to adapt suitable system according to their requirements. This study by applying machine learning in agriculture it enhances the irrigation system [3]. It helps to use the water in efficient manner and reduces water wastage. This integration process of automated data analysis, data recording, and decision making with the machine learning implementation is completely knowledge-based system. It increases the production level and quality of crops. This survey may helpful to provide prior knowledge for the farmers to adopt the machine learning techniques with irrigation system based on their requirements and improves the productivity.

Jeeva N, Siva Sanjeev M, Swathi T, UdhayanGirishan S, Sruthi B (2018) has proposed an irrigation system is supposed for watering the crops render to the optimized data from webcam and wireless sensor networks [4]. The Convolutional Neural Networks is that the main program of this machine learning system, using the algorithms supported the CNN. The system is going to be updated automatically for all weather and there is no dispersal of water for crops. This setup is often quickly sensing the weather by analyzing the cloud and sensing the temperature at that point, by using this it is often served as a water saving system. This proposed irrigation system the machine will automatically learn itself rendering to the climatological condition which will cause weather prediction. The system is conversant and economical. It does not need any individual on duty as it is facile and reliable for cultivation process.

Thomas van Klompenburga, AyalewKassahuna and CagatayCatal (2020) has performed a Scientific Literature Review (SLR) to extract and synthesize the algorithms and features that are utilized in crop yield prediction studies. supported our search criteria, we retrieved 567 relevant studies from six electronic databases, of which we have selected 50 studies for further analysis using inclusion and exclusion criteria [5]. We investigated these selected studies carefully, analysed the methods and features used, and provided suggestions for further research. consistent with our analysis, the foremost used features are temperature, rainfall, and soil type, and therefore the most applied algorithm is Artificial Neural Networks in these models. After this observation supported the analysis of machine learning-based 50 papers, we performed a further search in electronic databases to spot deep learning-based studies, reached 30 deep learning-based papers, and extracted the applied deep learning algorithms. consistent with this extra analysis, Convolutional Neural Networks (CNN) is that the most generally used deep learning algorithm in these studies, and therefore the other widely used deep learning algorithms are Long-Short Term Memory (LSTM) and Deep Neural Networks (DNN).

Rohit Sharma, Sachin S Kamble, Angappa Gunasekaran, Vikas Kumar, Anil Kumar (2020) has presented a scientific review of machine learning (ML) applications in agricultural supply chains (ASCs) [6]. Ninety-three research papers were reviewed supported the applications of various ML algorithms in several phases of the ASCs. The study highlights show how the ACSs can enjoy ML techniques and causes ASC sustainability. supported the study findings an ML applications framework for sustainable ASC is proposed. The framework identifies the role of ML algorithms in providing real-time analytic insights for pro-active data-driven decision-making within the ASCs and provides the researchers, practitioners, and policymakers with guidelines on the successful management of ASCs for improved agricultural productivity and sustainability.

M Kalimuthu, P Vaishnavi and M Kishore has proposed system analyses the application of supervised machine learning approaches the class with the absolute best chance is considered as the possibly class [7]. Here the category is nothing however the crop that get foretold for the given input parameters. Once the crop is foretold, it will facilitate the farmers to predict the affordable crop for their individual land. Then, the farmers are guided with an application in mobile tend to make them to understand that what quite seeds we will tend to sow in land to induce higher yielding. Within the past preceding data, crop prediction was calculated by analysing farmer's previous expertise on climatic condition. So, the correct data regarding history of climatic condition is a vital factor for creating selections in choosing crops. Therefore, this paper proposes a thought to predict the affordable crop for the given input parameter for the poor farmers using machine learning. Thereby this proposed work will suggest the farmers with effective solutions for more profitable cultivation.

Bhawana Sharma, Jay Kant Pratap Singh Yadav and Sunita Yadav has proposed a technique to classify data instances by constructing a linear separating hyperplane, they use intrinsically binary classifier SVM [8]. This introduced the work of statically learning theory. Kernel tricks used to enhance classification capabilities of traditional SVM by transforming original features space into hyperdimensional feature space. According to the author high dimensional spaces fitting problem handled using SVM, used for clustering, classification, and regression. In his first study, author used an artificial neural network model and spectral reflectance features and presented a way to identify either wheat yellow rust healthy or infected. Accuracy of this method helps in identifying the need for pesticides in the field. In their second study work done to identify yellow rust healthy or infected. Wheat a real-time remote sensing system used which based on SOM neural network and multi-spectral fluorescence imaging and the data fusion of the hyperspectral reflection. SOM stands for Self-Organizing Map. This study helps in identifying infected yellow rust winter wheat cultivar "Madrigal" even before it is visible. Author in their third study developed a method to identify infected yellow rust and nitrogen stressed in wheat plants. This method is based on the hyperspectral reflectance imaging with of self-organizing map neural network. This method helps in identifying the nutrient defences under the field conditions. In this paper author identified weather-based prediction model of plant diseases by using SVM.

Prateek Jain, Prakash Kumar and D.K Palwalia showed the simulation and modelling of a crop yield; as a function of local weather [9], soil condition and crop management practices; is termed as crop modelling. It is generally defined as empirical models, statistical model, functional model, and mechanistic model. Precision agriculture is a type of empirical model and depends on soil moisture, local meteorological conditions, fertilizer treatment & facility agriculture. Facility agriculture refers to intensive labour involvement to involvement of the sophisticated modern agriculture technology. Precision agriculture mainly depends on climatic data like temperature & precipitation; Crops need favourable local condition and suitable soil moisture level to have proper growth. Development of power electronics based equipments, remote communication units, renewable energy-based generation and sophisticated sensing sensors have renovated the monitoring and control of domestic applications, agricultural activities & environment alteration (to create suitable atmosphere for crop inculcation). This paper presents precision agriculture-based crop model considering soil moisture and air temperature as key factors. Soil moisture has been sensed using homemade moisture sensor and micro-controller units acts as controller to ensure smart irrigation. Net water table requirement can be reduced using the presented system to keep the notion of 'more crop per drop'.

III. Materials and Methods

Machine Learning

Fig. 1 *Types of Machine Learning*

Machine Learning provides computers the potential to find out without being explicitly programmed. It is a branch of artificial intelligence based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention. The various types of ML algorithm is shown in Fig. 1.

Supervised Learning

Supervised learning is that the machine learning task of learning a function that maps an input to an output supported example input-output pairs. It infers a function from labelled training data consisting of a set of training examples. In supervised learning, each example may be a pair consisting of an input object and a desired output value. A supervised learning algorithm analyses the training data and produces an inferred function, which may be used for the mapping new examples. An optimal scenario will leave the algorithm to properly determine the category labels for unseen instances. This requires the training algorithm to generalize from the data given to the Algorithm to deal with the unseen situations during a "reasonable" way. This statistical quality of an algorithm is measured through the so-called generalization error.

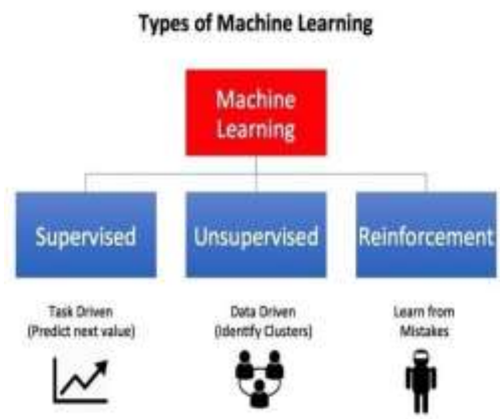
Types of Supervised Learning

1. Classification: It is a Supervised Learning task where output has defined labels (discrete value). For example, Output – Purchased has defined labels i.e., 0 or 1; 1 means the customer will purchase and 0 means the 0 means customer will not purchase. The goal here is to predict discrete values belonging to a specific class and evaluate on the idea of accuracy.

2. Regression: It is a type of Supervised Learning task where the output has continuous value.

Unsupervised learning

Unsupervised learning (UL) is a sort of algorithm that learns patterns from untagged



data. The hope is that through mimicry, the machine is forced to create a compact representation of its world. In contrast to supervised learning (SL) where data is tagged by a person, e.g., as "car" or "fish" etc, UL exhibits self-organization that captures patterns as neuronal predilections or probability densities. The opposite level within the supervision spectrum are

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reinforcement learning where the machine is given only a numerical performance score as its guidance, and semi-supervised learning where a smaller portion of the info is tagged. Two broad methods in UL are Neural Networks and Probabilistic Methods.

Training data we are feeding is –

• Unstructured data:May contain noisy (meaningless) data, missing values or unknown data.

• Unlabelled data:Data only contains value for input parameters, there is no targeted value (output). It is easy to gather as compared to labelled one in Supervised approach.

Reinforcement learning

Reinforcement learning is an area of Machine Learning. It is about taking suitable action to maximize reward during a particular situation. It is employed by various software and machines to seek out the simplest possible behaviour or path it should absorb a selected situation. Reinforcement learning differs from the supervised learning in a way that in supervised learning the training data has the answer key with it, so the model is trained with the correct answer itself whereas in the reinforcement learning, there is no such answer, but the reinforcement agent decides what to try to perform the given task. In the absence of a training dataset, it is sure to learn from its experience.

Steps of Machine Learning

Data Collection:

. The quantity & quality of your data dictate how accurate our model is.

- The outcome of this step is generally a representation of data (Guo simplifies to specifying a table) which we will use for training.
- Using pre-collected data, by way of datasets from Kaggle, UCI, etc., still fits into this step.
- Tune model parameters for improved performance.
- Simple model hyperparameters may include number of training

steps, learning rate, initialization values and distribution, etc.

Make predictions:

With the help of our trained our trained the data for which we must find the crop is given to the machine learning model to obtain the result. Steps in Machine Learning is shown in Fig. 2.

Fig. 2 *Steps in Machine Learning*

Boosting algorithms

The term 'Boosting' refers to a family of algorithms which converts weak learner to strong learners. Boosting is an ensemble method for improving the model predictions of any given learning algorithm. The thought of boosting is to teach weak learners sequentially, each trying to correct its predecessor.

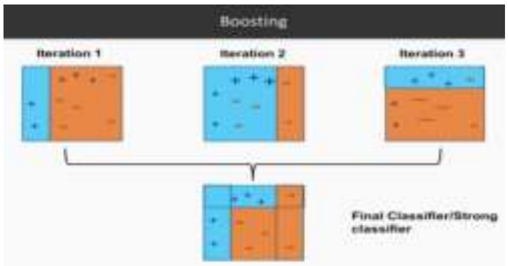

Fig. 3 *Boosting*

Gradient Boosting

Gradient boosting may be a machine learning technique for regression and classification problems, which produces a prediction model within the type of an ensemble of weak prediction models, typically decision trees. When a choice tree is that the weak learner, the resulting algorithm is known as gradient boosted trees, which usually outperforms random forest. It builds the model during a stage-wise fashion like other boosting methods do, and it generalizes them by

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allowing optimization of an arbitrary differentiable loss function.

Fig. 4 *Gradient Boosting*

LightGBM

LightGBM is an extremely fast, distributed, high-performance gradient boosting framework supported decision tree algorithm that is used for ranking, classification and much of other machine learning tasks. Since it's supported decision tree algorithms, it splits the tree leaf wise with the only fit whereas other boosting algorithms split the tree depth wise or level wise rather than leaf-wise. So when growing on the same leaf in LightGBM, the leafwise algorithm can reduce more loss than the level-wise algorithm and hence results in much better accuracy which may rarely be achieved by any of the prevailing boosting algorithms. Also, it's surprisingly in no time, hence the word 'Light'. Before is a diagrammatic representation by the manufacturers of the sunshine GBM to elucidate the difference clearly. Leafwise splits cause increase in complexity and should cause overfitting and they are often overcome by specifying another parameter max-depth which specifies the depth to which splitting will occur.

Advantages of LightGBM

- Higher training efficiency and speed: LightGBM uses a histogram-based technique, which buckets continuous feature values into discrete bins to speed up the training process.
- Lower memory usage: Replaces continuous values to discrete bins which result in lower memory usage.
- Better accuracy than any other boosting algorithm: By using a leaf wise split technique rather than a levelwise approach, it builds far more complex trees, which is the major factor in achieving higher accuracy.It can, however, cause over fitting, which can be avoided by specifying the max_ depth parameter.
- Large Dataset Compatibility: It is capable of performing similarly well with large datasets while requiring significantly less training time than XGBOOST.

Tuning parameters of LightGBM

LightGBM uses leaf wise splitting over depth-wise splitting which enables it to converge much faster but also leads to overfitting. So here is a quick guide to tune the parameters in LightGBM.

- Num_leaves This parameter determines how many leaves will be developed in a tree.
- Num leaves = 2(max depth) is the theoretical relationship between num leaves and max depth. However, in the case of LightGBM, this is not a realistic estimate because splitting occurs leaf by leaf rather than depth by depth. As a result, num leaves must be less than 2(max depth), else overfitting may occur. Because there is no direct relationship between num leaves and max depth in LightGBM, the two must not be linked.
- Min_data_in_leaf: It is also one of the important parameters in dealing with overfitting. Setting its value smaller may cause overfitting and hence must be set accordingly. Its value should be hundreds to thousands of large datasets.
- Max_depth: It specifies the maximum depth or level up to which tree can grow.

For faster speed

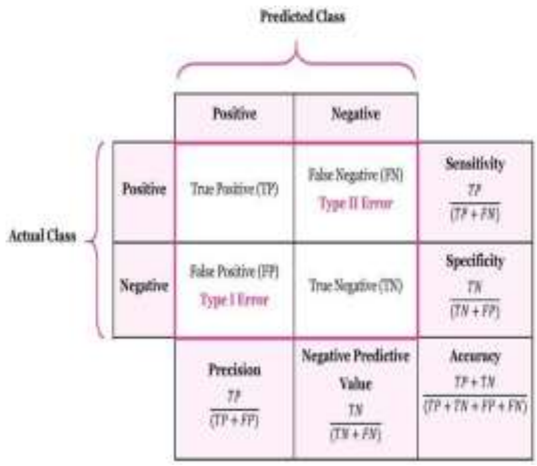
- Bagging_fraction: Is used to perform bagging for faster results
- Feature_fraction: Set fraction of the features to be used at each iteration
- Max_bin: Smaller value of max_bin can save much time as it buckets the feature values in discrete bins which is computationally inexpensive.

For best accuracy

- Use bigger training data.

- Numleaves:Setting it to high value produces deeper trees with increased accuracy but lead to overfitting. Hence its higher value is not preferred.
- Max bin:Setting it to high values has similar effect as caused by increasing value of numleaves and also slower our training procedure.

Table I. Confusion Matrix



CatBoost

CatBoost is an open-source software library developed by Yandex. It provides a gradient boosting framework which attempts to solve for Categorical features using a permutation driven alternative compared to the classical algorithm.

Tkinter is the most commonly used library for developing GUI (Graphical User Interface) in Python. It is a typical Python interface to the Tk GUI toolkit shipped with Python. As Tk and Tkinter are available on most of the Unix platforms also as on the Windows system, developing GUI applications with Tkinter becomes the fastest and easiest.

IV. RESULTS

The project work was carried out successfully and tested by using the software. The results were obtained as expected and the following observations were made. The software setup of smart crop prediction and irrigation management is shown below in Fig. 5& 6. Dataset Collection The project started with collection of data from repositories like github. The data set for crop prediction is shown in Fig. 5.

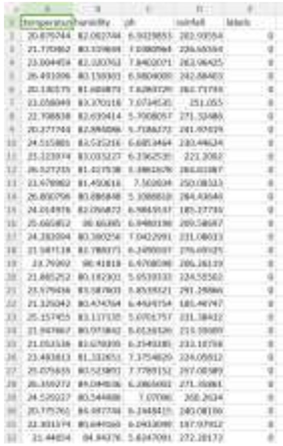


Fig. 5 *Dataset for Crop Prediction System*

humidity	temp	moist	ldr	label
12	32	1018	100	0
12	31	1017	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1021	100	0
12	31	1022	100	0
12	31	1021	100	0
13	30	1021	100	0
13	30	1021	100	0
13	30	1022	100	0
13	30	1021	100	0
13	30	1018	100	0
13	30	1021	100	0
13	30	1021	100	0
13	30	1021	100	0
13	30	1021	100	0
13	30	1021	100	0
13	30	1021	100	0
13	30	1021	100	0

Fig. 6 *Dataset for Irrigation Management System*

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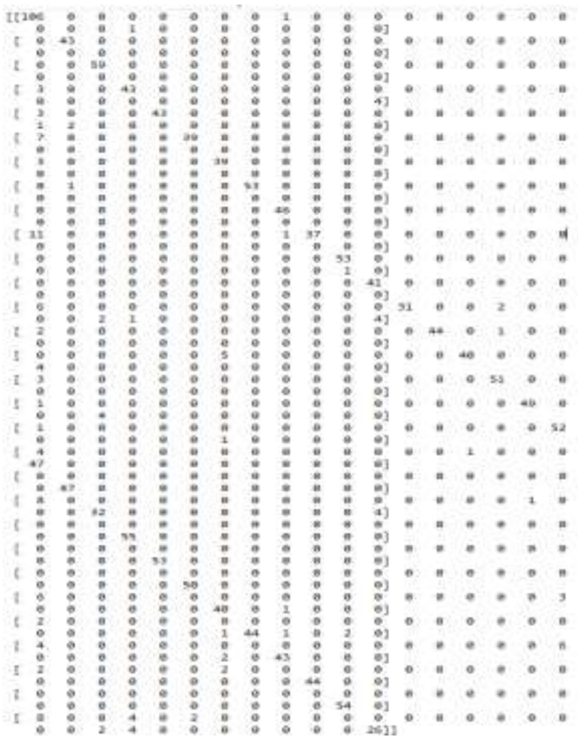

Fig. 7 *Confusion Matrix for Crop Prediction*

clasification report:

	precision	recall	f1-score	support
0	0.85	1.00	0.92	17
1	0.65	0.65	0.65	17
2	1.00	1.00	1.00	17
3	0.87	1.00	0.93	20
4	1.00	1.00	1.00	22
5	0.89	0.89	0.89	19
6	0.96	1.00	0.98	23
7	0.93	0.88	0.90	32
8	1.00	0.89	0.94	27
9	0.88	1.00	0.94	15
10	0.94	1.00	0.97	16
11	1.00	1.00	1.00	24
12	1.00	0.94	0.97	17
13	0.76	0.84	0.80	19
14	0.96	0.96	0.96	25
15	1.00	1.00	1.00	16
16	1.00	0.92	0.96	13
17	1.00	0.91	0.95	22
18	0.94	1.00	0.97	16
19	1.00	0.93	0.97	15
20	0.81	0.72	0.76	18
21	1.00	1.00	1.00	20
22	0.95	0.86	0.90	22
23	1.00	0.96	0.98	26
24	0.86	0.95	0.90	19
25	0.86	0.95	0.90	20
26	1.00	1.00	1.00	17
27	0.92	0.92	0.92	25
28	1.00	0.89	0.94	19
29	0.89	0.89	0.89	19
30	1.00	1.00	1.00	23
accuracy			0.93	620
macro avg	0.93	0.93	0.93	620
weighted avg	0.94	0.93	0.93	620

Fig. 8 *Classification Report of LightGBM*

Displaying of Results in Application

The results are displayed in the application made by using tkinter.

```
Enter Air Humidity50.5

Enter the temperature35

Enter Soil Humidity240

Enter the amount of light65
[1.42339029]
Unfavorable
```

Fig. 9 *Results for Irrigation Management System*

```
LightGBM
The accuracy of this model is:  93.38709677419355
Mean Absolute Error: 0.682258064516129
Mean Squared Error: 9.798387096774194
Root Mean Squared Error: 3.130237546381136
Accuracy: 0.9338709677419355
F1 score: 0.9339419985291444
Recall: 0.9338709677419355
Precision: 0.9365519530520355
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Fig. 10 *Accuracy, Precision Recall for LightGBM*

Fig. 11 *GUI Application for Crop Prediction*

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V. CONCLUSION

The work involves successful implementation for crop prediction system using LightGBM and Irrigation management system using CatBoost.Since these are boosting algorithms accuracy is better compared to other algorithms. Both in-sample and out-sample testing are done and accuracy is obtained for verification.The results obtained are displayed in a GUI application made by using tkinter.Instead of manually entering the data for crop prediction system a weather prediction system can be made which feed the data to the crop prediction system and pH of the soil can be sent the machine learning model with the help of nodeMCU so that the process can be fully automated. For the irrigation management system sensors such as humidity sensor, soil pH sensor and real time weather data can be used for accurate prediction. Finally, all the results can be made to display in a webpage.

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