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RESEARCH ARTICLE

Grain Yield Estimation in Cultivated Land Using Machine Learning Techniques

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A B S T R A C T

Agriculture contributes approximately 28 percent of India's GDP, and agriculture employs approximately 65 percent of the country's labor force. India is the world's second-largest agricultural crop producer. Agriculture is not only an important part of the expanding economy, but it is also necessary for our survival. The technological contribution could assist the farmer in increasing his yield. The selection of each crop is critical in the planning of agricultural production. The selection of crops will be influenced by a variety of factors, including market price, production rate, and the policies of the various government departments. Numerous changes are required in the agricultural field in order to improve the overall performance of our Indian economy. By using machine learning techniques that are easily applied to the farming sector we can improve agriculture. Along with all of the advancements in farming machinery and technology, the availability of useful and accurate information about a variety of topics plays an important role in the success of the industry. It is a difficult task to predict agricultural output since it depends on a number of variables, such as irrigation, ultraviolet (UV), insect killers, stimulants & the quantity of land enclosed in that specific area. It is proposed in this article that two distinct Machine Learning (ML) methods be used to evaluate the yields of the crops. The two algorithms, SVR and Linear Regression, have been well suited to validate the variable parameters of the continuous variable estimate with 185 acquired data points.

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Introduction

In the field of agriculture, technologically driven solutions have been implemented in recent history.

Most of the field work was carried out by expert's experimentation in the laboratories. In recent times, however, a trend is to grow a culture of data analytical results which is used to identify issues that hinder the sector and ultimately curate the correct information to identify the contributory factor which leads to plant health deprivation.

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There is still a considerable disconnect between the usage of data and the analysis of that data. The disparity between rich and poor in the Indian agriculture industry is much greater. Even if the demand side continues to increase, the supply-side issues will continue to be a concern. In a situation like this, when there is an obvious disparity between supply and demand, it is critical to increase supply. As a result, yield prediction becomes a critical element in the solution of this issue. Predictive analysis aids in the analysis of the supply side of things, which ultimately aids in the resolution of the problems faced by farmers by identifying the correct root cause. Attempts to address the issue are made in this article, which proposes an continuous resolution for the causative element of the yields bad health as well as a method for predicting its production. The target audience for this article is people who will use this application to evaluate and forecast crop yields.

Google's Tensor Flow Library is extensively used for implementing Machine learning methods in Python, because it was available for free. Data scientists across the globe are increasingly requesting that methods of deep learning be implemented, and this tool is intended to fulfill that need in a scalable manner. It is actually a symbolic implementation of the GPU or native coding machine learning dataflow pipeline. The aim of the tensor flow is to meet a human nervous system's basic structural configurations. Tensor Flow allows quick calculation of numerical matrices in accordance with the data flow of the model. Classical optimization problems are solved by neural networks. They are made up of neurons, which take an input and calculate it. To produce the final neuron output, this generated value is given as an contribution to foundation function, which is defined as follows: The sigmoid function is often employed as an foundation function in computer science. Shade [1, 2], figure [3], edge recognition, Gaussian distribution, shade, and touch were all used by many researchers in the field of plant disease recognition. K-Means method [4], Neural Networks [5], rule based [5], Naive bays and major module investigation [6], vector machines [7] are some of the categorization techniques that have been utilized in the field. The technique presented is targeted at detecting nutritional components in paddy fields using neural network pictures and k means classifiers. It is currently under development. The ROI that was utilized in this procedure was the picture sample set. The remainder portion of the paper is divided into four parts, which are as follows: After discussing the literature survey in Section 2, the methodology is discussed in Section 3, the Results are shown in section 4, followed finally the conclusion Section 5.

Crop yield forecasting will undoubtedly benefit farmers. The farmer can make crop selection decisions and contribute more to the farm's profit. Many crop production prediction models are available, some of which utilize actual weather data while others use static parameters. Machine learning has been recognized as a very attractive area for agriculture. Machine learning models can take a variety of precise inputs and produce concrete results. Based on the Indian government's dataset, this research offers machine learning models to forecast agricultural returns and crop success rates. The dataset is enormous, including data for all areas of India, which was then filtered to get data for different states, for a total of 15000 entries. The dataset was created by combining data from several sources. The artificial neural network back propagation algorithm is utilized in crop yield forecast model. It is necessary to use a method known as multi-layer perception. By taking into consideration the available data, the researchers hope to create a crop production forecast model that will be useful in the future.

Related Work

The prediction of crop yield is critical for decision-makers at all levels, including nationwide and area wide. Farmers can use an exact crop forecast model to assist them decide what to grow and when to cultivate it. Crop yield prediction can be classified in many different of ways. This article has examined what was done in the literature by using machine learning for crops forecast.

One of the exclusion criteria during the study of published work is that the publications are normal conventional evaluation papers. In fact, these magazines are related and discussed in this section. Chlingaryan and Sukkarieh conducted a nitrogen status assessment study using machine learning [8] The paper discusses about the rapid improvements in intelligent technology and ML procedures will produce cost efficient explanations in farming.

A review of published papers on machine learning methods connected with crop yield forecast dependent on environmental factors was carried out by Elavarasan et al. in this study. The paper advises that more parameters are available which take into account crop yields [9]. An article by Liakos et al.[10] on the usage of machine learning in the farming division was published in Science Advances. It was decided to conduct the analysis using publications that focused on harvest and share market managing, irrigation and mud usages respectively. Researchers Leomonturine and Blustery conducted an investigation into how to determine when fruits are ripe in order to determine the best production time and yield forecast [11]. Aspects of the Applications & methods that are come across in the areas of image processing & machine learning in the farming segment, particularly in the discovery of syndromes were addressed in[11] Mayuri & Menon (Mayuri & Menon, A number of machine learning approaches, as well as their request in plant biology, were presented by Somusvash[12]For their Survey work on the usage of data mining in the farming field, Gandhi and Armstrong included a section on decision making. They came to the conclusion that more research is needed to determine how the performance of data mining in composite farming datasets was addressed in [13]. Belaulamn conducted a review on the application of data mining methods that were worn for crop forecast, and she came to the conclusion that using data mining techniques to solve the problem of crop yield prediction [14]

According to our review report, the key papers existing in this part, this work is the primary one to focus on machine learning for the problem of crop forecasting. The accessible survey work does not conduct a systematic evaluation, & the majority of them only looked at work that focused on a particular phase of harvest yield forecasting.

Huu Quan Cap and colleagues use a leaf localization method in conjunction with a Machine Learning approach to classify leaf diseases. The computing neural network is used to identify a leaf as a 03 stage classifier. The general precision is 86%[15]. Subahviru Kaushik and colleagues suggested a method for partially usual disease discovery in the soya beans plant. [16] The calculation can distinguish sicknesses with an exactness of 85% by arranging leaf pictures into four classes: solid, frog eye, leaf curse, and wool buildup. Pragabhun Pakkula et al. proposed an AI calculation to distinguish plant leaf sicknesses and to assess illness seriousness. The outspread premise work, related to the portion based help vector machine calculation, is utilized to distinguish infections in groundnut, apple, potato, and tomato plants. To decide the seriousness of sicknesses in leaf pictures [17], the K mean calculation is used]. Zhoaibun lung et al. proposed an audit paper on the distinctive shape, shading and surface qualities needed for acknowledgment of plants [18]. Hamilul Duimusen et al. have been utilizing a profound learning procedure, for example, Alexnet and Squeeze-Net to recognize tomato leaf illness. Alexnet's accuracy is better than Squeeze-Net. GPU validations are performed [19]. Den number et al., anticipated algorithms for the discovery of rice plant diseases using a hybrid transformation method with a gray level co incidence matrix. Features were investigated with the adjacent neural neighborhood, reverse broadcast, Naive Baye's and multi-class SVM. Multi-class SVM include improved accurateness of 99.53 percent among the whole classifiers [20]. Vijay et al. utilized soft computing to recognize plant leaf infection. The threshold value was masked with green colored pixels.

It was necessary to divide an picture in order to categorize leaf infection based on the threshold value. Color co-occurrence methodology was used to extract the characteristics of the data. The two classifiers that were used were the minimum distance criteria and the SVM. The total identification accuracy achieved for MDC with K means was 86.54 percent, 95.47 percent for SMC with the projected method, and 96.53 percent for SVM, according to [21]. Ehsan Kiani and colleagues have developed a fuzzy logic method for identifying plant infection in the case of strawberry illnesses, which they believe would be useful. For the purpose of distinguishing between green and red pixels, a color dispensation discovery algorithm was utilized. For the purpose of determining the finest green & black concentration standards, various thresholds were tested. [22] The algorithm achieved a detection accuracy of 97 percent when it came to disease detection. The researchers at Akansha et al. have created a network illness discovery scheme that makes use of compressed sensing for the classification of diseases in leaves. A feature extraction procedure was conducted after the picture was segmented and the use of compressed sensing was applied, and the classification process was finished with the help of SVM. Each impacted region is calculated using the method, which takes into account the infection affected region, the quantity of blocks in every infection affected region, & the proportion of data decrease in each affected area. The categorization method has an overall accuracy of more than 98 percent [23], according to the results.

Methodology

Every machine learning operation involves understanding the algorithm and knowing when it is time to run the simulation processes that are being used. Mainly, this work is to determine the relationship among the self-sufficient features and its shortage. A classifier and a regression model are the two most important courses of sequence in machine learning, and they will be used to generate distinct and constant values respectively. Working with this one will necessitate the use of the failure function, and if classification is employed, the model may be assessed using the core functions to ensure that the underlying assumption is correct. Initially, a collection of datasets with influencing parameters is gathered in order to differentiate the yield information. This is followed by the repetition of the entire process twice more, with the first iteration serving as the preparation one and next serving as the assessment iteration. Both sides were divided into 02 groups, one is a teaching set and other as a test set. The preparation one will take place all over the data using the organization of algorithms and certain conditions to make sufficient changes to the learning process. In Fig. 1, the procedure is depicted by a flow diagram; with each step occurring after the previous one has been completed. During the testing stage, a comparable methodology is utilized, however the cycle takes a marginally extraordinary turn to assess the information and roll out the vital improvements to confirm the model's result. Produce yield information has been accumulated from the United States Department of Agriculture (USDA) to show the real changes that have happened in the space that has been investigated. Persistent qualities, which for this situation are the yield data that is scattered across a wide scope of qualities from which data can be determined, are assessed utilizing these models. UV, water, pesticides and compost were among the factors included in the dataset, as well as the area of land covered with harvests such as wheat, soybeans, corn, & sugar beets and their respective harvest rates. The dataset also included crop yields for the crops in question. [24] Using the system, the farmer will be able to determine which attribute needs to be changed and will be able to measure the increase in yield that can be achieved by changing that attribute.

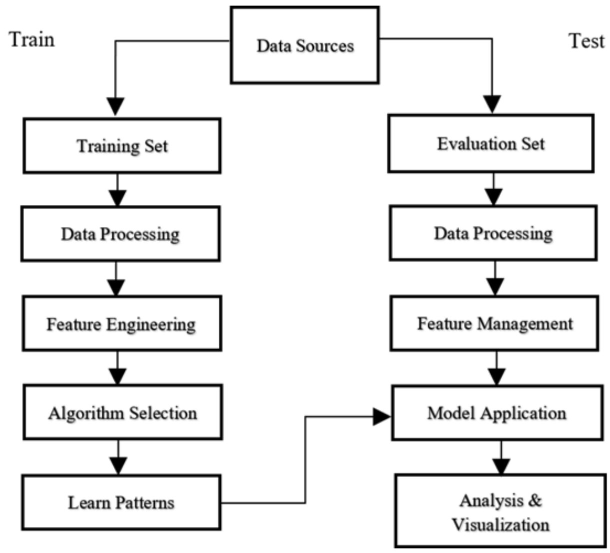

Figure 1. Methodology

The instruction procedure trails a sequence of information from a dispersed sequence of information. In order to be useful, the data must be processed through each of its subsequent flaws, which must then be fixed and prioritized in order to be processed again. Data is fitted to a line in the following step, and the appropriate values for the line's coefficient & cut off are calculated to build the hyper plane well the information tips in such a way that accuracy is not lost in the process. It is necessary to specify the model with linear, nonlinear, and kernel functions. Different histograms and charts are observed in this step in order to make working and learning more easy. Outliers of data are critical. The trigger for the classifiers from data supplied in pertained to classify elements is a common difficulty in machine learning. It is possible to change the missing values to the average of the set or to alter them through interpolation techniques[25] depending on the length of time the information was collected, for example monthly data. At the end of the model creation process, the results are displayed in the regression format that was specified as the kernel. The neural network generates weighted common standards, & foundation function is set to be similar to the definite output estimate than the previous one. MSE mistakes are computed by using equation 1, which takes into consideration the difference between current and forecast errors. Multiple linear regressions aid in the determination of the output value by focusing on different parameter values; as a result, due to the various information overlays, noise values are added to the data points in order to improve accuracy.

$$Error = \frac{1}{n}\sum_{j=1}^{n}(yj - y_j)2 \rightarrow (1)$$

In Fig. 2 every step directs the calculation and every flow. It is necessary to use K-Fold validation on each epoch with aid in the breakdown of the exercise to test percentage. For this, the ratio was fixed to 70:30, with 70 percent of qualified values and the residual 30 percent of the difficult values being used, with each element being used under this circumstance. As in its learning process it will not repeat the same dataset, justification is a important pace to increase the intensity of accuracy. The inputs are initially laid down and approved throughout the secret layer, where the data is processed in this scenario using three layers and then the results are presented. As a result, 140 data points serve as nodes in the hidden layer, communicating with output during a sequence of elements associated to one another. At every stage of the dispensation, from contribution to the secret layer, the weighted average must be tuned before moving on to the next stage of processing. The actual unit in which the main computation is performed for processing the data and making it possible to evaluate the correct output is the hidden layer. However, while every chart has one exponential stream from the start hyperplane structure, the data shows a different statistical distribution. Finally, the results are displayed in the analysis and visualization step; in this time, the MSE fault price is shown in order to supply an improved understanding of the model prediction accurateness on the data set in consideration.

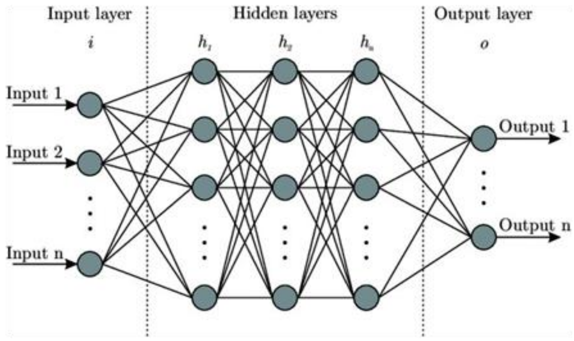

Fig. 2. Neural Network Constitution

In the case where each node can be considered a step in the process, the output from the input requires only a small number of clearly defined steps to be completed. The most significant advantage of ANN is that, by continuously going through each step, it assists in the processing of better results. Iteration continues after iteration and finds adjusted information, which ensures a continuous range of phase shifted content, following all entries and background propagation. Throughout the hidden layers section, every input is connected to every node in order to share information with the remaining elements and increase the heaviness of every link in order to favor the accurate model more than the incorrect pattern. Every propagation follows the eqtns 2 & 3, and every entropy term serves as fault to be assessed all through the process. Every location of results is assessed past each stage in order to ensure that the results are in line with the set of results. The loss can also be reduced because the information that provides more errors can easily be debugged. Condition 2 will give the expense capacity of the last secret layer and the yield layer, while Eq. 3 will give the expense capacity of both the last secret layer and the yield layer, as expressed in both the conditions. The entire equation is linked to the preceding node link standards to build the estimate as accurate as possible with regard to the required results. The rate function, which was essentially an estimation of the mistake of the mold when assessing the information that has been supplied, can be seen through the solution of the equation, which we can see by solving the equation. The time it takes to run each individual simulation has proven to be a significant drawback for the project. It should be noted that when the forward stage is completed in Eq. 3, it is necessary to use the value obtained during the back propagation stage. This will aid in the deliberation of load rate, resulting in a more exact precision of the form, as depicted in the following example.

$$\frac{\delta E}{\delta w12} = -\frac{y1}{\ln(10)*^{\wedge}y1(1+e^{-w11x1})} \rightarrow (2)$$

$$\frac{\delta E}{\delta w11} = -\frac{y1w12x1e^{-w11x1}}{\ln(10)*^{\wedge}y1[(1+e^{-w11x1})2]} \rightarrow (3)$$

Results

A. Following the preparation of the data for placement in the fraction models, it is divided into different data sets for training and testing to ensure it is as accurate as possible. When the results are compared to the previous results, the performance will not be assessed as a improved conclusion for yield forecast if the train-to-test ratio remains the same as it was previously. As a result, there are a few actions that can be taken to improve the model used for error analysis.

B. Data Modeling: It is the yield amount that will be represented by the y-axis variables, and they will act as dependent variables. The x-axis, on the other hand, will represent the influencing characteristics indicated in the above eqtns, and they will behave as autonomous variables in this situation.

C. K-Fold justification: It is essential to carry out this validation in order to validate the model's execution across a range of various test set configurations. Since it allows for alteration after every time in the share of train and examination set, it results in a more accurate predictor in terms of mean squared error and R2 than was previously possible.

Harvest yield predictions were made using supervised models such as linear regression & degeneration, which were both considered for this study. Moreover, regression models are taken into consideration as division of non direct information that is being made to assess the presentation of the yield assessment of various classes. This is controlled by the hyper plane framed in the two models to gauge the harmony between the test sets, which is utilized to decide the precision of the presumption. Thus, the MSE and R2 decline as the precision of the presumption increments.

Figure 3 depicts the preliminary results for Linear Regression model and Support Vector Regression. It can be seen that the form replies to the accurate yield charge are fairly close to the definite one. Implementing regular measures will allow for the observation of variations between the predicted and actual outputs more promptly than previously possible. The error observed is determined based on Fig. 3 using the MSE values of 0.53 percent and 0.46 percent, as well as the R2 value of 0.85 percent, where the higher the R2 value, the better the result.

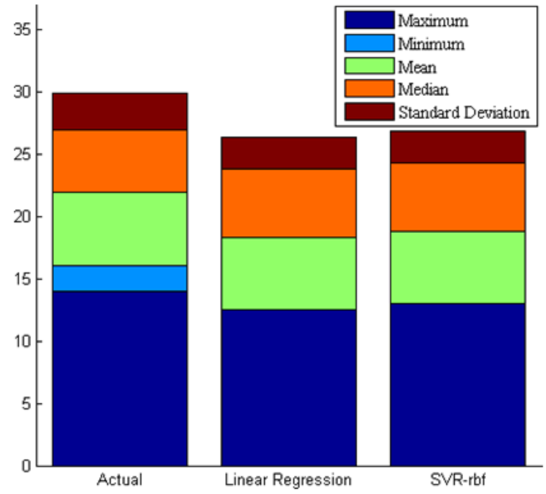

Fig. 3. Comparison between actual and ANN statistical measures

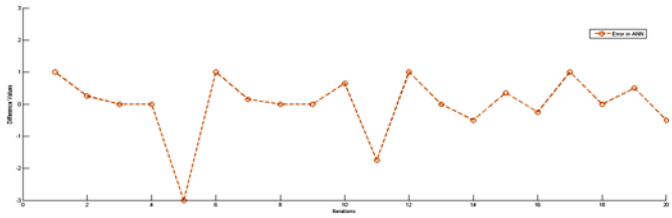

Fig. 4. Error Values for ANN deviation

Conclusion

Agriculture is the field that helps our country's economic growth. However, when it comes to using new machine learning technologies, this is lacking. As a result, our farmers should be aware of all new machine learning and other techniques. These techniques assist in maximizing crop yield. Many machine learning techniques are applied on agriculture to improve crop yields. These techniques also help to solve agricultural problems. We can also achieve the precision of the return by checking for various methods. This allows us to improve performance by checking the accuracy of various crops. In many agriculture sectors, sensor technologies are implemented. This paper assists in obtaining the highest possible yield rate from the crops. The results shown provide a better recommendation to use artificial neural networks to predict continuous multiple regression models as the base algorithm. With the recent observation, it can be concluded that uncontrolled learning is preferable to the controlled learning algorithms for the achievement of continuous prediction results. After that, the results could be used to develop hardware implementations, similar to the ones described in [26], in which each sensor acts as a data point, and cloud implementations will enhance the usage of modular applications.

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