

Crop Yield Prediction Through Artificial Neural Networks

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Abstract—Evolving technologies like Artificial Intelligence, Machine Learning and Data Science are being integrated with almost all sectors. Agriculture, being one of the primary sectors is a no exception to this. Regular technological advancements happening in the agricultural field ensures food security and economical balance in the country. Variety of parameters like soil type, rainfall, temperature, market price influence the yield of a crop. Having dependable information about previous crop yield patterns is essential for making assessments on agricultural risk management and predicting yields. Predicting crop yields is a difficult task for the decision makers. A good crop yield forecast model might be adopted by farmers the choice of what and when to plant. The increasing population with changing environmental conditions impact the crop yield. This paper discusses a model that predicts the Crop Yield through Neural Networks which is an important part of the Machine Learning.

Keywords—*Crop Yield, Neural Networks, Machine Learning, Deep Learning, ANN*

I. INTRODUCTION

Agriculture is not only a growing economy but also it is essential for the survival. National food security is strengthened by the accurate predictions made by policy makers. The farmers also benefit from the accurate crop yield predictions which assists them to make informed decisions in quick time. Changing factors like soil conditions, temperature and other environmental factors, the crop yield prediction turns out to be a very complex task. There are different approaches to predict the crop yield. Machine learning has an important part to play in this[1]

A. **Technology:** There are different algorithms used for this purpose out of which this paper lists out the most frequently used algorithms used. This technology utilizes historical data, environmental factors, and other variables to create predictive models that can help farmers make informed decisions about crop management. Big Data also has a crucial role in this[2]. Neural networks are particularly well-suited for this task because they can learn complex relationships between input variables and

output predictions and can handle nonlinearities and interdependencies in the data. There is an algorithm in AI that functions similar to neurons in the brain. They are Neural Networks. They consist of multiple layers of interconnected nodes, each of which performs a simple computation and passes its output to the next layer. On repeated training, the network adjusts weights between nodes to decrease the discrepancy between the outputs(observed and predicted).

a. **Types of Algorithms :**The type of algorithm chosen can vary on the type of problem. The primary algorithms used are:

- Concurrent Neural Networks
- Long Short Term Memory
- Artificial Neural Networks

The crop yield prediction consists of complicated steps. It addresses one of the main problems in the agricultural sector today i.e. coping with changing environmental conditions. There are different factors to predict crop yield. They include type of soil, temperature, seed, rainfall, types of fertilizers and manures. This paper primarily focuses on two factors- temperature and soil. In general, more is the volume of data being used for predictions, higher is the probability of achieving better results. When the producers of the crops know the precise and accurate information on the types of crops to be grown, it helps in reducing the losses. Artificial Intelligence and Machine Learning are being integrated in most of the sectors today [23]. Agriculture, in particular have seen some major advancements technologically. The equipment, machinery utilized in the field has been drastically improved and made the process of crop growth easy.

Handling of these tools is easy and accessible to most of the producers. Sensor technology in the crop fields helps in the detection of various parameters like pH, water content, temperature, and other environmental factors. These variables can be integrated into a neural network model, which can then be used to output crop yields based on the input data. The software working in the backend which is proctored by the automated systems using AI has made the process even more simple [24]. The architecture behind these systems is complex which consists of various algorithms.

- B. Statistics:** The worth of AI in agricultural market is estimated to be U.S.D 4 billion by 2026. The Compound Annual Growth Rate (CAGR) is expected to be expanding at a rate of 37.3% from 2023 to 2030. Traditional statistical models often assume linear relationships, which may not reflect the true complexity of the underlying data. Neural networks are able to identify and model nonlinearity and interdependencies, leading to more accurate and reliable predictions [25].

A systematic literature also has been done on the various types of techniques used in the field of machine learning for the prediction of crop yield. The most widely used algorithms are Long Short Term Memory(LSTM) and Deep Neural Networks [26].

- C. Artificial Neural Networks:** It is a type of deep learning algorithm that can learn complex patterns in data, making them ideal for crop yield prediction. The process involves collecting data on crop yields from previous years, as well as information on environmental factors. This data is used to train the ANN to predict yields based on current and forecasted conditions [27]. The ANN model consists of several layers of interconnected nodes, which are trained using backpropagation algorithms to adjust the weights between nodes and improve the accuracy of the model [28]. Once trained, the model can be made more efficient.

Crop yield prediction using ANNs has several advantages over traditional methods, it can handle nonlinear relationships between the variables, the ability to make predictions in real-time, and the ability to improve accuracy over time as more data becomes available [29].

II. LITERATURE REVIEW

Crop yield forecast is a crucial responsibility for decision-makers at every level (such as the EU level). An accurate model helps growers to decide what type of crop to grow in what conditions. There are different methods to predict the yield. In this literature review, various applications of machine learning algorithms have been reviewed.

This review is performed on various publications on the yield prediction associated with the fields of machine learning.

One of the most important factor to be considered for the crop yield prediction is the accuracy.

There are different algorithms that work with a huge amount of data and yields results with a huge variance. An algorithm which has failed to predict the required output may be successful in another environment or a given situation. Therefore, it can be deduced that despite the existence of multiple algorithms that could be integrated into the model, it is imperative to carefully select the most efficient one[3] [17], given the parameters involved, including those pertaining to the environment and crops. The only way to achieve this is through rigorous and repeated training and testing of the model.

The literature reviews of various papers have been provided in this section.

A study compared the performance of deep CNN algorithms on RGB data versus NDVI data and found that the model performed better on the RGB data in the early growth stages [4]. The Deep Learning models are becoming more popular than the standard machine learning methods[30].

Dilli Paudel , Allard de Wit et al[5] discussed on the interpretability and performance of deep learning models. The crops chosen were Soft wheat and grain maize. The paper concludes that the deep learning models provided better accuracy than standard techniques which are relied upon expert designers. As discussed above, the usage of an algorithm for a model depends on the parameters given. The crops chosen for this study were wheat and barley.

Martin Kuradusenge, Eric Hitimana et al [6] evaluated various techniques from data mining to output yield of crops. The selected crops were Potato and Maize. The research concluded that the model using the Random Forest technique was the best [31]. The Random forest has become a very popular regression algorithm.

S Iniyana b, V Akhil Varma et al [7] implemented ML algorithms that can predict the yield of crops. The work concluded that LSTM(Long Short Term Memory) was the most efficient model [32].

Yiting RenQiangzi Li et al [8] presented a model that predicted the yield of corn at various phases using a deep learning and a WOFOST model [33]. The work concluded that the predicted model improved significantly as the growth advanced.

K. Mamatha, Shantideepa Samantha et al [9] presented a paper which predicts the crop yield for the Karnataka state. The model used in the research is the Neural network model with regression [34]. The paper concluded that this model gave better efficiency.

Jun Qi, Jun Du et al evaluated the properties of Absolute mean error for the Deep Neural Networks [35]. The work demonstrates how the loss function can be understood as an error using a Laplacian distribution model[10].

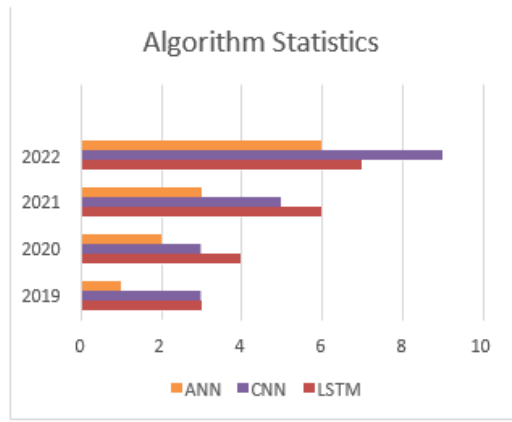


Fig. 1. Usage of Algorithms in Yield Prediction from 2019.

Snehal S. Dahikar et al [11] evaluated how ANN is widely being used in predicting yield and the crops taken into consideration were Wheat, Bajra, Groudnut etc.

Khaki S et al[12] proposed a framework for the prediction of Crop Yield. They used CNN-RNN The hybrid model improved the performance and the accuracy resulting in higher efficiency.

Kassahun A et al [13] proposed a literature review on various machine learning algorithms and throughout the years. It has also discussed how important it is to integrate machine learning to agriculture. This review evaluated more than 100 papers.

The type of algorithms that were used in the Crop Yield Prediction from 2019-2022 have been represented in the following chart. It shows the Convolutional Neural Networks algorithm and Artificial Neural Networks are gaining popularity day by day [38].

III. METHODOLOGY

The Artificial Neural Network[24] is characterized by three types of parameters:

- Connection pattern between different layers of neurons.
- Process of changing the interconnected weights through learning.
- An activation function that changes the weighted input of neuron to its output activation. A neural network model called the feed forward back propagation is examined in this paper.

A. **Data Collection and Pre Processing:** The data from the last 5 years[22] related to various crops from different states of India have been collected. The first stage involved is to pre-process the data to make it more accurate and efficient [41-43]. To achieve this, there is a need to remove duplicate and null values from the dataset. The dataset used for this particular project is of the type “Comma Separated Values”. This dataset contains various parameters such as name of the crop, season, area available, temperature, pH[14][23]

B. **Architecture:** The Artificial Neural Networks have a complex architecture.

- **Input Layer-** Each neuron in the input layer corresponds to an input feature, and the input values are fed into these neurons.
- **Hidden Layers-** They are present in between the input and final layers. These layers perform complex transformations on the input data, learning to identify patterns and features that are relevant for the task at hand [39].
- **Output Layer-** To predict the output.

The backpropagation technique allows us to train the network by adjusting the weight between neurons. Pattern examination and neural network processing is explained by the term “Feedforward”. The layers of neural network are connected to each other[19][20].

The backpropagation is a method used to train neural networks, which involves comparing the actual output of the network with a reference output. This comparison is necessary to update the network's weights and improve its performance during training. By iteratively adjusting the weights in the neural network using backpropagation, the network can learn to make more accurate predictions for a given task, such as image recognition or speech recognition. Backpropagation is an important aspect of training ANNs[11][16] and it has enabled the development of deep learning models that can learn from vast amounts of data. The method used in backpropagation is gradient descent. The computation is performed on squared error function. Then, the derivative is taken[21, 37] with respect to the network's weights. The squared error function is the function that measures the difference between the expected and the observed outputs.

$$E = 1/2 (t - y)^2 \quad (1)$$

E=squared error
t=predicted output
y=actual output

$$y = \sum_{j=1}^n w_j x_j \quad (2)$$

n= total number of inputs given to the neuron
w_i= weight of the ith neuron
x_i=value inputted to the neuron.

This applies to a linear function. For an activation function which is differentiable and non-linear, we use the equation:

$$y' = \left(\sum_{j=1}^n w_j x_j \right) \quad (3)$$

Then, the derivatives of the squared error function with respect to the changes in weights, output, and other factors are computed.

$$\frac{\partial E}{\partial w_i} \frac{dE}{dy} \frac{dy}{d(y)} \frac{d(y)}{\partial w_i} \quad (4)$$

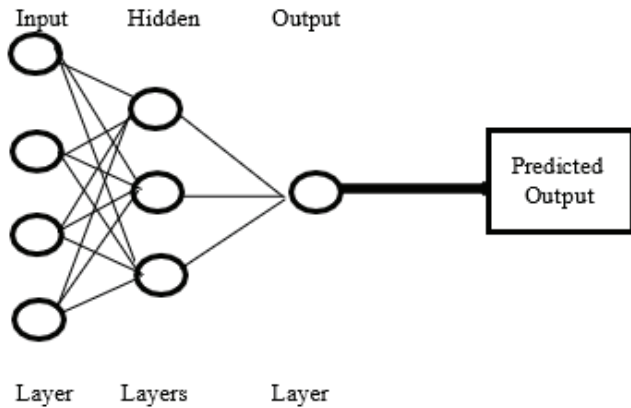


Fig. 2. Architecture of Artificial Neural Network

C. **Feature Selection and Testing:** Feature selection[25] helps in selecting the most relevant parameters and features that affects the yield of a crop. They may include temperature,, rainfall, type of crop, pH of the soil and others. The feature selection process is important as it assists in the elimination of irrelevant features. Type of crop, rainfall, pH and temperature are the main features used for our research. Data was categorized as Train and Test.

D. **Prediction of the output:** After training the model, it was given with n number of inputs with varying temperatures, pH and rainfall (in cms) to predict the suitable crop and yield. The error between the expected and observed outputs should be minimum for the accuracy to be high.

IV. RESULTS AND CONCLUSION

The ANN feedforward back propagation model first showed on accuracy of 76%. With the iterative training, the model achieved an approximate accuracy of 92%. Cotton, wheat, and Rice are the crops chosen. The Artificial Neural Network is gaining its popularity in the current years due to its scalability and ability to handle large datasets and complex problems with non-linear relationships. It is a powerful tool to solve wide range of problems. As agriculture is one of the primary sectors , it requires a boost in production of crop yield with a good quality. Machine Learning algorithms like ANN are of a great use to the researchers[15]. The following chart represents the type of crop suitable for the given amount of pH:

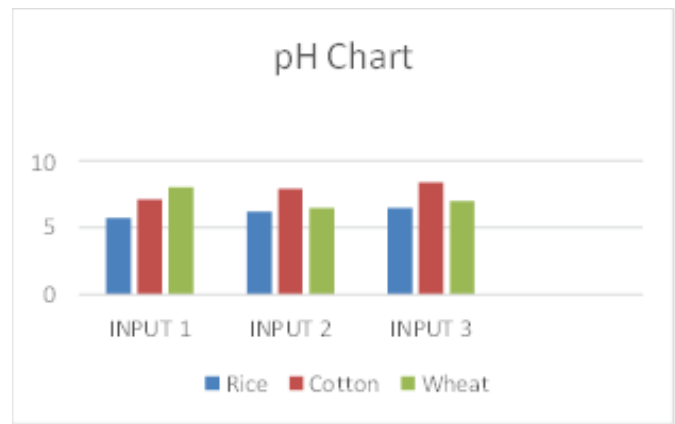


Fig. 3. pH range and the crop suitable to grow

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