CROP PREDICTION USING DEEP NEURAL NETWORK

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ABSTRACT

Agriculture played an important role in Indian economy. Technology in agriculture is still very new in India. This paper builds a crop prediction model using deep learning. In most of the previous research works, machine learning was used for crop prediction and few limited crops are included. Our model is built using Deep Neural Network to predict appropriate crop for every district of India. 124 crops are included in our work. Predictions are made on the basis of dataset taken from Indian government agricultural portal. 75% of dataset used as training dataset and remaining 25% is used as test dataset. Sigmoid Activation function and SGD optimizer is used in this work. This model gave the accuracy of 99.19%.

KEYWORDS: Crop Prediction, Deep Learning, Deep Neural Network

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INTRODUCTION

Economy of India generously depends upon the Agricultural sector of the country. Agricultural practices had been an income source for most of the Indians from days of yore which makes the Indian economy generously dependable on agriculture. More than 1.6 million square-kilometres of India's land area are used for cultivation purpose. In recent times, farmers are struggling a lot in making right choices of crops to be sown at appropriate season for better production of crop. Technology in agriculture is still very new in India as most of the agricultural practices are in rural areas. Due to the lack of knowledge regarding crop selection, the farmers suffer loss which leads to increase the number of suicidal cases of farmers [1].

Crop Prediction is of excessive importance to total food production [2]. Hence, there is a need of effective crop prediction technique for better crop production [3]. Various machine learning algorithms are used for predicting crop on the basis of various factors. Some of them are: Random forest, K-nearest neighbour, Support vector machine, Naïve Bayes, etc. Machine Learning is an arena of training that offers system to self-learn and progress from experience. Machine learning is an effective method to provide optimized crop prediction for the farmers [5].

Deep Learning is a subclass of machine learning based on the Artificial Neural Networks. Our proposed work uses Deep Neural Network to train model for the prediction of crops. Predictions are made on the basis of dataset taken from Indian government agricultural portal [17]. Sigmoid Activation function is used for mathematical computation and SGD optimizer is used for updating parameters and weights to reduce loss function in this work.

The assembly of this paper is as follows: Section II contains Related Work i.e. brief review of previous work. Section III is Methodology which further includes dataset, data pre-processing and prediction. Section IV includes the Experiment Results and lastly, Section V is Conclusion and References.

RELATED WORK

In [1], considering south Indian states, a Hybrid Crop recommender system was proposed that uses classifier algorithms like Naïve Bayes, J48 and association rules. In this work, recommendations are made based on the climatic and geographical features. In this work, Naïve Bayes gave accuracy of 69.90% and J48 classifier gave accuracy of 95.93%.

A crop recommender system was proposed in [7], recommending crop and the ratio of fertilizer required according to soil and atmospheric features. Crop and fertilizer sample data is used for recommendation. This model uses classification algorithms like Random Forest and Back Propagation. Back propagation gave higher error rate than Random forest.

An ensembling technique was used in [8] to build a Crop Recommender System. In this work, ensembling technique used base learner like Naïve Bayes, Random Forest and linear SVM. The class labels of each classifier are combined by the use of majority voting. 99.91% of average accuracy was obtained in this work.

A Crop Recommender System was proposed in [9] that used satellite images to recommend crop on the basis of environmental factors. The researcher proposed a modified CNN which used spatial features as input. The model was trained using back propagation. The error rate of prediction was reduced in this work.

In [10], researcher proposed an expert system for the farmer that helps them to know which crop should be sown at outlined location. This model also provides knowledge about the diseases on plants. To detect the location for gaining information about the weather condition, soil type, crop pattern and groundwater information, etc. GPS system was used. The classifiers used in this model are: Convolutional Neural Network and Recurrent Neural Network.

‘AgroConsultant’ named recommender system was proposed in [11] which predicts the crop to be sown on the basis of various parameters like season, soil type, geographical location, rainfall and temperature. 21 numbers of crops were included in this work. Neural Network was used in this work which provided the accuracy of 91%.

In [13], the researcher proposed a recommender system that used ensembling technique and make prediction on the basis of soil type. In this work, researchers used 9 crops for prediction. This work used Support Vector Machine (SVM), Multi-Layer Perceptron (ANN), Naïve Bayes, and Random Forest as base learners.

The Researcher used ensembling model to design a recommender system in [14]. The numbers of crops used in this work are 10. In this work, majority voting technique was used to combine class labels of each of CHAID, Random Forest, Naïve Bayes, and KNN classifiers. 88% of accuracy was achieved by this model.

In [15], a recommender system was proposed which suggests the crops and fertilizers for growing productivity on the basis of the condition of the land. This model makes prediction for 9 minor crops. ANN was used for modelling and prediction. 90% of accuracy was attained by this work.

METHODOLOGY

In this work, a crop prediction model is designed using Deep Neural Network. The dataset used in this work is taken from Indian government agricultural portal [17]. The framework of proposed work is illustrated in Figure 1.

Figure 1: Basic Framework of Proposed Work.

Dataset

The dataset used in this work is taken from Indian government agricultural portal [17]. This dataset includes parameters like state name, district, crop, season, area and production. This data carries the crop production data of various districts of each state of India from 1997 to 2015. This dataset includes 124 crops. Table 1 illustrates the dataset statistics.

Table 1: Dataset Statistics

Number of Crops	124
Number of States	28
Number of UTs	7
Number of Seasons	5

The sample of the dataset taken from Indian government agricultural portal is illustrated in Figure 2.

1	State_Name	District_Name	Crop_Year	Season	Crop	Area	Production
2	Andaman and Nicobar Islands	NICOBARS	2000	Kharif	Areca nut	1254	2000
3	Andaman and Nicobar Islands	NICOBARS	2000	Kharif	Other Kharif	2	1
4	Andaman and Nicobar Islands	NICOBARS	2000	Kharif	Rice	102	321
5	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Banana	176	641
6	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Cashew nut	720	165
7	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Coconut	18168	65100000
8	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Dry ginger	36	100
9	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Sugarcane	1	2
10	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Sweet potato	5	15
11	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Tapioca	40	169
12	Andaman and Nicobar Islands	NICOBARS	2001	Kharif	Areca nut	1254	2061
13	Andaman and Nicobar Islands	NICOBARS	2001	Kharif	Other Kharif	2	1
14	Andaman and Nicobar Islands	NICOBARS	2001	Kharif	Rice	83	300
15	Andaman and Nicobar Islands	NICOBARS	2001	Whole Year	Cashew nut	719	192
16	Andaman and Nicobar Islands	NICOBARS	2001	Whole Year	Coconut	18190	64430000
17	Andaman and Nicobar Islands	NICOBARS	2001	Whole Year	Dry ginger	46	100
18	Andaman and Nicobar Islands	NICOBARS	2001	Whole Year	Sugarcane	1	1
19	Andaman and Nicobar Islands	NICOBARS	2001	Whole Year	Sweet potato	11	33
20	Andaman and Nicobar Islands	NICOBARS	2002	Kharif	Rice	189.2	510.84
21	Andaman and Nicobar Islands	NICOBARS	2002	Whole Year	Areca nut	1258	2083
22	Andaman and Nicobar Islands	NICOBARS	2002	Whole Year	Banana	213	1278
23	Andaman and Nicobar Islands	NICOBARS	2002	Whole Year	Black pepper	63	13.5
24	Andaman and Nicobar Islands	NICOBARS	2002	Whole Year	Cashew nut	719	208
25	Andaman and Nicobar Islands	NICOBARS	2002	Whole Year	Coconut	18240	67490000
26	Andaman and Nicobar Islands	NICOBARS	2002	Whole Year	Dry chillies	413	28.8
27	Andaman and Nicobar Islands	NICOBARS	2002	Whole Year	Dry ginger	47.3	133
28	Andaman and Nicobar Islands	NICOBARS	2002	Whole Year	Sugarcane	5	40
29	Andaman and Nicobar Islands	NICOBARS	2003	Kharif	Rice	52	90.17

Figure 2: Sample of the Dataset Used.

Preprocessing

The obtained dataset is converted into numeric data. The dataset is split into training and test dataset. 75% of data is for training and the remaining 25% is used for validation. Label Encoder () was used to transform text data into numeric labels. It is also used for normalization. 2D-matrix of the data is created.

Deep Neural Network

Deep Neural Network obliges as compact outline to Deep Learning. In DNN, multiple layers of neurons are connected passing signals in single direction. From the training dataset, the model is trained to acquire the correlation among the given input and the output. Corresponding to the given set of input, a set of output is obtained by using feed-forward learning through multiple hidden layers.

We have trained our model using DNN having one input layer, two hidden layers and one output layer. We have used sigmoid as activation function. SGD optimizer is used for updating parameters and weights to reduce loss function in this work.

A Deep Neural Network Architecture is illustrated in Figure 3. Here, we input the State, District and Season to the network and on the basis of the production of crop from 1997 to 2015, crops are predicted.

Figure3: Deep Neural Network Architecture.

Prediction

The crop prediction is made on the basis of the production of crop in different districts from 1997 to 2015. Finally, the crop prediction is made for various season and district of each state of India.

EXPERIMENTAL RESULTS

In this work, we have evaluated our proposed model on various metrics like accuracy, mean absolute error and mean square error. The values of performance metrics are illustrated in Table 2.

Table 2: Performance Evaluation Table Showing Values of Accuracy, MAE, MSE and Loss

Performance Parameters	Results
Accuracy	99.19%
MAE	0.0157
MSE	0.0078
Loss	0.391

Accuracy is measured as the difference between the predicted value and true value.

$$\text{Acc} = \frac{y_{\text{pred}} - y_{\text{true}}}{n} \quad (1)$$

Mean Absolute Error (MAE) measures the average of the difference between the predicted value and true value.

$$\text{MAE} = \frac{1}{n} \sum_{x,y} |y_{\text{pred}} - y_{\text{true}}| \quad (2)$$

Mean Square Error measures the average of square of difference between predicted value and true value.

$$\text{MSE} = \frac{1}{n^2} \sum_{x,y} |y_{\text{pred}} - y_{\text{true}}|^2 \quad (3)$$

Loss is measured using Binary Cross Entropy. Binary Cross Entropy function is used for binary classification problems.

$$L(y_{\text{true}}, y_{\text{pred}}) = \frac{1}{n} \sum_{i=0}^n (y_{\text{true}} * \log(y_{\text{pred}}) + (1 - y_{\text{true}}) * \log(1 - y_{\text{pred}})) \quad (4)$$

Where n is total number of data, x is set of parameters (state, district, season), y represents label (crop). y_{pred} represents predicted value and y_{true} represents actual value.

During the training period, dataset is divided into two subclasses, one for training and the other for validation. 75% of data is used for training and the remaining 25% is used for validation. Figure 4 illustrates the comparison of train and val. Here, 'Train' defines the trained sample's accuracy whereas 'Val' defines the accuracy of validation subclass.

Figure.4: Train Versus Val Graph for Accuracy.

The comparison of loss during training and validation is illustrated in Figure 5.

Figure 5: Train Versus Val Graph for Loss.

We have compared our work with few previous works on the basis of accuracy obtained and the performance is illustrated in Table 3 and Figure 6.

Table 3: Comparison of Our Work with Existing Work on the Basis of Accuracy

Works	Accuracy
Our Work	99.19%
Vivilya et al. [1]	95.93%
Doshi et al. [11]	91%
Pudumalar et al. [14]	88%
Giritharan et al. [15]	90%

Figure 6: Comparison of Our Work with Existing Work on the Basis of Accuracy.

CONCLUSIONS

In this paper, we have designed a framework of crop prediction using Deep Neural Network. The proposed model predicts crops for different seasons and districts of each state on the basis of the production of crop from 1997 to 2015. The model is trained using Deep Neural Network (DNN) having multiple layers. Sigmoid activation function and SGD optimizer are used in this model. The performance of the model is evaluated on various metrics like accuracy, mean absolute error, mean square error. The proposed model achieved accuracy of 99.19%.

This work is mainly proposed to help farmers in choosing right crops according to the season and location so as to increase the production of crop. Our work achieved the accuracy of 99.19%. In future, this work can be extended by taking more parameters like rainfall, temperature and soil type, etc.

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