Analysis and Prediction of Crop Yield using Data Mining and Machine Learning Algorithms

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ABSTRACT

Agriculture plays a vital role in India’s economy and majority of India’s population is dependent on agriculture but farmer’s still face a lot of challenges and issues both in terms of productivity and cost management due to the varying climatic conditions and lack of modern agricultural knowledge. In this work we have built a simulation model to predict the yield of crops in each district of Karnataka, by considering various parameters like rainfall, season, crop year, district and area of the land in which the crop is to be grown. WEKA Tool is used for data pre-processing. Python is used for data analysis and jupyter notebook is used as a tool for applying the machine learning algorithms for predicting the crop yield. The algorithm that performed best in simulation was later implemented using python in jupyter notebook.

Keywords: Data Preprocessing, Aggregation, Dimensionality Reduction, Feature subset selection, Random forest regression.

1. INTRODUCTION

Farmers getting to know the yield rate of crops well before cultivation has a lot of benefits such as they can use their land size effectively, calculate their profits, avoid losses and can plan their expenditure on the crops effectively [2]. Thus it overall improves the agricultural technique in India.

Data mining is the process of retrieving required information from a large dataset. Data mining process includes the following stages such as Extracting, Transforming loading data in a repository and Data management [4]. Data collection is the first stage of data mining in which the required data is collected from various resources and arranged in a systematic order. Later the collected dataset is pre-processed to get the required information, the following pre-processing techniques [1] are used: Feature subset selection, Dimensionality reduction, aggregation and data transformation.

Feature subset selection is the process of selecting relevant and required features according to our objectives from the available dataset. After performing this process, we make use of dimensionality reduction, in which the unwanted and irrelevant tuples and columns are deleted to reduce the size of the dataset, therefore analyzing a small dataset is less time consuming and efficient. After dimensionality reduction, Aggregation is performed. It is the process of combining two or many features into one. By doing so the variability of the data is reduced. After aggregation the final pre-processing
technique used is Data Transformation. It is the process of converting data from one type to another, for example converting categorical data type into continuous data type.

The processed dataset can now be used for applying Machine Learning algorithms. In our work, WEKA Tool is used for data pre-processing and to obtain the simulation results of Machine Learning algorithms. Since, the target variable is of continuous type, regression algorithms must be used for prediction [1]. Out of many algorithms available, the most popular one’s for this type of problem are chosen, such as Linear Regression, K-Nearest Neighbor(KNN), Decision Tree and Random Forest[4]. These following algorithms where simulated using WEKA Tool and the results were obtained.

2. RELATED WORK
In [1] they have proposed a machine learning approach which aims at predicting the best yielded crop for a particular region by analyzing various atmospheric factors like rainfall, temperature, humidity etc., and land factors like soil pH, soil type including past records of crops grown and they finally conclude by saying Random forest gives the better yield prediction as compared to Polynomial Regression and Decision Tree. In [2] different supervised techniques with hybrid approach have been analyzed and it can suggest farmers with the right crop to be grown according to the conditions and they conclude by saying that hybrid machine learning algorithm works better than the existing supervised classification techniques.

In [3] they focus on predicting the yield of the crop by applying various machine learning techniques and they finally conclude that random forest regressor algorithm has the highest yield prediction accuracy. In [4] they have built a system to analyze large dataset and to predict the crop yield, in this work they have concluded saying Random Forest algorithm out performs Multiple Linear Regression algorithm in every performance statistics and Random forest is a efficient machine learning algorithm for crop prediction.

3. PROBLEM DEFINITION
With the increase in food consumption due to rapid raise in population, it is very important for farmers to produce crops with high yield without affecting their profit percentage, thus our work is to design, develop and implement a simulation model to predict the yield of crops with the help of suitable machine learning algorithms using different parameters such as temperature, rainfall and location. Using which the yield of a particular crop in a particular region can be known well in advance and the appropriate crop can be grown and harvested.

4. PROPOSED METHODOLOGY

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4.1 Agriculture Dataset

The first stage is collection of data, it is one of the primary needs of a machine learning project. In data collection, data is collected from various resources according to the project requirements and it is later preprocessed to obtain the final dataset on which the machine learning algorithm[3] can be applied.

For this work we have collected two separate datasets, the first dataset contains the crop yield along with different features such as district name, season name, area and crop name, the total number of tuples present in the dataset are 2,46,792 with 7 attributes, the second dataset contains the information regarding the rainfall in each district for the past 10 years and the total number of tuples present in this dataset are 190 along with 15 attributes. The crop dataset and rain dataset was downloaded from different data sources, a few tuples of both the dataset are shown below.

<table>
<thead>
<tr>
<th>State_Name</th>
<th>District_Name</th>
<th>Crop_Year</th>
<th>Season</th>
<th>Crop</th>
<th>Area</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2009</td>
<td>Kharif</td>
<td>Areca nut</td>
<td>1254</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2009</td>
<td>Kharif</td>
<td>Other Kha</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2009</td>
<td>Kharif</td>
<td>Rice</td>
<td>102</td>
<td>321</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2009</td>
<td>Whole Ye</td>
<td>Banana</td>
<td>176</td>
<td>641</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2009</td>
<td>Whole Ye</td>
<td>Cashew</td>
<td>720</td>
<td>165</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2009</td>
<td>Whole Ye</td>
<td>Coconut</td>
<td>18168</td>
<td>6510000</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2009</td>
<td>Whole Ye</td>
<td>Dry ginger</td>
<td>36</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2009</td>
<td>Whole Ye</td>
<td>Sugarcane</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2009</td>
<td>Whole Ye</td>
<td>Sweet pot</td>
<td>5</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2009</td>
<td>Whole Ye</td>
<td>Tapioca</td>
<td>40</td>
<td>169</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2010</td>
<td>Kharif</td>
<td>Areca nut</td>
<td>1254</td>
<td>2061</td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar NICOBARS</td>
<td>2010</td>
<td>Kharif</td>
<td>Other Kha</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Fig 2. Crop dataset
4.2 Data Preprocessing

There are a number of data mining preprocessing techniques available for preparing the data for analysis purpose, some of the preprocessing techniques[2] which we have used are:

- Feature Subset Selection
- Dimensionality Reduction
- Aggregation
- Data Transformation

**Feature Subset Selection:**

Feature Subset Selection is the process of selecting a set of attributes or features which are relevant for the model creation.

In this paper, the objective is to predict the yield of different crops which are suitable for different districts and various seasons in the state of Karnataka, therefore out of the 33 states available in the dataset, we have selected only the state of Karnataka and by doing so the dimensionality of the dataset has been reduced significantly from two lakh forty six thousand to twenty one thousand. Further in the process only the three most popular crops from each district has been selected, further reducing the size of data to 2503. The sample dataset after performing feature subset selection is as shown below.

![Dataset after performing feature subset selection](image-url)

**Dimensionality Reduction:**

Dimensionality Reduction is the process of deleting irrelevant or less important attributes in the dataset before model creation.
In this dataset, we have deleted the attribute ‘State Name’ as it has less importance during model creation, the dataset after performing dimensionality reduction is as shown below.

![Fig 5. Dataset after performing dimensionality reduction](image)

**Aggregation:**

Aggregation is the process of combining two or more columns or two different datasets from different data sources to get a summarized dataset.

For the above dataset after performing dimensionality reduction, we have aggregated the season wise rainfall and then added the rainfall attribute to crop dataset, the dataset obtained after performing aggregation is as shown below.

![Fig 6. Dataset after performing aggregation](image)
Data Transformation:
Data transformation is the process of converting data from one type into another type, it is the last step of data preprocessing. The purpose of data transformation is to transform categorical data types into numeric data type, so that the dataset is ready to be analyzed by regression algorithms. Data transformation was done using python in jupyter notebook with the help of sklearn preprocess library to convert the categorical data type into numeric data type, and the final dataset after performing all the preprocessing techniques is as shown below.

![Fig 7. Final dataset after applying preprocessing techniques](image)

4.3 Machine Learning Algorithms
Machine learning algorithms are classified as

- Classification
- Regression
- Association
- Clustering

Since we need to use supervised learning type of algorithm and our target variable is of continuous type, we are using regression technique, out of many available algorithms[4] in regression, we simulated for Linear Regression, K-Nearest Neighbor (KNN), Decision tree and Random Forest algorithm using WEKA TOOL. On running the simulation, we found that Random Forest algorithm was a high accuracy rate compared to the other three and thus Random Forest algorithm was implemented in jupyter notebook using python and the results obtained are discussed below.

5. RESULTS AND ANALYSIS

5.1 Pre-processed dataset
The dataset collected was preprocessed during different data mining preprocessing techniques as mentioned above and the tool which we have used for preprocessing is WEKA tool and Jupyter notebook. The final preprocessed dataset is as shown below.
5.2 Simulation Results

After obtaining the final dataset, different machine learning algorithms such as, Linear Regression, K-Nearest Neighbor, Decision Tree, and Random Forest algorithm were applied on the dataset, the simulation was done using WEKA tool and the simulation results of each algorithm is as shown below.

**LINEAR REGRESSION ALGORITHM**

![Fig 9. Graph of actual yield vs predicted yield using Linear Regression](image)

Linear Regression algorithm was applied using WEKA tool and the accuracy and error rate obtained through simulations are as shown below.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation coefficient</td>
<td>0.8982</td>
</tr>
<tr>
<td>Mean absolute error</td>
<td>20564.466</td>
</tr>
<tr>
<td>Root mean squared error</td>
<td>32356.352</td>
</tr>
<tr>
<td>Relative absolute error</td>
<td>51.1483 %</td>
</tr>
<tr>
<td>Root relative squared error</td>
<td>44.526 %</td>
</tr>
<tr>
<td>Total Number of Instances</td>
<td>851</td>
</tr>
</tbody>
</table>

![Fig 10. Simulation results of Linear Regression algorithm](image)

**K-NEAREST NEIGHBOR (KNN) ALGORITHM**

![Fig 11. Graph of actual yield vs predicted yield using K -Nearest Neighbor](image)

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K-Nearest Neighbor algorithm was applied using WEKA tool and it is seen that it performs better than Linear Regression model, the accuracy and error rate obtained through simulations are as shown below.

![Fig 12. Simulation results of K-Nearest Neighbor algorithm](image)

**DECISION TREE ALGORITHM**

![Fig 13. Tree view of Decision Tree model](image)

Decision Tree algorithm was applied using WEKA tool and it is seen that it performs better than Linear Regression model and also K-Nearest Neighbor model, the accuracy and error rate obtained through simulations are as shown below.

![Fig 14. Simulation results of Decision Tree model](image)

**RANDOM FOREST ALGORITHM**

![Fig 15. Graph of actual yield vs predicted yield using Random Forest algorithm](image)
Random Forest algorithm was applied using WEKA tool and it is seen that it performs better than Linear Regression model, K-Nearest Neighbor model and Decision Tree model, the accuracy and error rate obtained through simulations are as shown below.

![Fig 16. Simulation results of Random Forest model](image1)

Since Random Forest Algorithm showed high accuracy compared to the other three, we have implemented Random Forest algorithm in jupyter notebook using python language and the output is as shown below.

![Fig 17. Performance measurements of Random Forest model using python](image2)

![Fig 18. Final output to end user in jupyter notebook](image3)
6. CONCLUSION

In the future a better user interface would be developed for the model so that anyone from a remote location can access it and additional attributes can be added to the dataset to get even more accurate predictions. Thus in this paper we have discussed about the data collection from various resources and how to preprocess the collected data using different preprocessing techniques, later using WEKA tool different regression algorithms were applied and the simulation results were analyzed, on analyzing the results, we can conclude that Random Forest algorithm has the highest accuracy rate compared to the other algorithms. With the help of the crop yield prediction model, a farmer can increase his profitability and reduce his losses.

REFERENCES


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