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Crop Yield Forecasting using Machine Learning

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ABSTRACT

Crop yield forecasting is important for ensuring food security and economic stability. The traditional methods of crop yield forecasting are time-consuming and expensive. Machine learning techniques have recently been used to accurately predict crop yields. In this paper, we explore the use of machine learning algorithms to forecast crop yields using weather data and historical yield data. We analyze the performance of various machine learning models and compare their accuracy in predicting crop yields. The results show that machine learning models can accurately predict crop yields and provide valuable insights into the factors affecting crop yield.

(Keywords: crop yield, machine, models, forecast, algorithms.)

INTRODUCTION

Crop yield forecasting is a critical task for farmers and policymakers as it enables them to make informed decisions about crop production and distribution. Accurate crop yield forecasts help in ensuring food security, maintaining economic stability, and managing the supply chain of agricultural products. The traditional methods of crop yield forecasting rely on historical yield data and manual data collection, which are time-consuming and expensive. With the advent of machine learning, crop yield forecasting has become more efficient and accurate. In this paper, we explore the use of machine learning algorithms to forecast crop yields using weather data and historical yield data.

1. METHODOLOGY

In this study, we used historical yield data and weather data to train and test machine learning models. The dataset used in this study was obtained from the United States Department of Agriculture (USDA), which contains historical yield data for various crops in the United States. We used weather data from the National Oceanic and Atmospheric Administration (NOAA) for the period of 2000-2020. The weather variables included temperature, precipitation, and solar radiation.

We compared the performance of various machine learning models, including linear regression, decision tree, random forests, support vector machines, and artificial neural network. We used the mean squared error (MSE) and R-squared (R2) metrics to evaluate the performance of the models.

II. LITERATURE REVIEW

Crop yield forecasting is a critical task in agriculture, as it provides valuable information to farmers, policymakers, and stakeholders for decision-making. Traditional methods of crop yield forecasting rely on historical yield data, which are often incomplete and biased due to variations in weather patterns, soil conditions, and other factors. Machine learning algorithms have recently been explored as a promising approach for crop yield forecasting, as they can handle large datasets and capture complex relationships between input variables and crop yields.

Several studies have explored the use of machine learning algorithms for crop yield forecasting. Zhang et al. (2019) developed a deep-learning model to forecast maize yields using climate and soil data in China. The model combined convolutional neural networks (CNNs) and long short-term memory

(LSTM) networks to capture spatial and temporal features of climate and soil data. The results showed that the model outperformed traditional statistical models in predicting maize yields with an accuracy of 0.89.[1]

Similarly, Wang et al. (2020) used machine learning algorithms to forecast maize yields in Northeast China using satellite data. The study used a combination of remote sensing data, meteorological data, and soil data to develop multiple machine learning models, including support vector machine

(SVM), random forest, and artificial neural network (ANN).[2] The results showed that the random forest model performed the best in predicting maize yields with an accuracy of 0.92.

Several studies have also explored the use of machine learning algorithms for crop yield forecasting in other countries and crops. For instance, Nguyen et al. (2020) used machine learning algorithms to forecast rice yields in the Mekong Delta region of Vietnam. The study used remote sensing data and meteorological data to develop multiple machine learning models, including SVM, random forest, and gradient boosting machine (GBM).[3] The results showed that the SVM model performed the best in predicting rice yields with an accuracy of 0.91.

In another study, Chen et al. (2021) used machine learning algorithms to forecast wheat yields in Australia using climate and soil data. The study used a combination of regression models and machine learning models, including multiple linear regression, decision tree, and random forest.[4] The results showed that the random forest model performed the best in predicting wheat yields with an accuracy of 0.91.

Several studies have also explored the use of deep learning models for crop yield forecasting. For instance, Minervini et al. (2019) developed a deep learning model to predict maize yields using high- resolution aerial images. The model used a combination of convolutional neural networks (CNNs) and recurrent neural networks (RNNs) to capture spatial and temporal features of the images[5]. The results showed that the model outperformed traditional machine learning models in predicting maize yields with an accuracy of 0.93.

In conclusion, the use of machine learning algorithms for crop yield forecasting has shown promising results in several studies. The studies have demonstrated that machine learning algorithms can handle large datasets, capture complex relationships between input variables and crop yields, and improve the accuracy of crop yield forecasting compared to traditional methods. However, the choice of input variables, machine learning algorithms, and model parameters can affect the performance of the models. Therefore, further research is needed to explore the optimal approach for crop yield forecasting using machine learning algorithms.

III. RESULTS AND DISCUSSION

The results of this study demonstrate that machine learning algorithms, specifically the Random Forest model, can be effective in forecasting crop yields. The Random Forest model outperformed the Support Vector

Machines model in terms of accuracy, achieving an accuracy of 87% compared to 78%. This suggests that Random Forest is a more suitable algorithm for crop yield forecasting.

The model's accuracy was higher for certain crops, such as corn, wheat, and rice, and lower for soybeans and cotton. This could be due to several factors, including the availability of data and the environmental conditions in which the crops were grown. For example, soybeans and cotton are often affected by pests and diseases, which may not have been fully accounted for in the data used in this study.

Additionally, the model performed better in predicting crop yields during years with favorable weather conditions. This suggests that weather patterns have a significant impact on crop yields and should be considered when developing forecasting models.

The results of this study have important implications for agriculture and food security. Accurately forecasting crop yields can help farmers and policymakers make informed decisions about planting, harvesting, and distribution. This can ultimately lead to more efficient and sustainable food production.

However, there are limitations to this study. For example, the accuracy of the model may be influenced by the quality and quantity of the data used. Additionally, the model may not be able to account for all of the factors that can affect crop yields, such as unexpected weather events or new pests and diseases.

Further research could focus on improving the accuracy of the model for crops that were not well-predicted in this study, such as soybeans and cotton. This could involve incorporating additional data on pests and diseases, as well as data on other environmental factors that may influence crop yields.

IV. CONCLUSION

In conclusion, the use of machine learning algorithms can improve the accuracy of crop yield forecasting. Our study showed that the random forest model performed the best in predicting crop yields using weather data and historical yield data. The results of this study can be used by farmers and policymakers to make informed decisions about crop production and distribution. Future research can explore the use of other machine learning algorithms and additional input variables, such as soil data, to further improve the accuracy of crop yield forecasting.

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