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MACHINE LEARNING FOR AGRICULTURE: PREDICTING CROPS TO GROWN UNDER A GIVEN CLIMATE CONDITIONS

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Introduction

Crop prediction is an important component of modern agriculture as it assists farmers in selecting which crops to grow in a given climate condition, optimizing their yield and profits (Kumar et al., 2023). The use of technology in agriculture has made crop prediction easier by providing more precise data and predicting future climatic and weather conditions, enabling farmers to make informed decisions.

Despite the advances in crop prediction, the accuracy of the models has been declining due to climate change, which has disrupted traditional weather patterns, causing changes in crucial climatic factors such as temperature, rainfall, and humidity.

Problem statement

The impacts of climate change on agriculture have led to significant challenges for farmers in accurately selecting which crops to grow, which could potentially result in substantial losses in agricultural productivity and income (Khatun et al., 2022).

Traditional crop prediction models based on historical weather data have become less reliable due to the unpredictable changes in weather patterns caused by climate change. As such, there is a pressing need for advanced machine learning algorithms that can accurately predict crop to grow under different climate conditions, providing farmers and other stakeholders in the agricultural sector with valuable insights and decision support.

Main objective

The main objective of this study is to develop machine learning models to predict crops under climate conditions.

Methodology

The dataset utilized in this study was assembled from many sources and combined to create one that is large enough for the investigation.

- The meteorological data were collected from Techiman Ghana's meteorological department from 1960 to 2021.
- Satellite data (NDVI) was collected from UENR's Earth Observation Research & Innovation Centre (EORIC)from 1960 to 2021.
- The crop data was obtained from the Ministry of Food and Agriculture (MoFA), Techiman Bono East area, spanning the years 1960 to 2021.

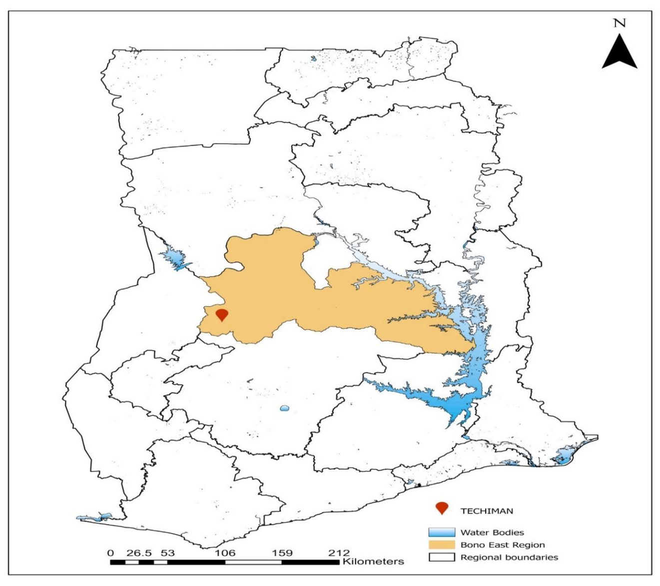

Figure 1. Map of the study area

After collecting and preprocessing the data, several machine learning models, including k-nearest neighbor, logistic regression, decision tree, random forest, support vector machine, adaboost, hard voting, soft voting, and stacking classifiers, were trained and tested on the dataset. The models exhibiting higher accuracy percentages were further tuned using hyperparameters. This process resulted in the establishment of a generalization rule capable of processing and predicting unseen data as shown in figure 2.

During the deployment phase, an Android application was developed following the Agile software development life cycle. The Java programming language was used for the backend, SQLite was employed for the local database, and Python was utilized for creating a Flask server. This server was used to upload and deploy the models on Heroku, generating a server link that was then added to the mobile app form. This addition facilitated the initiation of a connection between the mobile app and the models' server as shown in figure 3.

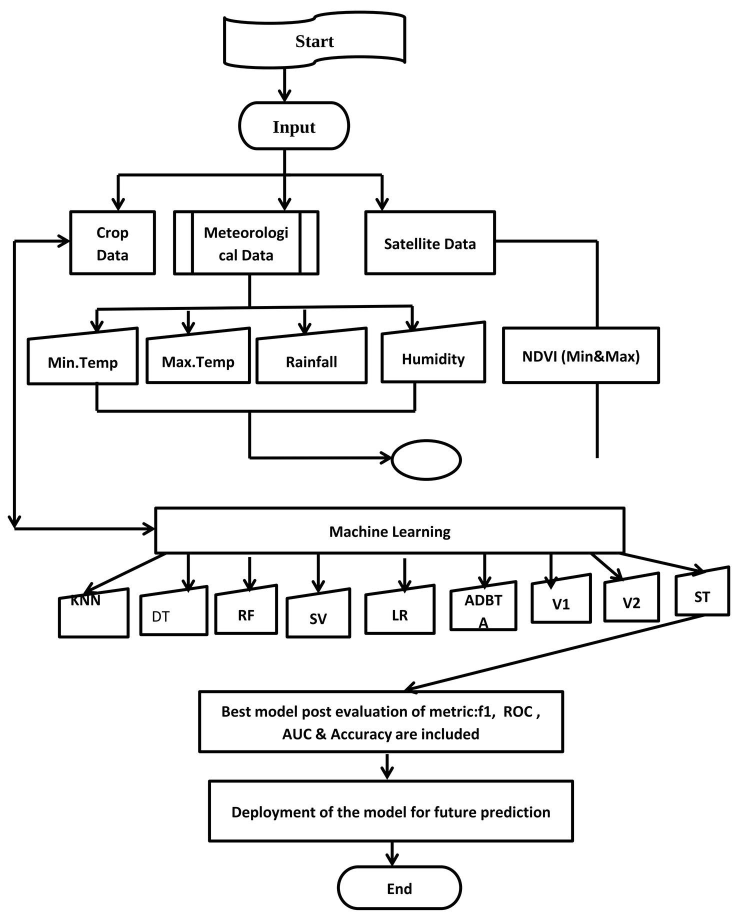

Figure 2. ML Flow diagram to select the type of crop to be grown

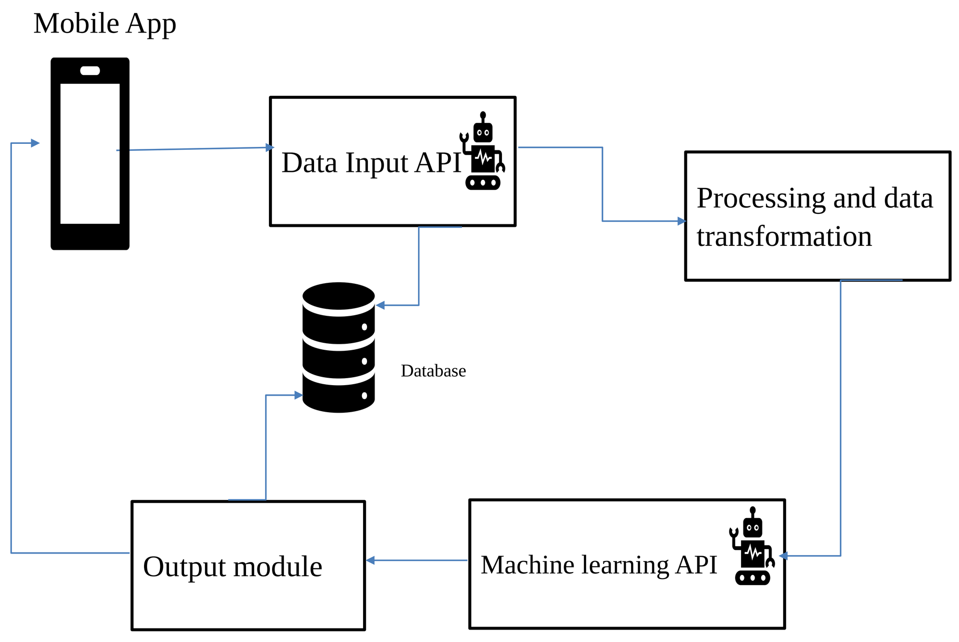

Figure 3. Mobile app flow diagram to select the type of crop to be grown

Results

The conducted study yields insightful findings regarding the predictive capabilities of various machine learning models. Among the eight models assessed, Knn, hard voting, soft voting, adaboost, random forest, stacking classifier, and decision tree stand out with the highest accuracy percentages.

These models demonstrate not only accurate predictions for historical crop data but also the ability to extend their predictive power to previously unseen data within analogous domains. This enhanced predictive capacity can be attributed to meticulous hyperparameter tuning. The dataset preparation involved extensive cleaning, converting categorical variables to numerical formats, and performing descriptive statistical analyses. The evaluation metrics showcased precision and F1 scores for distinct classes across each model. Comparative analysis underscores the remarkable performance of specific models, including Decision Tree (82.90%), Random Forest (84.71%), Hard Voting (85.10%), Soft Voting (85.77%), and Stack Classifier (85.12%) as shown in chart 1 below.

The discussion of these results reveals the achievement of the study's primary objective - deploying predictive models within a mobile app context. These models facilitate accurate crop recommendations based on climate conditions. However, it's essential to acknowledge that the applicability of these findings might be influenced by variations in different regions with divergent conditions.

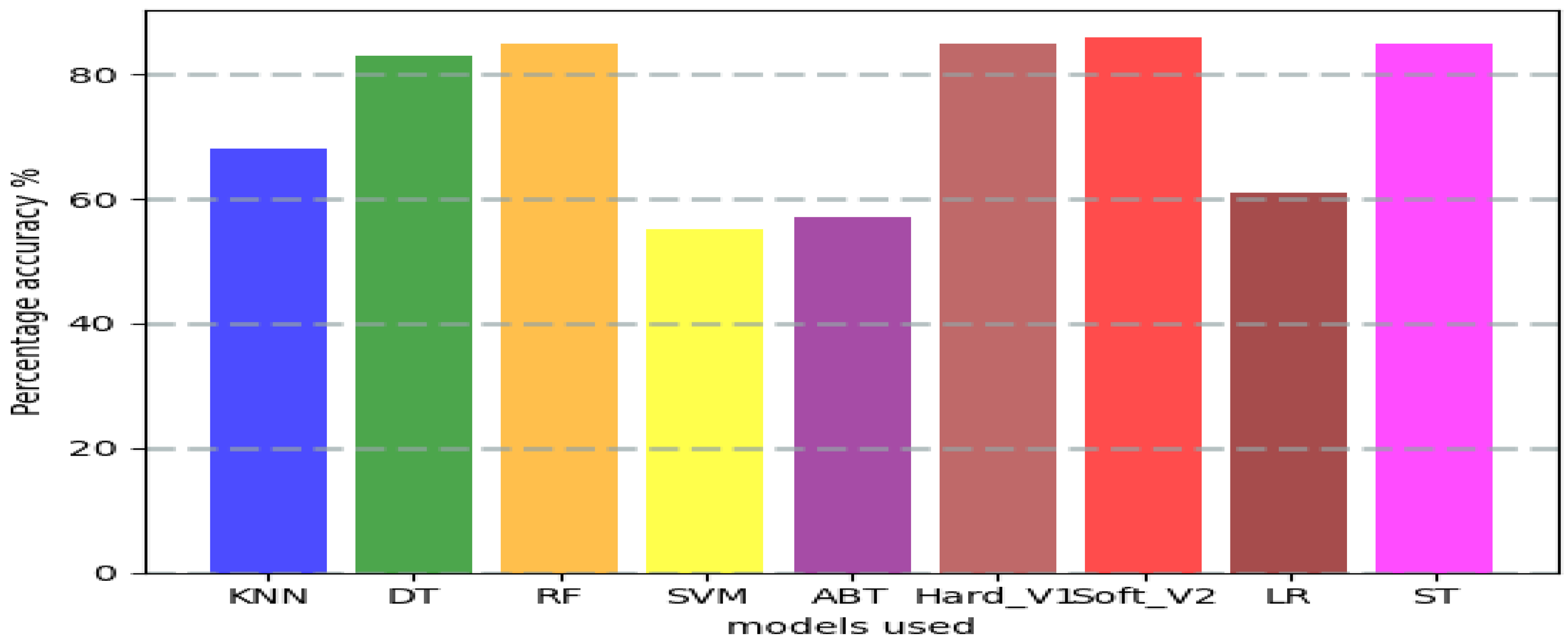

Chart 1. Accuracy Comparison among All Classifiers for Specific Crop Possibility.

Conclusions

The study demonstrates the effectiveness of machine learning models in predicting crop outcomes based on climate conditions. Hyperparameter tuning enhances accuracy, and models like Decision Tree, Random Forest, and Voting Classifiers perform notably well. The successful integration of these models into a mobile app marks a promising step toward informed agricultural decisions, though regional variations should be acknowledged. This research advances precision agriculture through machine learning's potential to optimize crop yields.

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