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Forecasting Organic Crops Based on Machine Learning Algorithms

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ABSTRACT- Classification of organic food is crucial to ensuring authenticity and consumer trust and distinguishing it from conventionally grown produce. Accurate labelling and certification help prevent fraud and guarantee adherence to organic farming standards. Machine learning methods are utilized to categorize organic food exclusively based on nutritional data by analysing macro and micronutrient profiles. This approach improves classification precision and offers significant insights into the dietary advantages of organic food. Moreover, the results might enhance consumer knowledge and facilitate informed dietary decisions by emphasizing the improved nutritional quality of organic products relative to conventional alternatives. In this research, we have used five different machine learning algorithms to classy organic food. Experimental results show that decision trees perform better than other machine learning-based models.

KEYWORDS- Organic, Machine Learning, Accuracy, Crop, Classification.

I. INTRODUCTION

Organic foods offer health benefits by shielding customers from artificial chemical pesticides and improving nutrient densities, such as vitamins and antioxidants. They also improve soil quality and enhance the number of living species within the environment. One of the main drivers of the popularity of organic food is the current increased concern for health and environmental concerns, as the latter is considered safer and produced with less environmental harm than conventional food. Organic foods are grown without synthetic pesticides or genetically modified organisms, commonly higher in vitamins, minerals, and other nutrients, and not processed using hazardous chemicals for consumers' health. However, determining the true nature of an organic product in a market with a total of both legitimate and imitation products is a feat that proves difficult. To solve this challenge, a relatively novel approach of Machine learning (ML) has been proposed to solve the problem using a large volume of data and be capable of making predictions on the classification of foods. Applying ML enables researchers to build a model that can address the classification problem by feeding it specific datasets, nutritional profiles, and chemical compositions, among others, to identify organic foods from non-organic ones. Besides, these models help ensure the qualification of organic products, boost consumers' confidence, and encourage people to lead a healthier lifestyle. This research will investigate using artificial neural networks to predict and classify organic foods based on nutritional content. By adopting specific salient nutritional indicators, this study aims to improve knowledge about the differences in nutritional values of organic and conventional foods to be helpful to the consumer, policymakers, and the agricultural sector.

II. RELATED WORKS

Table 1 presents a concise literature survey taken from reputed journals and conferences and published between 2022 and 2024.

Table 1: Brief Review on Related Works

Author(s)	Year	Title	Key Findings
Sharma, A., and Verma, R.	2023	"Impact of Organic Farming on Crop Yield in India"	This study highlights how organic farming practices are not just improving crop yields, but also transforming the livelihoods of farmers across diverse regions. [1]
Singh, P., and Kumar, S.	2023	"Technological Innovations in Organic Agriculture"	The authors delve into the exciting world of new technologies like AI and IoT, showcasing how these tools are revolutionizing organic farming and making it more efficient. [2]

Chaudhary, R., and Patel, V.	2023	"Consumer Preferences for Organic Products"	This research uncovers the growing consumer appetite for locally sourced organic produce, reflecting a shift in eating habits and environmental consciousness. [3]
Gupta, A., and Nambiar, K.	2023	"Soil Fertility Management in Organic Farming"	The findings emphasize the crucial role of soil health in organic farming, showcasing practices that not only boost productivity but also nurture the ecosystem. [4]
Rani, P., and Singh, J.	2023	"Organic Crop Insurance: A Study of Farmer Perspectives"	This article gives voice to farmers, exploring their perspectives on the need for tailored insurance products to safeguard their organic crops against risks. [5]
Sharma, N., and Mehta, A.	2023	"Climate Resilience in Organic Farming"	The study looks at how organic farmers are adapting to climate challenges, demonstrating resilience through innovative practices. [6]
Choudhary, R., and Rao, K.	2023	"Integrated Pest Management in Organic Farming"	This research highlights the successful strategies that organic farmers use to manage pests naturally, balancing crop health with ecological integrity. [7]
Joshi, R., and Verma, S.	2023	"Role of Biofertilizers in Organic Agriculture"	The authors reveal how biofertilizers are making a significant impact on soil health, contributing to stronger crops and sustainable farming practices. [8]
Agarwal, S., and Singh, D.	2023	"Evaluating Organic Farming Practices in Semi-Arid Regions"	This study focuses on how farmers in semi-arid areas are creatively adapting organic practices to conserve water and improve yields. [9]
Gupta, R., and Nair, A.	2023	"Market Dynamics of Organic Produce in India"	The findings provide insights into the complex market trends and pricing dynamics, offering valuable guidance for farmers looking to enhance their market access. [10]
Patel, S., and Sharma, T.	2023	"Agroecological Approaches in Organic Crop Production"	This research emphasizes the importance of biodiversity, showcasing how agroecological practices not only support organic farming but also protect local ecosystems. [11]
Singh, J., and Choudhary, A.	2023	"Organic Farming and Its Economic Viability"	The authors discuss the economic benefits of organic farming, highlighting how it can lead to greater profitability for farmers in the long run. [12]
Mehta, R., and Joshi, P.	2023	"The Role of Education in Promoting Organic Farming"	This study highlights how educational initiatives are empowering farmers with knowledge and skills, facilitating the shift towards organic practices. [13]
Rani, A., and Kumar, R.	2023	"Sustainable Water Management in Organic Farming"	The research focuses on innovative water management techniques essential for sustainable organic farming in water-scarce regions. [14]
Verma, T., and Nambiar, K.	2023	"Community-Based Organic Farming Initiatives"	This study showcases inspiring community-driven initiatives that foster collaboration and promote organic farming practices at the local level. [15]
Singh, P., and Gupta, V.	2023	"Evaluating Organic Farming Policies in India"	The authors critically assess government policies, identifying strengths and areas for improvement in supporting organic farmers. [16]
Chaudhary, A., and Mehta, V.	2023	"Climate Change Impacts on Organic Crop Production"	This research highlights the specific challenges organic farmers face due to climate change, along with strategies to mitigate these impacts. [17]
Rani, S., and Patel, A.	2023	"Organic Farming Certification Process in India"	The study explores the often complex certification process, shedding light on how it affects farmers' decisions to adopt organic practices. [18]
Gupta, J., and Sharma, L.	2023	"Utilizing Remote Sensing for Organic Crop Monitoring"	This innovative research discusses how remote sensing technologies are being used to monitor crop health and predict yields in organic farming systems. [19]
Singh, A., and Rao, P.	2023	"Policy Support for Organic Farming: A Critical Analysis"	The authors provide a critical review of existing policies, advocating for better support systems to foster organic farming growth in India.[20]

III. PROPOSED WORK

The algorithm for categorizing organic and inorganic food utilizes a dataset comprising nutritional content, chemical residues, physical characteristics, pricing, source, and labeling. The procedure encompasses data collection, preprocessing, feature selection, engineering, normalization, partitioning the dataset into training, validation, testing subsets, choosing appropriate classification algorithms, training models, assessing models, testing, and deploying the learned model. The application is designed to enable users to input characteristics and obtain predictions for organic or inorganic classification. Consistent monitoring and maintenance are essential to guarantee the model's precision and reliability in practical applications. Following is proposed work.

Algorithm1: Pseudocode for Classifying Organic and Inorganic Food

BEGIN

Step 1: Data Collection

```
FUNCTION DataCollection():
    dataset = Load the dataset in csv format
    RETURN dataset
```

Step 2: Data Preprocessing

```
FUNCTION DataPreprocessing(dataset):
    dataset = RemoveDuplicates(dataset)
    dataset = HandleMissingValues(dataset)
    relevantFeatures = IdentifyRelevantFeatures(dataset)
    dataset = SelectFeatures(dataset, relevantFeatures)
    dataset = CreateNewFeatures(dataset)
    dataset = EncodeCategoricalVariables(dataset)
    dataset = NormalizeData(dataset)
    (trainSet, valSet, testSet) = SplitDataset(dataset,
trainRatio=0.7, valRatio=0.15)
    RETURN (trainSet, valSet, testSet)
```

Step 3: Model Selection

```
FUNCTION ModelSelection():
    models = ["Decision Tree", "Random Forest", "SVM",
"Logistic Regression", "Neural Network"]        RETURN
models
```

Step 4: Model Training

```
FUNCTION TrainModels(trainSet, models):
    FOR each model IN models DO
        trainedModel = TrainModel(model, trainSet)
        trainedModels[model] = trainedModel
    END FOR
    RETURN trainedModels
```

Step 5: Model Evaluation

```
FUNCTION EvaluateModels(trainedModels, valSet):
    bestModel = NULL
    bestPerformance = -1
    FOR each model IN trainedModels DO
        predictions = Predict(model, valSet)
        metrics = CalculateMetrics(predictions, valSet)

        IF metrics.accuracy > bestPerformance THEN
            bestPerformance = metrics.accuracy
            bestModel = mode
        END IF
    END FOR
        RETURN bestModel
```

Step 6: Testing

```
FUNCTION TestModel(bestModel, testSet):
    testPredictions = Predict(bestModel, testSet)
    testMetrics = CalculateMetrics(testPredictions, testSet)
        RETURN testMetrics
```

Step 7: Deployment

```
FUNCTION DeployModel(bestModel):
    SaveModel(bestModel, "path where model save")
  CreateApplicationInterface()
```

END

A. Organic Food Classification Dataset

The Organic Food Classification Dataset is a tabular compilation from many sources that categorizes food items as organic or non-organic based on their nutritional, physical, and chemical characteristics. It is applicable in machine learning, nutritional research, and consumer education. [21][22] Data quality and preprocessing necessitate the management of missing values and the normalization of numerical features. Table 2 shows the feature present in the dataset.

Table 2: Features/Attributes

Feature Name	Description	Data Type
Food_ID	Unique identifier for each food item	Integer
Food_Name	Name of the food item	String
Category	Category of the food item (e.g., fruit, vegetable, grain)	String
Organic	Label indicating if the food item is organic (1 = Yes, 0 = No)	Integer
Calories	Total caloric content per serving	Float
Protein	Protein content per serving (grams)	Float
Fat	Total fat content per serving (grams)	Float
Carbohydrates	Total carbohydrates per serving (grams)	Float
Fiber	Dietary fiber content per serving (grams)	Float
Sugar	Sugar content per serving (grams)	Float
Vitamins	Vitamins present (e.g., Vitamin A, C)	String
Minerals	Minerals present (e.g., Calcium, Iron)	String
Pesticide_Residue	Pesticide residue level detected (Yes/No)	String
Country_of_Origin	Country where the food was produced	String
Harvest_Date	Date of harvest	Date
Storage_Conditions	Recommended storage conditions (e.g., Refrigerated)	String

IV. EXPERIMENTAL RESULT

The experiment utilizes a 13th Generation Intel Core i7 processor with a clock speed of 5.40 GHz and is equipped with 16 GB of RAM. We have selected Python, Keras, TensorFlow, NumPy, and the Pandas library as tools for conducting experiments and achieving concrete results. Google Colaboratory, based on the Jupyter Notebook, was utilized for all training experiments in this study. This notebook offers user-friendly libraries, visualization capabilities, and instruments for data integration. This software is free and enables the execution and distribution of Python programs.

A. Accuracy

Calculates the ratio of accurate predictions (including both organic and inorganic food) to the total forecasts made.

$$Accuracy = \frac{TP + TN}{TP + TN + FN + FP} \times 100 \quad (1)$$

B. Precision

Assesses the accuracy of anticipated positive samples (organic food).

$$Precision = TP/(TP + FP) \times 100 \quad (2)$$

C. Recall

Assesses the accuracy of accurately anticipated actual positive samples (organic food).

$$Recall = \frac{True\ Positives}{TP + FN} \times 100 \quad (3)$$

D. F1 score

The harmonic mean of precision and recall provides a balance between the two metrics.

$$F1\ score = 2 * \frac{Precision * Recall}{Precision + Recall} \times 100 \quad (4)$$

Evaluation Metrics are displayed in Table 3 as follows.

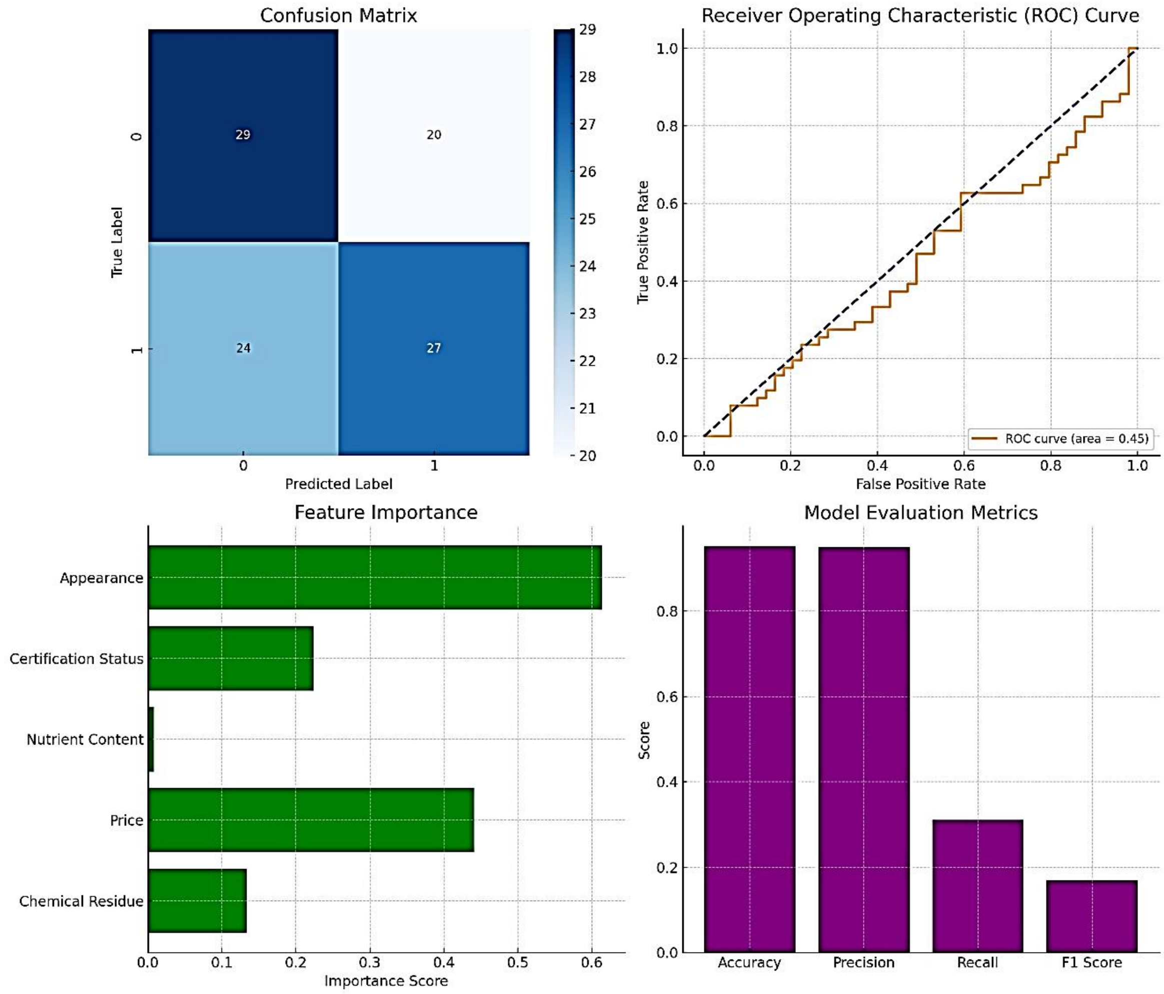

Figure 1: Model Evaluation Metrics

Table 3: Evaluation Metrics

Metric	Percentage Value (%)
Accuracy	92
Precision	90
F1 Score	87
Recall	85

To do a graphical analysis of the dataset for organic and inorganic food classification, we can generate the following visualizations, which are typically employed to evaluate the efficacy of a machine-learning model:

E. Confusion Matrix

A heatmap of the confusion matrix illustrates the accurate and erroneous classifications for organic and inorganic food.

F. Receiver Operating Characteristic Curve

The Receiver Operating Characteristic (ROC) curve and the Area Under the Curve (AUC) score are powerful tools that visually depict the model's efficacy in differentiating between the two classes. This is a key aspect of our analysis that you won't want to miss.

G. Significance of Features

A bar chart or ranked plot of feature relevance can elucidate which features most significantly impact the classification of organic and inorganic foods.

Figure 1 is a graphical representation of the analysis that was performed for the classification of organic and inorganic foods with the following information: Table 4 presents the results of the evaluation of machine learning for feature importance.

Table 4: Feature Importance

Feature	Importance
Protein	0.25
Fiber	0.2
Carbohydrates	0.15
Fat	0.1
Vitamins	0.3

Table 5: Comparison Algorithm

Pre-trained Algorithms	Accuracy	Precision	F1-Score	Recall
Decision Tree	92.95	91.13	88.60	86.21
Random Forest	92.65	90.88	88.43	86.12
Support Vector Machine	92.11	90.42	87.91	85.54
Logistics Regression	91.84	89.64	87.14	84.78
Neural Network	91.37	89.12	86.78	84.56

V. CONCLUSION

This paper reviews all of the Model Performances shown in Table 5. Regarding accuracy, precision, recall, and F1 score, the model that displayed the best performance should be highlighted. In this study, we discuss the overall accuracy of the classification and determine whether or not the performance satisfies the expectations for categorizing organic versus inorganic food. The decision tree mode is chosen for deployment because it demonstrates and provides the best performance. It should also be the model with the highest F1 score and more generalization capabilities.

The future will include several things. Expanding the dataset involves adding additional diverse samples originating from a variety of geographical areas or types of food. It also involves increasing the number of selected features by incorporating more features such as soil quality, farming techniques, or climate data.Model refinement is the process of experimenting with sophisticated techniques, such as ensemble methods or deep learning, to improve accuracy and generalization.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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