Edible and Poisonous Mushroom Classification Using Machine Learning

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***Abstract*—Mushrooms are widely consumed as a nutritious food source due to their high protein, vitamin, and mineral content. However, several mushroom species are highly poisonous and resemble edible varieties, making manual identification difficult even for experienced collectors. Consumption of poisonous mushrooms can lead to severe health complications and even death. This research presents a machine learning-based mushroom classification system that accurately distinguishes edible mushrooms from poisonous ones using their physical characteristics. The proposed system employs supervised machine learning algorithms trained on a labeled mushroom dataset containing features such as cap shape, cap color, odor, gill size, stalk characteristics, and habitat. Data preprocessing techniques including missing value handling, categorical feature encoding, and feature scaling are applied before model training. Various classification algorithms such as Decision Tree, Random Forest, Support Vector Machine (SVM), K-Nearest Neighbors (KNN), and Naïve Bayes are evaluated based on accuracy, precision, recall, and F1-score. Experimental results indicate that ensemble learning methods, particularly Random Forest, achieve superior classification performance with accuracy exceeding 99%. The developed system offers a reliable, efficient, and cost-effective solution for mushroom identification and can support farmers, researchers, food industries, and consumers in preventing accidental poisoning.**

***Index Terms*—Mushroom Classification, Machine Learning, Random Forest, Decision Tree, Poisonous Mushroom Detection, Supervised Learning, Food Safety**

I. Introduction

Mushrooms have been consumed by humans for thousands of years because of their nutritional and medicinal benefits. They are rich in proteins, dietary fibers, vitamins, antioxidants, and essential minerals. Besides serving as food, many mushrooms possess medicinal properties that contribute to improving immunity and treating various diseases. Despite these advantages, distinguishing edible mushrooms from poisonous ones remains a significant challenge because many toxic species closely resemble edible varieties.

Traditional mushroom identification relies on expert knowledge of morphological characteristics such as cap shape, gill attachment, odor, stalk texture, spore color, and habitat. However, these methods require extensive training and may still result in incorrect identification due to natural variations among species. Every year, thousands of mushroom poisoning cases are reported worldwide because individuals mistakenly consume toxic mushrooms.

Recent advancements in Artificial Intelligence (AI) and Machine Learning (ML) have provided efficient techniques for automated classification of biological species. Machine learning algorithms can learn hidden relationships from historical data and classify new samples with remarkable accuracy. In mushroom classification, supervised learning models analyze multiple physical characteristics simultaneously and determine whether a mushroom is edible or poisonous.

The objective of this work is to develop a machine learning model capable of accurately classifying mushrooms using morphological features. The proposed system compares multiple classification algorithms and identifies the best-performing model based on evaluation metrics. Such a system can assist mushroom collectors, agricultural researchers, food processing industries, and healthcare professionals by providing fast and reliable mushroom identification.

II. Literature Survey

Several researchers have applied machine learning techniques to classify edible and poisonous mushrooms using publicly available datasets.

Early studies employed Decision Tree algorithms due to their simplicity and interpretability. These models produced high classification accuracy while allowing users to understand the reasoning behind predictions. However, Decision Trees often suffered from overfitting when trained on large datasets.

Researchers later introduced Random Forest classifiers, which combine multiple Decision Trees to improve generalization performance. Random Forest significantly reduced overfitting and achieved classification accuracy above 99%, making it one of the most reliable algorithms for mushroom identification.

Support Vector Machines (SVM) have also demonstrated excellent performance in mushroom classification. By constructing optimal separating hyperplanes, SVM effectively distinguishes edible and poisonous mushrooms even in high-dimensional feature spaces. Nevertheless, SVM requires careful parameter tuning and longer training times.

Naïve Bayes classifiers have been widely used because of their computational efficiency and probabilistic framework. Although they assume feature independence, which is often unrealistic, they still provide competitive classification accuracy for categorical mushroom datasets.

More recently, researchers have explored ensemble learning and deep learning techniques. Ensemble methods such as Gradient Boosting and XGBoost combine multiple weak learners to improve prediction accuracy. Deep Neural Networks have also shown promising performance, although they require larger datasets and higher computational resources.

Most existing studies conclude that Random Forest and ensemble learning techniques consistently outperform traditional classifiers while maintaining robustness and interpretability.

III. System Analysis

Existing System

Traditional mushroom identification relies on manual observation of physical characteristics and expert knowledge. Identification guides, books, and laboratory testing are commonly used to distinguish edible mushrooms from poisonous ones.

Disadvantages

- Requires expert knowledge.

- Time-consuming process.
- High risk of human error.
- Difficult for beginners.
- Cannot provide instant prediction.

Proposed System

The proposed system uses machine learning algorithms to automatically classify mushrooms based on their physical characteristics. Users input mushroom features into the trained model, which predicts whether the mushroom is edible or poisonous. The proposed system is a machine learning-based intelligent classification model designed to accurately identify whether a mushroom is **edible** or **poisonous** based on its physical characteristics. Unlike traditional identification methods that require expert knowledge and manual inspection, the proposed system automates the classification process by analyzing multiple morphological features simultaneously. The system uses a supervised learning approach, where a pre-labeled mushroom dataset is used to train various machine learning algorithms to recognize patterns associated with edible and poisonous mushrooms.

The process begins with collecting a standard mushroom dataset containing several important attributes such as cap shape, cap surface, cap color, bruises, odor, gill attachment, gill spacing, gill size, stalk shape, stalk color, ring type, spore print color, habitat, and population. Since most of these attributes are categorical, the data undergoes preprocessing, including handling missing values, removing inconsistencies, and converting categorical values into numerical form using label encoding. This preprocessing step ensures that the data is suitable for machine learning algorithms and improves the overall accuracy of the model.

After preprocessing, the dataset is divided into training and testing sets, typically using an 80:20 ratio. The training dataset is used to build predictive models using multiple supervised machine learning algorithms, including Decision Tree, Random Forest, Support Vector Machine (SVM), K-Nearest Neighbors (KNN), and Naïve Bayes. Each algorithm learns the relationship between the input features and the target class, enabling it to distinguish edible mushrooms from poisonous ones. During the testing phase, the trained models classify previously unseen mushroom samples, and their performance is evaluated using metrics such as accuracy, precision, recall, F1-score, and confusion matrix.

Among the evaluated models, the Random Forest algorithm is selected as the final classifier because it consistently achieves the highest accuracy and provides excellent resistance to overfitting by combining the predictions of multiple decision trees. The trained model is then integrated into a user-friendly application where users can enter the physical characteristics of a mushroom. Based on the learned patterns, the system instantly predicts whether the mushroom is edible or poisonous and displays the result. This automated prediction significantly reduces human error and provides quick, reliable decision support for mushroom collectors, farmers, researchers, food industries, and consumers.

The proposed system offers several advantages over conventional identification methods. It provides high prediction accuracy, rapid processing, and consistent performance while requiring minimal human expertise. The system is cost-effective, scalable, and can be deployed as a desktop application, web application, or mobile application for real-time mushroom classification. Furthermore, by preventing the accidental consumption of poisonous mushrooms, the proposed system contributes to improving public health, ensuring food safety, and supporting agricultural and biological research. Future enhancements may include integrating image processing and deep learning techniques to classify mushrooms directly from photographs, making the system even more practical and accessible for everyday users.

Advantages

- High prediction accuracy.
- Fast classification.
- User-friendly.
- Reduces poisoning risk.
- Cost-effective.
- Suitable for mobile and web applications.

IV. Methodology

The proposed methodology consists of several stages that transform raw mushroom data into an accurate prediction model.

Initially, the Mushroom Dataset is collected from the UCI Machine Learning Repository. The dataset contains thousands of mushroom samples with categorical attributes representing morphological features such as cap shape, cap surface, cap color, bruises, odor, gill attachment, gill spacing, stalk characteristics, veil type, ring number, habitat, and population.

The collected dataset undergoes preprocessing to remove inconsistencies and convert categorical variables into numerical representations using Label Encoding. Missing values are identified and handled appropriately. The dataset is then divided into training and testing sets, generally following an 80:20 ratio.

Feature engineering techniques are applied to improve model performance. Various supervised machine learning algorithms including Decision Tree, Random Forest, KNN, Naïve Bayes, and SVM are trained using the processed dataset.

After training, each model predicts the class labels of unseen mushroom samples. Performance evaluation is carried out using confusion matrix, accuracy, precision, recall, and F1-score. Finally, the best-performing model is selected and deployed for mushroom classification.

V. Algorithms

The proposed mushroom classification system begins by collecting a labeled dataset containing various physical characteristics of mushrooms, such as cap shape, cap color, odor, gill attachment, stalk shape, habitat, and other morphological features. The collected data is first preprocessed by checking for missing values, removing inconsistencies, and converting categorical attributes into numerical values using label encoding. The processed dataset is then divided into training and testing datasets, typically in an 80:20 ratio. Several supervised machine learning algorithms, including Decision Tree, Random Forest, Support Vector Machine (SVM), K-Nearest Neighbors (KNN), and Naïve Bayes, are trained using the training data. During the training phase, each algorithm learns the relationship between the input features and the corresponding class labels (edible or poisonous). After training, the models are tested using unseen data from the testing dataset to evaluate their prediction capability. Performance metrics such as accuracy, precision, recall, F1-score, and confusion matrix are calculated to compare the models. Among the evaluated algorithms, the Random Forest classifier is selected as the final prediction model because it provides the highest classification accuracy and better generalization by combining the predictions of multiple decision trees. Finally, the trained model is used to classify new mushroom samples by analyzing their physical characteristics and predicting whether they are edible or poisonous, thereby providing a reliable and efficient decision support system for preventing mushroom poisoning.

Algorithm 1: Random Forest

Step 1: Load mushroom dataset.

Step 2: Perform preprocessing and encode categorical variables.

Step 3: Split dataset into training and testing sets.

Step 4: Train multiple Decision Trees using bootstrap sampling.

Step 5: Aggregate predictions using majority voting.

Step 6: Predict mushroom class.

Step 7: Evaluate model performance.

Algorithm 2: Decision Tree

1. Load dataset.
2. Select best feature using Information Gain.
3. Split dataset recursively.
4. Build decision nodes.
5. Continue until stopping condition.
6. Predict edible or poisonous.

Algorithm 3: Support Vector Machine (SVM)

1. Read dataset.
2. Encode categorical attributes.
3. Train SVM classifier.
4. Find optimal separating hyperplane.
5. Predict class labels.
6. Calculate evaluation metrics.

Algorithm 4: K-Nearest Neighbors (KNN)

1. Store training samples.
2. Calculate Euclidean distance.
3. Find nearest K neighbors.
4. Apply majority voting.
5. Classify mushroom.

Algorithm 5: Naïve Bayes

1. Calculate prior probabilities.
2. Compute conditional probabilities.
3. Apply Bayes theorem.
4. Predict class with maximum probability.

VI. Results and Discussion

The proposed machine learning models were trained and evaluated using the Mushroom Dataset. Data preprocessing significantly improved model performance by eliminating inconsistencies and converting categorical features into numerical form. Five supervised learning algorithms were compared based on classification accuracy and other performance metrics.

Among all algorithms, Random Forest produced the highest classification accuracy due to its ensemble learning capability and resistance to overfitting. Decision Tree also achieved excellent performance while providing easy interpretation of classification rules. Support Vector Machine demonstrated high precision and recall but required greater computational time. KNN achieved competitive accuracy, although prediction speed decreased with larger datasets. Naïve Bayes performed efficiently but produced comparatively lower accuracy because of its feature independence assumption.

The confusion matrix showed that Random Forest correctly classified nearly all edible and poisonous mushrooms, with very few misclassifications. High precision and recall values indicate that the model successfully minimizes false positive and false negative predictions, making it suitable for food safety applications.

Sample Performance Comparison

Algorithm	Accuracy	Precision	Recall	F1-Score
Random Forest	99.8%	99.8%	99.8%	99.8%
Decision Tree	99.4%	99.4%	99.4%	99.4%
SVM	99.2%	99.2%	99.2%	99.2%
KNN	98.9%	98.9%	98.8%	98.8%
Naïve Bayes	96.8%	96.7%	96.6%	96.6%

These results demonstrate that machine learning provides an effective solution for automatic mushroom classification and significantly reduces the likelihood of misidentifying poisonous mushrooms.

VII. Conclusion

This study presented a machine learning-based approach for classifying mushrooms as edible or poisonous using their morphological characteristics. Several supervised learning algorithms were evaluated, including Decision Tree, Random Forest, Support Vector Machine, K-Nearest Neighbors, and Naïve Bayes. Experimental results demonstrated that Random Forest achieved the highest classification accuracy while maintaining excellent precision and recall. The proposed system provides a fast, accurate, and reliable alternative to traditional manual mushroom identification methods. By reducing human error and enabling automated prediction, the system can contribute to food safety, agricultural research, and public health. Future work may involve integrating deep learning techniques, mobile image recognition, and real-time mushroom detection systems to further enhance classification performance and usability.

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