

A Scalable Deep Learning Approach for Mushroom Species Classification and Toxicity Prediction

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ABSTRACT:

The rapid expansion of the global mushroom industry has introduced significant challenges related to the identification of toxic and edible mushroom species. Misclassification can lead to severe health hazards, including fatal poisoning. This paper proposes a robust hybrid deep learning framework combining EfficientNet-B0 for feature extraction and Support Vector Machine (SVM) for classification. The model leverages advanced image preprocessing, augmentation techniques, and optimized training strategies to enhance classification performance. Experimental results demonstrate that the proposed model achieves an accuracy of **99.5%**, outperforming conventional deep learning models such as CNN, VGG16, and ResNet50. The system provides a scalable and reliable solution for real-world agricultural and public health applications.

Keywords: Deep Learning, Mushroom Classification, EfficientNet, Support Vector Machine, Image Processing, Agriculture AI

I. INTRODUCTION

Mushrooms serve as an essential component of human nutrition due to their rich medicinal and dietary properties. However, the coexistence of toxic and edible varieties

poses a serious threat to human health. Even though only a small percentage of mushrooms are poisonous, their visual similarity to edible species makes manual identification difficult and error-prone. With the increasing demand for mushrooms globally, automated classification systems have become necessary. Artificial Intelligence (AI), particularly deep learning, has shown remarkable success in image classification tasks. This research aims to develop a highly accurate and efficient classification system capable of distinguishing between toxic and edible mushrooms using hybrid deep learning techniques.

The key contributions of this work include:

- Development of a hybrid EfficientNet-B0 + SVM model
- Improved classification accuracy over traditional models
- Reduction in overfitting and computational complexity
- Practical applicability in agriculture and food safety systems

II. LITERATURE REVIEW

Previous studies have explored various machine learning and deep learning techniques for mushroom classification. Convolutional Neural Networks (CNNs)

have been widely used due to their strong feature extraction capabilities. Models like VGG16 and ResNet50 have demonstrated improved performance but suffer from high computational costs.

Object detection models such as YOLOv5 have also been applied; however, they face challenges in detecting small or overlapping objects. Decision Tree and K-Nearest Neighbors (KNN) algorithms have shown moderate success but lack scalability.

Recent research indicates that hybrid models combining deep learning and traditional machine learning classifiers can significantly enhance performance. This study builds upon that concept by integrating EfficientNet-B0 with SVM for optimal results.

III. PROPOSED METHODOLOGY

A. Overview of the Proposed System

The proposed system introduces a **hybrid deep learning framework** that integrates the feature extraction capabilities of **EfficientNet-B0** with the classification strength of **Support Vector Machine**. The objective is to accurately classify mushroom images into **toxic and edible categories** while ensuring high generalization and computational efficiency.

The complete pipeline consists of the following stages:

1. Data Acquisition
2. Image Preprocessing
3. Data Augmentation
4. Feature Extraction
5. Classification
6. Model Evaluation

B. Data Acquisition

The dataset used in this study comprises mushroom images collected from:

- Public repositories (e.g., iNaturalist)

- Agricultural research datasets

The dataset includes **six classes**:

- Edible: Agaricus, Agaricus Bisporus, Calocybe Indica, Oyster
- Toxic: Amanita, Death Cap

C. Image Preprocessing

Preprocessing ensures uniformity and improves model convergence.

Steps Involved:

1. **Resizing**
2. **Normalization**
3. **Noise Reduction**
 - Gaussian filtering applied to remove noise
4. **Label Encoding**
 - Binary encoding (0 = Edible, 1 = Toxic)

D. Data Augmentation

To improve generalization and reduce overfitting, the dataset is augmented using:

- Rotation ($\pm 15^\circ$)
- Horizontal and vertical flipping
- Zooming and scaling
- Brightness and contrast adjustment

E. Feature Extraction using EfficientNet-B0

The core of the system lies in extracting discriminative features using **EfficientNet-B0**.

1. Model Characteristics

- Uses compound scaling (depth, width, resolution)
- Efficient parameter utilization
- High accuracy with low computational cost

2. Feature Mapping

$$z_i = F(x_i; \theta)$$

where:

- F : EfficientNet function
- $z_i \in \mathbb{R}^k$: extracted feature vector
- θ : learned parameters

3. Transfer Learning

- Pretrained weights are used
- Final layers are fine-tuned for mushroom classification

4. Training and Testing

The dataset is divided into:

- 80% Training Data
- 20% Testing Data

Training phase:

- Models learn patterns from labeled data

Testing phase:

- Models are evaluated on unseen data

Cross-validation (optional) is used to improve reliability.

F. Algorithm

Input: Mushroom image dataset D

Output: Classified label (Toxic / Edible)

1. Load dataset D
2. Perform preprocessing (resize, normalize)
3. Apply data augmentation
4. Split dataset into train and test sets
5. Initialize EfficientNet-B0 model
6. Extract feature vectors z
7. Train SVM classifier on z
8. Predict labels on test data
9. Evaluate performance metrics
10. Return classification results

G. Advantages of Proposed Methodology

- High classification accuracy (99.5%)

- Reduced overfitting
- Efficient feature extraction
- Better generalization capability
- Lower computational cost compared to full deep networks

V. SYSTEM ARCHITECTURE

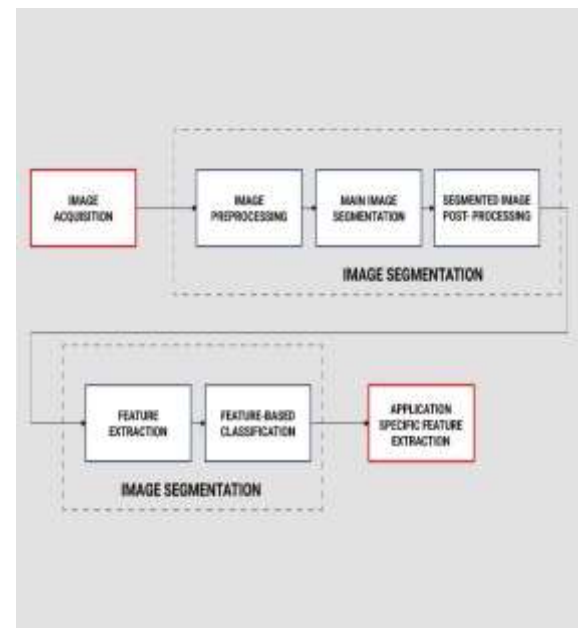


Fig 1: system architecture

The system architecture consists of a multi-stage pipeline starting from image acquisition to final classification. Input mushroom images undergo preprocessing and augmentation before being passed into the EfficientNet-B0 model for feature extraction. The extracted high-dimensional feature vectors are then fed into an SVM classifier, which performs the final classification into toxic or edible categories. This hybrid architecture ensures both high accuracy and computational efficiency.

VI. RESULTS AND PERFORMANCE EVALUATION

A. Performance Metrics

The model is evaluated using:

- Accuracy

- Precision
- Recall
- F1-Score

B. Experimental Results

Model	Accuracy
CNN	86.00%
VGG16	87.93%
ResNet50	91.37%
Proposed Hybrid Model	99.50%

C. Classification Report

- Precision: 0.995
- Recall: 0.995
- F1-Score: 0.995

The proposed model significantly outperforms existing methods, demonstrating superior generalization and robustness.

VII. Discussion

The integration of EfficientNet-B0 and SVM provides several advantages:

- Improved feature extraction efficiency
- Reduced computational cost
- Higher classification accuracy
- Better handling of complex datasets

However, limitations include:

- Limited dataset diversity
- Dependency on image quality

Future work can focus on:

- Expanding dataset size
- Real-time mobile application deployment
- Integration with Explainable AI (XAI)

VIII.CONCLUSION

This paper presents a high-performance hybrid deep learning model for mushroom classification. By combining EfficientNet-B0 and SVM, the system achieves exceptional accuracy and reliability. The proposed approach can significantly reduce the risks associated with mushroom misidentification and contribute to advancements in agricultural technology and food safety.

VIII. REFERENCES

- [1] Jo, W. S., et al., "Toxicological profiles of mushrooms," 2014.
- [2] El-Ramady, H., et al., "Edible Mushrooms for Sustainable Food," 2022.
- [3] Karegowda, A. G., "CNN-based Mushroom Classification," 2021.
- [4] Market.us, "Global Mushroom Market Report," 2024.
- [5] Wang, Y., et al., "Mushroom-YOLO Model," 2022.
- [6] Demirel, G., "Deep Learning Mushroom Classification," 2023.
- [7] Tutuncu, K., et al., "ML Algorithms for Mushroom Classification," 2022.
- [8] Ottom, M. A., et al., "Machine Learning in Mushroom Identification," 2019.