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MUSHROOM CLASSIFICATION SYSTEM: A COMPREHENSIVE REVIEW

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ABSTRACT

Mushroom classification has become an important area of research due to the increasing demand for accurate identification of edible and poisonous mushroom species. Traditional identification methods rely on expert knowledge and morphological characteristics, making the process time-consuming and susceptible to human error. Recent advancements in artificial intelligence, machine learning, and deep learning have significantly improved the accuracy and efficiency of mushroom classification systems. This review presents a comprehensive analysis of conventional and intelligent mushroom classification approaches reported in recent literature. Various image processing techniques, feature extraction methods, and classification algorithms, including Support Vector Machine (SVM), Decision Tree (DT), Random Forest (RF), k-Nearest Neighbors (k-NN), Artificial Neural Networks (ANN), and Convolutional Neural Networks (CNN), are examined. Publicly available mushroom datasets and evaluation metrics such as accuracy, precision, recall, and F1-score are also discussed. Furthermore, the review highlights current challenges, including dataset imbalance, environmental variations, and real-time deployment issues, while identifying future research opportunities involving explainable artificial intelligence, lightweight deep learning models, and mobile-based mushroom recognition systems. This review provides researchers with a consolidated understanding of recent developments and emerging trends in automated mushroom classification.

Keywords: Mushroom Classification, Machine Learning, Deep Learning, Image Processing, Computer Vision, Convolutional Neural Network.

I. INTRODUCTION

The Mushrooms are a diverse group of fungi that play a significant role in ecological balance, agriculture, medicine, and food production. Thousands of mushroom species exist worldwide, with only a small proportion considered edible, while many species are poisonous or toxic to humans. Accurate identification of mushroom species is therefore essential to ensure food safety, biodiversity conservation, and commercial cultivation. Traditional mushroom identification depends primarily on experienced taxonomists who analyze physical characteristics such as cap shape, gill structure, stem morphology, color, spore prints, odor, and habitat. Although these methods are effective, they require specialized knowledge and extensive field experience, making them unsuitable for non-experts.

Advances in computer vision and artificial intelligence have transformed biological classification systems by enabling automated identification from digital images. Machine learning algorithms can learn discriminative patterns from extracted features, whereas deep learning models automatically learn hierarchical visual representations directly from images. These intelligent techniques have demonstrated remarkable success in identifying mushroom species with high classification accuracy while reducing manual effort and subjective interpretation.

Recent studies have explored various computational approaches for mushroom classification, including traditional image processing, feature engineering, supervised learning, ensemble learning, and deep convolutional neural networks. Public datasets and improved computational resources have further accelerated research in this domain. Modern classification systems not only distinguish edible and poisonous mushrooms but also classify multiple species under varying environmental conditions.

Despite considerable progress, several challenges remain. Variations in lighting conditions, background complexity, occlusion, image quality, seasonal changes, and inter-species similarity continue to affect classification performance. Additionally, limited availability of balanced datasets for rare mushroom species restricts the generalization capability of many learning algorithms.

The primary objective of this review paper is to present a comprehensive overview of mushroom classification systems developed using conventional image processing, machine learning, and deep learning techniques. The review summarizes commonly used datasets, feature extraction methods, classification algorithms, evaluation metrics, current research challenges, and future directions. The paper aims to provide researchers, academicians, and practitioners with an organized understanding of the current state of mushroom classification research and potential opportunities for further investigation.

II. METHODOLOGY

This review paper follows a systematic approach to analyze the recent developments in mushroom classification systems. The primary objective is to identify, compare, and summarize existing research related to the automated classification of mushrooms using image processing, machine learning, and deep learning techniques. The review emphasizes classification accuracy, computational efficiency, datasets, feature extraction methods, and challenges associated with different approaches.

A. Review Methodology

The literature survey was conducted by collecting research articles from reputed scientific databases, including IEEE Xplore, ScienceDirect, SpringerLink, ACM Digital Library, MDPI, and Google Scholar. Research papers published between 2018 and 2025 were primarily considered to ensure that the review reflects recent advancements in mushroom classification technology.

The collected studies were screened based on the following inclusion criteria:

* Research focused on mushroom classification or identification.
* Studies utilizing image processing, machine learning, or deep learning techniques.
* Peer-reviewed journal articles and conference papers.
* Studies reporting quantitative performance metrics such as accuracy, precision, recall, or F1-score.

Articles that did not provide sufficient methodological details or experimental evaluation were excluded from the review.

B. Literature Collection Process

The literature search was performed using combinations of the following keywords:

* Mushroom Classification
* Mushroom Identification
* Computer Vision for Mushroom Recognition
* Deep Learning in Mushroom Classification
* Machine Learning for Mushroom Detection
* Edible and Poisonous Mushroom Recognition
* Convolutional Neural Networks for Mushroom Images
* Fungal Species Classification

The selected publications were carefully analyzed to understand the methodologies, datasets, preprocessing techniques, feature extraction approaches, classification algorithms, and reported experimental results.

C. Review Framework

The overall review framework adopted in this paper consists of the following stages:

1. Identification of relevant literature.
2. Screening based on predefined inclusion and exclusion criteria.
3. Detailed examination of research methodologies.
4. Comparative analysis of machine learning and deep learning models.
5. Evaluation of datasets, feature extraction techniques, and performance metrics.
6. Identification of research gaps and future research opportunities.

This systematic framework ensures that the review presents a comprehensive and unbiased overview of the current state of mushroom classification research.

D. Mushroom Classification Workflow

A generalized mushroom classification system consists of several sequential stages. Although individual studies may differ in implementation, the overall workflow remains similar.

Step 1: Image Acquisition

Digital images of mushrooms are collected using cameras, smartphones, or publicly available datasets. Images may represent multiple species captured under different environmental conditions.

Step 2: Image Preprocessing

Preprocessing improves image quality before feature extraction. Common preprocessing operations include image resizing, noise removal, histogram equalization, color normalization, background removal, and contrast enhancement.

Step 3: Feature Extraction

The informative characteristics of mushroom images are extracted using traditional or deep learning methods. Frequently used features include:

* Shape descriptors
* Color features
* Texture features
* Cap morphology
* Gill characteristics
* Stem dimensions
* Deep convolutional features

Traditional feature extraction methods often employ Histogram of Oriented Gradients (HOG), Local Binary Patterns (LBP), Gray Level Co-occurrence Matrix (GLCM), and Scale-Invariant Feature Transform (SIFT).

Step 4: Classification

The extracted features are supplied to classification algorithms. Commonly used classifiers include:

* Support Vector Machine (SVM)
* Decision Tree (DT)
* Random Forest (RF)
* k-Nearest Neighbors (k-NN)
* Naïve Bayes
* Artificial Neural Networks (ANN)
* Convolutional Neural Networks (CNN)
* Transfer Learning Models (ResNet, EfficientNet, MobileNet, DenseNet)

The classifier predicts the mushroom species or categorizes it as edible or poisonous.

Step 5: Performance Evaluation

The effectiveness of the classification model is evaluated using standard performance metrics such as:

* Accuracy
* Precision
* Recall
* F1-Score
* Confusion Matrix
* ROC Curve
* Area Under Curve (AUC)

These metrics provide a comprehensive assessment of the robustness and reliability of the proposed classification models.

E. Advantages of Automated Mushroom Classification

Automated mushroom classification systems offer several advantages over traditional manual identification methods:

* Faster and more accurate identification of mushroom species.
* Reduced dependency on expert taxonomists.
* Early detection of poisonous mushrooms.
* Support for agricultural and commercial mushroom cultivation.
* Improved biodiversity monitoring and ecological studies.
* Integration into smartphone applications for real-time field identification.
* Potential use in healthcare and pharmaceutical research involving medicinal mushrooms.

The continuous development of deep learning architectures and computer vision technologies is expected to further enhance the accuracy, efficiency, and practical applicability of automated mushroom classification systems.,

III. MODELING AND ANALYSIS

Model # III. MODELING AND ANALYSIS

The development of automated mushroom classification systems has evolved from traditional image processing techniques to advanced deep learning models. The choice of methodology depends on factors such as dataset size, computational resources, feature complexity, and the required classification accuracy. This section reviews the major computational approaches used for mushroom classification and compares their characteristics.

A. Traditional Image Processing Techniques

Early mushroom classification systems relied on handcrafted image features extracted from digital photographs. These methods typically involve preprocessing, segmentation, feature extraction, and classification.

Image Preprocessing

Image preprocessing improves image quality and reduces unwanted variations before feature extraction. Common preprocessing techniques include:

* Image resizing
* Noise reduction using median or Gaussian filters
* Histogram equalization
* Contrast enhancement
* Color normalization
* Background removal
* Edge enhancement

These operations help improve the consistency of input images and increase classification performance.

Image Segmentation

Segmentation isolates the mushroom from the background, allowing the classifier to focus on relevant visual information. Common segmentation techniques include:

* Thresholding
* Otsu's method
* Region growing
* Watershed segmentation
* K-means clustering
* Edge-based segmentation

Accurate segmentation reduces background interference and improves feature extraction.

B. Feature Extraction

Feature extraction converts visual information into numerical descriptors that can be processed by machine learning algorithms.

Frequently used handcrafted features include:

Shape Features

Shape features describe the geometric characteristics of mushrooms, such as:

* Cap diameter
* Stem length
* Stem thickness
* Cap curvature
* Aspect ratio
* Circularity

Color Features

Color is one of the most important characteristics for identifying mushroom species. Common color descriptors include:

* RGB color histogram
* HSV color model
* Mean and standard deviation of color channels

Texture Features

Texture analysis helps distinguish mushroom species with similar shapes but different surface patterns.

Popular texture descriptors include:

* Gray Level Co-occurrence Matrix (GLCM)
* Local Binary Pattern (LBP)
* Gabor filters
* Histogram of Oriented Gradients (HOG)

These handcrafted features are then provided to machine learning classifiers.

C. Machine Learning-Based Classification

Machine learning algorithms classify mushrooms using extracted numerical features. Several supervised learning algorithms have demonstrated promising performance.

Support Vector Machine (SVM)

Support Vector Machine constructs an optimal decision boundary that separates different mushroom classes. It performs well on medium-sized datasets and high-dimensional feature spaces. SVM is widely used because of its robustness and ability to handle nonlinear classification through kernel functions.

Decision Tree (DT)

Decision Trees classify mushrooms by recursively splitting the dataset based on discriminative features. They are simple to interpret and computationally efficient but may suffer from overfitting if not properly pruned.

Random Forest (RF)

Random Forest combines multiple decision trees to improve prediction accuracy and reduce overfitting. It generally performs better than a single decision tree due to ensemble learning and is commonly used in mushroom classification studies.

k-Nearest Neighbors (k-NN)

The k-NN algorithm classifies a mushroom by identifying the most similar samples in the training dataset. Although easy to implement, its computational cost increases with larger datasets.

Naïve Bayes

Naïve Bayes applies probability theory under the assumption of feature independence. It provides fast classification and performs well for structured datasets but may be less effective when feature dependencies are significant.

D. Deep Learning-Based Classification

Deep learning has significantly improved mushroom classification by automatically learning complex visual features from images without manual feature engineering.

Convolutional Neural Network (CNN)

CNN is the most widely used architecture for mushroom image classification. It consists of convolutional layers, pooling layers, activation functions, and fully connected layers that automatically learn hierarchical image features.

Advantages include:

* Automatic feature learning
* High classification accuracy
* Reduced dependence on handcrafted features
* Robust performance under varying imaging conditions

Transfer Learning

Transfer learning enables researchers to use pretrained deep neural networks and fine-tune them for mushroom classification with relatively small datasets.

Frequently used pretrained models include:

* ResNet
* VGG16
* VGG19
* InceptionV3
* DenseNet
* EfficientNet
* MobileNet

Transfer learning reduces training time while improving classification performance.

These datasets differ in terms of image quality, species diversity, and annotation methods, influencing the performance of classification models.

F. Performance Evaluation Metrics

The effectiveness of mushroom classification systems is commonly evaluated using the following metrics:

* Accuracy: Percentage of correctly classified samples.
* Precision: Ability of the classifier to correctly identify positive instances.
* Recall: Ability to detect all relevant positive samples.
* F1-Score: Harmonic mean of precision and recall.
* Confusion Matrix: Displays correct and incorrect classifications for each class.
* Receiver Operating Characteristic (ROC) Curve: Illustrates the trade-off between true positive rate and false positive rate.

These metrics enable objective comparison among different classification techniques.

The evolution from traditional image processing to deep learning has significantly improved the performance of mushroom classification systems. Deep learning models, particularly CNNs and transfer learning architectures, consistently achieve higher accuracy by automatically learning representative image features. Nevertheless, challenges such as dataset imbalance, environmental variability, and computational requirements continue to motivate ongoing research in this field.

IV. RESULTS AND DISCUSSION

The # IV. RESULTS AND DISCUSSION

This review examines recent developments in mushroom classification systems based on image processing, machine learning, and deep learning techniques. The reviewed studies demonstrate a clear transition from conventional feature-based approaches to deep learning models capable of automatically extracting discriminative features from mushroom images. Performance has improved considerably due to advances in neural network architectures, transfer learning, and the availability of larger image datasets.

Traditional machine learning methods such as Support Vector Machine (SVM), Decision Tree (DT), Random Forest (RF), and k-Nearest Neighbors (k-NN) provide satisfactory performance when combined with effective handcrafted features. However, their classification accuracy depends heavily on the quality of feature extraction and image preprocessing. Variations in illumination, background complexity, and morphological similarities between mushroom species can significantly affect their performance.

Deep learning models, particularly Convolutional Neural Networks (CNNs), have become the dominant approach for mushroom classification. Unlike conventional methods, CNNs automatically learn hierarchical image features directly from raw images, reducing the need for manual feature engineering. Furthermore, transfer learning models such as ResNet, DenseNet, EfficientNet, and MobileNet achieve excellent performance even when training datasets are relatively small.

Recent research has also focused on developing lightweight classification models suitable for mobile applications, enabling real-time mushroom identification in natural environments. These systems can assist farmers, researchers, forest officers, and the general public in distinguishing edible mushrooms from poisonous species.

Discussion

The comparative analysis reveals several important observations:

1. Deep learning has become the preferred approach for mushroom classification because it eliminates the need for handcrafted feature extraction and achieves superior classification accuracy.

2. Transfer learning has significantly reduced the computational effort required to train deep neural networks. Pretrained models provide high performance even with limited datasets.

3. Dataset quality has a direct influence on classification performance. Large, balanced, and well-annotated datasets generally produce more reliable models.

4. Image preprocessing remains an important stage, particularly for removing background noise, correcting illumination, and improving feature visibility.

5. Class imbalance continues to be a major challenge because rare mushroom species often have insufficient training samples.

6. Real-world deployment requires classifiers that are robust to varying weather conditions, lighting, camera quality, and viewing angles.

7. Explainable Artificial Intelligence (XAI) is gaining attention because users require understandable explanations for classification decisions, especially when identifying poisonous mushrooms.

8. Mobile-based identification systems are emerging as practical tools for field applications due to improvements in lightweight deep learning architectures.

Research Gaps

Although substantial progress has been achieved, several challenges remain:

* Limited availability of large, publicly annotated mushroom image datasets.
* High similarity among visually related mushroom species.
* Difficulty in recognizing immature or damaged mushrooms.
* Sensitivity to environmental conditions such as lighting and background clutter.
* Limited explainability of deep learning models.
* High computational requirements for advanced neural networks.
* Lack of standardized benchmarking datasets for fair comparison.

Future Research Directions

Future studies may focus on the following areas:

* Development of larger and more diverse mushroom image datasets.
* Integration of multimodal information such as image, habitat, and environmental data.
* Lightweight deep learning models for smartphones and embedded devices.
* Explainable AI techniques to improve user confidence.
* Federated learning approaches for privacy-preserving mushroom recognition.
* Vision Transformer and hybrid deep learning architectures.
* Real-time mushroom classification systems using edge computing and Internet of Things (IoT) technologies.

Overall, the reviewed studies demonstrate that mushroom classification has advanced significantly with the adoption of artificial intelligence and deep learning. Continued research in dataset development, explainable models, and resource-efficient architectures is expected to further improve the accuracy, reliability, and practical usability of automated mushroom classification systems.

V. CONCLUSION

Mushroom classification has emerged as an important research area because of its applications in agriculture, food safety, biodiversity conservation, and healthcare. This review examined the evolution of mushroom classification techniques from traditional image processing methods to advanced machine learning and deep learning approaches. Conventional algorithms such as Support Vector Machine, Decision Tree, Random Forest, and k-Nearest Neighbors have demonstrated satisfactory performance when combined with effective feature extraction methods. However, recent studies indicate that deep learning models, particularly Convolutional Neural Networks and transfer learning architectures, achieve superior classification accuracy by automatically learning discriminative image features.

The review also highlighted the importance of preprocessing, feature extraction, dataset quality, and evaluation metrics in developing reliable mushroom classification systems. Although significant improvements have been achieved, challenges such as class imbalance, environmental variations, limited annotated datasets, and model interpretability continue to affect practical deployment. Emerging technologies including explainable artificial intelligence, lightweight deep learning models, Vision Transformers, and edge computing offer promising directions for future research.

Overall, automated mushroom classification systems have the potential to provide fast, accurate, and reliable identification of mushroom species, supporting researchers, farmers, and the general public in reducing identification errors and improving decision-making. Continued research in intelligent image analysis and artificial intelligence is expected to further enhance the performance and real-world applicability of mushroom classification systems.

VI. REFERENCES

[1] D. Dua and C. Graff, *UCI Machine Learning Repository*, University of California, Irvine, School of Information and Computer Sciences, 2019.

[2] F. Chollet, “Xception: Deep Learning with Depthwise Separable Convolutions,” in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2017, pp. 1251–1258.

[3] K. He, X. Zhang, S. Ren, and J. Sun, “Deep Residual Learning for Image Recognition,” in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2016, pp. 770–778.

[4] M. Tan and Q. Le, “EfficientNet: Rethinking Model Scaling for Convolutional Neural Networks,” in *Proceedings of the 36th International Conference on Machine Learning (ICML)*, 2019.

[5] A. G. Howard *et al.*, “MobileNets: Efficient Convolutional Neural Networks for Mobile Vision Applications,” arXiv:1704.04861, 2017.

[6] G. Huang, Z. Liu, L. Van Der Maaten, and K. Q. Weinberger, “Densely Connected Convolutional Networks,” in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2017, pp. 4700–4708.

[7] A. Krizhevsky, I. Sutskever, and G. E. Hinton, "ImageNet Classification with Deep Convolutional Neural Networks," *Communications of the ACM*, vol. 60, no. 6, pp. 84–90, 2017.

[8] L. Breiman, "Random Forests," *Machine Learning*, vol. 45, no. 1, pp. 5–32, 2001.

[9] C. Cortes and V. Vapnik, "Support-Vector Networks," *Machine Learning*, vol. 20, no. 3, pp. 273–297, 1995.

[10] T. Cover and P. Hart, "Nearest Neighbor Pattern Classification," *IEEE Transactions on Information Theory*, vol. 13, no. 1, pp. 21–27, 1967.

[11] J. R. Quinlan, *C4.5: Programs for Machine Learning*. San Mateo, CA, USA: Morgan Kaufmann, 1993.

[12] F. Pedregosa *et al.*, "Scikit-learn: Machine Learning in Python," *Journal of Machine Learning Research*, vol. 12, pp. 2825–2830, 2011.

[13] I. Goodfellow, Y. Bengio, and A. Courville, *Deep Learning*. Cambridge, MA, USA: MIT Press, 2016.

[14] R. Szeliski, *Computer Vision: Algorithms and Applications*, 2nd ed. Springer, 2022.

[15] I. P. Sari and L. Elvitaria, "Classification of Mushroom Types Based on Digital Image Processing Using Convolutional Neural Network," *Jurnal Mandiri IT*, 2024.

[16] F. A. Prayogi, F. H. Arvianto, D. R. Pratama, and S. Sugiyanto, "Mushroom Classification Using Convolutional Neural Network MobileNetV2 Architecture for Overfitting Mitigation and Enhanced Model Generalization," *Journal of Applied Informatics and Computing*, 2025.

[17] R. N. Bashir, O. Mzoughi, N. Riaz, M. Mujahid, M. Faheem, M. Tausif, and A. R. Khan, "Mushroom Species Classification in Natural Habitats Using Convolutional Neural Networks," *IEEE Access*, vol. 12, pp. 176818–176832, 2024.

[18] A. A. Ahmad, M. A. Johab, and N. Aman, "Explainable Deep Learning Framework for Multi-Species Mushroom Classification Using DenseNet121," in *2025 IEEE 4th International Conference on Robotics, Automation, Artificial Intelligence and Internet of Things (RAAICON)*, 2025.

[19] "Convolutional Block Attention-Based Deep Neural Network for Mushroom Classification," *Discover Artificial Intelligence*, 2025.

[20] "Automated Mushroom Identification Using Convolutional Neural Networks: Performance and Insights," in *Proceedings of the IEEE International Conference on Computing and Communication Technologies*, 2025.

[21] A. Zakeri *et al.*, "M18K: A Comprehensive RGB-D Dataset and Benchmark for Mushroom Detection and Instance Segmentation," arXiv:2407.11275, 2024.

[22] B. Zhang, Y. Zhao, and Z. Li, "Using Deep Convolutional Neural Networks to Classify Poisonous and Edible Mushrooms Found in China," arXiv:2210.10351, 2022.

[23] G. Retsinas, N. Efthymiou, and P. Maragos, "Mushroom Segmentation and 3D Pose Estimation from Point Clouds Using Fully Convolutional Geometric Features," arXiv:2404.12144, 2024.

[24] J. Deng *et al.*, "ImageNet: A Large-Scale Hierarchical Image Database," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2009, pp. 248–255.

[25] A. Paszke *et al.*, "PyTorch: An Imperative Style, High-Performance Deep Learning Library," *Advances in Neural Information Processing Systems (NeurIPS)*, vol. 32, 2019.