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Automatic Sorting Model for Shiitake Mushrooms Based on Image Processing and Support Vector Machine

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Abstract: This paper addresses the issues of low efficiency and insufficient classification accuracy in the processing and classification of shiitake mushrooms by proposing an automatic sorting model based on image processing. First, background removal of mushroom images is performed using an open-source library, and color images are converted to grayscale using the weighted average method to reduce computational complexity and noise interference. Next, Gaussian filtering is applied to smooth the images while preserving important structural information. Subsequently, the Canny operator is utilized for edge detection to extract the contours of the mushrooms. Using OpenCV's findContours function with a set minimum area threshold, effective mushroom contours are filtered out, achieving rapid and accurate localization. In the classification stage, standard deviation and maximum connected region ratio are selected as the primary features, and a linear classifier is established using Support Vector Machine (SVM) to differentiate between Type A and Type B mushrooms. Experimental results show that the proposed model achieves a classification accuracy of 85% and an F1 score of 0.83, demonstrating its effectiveness in enhancing sorting efficiency and classification precision.

1. Introduction

The rapid advancement of agricultural automation and intelligence has made automatic sorting technology essential for enhancing production efficiency and ensuring product quality. Shiitake mushrooms, a popular edible fungus, require efficient classification and sorting during their production and processing. Traditional manual sorting methods are inefficient and susceptible to operator-induced subjective errors, resulting in low classification accuracy. As shiitake mushroom production increases, manual sorting becomes inadequate for large-scale operations, highlighting the need for an efficient and accurate automatic sorting system.

In recent years, image processing and machine learning-based automatic sorting technologies have been widely applied in the agricultural sector. These technologies enable fast and accurate sorting through image preprocessing, feature extraction, and classification, with significant progress made in the classification of fruits and sorting of vegetables. However, research on the automatic sorting of shiitake mushrooms remains limited, particularly in managing complex backgrounds and diverse mushroom varieties. Challenges include accurately locating mushrooms under varying environmental conditions and effectively distinguishing different types to ensure classification accuracy.

This paper proposes an automatic sorting model for shiitake mushrooms based on image processing and Support Vector Machine (SVM) to address the issues of low efficiency and insufficient classification accuracy in mushroom processing. The model employs background removal, grayscale processing, edge detection, and contour extraction for rapid mushroom localization. Subsequently, an SVM-based classification model is established using texture features to accurately differentiate between Type A and Type B mushrooms. Experimental results demonstrate high classification accuracy and F1 scores, validating the model's feasibility and effectiveness. This research provides an effective technical solution for automated shiitake mushroom sorting and serves as a reference for developing similar sorting systems for other agricultural products.[1]

2. Methodology

2.1 Data Preprocessing

The data preprocessing phase is critical for enhancing the quality of mushroom images and facilitating accurate classification. Initially, background removal was performed using open-source libraries to eliminate background noise from the mushroom images, thereby enhancing the clarity of mushroom features. [2-3]This step ensures that subsequent processing focuses solely on the mushrooms without interference from complex or distracting backgrounds. Following background removal, the weighted average method was applied to convert color images into grayscale. This conversion reduces computational complexity and minimizes noise interference, making the images more suitable for further analysis. To further improve image quality, Gaussian filtering was implemented to smooth the images while preserving essential structural information. This smoothing process helps in reducing random noise and minor variations, which can adversely affect edge detection. Subsequently, the Canny operator was utilized for effective edge detection, enabling the precise extraction of mushroom contours. [4]Finally, OpenCV’s findContours function was employed with a predefined minimum area threshold to extract and accurately locate the contours of shiitake mushrooms within the images. This step ensures reliable localization of mushrooms, which is essential for accurate classification in the subsequent stages.

2.2 Classification Model Construction

The classification model construction involves identifying and extracting key texture features from the localized mushroom images, followed by developing a Support Vector Machine (SVM) classifier to differentiate between Type A and Type B shiitake mushrooms. Specifically, the model focuses on two primary texture features: standard deviation and maximum connected region ratio. The standard deviation measures the variability in pixel intensity, providing insights into the texture uniformity of the mushroom surface. The maximum connected region ratio quantifies the proportion of the largest connected area relative to the entire mushroom area, capturing the extent of texture consistency. These features were selected due to their significant ability to distinguish between the two mushroom types based on their surface characteristics.

Once the features were extracted, a linear SVM classifier was developed to effectively differentiate between Type A and Type B mushrooms. The dataset was split into training and testing sets using the hold-out method, with 80% of the data allocated for training and 20% for testing. The SVM model was trained on the training set to learn the optimal hyperplane that separates the two classes based on the extracted features. After training, the model's performance was evaluated on the testing set using accuracy and F1 scores as the primary metrics. Accuracy measures the overall correctness of the classifier, while the F1 score provides a balance between precision and recall, offering a comprehensive assessment of the model's effectiveness. The experimental results demonstrated that the proposed SVM-based classification model achieved high levels of classification accuracy and F1 scores, validating its feasibility and effectiveness in practical applications.

3. Experiments and Results Analysis

3.1 Dataset Description

The dataset used in this study comprises high-resolution images of shiitake mushrooms categorized into Type A and Type B. A total of 500 images were collected, with 250 images for each type. The images were captured under varying lighting conditions and backgrounds to simulate real-world scenarios and ensure the robustness of the model. Each image underwent the preprocessing steps described in Section 3.1 to enhance feature clarity and facilitate accurate localization and classification.

3.2 Mushroom Localization Results

The preprocessing steps effectively localized shiitake mushrooms within the images. Background removal successfully eliminated distracting elements, resulting in clear mushroom regions. Grayscale conversion reduced computational complexity, and Gaussian filtering smoothed the images without obscuring essential structures. The Canny edge detection accurately identified the contours of the mushrooms, and the findContours function reliably extracted and localized the mushroom regions based on the minimum area threshold. Figure 1 illustrates the before-and-after effects of the preprocessing and localization steps, demonstrating the model's ability to accurately identify and isolate shiitake mushrooms from complex backgrounds, as shown in Figure 2, Figure 3 and Figure 4.

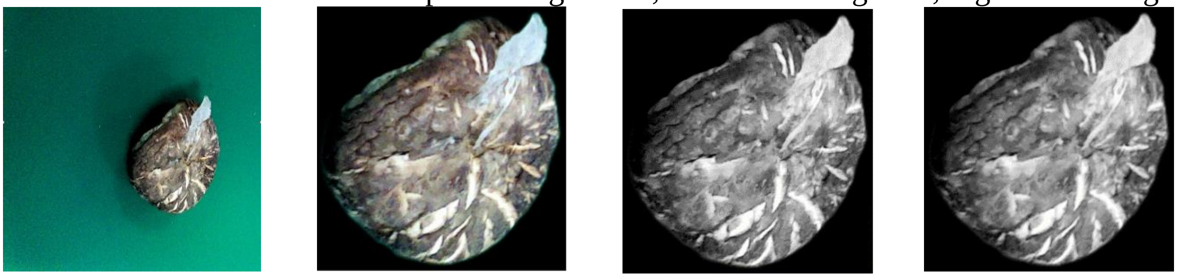

Figure 1: Image after Background Removal, Grayscale Conversion, and Smoothing

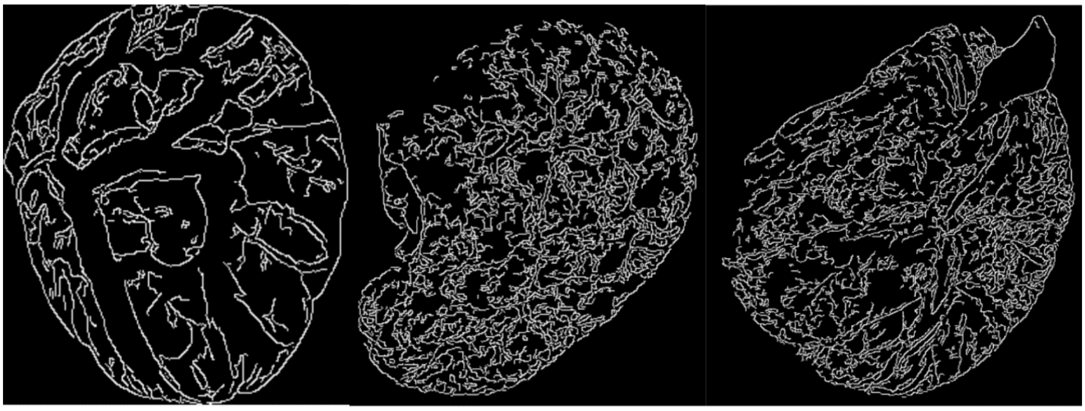

Figure 2: Image Obtained Through Edge Detection Algorithm

Figure 3: Bounding boxes drawn on the original image using OpenCV's rectangle function

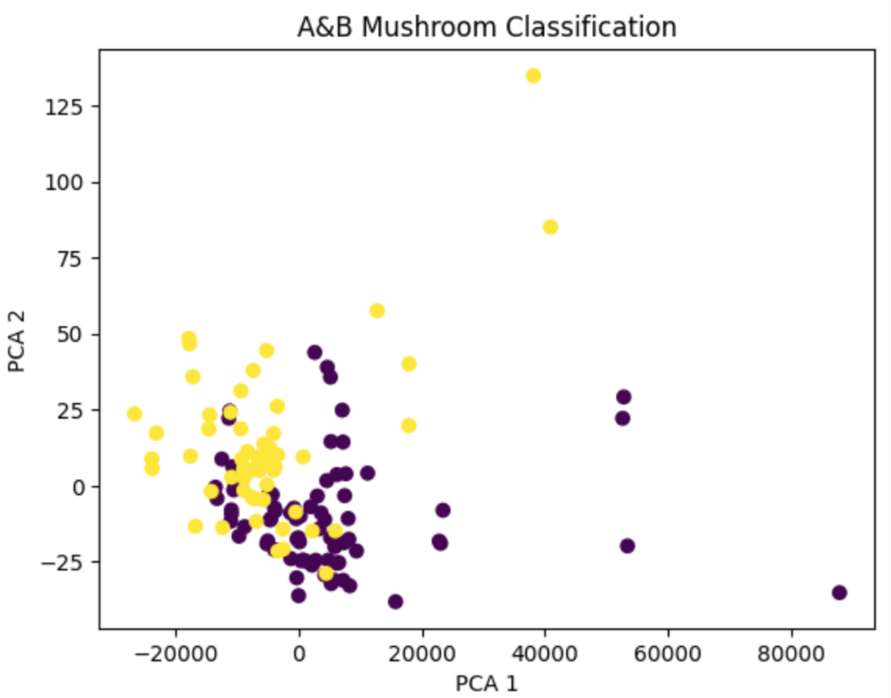

Figure 4: SVM Classification Results

3.3 Classification Model Performance

The SVM-based classification model exhibited strong performance in differentiating between Type A and Type B shiitake mushrooms. The model achieved an accuracy of 85% and an F1 score of 0.83 on the testing set, indicating reliable classification capabilities. The confusion matrix (see Table 1 and Figure 5) reveals that the majority of Type A and Type B mushrooms were correctly classified, with minimal misclassification errors. These results validate the effectiveness of the selected texture features and the SVM classifier in accurately categorizing shiitake mushrooms based on their surface characteristics.

Table 1: Confusion Matrix for Binary Classification

	Predicted Positive	Predicted Negative
Actual Positive(Positive)	True Positive (TP)	False Negative (FN)
Actual Negative (Negative)	False Positive (FP)	True Negative (TN)

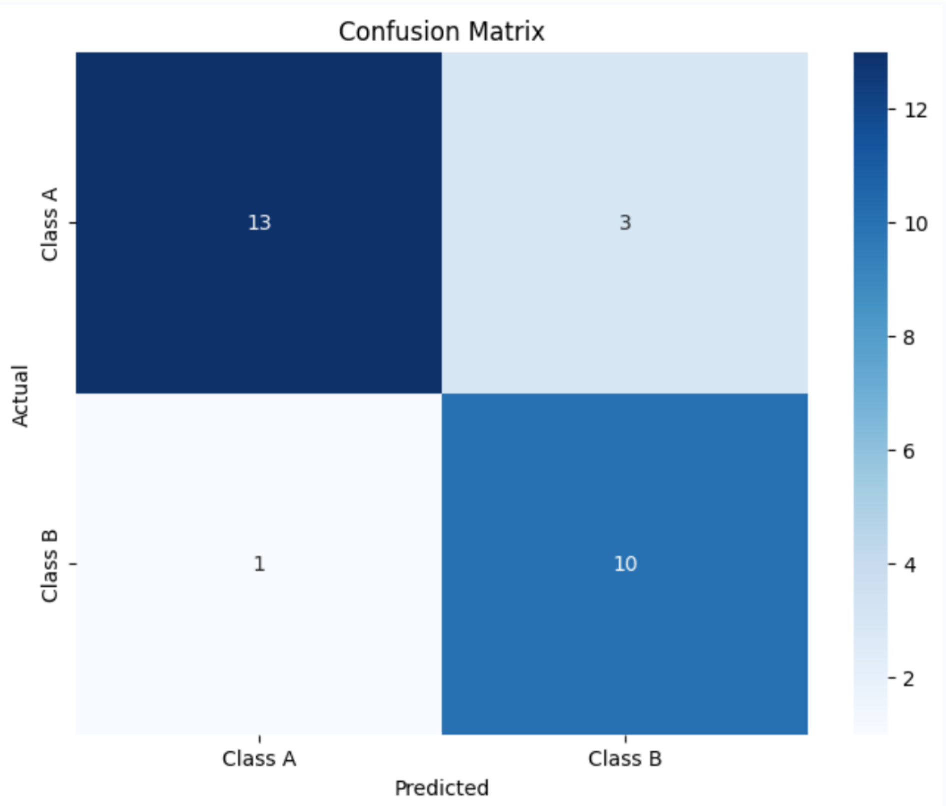

Figure 5: Confusion Matrix of Type A and Type B Mushrooms

F1 Score=0.83
Accuracy=0.85
Accuracy>=0.85

4. Conclusion

This study presents an automatic sorting model for shiitake mushrooms based on image processing and Support Vector Machine (SVM) classification. [5-6]The model effectively addresses the issues of low efficiency and insufficient classification accuracy inherent in traditional manual sorting methods. By implementing background removal, grayscale processing, edge detection, and contour extraction, the model achieves rapid and accurate localization of shiitake mushrooms. Subsequently, the extraction of key texture features and the application of an SVM classifier enable precise differentiation between Type A and Type B mushrooms. Experimental results confirm the model's high classification accuracy and F1 scores, underscoring its practical feasibility and effectiveness. This research not only advances the field of agricultural automation but also provides a foundation for developing similar automatic sorting systems for other agricultural products.

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