Automated Classification of High-Grade Dried Shiitake Mushrooms Using Machine Learning

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Abstract

This study aims to automate shiitake mushroom sorting using an anomaly detection system with Autoencoders (AE) trained on acceptable product data. Initial experiments using CNN approaches highlighted challenges in achieving high accuracy for acceptable product classification, necessitating improvement. The AE-based approach showed progress in detecting defective products via data cleansing, augmentation, and training optimization. However, misclassification of acceptable products with features like darker areas or complex textures remains an issue. This presentation outlines current findings and strategies, including data expansion and model improvements, to address these challenges.

Keywords: Autoencoders (AE), Convolutional Neural Networks (CNN), Model Optimization, Shiitake Mushrooms

1. Introduction

Sorting tasks of shiitake mushrooms have long relied on the experience of skilled workers. However, due to aging and labor shortages, there is a strong demand to improve efficiency and automate the sorting tasks traditionally performed by humans. Specifically, the visual evaluation of shiitake mushrooms, based on attributes such as color and shape, has been challenging to automate due to the ambiguous and subjective nature of sorting criteria.

This study, conducted in collaboration with Sugimoto Shoten in Takachiho Town, Miyazaki Prefecture, aims to develop an automatic discrimination system using machine learning. The study focused on addressing the following two challenges:

Data Scarcity and Bias: How to utilize limited data, especially given the difficulty of collecting defective product data.

Improving Identification Accuracy: Designing algorithms capable of handling the variability and complexity inherent to natural objects.

2. Environment

In this study, the following environment was used:

Hardware:
CPU: Intel Core i7-11800H
GPU: NVIDIA RTX3050Ti
RAM: 16GB

Software:
Anaconda(Python/Jupyter Notebook)
Google Colaboratory

Library:
OpenCV: For data preprocessing (background removal, noise reduction)
PyTorch: For model construction and training
Scikit-learn: For statistical analysis and evaluation

In this study, we divided the time-consuming training tasks between Anaconda for the training phase and Google Colaboratory for execution. This approach distributed the high-load processing tasks, ensuring stable execution. Additionally, given the extensive use of images, we constructed an efficient data pipeline for image processing and machine learning, automating data augmentation and cleansing processes.

3. Research Methods

3.1 Data Collection and Preparation

In this study, shiitake mushroom samples were collected from Sugimoto Shoten as follows:
Good Quality Data: 3,564 images
Defective Data: 864 images
To address the data scarcity, data augmentation techniques such as rotation, scaling, and noise addition were applied, resulting in more than doubling the total data volume.

3.2 Data creasing

Using OpenCV, we removed the background[1] and applied a process to emphasize the shape of the shiitake mushrooms. During the process, there were instances where the background was not properly removed and excessively adapted to the background. For complex background data, manual corrections were made to minimize the impact of noise (Fig.1, Fig.2).

Fig.1 Before image

Fig.2 After Data Cleansing
(Background Removal)

3.3 Model Design and Training Process

Autoencoder (AE):
The AE[2] is a method that learns only good quality data and detects anomalies based on reconstruction errors. Specifically, the model was constructed through the following steps:

1. Use good quality images as input data.
2. Calculate the mean and variance of reconstruction errors to set the identification threshold.
3. If the reconstruction error exceeds the threshold, the item is determined to be defective.

Convolutional Neural Network (CNN):
For the CNN, we utilized labeled data with annotations and conducted supervised learning. The following elements were incorporated:

1. Applied weighting to each layer of data to reduce bias.
2. Added preprocessing steps such as edge detection to emphasize features of defective items (e.g., color irregularities, shape anomalies).

3.4 Improvement Process

To mitigate misclassification due to data bias and insufficient training, the following improvements were implemented (Fig.3):

1. Increased the number of training iterations from 30 to 100, and then to 500, to analyze the effects of overfitting.
2. Focused data augmentation on misclassified data to enhance the model's generalization performance.
3. Utilized Google Collaboratory to enable high-precision computational processing.

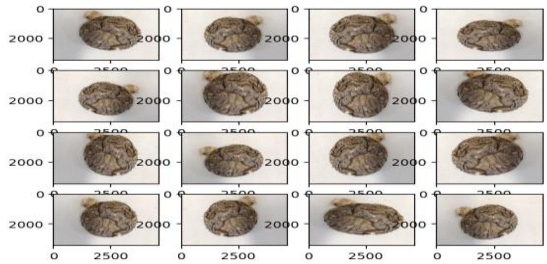

Fig3 Examples of Data

4 Results

This time, we were able to conduct up to four rounds. We reviewed up to three rounds, and in the fourth round, we decided to check the output results of overfitting.
Below are the details of the results and improvements.

First Trial:
Accuracy: Good Quality 20%, Defective 10%
Issues: Misclassifications frequently occurred due to the mixture of front and back images (Fig. 4, Fig. 5). Additionally, there were many backgrounds present (Fig. 4), leading to the hypothesis that the model excessively adapted to the background.

Fig.4 front image

Fig.5 back image

Improvement: Limited to front images and manually removed the background (Fig. 6, Fig. 7).

Fig.6 Images with a lot of background that couldn't be removed by OpenCV

Fig.7 Manually removed images

Second Trial:
Accuracy: Good Quality 14.68%, Defective 80.59%
Issues: The number of training iterations was limited to around 30, resulting in poor generation similar to the "Reconstructed" images.
Consequently, the reconstruction error values could not be determined, leading to a low classification rate (Fig.8).

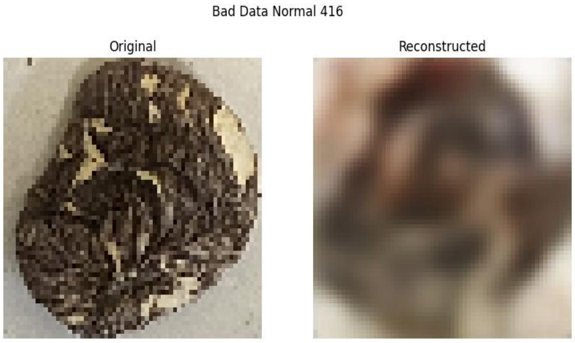

Fig.8 Misclassification of detective items

Improvement: Increase the Number of Training Iterations (Fig.9).

Third Trial:
Accuracy: Good Quality 24.36%, Defective 81.24%
Issues: Dirt on the platform caused noise, leading to misclassifications.
Improvement: Focused on augmenting data that includes dirt and corrected the training bias.

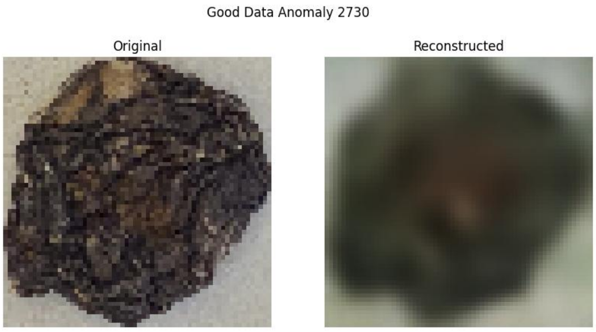

Fig.9 Misclassification of Good Quality Items with High Noise

Fourth Trial:
Accuracy: Good Quality 20.1%, Defective 83.5%
Issues: While overfitting caused color reproduction to deteriorate, the shapes were accurately generated (Fig.10).

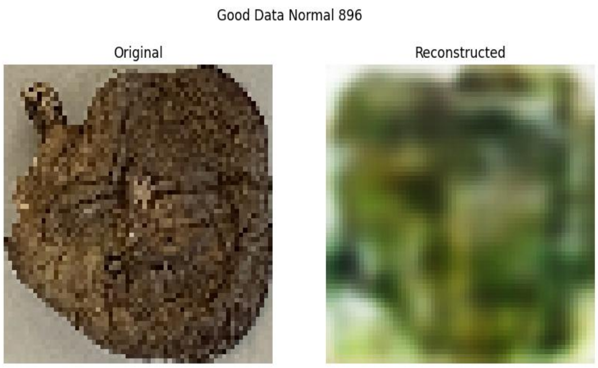

Fig.10 Output Result

Improvement:
By reviewing the output results during overfitting, we recognized the importance of early stopping.

5. Future Work

In the future, we will address the following issues:

Utilization of CNN with Annotations:
By using data labeled with details of defective parts, we aim to improve identification accuracy. We plan to test multiple CNN architectures such as ResNet and EfficientNet.

Enhancement of Data Collection:
We will request video data of good quality products from companies in Takachiho, Miyazaki Prefecture, to create a large-scale dataset. Additionally, we will utilize public datasets to compare identification performance.

Comparison with Other Methods:
We will try methods other than AE and CNN (for example, decision trees and support vector machines) to identify the best model for the specific characteristics of shiitake mushrooms.

The insights gained from this research can be applied to the identification of other natural objects besides shiitake mushrooms, and further development is expected.

6. Conclusion

This paper describes the basic study on automatic sorting of high-quality dried shiitake mushrooms. In the future, we would like to increase the amount of detailed learning data and strive to improve the recognition rate. Finally, this work was supported by JSPS KAKENHI Grant Numbers JP24K0792901 and JP24K15516.

Reference

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Authors Introduction

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She is a master student at Department of Computer Science and System Engineering, University of Miyazaki. His current research interests are image processing, machine learning, and so on.

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Dr. Akihiro Kudo

He received Ph.D. degree from Nagaoka University of Technology He is a professor in the Department of engineering for innovation, National Institute of Technology, Tomakomai college. He is a member of Acoustical society of Japan, Information and Communication Engineers (IEICE).

Mr. Kazuhide Sugimoto

He was Born in Takachiho town, Miyazaki Prefecture. After working in sales in the food service and apparel industries, he joined SUGIMOTO Co., Ltd., a wholesaler of dried shiitake mushrooms produced in Takachiho town, in 2011 after the Great East Japan Earthquake. In response to the current harsh situation, such as aging contract farmers and sluggish demand for dried shiitake mushrooms, he decided to protect the producers by promoting new business development, which he had experienced in sales. New items developed using shiitake mushrooms from Takachiho Township have become a standard item at supermarkets and department stores outside the prefecture. In March 2020, he was appointed as Representative Director, and in 2021, he was selected as a Small and Medium Enterprise Supporter and GFP Ambassador.

Dr. Makoto Sakamoto

He is a professor in the Faculty of Engineering, University of Miyazaki. He is a theoretical computer scientist, and his current main research interests are computer science and information processing.