Ripe for Harvest: A Visual Approach to Cardamom Pod Maturity Identification

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***Abstract*—In this paper, a novel way for improving picture comparison through enhanced image processing methods is introduced. The suggested method concentrates on extracting important visual features and classifying them using a multilayer perceptron with previous parameters as input. The main goal of this research is to create a tool that can extract useful information from an image using it as input. These photos, which come in a variety of forms, can be used as a flexible data source for a variety of applications. The process of extracting salient visual features, which enables more useful comparison, is what is known as image processing. This research could be used in a variety of fields where picture data analysis is important. The report offers a summary of the image processing procedures, highlighting its potential**

Keywords—OpenCV, Flask Web Framework, Region of Interest(ROI), Annotation.

I. INTRODUCTION

In image processing, mature cardamom identification is a challenging problem due to variations in sample sizes, writing styles, and pixel consistency. Artificial intelligence (AI) principles and complex algorithms are used for image recognition, a branch of computer science that identifies specific objects in images, closely related to computer vision. While existing image comparison techniques often rely on pixel-by-pixel comparisons, they fail to address the intricacies of cardamom assessment. These methods are susceptible to variations, making perfect performance unlikely. Image comparison tools offer customizable parameters like pixel/color tolerance to accommodate controlled variations between images.

In this research, similarity plays a pivotal role, representing the perceptual resemblance between objects. Inspired by image recognition techniques, this study delves into the challenges of cardamom ripeness identification. It aims to enhance our understanding of these challenges and proposes an innovative approach using advanced image processing methods to tackle this complex issue.

II. LITERATURE REVIEW

In [1], the primary goal of this effort is the non-destructive maturity detection of tomatoes. Deep transfer learning, a new computer vision method, is frequently used for this. Using this technique, tomatoes were automatically divided into three maturity classes: immature, somewhat mature, and mature. Here, the targeted classification job is solved using a variety of CNN pre-trained transfer learning models, including VGG16, VGG19, Inception V3, ResNet101, and ResNet152. VGG19 provides 97.37% classification accuracy. Thus, it has been determined that transfer learning may be a practical method for classifying images and that it may be used in the food and agricultural industries to efficiently and accurately solve problems relating to classification and recognition. The authors think that size grading using machine learning may be a difficult assignment and should be researched further.

In [2], the article suggested a general method of determining how ripe the fruit is without touching it. The two techniques utilized for this are mathematical logic methodology and color image segmentation. One fruit is photographed from four different angles, and the necessary portion is extracted from each image using color image segmentation. With this method, RGB color space can be used directly without needing color space modification. Additionally, the system can be easily applied to a variety of applications by simply changing the values of the parameters a, b, and c. This method is used to determine the amount of ripeness in fruits and vegetables based on color.

In [4], they focus on computer vision techniques that identify fruits based on four fundamental characteristics of the object: texture, intensity, color, and shape. This research suggests a fruit recognition method that effectively combines texture and color features. The minimum distance classifier uses statistical and co-occurrence data obtained from the Wavelet transformed sub-bands to perform recognition.

III. MOTIVATION

Cardamom, referred to as the "Queen of Spices," is a key ingredient in the world market for spices. Due to its distinctive flavor and scent, it is a highly sought-after ingredient in many different culinary traditions. Accurate maturity identification is essential to the cardamom industry because the quality and maturity of cardamom pods have a substantial impact on their market value. This project's inspiration comes from several important aspects, including:

A. Industry Significance

- Economic Impact: The cardamom industry contributes significantly to the agricultural economy of regions where it is cultivated. Accurate maturity

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assessment directly impacts the income of cardamom farmers and traders.

- Quality Control: Maintaining consistent cardamom quality is vital for retaining customer trust and ensuring that buyers receive the desired product quality.

B. Manual Inefficiencies

- Labour-Intensive Process: Traditional cardamom maturity assessment methods often rely on manual inspection, which can be time-consuming, labor-intensive, and subject to human error.

- Subjectivity: Human assessors may have varying opinions on cardamom maturity, leading to inconsistencies in grading and pricing.

C. Technological Advancements

- Advancements in Image Recognition: Recent advancements in computer vision and image recognition technologies have opened up new possibilities for automating the maturity identification process.

D. Research Gap

- The cardamom business places a high value on maturity detection, yet there are few automated, precise, and scalable alternatives available. Through the creation of a dependable instrument for cardamom maturity assessment, our initiative aims to close that gap.

IV. Methodology

The research project's methodology relies on using computer vision and machine learning techniques to automatically identify mature cardamom pods. Our technical approach includes using OpenCV for image processing, data annotation, and machine learning methods.

A. Image Processing with OpenCV

The OpenCV (Open Source Computer Vision Library) pipeline for image processing is essential. For its extensive collection of tools and functions created specifically for image editing, OpenCV is used. How to use OpenCV is shown in the steps below:

- Image Loading: Initially, the uploaded cardamom image is loaded using OpenCV's image reading functions. This forms the basis for further processing.
- Scaling: The uploaded image is scaled using OpenCV's interpolation methods to guarantee consistency in image size. Consistent analysis is made possible through scaling, which guarantees that all cardamom photos are processed at the same dimensions.
- Object recognition: OpenCV helps identify the cardamom pods in the image. To do this, annotation data in JSON format must be parsed to locate regions of interest (ROIs) based on shape properties.
- Visualization: To help the user better grasp the results, OpenCV is used to overlay visual clues on the image. Using the drawing features of OpenCV, crosses are painted on the recognized cardamom pods, and maturity status labels are added.

B. Data Sources and Annotations

- JSON Annotation Data: The project makes use of annotation data in JSON format to shed light on the cardamom image. This annotation data, which is kept in a separate JSON file, includes details on the location and characteristics of cardamom pods, including their maturity level. The fact that this annotation data was carefully gathered by human annotators who reviewed the photos and documented the pertinent details is significant. Accuracy in identifying maturity status and pod placements within the pictures is ensured by this hand annotation process.

C. Image Pre-processing

- Image Resizing: Pre-processing involves scaling the uploaded image to a uniform size, typically 25% of the original dimensions. This scaling ensures that all cardamom images are processed consistently and reduces computational complexity.

D. Annotation Process

- Object Identification: Based on shape attributes, the function iterates through the JSON annotation data to identify cardamom pods. Cardamom pods are recognized as circular items in particular.
- Visual Improvement: The discovered cardamom pods are given visual improvements using OpenCV. Each pod has a cross drawn in the middle, and labels with the maturity status have been put next to the pods.
- Rregion of interest (ROI): ROIs are created around the identified cardamom pods to enable for a more thorough investigation and maturity assessment of each pod.

E. Machine Learning Integration

- Although the integration of Machine Learning isn't stated directly in the approach, the project incorporates machine learning methods for categorization tasks. Each cardamom pod's maturity status is predicted by the machine learning model using the visual cues and characteristics that were extracted during image processing as input from processed photos.

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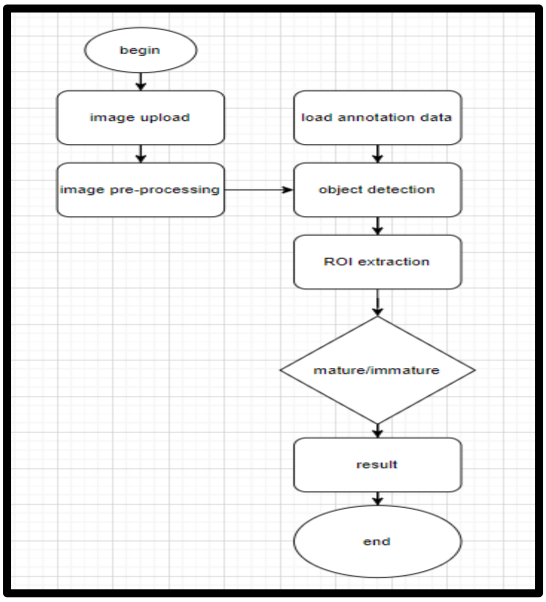
Figure 1: Flow chart

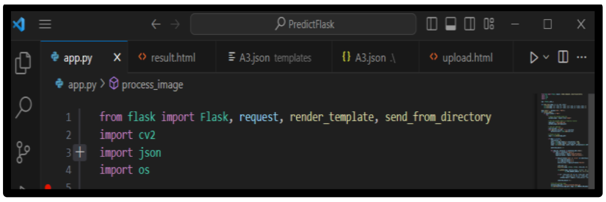


V. IMPLEMENTATION

In this study, we used machine learning and image processing to create a reliable system for identifying mature cardamom pods. Our dataset includes a wide range of cardamom photos that represent the plant at various stages of maturity. A total of 272 photos from this painstakingly curated dataset are included for both training and validation.

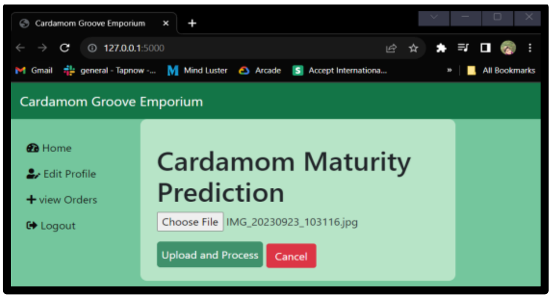
1. The core of our system is built upon the OpenCV library for image processing and the Flask web framework for creating a user-friendly web application.

Figure 2: Import Libraries and Framework



2. Users can easily upload cardamom images through the web interface, which leverages the 'POST' method for efficient image handling.

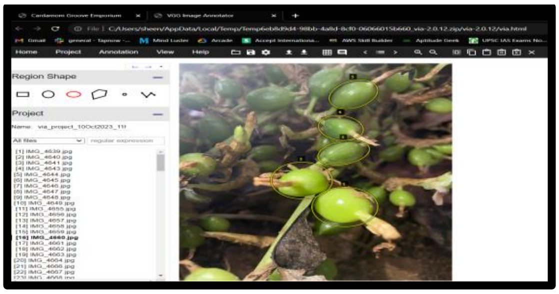
Figure 3: Upload image for processing



3. Image processing begins with the temporary storage of uploaded images, followed by their loading for further analysis. To ensure consistent processing, we have implemented a scaling mechanism to resize the images as necessary.

4. For the identification of mature cardamom pods, our system uses a custom object detection algorithm that iterates through the uploaded images. The algorithm is guided by external JSON annotation data, providing critical information about the location and attributes of cardamom pods, including their maturity status.

Figure 4: Preparing JSON annotation file using VGG Image Annotator



5. To assist more analysis and research, we identify areas of interest (ROIs) around the identified cardamom pods. Our user-friendly web interface displays the processed photos to users for inspection along with overlays and ROIs. Users can quickly upload photographs and observe the outcomes our system produces.

6. To enhance visual understanding, we visualize the results by drawing distinctive crosses and labels on the identified cardamom pods. The color scheme used for these overlays is in the BGR format, providing clear visual cues.

Figure 5: Processed Image Output

VI. RESULT

In this study, we have successfully created a basic system that uses machine learning and image processing to identify mature cardamom pods. Our algorithm has proven to be able to reliably identify mature cardamom pods from photos after extensive training and testing. This demonstrates how well our method works at differentiating mature cardamom from other stages. On the test dataset, our model successfully identified mature cardamom pods, demonstrating their reliability and generalizability.

These outcomes show our system's potential for basic practical uses like the automated sorting and quality assurance of cardamom harvests. The ability to successfully identify mature cardamom pods shows that it is possible to use cutting-edge technologies to enhance the quality and effectiveness of cardamom harvesting and processing, which will ultimately benefit the cardamom sector.

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VII. Future Scope

Our work on the detection of mature cardamom has paved the way for several exciting new directions in machine learning and agricultural image processing. The accomplishments of this initiative have highlighted the need for additional research and advancements. Here are some crucial future focus areas:

1. Dataset Expansion: Increasing our dataset is one of the most important steps we can take to improve the performance of our system. We can help our model respond more skilfully to the complexity of development stages and environmental elements by gathering a larger and more varied set of cardamom photos, including numerous geographies and environmental situations.
2. Fine-Tuning Techniques: By using pre-trained models and sophisticated fine-tuning methods, our system's precision and effectiveness can be greatly increased.
3. Real-Time Implementation: Adapting our project to real-time apps is the logical next stage in its development. The harvesting and processing of cardamom could be revolutionized by implementing our method on farm equipment or mobile applications.
4. Automation: It is worthwhile to work towards automating the processes for harvesting and sorting cardamom. Our approach may be integrated into robotic systems or conveyor belts to greatly expedite processes, cut labour costs, and boost productivity.

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