

Classification of Papaya Fruit Maturity with CNN Method Using Drone Camera

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Abstract— This study used drone camera technology and Convolutional Neural Network (CNN) in classifying the maturity level of papaya fruit based on skin color. A dataset of 4800 papaya images, including ripe, undercooked, and raw, was taken with a drone camera. Hardware in the form of a laptop with a 2.70 GHz Intel i7-7500 processor and 16GB RAM is used. Libraries such as OpenCV, NumPy, and imaug supported the research. CNN models were trained for 30 epochs. The results show good accuracy in detecting the ripeness of papaya fruit on drone camera images. The model can also be used to detect objects on drone video footage. This research has great potential in improving the efficiency and productivity of papaya farming and reducing untimely crop losses.

Keywords— Drone Camera, Papaya, CNN, Object Recognition.

I. INTRODUCTION

Papaya plant is one type of tropical plant that is popularly cultivated in Indonesia. This papaya fruit comes from Mexico. Papaya fruit itself has a fairly high vitamin content, namely vitamin A and vitamin C, not only that papaya fruit contains minerals in the form of calcium, phosphorus, iron and magnesium [1]. This plant is generally grown both in the yard and on farmland. However, the use of papaya by the Indonesian people so far tends to be limited to meeting the needs of fresh fruit consumption or as raw materials in the food and beverage industry.

Papaya fruit plant (*Carica papaya*) is one of the agricultural commodities that has high economic value and increasing demand. To maximize the production and quality of papaya fruit, determining the right harvest time is crucial. Currently, the process of observing and determining the harvest period is still mostly done manually by farmers. However, with advances in technology, the use of drone cameras has become an effective alternative in supporting the determination of the harvest period in papaya fruit plants [2].

In papaya fruit production, the process of identifying the ripeness of the fruit is a complicated task, determining the maturity of papaya manually depends on visual analysis of papaya skin color by humans [3]. This recognition process has several disadvantages, such as requiring a lot of manpower to classify, different perceptions of the degree of ripeness of the fruit, and no one guarantees human consistency in determining the level of ripeness with the same accuracy. Limited human stamina also means potential fatigue, while subjective evaluation of maturity Drone cameras have become an innovative solution in the agricultural sector, including in monitoring crop growth and estimating harvest periods [4]. Use of drone cameras in Agricultural Monitoring provides Significant advantages compared to traditional methods.

Drone cameras allow farmers to get a high-precision picture of land area, allow observation of plants from different points of view, as well as obtain accurate data on the growing conditions and maturity of papaya fruits.

Fruit by man can produce differences of opinion. As a result, it takes quite a long time to classify and identify the maturity level of papaya fruit [5].

From the explanation above, a solution is needed to recognize the maturity of papaya fruit with accuracy by utilizing computer assistance to classify the maturity level of papaya fruit. One solution is with object detection. Object detector or can be called an object detector, is the application of a computer that aims to detect and identify certain objects. This ability is one part of the field of computer vision science, the goal is to teach computers to recognize objects can analyze videos and images to solve various problems.

In the previous description, a solution is needed that can use computer capabilities to accurately recognize the ripeness of papaya fruit. One solution that can be used in utilizing object detection technology using computer technology. This approach, known as object detection, utilizes the computer's ability to detect and identify specific objects. This capability is integral to the field of computer vision science, which studies how computers can work similarly to the human eye in recognizing objects. In the context of computer vision, object detection can be applied to video and image analysis to solve a variety of existing problems [6].

In this study, the method used for object detection is a deep learning method with significant results on color imagery is (CNN) Convolutional Neural Network. This could be because the CNN method seeks to resemble recognizing images with the human visual cortex so that it can process information about images. However, the Convolutional Neural Network method is the same as other deep learning where there are shortcomings such as the model training process which is quite time-consuming, but can be overcome by using a supporting GPU. There are several other methods used to process digital images, such as the use of the same Neural Network (CNN). CNN is a deep learning model implementation. The Convolutional Neural Network method is used in detecting and recognizing objects in the image. The Convolutional Neural Network method has weight, bias and activation functions [7].

This study aims to develop a classification system for the harvest period of papaya fruit plants using drone cameras. By utilizing remote sensing technology and image analysis, This system will be able to identify the maturity of papaya fruit

automatically and provide accurate information about the right time to harvest. With this system, farmers are expected to increase the efficiency and productivity of their farms, reduce labor costs, and minimize losses due to delays or untimely harvests.

The purpose of this study is to create a system that can detect the harvest period of papaya fruit and provide recommendations on how to calculate from the beginning of papaya fruit harvest to the harvest period of papaya fruit.

Accurate and efficient classification at the harvest stage can help farmers to determine the right time to harvest papaya fruit, thereby reducing losses caused by too early or late harvest. The system will use computer vision techniques to analyze images of the plant and identify the harvest period of papaya ripeness using drone cameras.

II. RESEARCH METHODS

In this section, an analysis of the needs of the papaya fruit maturity detection system will be carried out which will be built with this CNN method.

2.1 Data Collection Methods

In this method, the author collects image data. The image was taken with the downloaded dataset residing in Kaggle. This research was conducted in an open room with sufficient lighting, so that the resulting image is clearly visible.

Papaya fruit image data was taken with the SJRC F11s 4K PRO drone camera by adjusting from settings with 720p video resolution with a frame rate of 30fps. The image dataset used for the trial data was 4800 images consisting of 1600 ripe papayas, 1600 half-ripe papayas and 1600 raw papayas. For training data as much as 1 image with good video quality in mp4 format and collected in one folder.

2.2 Preprocessing and image selection

All images that have been taken from drone cameras are put into each folder with separate folders of ripe papaya, papaya and raw papaya.



Figure 1. Raw Papaya Dataset



Figure 2. Mature Papaya Dataset

The image data used as training is labeled with a name with each image. The image of papaya fruit is taken from various sides in order to get more image data from all sides. This makes it easier for researchers to determine the class of maturity class of papaya fruit. The following is an example of papaya fruit maturity dataset.

2.3 Import Data

Making programs begins with importing libraries on import dependencies whose function is to import various python libraries and modules needed for image processing tasks and image data analysis.

```

Import Dependencies
import os
import sys
import random
import math
import numpy as np
import cv2
import matplotlib.pyplot as plt
import json
import pydicom
from imgaug import augmenters as iaa
from tqdm import tqdm
import pandas as pd
import glob
import skimage.draw
    
```

Figure 3. Proses import Data

In figure 3, each module has several commands, such as import os, which serve as a collection of commands for importing modules. In addition, there is a Python library that is essential for the processing and analysis of medical images, as shown in the figure. Modules such as numpy are used to represent image data in numerical form, while cv2 (OpenCV) is very useful for reading, processing, and analyzing images, and also importing imgaug to perform image augmentation to increase the variety of training data, and pydicom to read and process medical images in "DICOM" format. Other modules, such as matplotlib.pyplot and pandas, are used to display and transform data. In addition, to monitor this research, you can use glob to search for files based on specific patterns and tqdm to create progress bars during iterations. Overall, this code provides an important basis for work involving processing and analysis.

2.4 Data Training

The data that has been collected will then be carried out training where the system will learn the conditions according to the dataset with the approach.

```

# Train the head branches
# Passing layers='heads' freezes all layers except the head
# layers. You can also pass a regular expression to select
# which layers to train by name pattern.
model.train(dataset_train, dataset_val,
            learning_rate=config.LEARNING_RATE,
            epochs=30,
            layers='heads')
    
```

Figure 4. Training Data

In the explanation of figure 4 this is used to train the part (head) of an artificial neural network model used for object detection tasks.

Model.train(dataset_train, dataset_val, learning_rate=config.LEARNING_RATE, epochs=30, layers='heads') is an example of dataset.train. To train a model, this code uses the train method of the model object, which must previously be defined. The following parameters are given: dataset_train and dataset_val will be used during training. The training dataset contains data to teach the model, while the dataset_val is used

to measure the model's performance during training. `learning_rate=config`. Learning level is the level of learning used during training. It controls the speed of the model to change its weight to match the data. The number of training iterations (epochs) to be conducted is 30. One epoch is a one-time processing of the entire training dataset. `layers='heads'`: This parameter specifies which layer to use.

2.5 Predict Image

This system after conducting data training, the system has been able to understand each fruit condition according to the dataset used and the system is ready to predict data.

```
# Show few example of ground truth vs. predictions on the validation dataset
dataset = dataset_val
fig = plt.figure(figsize=(10, 30))
start_idx = 0
for i in range(start_idx, start_idx + 3):
    image_id = random.choice(dataset.image_ids)

    original_image, image_meta, gt_class_id, gt_bbox, gt_mask = \
        modellib.load_image_gt(dataset_val, inference_config,
                               image_id, use_mini_mask=False)
    plt.subplot(6, 2, 2*(i-start_idx) + 1)
    visualize.display_instances(original_image, gt_bbox, gt_mask, gt_class_id,
                              dataset.class_names,
                              colors=colors_for_class_ids(gt_class_id), ax=fig.axes[-1])

    plt.subplot(6, 2, 2*(i-start_idx) + 2)
    results = model.detect([original_image]) #, verbose=1)
    r = results[0]
    visualize.display_instances(original_image, r['rois'], r['masks'], r['class_ids'],
                              dataset.class_names, r['scores'],
                              colors=colors_for_class_ids(r['class_ids']), ax=fig.axes[-1])
```

Figure 5. Predict Data

In figure 5 explains this program is used to display several examples of comparisons between the object detection results (predictions) of the model with the ground truth (actual results) in the validation dataset. Here's a more detailed explanation. The initial step to set up the dataset that will be used to display examples of detection results is the validation dataset (`dataset_val`). To display examples of detection results, it creates a figure with a size of 10 x 30 inches. Variabel `start_idx = 0` Set the initial index of the example to be displayed, this example starts with index 0. Loop for `i in range(start_idx, start_idx+3)`: This loop will display three examples hasil deteksi.

You can replace 3 with a number that corresponds to the number of examples you want to display. Inside the loop, there are the following actions: To select one image ID from the validation dataset, `image_id = random.choice(dataset.image_ids)`.

The program uses `modellib.load_image_gt` to load the original image as well as ground truth information related to the selected image.

To display a basic truth image, use `plt.subplot(6, 2, 2*(i-start_idx) + 1)`. This is the first subplot for the basic truth picture.

The `visualize.display_instances` function is used to display the original image along with bounding boxes (BBOX) and ground truth object masks. The variables `gt_bbox`, `gt_mask`, and `gt_class_id` provide this data. Next, to display the predicted results from the model, the same procedure is repeated in the subplot for the ground truth image:

To show the predicted result, use `plt.subplot(6, 2, 2*(i-start_idx) + 2)` next to the basic truth image. `Model.detect([original_image])`: This calls the model to find objects in the original image (`original_image`) and stores the

prediction results on the variable `r`. `Visualize.display_instances`: It displays the original image with bounding boxes and protects the object predicted by the model. The variable `r`, which contains the results of the model's predictions, provides this data.

The goal of this program is to provide a visual understanding of how well your model detects objects in images in the validation dataset. This allows you to check if your model is performing the right detections and how well its prediction results compare to ground.

III. RESULTS AND DISCUSSION

Making a classification has been completed in this chapter will discuss the results of detecting papaya fruit image classification with the convolutional neural network (CNN) method which will be explained in this chapter. The trial of this system aims to find out whether this program is in accordance with the desired results or not.

3.1 Observational Data

Observational data is obtained from testing learning outcome programs. The learning results program is tested by manually inputting images with uploads contained in the dataset trial program.

3.2 Observations on Learning Outcomes

The results of the training and testing process using the CNN method with validation at both stages. Test results are based on models generated by Convolutional Neural Networks.





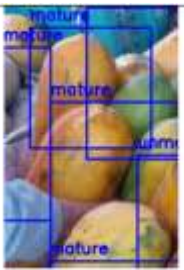

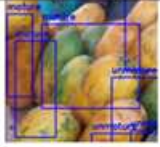

No.	Hasil Dari Video	Klasifikasi Machine Learning	Keterangan
1.		Unmature	Machine Learning Membaca Secara Akurat
2.		Unmature	Machine Learning membaca secara akurat.


Figure 6. Detected Raw and mature Papaya

No.	Hasil Dari Video	Klasifikasi Machine Learning	Keterangan
3.		Unmature	Machine Learning Membaca Secara Akurat
4.		Unmature	Machine Learning Membaca Secara Akurat

5.		Mature	Machine Learning Membaca Secara Akurat
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No.	Hasil Dari Video	Klasifikasi Machine Learning	Keterangan
6.		Mature	Machine Learning Membaca Secara Akurat
7.		Mature	Machine Learning Membaca Secara Akurat

8.		Mature	Machine Learning Membaca Secara Akurat
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No.	Hasil Dari Video	Klasifikasi Machine Learning	Keterangan
9.		Mature dan Unmature	Machine Learning Membaca Secara Akurat
10.		Mature dan Unmature	Machine Learning Membaca Secara Akurat

average accuracy that has been detected by machine learning can all be said to be accurate. Because it is joined by other papaya objects that are flat still raw. This proves that the system made flat is able to read the ripeness of papaya fruit derived from drone camera images.

IV. CONCLUSION

After making an object classification model trained by the Convolutional Neural Network algorithm, the conclusion of the object detection research in papaya fruit maturity trials is that the CNN algorithm has successfully trained a machine learning model in detecting objects at the trial level. maturity of papaya fruit.

The model can also distinguish from the color of the fruit whether the fruit is still ripe or its raw papaya fruit. The process of detecting objects in video format from the SJRC F11s Pro drone camera footage is then processed using the python programming language. For this study, it can be concluded if the model can detect raw or ripe papaya fruit.

For further model development, useful suggestions are needed, constructive, and can make the model "classification of papaya fruit ripeness color or color with the CNN method using drone cameras" better in the future. The constructive suggestions include:

1. Models can meticulously provide maturity level analysis by utilizing additional more complex algorithms and programs to be able to produce accurate game analysis.
2. Models can run more accurately by using faster GPU CPUs for real-time detection.

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