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Fruit Ripeness Classification System Using Convolutional Neural Network (CNN) Method

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***Abstract* – The increasing consumer demand in the fruit industry has also demanded that various sectors of the fruit processing industry be able to adapt to this situation. To meet the growing demand for high-quality, fresh fruit, technological advancements and supporting systems in the fruit processing industry are required. Referring to this, this study aims to detect the type and maturity of fruit using machine learning with the CNN (convolutional neural network) method using the function of a camera that is integrated with the program algorithm. This research is a refinement of previous research that has been made at the university by increasing the ability to read objects based on color with different methods. In this programming language, Python also requires several additional libraries to carry out the object detection process, namely the cvzone library as the main library. This study shows that the detection of fruit and ripeness using the CNN method was successful in detecting the type and maturity of the fruit. In the design and trial of this research, it can run well according to the algorithm created by the researcher. The success rate and accuracy of the detection of the type and maturity of this fruit reach 90%.**

Keywords: CNN, Python, Machine Learning, Computer Vision.

I. INTRODUCTION

The food industry is very important for all people because people really need food all the time. In agriculture or the food industry, there are various types of food, such as rice, vegetables, and fruits [4]. The crops of these farmers and traders must then be sold to consumers or buyers. But in the process of distributing crops in the form of vegetables and fruits to consumers, it must take a short time because vegetables and fruits must be fresh and in good condition when they reach the hands of consumers or buyers. Because fruit contains nutrients, vitamins, and minerals that are very beneficial for the health of the human body, it is highly recommended that fruits be consumed every day and regularly. That's why the food sector requires speed and accuracy, especially for the fruit farming sector [5]. In the field of fruit farming, it really needs speed in processing, both in grouping and packing, because buyers or consumers want the fruits that are purchased and consumed to be in fresh condition and suitable for consumption.

Technology such as cameras was at first only used to take pictures, but as time went on, cameras became more sophisticated, not only taking pictures but also recording them every time. Technological advancements are relentless; eventually, the camera can function as input in a computer to detect any object captured on the camera itself [3].The images captured by the camera are then processed on a computer device using image processing methods. The data processing using this camera, also known as "computer vision," aims to duplicate human vision into electronic objects so that the tool can understand objects and the meaning of the image entered in the system. so that a computerized camera can be used for many sensors, such as color sensors, shape detection sensors, motion sensors, and so on [13]. This research for the process of detecting fruit objects necessitates the process of photographing objects with a teachable machine [1].Teachable Machine is a web-based machine learning system that is supported by the latest classification algorithms, such as convolutional neural networks (CNN) [6] [2]. This teachable machine functions in the object reading training process, where we can use it according to our needs. In the field of processing objects, tracking techniques are often implemented to assist human activities [10] [11]. The tracking process can also experience problems or failure if the object is blocked by other objects, the light intensity is not good, or the shape and color of the object are similar [8]. This research is based on phenomena in the fruit industry sector, some of which often work manually to classify types of fruit to be marketed to the public for sale. So, technological developments are urgently needed by fruit farming communities and the fruit food industry. Industrial

developments in the fruit sector must be developed, especially technological developments and programs for distinguishing types of fruit [12]. This research emphasizes the use of computer vision with the CNN method using the Python programming language; the goal is to be able to distinguish types and maturity of fruits, even to make it easier for the industry to select the types of fruits to choose [7]. This researcher's detection of fruit type and ripeness is an extension of previous research at our university, demonstrating that the application of a pan-tilt camera system for object detection based on color using Raspberry PI has been successfully carried out [14].The research conducted by the author at this time is a way to detect the type of fruit and the ripeness of the fruit itself using a teachable machine with the Convolutional Neural Network (CNN) method.

II. METHOD AND DESIGN

Figure 1 depicts the author's research method, which includes a literature review, tool design, results and discussion, and finally drawing conclusions from all of the research content's results. The purpose of this literature study is to identify problems and find solutions to solve them. The detection of fruit objects that are designed and arranged to be implemented follows the solutions that have been obtained from the problems it receives after knowing the problem. The advantage of implementing object detection with a teachable machine is that it is an addition to the process for detecting types of fruit objects in the fruit industry and among farmers. If there are errors, this study detects fruit objects for trials.

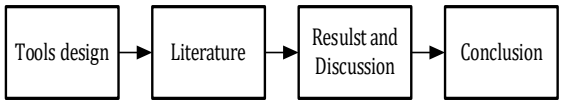

Figure 1. Research methods

A. Main device design

This research process requires important equipment, namely having to prepare a studio box, room lighting or lights, and a USB webcam camera. The following figure 2 is the form of the studio box used. The size of the studio box used must match the size of the fruit object to be detected. In general, the studio box is equipped with lighting, the lights for this studio box use LED lights. The camera used to detect objects is a USB webcam camera, as shown in Figure 3. This webcam is used by connecting to a PC/laptop via a USB port. This webcam type camera is connected and processed on a computer, which is capable of capturing images or recording a place or object in real-time/directly.

On the webcam camera that will be used, it is necessary to look at the specifications for the resolution of the resulting image. Because the pixel resolution generated from the webcam camera also affects taking pictures to detect objects. The required webcam specifications have a minimum resolution of 720p HD, the higher the resolution produced by the camera, the more optimal the results of taking pictures of objects when the process of detecting a fruit object.

Figure 2. Studio Box

Figure 3. *Webcam*

B. Teachable Machine with the CNN method

This chapter will show how the train model works. There are 5 types of fruit available: bananas, apples, grapes, chilies, and oranges. The Teachable Machine is a web-based machine learning system that is supported by the latest classification algorithms, such as a convolutional neural network (CNN), using the mBlock 5 visual model with CNN adapted from the Google Teachable Machine. Teachable machines offer three alternatives for training predictive models. The aim of the Image tool (Figure 6) is to train a model using the CNN method to classify images, in which the training data is uploaded to the teachable machine environment from the user's computer or captured from the user's web camera. CNN (Convolutional Neural Network) is a type of deep learning algorithm that can receive input in the form of an image, which determines any object in the image that the machine uses to recognize object images and determine the differences between each other object. This research uses the CNN method to detect the kind of fruit. This study intends to design a model with the CNN method that can classify fruit images with good accuracy because the CNN algorithm has two parts, namely extraction and classification.

C. Convolutional Neural Network Architecture

This CNN architecture includes several stages consisting of four main components: the kernel, the convolution layer, the non-linear activation function, and the pooling or subsampling layer. Each of these stages has the goal of representing features as a collection of arrays, or what can be called a feature map. Convolution by means of a filter in the input and then combining the input value + filter value on the

feature map is the technique used in the preparation of the CNN algorithm so that the CNN can function to recognize objects or images based on the features recognized by the CNN algorithm, which can be seen in the image. The AI model used in this teachable machine uses TensorFlow. There are several stages in the process of creating a CNN classification system, as shown in Figure 4 below.

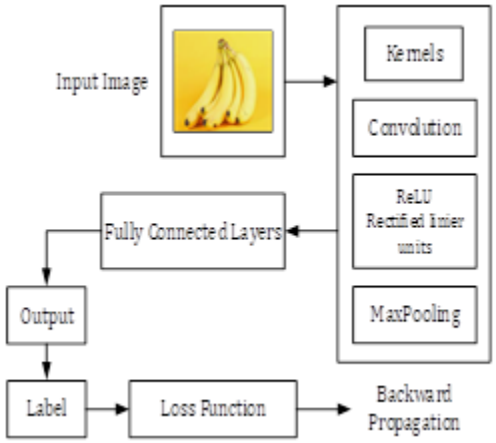

Figure 4. Chart Convolutional Neural Network

This bank or kernel filter has the goal of detecting certain characteristics at each input location. Therefore, the spatial translation of the input from the characteristic detection layer will be transferred to the output unchanged. The feature map is calculated using the following equation (1):

$$Y_i^{(i)} = B_i^{(i)} + \sum_{J=1}^{mI^{(I-1)}} K_{ij}^{(I)} * Y_j^{(I-1)} \qquad (1)$$

The convolution operation is widely used in digital image processing, where the 2D matrix representing the image (I) is deflected by a smaller 2D kernel matrix (K), hence the mathematical formula with zero padding in equation (2) below.

$$s_{i,j} = (I * K)_{i,j} = \sum_m \sum_n I_{i,j} * K_{i-m,j-n} \qquad (2)$$

In the convolution process, the small shear filter operates from left to right through the image from top to bottom, calculating the amount of product between each kernel element and the corresponding input element. This process is repeated using different kernels to form as many output feature maps as desired.

D. Training Process and Object Detection

In the process of training this model, there are several steps that need to be carried out, including configuration and batch size. This epoch is a sample in the training dataset; for example, if we enter an epoch value of 500 samples, it means that the model we are going to train will work through the entire training data set 500 times. Then in the batch size process, there is a set of samples used in the training model iteration. For example, we have a sample of 80 images, and we choose a batch size of 16. This means the data will be divided into 80/16, or 5 batches. In this study, the authors used an epoch value of 200 and sampled 500 images for each object. After this configuration is complete, the model is ready to be trained. The following is Figure 5 of the training process flow.

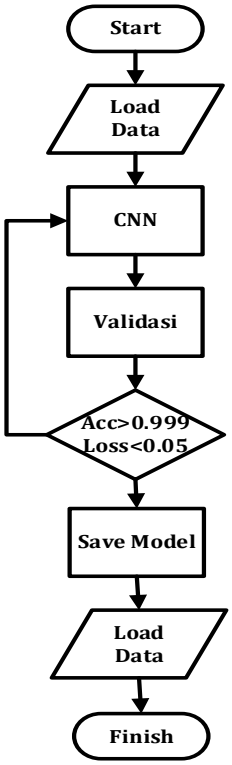

Figure 5. Flowchart Train Model

After the data training process is complete and produces output in the form of AI TensorFlow, the training data is ready to be processed in a program using the Python programming language for the flow of reading fruit samples, which can be seen in the picture below.

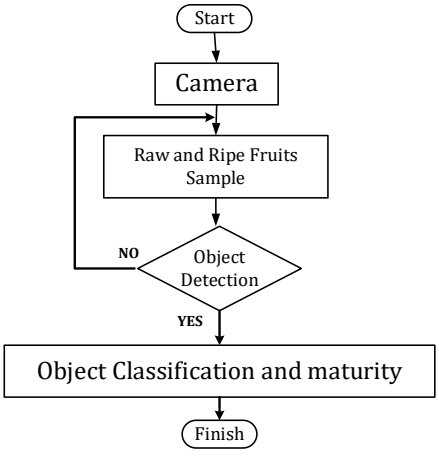

Figure 6. Flowchart Object Detection and Maturity

III. RESULTS AND DISCUSSION

The design of the main tool and tool components is shown in Figure 7. There is a studio box that is used for room detection of fruit objects, a laptop for hardware used to program all research to detect objects, and a webcam camera that is intended as a tool for taking pictures and detecting objects. Of course, there are five types of fruits to be detected for this study.

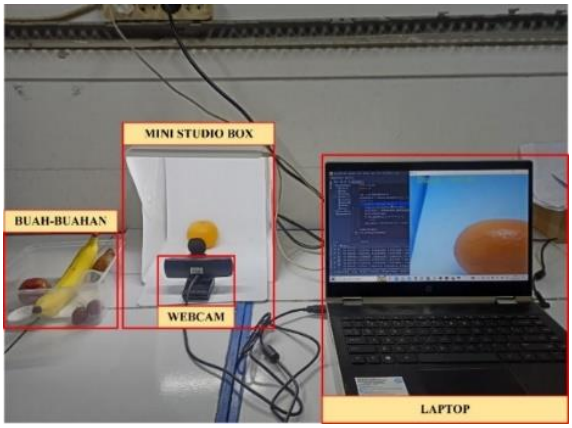

Figure 7. Object Detection Studio

A. Results of Classification of Object Detection and Ripeness of Fruit.

In the trial conducted by the author this time the trial was carried out under fairly bright lighting conditions and the camera used a webcam. This trial is the result of making the CNN algorithm in the research method above. The first detection can be seen in Figure 8 (a) and (b). We use apple sampling where apples that have different colors are classified into ripe and unripe fruit. In this trial, the accuracy in reading apples is very accurate.

(a)

(b)

Figure 8. Object detection and ripeness of apples.

The second detection can be seen in Figure 9. We use grape sampling where grapes have different colors and shapes. We classify them into ripe and unripe fruit. In this trial, the accuracy in reading grapes is very accurate.

(a)

(b)

Figure 9. Object detection and ripeness of grapes.

The third detection can be seen in Figure 10. We use chili sampling where chilies that have different colors are classified as ripe and unripe. In this trial, the accuracy in chili readings is very accurate.

(a)

(b)

Figure 10. Object detection and ripeness of chillis.

The fourth detection can be seen in Figure 11. We use orange sampling, where oranges that have different

colors are classified as ripe and unripe. In this trial, the accuracy in reading oranges was very high.

(a)

(b)

Figure 11. Object detection and ripeness of oranges.

The fifth detection can be seen in Figure 12. We use banana sampling where bananas that have different colors are classified as ripe and unripe. In this trial, the accuracy in reading bananas is very accurate.

(a)

(b)

Figure 12. Object detection and ripeness of bananas.

B. Object Detection Distance

The detection of this fruit object has a limited detection distance. In detecting this object, it depends on the background used in the studio box when training the model. If training a background model on a large scale affects the distance of object detection, modeling on fruit will also affect the distance of object detection. The lighting used is also very influential on detection. Following are the results of measuring the detection distance with the train model parameters that we use in this study, which can be seen in Table 1.

Table 1. Table of Detection Success within a certain distance

No	Fruit Name	Distance		
		10 cm	20 cm	50 cm
1	Orange	Succeed	Succeed	It doesn't work
2	Wine	Succeed	Succeed	It doesn't work
3	Chili	Succeed	Succeed	It doesn't work
4	Banana	Succeed	It doesn't work	It doesn't work
5	Apple	Succeed	Berhasil	Berhasil

IV. CONCLUSION

Based on the test results in this study, it can be concluded that the design of object detection and object maturity based on the CNN (convolutional neural network) algorithm can function according to the algorithm with AI modeling using TensorFlow. The trials that have been carried out can detect objects and object maturity with a high degree of accuracy and minimal errors. The detection distance to this object also depends on the lighting conditions and the model being trained. In the future, this tool can be used in the food industry for sorting fruit..

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