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Differentiate the Varieties of Plants Using Leaf Images with YOLOv4

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ABSTRACT

There are many types of plant, not all recognized by people. Indonesia has many varieties of plants across the country, from Sabang to Merauke. Often, we find some fruits or plants that grow in different areas called by different names. The goal of this research is to create an application that can recognize plant types from their characteristics. These characteristics can be leaves, fruit, flowers or roots. Current research focuses on distinguishing several types of plants including their varieties using leaf images. It is hoped that apart from being able to determine the mango plant, we can also determine the type of mango, such as manalagi, harum manis, as well as guava and orange. To be able to recognize these types of plants, an object recognition algorithm based on CNN (Convolutional Neural Network) will be used. The algorithm that will be used is YOLO (You Only Look Once) version 4. Method in this research includes data collection, all data was taken using webcam or mobile phone camera. The next step is data preparation and creating a bounding box. Next step is creating model using training data and the last step was compare model with testing data, The result we got is really encouraging with almost 100 percent accuracy. The lowest accuracy is 98 percent for jambu air. This research show us that YOLOv4 can be used to differentiate varieties of plants.

1. Introduction

Indonesia has a lot of variety of plants across the country. For many people it is difficult to acknowledge the plant. Each plant has its own uniqueness, and its parts have different benefits. If people can acknowledge the plant and its benefits, then people can use it when needed. For example, if lost in the jungle, people can eat plants that are not poisonous. This research tries to create a model that can distinguish different types of plants.

To recognize the type of plant, you can look at its leaves, fruit, and flowers. In previous research, researchers were already using YOLO to differentiate faces in real time using CCTV and got a good result [1]. After that, researchers were using YOLO algorithm to differentiate the types of mango plants, namely mangga manalagi, mangga harum manis, mangga gedong or mangga apel from the image of the leaves [2] and in another research we differentiate the health of mango plants using leaf images [3].

In the current research, researchers want to add other types of plants and see whether the YOLO algorithm can differentiate each plant and its varieties well. There is already much research trying to differentiate plants using their leaves., such as Perlindungan & Risnawati [4] tried to identify chili plants using CNN. There is another research to identify herbal leaves using CNN [5] and trying to identify the tomatoes disease using leaves [6]. There are more research that gave very good results to identify plant leaf diseases using CNN [7], [8].

The final goal of this research is to identify herbal plants. This research chose to use mango, guava, and orange plants rather than herbal plants. This is because fresh herbal plant leaves are difficult to obtain for different varieties, for example leaves for red ginger, white ginger, or elephant ginger.

Researchers want to use primary data, apart from ensuring each sample, also to create a leaf dataset. The sample of mango, guava and orange leaves are easier to get because those grow in a lot of houses in the neighborhood. It is assumed that if the model obtained can differentiate mango, guava, and orange plant varieties, it can also be used to differentiate herbal plant varieties. If this research is successful, the next research will add another part of plant like its fruit, flower, and root. So, it can predict the variety of the plant not only by leaves.

2. Research Methods

This research follows the steps that we can see in figure 1.

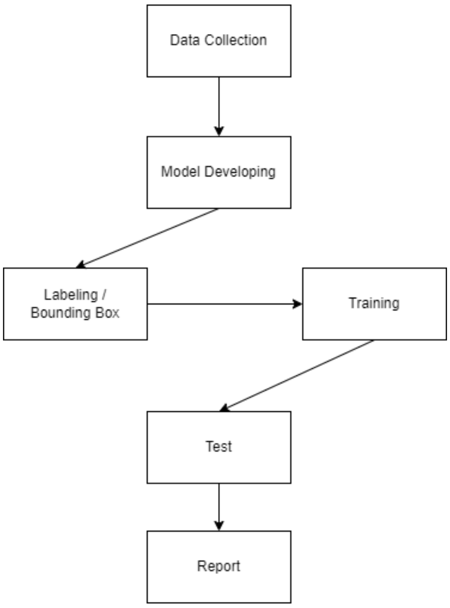

Figure 1. Research Flow

2.1 Data Collection

The first step taken is to collect the necessary data. The expected data is primary data. After the data is collected, images are taken using a webcam and camera and classified. It is hoped that the total data obtained will reach 200 – 300 samples.

In this research, several types of leaves were used, namely guava leaves, orange leaves and mango leaves. The guava leaves consist of several types, namely jambu air, jambu bol, jambu biji, jambu mede, and jambu batu. The orange leaves used are jeruk bali, jeruk peras, jeruk limo and jeruk purut. Meanwhile, the mango leaves used are mangga bacang, mangga manalagi, mangga apel, mangga harum manis and mangga golek.

The pictures were taken using mobile phones. Each leaf gave us four pictures, that is the front side and the back side. Every picture was taken in normal light and less light. Sample guava leaf (jambu batu) can be seen in Figure 2 and Figure 3. Both pictures are taken using norma light (high brightness).

Figure 2. Guava leaf (front side)

Figure 3. Guava leaf (back side)

The total data collected was 404 pieces. This data is divided into pictures with low and high brightness. However, the leaves of mangga manalagi, mangga apel, mangga harum manis and mangga golek were not photographed with low brightness. The data that has been obtained will be used for training and datasets as we see in table 1.

Table 1. Leaf Dataset

No	*Type of Fruits*	*Type of Leaves*	*Low Brightness*	*High Brightness*	*Total*
1	Guava	Jambu Air	12	12	24
2		Jambu Bol	15	15	30
3		Jambu Biji	21	21	42
4		Jambu Mede	23	23	46
5		Jambu Batu	8	8	16
6	Orange	Jeruk Bali	24	24	48
7		Jeruk Peras	15	15	30
8		Jeruk Limo	12	12	24
9		Jeruk Purut	11	11	22
10	Mango	Mangga Bacang	23	23	46
11		Mangga Manalagi	0	19	19
12		Mangga Apel	0	22	22
13		Mangga Harum Manis	0	22	22
14		Mangga Golek	0	13	13

The next step before creating a model is to prepare the data. We go through all the pictures to see any defect. If there is a picture that is not good enough, then we need to collect it again.

After all the pictures go through selection process and no defect was found then we can continue to create a model.

2.2 Model Development

Once the required data is complete, training will be used from the existing data. Model development will use deep learning. The deep learning method we use is Convolutional Neural Network (CNN). The object recognition algorithm that will be used is YOLO (You Only Look Once) that derived from CNN.

There are a lot of object recognition algorithms, why does this research focus on YOLO? YOLO can predict objects during real time with good accuracy and very fast also can be embedded into device [9]. Other researchers have used YOLO in their research and give good predictions, such as leaf base disease detection for bell pepper plant [10] and crop disease detection [11].

In this research, YOLO version 4 [12] will be used, because it has been used in previous research. YOLOv4 is based on YOLOv3 developed by Joseph Redmon [13]. YOLOv4 is significantly faster than YOLOv3 [14]

Before we train all the data we have collected, there is a need to create a bounding box. After the data has been trained, testing will be carried out using the dataset that has been prepared for that purpose. It is hoped that the accuracy achieved is accurate enough to differentiate plant types and varieties.

2.2.1 Bounding Box

Preparation for data training is to create a bounding box from all the data that has been obtained. This bounding box is used to label the data and classify leaf types. Bounding boxes and labels are done manually using an application to maintain data accuracy.

In the beginning we tried to create a program to create the bounding box automatically, but not all leaves got the box correctly. Because of time restriction, we choose to use an application to draw bounding box manually. The application we use is YoloLabel

Using this application, we manually create a bounding box for each leaf. After that, we need to choose which label this leaf belongs to. How to create a bounding box and given the label can be seen in figure 4 and figure 5.

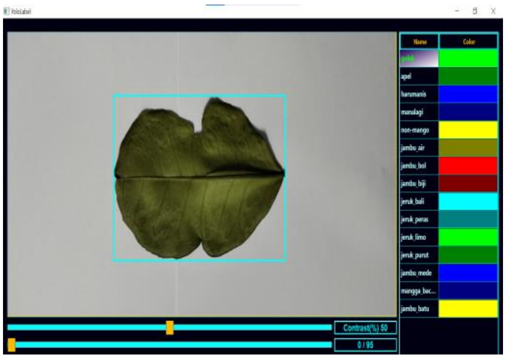

Figure 4. Jeruk Bali Leaf (Low Brightness Labeling)

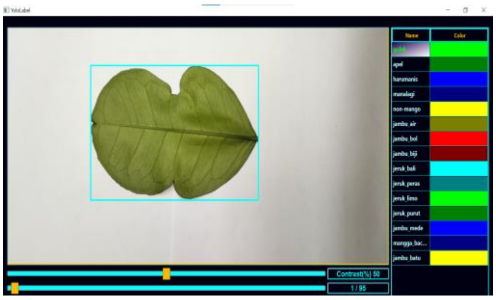

Figure 5. Jeruk Bali Leaf (High Brightness Labeling)

2.2.2 Training

After data preparation is complete, that is all the pictures have already been bound into the box and given the correct label then we can continued with dataset training.

We divided the dataset for training and testing using around 80 percent for training and 20 percent for testing. So, from the 404 pictures we have, we used 322 pictures for the training dataset, 82 pictures of total data were used for testing.

The selection of pictures for testing was done manually. From every category we collect some pictures, if possible, we choose picture that has been taken in low brightness and in high brightness. All the training data was used by the YOLOv4 algorithm to build a model for prediction. The YOLO algorithm will resize the pictures automatically and for this research we use default size, that is 412 x 412.

3. Results and Discussion

3.1 Results

Based on the results of the training that has been carried out, an object recognition model using YOLOv4 is obtained.

After the training finished and we got the model, the next step is to run the test to see the prediction accuracy. Then, after the data prepared for testing is run on the model, the results obtained are as shown in table 2. The testing data for mango number 11 to 14 (Mangga Manalagi, Mangga Apel, Mangga Harum Manis and

Mangga Golek) are twice from other leaves, because those leaves only have pictures in high brightness. We did not have low brightness pictures for those data.

Table 2. Prediction Results

No	*Types of Leaves*	*Amount of Testing Data*	*Average Prediction Accuracy in %*
1	Jambu Air	5	98
2	Jambu Bol	4	99,5
3	Jambu Biji	4	100
4	Jambu Mede	4	100
5	Jambu Batu	5	100
6	Jeruk Bali	4	100
7	Jeruk Peras	4	99,75
8	Jeruk Limo	4	99,75
9	Jeruk Purut	4	100
10	Mangga Bacang	4	100
11	Mangga Manalagi	10	100
12	Mangga Apel	10	98,5
13	Mangga Harum Manis	10	100
14	Mangga Golek	10	99,9

We can see from the table that the prediction accuracy is very good. There are eight leaves that were predicted correctly with accuracy 100 percent. The other leaves still get more than 98 percent accuracy. The lowest prediction accuracy was 98 percent and only for one leaf that is from guava (Jambu Air). The figures below will show us how to get those accuracy numbers.

Figure 6. Jambu Biji Leaf Prediction Results

Figure 7. Jeruk Bali Leaf Prediction Results

Figure 8. Mangga Bacang Leaf Prediction Results

As we can see from those figures, after the test was run YOLO will save the result into pictures and show us the name of the leaves it predicts and its accuracy.

From the test results shown in the figures above, we can see that the model generated using YOLOv4 can differentiate between the types of mangoes, orange and guava leaves very good, because the lowest correct prediction result is 98 percent.

3.2 Discussion

From the results obtained, it can be seen that YOLOv4 almost succeeded in detecting each type of leaf. Almost all the test data can be identified correctly. There is only one piece of data that is not detected.

Test results that reach 100 percent for each leaf are very encouraging, but this also requires further research. Is it because the algorithm or because the dataset is too low.

During data collection, besides taking pictures we also collected height and width of each leaf. These data could be integrated into further research.

4. Conclusion

From the research that has been carried out, it can be concluded that the YOLOv4 algorithm has been successful in determining varieties for each plant type. Each different plant variety can be detected with excellent accuracy.

The research results show that YOLOv4 can differentiate whether this is a mango or orange plant, and the variety of each plant. For example, it can predict the leaf is a leaf from a mango plant and the variety is mango manalagi.

The benefit of this research is that you can differentiate plant types from leaf images. In the future, datasets can be developed for more plant types. Apart from that, you can also add other parts of the plant, such as flowers, fruit, and roots, so that the data will be more complete.

With a method that has proven successful in distinguishing plant types, a mobile application can be developed to be implemented directly.

The disadvantages of this research are very small datasets. This research only has 404 pictures. Another disadvantage is some of the pictures were taken using a web camera, so some of the pictures are a bit blurry. All the pictures that were taken using a mobile phone camera are of very good quality. Mobile phone used was OPPO A77S and the camera has 50 MP capacity.

5. Suggested

Yolov4 has given a very good prediction, another researcher can add more datasets for plants and varieties to check the prediction. YOLO is always developing, today we have new versions of YOLO. Those are versions 7 and 8 [15]. YOLOv7 is said to be faster and give better accuracy then YOLOv4 [16]. There is already research that detect tea leaf disease using version 7 [17]. It is interesting to compare the results that we get in this research using another version of YOLO.

As we said before, YOLO is one of the algorithms that can be used to predict the object. We can compare YOLO with another object recognition algorithm to compare the speed and the accuracy of prediction. As YOLO is good for making predictions in real time, we can create an application that uses the model and compare the result.

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