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Implementation of YOLOv5 for Digital Image-Based Banana Disease Detection

[1*] **Anis Yusrotun Nadhiroh,** [2] **Moh. Jasri,** [3] **Wali Ja'far Shudiq**
[1,2,3] Informatics Engineering, Faculty of Engineering, Nurul Jadid University, Paiton Probolinggo.
[1] anis@unuja.ac.id, [2] jasri@unuja.ac.id, [3] wali.jafar@unuja.ac.id

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ABSTRACT

Banana is one of the tropical fruit commodities with high economic value; however, it is susceptible to diseases such as anthracnose (spot), crown rot, and fruit rot, which can reduce yield and fruit quality. Conventional manual detection methods are still widely used, but they often face limitations in consistency, efficiency, and scalability. Therefore, this study aims to develop a banana disease detection system based on digital image processing using the You Only Look Once version 5 (YOLOv5) algorithm. This research employed a quantitative experimental approach using a dataset of 1,005 banana images labeled through the Roboflow platform. The training process was conducted in Google Colaboratory using four epoch configurations: 20, 50, 80, and 100 epochs. Model performance was evaluated using precision, recall, F1-score, mean Average Precision (mAP), and confusion matrix analysis. Experimental results showed that the best model performance was obtained at 50 epochs, achieving an mAP@50 value of 8.17%. These findings indicate that YOLOv5 can support effective banana disease detection under the experimental conditions applied in this study. In addition, the developed web-based system using Flask improves accessibility and usability for users in monitoring banana diseases. Nevertheless, this study is limited by the relatively small dataset size and controlled image acquisition conditions, which may affect model generalization in real-world environments. Future studies are recommended to expand the dataset, incorporate more diverse environmental conditions, and develop mobile-based implementations for real-time field applications.

Corresponding Author:
Anis Yusrotun Nadhiroh
Informatics Engineering, Faculty of Engineering, Nurul Jadid University, Paiton Probolinggo
Jl. KH. Zaini Mun'im, Tj. Lor, Karanganyar, Paiton, Probolinggo Regency, East Java 67291
Email: anis@unuja.ac.id

1. Introduction

Indonesia is one of the largest banana-producing countries in the world, with various banana varieties distributed across the archipelago. Bananas have an important role not only as a food commodity but also as a source of economic income for farmers and the agricultural sector. However, the productivity and quality of bananas are frequently threatened by fruit diseases, such as anthracnose, crown rot, and fruit rot. These diseases can reduce market quality, accelerate fruit decay, and cause significant economic losses during post-harvest distribution and storage. Anthracnose is generally characterized by blackish-brown spots on the banana peel, crown rot attacks the crown area causing tissue softening and blackening, while fruit rot damages the inner flesh of the banana and produces an unpleasant odor [1],[3].

Disease identification in bananas is still commonly performed through manual visual inspection. However, this method is highly dependent on human observation, making it susceptible to inconsistencies, misclassification, and low efficiency, especially when conducted on a large scale. In addition, early symptoms of banana diseases often appear visually similar, making accurate detection more difficult using conventional approaches. Therefore, an automated detection system is needed to support faster, more consistent, and more accurate disease identification.

The development of deep learning technology, particularly object detection algorithms, has shown promising results in agricultural applications. One of the most widely used methods is You Only Look Once version 5 (YOLOv5), which offers high detection speed and good accuracy in identifying objects from digital images. Previous studies have applied YOLO-based approaches for detecting plant diseases and pests in several agricultural commodities. Research on durian leaf disease detection achieved an mAP value of 0.815 at 100 epochs [4]. Another study on chili plant disease detection reported precision, recall, and F1-score values of 0.946, 0.936, and 0.959, respectively [5]. YOLO has also been implemented for potato pest classification [6], corn disease detection [7], and fresh versus rotten fruit classification [8]. These studies indicate that deep learning-based object detection has strong potential for improving agricultural monitoring systems.

Although previous studies have demonstrated the effectiveness of YOLO-based algorithms for plant disease detection, most studies focused on leaf diseases, pest detection, or fruit freshness classification in crops such as durian, chili, potato, and corn. Research specifically addressing banana fruit diseases, particularly anthracnose, crown rot, and fruit rot, remains limited. In addition, previous studies generally emphasized model performance evaluation without integrating the detection system into a web-based application that can improve accessibility and practical use for farmers or end users. Therefore, this study aims to fill this gap by developing a YOLOv5-based banana disease detection system integrated with a Flask web application for real-time image-based detection.

Based on these problems, this study aims to develop a YOLOv5-based banana disease detection model capable of identifying anthracnose, crown rot, and fruit rot diseases from digital images. Furthermore, this study evaluates the model performance using precision, recall, F1-score, and mean Average Precision (mAP), while also implementing the model into a Flask-based web application to support practical and accessible disease detection. The developed system is expected to assist farmers and agricultural practitioners in improving the efficiency and accuracy of banana disease identification.

2. Methodology

The research stages explain in more detail the research steps carried out from start to finish. The following are the stages and research design, as seen in Figure 1.

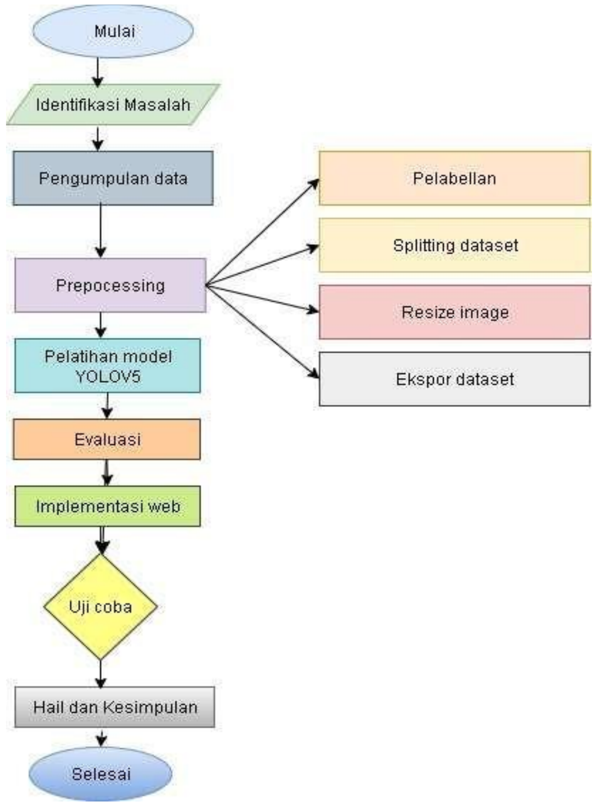


Figure 1. Research Method and Design

a) Identification of problems

In this research, the problem identification stage is to find out the problems that arise until push existence study This. Studies literature is a series activity Which please with collection data, reading, take notes And process material study from various source.

b) Dataset Collection

Dataset Collection collected from source provider data website on line that is Kaggle.[9] This dataset contains 1,005 images of bananas. affected *by anthracnose* , crown rot , and *fruit rot* in JPG format.

c) Pre-processing

The data pre-processing stage was carried out to prepare the dataset before training the YOLOv5 model. This stage consisted of annotation, annotation validation, image resizing, dataset splitting, and dataset export.

1. Data Annotation

   The annotation process was conducted using the Roboflow platform: Roboflow Platform. Each banana image was manually labeled using bounding boxes according to the disease category. Three object classes were used, namely: Anthracnose, Crown Rot, Fruit Rot

   The annotation process was performed manually by two annotators with knowledge of banana fruit disease characteristics based on visual symptoms obtained from agricultural literature and previous studies.

2. Annotation Guidelines and Quality Control
   To ensure annotation validity and dataset reliability, a labeling guideline was established before the annotation process. The guideline included:
   a. Consistent class naming for each disease category
   b. Criteria for determining infected regions
   c. Bounding box placement covering the entire visible disease area
   d. Avoidance of overlapping or incomplete labels

   After annotation, the labels were validated through a two-stage quality control process:
   a. Cross-check validation between annotators to verify label consistency
   b. Bounding box inspection to ensure that the annotated regions accurately covered the infected areas without excessive or missing object regions

   Incorrect or inconsistent annotations were revised manually before the dataset was finalized. This validation process was conducted to reduce labeling bias and improve model reliability during training and evaluation.
3. Image Resizing
   All images were resized to 640 × 640 pixels to match the YOLOv5 input configuration and improve computational efficiency during training.
4. Dataset Splitting
   The annotated dataset was divided into three subsets using a consistent ratio of:
   a. 80% training data
   b. 10% validation data
   c. 10% testing data

   From the total 1,005 images, the final distribution consisted of: 804 training images, 101 validation images, 100 testing images.
5. Dataset Export
   The processed dataset was exported in YOLOv5 format containing: train, valid, test and data.yaml. The dataset was compressed in ZIP format and extracted for the training process.

d) YOLOv5 Model Training

In stages This is manufacturing program in detect disease fruit banana model Which used is *You Only Look Once* (YOLOv5) with 3 classes disease that is disease spots with marked spots chocolate blackish on fruit banana, disease rotten crown with marked rotten part crown fruit banana, And disease rotten Which attack part in meat fruit marked bananas with smell No delicious as well as softening texture . Disease This attack on skin fruit banana Which will result fruit become rotten with fast .

e) Evaluation

On stage This, evaluation model done in the picture fruit banana Which The Yolov5 model has undergone training. Model evaluation is conducted after the training process is complete. The evaluation process aims to determine how well the model detects banana fruit diseases.

f) Web Implementation

The next step is to implement the model into a web-based application. This study uses the Flask *framework* to connect the model to the web. The detection process generates bounding boxes and disease class labels. The detection results are displayed directly on the web page.

g) Trials

The model testing phase was conducted to ensure that the method performed as expected. The YOLOv5 method was tested using testing data to detect banana diseases, calculated based on the number of correctly detected images. compared to with overall data test.

3. Results and Discussion

a. Dataset Collection

In this study, the data set used was banana fruit disease with amount dataset as much as 1,005 data picture disease fruit banana with 3 diseases, namely spots (*anthracnose),* *crown* rot , and *fruit rot*. The following is an example of a dataset which can be seen in Figure 2.

(a) Spots *(b) Rot crown* *(c) Rotten*

Figure 2. Example dataset

b. Pre-processing

Before the image data above is trained with the YOLOv5 model, the image will be processed first by performing data pre-processing. data is stages beginning For process data that Already collected

for further processing. Data pre-processing here includes several stages such as labeling (annotation), splitting data, resize image, And export dataset Which carried out using Roboflow with the aim of facilitating dataset processing.

1. Labeling data (annotation)

After upload picture furthermore do labeling on images, so that the detection results are more accurate and efficient. Figure 3 shows how to manually label in Roboflow.

Figure 3. Manual labeling in roboflow

2. Resize image

Next, Figure 4 shows the image resizing process in Roboflow. From all the collected datasets, there are many image sizes that have differences in size, so it is necessary to equalize the image sizes so that the position... label No exceed size picture Which other. Process resize image This set directly by roboflow after labeling the image in roboflow with 640 x 640 pixels.

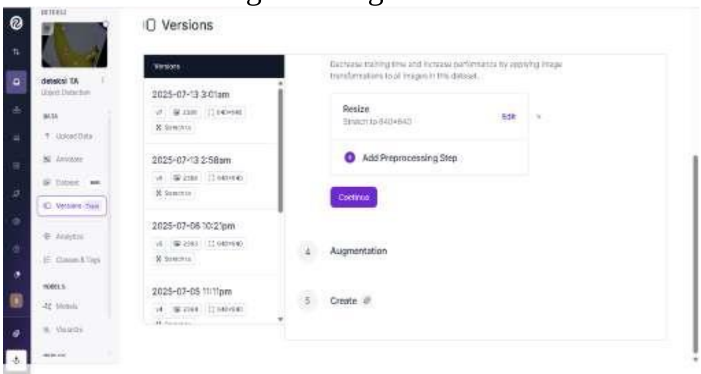


Figure 4. Image Resizing Process

3. Splitting dataset

Splitting the dataset can also be called data division, which is preprocessing in dataset that used in study This. The dataset that The data used comes from an image of a banana, then uploaded using the Roboflow platform. The splitting or data division process is carried out automatically by Roboflow after the annotation stage is complete.

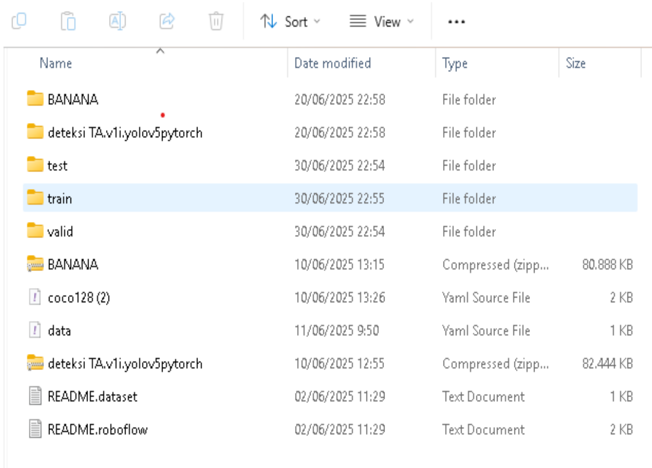


Figure 5. Splitting dataset

The processed dataset is divided into three folders: the training set, the validation set, and the test set, with a commonly used ratio of 80% for train, 10% for validation, and 10% for test. This data distribution is stored in *YAML file format, simplifying the training process for the banana disease detection model, particularly when using the YOLOv5 algorithm. The splitting stage can be seen in Figure 5.

4. Export dataset

After arrange resize image. So do editing augmentation which are desired, And after That crate new version For make dataset Import the yolov5 conversion, resulting in a version file like the one below. This can be seen in Figure 6.

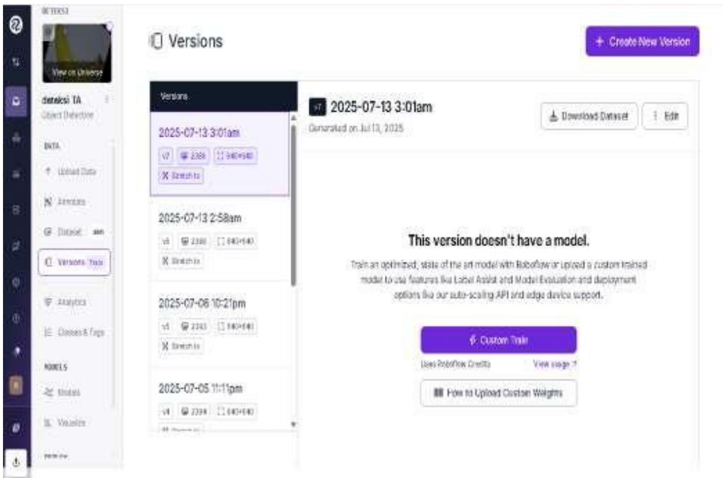


Figure 6. file version

c. YOLOv5 Model Training

This research analyzes the collected data to detect banana fruit diseases with specified classes such as anthracnose , fruit rot , and *crown rot* . The implementation of YOLOv5 here will begin by preparing a labeled dataset. In the labeling stage using the Roboflow platform, each object is manually labeled according to its respective object class. Once completed, the dataset is exported using the YOLOv5 PyTorch format (*TXT). Results export from roboflow saved in One folder ZIP Which contains 1,005 picture dataset banana in format .jpg, configuration in format *YAML, the folder structure of the train, valid, and test datasets. The unzipped image can be seen in Figure 7.

```
Jumlah data TRAIN : 2368
Jumlah data VALID : 100
Jumlah data TEST  : 105
```

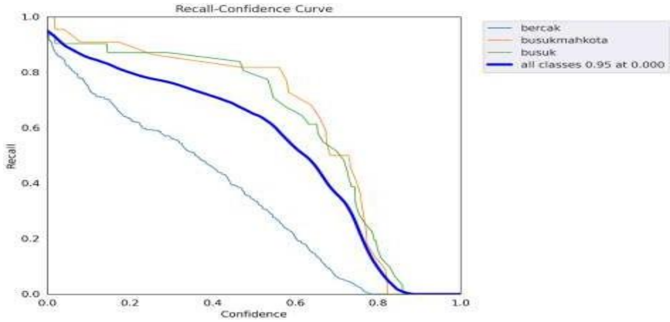
Picture 7. Result of unzipping dataset

These detected images will not replace the original data but will be stored separately to maintain the integrity of the original dataset. Sample data results can be seen in Figure 8.

a. spots b. crown rot c. rotten

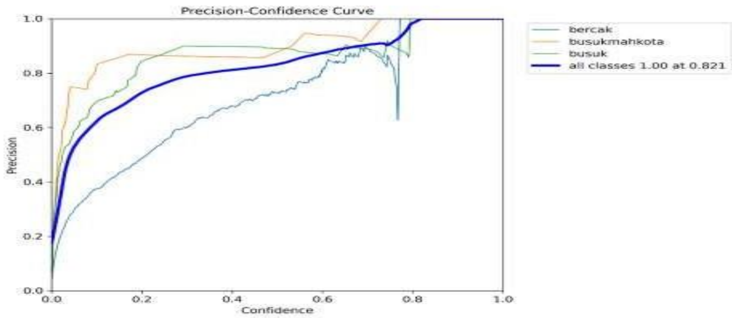
Picture 8. Results sample data

Trials were also conducted For see how much Good performance from YOLOv5 method in detect object . So that it can get results optimal performance , research This compare 4 times some trials , trials First done with amount epoch as much as 20 epoch, Which results mark recall his Can seen in figure 10. below This .



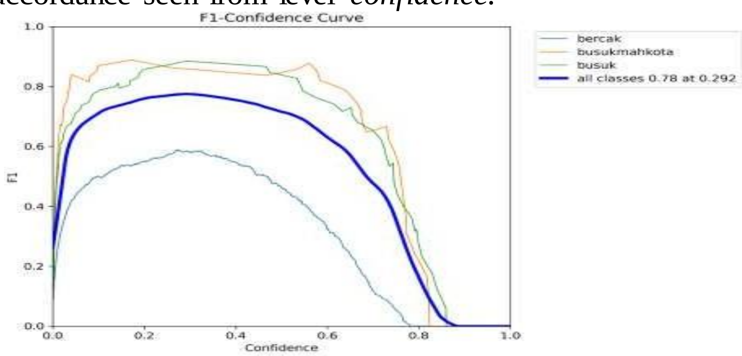
Picture 10. Recall Value

In Figure 10. *Recall* is graph showing how much both YOLOv5 models in recognize objects that are should detected . Mark his seen from various *confidence,* So bias seen How current model performance try detect object in a way comprehensive .



Picture 11.Precision Values

In Figure 11. the value Chart *Precision* show how much exact model YOLOv5 give results detect . So, chart This help check whether object Which succeed detected model That of course Correct - Correct in accordance seen from level *confidence.*



Picture 12. F1- score value

The *F1-score* used For show how much Good balance between same *precision recall* that the YOLOv5 model has . The graph connect between confidence value with results *F1-score* in each experiment . Because *F1-score* This combine two metric (*precision* And *recall*), its value Can help explain how much good model in introduce object in a way overall . Graphic image mark *F1-score* with epoch 20 can seen in figure 12.

d. Web Implementation

Next the image is processed, the detection results will be displayed. in page web Which The same. Appearance This show that The application is ready to be used to detect diseases based on digital images of bananas.

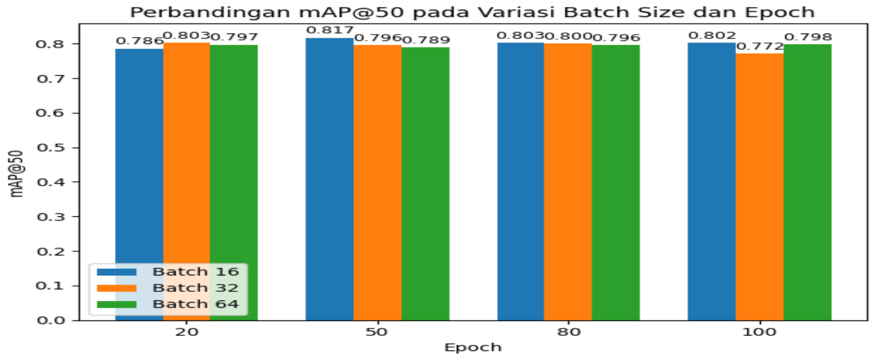
Picture 13. Results uploading on flask disease spots banana

In Figure 13. This is the result of the image upload process in the Flask implementation. Process This show that system has succeed read files picture And Ready do detection disease on fruit banana in a way automatically. On example This, picture Which tested is fruit banana with disease spots , so that the system will detect and classify the type of disease accurately. automatic based on model Which has trained. Process This show that system succeed read file picture And operate function detection appropriately . Table 1 explains the comparison of epoch and batch size with a mAP.50 value of 0.817.

Table 1. Epoch comparison And batch size

<table>
<tr><th>Batch size</th><th>Epoch</th><th>mAP- 50</th></tr>
<tr><td rowspan="4">16</td><td>20</td><td>0.786</td></tr>
<tr><td>50</td><td>0.817</td></tr>
<tr><td>80</td><td>0.803</td></tr>
<tr><td>100</td><td>0.802</td></tr>
</table>

Mark folder overall precisely A little more tall on epoch 50 compared to epochs 80 and 100 (0.817 vs 0.803, 0.802). This indicates that training no longer always give more results good , even Can causing the model to overfit the training data .



Picture 14. Batch Comparison size

Picture 14. show comparison mark mAP@50 on various combination amount epoch (20, 50, 80, And 100) And batch size (16, 32, And 64). The value of mAP@50 is metric evaluation used For measure model performance in detect objects at the IoU threshold by 0.5. Based on graph , visible that mAP-50 values are in the range of 0.77 to 0.82, which indicates relative model performance stable to variation of the parameters tested . At the 50th epoch, the model with batch size 16 obtains mAP-50 value highest compared to configuration other . Temporary That , model performance with batch size 32 and 64 tends to similar and a little is below batch size 16 in most cases big epoch.

4. Conclusion

This study successfully implemented the YOLOv5 method for detecting banana fruit diseases consisting of three classes, namely Anthracnose, Crown Rot, and Fruit Rot. The model was trained using 1,005 annotated banana images and evaluated using testing data to measure detection performance. Based on the experimental results, the YOLOv5 model was able to detect disease objects on banana fruit images with good performance, achieving an mAP@50 value of 0.817. Therefore, the obtained result indicates that the model has potential for assisting automatic banana disease detection in image-based applications.

However, this study still has several limitations. The dataset size is relatively limited and only uses images from a public dataset, which may not fully represent real environmental conditions. In addition, the testing process was conducted under controlled conditions and has not yet been validated directly in real agricultural environments. Therefore, the claim regarding model effectiveness should be limited to the experimental dataset and testing scenario used in this study.

For future research, several improvements are recommended:

1. Expanding the dataset with more diverse image variations, lighting conditions, and disease severity levels.
2. Conducting field validation using real-time banana plantation images to evaluate model robustness in practical conditions.
3. Implementing and testing the model in real-time detection systems such as mobile or IoT-based agricultural applications.
4. Comparing YOLOv5 with newer object detection architectures to improve detection accuracy and inference performance.

These improvements are expected to increase the reliability, generalization capability, and practical applicability of banana disease detection systems in the agricultural sector.

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