



IMPROVING THE ACCURACY OF DEEP LEARNING-BASED OBJECT DETECTORS ON RASPBERRY PI

HASIBULLAH ATIQUI



COMPUTER SCIENCE MASTER PROGRAM
SCHOOL OF DATA SCIENCE, MATHEMATICS, AND INFORMATICS
IPB UNIVERSITY
BOGOR
2025



@Hak cipta milik IPB University

Hak Cipta Dilindungi Undang-undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :

- a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
- b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.

2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.



STATEMENT REGARDING THE THESIS AND SOURCES OF INFORMATION AND ASSIGNMENT OF COPYRIGHT

I hereby declare that the thesis entitled "Improving the Accuracy of Deep Learning-Based Object Detectors on Raspberry Pi " is my work under the direction of my supervisors and has not been submitted in any form to any university. Sources of information originating or quoted from published or unpublished works of other authors have been mentioned in the text and included in the Bibliography at the end of this thesis.

I hereby assign the copyright of my written work to the IPB University.

Bogor, August 2025

Hasibullah Atiqi

G6501222801

- Hak Cipta Dilindungi Undang-undang
1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
 2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.

SUMMARY

HASIBULLAH ATIQL. Improving the Accuracy of Deep Learning-Based Object Detectors on Raspberry Pi. Supervised by SRI WAHJUNI and MUSHTHOFA

This study focuses on the implementation and performance evaluation of the YOLOv8 object detection algorithm on a resource-limited device, Raspberry Pi 5, to detect abnormalities in melon leaves. A secondary dataset containing images of melon leaves captured using a Raspberry Pi camera was utilized in two forms: original and augmented. The model was trained and evaluated using key performance metrics such as mean Average Precision (mAP), precision, recall, and F1 score. Two backbone architectures, Original and GhostNet, were compared to assess both detection accuracy and computational efficiency. The results revealed that data augmentation significantly improved detection performance, with mAP@0.5 for the Original Backbone increasing from 0.52 to 0.80, and for GhostNet from 0.49 to 0.78. After hyperparameter tuning, the best results achieved were mAP@0.5 of 0.81 for the Original Backbone and 0.80 for GhostNet. Although the Original Backbone attained slightly higher accuracy, the GhostNet model demonstrated superior computational efficiency with faster inference speed (3.97 FPS vs. 2.75 FPS), lower latency, and smaller model size (9.23 MB vs. 20 MB). Based on these findings, the GhostNet backbone with augmented data and optimized hyperparameters provides the best trade-off between accuracy and efficiency, making it the most suitable option for real-time deployment on low-powered devices such as Raspberry Pi 5, and offering a promising solution for field-based monitoring of melon leaf abnormalities in resource-constrained agricultural environments.

Keywords: Deep learning, YOLOv8, GhostNet. Melon leaf, Raspberry Pi.



- Hak Cipta Dilindungi Undang-undang
1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
 2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.

© IPB's Copyright, 2025

Copyright Protected by Law

It is forbidden to cite part or all of this paper without listing or mentioning the source. Citations are only for the purpose of education, research, writing scientific papers, preparing reports, writing criticisms, or reviewing an issue, and such citations are not detrimental to the interests of IPB.

It is forbidden to publish and reproduce part or all of this paper in any form without IPB's permission.

IMPROVING THE ACCURACY OF DEEP LEARNING- BASED OBJECT DETECTORS ON RASPBERRY PI

HASIBULLAH ATIQUI

Thesis
as one of the requirements for obtaining a degree
Masters in
Computer Science Study Program

COMPUTER SCIENCE MASTER PROGRAM
SCHOOL OF DATA SCIENCE, MATHEMATICS, AND INFORMATICS
IPB UNIVERSITY
BOGOR
2025



@Hak cipta milik IPB University

Hak Cipta Dilindungi Undang-undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.

External Examiners of the Supervisory Commission on the Thesis Exam:
Dr. Toto Haryanto, S.Kom., M.Si.

Title : Improving the Accuracy of Deep Learning-Based Object
Detectors on Raspberry Pi
Name : Hasibullah Atiqi
NIM : G6501222801

Approved by

Supervisor 1:
Dr. Ir. Sri Wahjuni, M.T.

Supervisor 2:
Dr. Mushthofa, S.Kom., M.Sc.

Acknowledged by

Head of Study Program:
Dr. Toto Haryanto, S.Kom., M.Si.
NIP 19821117 201404 1 001

Dean of the School of Data Science, Mathematics, and
Informatics:
Prof. Dr. Ir. Agus Buono, M.Si., M.Kom.
NIP. 19660702 199302 1 001

Exam Date: 25 July 2025

Graduation Date:



FORWORD

Praise and gratitude are expressed to Almighty Allah SWT for His blessings and mercy, allowing the author to complete this thesis entitled *"Improving the Accuracy of Deep Learning-Based Object Detectors on Raspberry Pi."* This thesis is prepared as a requirement for obtaining a Master's degree in the Information Technology program. This research focuses on the development and optimization of deep learning-based detection models implemented on Raspberry Pi to identify abnormalities in melon leaves. Through this approach, it is expected to provide an efficient and real-time solution for farmers to monitor plant health directly in the field.

The author realizes that the completion of this thesis would not have been possible without the support and assistance of many parties. Therefore, the author would like to express the deepest gratitude to the supervisors, family, and colleagues who have provided support, suggestions, and motivation throughout the research and writing process. The author hopes that the results of this research can contribute positively to technology-based agriculture and serve as a reference for future studies.

Hopefully this scientific paper will be useful for those in need and for the advancement of science.

Bogor, August 2025

Hasibullah Atiqi

- Hak Cipta Dilindungi Undang-undang
1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
 2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.



TABLE OF CONTENT

TABLE LIST xi

FIGURE LIST xi

ATTACHMENT LIST xii

I. INTRODUCTION 1

1.1 Background 1

1.2 Problem Formulation 4

1.3 Research Objectives 4

1.4 Research Benefits 4

1.5 Scope 4

II. LITERATURE REVIEW 5

2.1 One-Stage Object Detection 5

2.2 GhostNet 7

2.3 Raspberry Pi 7

2.4 Abnormality of Melon Plant Leaves 7

2.5 Model Evaluation 8

III. METHODOLOGY 10

3.1 Data and Study Area 10

3.2 Research Stage 10

3.3 Cross Validation 10

3.4 Model Training 11

3.5 Model Evaluation 13

3.6 Implementation on the Raspberry Pi 13

3.7 Algorithm Performance Comparison Analysis 14

3.8 Development Environment 14

IV. RESULT AND DISCUSSION 15

4.1 Data Analysis Results 15

4.2 Original Dataset characteristics 15

4.3 Cross Validation Results 17

4.4 Initial Model Training Results 20

4.5 Hyperparameter Tuning Results 24

4.6 Model Evaluation Result 27

4.7 Analysis and Comparison with Previous Model 29

4.8 Implementation to Raspberry Pi 30

V. CONCLUSION AND SUGGESTIONS 32

5.1 Conclusion 32

5.2 Suggestions 32

REFERENCES 33

CURRICULUM VITAE 38

ATTACHMENTS 39

Hak cipta milik IPB University

Hak Cipta Dilindungi Undang-undang
1. Dianggot sebagai bagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
2. Dianggot mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.



1 Accuracy, speed, and size of five YOLOv8 models (source: Ultralytics)	6
2 Initial Modelling	12
3 YOLOv8 Hyperparameters	13
4 Original Dataset	15
5 Data augmentation technique	16
6 Total augmented data and its object	17
7 Cross validation with original data	18
8 Cross validation with augmented Data	18
9 Initial model training result	20
10 Original Backbone hyperparameter combination	25
11 GhostNet hyperparameter combination	26
12 Initial model evaluation	27
13 Hyperparameter tuning model evaluation	28
14 Results of the implementation of the original model and ghost best.pt	30
15 Results of the implementation of the original best.onnx model	31

FIGURE LIST

1 Illustration of YOLO model	5
2 YOLO architecture	6
3 Research stage	10
4 Model implementation on Raspberry Pi5	14
5 Comparison of Total Abnormal and Normal Object per Dataset	15
6 Sample image of augmented images	17
7 Range of Object Counts Across Cross-Validation Folds	19
8 Box plot for performance metrics for all folds	19
9 Performance improvement due to augmentation	21
10 Training time per image	22
11 Model Size	22
12 mAP@0.5 vs. Dataset Variability	23
13 Distribution of mAP@0.5 across folds	24
14 Performance Metrics on Augmented dataset	24
15 Average Model Size in Training with Augmented Data	28
16 Average Training Time in Training with Augmented Data	29

ATTACHMENT LIST

1 Results of the implementation of the original and ghost architecture best.pt models	39
2 Results of the implementation of the original and ghost architecture best.onxx models	40

Hak Cipta Dilindungi Undang-undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :

- Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
- Pengutipan tidak merugikan kepentingan yang wajar IPB University.

2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.