**UNDERGRADUATE THESIS**

# HYBRID METHOD OF EFFICIENTNET-B0 AND PROTOTYPICAL NETWORK FOR MULTI-CLASS CLASSIFICATION OF DIABETIC RETINOPATHY


**ABI EKA PUTRA WULYONO**

NPM 22081010190


**THESIS ADVISORS**

Dr. Faisal Muttaqin, S.Kom, M.T

Budi Mukhamad Mulyo, S.Kom., MT


**MINISTRY OF HIGHER EDUCATION, SCIENCE AND TECHNOLOGY**

**UNIVERSITAS PEMBANGUNAN NASIONAL VETERAN JAWA TIMUR**

**FACULTY OF COMPUTER SCIENCE**

**INFORMATICS STUDY PROGRAM**

**SURABAYA**


**2026**

# APPROVAL SHEET

## HYBRID METHOD OF EFFICIENTNET-B0 AND PROTOTYPICAL NETWORK FOR MULTI-CLASS CLASSIFICATION OF DIABETIC RETINOPATHY

**By:**
ABI EKA PUTRA WULYONO
NPM. 22081010190

Has been defended before, and accepted by, the Board of Assessors of the Thesis Examination of the Informatics Study Program, Faculty of Computer Science, Universitas Pembangunan National Veteran Jawa Timur, on 13 March 2026.

**Dr. Faisal Muttaqin, S.Kom. M.T.**
**NIP. 19851231 2021211 009** ..... **(Advisor I)**

**Budi Mukhamad Mulyo, S.Kom., MT.**
**NIP. 19891118 2024061 003** ..... **(Advisor II)**

**Retno Mumpuni, S.Kom., M.Sc.**
**NIP. 19870716 2025212 045** ..... **(Head Assessor)**

**Henni Endah Wahanani, ST. M. Kom.**
**NIP. 19780922 2021212 005** ..... **(Assessor)**

**Acknowledge by,**
**Dean of Faculty of Computer Science**

**Prof. Dr. Ir. Novirina Hendrasarie, MT**
**NIP. 19681126 199403 2 001**

# APPROVAL SHEET

**HYBRID METHOD OF EFFICIENTNET-B0 AND PROTOTYPICAL NETWORK FOR MULTI-CLASS CLASSIFICATION OF DIABETIC RETINOPATHY**

By:
ABI EKA PUTRA WULYONO
NPM. 22081010190

Approved to proceed to the Thesis Examination

**Approved by,**
**Coordinator of Informatics Study Program**
**Faculty of Computer Science**

**Fetty Tri Anggraeny, S.Kom. M.Kom.**
**NIP. 19820211 2021212 005**

# STATEMENT OF ORIGINALITY

I am the undersigned:

| | |
|---|---|
| Name | : ABI EKA PUTRA WULYONO |
| NPM | : 22081010190 |
| Program | : Bachelor (S1) |
| Study Program | : Informatics |
| Faculty | : Faculty of Computer Science |

Hereby declare that this thesis document contains no part of another academic work that has been submitted to obtain an academic degree at any higher education institution, and also contains no work or opinion that has been written or published by any other person or institution, except those cited in writing in this document and listed in full in the bibliography.

I also declare that this academic document is free from elements of plagiarism. If plagiarism is subsequently found in this thesis, I am willing to accept sanctions in accordance with the applicable laws and regulations.

This statement is made truthfully without any coercion from any party and to be used as necessary.

Surabaya, 9 April 2026
The Author,


ABI EKA PUTRA WULYONO
NPM. 22081010190

# ABSTRACT


| | | |
|---|---|---|
| Student Name / NPM | : | Abi Eka Putra Wulyono / 22081010190 |
| Thesis Title | : | Hybrid Method of EfficientNet-B0 and Prototypical Network for Multi-Class Classification of Diabetic Retinopathy |
| Supervisor | : | 1. Dr. Faisal Muttaqin, S.Kom, M.T. |
| | : | 2. Budi Mukhamad Mulyo, S.Kom., MT. |



Diabetic Retinopathy (DR) is a microvascular complication of diabetes mellitus that can lead to permanent blindness if not detected at an early stage. Automated deep learning-based classification systems have emerged as a practical approach to support consistent and efficient screening processes. However, severe class distribution imbalance in retinal fundus image datasets remains a fundamental challenge that degrades model performance, particularly for classes with limited training samples. This study proposes a hybrid model that integrates EfficientNet-B0 as a transfer learning-based feature extractor with a Prototypical Network as a metric learning-based classifier, trained *end-to-end* for five-class DR severity classification using the *APTOS 2019 dataset*. Four baseline models were constructed as comparators, consisting of EfficientNet-B0 with a softmax classifier and a standalone Prototypical Network, each evaluated with and without enhanced green channel preprocessing. Model performance was assessed using accuracy, macro precision, macro recall, macro F1-score, and Quadratic Weighted Kappa (QWK) as the primary metric given its suitability for ordinal classification. The proposed model without preprocessing achieved the best results with an accuracy of 82.26% and QWK of 0.8807, outperforming Baseline 1 as the strongest baseline model which reached only 80.35% accuracy and QWK of 0.8529. Confusion matrix analysis shows that the proposed model produces error patterns more consistent with the ordinal class structure, where misclassifications predominantly occur between adjacent severity classes rather than distant ones. t-SNE visualizations further confirm that the proposed model forms a more structured *embedding space* with clearer inter-class separability, attributed to the prototypical loss mechanism that explicitly optimizes inter-class distances. Additionally, this study reveals that enhanced green preprocessing produces opposing effects depending on the model type, degrading performance for transfer learning-based models while improving it for from-scratch models, which implies that preprocessing strategy must be aligned with the architectural properties and the source domain of the pretrained weights used.



**Keywords**: Diabetic Retinopathy, EfficientNet-B0, Prototypical Network, *Few-shot learning*, Transfer Learning

# ACKNOWLEDGEMENTS

All praise and gratitude are rendered to the presence of Allah SWT. for His abundant grace, guidance, and mercy, so that the author has been able to complete the preparation of this thesis entitled **"Hybrid Method of EfficientNet-B0 and Prototypical Network for Multi-Class Classification of Diabetic Retinopathy"**. The writing of this thesis is the final stage that must be completed to obtain the degree of Bachelor of Computer Science in the Informatics Study Program, Faculty of Computer Science, Universitas Pembangunan Nasional "Veteran" Jawa Timur.

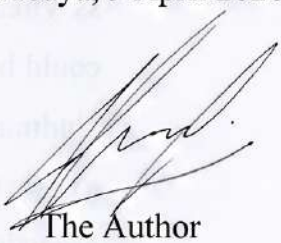
In the process of preparing this thesis, the author acknowledges that the achievements accomplished were inseparable from the assistance, support, and prayers of various parties who have contributed both morally, spiritually, and materially. Therefore, with all humility, the author extends sincere gratitude to:

1. Prof. Dr. Ir. Novirina Hendrasarie, MT, as Dean of the Faculty of Computer Science, UPN "Veteran" Jawa Timur.
2. Fetty Tri Anggraeny, S.Kom., M.Kom., as Head of the Informatics Study Program.
3. Eka Prakarsa Mandyartha, ST., M.Kom., as the author's academic advisor who has provided assistance in academic counseling from the beginning of studies until the end.
4. Dr. Faisal Muttaqin, S.Kom., M.T. and Budi Mukhamad Mulyo, S.Kom., MT., as Thesis Supervisors who have guided and provided direction so that the author was able to complete this thesis.
5. Retno Mumpuni, S.Kom., M.Sc. and Henni Endah Wahanani, ST., M.Kom., as Thesis Examiners who have also directed the author so that this thesis could be properly prepared.
6. Andreas Nugroho Sihananto, S.Kom., M.Kom., who has assisted the author in completing all administrative matters related to the thesis defense proceedings through to graduation.
7. All lecturers of the Informatics Study Program at UPN "Veteran" Jawa Timur who have imparted knowledge, guidance, and inspiration of great significance in the author's academic development.

8. The author's family, who have always prayed, provided financial support, and given unwavering mental support throughout, enabling the author to complete this thesis.
9. Muhammad Adeva, a fellow student who accompanied and went through every stage of thesis supervision and academic proceedings together.
10. Semma Aisyah Nur Setyo Rahayu, who has always motivated the author to complete this thesis, offering companionship, support, and encouragement until the very end.
11. Alief, Fadika, and Nabil, fellow students throughout the study period who have always been present, accompanied, and supported each other through every process undertaken together.
12. All members and administrators of the Informatics Student Association (Himpunan Mahasiswa Informatika) at UPN "Veteran" Jawa Timur who have taught the meaning of camaraderie, the importance of teamwork and leadership, and provided invaluable experiences for the author's future.
13. All parties who cannot be mentioned one by one, who have been part of the author's journey and have grown together in the academic world.

The author also acknowledges that this thesis is far from perfect. Therefore, all constructive criticism and suggestions are greatly appreciated for future improvements. It is hoped that this work can provide benefits to all parties, both in the development of knowledge and as a reference for further research.

Surabaya, 9 April 2026



The Author

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES