UNDERGRADUATE THESIS

COMPARISON OF CROSS FUSION CHANNEL ATTENTION AND COORDINATE ATTENTION IN THE CAS-UNET ARCHITECTURE FOR RETINAL BLOOD VESSEL SEGMENTATION

HILYA 'ZADA MARDHATILLA AL HAADIY
NPM 22081010172

THESIS ADVISORS
Fetty Tri Anggraeny, S.Kom., M.Kom.
Eva Yulia Puspaningrum, S.Kom., M.Kom.

MINISTRY OF HIGHER EDUCATION, SCIENCE, AND TECHNOLOGY
UNIVERSITAS PEMBANGUNAN NASIONAL VETERAN JAWA TIMUR
FACULTY OF COMPUTER SCIENCE
INFORMATICS STUDY PROGRAM
SURABAYA
2026

APPROVAL SHEET

COMPARISON OF CROSS-FUSION CHANNEL ATTENTION AND COORDINATE ATTENTION IN THE CAS-UNET ARCHITECTURE FOR RETINAL BLOOD VESSEL SEGMENTATION

By :
HILYA 'ZADA MARDHATILLA AL HAADIY
NPM. 22081010172

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 Nasional Veteran Jawa Timur, on May 20, 2026:

Approved,

Fetty Tri Anggraeny, S.Kom., M.Kom.
NIP. 19820211 202121 2 005 ..... **(Advisor I)**

Eva Yulia Puspaningrum, S.Kom., M.Kom
NIP. 19890705 202121 2 002 ..... **(Advisor II)**

Dr. Eng. Ir. Anggraini Puspita Sari, S.T., M.T.
NPT. 222198 60 816400 ..... **(Head Assesor)**

Dr. Budi Nugroho, S.Kom., M.Kom.
NIP. 19800907 202121 1 005 ..... **(Assesor 1)**

Acknowledge by,
Dean od the Faculty of Computer Science

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

APPROVAL SHEET

COMPARISON OF CROSS-FUSION CHANNEL ATTENTION AND COORDINATE ATTENTION IN THE CAS-UNET ARCHITECTURE FOR RETINAL BLOOD VESSEL SEGMENTATION

By :
HILYA 'ZADA MARDHATILLA AL HAADIY
NPM. 22081010172

Approved to proceed to the Thesis Examination

Approved by,

Coordinator of Informatics Study Program

Faculty of Computer Science

Dr. Intan Yuniar Purbasari, S.Kom., MSc.
NIP. 19800602 202521 2 029

STATEMENT OF ORIGINALITY

I am the undersigned:

Student Name	:	Hilya 'Zada Mardhatilla Al Haadiy
NPM	:	22081010172
Degree Program	:	Bachelor (S1)
Study Program	:	Informatics
Faculty	:	Faculty of Computer Science

Hereby declares that this undergraduate thesis contains no part of any other scientific work that has been submitted to obtain an academic degree at any higher education institution. Furthermore, it does not contain any work or opinions previously written or published by others, except for those which are explicitly cited in this thesis and listed completely in references.

And I declare that this scientific document is free from elements of plagiarism. If in the future indications of plagiarism are found in this Thesis, I am willing to accept sanctions in accordance with the applicable laws and regulations.

Thus, I made this statement without any coercion from anyone and to be used as it should.

Surabaya, June 11, 2026

Declarant,

HILYA 'ZADA MARDHATILLA AL HAADIY

NPM. 22081010172

ABSTRACT

Student Name / NPM	:	Hilya 'Zada Mardhatilla Al Haadiy / 22081010172
Thesis Title	:	COMPARISON OF CROSS-FUSION CHANNEL ATTENTION AND COORDINATE ATTENTION IN THE CAS-UNET ARCHITECTURE FOR RETINAL BLOOD VESSEL SEGMENTATION
Advisor	:	1. Fetty Tri Anggraeny, S.Kom. M.Kom. 2. Eva Yulia Puspaningrum, S.Kom., M.Kom

Retinal blood vessel segmentation is a crucial step in fundus image analysis to support the early detection of ocular diseases, such as diabetic retinopathy. However, the thin, branching structures of blood vessels and their low contrast with the background make the segmentation process a challenging task. This study aims to develop and compare the performance of the CAS-UNet architecture with two attention mechanisms, namely Cross-Fusion Channel Attention (CFCA) and Coordinate Attention (CA), for retinal blood vessel segmentation. The study was conducted using a combined dataset of DRIVE and CHASE_DB1. The methodology includes data collection and splitting, preprocessing, patch extraction, model training, and evaluation using accuracy, sensitivity, specificity, F1-score, and Intersection over Union (IoU) metrics. Several parameter *testing* scenarios were performed to obtain the optimal configuration. The results indicate that both models achieve high and stable performance. Under the best configuration, CAS-UNet with CFCA achieved an accuracy of 97.10%, sensitivity of 82.45%, specificity of 98.39%, F1-score of 82.11%, and IoU of 69.65%. Meanwhile, CAS-UNet with CA achieved an accuracy of 97.12%, sensitivity of 80.20%, specificity of 98.60%, F1-score of 81.79%, and IoU of 69.18%. Although both models show comparable accuracy, the CFCA-based model outperforms CA in terms of sensitivity, F1-score, and IoU. Therefore, it can be concluded that CAS-UNet with the CFCA module is more optimal for retinal blood vessel segmentation compared to the CA module. This study is expected to serve as a reference for the development of deep learning-based medical image segmentation methods.

Keywords : Image Segmentation, Retinal Blood Vessels, CAS-UNet, CFCA, Coordinate Attention, Deep Learning

ACKNOWLEDGEMENTS

Alhamdulillāhi rabbil ‘alamin, all praise be to Allah SWT, the Lord of all the worlds, the One who governs destiny in the most beautiful unfolding of His divine design. To Him alone belongs all gratitude, for through His mercy and will, the author was nurtured within the embrace of a loving family, raised with sincere affection, and guided along a life journey filled with meaning, lessons, and reflection, until finally being able to pursue an academic path at Universitas Pembangunan Nasional “Veteran” Jawa Timur. By His infinite grace and blessing, the thesis entitled **“Comparison of Cross Fusion Channel Attention and Coordinate Attention in the CAS-UNet Architecture for Retinal Blood Vessel Segmentation”** has ultimately been completed.

The author realizes that this journey was not solely shaped by personal effort, but also by prayers, support, and the presence of many precious individuals whose kindness has silently accompanied every step. Therefore, with utmost humility, the author would like to express sincere and deepest gratitude to:

1. To my beloved parents, Mr. Hadi Pranowo and Mrs. Sri Indarwati, who not only raised me but also instilled values, shaped my thoughts, and strengthened my heart. Behind every step I have taken lies prayers that never ceased, exhaustion that was never fully revealed, and sacrifices that often remained unspoken yet always existed in the form of unconditional love. From the warmth of this family, I have learned the meaning of togetherness, patience, and hope that never fades. Moreover, I have come to realize that every achievement I hold today is truly a reflection of their prayers and struggles, which may never have been written, yet have always become the reason I am able to stand and continue this journey until this very point.
2. Prof. Dr. Ir. Akhmad Fauzi, M.MT., IPU., Rector of Universitas Pembangunan Nasional “Veteran” Jawa Timur, for the invaluable opportunity and academic space that has allowed the author to grow, learn, and gain meaningful experiences.

3. Prof. Dr. Ir. Novirina Hendrasarie, M.T., Dean of the Faculty of Computer Science, for providing support and ensuring the smooth provision of academic facilities throughout the educational process.
4. Dr. Intan Yuniar Purbasari, S.Kom., MSc., Head of the Informatics Study Program, for her continuous coordination and guidance that has contributed greatly to students' academic development.
5. Dr. Ir. Kartini, S.Kom., M.T., as Academic Advisor, for her patience, guidance, and direction throughout the years of study.
6. Mrs. Fetty Tri Anggraeny, S.Kom., M.Kom. and Mrs. Eva Yulia Puspaningrum, S.Kom., M.Kom., as thesis supervisors, for their time, dedication, and patience in guiding and broadening the author's academic perspective, which ultimately enabled the completion of this thesis.
7. Klinik Mata Jombang, which has provided invaluable support in the form of a dataset validation letter for this research. This contribution is not merely administrative assistance, but also a crucial element in ensuring the validity and credibility of the data used in this study. Without such openness and cooperation, this research would not have been able to proceed as smoothly as it has.
8. Author's younger sisters, Naura Kayyasah and Nadhila Hasna, who complete the journey of life in their own quiet yet meaningful way, bringing small laughter amid exhaustion and reminding me that home will always remain the warmest place to return to in the midst of life's struggles.
9. Mamak Tukiyah, Budhe Zulaikha, cousins, and the entire large family of Bani Jauri and Bani Soebari, who have provided support in many forms, both visible and unseen, flowing silently through sincere prayers that have never ceased, becoming an invisible yet powerful strength throughout this journey.
10. Author's friends in college, Azzahra Adelia Sabrina Salsabila, Dhea Intan Sagita, and Cheisya Alya Natasha, who have not only been study companions but also safe spaces to grow, share burdens, and strengthen one another when the journey felt heavy and uncertain.

11. Author’s friends since high school, Eka Rahmaningrum, Dzikha Kartika Sari, and Dita Putri Dwi Natarina, whose sincerity and support have remained constant across time and distance, becoming part of a journey that has never truly been walked alone.
12. Fia, Tisa, Nanda, Cici, Alvi, Intan, Firnanda, and the entire IMAJIPENA family, who have become a second home filled with color, where ideas, laughter, and enthusiasm grow together, teaching the meaning of unity in diversity of purpose and steps.
13. Autor’s friends during KKN 124, Vivi, Rizna, and others, who have shared a meaningful phase of service filled with stories, exhaustion, and simple yet memorable joy, making every process feel lighter and more meaningful.
14. Brilia, Hana, Mbak Zahrin, Mbak Ji, and Mbak Dwi, who have not only shared knowledge but also tranquility of heart, where every meeting becomes reflection, every discussion becomes enlightenment, and every togetherness leaves an unforgettable trace.
15. To every soul who has ever crossed paths with me, whether briefly or for a long time, I extend my deepest gratitude. Every fall has become a lesson, every doubt has turned into wisdom, and every silent prayer has become unseen strength that has shaped me into who I am today. Even those who came and went have left traces that helped form this present moment.
16. To myself— who has endured every rise and fall of this journey, who chose to keep moving forward despite uncertainty, who remained standing despite exhaustion, and who continued to believe that no process is ever in vain, because every step is part of a destiny being gently perfected.
17. All fellow students of the Informatics Study Program, whose names cannot be mentioned individually, thank you for the shared journey throughout academic life, for discussions, mutual assistance in understanding materials, and even simple laughter amidst heavy academic pressure. Your presence has added color to this growth process, making every step feel lighter and more meaningful.
18. And to all parties who have supported the author in any form, directly or indirectly, whose names may not be mentioned one by one but whose

kindness is never forgotten, the author extends sincere gratitude. Every help, prayer, and small act of kindness has become an essential part of this journey until the completion of this thesis.

May Allah SWT grant abundant blessings in return for all kindness given, expand sustenance, bring peace to every heart, and strengthen all of us in facing life's trials. This thesis is not merely the result of personal effort, but a series of prayers, support, and divine decree beautifully arranged by Him. The author also realizes that this work is still far from perfect; therefore, constructive criticism and suggestions are highly expected for future improvement. Finally, may this thesis bring benefits not only to the author and readers, but also to the advancement of knowledge in general.

Surabaya, June 11, 2026

The Author

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES