MAMMOGRAPHIC BREAST CANCER DETECTION USING RESNET-50 WITH TRANSFER LEARNING: A CASE STUDY IN TIMOR-LESTE AND INDONESIA

SKRIPSI

OLEH:
IVONIA FATIMA VIEGAS
2215101085

PROGRAM STUDI ILMU KOMPUTER (S1)
JURUSAN TEKNIK INFORMATIKA
FAKULTAS TEKNIK DAN KEJURUAN
UNIVERSITAS PENDIDIKAN GANESHA

- UU ITE No. 11 Tahun 2008 Pasal 5 Ayat 1 "Informasi Elektronik dan/atau hasil cetaknya merupakan alat bukti hukum yang sah"
- Dokumen ini telah ditandatangani secara elektronik menggunaan sertifikat elektronik yang diterbitkan BSrE - BSSN, validitias dokumen elektronik ini bisa dicek menggunakan aplikasi mobile VeryDS oleh BSrE
- Cetakan dokumen ini merupakan salinan dari file dokumen bertandatangan elektronik yang keabsahannya dapat diakses melalui scan QRCode yang terdapat pada sertifikat ini.

Balai Besar Sertifikasi Elektronik

- UU ITE No. 11 Tahun 2008 Pasal 5 Ayat 1 "Informasi Elektronik dan/atau hasil cetaknya merupakan alat bukti hukum yang sah"
- Dokumen ini telah ditandatangani secara elektronik menggunaan sertifikat elektronik yang diterbitkan BSrE - BSSN, validitias dokumen elektronik ini bisa dicek menggunakan aplikasi mobile VeryDS oleh BSrE
- Cetakan dokumen ini merupakan salinan dari file dokumen bertandatangan elektronik yang keabsahannya dapat diakses melalui scan QRCode yang terdapat pada sertifikat ini.

Balai Besar Sertifikasi Elektronik

SKRIPSI

DIAJUKAN UNTUK MELENGKAPI TUGAS DAN MEMENUHI SYARAT-SYARAT UNTUK MENCAPAI GELAR SARJANA KOMPUTER

Menyetujui

Pembimbing I	Dr. Agus Aan Jiwa Permana, S.Kom., M.Cs. NIP.198708042015041001
Pembimbing II	Dr. Ni Ketut Kertiasih, S.Si., M.Pd. NIP.197011181997032001

- UU ITE No. 11 Tahun 2008 Pasal 5 Ayat 1 "Informasi Elektronik dan/atau hasil cetaknya merupakan alat bukti hukum yang sah"
- Dokumen ini telah ditandatangani secara elektronik menggunaan sertifikat elektronik yang diterbitkan BSrE - BSSN, validitias dokumen elektronik ini bisa dicek menggunakan aplikasi mobile VeryDS oleh BSrE
- Cetakan dokumen ini merupakan salinan dari file dokumen bertandatangan elektronik yang keabsahannya dapat diakses melalui scan QRCode yang terdapat pada sertifikat ini.

Balai Besar Sertifikasi Elektronik

Skripsi oleh Ivonia Fatima Viegas ini
telah dipertahankan di depan dewan penguji
Pada tanggal 08 Juni 2026

Dewan Penguji

Ketua	Ni Putu Novita Puspa Dewi, S.Kom., M.Cs., MIM. NIP.199410032020122015
Anggota	Dr. Ni Wayan Marti, S.Kom., M.Kom. NIP.197711282001122001
Anggota	Dr. Agus Aan Jiwa Permana, S.Kom., M.Cs. NIP.198708042015041001
Anggota	Dr. Ni Ketut Kertiasih, S.Si., M.Pd. NIP.197011181997032001

- UU ITE No. 11 Tahun 2008 Pasal 5 Ayat 1 "Informasi Elektronik dan/atau hasil cetaknya merupakan alat bukti hukum yang sah"
- Dokumen ini telah ditandatangani secara elektronik menggunaan sertifikat elektronik yang diterbitkan BSrE - BSSN, validitias dokumen elektronik ini bisa dicek menggunakan aplikasi mobile VeryDS oleh BSrE
- Cetakan dokumen ini merupakan salinan dari file dokumen bertandatangan elektronik yang keabsahannya dapat diakses melalui scan QRCode yang terdapat pada sertifikat ini.

Balai Besar Sertifikasi Elektronik

Diterima oleh Panitia Ujian Fakultas Teknik dan Kejuruan
Universitas Pendidikan Ganesha
guna memenuhi syarat-syarat untuk mencapai gelar Sarjana Komputer

Menyetujui

Ketua Ujian	Ir. Made Windu Antara Kesiman, S.T., M.Sc., Ph.D. NIP.198211112008121001
Sekretaris Ujian	I Nyoman Saputra Wahyu Wijaya, S.Kom., M.Cs. NIP.198910262019031004

Mengesahkan,
Dekan Fakultas Teknik dan Kejuruan

Prof. Dr. Kadek Rihendra Dantes, S.T., M.T.

NIP.197912012006041001

- UU ITE No. 11 Tahun 2008 Pasal 5 Ayat 1 "Informasi Elektronik dan/atau hasil cetaknya merupakan alat bukti hukum yang sah"
- Dokumen ini telah ditandatangani secara elektronik menggunaan sertifikat elektronik yang diterbitkan BSrE - BSSN, validitias dokumen elektronik ini bisa dicek menggunakan aplikasi mobile VeryDS oleh BSrE
- Cetakan dokumen ini merupakan salinan dari file dokumen bertandatangan elektronik yang keabsahannya dapat diakses melalui scan QRCode yang terdapat pada sertifikat ini.

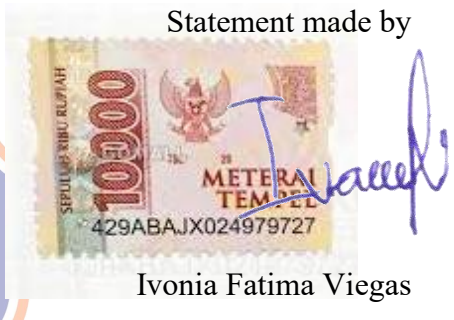
Balai Besar Sertifikasi Elektronik

STATEMENT OF AUTHENTICITY

I hereby declare that this academic work entitled " **Mammographic Breast Cancer Detection Using ResNet-50 with Transfer Learning : A Case Study in Timor-Leste and Indonesia**" and all it's cotents are truly my own work, and I have not commited plagiarism or cited in ways inconsistent with the ethics privailing in the academic community. I am prepared to bear any risk/ sanction imposed on me if violations of academic ethics are found in this work or if there are claims against its authenticity.

Singaraja, June, 8th 2026

Statement made by



Ivonia Fatima Viegas

SIN. 2215101085

PREFACE

All praise and gratitude the author extends to the Almighty God Jesus Christ and Mother Marry for the blessings that this undergraduate thesis, entitled **"Mammographic Breast Cancer Detection Using ResNet-50 with Transfer Learning: A Case Study in Timor-Leste and Indonesia"**, could be completed. This undergraduate thesis is submitted as a requirement to obtain a Bachelor's degree in Computer Science at Universitas Pendidikan Ganesha.

In the process of completing this undergraduate thesis, the author has received significant support. Therefore, the author would like to express sincere gratitude to:

1. Prof. Dr. Kadek Rihendra Dantes, S.T., M.T., Dean of the Faculty of Engineering and Vocational, for his encouragement and the facilities provided, which enabled the author to complete the study as planned.
2. Ir. Made Windu Anantara Kesiman, S.T., M.Sc., Ph.D., Vice Dean I of the Faculty of Engineering and Vocational, for the motivation and facilities provided.
3. I Nyoman Saputra Wahyu Wijaya, S.Kom., M.Cs., Coordinator of the Bachelor's Program in Computer Science and also my academic advisor, for the motivation all the way of undergraduate process.
4. Ni Putu Novita Puspa Dewi, S.Kom., M.Cs., MIM., as Examiner 1, for all of her feedback and evaluation.
5. Dr. Ni Wayan Marti, S.Kom., M.Kom., as Examiner 2, for all the feedback and evaluation.
6. Dr. Agus Aan Jiwa Permana, S.Kom., M.Cs., as the first academic advisor, you are simply extraordinary. Thank you for never getting tired of guiding me, for always believing in me even when I doubted myself, for your endless patience, and for every little push that kept me going. You didn't just teach me how to finish this undergradute thesis; you taught me how to keep walking even when the road felt impossible.
7. Dr. Ni Ketut Kertiasih, S.Si., M.Pd, as the second academic advisor, for her warmth, guidance, direction, advice, and motivation throughout the undergraduate thesis writing process.

8. The staff members of the Faculty of Engineering and Vocational who assisted in the administrative processes.
9. Alberto Viegas Soares & Elisa Moniz Fatima, my beloved parents, thank you for everything, and to my siblings Zelita Viegas, Epifania Viegas, Denilson Viegas, Idalia Viegas and all of my Cousins, for your unwavering material, motivational, and spiritual support throughout my entire academic journey. You are my roots and my wings.
10. The Dili Medical Center (DMC) in Timor-Leste, and RSUD Buleleng, for their invaluable assistance in providing the medical imaging data that made this research possible.
11. TIC Timor IP., for welcoming me as an intern and allowing me to work on this thesis in that inspiring environment the experience shaped me more than words can say.
12. The big family of PSHT (Persaudaraan Setia Hati Terate). Through you, I learned to stand on my own two feet, to be wiser in every step I take, and to face any path with courage and integrity. PSHT taught me not just martial arts, but the art of living.
13. The cozy cafés that became my second home during this long journey: Dadidu, Halamang Belakang, Tempus, NAU, and others I visited while working on this thesis. Thank you for the free Wi-Fi, the warm corners, the iced coffees that never judged me, and the quiet atmosphere that somehow made my thoughts flow or at least made staring at my laptop screen feel a little less lonely.
14. My close friends, Nora, Bin Jessy, MM's for standing by me through the laughter and the tears, through the breakthroughs and the burnout. You made the heavy days lighter and the good days unforgettable to every small blessing, every unexpected smile, every stranger who held the door open, every late-night text asking "are you still alive?" thank you.

This undergraduate thesis was written with tired eyes but a full heart. The author acknowledges that this thesis is not without its shortcomings and sincerely welcomes constructive feedback. It is hoped that this work may offer meaningful contributions to technology development, especially in breast cancer detection, for the people of Timor-Leste, Indonesia, and beyond.

Singaraja, June 8th 2026

Author

TABLE OF CONTENTS

PAGE

COVER i

TITLE PAGE ii

SUPEVISOR APPROVAL PAGE iii

EXAMINER APPROVAL PAGE iv

ENDORSEMENT PAGE v

STATEMENT PAGE vi

PREFACE vii

ABSTRACT ix

TABLE OF CONTENTS xi

LIST OF TABLES xv

LIST OF FIGURES xvi

LIST OF APPENDICES xviii

CHAPTER I INTRODUCTION 1

1.1 Background 1

1.2 Problem Identification 7

1.3 Problem Scope 9

1.4 Research Question 11

1.5 Research Objectives 11

1.6 Research Benefits 13

CHAPTER II THEORETICAL FRAMEWORK 15

2.1 Theoretical Foundation 15

2.1.1 Breast Cancer 15

2.1.2 Mammography 19

2.1.3 Deep Learning 25

2.1.4 Convolutional Neural Networks (CNN'S) 29
2.1.5 Transfer Learning 33
2.1.6 ResNet-50 Architecture 39
2.1.7 Performance Evaluation Metrics 43
2.1.8 Focal Loss 47
2.1.9 Weighted Random Sampling 49
2.1.10 Grad-Cam 52
2.2 Relevant Research 55

CHAPTER III RESEARCH METHODOLOGY 59

3.1 Research Design 59
3.2 Mammographic Dataset Acquisition 61
3.2.1 Primary Dataset Acquisition 61
3.2.2 Secondary Dataset Acquisition 63
3.3 Data Preprocessing 65
3.3.1 Data Selection 65
3.3.2 Image Preprocessing 66
3.3.3 Labeling and Dataset balancing 68
3.3.4 Dataset Splitting 70
3.3.5 CBIS-DDSM Specific Preprocessing 72
3.4 Model Development 73
3.4.1 Development Environment 74
3.4.2 Model Architecture Design 74
3.4.3 Transfer Learning Strategies 77
3.4.4 Hyperparameter Configuration 78
3.4.5 Training Procedures 81
3.5 Model Testing and Deployment 83
3.5.1 Model Performance Testing 83
3.5.2 Threshold Analysis 85
3.5.3 Web Application Deployment 85
3.6 Research Location and Timeline 88
3.6.1 Research Location 88

3.6.2 Research Timeline 89

CHAPTER IV FINDINGS AND DISCUSSION 90

4.1 Primary Dataset Analysis 90
4.1.1 Dataset Composition 90
4.1.2 Label Distribution 91
4.1.3 Dataset Splitting 92
4.2 Data Augmentation Analysis 94
4.2.1 Augmentation Techniques Visualization 94
4.2.2 Data Distribution Before and During Training 95
4.3 Primary Dataset Model Performance 96
4.3.1 Hyperparameter Tuning Journey 96
4.3.2 Transfer Learning Strategy Comparison 97
4.3.3 Test Set Evaluation Results 99
4.3.4 Best Model Training Details 102
4.4 CBIS-DDSM Dataset Analysis 103
4.4.1 Dataset Composition and Preprocessing 103
4.4.2 Dataset Splitting 105
4.4.3 Augmentation Analysis for CBIS-DDSM 106
4.4.4 Training History for CBIS-DDSM 108
4.5 CBIS-DDSM Model Performance 109
4.5.1 Transfer Learning Strategy Comparison 109
4.5.2 Ensemble Performance 110
4.5.3 Threshold Analysis 111
4.6 Comparative Analysis of Primary Dataset vs CBIS-DDSM 113
4.6.1 Direct Comparison 113
4.6.2 Key Insights from Comparison 115
4.6.3 Qualitative Analysis of Image Feasibility for Model 116
4.7 Discussion 117
4.8 Limitations 120
4.9 Application Overview 121

CHAPTER V CONCLUSION 128

5.1 Conclusions 128

5.2 Recommendations 129

REFERENCES 131

CURRICULUM VITAE 135

APPENDICES 136

UNIVERSITAS PENDIDIKAN GANESHA
UNDIKSHA

LIST OF TABLES

PAGE

Table 2.1 Confusion Matrix……..44

Table 2.2 Related Studies on Deep Learning for Mammogram Classification……....56

Table 3.1 Primary Dataset Composition……...63

Table 3.2 CBIS-DDSM Dataset Summary……...64

Table 3.3 Data Augmentation Techniques……69

Table 3.4 Primary Dataset Split Distribution……71

Table 3.5 Modified ResNet-50 Architecture……76

Table 3.6 Hyperparameter Configuration……80

Table 3.7 Research Timeline……89

Table 4.1 Primary Dataset Composition by Source……..90

Table 4.2 Label Distribution - Primary Dataset……....91

Table 4.3 Primary Dataset Split Distribution……....93

Table 4.4 Augmentation and Sampling Comparison-Primary Dataset……95

Table 4.5 Hyperparameter Tuning Journey and Results……...96

Table 4.6 Transfer Learning Strategy Comparison……...98

Table 4.7 Confusion Matrix-Primary Dataset Test……...99

Table 4.8 Per-Class Performance Metrics - Primary Dataset……...100

Table 4.9 Global Performance Metrics - Primary Dataset……101

Table 4.10 CBIS-DDSM Dataset Distribution After Filtering……..103

Table 4.11 CBIS-DDSM Dataset Split Distribution……105

Table 4.12 CBIS-DDSM Dataset Summary with Augmentation……..107

Table 4.13 Transfer Learning Strategy Comparison - CBIS-DDSM……109

Table 4.14 Ensemble Performance - CBIS-DDSM Test Set……110

Table 4.15 Threshold Analysis - CBIS-DDSM……112

Table 4.16 Comparative Performance: Primary Dataset vs CBIS-DDSM……....113

Table 4.17 Sample Images Available in Web Application……123

LIST OF FIGURES

PAGE

Figure 2.1 Example of CC View Mammogram 21
Figure 2.2 Example of MLO View Mammogram 22
Figure 2.3 BI-RADS Assessment Categories 23
Figure 2.4 Deep Neural Network Architecture 27
Figure 2.5 CNN Architecture Diagram 32
Figure 2.6 Transfer Learning Concept 33
Figure 2.7 Transfer Learning Strategies Comparison 36
Figure 2.8 ResNet-50 Architecture Diagram 42
Figure 2.9 ROC Curve Example 46
Figure 2.10 Grad-CAM Visualization Process 53
Figure 3.1 Research Workflow 59
Figure 3.2 Example of Preprocessed Mammogram 67
Figure 3.3 Label Distribution - Primary Dataset 68
Figure 3.4 Dataset Split Visualization 72
Figure 3.5 Modified ResNet-50 Architecture 76
Figure 3.6 Three Transfer Learning Strategies 78
Figure 3.7 Web Application Workflow 87
Figure 3.8 Research Location Map 88
Figure 4.1 Sample Mammogram Images from Primary Dataset 90
Figure 4.2 Label Distribution - Primary Dataset 92
Figure 4.3 Dataset Split Visualization 93
Figure 4.4 Super Aggressive Augmentation- Malignant Case 94
Figure 4.5 Data Distribution: Before vs During Training 96
Figure 4.6 Training History Comparison 99
Figure 4.7 Confusion Matrix - Primary Dataset 100
Figure 4.8 ROC Curve - Primary Dataset 101

Figure 4.9 Best Model Training Details - Model 1 (Frozen) 102
Figure 4.10 CBIS-DDSM Dataset Distribution 104
Figure 4.11 Sample Images After Preprocessing - CBIS-DDSM 105
Figure 4.12 CBIS-DDSM Dataset Split Visualization 106
Figure 4.13 Super Aggressive Augmentation - CBIS-DDSM 107
Figure 4.14 Best Model Training Details - CBIS-DDSM 108
Figure 4.15 Training History Comparison - CBIS-DDSM 110
Figure 4.16 Ensemble Confusion Matrix - CBIS-DDSM 111
Figure 4.17 Threshold Analysis Curves - CBIS-DDSM 112
Figure 4.18 Performance Comparison Bar Chart 114
Figure 4.19 Good and Poor Quality Images of Mammogram Detection 117
Figure 4.20 Discriminative Features of Malignant Case 126
Figure 4.21 Discriminative Features of Benign Case 127

UNIVERSITAS PENDIDIKAN GANESHA
UNDIKSHA

LIST OF APPENDICES

PAGE

Appendix 1. Research Questionnarie Instrument..... 136

Appendix 2. Statement of Willingness to Collaborate 138

Appendix 3. Request Letter for Data Collection..... 139

Appendix 4. Web Application Interface Screenshots..... 140

UNIVERSITAS PENDIDIKAN GANESHA
UNDIKSHA