

LB/TH/33/2025

TH5918

**WEAKLY SUPERVISED LEARNING FOR FINE-
GRAINED PLANT DISEASE CLASSIFICATION: A
HYBRID APPROACH**

Logeshwaran Praveenath

218533L

Master of Science in Artificial Intelligence

Department of Computational Mathematics

University of Moratuwa

Sri Lanka

June 2025

**WEAKLY SUPERVISED LEARNING FOR FINE-
GRAINED PLANT DISEASE CLASSIFICATION: A
HYBRID APPROACH**

Logeshwaran Praveenath

218533L

Dissertation submitted in partial fulfillment of the requirements for the degree
Master of Science in Artificial Intelligence

Department of Computational Mathematics

University of Moratuwa

Sri Lanka

June 2025

DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:

Date: 22/06/2025

The above candidate has carried out research for the PhD/MPhil/Masters dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Prof A T P Silva

Signature of the Supervisor:

Date: 23/06/2025

DEDICATION

To my dearest father,

I dedicate this work and all that I am to you, the man who gave me the tools, values, and unwavering love to stand where I am today. You taught me to embrace every challenge, to learn from mistakes, and to rise stronger, just as you always said: “Try and grow from every setback”. Though you are no longer here to witness this moment, your wisdom guides me still. Every lesson you shared, every sacrifice you made, and every quiet pride you took in my journey live on in this achievement.

This MSc in AI is not mine alone; it is yours too. You believed in me long before I believed in myself, and your trust gave me the courage to pursue higher education. I hope, wherever you are, you know how deeply you are missed – and how profoundly you are loved. I strive daily to make you proud, just as I am proud to call you my father, teacher, and compass.

Forever your grateful child,

Logeshwaran Praveenath

ACKNOWLEDGEMENT

This dissertation could not have been completed without the guidance and support of many individuals who significantly contributed to its preparation. I want to express my deep gratitude to Professor Thushari Silva, a faculty member at the Faculty of Information Technology, University of Moratuwa. His supervision and the opportunity to engage in this research have been indispensable. I am sincerely thankful for his professional guidance and support, which will undoubtedly influence my future endeavours. I also wish to acknowledge my classmates and friends who assisted me in developing my ideas and provided essential information throughout this process. Finally, I sincerely thank my family for their steadfast moral and financial support, especially my wife, who has been an ongoing source of encouragement.

I am grateful to all who contributed to this journey. Thank you.

ABSTRACT

Agricultural productivity is significantly impacted by plant diseases, resulting in economic losses and risks to food safety. The accurate detection of plant diseases with minimal supervision is considered crucial for the resolution of these issues, rather than having sole reliance placed on traditional methods such as manual inspections. Promising solutions for the automation of disease classification have been presented by recent advancements in computer vision, particularly those achieved through deep learning techniques. However, the requirement of large, annotated datasets is often associated with these methods, and such datasets can be both expensive and labour-intensive to obtain. This dissertation aims to design and evaluate a hybrid deep learning model capable of achieving high fine-grained plant disease classification accuracy under weak supervision with limited labelling effort. In order to increase the accuracy of fine-grained plant disease classification problems under weak supervision, a novel hybrid architecture combining ResNet50 and Vision Transformer is described. A series of experiments was executed utilizing diverse parallel hybrid configurations, and their performance was systematically compared against that of the standalone ResNet50 and Vision Transformer models. Distinct feature fusion strategies, including addition, concatenation, and weighted combinations, were employed by each model to combine the intermediate feature maps. The models were trained and assessed using the Crop Pest and Disease Detection (CCMT) dataset, and accuracies of 84.53%, 84.56%, and 86.26% were yielded, respectively. These performance metrics were exceeded in comparison to the individual models, with an accuracy of 63.56% achieved by ResNet50 and 81.88% attained by the Vision Transformer. The efficacy of the proposed hybrid architecture for fine-grained classification in scenarios characterized by minimal supervision is underscored by the results. This study provides a practical pathway toward scalable, cost-effective plant disease detection systems for real-world agricultural deployments. The intrinsic limits of current classification frameworks are successfully addressed, and this research significantly advances the field of fine-grained classification under limited supervision.

Keywords: Weakly Supervised Learning, Fine-grained Classification, Hybrid Approach, ResNet50, Vision Transformer

TABLE OF CONTENTS

Declaration	i
Dedication	ii
Acknowledgement.....	iii
Abstract	iv
Table of Contents	v
List of Figures	ix
List of Tables.....	x
List of Abbreviations.....	xi
List of Appendices	xii
Chapter 1	1
Introduction	1
1.1 Prolegomena.....	1
1.2 Background and Motivation	2
1.3 Aim and Objectives	3
1.4 Problem in Brief.....	3
1.5 Hybrid approach for fine-grained classification.....	3
1.6 Resource requirements	4
1.7 Structure of the thesis	4
1.8 Summary	5
Chapter 2	6
Review of fine-grained Plant disease classification.....	6
2.1 Introduction	6
2.2 Gestation of fine-grained plant disease classification	6
2.3 Major developments in fine-grained plant disease classification.....	7
2.4 Future Trends of fine-grained plant disease classification	9
2.5 Summary of Challenges in fine-grained plant disease classification	9
2.6 Problem definition	10
2.7 Summary	10
Chapter 3	11

technology adopted	11
3.1 Introduction	11
3.2 Techniques for weakly supervised fine-grained classification	11
3.2.1 ResNet50 for Learning Local Context	11
3.2.2 Vision Transformer (ViT) for Global Context Learning	12
3.2.3 Hybrid Integration of ResNet50 and ViT.....	14
3.2.4 Weakly Supervised Learning Approach	16
3.3 Training strategy for weakly supervised fine-grained classification	16
3.3.1 Optimizer.....	17
3.3.2 Loss function.....	17
3.3.3 Training Configurations	18
3.4 Summary	19
Chapter 4	20
A hybrid approach for plant disease classification	20
4.1 Introduction	20
4.2 Hypothesis	20
4.3 Input.....	20
4.4 Output.....	21
4.5 Process.....	21
4.6 Features	22
4.7 Users	22
4.8 Summary	22
Chapter 5	23
Design	23
5.1 Introduction	23
5.2 Top-level Architecture.....	23
5.3 Hybrid Approach.....	23
5.3.1 Local Feature Extractor.....	24
5.3.2 Linear Layer (L1).....	24
5.3.3 Global Feature Extractor	24
5.3.4 Linear Layer (L2).....	24
5.3.5 Hybrid Link.....	24

5.3.6	Classification Head	25
5.4	Summary	25
Chapter 6	.....	26
Implementation	.....	26
6.1	Introduction	26
6.3	Hybrid Approach	26
6.3.1	Input	27
6.3.2	Feature Extraction	28
6.3.3	Linear Transformation	28
6.3.4	Combining features using Hybrid Link.....	29
6.3.5	Classification Head	30
6.4	Model training	30
6.5	Summary	31
Chapter 7	.....	32
Evaluation	.....	32
7.1	Introduction	32
7.2	Participants	32
7.3	Experimental design	32
7.4	Testing strategy	34
7.5	Test Cases.....	34
7.5.1	Correctly Classified Samples	35
7.5.2	Misclassified Samples.....	35
7.5.3	Low-Quality Image Samples.....	36
7.6	Results	36
7.6.1	ResNet50.....	37
.....	.....	38
7.6.2	ViT	38
.....	.....	38
7.6.3	Hybrid with Addition	39
7.6.4	Hybrid with Concatenation	40
7.6.5	Hybrid with Weighted Combination	41
.....	.....	41

.....	42
7.7 Summary	42
Chapter 8	43
Conclusion	43
8.1 Introduction	43
8.2 Objective-wise conclusion	44
8.3 Limitations.....	45
8.4 Further work	45
8.5 Summary	45
References	47
APPENDICES	50
APPENDIX A	50
APPENDIX B	51
APPENDIX C	63
APPENDIX D	65
APPENDIX E	68

LIST OF FIGURES

Figure 1 Residual learning block	11
Figure 2 Transformer encoder overview	14
Figure 3 Architecture of the hybrid module	21
Figure 4 Hybrid Model Architecture	23
Figure 5 Training, validation, and testing workflow	27
Figure 6 Weighted random sampling	28
Figure 7 Initialization of pre-trained ResNet50 model	28
Figure 8 Initialization of pre-trained ViT model	28
Figure 9 Defining linear layers	29
Figure 10 Defining ResNet50 configurations	29
Figure 11 Defining ViT configurations	29
Figure 12 Hybrid Link - Addition	29
Figure 13 Hybrid Link - Concatenation	30
Figure 14 Hybrid Link - Weighted combination	30
Figure 15 Defining the classification head	30
Figure 16 Class distribution in CCMT dataset	33
Figure 17 Correctly classified samples	35
Figure 18 Misclassified Samples	35
Figure 19 Low-quality Image Samples	36
Figure 20 Confusion Matrix - ResNet50	37
Figure 21 Classification Report - Resnet50	38
Figure 22 Confusion Matrix - ViT	38
Figure 23 Classification Report - ViT	39
Figure 24 Confusion Matrix - Hybrid Add	39
Figure 25 Classification Report - Hybrid Add	40
Figure 26 Confusion Matrix - Hybrid Concat	40
Figure 27 Classification Report - Hybrid Concat	41
Figure 28 Confusion Matrix - Hybrid WC	41
Figure 29 Classification Report - Hybrid WC	42

LIST OF TABLES

Table 1 Training Configuration	18
Table 2 Model Performance Comparison	37

LIST OF ABBREVIATIONS

CV	Computer Vision
ML	Machine Learning
CNN	Convolutional Neural Network
WSFPDC	Weakly Supervised Fine-Grained Plant Disease Classification
ViT	Vision Transformer
LBP	Local Binary Patterns
HOG	Histogram of Oriented Gradients
CAM	Class Activation Mapping
SPP	Spatial Pyramid Pooling
GPU	Graphical Processing Unit
CUDA	Compute Unified Device Architecture

LIST OF APPENDICES

APPENDIX – A	Algorithm for AdamW optimizer	50
APPENDIX – B	Code Segments	51
APPENDIX – C	Model Evaluation Metrics	63
APPENDIX – D	Model training and validation results	65
APPENDIX – E	Dataset for Crop Pest and Disease Detection	68