

TABLE OF CONTENTS

TABLE OF CONTENTS.....	i
LIST OF FIGURES	iv
LIST OF TABLES.....	vi
FOREWORD	ix
CHAPTER I INTRODUCTION.....	1
1.1. Research Background	1
1.2. Research Problem	4
1.3. Research Objective	5
1.4. Research Scopes	5
1.5. Research Advantage	5
1.6. Research Schematic	5
CHAPTER II LITERATURE REVIEW	7
CHAPTER III BASIC THEORY	17
3.1. Dermoscopic Images.....	17
3.2. Macroscopic Images	17
3.3. ABCD Rule.....	18
3.3.1 Asymmetry	19
3.3.2 Border Irregularity.....	20
3.3.3 Colour.....	20
3.3.4 Diameter	21
3.4 Otsu Thresholding.....	21
3.5. MobileNetV2	22
3.6. Random Forest.....	23
3.7. Support Vector Machine	24
3.8. Ensemble Learning	26
3.8.1 Voting.....	27
3.8.1.1 Hard Voting	27
3.9. Classification Metrics	28
3.9.1. Confusion Matrix	29
3.9.2. Accuracy Score	29
3.9.3. Precision	30
3.9.4. Recall.....	30
3.9.5. F-Score	31
3.10 K-Fold Cross Validation.....	31
CHAPTER IV RESEARCH METHODOLOGY	33
4.1. Research Description	33
4.2. Data Description	34
4.2.1 Data Description of HAM10000 Dataset.....	34
4.2.2. Data Description of PAD-UFES-20.....	35
4.3 Dataset Pre-Processing	37



4.3.1 Dataset Augmentation	37
4.3.2 Resizing.....	37
4.3.3 Hair Removal	38
4.3.4 Data Splitting.....	39
4.4. Dataset Segmentation	40
4.5. Feature Extraction.....	40
4.6. Model Architecture	40
4.6.1. Model Architecture of MobileNetV2	41
4.6.3. Model Architecture of Support Vector Machine.....	43
4.6.4. Initialisation of the Models	43
4.6.5. Training of the Models with Training Data	44
4.7. Ensemble Model	44
4.7.1 Hard Voting.....	44
4.8. Evaluation Procedure	45
4.8.1. Model Validation.....	45
4.8.2. Validation Strategy.....	46
4.8.3. Model Comparison.....	46
CHAPTER V IMPLEMENTATION.....	47
5.1 Dataset Acquisition Implementation	47
5.1.1 Environment Setup.....	48
5.1.2 Data Conversion.....	48
5.1.3 Grouping Dataset Images by Classes	49
5.2 Dataset Pre-Processing	50
5.2.1 Hair Removal	51
5.2.2 Dataset Augmentation	52
5.2.3 Pixels Per Millimetre Extraction and Segmentation	52
5.3 Feature Extraction.....	56
5.3.1 ABCD Rule	56
5.4 Model Training	62
5.4.1 Random Forest	62
5.4.2. Support Vector Machine	64
5.4.3 MobileNetV2	65
5.5 Hard Voting	68
5.6 Model Evaluation.....	68
5.6.1 Random Forest	68
5.6.2 Support Vector Machine(SVM).....	69
5.6.3 MobileNetV2.....	69
5.6.4 Hard Voting.....	70
CHAPTER VI. RESULTS AND DISCUSSION	72
6.1 Data Augmentation	72
6.2 Dataset Preprocessing Result.....	73
6.3 Feature Extraction Result.....	75



6.4 Model Evaluation.....	76
6.4.1 Random Forest.....	76
6.4.2 Support Vector Machine (SVM).....	78
6.4.3 MobileNet V2.....	79
6.5 Ensemble Evaluation	81
6.5.2 Dermoscopic Dataset.....	82
6.5.3 Macroscopic Dataset	84
CHAPTER VII. CONCLUSION AND FUTURE WORKS	86
7.1 Conclusion	86
7.2 Future Works	86
REFERENCES	88
APPENDIX.....	97

LIST OF FIGURES

Figure 3.1 International Skin Imaging Collaboration Dermoscopic Image (International Skin Imaging Collaboration, 2023).....	17
Figure 3.2 Dermoscopic Image Taken Using Smartphone Camera (Pacheco, et al., 2020).....	18
Figure 3.3 Illustration of Asymmetry calculation of a lesion (Stolz & Kunz, 2023) .	19
Figure 3.4 Calculations of lesion border irregularity (Stolz & Kunz, 2023)	20
Figure 3.5 Extraction of lesion diameter (Messadi, et al., 2020).....	21
Figure 3.8 Support Vector Machine (Kanade, 2022).....	25
Figure 3.9. Kernel Trick From 2D to 3D Space (Zhang, 2018)	25
Figure 3.10. Pseudocode of Support Vector Machine (Hassan & Manaa, 2022).....	26
Figure 3.11. Illustration of Hard Voting Algorithm (Ahmed, 2023).....	28
Figure 3.12 . Binary Classification Confusion Matrix (Bhadari, 2024)	29
Figure 3.13 K-Fold Cross Validation (UltraLytics, 2023).....	32
Figure 4.1 Research Flowchart	33
Figure 4.2 mel class dermoscopic image (The International Skin Imaging Collaboration, 2018)	35
Figure 4.3 Mel Class of Macroscopic Image (Pacheco, et al., 2020)	36
Figure 4.4 Illustration of Hair Removal Algorithm.....	39
Figure 4.5 Flowchart Architecture of the Models.....	41
Figure 4.6 MobileNetV2 Architecture.....	42
Figure 4.7 Image of Random Forest Algorithm Simplified (Reinstein, 2017).....	42
Figure 4.8. Illustration of Hard Voting Algorithm	45
Figure 5.1 Environment Setup	48
Figure 5.2 Dataset Conversion.....	49
Figure 5.3 Dataset Grouping.....	50
Figure 5.4 Hair Removal Implementation	51
Figure 5.5 Dataset Augmentation	52
Figure 5.6 Functions to do ROI Extraction.....	53
Figure 5.7 ROI Extraction	53
Figure 5.8 Diameter Calculation.....	55
Figure 5.9 Implementation of Asymmetry Extraction.....	57
Figure 5.10 Border Irregularity	59
Figure 5.11 Colour Analysis Calculation	61
Figure 5.12 Random Forest Implementation	64
Figure 5.13 SVM Implementation	65
Figure 5.14 MobileNetV2 Implementation	68
Figure 5.15 Hard Voting Implementation.....	68
Figure 5.16 Random Forest Evaluation	69
Figure 5.17 MobileNetV2 Evaluation	69



Figure 5.18 MobileNetV2 Evaluation	70
Figure 5.19 MobileNetV2 Evaluation	71
Figure 6.1 Mel Class Sample From HAM 10000 Dataset.....	73
Figure 6.2 Hair Removal Process	73
Figure 6.3 Segmentation Result.....	75
Figure 6.4 Diameter Extraction Result	75
Figure 6.4 Random Forest Confusion Matrix.....	78
Figure 6.5 SVM Confusion Matrix.....	79
Figure 6.5 Confusion Matrix of MobileNetV2.....	81
Figure 6.6 Confusion Matrix of Ensemble Learning on Combined Dataset	82
Figure 6.7 Confusion Matrix of Ensemble Learning on Dermoscopic Dataset.....	84
Figure 6.8 Confusion Matrix of Ensemble Learning on Macroscopic Dataset	85

LIST OF TABLES

Table 2.1 Learning Methods	13
Table 4.2 Summary of PAD-UFES-20 dataset	36
Table 4.3 Summary of each dataset	36
Table 5.1 Number of picture in Selected Classes HAM-10000	47
Table 5.2 Number of picture in Selected Classes PAD-UFES-20	47
Table 5.3 Number of Picture in Dataset	48
Table 6.1 HAM 10000 Augmentation	72
Table 6.2 PAD-UFES-20 Augmentation	72
Table 6.3 Percentage of Successfully Segmented Pictures of HAM-10000	74
Table 6.4 Percentage of Successfully Segmented Pictures PAD-UFES-20	74
Table 6.5 Feature Extraction Result	75
Table 6.6 Random Forest Hyperparameter Combination	76
Table 6.7 Random Forest Performance Metrics	77
Table 6.8 SVM Hyperparameters Combination	78
Table 6.9 SVM Results	78
Table 6.10 MobileNetV2 Hyperparameter Tuning	80
Table 6.11 MobileNetV2 Results	80
Table 6.12 Ensemble Performance on Combined Dataset	81
Table 6.13 Ensemble Learning on Dermoscopic Dataset	83
Table 6.14 Ensemble Learning on Macroscopic Dataset	84