

TABLE OF CONTENTS

| | |
|--|-----|
| APPROVAL PAGE..... | i |
| STATEMENT | ii |
| FOREWORD..... | iii |
| TABLE OF CONTENTS | iv |
| TABLE OF TABLES | vi |
| TABLE OF FIGURES | vii |
| ABSTRACT | ix |
| ABSTRAK | x |
| CHAPTER I INTRODUCTION | 1 |
| 1.1 Research Background..... | 1 |
| 1.2 Research Problem | 2 |
| 1.3 Research Scope..... | 2 |
| 1.4 Research Objective | 2 |
| 1.5 Research Advantages..... | 3 |
| CHAPTER II LITERATURE REVIEW | 4 |
| CHAPTER III BASIC THEORY..... | 8 |
| 3.1 Computer Vision | 8 |
| 3.2 Image Classification | 8 |
| 3.2.1 Histogram of Oriented Gradients | 8 |
| 3.2.2 Support Vector Machines | 10 |
| 3.3 Image Detection..... | 13 |
| 3.3.1 Sliding Window Search..... | 13 |
| 3.3.2 Non Maximum Suppression..... | 14 |
| 3.3.3 Intersection Over Union Threshold..... | 15 |
| 3.4 Confusion Matrix..... | 16 |
| 3.5 OpenCV | 17 |
| CHAPTER IV RESEARCH METHODOLOGY | 18 |
| 4.1 Research Description..... | 18 |
| 4.2 Data Preprocessing | 19 |
| 4.3 Data Training..... | 19 |
| 4.3.1 Histogram of Oriented Gradients (HOG)..... | 19 |
| 4.3.2 Final Descriptor Size | 22 |
| 4.4 SVM Classifier Model..... | 22 |
| 4.5 Non Maximum Suppression | 23 |
| 4.6 Intersection over Union Threshold..... | 24 |
| 4.7 Experiment | 25 |
| 4.8 Evaluation..... | 26 |

| | |
|--|-----------|
| 4.8.1 Average Precision, Recall Score and F-1 Score..... | 26 |
| CHAPTER V IMPLEMENTATION | 27 |
| 5.1 Specification of Hardware and Software..... | 27 |
| 5.2 System Implementation | 27 |
| 5.3 Implementation of Image Preprocessing | 28 |
| 5.3.1 Importing Library | 28 |
| 5.3.2 Resizing Images | 28 |
| 5.4 Extracting HOG Features | 29 |
| 5.4.1 Importing Library | 29 |
| 5.4.2 Loading Data | 30 |
| 5.4.3 Calculating Gradients | 30 |
| 5.5 SVM Model | 34 |
| 5.5.1 Importing Library | 34 |
| 5.5.2 Splitting Data and Predicting the SVM Model | 34 |
| 5.5.3 Saving and Loading the Model | 36 |
| 5.6 Human Detection Process..... | 36 |
| 5.6.1 Sliding Window Search..... | 36 |
| CHAPTER VI RESULT AND DISCUSSION | 40 |
| 6.1 Results of Preprocessing Data | 40 |
| 6.2 HOG Visualization | 41 |
| 6.3 Result of SVM Classification..... | 42 |
| 6.4 Result of the Detection | 46 |
| CHAPTER VII CONCLUSIONS AND SUGGESTIONS | 50 |
| 7.1 Conclusions | 50 |
| 7.2 Suggestions..... | 50 |
| REFERENCES | 51 |

TABLE OF TABLES

| | |
|---|----|
| Table 2.1 Summary review of resource papers | 6 |
| Table 3.1 Confusion Matrix | 16 |
| Table 6.1 Confusion Matrix Comparison of the SVM Model Experiments | 45 |
| Table 6.2 Comparison of Detection Accuracy between each Experiments | 45 |
| Table 6.3 Test Images IoU Bounding Box Scores | 49 |

TABLE OF FIGURES

| | |
|---|----|
| Figure 3.1 Example of HOG extracted features | 10 |
| Figure 3.2 Example of SVM Parameter C..... | 11 |
| Figure 3.3 N-Linear SVM classifier lines | 12 |
| Figure 3.4 Convex polygon and their SVM | 12 |
| Figure 3.5 Example of Image Pyramid Scaling..... | 14 |
| Figure 3.6 Non Maximum Suppression pseudo code..... | 15 |
| Figure 3.7 Example of Non-Maximum Suppression process..... | 15 |
| Figure 3.8 Example of Bounding Box IoU sample scores | 16 |
| Figure 4.1 Research Description Flowchart | 18 |
| Figure 4.2 Samples of the Image from the dataset | 19 |
| Figure 4.3 Samples of the training Image from the dataset..... | 20 |
| Figure 4.4 Zoomed of the training Image from the dataset with 8x8 cell | 20 |
| Figure 4.5 Flowchart of HOG model | 21 |
| Figure 4.6 Dalal and Triggs 2 cells by 2 cells block normalization | 22 |
| Figure 4.7 Flowchart of SVM Classifier model | 23 |
| Figure 4.8 Flowchart of the NMS model..... | 24 |
| Figure 4.9 The Detection Ground Truth Bounding Box and IoU score Example of the Detected Bounding Boxes | 24 |
| Figure 4.10 Flowchart of the Threshold model | 25 |
| Figure 4.11 Detailed Flowchart of the model..... | 26 |
| Figure 5.1 Importing the Library for Image Preprocessing..... | 28 |
| Figure 5.2 Resizing the Images | 29 |
| Figure 5.3 Importing Library for HOG Features Descriptor | 29 |
| Figure 5.4 Importing Dataset of Human and No Human | 30 |
| Figure 5.5 Color Histogram Features | 31 |
| Figure 5.6 Parameters for Feature Matrix of HOG Descriptor | 32 |
| Figure 5.7 The Hyperparameters used for Extracting Features..... | 32 |
| Figure 5.8 Converting an Image into Gray Channel | 33 |
| Figure 5.9 Making the Label for SVM classifier | 33 |
| Figure 5.10 Importing Library for Implementing SVM as Classifier | 34 |
| Figure 5.11 Splitting the Data | 34 |
| Figure 5.12 Training and Predicting the Model | 35 |
| Figure 5.13 Saving the Model Prediction..... | 36 |
| Figure 5.14 Defining the Sliding Window and the Detector..... | 37 |
| Figure 5.15 Predicting the Region of Interest in Tested Image..... | 38 |

| | |
|--|----|
| Figure 5.16 Testing Image for Sliding Window Search and Coordinate Extraction..... | 38 |
| Figure 5.17 IoU Score and Human Detection Output | 39 |
| Figure 6.1 Sample Images of Resized Positive and Negative from the Datasets | 40 |
| Figure 6.2 Positive Sample Images in HOG Visualization | 41 |
| Figure 6.3 Negative Sample Images in HOG Visualization..... | 42 |
| Figure 6.4 Comparison of Confusion Matrix | 44 |
| Figure 6.5 Negative Human Detections in Test Image | 46 |
| Figure 6.6 Positive Human Detections in Test Image With and Without NMS | 47 |
| Figure 6.7 Image 1 Bounding Box IoU Score Experiment Results | 48 |
| Figure 6.8 Image 2 Bounding Box IoU Score Experiment Results | 48 |