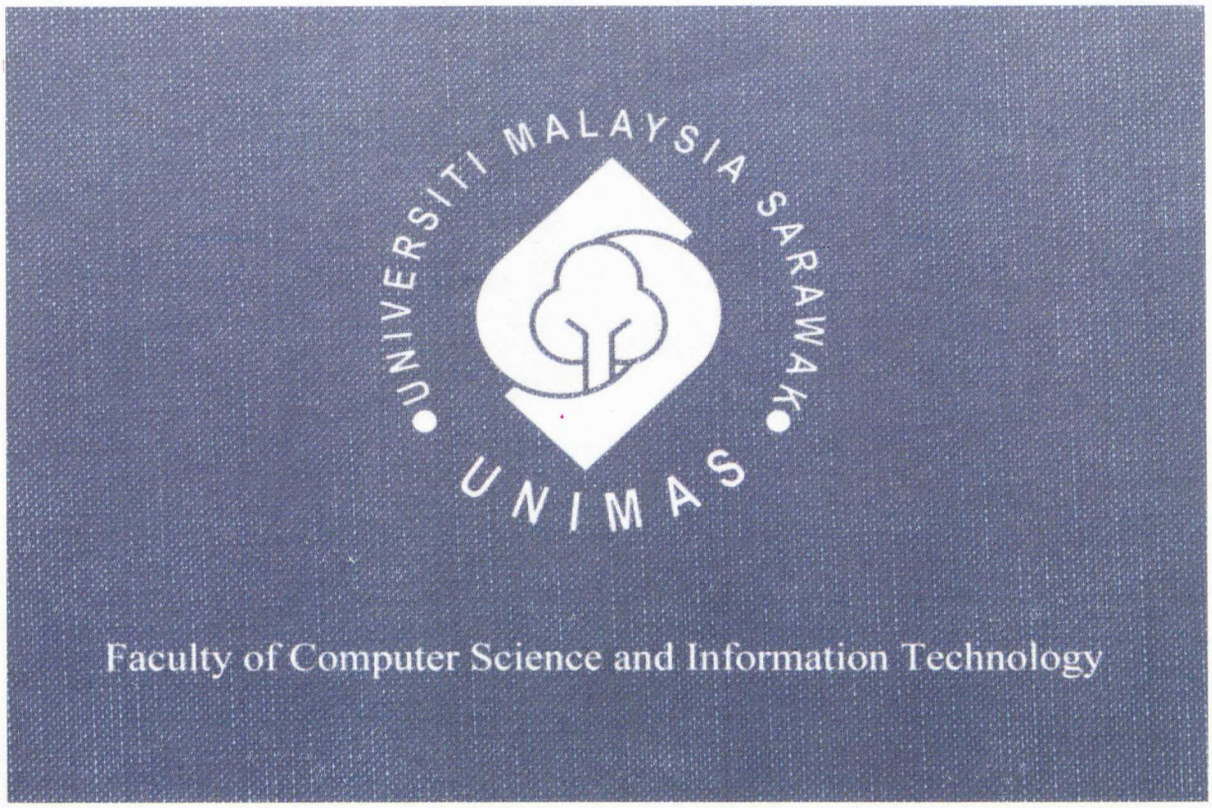

VEHICLE CLASSIFICATION TECHNIQUE FOR AUTOMATED ROAD TRAFFIC CENSUS

Bong Shuk Hui

Bachelor of Computer Science with Honors
(Software Engineering)
2014

TEKNIK KLASIFIKASI KENDERAAN UNTUK AUTOMATIK ROAD TRAFFIC BANCI

BONG SHUK HUI

Projek ini merupakan salah satu keperluan untuk
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ABSTRACT

This thesis proposes the development of vehicle classification technique for automated road traffic census prototype to replace manually vehicle classification by applying morphological techniques for image classification. The developed prototype consists of three main phases: the first phase is video frame pre-processing by applying thresholding, masking, image differencing, and median filter to obtain a resultant image for vehicle detection algorithm. The second phase is vehicle detection algorithm by processing the resultant image with 'Sobel' edge detection, first level dilation, binary filling of holes, boundary vehicle elimination, second level binary dilation, and morphological binary open to obtain a final output image for vehicle classification. Vehicle classification is taken into place by drawing a bounding box on the blob in binary image. Blob analysis will be performed to calculate the area of pixels of the vehicle's blob. The vehicle will be classified based on the experimental area to classify vehicle into three categories which are mini car, saloon car, and bus. The performance of the prototype is tested on three pre-recorded video under homogenous road environment. The experiments results shown that the prototype can achieve an overall accuracy of 88.42% for vehicle classification. The result of the vehicle classification is affected by the result of vehicle detection. The vehicle will miss or wrongly classified if the vehicle blob does not fall in the region of interest.

ABSTRAK

Tesis ini bertujuan untuk mencadangkan pembangunan teknik mengklasifikasikan kenderaan bagi prototaip pembancian lalu lintas secara automatik untuk menggantikan pengkelasan kenderaan secara manual dengan menggunakan teknik morfologi untuk pengkelasan imej. Prototaip yang dibuat terdiri daripada tiga fasa utama: fasa pertama adalah bingkai video pra-pemprosesan dengan menggunakan *"thresholding"*, *"masking"*, pembezaan imej, dan penapisan median untuk mendapatkan imej yang terhasil daripada algoritma pengesan kenderaan. Fasa kedua adalah algoritma pengesan kenderaan dengan memproses imej yang terhasil melalui pengesan hujung *"Sobel"*, tahap pertama pengembangan, pengisian lubang secara binari, penghapusan kenderaan sempadan, pengembangan binari tahap kedua, dan morfologi binari terbuka untuk mendapatkan imej keluaran terakhir bagi pengkelasan kenderaan. Klasifikasi kenderaan dilakukan dengan melukis *"bounding box"* pada *"blob"* yang terdapat dalam imej binari. Analisis *"blob"* akan dilakukan untuk mengira bahagian piksel *"blob"* kenderaan. Kenderaan akan diklasifikasikan berdasarkan lingkungan eksperimen untuk mengklasifikasikan kenderaan kepada tiga kategori iaitu kereta mini, kereta salon, dan bas. Prestasi prototaip diuji melalui tiga video yang telah dirakam dalam persekitaran jalan raya yang sama. Keputusan daripada eksperimen tersebut menunjukkan bahawa prototaip boleh mencapai ketepatan keseluruhan 88.42% bagi pengelasan kenderaan. Hasil pengkelasan kenderaan dipengaruhi oleh hasil kenderaan dikesan. Kenderaan akan salah diklasifikasikan jika *"blob"* kenderaan tersebut tidak termasuk dalam bahagian yang telah dilukis.

CHAPTER 1: INTRODUCTION

1.1 Introduction

Vehicle Classification Techniques for Automated Road Traffic Census is a research based project to propose an accurate, powerful and robust method to classify vehicles into different vehicles types. Vehicle classification is an important component in Intelligent Transportation System (ITS) to identify the types of vehicles automatically. According to S. Matos and Souza (2012), vehicle classification is an important task in ITS to count the vehicles by categories to control and manage the traffic flow.

The goal of vehicle classification system is to analyze and manage moving vehicles in traffic scenes for monitoring traffic conditions, reducing congestion, and enhancing vehicles and roadways safe mobility automatically. There are two types of common use vehicle classification techniques which are hardware based classification and software based classification. Software based vehicle classification techniques will be studied for environmental friendly and reduction of pollution purpose. Yonsaf, Iftikhar and Javed (2012) stated that software based classification is easy to install with low installation and maintenance cost. Apart from that, software based classification provides more traffic information by monitoring wider view of traffic scenes.

Numerous vehicle type classification techniques are going to evaluate and study to highlight the most beneficial technique for vehicle classification for automated road traffic census. An algorithm to categorize vehicle into different vehicle types is going to adopt to achieve high accuracy and consistent rate on vehicle classification. Finally, the result of classification of vehicle is displayed on the interface for further analysis.

1.2 Problem Statement

Numerous vehicle classification techniques are available for automated road traffic census. Vehicle classification is a challenging and sophisticated task in computational science field to classify the vehicle types to 100% accurate rate. Typically, vehicle classification techniques is a convoluted job that cause lots of time consuming and high cost on implementation (Aarthi, Arumkumar, & Raghesh, 2011). According to Kanwal, Arta and Ali (2012), current vehicle classification algorithm, the accuracy rate still cannot reach to 100 percent rate of accuracy. Generally, most of the proposed system only able to classify vehicles based on their size. Based on Pandu, Ravi, Raja, and Naveen (2010), they proposed a vehicle classification algorithm that only can classify the vehicles into small, medium and large vehicle according to their size.

1.3 Objectives

The objectives of this project are:

- To study vehicle classification techniques for automated road traffic census.
- To adopt a suitable vehicle classification technique for automated road traffic census.
- To develop vehicle classification technique for automated road traffic census prototype.

1.4 Methodology

In order to implement this project, there are three main modules involved. First of all, a video camera is used to monitor a road on a defined lane for particular duration. Video obtained is broken into frame at a fixed interval to obtain current images for image pre-processing. The first module is image pre-processing. Background image without traffic is captured during day time to find the image differencing with the current image. The second module is vehicle detection to detect the vehicle for further vehicle classification. A binary image of vehicle with elimination of boundary and removal of unwanted object is obtained. The third module is vehicle classification module. Area of the irregular polygon shape of vehicle is calculated. The vehicles further classify into three vehicle types according to the area of the polygon size.

1.4.1 Phase 1: Video Capturing

Vertical camera position is chosen to cover whole region of interest (ROI). A video camera is used to capture traffic scenes. Video is used to monitor the traffic scene for a specific duration, 30 minutes to monitor the traffic scenes. The height of the camera position is important as the camera height is interrelated with the size of vehicle. Video frame is then extracted from the captured video and decompressed into JPG images.

1.4.2 Phase 2: Image Pre-processing

First, background image of the road traffic without vehicles is captured. The current image is obtained from the video frame. Mask is applied on the images to isolate region of interest. Both of the images are converted into grayscale for further image processing. Thresholding is also takes into place to obtain the best image resolution depends on the brightness of the image. Image differencing is required to differentiate the background and foreground of the image. Median filter is carrying out to remove the unwanted object from the image. After this stage, the image is ready for vehicle detection module.

1.4.3 Phase 3: Vehicle Detection

Vehicle detection stage applies a widely-used image processing techniques in detecting the moving vehicles. "Sobel" detector is used to get the vehicle outer edge. First level dilation is continuing to increase the size of the detected vehicle. Boundary of the vehicle will be eliminated by vehicle boundary elimination techniques. After that, second level dilation is carried out to increase the size of the detected object including the unwanted object. Removal of noise is performed by using the morphological opening technique. Now, the image is ready for vehicle classification.

1.4.4 Phase 4: Vehicle Classification

A bounding box in rectangular shape is drawn over the vehicle shape (blob). The blob analysis is performed to shape the features of the closed objects (vehicles) to remove the irrelevant region and consider only the useful blob. The number of blobs in each of the binary image will be calculated. After that, the area of each blob pixels (unit^2) will be calculated. The vehicles are classified into three vehicles types according to the area range. The vehicle types are mini-car, saloon car and bus.

1.5 Scope

The research is focusing on the study of the existing techniques in vehicle classification mainly. The system can be applied on single or multiple lanes roads at the same or opposite direction. All the video is captured under homogeneous background. The type of the vehicles can be classified into three classes that consist of mini-car, saloon car and bus.

1.6 Significance of Project

Vehicle Classification Techniques for Automated Road Traffic Census is essential for effective ITS. An intelligent software based prototype will be developed to identify the class of vehicle accurately. An algorithm is going to adopt to show greater accuracy rate for vehicle classification.

1.7 Outline of Project Report

The report consists of six chapters. Following by this introduction chapter, literature reviews on some vehicle classification techniques are presented in Chapter 2. In chapter 3, the literature review on vehicle classification techniques will be discussed and adopted suitable algorithms with the description on their functionalities in developing the prototype. In Chapter 4, the implementation of this project will be described in detail. Programming code used for the implementation phase will be discussed as well. In Chapter 5, the performance of the system is tested to examine the system performance on the vehicle classification on road scene. The result on the vehicle classification by using different types of techniques will be presented. Result analysis is performed with the reason that leads to inconsistent and incorrect based on the collection of result. In Chapter 6, conclusion and recommendation for future work will be provided.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Vehicle classification is a significant field of study as its importance in intelligent transportation system (ITS) that incorporate electronic, computer, and communication technologies into vehicles and roadways for monitoring traffic conditions, reducing congestion and enhancing traffic mobility. Video based vehicle classification had increased for traffic management which associated with low installation cost and wide range of information can be obtained. Different methods have been proposed for vehicle classification after image has been extracted from the captured video.

Numerous of algorithms have been implemented for classifying vehicle. Each algorithm follows different procedures for classifying vehicles. Some methods are using size, texture, linearity, Principle Components Analysis (PCA), and Linear Discriminant Analysis (LDA). In the classification phase, methods make use of known techniques such as Nearest Neighbour (KNN), neutral networks, Support Vector Machine (SVM), and Hidden Markov Models (HMM). Vehicle occlusions caused by shadow, lighting and climatic variations, sound, and lack of colour invariance can hinder the methods for collecting traffic parameter based on software based classification in real-world conditions.

Literature review is taking into place to compare the existing software based vehicle classification techniques. The three classification techniques are hybrid dynamic dayesian network (HDBD) technique, eigenface technique and morphological technique by using image processing. The further explanations on each technique will be further elaborated as below.

Among all the three techniques, a suitable technique is adopted for the vehicle classification for road traffic census prototype.

2.2 Study on Hybrid Dynamic Bayesian Network (HDBN) Technique

Hybrid dynamic Bayesian network (HDBN) is a vehicle classification technique proposed by Kafai and Bhanu (2012) for multiclass vehicle classification system that classifies vehicle into four classes: sedan, pickup truck, sport utility vehicle (SUV), and unknown. The accuracy of the vehicle classification can reach to 97.63% with approximately 2% of false alarm rate (Kanwal et al., 2012). The image of the vehicle's rear view is captured to extract the vehicle feature for vehicle classification. The novelty of the classification technique is using HDBN for rear-view vehicle classification in video. There are three main features for the feature extraction on the vehicle's rear view images. The three features consist of vehicle's rear view dimension, license plate, and tail light. The tail light is the vehicle's each tail light width and its distance from the license plate, and angle between tail light and license plate. The license plate location and size are as a reference to enable comparison and normalize tail light properties and vehicles sizes values. The procedure of the HDBN techniques is shown in Figure 1.

Gaussian mixture model and mixture model approach are used for vehicle detection to determine whether the pixel is belonging to the background model. Shadow is removed using the approach introduced by Nadimi and Bahnu (2001). The license plate extraction is important to determine the license plate corner coordinates and then as input for HDBC algorithm. It is extracted by using two separate methods, the first method is proposed by Abolghasemi and

Ahmadyfard (2009) by using colour texture in the plate. After that, additional methods are applied, blob detection and filtering method to enhance license plate detection.

Tail light extraction is also another important feature extraction where red colour pixels are dominant and the redness of each image pixel is computed by fusing two methods. The first approach is using HSV (Hue, Saturation, Value) colour space to convert the images and further classify the pixels into three main colours: red, green and blue. Method of Guo et al. (2008) is used as the second method to define red level of each pixel in the image. If the vehicle body is red, this issue can be overcome by using HSV colour space histogram analysis approach to determine the colour of vehicle. The vehicle features are extracted from each image frame and normalization phase is performed to standardize the feature extraction on the license plate and tail light on the width, height and distance.

Besides, feature selecion is also performed to improve the accuracy of vehicle classification by shortening computational time with sequential floating forward selection (SFFS). In the classification phase, the vectors of the vehicle features are classified as known or unknown. If the vehicle is classified as known, second stage of classification will be carried out to determine the known vehicle types. Then, HDBN algorithm is used for vehicle classification in the video based vehicle classification. It can give an effective way to represent and factor joint probability distributions in graphical display which make them relevant for classification purpose. Bayesian network uses nodes and edges for vehicle classification. The vehicle represents the root node whereas extracted feature of vehicle is another node. K2 algorithm that is introduced by Cooper and Herskovits in 1992 is used to determine optimum structure by adding parents to a node incrementally.

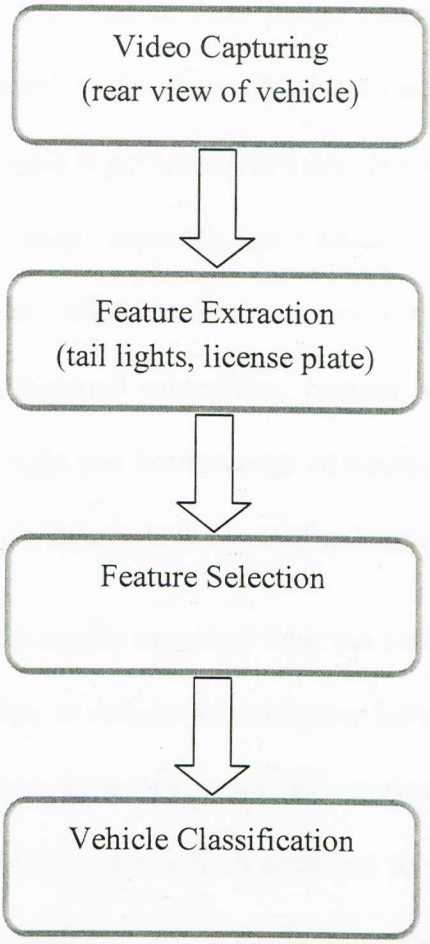

Figure 1: Procedure of hybrid dynamic Bayesian classification (HDBC) technique

2.3 Study on Eigenface Technique

Real time vehicle classification based on eigenface is proposed by Wang, Shang, Guo, and Qian (2011) that consists of two main steps which are training and classification. Eigenface technique can achieve 100% of accuracy for training set but not implemented in test set (Kanwal et al., 2012). The training step is using time average image approach to obtain and update background model. Left, right, and bottom border of vehicle outline are important to determine the face of left, right and bottom border on the vehicle. The height of vehicle face is a constant variable.

After normalization, the vehicle face image library is built. Target detection and extraction algorithm are critical to develop a high accuracy vehicle classification techniques. Background subtraction approach is performed to detect and extract online of the moving vehicle. In this paper, time average image approach and background subtraction are used for moving object detection. Background difference is necessary for removing impact of noise in the background image. After background subtraction, contour of moving vehicles are detected and extracted to extract the left, right and bottom edge of contour for left, right and bottom edge of vehicle face. The unified height threshold is selected to locate the height of vehicle face.

The vehicle face is a rectangle extracted from the vehicle front view image. The front fog lights is the left and right edge of vehicle face, bumper bottom as bottom edge, and windshield front bottom as top edge. After detection, extraction, moving objects front-end processing, and feature extraction, vehicle classification will be done and further proceed to classification phase. The classification can be achieved by identifying vehicle faces. The proposed vehicle classification based on feature face will be further discussed. The video is located to extract vehicle front image, and then the vehicle face will be pre-processing under size normalization and grayscale histogram equalization.

The size of vehicle face will be normalized to make test images be fixed size samples to process the image and classify samples with fixed size. Grayscale normalization uses gray histogram equalization to standardize the deviation and mean of the image so that the image brightness can be the same that cause by the impact of whether, light and angle on the image source. Set of vehicle training images and features of the face defined as the vehicle face space is calculated to be stored in the template library for system classification. The image of moving objects is

comparing feature stored in the library to determine whether it is a vehicle in the database. By using the training library as test library, we identify the vehicle faces by invoking the feature library produced by vehicle face image library in different sizes. Figure 2 shows the procedures of the eigenface techniques.

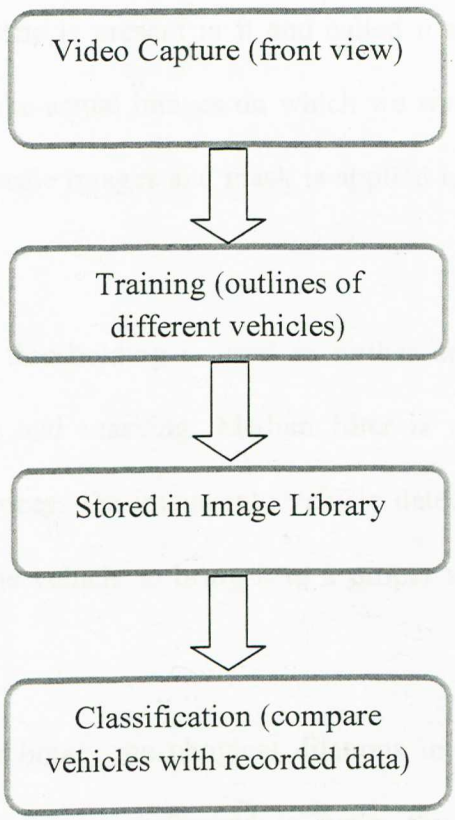

Figure 2: Procedure of eigenface technique

2.4 Study on Morphological Techniques for Image Classification

A simple and novel method for vehicle detection and classification had been proposed recently. Based on Ajmal and Hussain (2012), a novel and efficient algorithm presented based on image processing using vertically positioned camera for vehicle detection and classification according to

vehicles' size. The overall success rate is approximately 85% which is a high success rate (Ajmal & Hussain, 2012).

Four important phases are using which include of image differencing, thresholding, edge detection, and binary morphological process. In a particular road or road segment, an image taken once for the road where no traffic is present in it and called it as reference images for image differencing. Current image is the actual images on which we want to detect the vehicles. Both images are converted into grayscale images and mask is applied to isolate region of interest and remove unwanted objects.

From grayscale image, thresholding is used to further convert the images into binary images for image differencing and masking. Median filter is used to remove noise on the generated image in order to process the image into vehicle detection phase. Edge detection is used to connect boundary of the vehicle to bring it to a proper shape by Sobel edge detection approximation.

Then, a series of linear binary morphogical dilations in three directions: horizontally, vertically and through 45 degree are performed to make the vehicle shape become more prominent. Binary filling of holes is performed to fill the holes that cannot be reached from the edge of images. Convex hull of each object is calculated to reshape the object into near polygon shape. The vehicle is classified into three types: small, medium and big based on area and circumference of the vehicles. Figure 3 illustrates the procedure of morphological technique by image processing.