VEHICLE TRACKING AND SPEED ESTIMATION SYSTEM

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ABSTRACT

This project is intends to develop a vehicle tracking and speed estimation using digital image processing technique. Therefore this project needs a video input to make the system work. The system is designed to track the vehicle position and calculate its moving speed. The method that uses to estimate the speed of the moving vehicle currently is RADAR (Radio Detection and Ranging). But this method requires high end equipment, which means the cost for this method is high. Therefore an alternative way is needed. This proposed method is using the image processing technique. This system consists of 4 major steps: 1) image acquisition 2) image background subtraction 3) location detection 4) speed estimation. The rate of accuracy for this system is expected to have 99%.

ABSTRAK

Projek ini berhasrat untuk membangunkan Penjejakan kenderaan dan anggaran kelajuan yang menggunakan teknik pemprosesan imej digital. Projek ini memerlukan saluran video supaya sistem boleh jalan. Sistem ini direka untuk mengesan kedudukan kenderaan dan mengira kelajuan yang bergerak. Kaedah yang digunakan untuk menganggarkan kelajuan kenderaan yang bergerak pada masa kini adalah RADAR (Radio Detection and Ranging). Tetapi kaedah ini memerlukan peralatan canggih, yang bermakna kos bagi kaedah ini adalah tinggi. Oleh itu kaedah alternatif diperlukan. Kaedah yang dicadangkan adalah menggunakan teknik pemprosesan imej. Sistem ini terdiri daripada 4 langkah utama: 1) imej pengambilalihan 2) imej latar belakang penolakan 3) pengesanan lokasi 4) anggaran kelajuan. Kadar ketepatan untuk sistem ini dijangka mempunyai 99%.

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OpenCV   Open source Computer Vision

RADAR   Radio Detection and Ranging

LIDAR   Laser Imaging Detection and Ranging

CHAPTER 1

INTRODUCTION

1.1   Introduction

In the era of technology, the number of car in Malaysia on the road is increasing. Besides that, with the advance technology, the car manufacturers produce the car with the best quality. At the same time also produce the car that can move faster and faster by enhance the car engine and increase the maximum speed of the car. Due to this, the number of cases of accident happens on highway also increasing dramatically. So, there is a need to have a low cost vehicle speed detector system.

Currently, most of the vehicle speed detector system for the purpose traffic light speed law enforcement is based on RADAR (Radio Detection and Ranging) methods [1]. This method is using some kind of active devices, which are much more expensive compare to static camera system. At the same time, the RADAR based system is need and necessary to integrate with fast and high resolution imaging devices to capture the image for the vehicles. Other than RADAR method, there are audio system[2], LIDAR (Laser Imaging Detection And Ranging)[3]

The way of how the RADAR method works is known as Doppler shift phenomenon [4]. Doppler shift phenomenon is experience by us in our daily life frequently. It occurs when sound is generated by a moving vehicle and will create a sonic boom. The frequency of the sound will be change when the sound wave reflects back to the wave generator and the scientists will calculate the speed of the vehicle by using the frequency variation. However, the equipment to use this method is costly. So, finding other equipment to reduce the cost is necessary. Image processing technology can serve this well.

Object recognition can use to identify and track the vehicle [11]. The task of finding the target object in an image or video sequence can be done by object recognition. There are 2 methods in object recognition, which are appearance based method and feature based method. There 5 techniques in appearance based method. They are edge matching, divide and conquer search, grayscale maching, gradient matching and large model bases. While interpretation trees hypothesize and test, pose consistency, pose clustering, invariance geometric hashing, scale invariant feature transform (SIFT) and speeded up robust features (SURF) are techniques or algorithm of feature based method.

Image processing technology does not require any special hardware. It is based on the software component. With a typical video recorder and a computer is enough to create a vehicle speed detection system. A lot of work and effort have been done for vehicle detection and speed measurements. Vehicle detection based on frame difference [5], un-calibrated camera [6], motion trajectories [7], geometric al optics [8] and digital aerial image [9] are introduced.

1.2   Problem Statement

Due to the RADAR method need integrate with expensive equipment, the cost to develop vehicle speed detector system with this method will be high. Therefore, develop a low cost vehicle speed detector system is needed. This low cost vehicle speed detector system will use image processing method which will only need a video recorder and a computer is enough to create this system.

Although the cost using RADAR method is high, it will also have error and not 100% accurate [10]. When the direction of the radar gun is not on the direct path of the incoming vehicle, it will happen cosine error. This will cause the result of the speed that the vehicle that being track become not accurate.

In fact, RADAR method, can only track one car at a time. This is another limitation of this method. With image processing technology, the system can track more than one car at a same time [10].

Besides that, although with image processing has a lot of advantages, but it also has disadvantages, such as illuminating problem and overlapping problem. When the lighting condition is not good, the result of tracking may be degraded. For example, when it is rainy day, the environment is dark then the vehicle may be hard to track.

On the other hand, overlapping will also cause the tracking object hard to be track. For example, when 2 vehicle move at the same lane and both car drive close to each other, then the rear view of the vehicle will be block by the car that follow behind. This can cause those two object track as one object or hard to be track. Besides that, if a car that being track block by a big truck moving on the road, then the tracking process will be interrupted or fail.

1.3   Objective

There are 2 main objective needs to be done in this project:

i)   To study techniques of tracking method.
ii)   To develop a prototype for detecting the velocity of a moving vehicle.

1.4   Scope

Scope for the project is:

i)   Video data size is 640 × 480
ii)   Location case is at LPT highway.
iii)   The testing environment is on daytime (8am to 7pm) condition.
iv)   Static camera.
v)   Camera with 25fps.

vi)   5 video will be taken.

1.5   Thesis Organization

- There are consisting 5 chapters in the thesis which are chapter 1 to chapter 5.
- Chapter 1 is introduction, which include introduction, problem statement, objective and scope.
- Chapter 2 is literature review, which review papers that related to this project.
- Chapter 3 is methodology, which will explain the methodology that will use in this project.
- Chapter 4 is results and discussion.
- Last but not least is chapter 5, which will discuss on the conclusion of the project.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter will review some papers to get knowledge and understanding on the techniques had been proposed. All those techniques have the same aim which is track the vehicle and estimate the velocity of the moving vehicle.

2.1 Background

Speeding on road is serious problem. It can cause serious accident and will cause dead. So, there is a need to control and limit the velocity of moving vehicle, so that can reduce the number of cases of accident on road that cause by speeding

Nowadays, system use for purpose of traffic speed law enforcement is achieved by RADAR (Radio Detection and Ranging) or LIDAR (Laser Infrared Detection and Ranging) based method in most area. [1] Although these methods are commonly use in this field, but it have some weak point, such as the equipment is expensive, can only track one vehicle each time, and have some minor error.[10]

On the era modern technology, computer and vision machine are widely use in lot of area. So, the price of computer and vision machine is low. Therefore there is a cheaper method can use to track and estimate the velocity of moving vehicle. This method is image processing which with some simple devices will do.

Only a normal function computer and a 30fps video recorder is needed. These devices are much cheaper than the device will use on RADAR and LIDAR method.

2.2   Tracking

Tracking can be define as the problem of estimating the trajectory of an object in the image plane as it moves around a scene.[12] Which mean the object that being track has been assigned a consistent labels on it in different frames of video.

In the era of high technology, object tracking is an important task in the field of computer vision. Since computer has become very common device to us, the availability of camera with high quality and inexpensive, and the need for automated video analysis has increasing, all of these factors has increase the interest of people in object tracking.

Detection of interesting moving objects, tracking of such objects from frame to frame, and analysis of object tracks to recognize their behavior are three main steps in video analysis. There is few example of where object tracking apply to[12]:

- Motion-based recognition, that is, human identification based on gait, automated object detection, etc.
- Automated surveillance, that is, monitoring a scene to detect suspicious activities or unlikely events.
- Video indexing, that is, automatic annotation and retrieval of the videos in multimedia databases.
- Human-computer interaction, that is, gesture recognition eye gaze tracking for data input to computers.
- Traffic monitoring, that is, real-time gathering of traffic statistics to direct traffic flow.

- Vehicle navigation, that is, video-based path planning and obstacle avoidance capabilities.

    The ease of tracking will differ due to tracking domain. Tracking object can be complex due to[12]:

- Loss of information caused by projection of the 3D world on a 2D image
- Noise in images
- Complex object motion
- Non-rigid or articulated nature of objects
- Partial and full object occlusion
- Complex object shapes
- Scene illumination changes
- Real-time processing requirements

    Choosing the right feature for tracking is very important. Generally, the uniqueness of the object is the most desirable property so that the object can be distinguished easily from the image. Feature selection has a very close relation to the object representation. There are some common visual features, which are color, edges, optical flow, and texture. Among all the features, color is most widely use for tracking. For the object detection, there are some categories that are commonly use, which are point detector, segmentation, background modeling and supervised classifier.

2.3   Problem of Tracking

There are some factor may affect the result of tracking. Such as illuminating, overlapping of the tracking object, noise in image and size of the object

2.3.1   Illuminating

Tracking object may look different on different illuminating. The example of illuminating are:

- *Weather*. When the day is rainy day, the environment will be dark, then the object may be hard to be track.
- *Sunlight*. At noon, the sunlight is strong, the reflection of the sunlight will cause the camera hard to focus.
- *Lighting condition*. When the weather is not good, such as rainy day, the environment may be dark, the vehicles on road will switch on the lamp. This will cause the camera hard to focus too.
- *Shadow*. The shadow of the object, such as tree, beside the road, will influence the result of tracking.

2.3.2   Overlapping

This will happen when two or more car switch lane. The front view of the car will block by the car in front. This will cause the vehicle hard to be track.

Besides that, overlapping will also happen when a vehicle with smaller size block by a vehicle with bigger size. For example, a car blocks by a big truck that moving on the road.

2.3.3 Noise in the Image

This happen when the lighting condition not good and the quality of the camera not good. Then causes noise appear in the image and make influence the result of tracking.

2.3.4 Size of the Object

Tracking object may be either big or small. Big object may be easy to track due to their bigger size and easy to differentiate from the background or other object in the image. But, object with smaller size are hard to be track due to they may look alike with the noise in the image or some other object in the image. Besides, the viewing angle may also make the object hard to be track. This is because the shape of object may change with different viewing angle.

2.4 Methodology of Tracking

A study on 3 papers that proposed on topic of L Estimation of the speeds of moving vehicles from video sequences[13], Vehicle speed detection system[4], and Vehicle speed detection in video image sequences using CVS method[10] has been done. Below will discuss the methodologies that proposed by them.

2.4.1 Estimation of the Speeds of Moving Vehicles from Video Sequences

In this proposed paper, the methodology that proposed has 6 stages. Which are acquiring data from traffic scenes, extracting images from video source, identification of moving vehicles, identifying vehicle positions from images, and tracking and estimating the vehicle path. Figure 2.1 shows the key stages in the vehicle identification and tracking process.
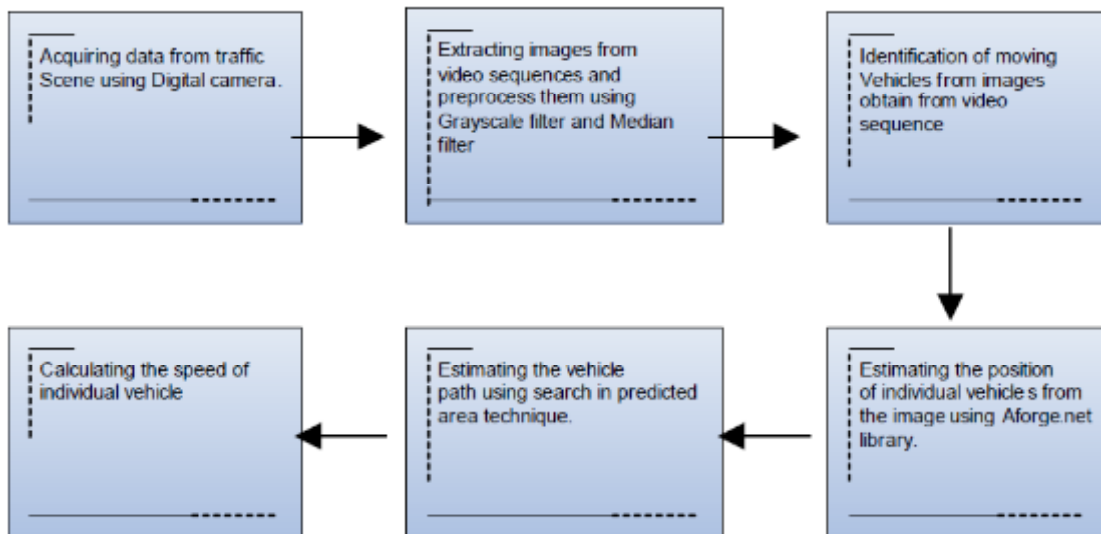
Figure 2.1: Key stages of vehicle identification and tracking process[14]

2.4.1.1 Acquiring Data from Traffic Scenes

On this stage, a camera is place on the bridge. Then, the entrance zone and the exit zone were marked before the video is takes from the selected location. Besides that, some identification marks were also placed at 10m distance from each other parallel to the entrance and exit zone. The video taken is with 30fps and the image resolution is 640 x 480 pixels.

2.4.1.2 Extracting Images from Video Source

Firstly, 2 software, SC Video Decompiler and JockerSoft.Media.dll are use to extract image from the recorded video. Then the image that extracted from the video are convert to grayscale images.

2.4.1.3 Identification of Moving Vehicles

In this stage, the consecutive image subtraction technique is used to identify the moving vehicles. Then, Sobel edge detection operator was choose to carry out the work to extract the moving vehicle from the difference images.

2.4.1.4 Identifying Vehicle Positions from Images

To estimate the position of the vehicle, an algorithm called connected component labeling algorithm was use to estimate the position of the blobs.

2.4.1.5 Tracking and Estimating the Vehicle Path

Position of the individual blobs is identified and a recording table is created after identifying moving vehicles from the traffic scene. The number of row in the recording table represents number of blobs that found in given image while number of column represents the parameter pertaining to each of the identified blobs. The blobs will process regularly and match with the parameter in the table when the vehicular identification and tracking is in the progress.

2.4.2   Vehicle Speed Detection System

In this proposed paper consist of 5 stages, which are image acquisition, image enhancement, image segmentation, image analysis and speed calculation. Figure 2.2 shows the structure chart of vehicle detection system.
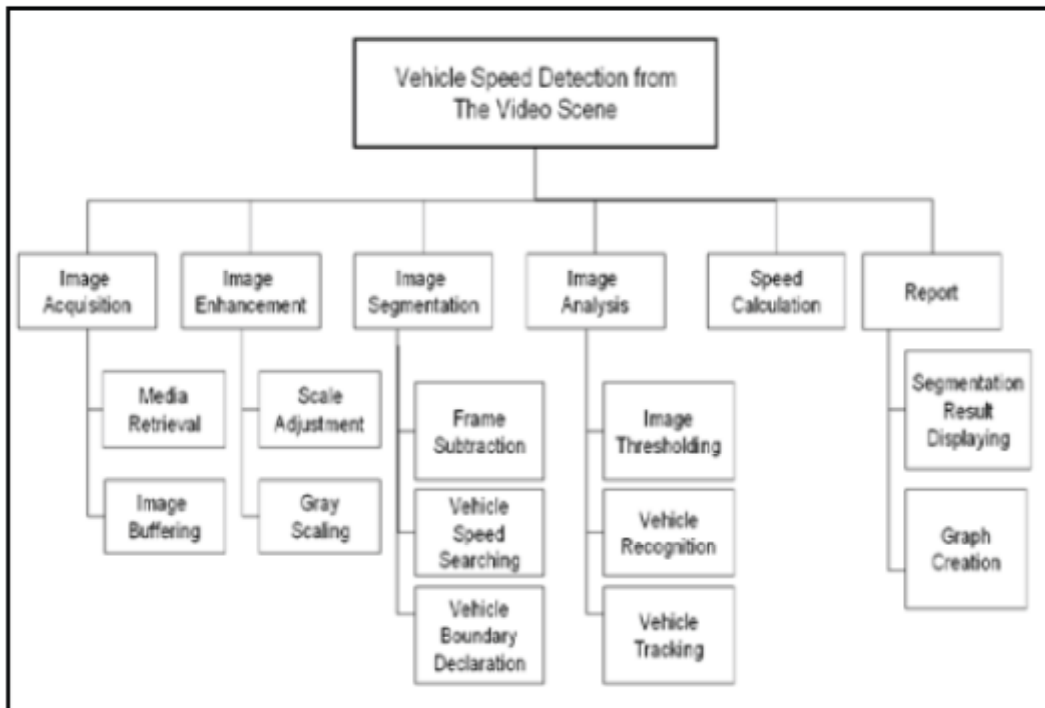
Figure 2.2: Structure chart of vehicle detection system[4]

2.4.2.1 Image Acquisition

On this stage, Microsoft Direct Show library has use as a tool to receive input to the system. Filter Graph Manager that provided by Microsoft Direct Show constructed of 3 filter type which are source filter, decoder filter and render filter. Then the image acquisition component is in charge of calling the filter graph, grabbing the single frame from the video stream and buffering each single image to the memory.

2.4.2.2 Image Enhancement

On this stage, 2 methodologies are used, which are image scaling and gray scaling. Image scaling is use to provide the possibility of having the various sizes

of input format. While gray scaling is use for convert color image to gray level image.

2.4.2.3 Image Segmentation

To segment the moving vehicle, image differentiation approach is used. Then the first image from the gray scale image sequence is selected as reference frame. After that subtract all image in the sequence with the selected reference frame. Then the result of subtraction will give the movement in binary form.

2.4.2.4 Image Analysis

This stage is responsible to find the position of mark-point in the reference point. Then the threshold method is use to distinguish the mark-point from the background.

2.4.2.5 Speed Detection

This stage will calculate the speed of moving vehicle from the image that subtracted from the previous stage. Figure 2.3 show the speed calculation formula.

Distance between vehicle and starting point measured in kilometer

$$\text{Distance} = Df * (D / D_x) * (P_n - P_0) \qquad \dots(1)$$

Time that vehicle spent in order to move to P_n in unit of hour

$$\text{Time} = Tf * (t_n - t_0) \qquad \dots(2)$$

Vehicle speed measured in format of kilometer per hour

$$\text{Speed} = \text{Distance} / \text{Time (Kilometer per Hour)} \dots(3)$$

Where D is the real distance between two marking points *(start point and end point) measured in meter*

D_x is the distance between two marking points measured in pixels

X   is the width of the video scene measured in pixels

Y   is the height of the video scene measured in pixels

P_0 is the right most of the vehicle position at time $t = 0$ measured in unit of pixels

P_n is the right most of the vehicle position at time $t = n$ measured in unit of pixels

t_0 is the tickler (timestamp) saved at time $t = 0$ measured in unit of milliseconds

t_n is the tickler (timestamp) saved at time $t = n$ measured in unit of milliseconds

Df is the distance conversion factor from meter to kilometer, which is $(1.00/(1000.00*60.00*60.00))$

Tf is the time conversion factor. In this case, the conversion is from millisecond to hour, which is $(1.00/1000.00)$

Figure 2.3: Speed calculation formula