PLATOON DISPERSION DOWNSTREAM OF TRAFFIC SIGNAL

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Dedicated to…

My beloved dad and mum, Mashros and Akmar,
who has so much faith in me.
Love you always.

To a special person, who has played a part in my life.
I could have never done it without you.

To all my friends, who have stood by me through thick and thin.
I treasure you all.

Thanks for showering me with love, support and encouragement.
Life has been wonderfully coloured by you.

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ABSTRACT

The potential benefits of studying platoon dispersion downstream of traffic signal are already known in traffic flow analysis, modelling and traffic engineering design. However, presently there is a lack of information on platoon dispersion on Malaysian roads. This study determines the arrival distribution pattern downstream of traffic signal which includes vehicle headway, intra-platoon headway and inter-platoon headway. It also looked into the roadway characteristic that affects platoon dispersion. Data for more than 1000 vehicles were collected using video cameras to record traffic movement at Saleng, Kulai. Vehicle type and time were determined for each vehicle on a per lane basis during the morning peak and off peak hours at several consecutive points downstream of traffic signal for analysis. Four mathematical distribution models namely shifted negative exponential distribution, erlang distribution, schuhl distribution and double displaced negative exponential distribution were fitted to the actual distribution data. It was observed that vehicle headways follow the shifted negative exponential distribution with shift equals to 1.0s, the intra-platoon headways have normal distribution and inter-platoon headways do not fit to any of the tested distribution models under peak and off peak hours. The level of friction at this road section is of low friction. The values of platoon dispersion factor and travel time factor are 0.16 and 0.86 during peak hour and 0.22 and 0.82 during off peak hour. The values of smoothing factor under these conditions are 0.21 (peak hour) and 0.17 (off peak hour). The higher value of smoothing factor indicates that the vehicles are able to travel on the road section more smoothly compared to lower value.

ABSTRAK

Potensi faedah mengkaji penyebaran platoon dihilir isyarat lalu lintas telah pun diketahui dalam analisis aliran lalu lintas, pembinaan model dan reka bentuk kejuruteraan lalu lintas. Walau bagaimanapun, pada masa kini masih terdapat kekurangan maklumat mengenai penyebaran platoon di jalan-jalan Malaysia. Kajian ini menentukan corak taburan ketibaan dihilir isyarat lalu lintas termasuklah masa kepala kenderaan, masa kepala dalam platoon dan masa kepala di antara platoon. Kajian ini juga melihat ciri-ciri jalan yang mempengaruhi penyebaran platoon. Data lebih daripada 1000 kenderaan dicerap mengunakan beberapa kamera video untuk merakam pergerakan lalu lintas di Saleng, Kulai. Jenis kenderaan dan masa ditentukan untuk setiap kenderaan dan diasingkan mengikut lorong masing-masing pada waktu pagi semasa waktu puncak dan bukan waktu puncak di beberapa lokasi berturutan dihilir isyarat lalu lintas bertujuan untuk analisis. Empat model taburan seperti taburan eksponen negatif teranjak, taburan erlang, taburan schuhl dan taburan eksponen negatif teranjak duaan telah digunakan untuk dipadankan dengan data taburan sebenar. Ianya telah diperhatikan bahawa masa kepala kenderaan mengikut taburan eksponen negatif teranjak, masa kepala dalam platoon mengikut taburan normal dan masa kepala di antara platoon tidak mengikut sebarang model taburan yang diuji dalam waktu puncak dan bukan waktu puncak. Tahap geseran di bahagian jalan ini ialah bergeseran rendah. Nilai faktor penyebaran platoon and faktor masa perjalanan ialah 0.16 dan 0.86 semasa waktu puncak dan 0.22 dan 0.82 semasa bukan waktu puncak. Nilai faktor kelicinan dalam keadaan ini ialah 0.21 (waktu puncak) dan 0.17 (bukan waktu puncak). Semakin tinggi nilai faktor kelicinan menunjukkan bahawa kenderaan boleh bergerak di atas bahagian jalan dengan lebih lancar berbanding nilai yang lebih rendah.

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FV	Following Vehicle
LV	Leading Vehicle
α	Platoon Dispersion Factor
β	Travel Time Factor
F	A Smoothing Factor
CBD	Central Business District
HGV	Heavy Good Vehicle
COV	Coefficient of Variation
SNE (0.5)	Shifted Negative Exponential Distribution with Shift equal 0.5
SNE (1)	Shifted Negative Exponential Distribution with Shift equal 1.0
ER(K=1)	Erlang Distribution with k=1
ER(K=2)	Erlang Distribution with k=2
DDNED	Double Displaced Negative Exponential Distribution

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CHAPTER 1

INTRODUCTION

1.1 Preamble

Platooning represents the clustering of traffic in urban arterial road networks with many signalised intersections (Taylor, Young and Bonsall, 1996). The existing of signals break up the through traffic flow along a road. The platoons are released periodically during the green time at each signal and then travel along the link to the next set of signals.

The effect of vehicle grouping weakens as the platoon moves downstream of traffic signal and subsequently spreading over the downstream road section. This phenomenon is known as platoon dispersion. The platoons may disperse along the road either more quickly or slowly depending on the actual road geometric and traffic conditions between the two adjacent intersections of interest.

The dispersion of vehicle platoons occurs due to the differences in the desired speeds of the various drivers that make up the platoon. However, a large portion of the dispersion is also caused by the fact that some vehicles will experience delays while travelling along the link which are random in terms of both their occurrence and duration. The majority of these random delays along links occur when vehicles slow down for other vehicles, which are either turning of the road at a mid-block location, or attempting to enter or leave on-street parking.

Dispersion or spreading of traffic platoons is a common feature of traffic in a city. It is of practical importance in the efficient coordination of successive traffic lights. Ideally, best coordination is obtained when the head of the platoon released at the start of green upstream, arrives at the downstream stop line concurrently with the dissipation of the queue at this line (Michalopoulos and Pisharody, 1980).

Field observations of platoon dispersion have been noted by researchers as early as in the 1950s (Gipps, 1984). Gipps concluded, their findings indicated that platoons do not remain in a compact bunch but gradually spread out as they move downstream. Lewis (1958) presented platoons in the form of frequency distributions of vehicle arrivals and noted that as distance increased, the peak of the distribution became lower and the distribution itself tended to tail out even more at the rear. The effect of this is that the leading vehicles in a platoon tend to arrive at the second and subsequent intersections along a road with linking somewhat early and are forced to wait until the start of the green stage, while vehicles in the tail tend to be cut off by the start of the red signal. Such dispersion makes the task of calculating the offset more difficult. However, if the dispersion characteristics are known, the optimum values of the offset and phase setting can still be determined.

Grace and Potts (1964) explain that the effect of a traffic signal at some point on a highway is to divide the traffic flow into a regular series of platoons of initial time length not greater than the green phase of the light. According to these authors, as each platoon moves down the highway it disperses and its time length increases. However, if this is not allowed for by increasing the green phase of a second light coordinated with the first, some of the vehicles will be forced to stop. Indeed, it is apparent that one of the important contributing factors in the occasional inefficiency in progressive light systems is the neglect of the effects of platoon dispersion.

1.2 Problem Statement

Management of transportation networks especially in major cities is impossible without traffic signals, and it is widely accepted that many practical problems remain to be solved. An intersection with traffic signals will group vehicles arriving during the red signal and departure of a queue. Then, vehicles will form platoon on downstream of stoppages of these characteristic can be managed properly. The setting of signal linking or pedestrian amenities can make full use of the arrival distribution. Presently, there is a lack of information on the platoon dispersion on Malaysian roads. Thus, this study is aimed at observing the characteristic of this dispersion and possibly to obtain the friction on different road categories and flows.

1.3 Objectives

The primary goal of this study is to determine the arrival distribution pattern downstream of traffic signal. This study also looked into the roadway characteristic that affects platoon dispersion.

1.4 Scope of Study

This study was carried out in arterial road by focusing on distribution pattern of vehicle headway, intra-platoon headway and inter-platoon headway downstream of traffic signal using three video cameras. Four mathematical distribution models were selected to fit the actual distribution including Shifted Negative Exponential Distribution, Erlang Distribution, Schuhl Distribution and Double Displaced Negative Exponential Distribution. The road section observed in order to accomplish this study was in the range of 402m from the stop line of traffic signal. The study also focuses on the roadway characteristic that was obtained based on platoon dispersion factor, travel time factor and smoothing factor.

1.5 Importance of the Study

The amount by which a platoon spreads out or disperses as it travels downstream at any point along a road has a major implication in traffic flow analysis, modeling, and also traffic engineering design. Therefore, this study is important in the design of traffic engineering facilities, such as:

(i) intersection design, where storage facilities required for waiting traffic depend on the arrival pattern of platoons from an upstream control;
(ii) traffic signal linking systems, where the spacing between signals over which linking can be effectively determined by the platoon dispersion of traffic;
(iii) the location and design of access facilities for traffic to enter arterial roads from uncontrolled points. A knowledge of the number, size and distribution of gaps in the arterial road flow is required to calculate absorption rates for entering vehicles and it is dependent on platoon dispersion on the arterial road; and
(iv) in the traffic modelling field such as in simulation modelling, platoon dispersion detail would provide increased accuracy in traffic arrival distribution.

Thus, the traffic management of those locations can be improved and at the same time, it will provide benefit to the road users who always want to travel fast and safe.