

Review on driver's behavior to find decision zones

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Abstract: At signalized intersections apart from cycle length and phase, the change and clearance interval play significant role with respect to safety and free movement of vehicle. It involves the dilemma zone characteristics at change and lost timings. The vehicle behavior in dilemma zone during change intervals is the decisive factor for uninterrupted safe movement of vehicle. Driving behavior differs in homogeneous and heterogeneous traffic. Most of the studies in the literature have investigated the dilemma zone driving behavior in homogeneous traffic conditions, but traffic in developing countries like India is heterogeneous containing various vehicle types, where vehicles vary in their physical dimensions and dynamic characteristics. The main objective of this paper is to empirically investigate driver's decision zone at flashing green and yellow indication at high-speed intersections. The driving behavior survey for heterogeneous traffic at a signalized intersection shall be carried out by videography. Data analysis will be based on the speed-distance diagram (S-D diagram) and an acceleration-deceleration diagram (A-D diagram). The behavior will be analyzed with respect to both qualitative and quantitative aspects to arrive at conclusions regarding measures for improvement for better safety. This is a literature review-based paper that aims at studying various researches already done in the field and drawing conclusions thereon.

Index Terms- dilemma zone; S-D diagram; A-D diagram; flashing green; Yellow Signal; driver's decision zone.

I. INTRODUCTION

Ahmedabad is seventh largest metropolis in India and the largest city in Gujarat. It is also very close to the State capital Gandhinagar. Ahmedabad is the commercial capital of the State and is also known as the textile capital of India. It lies in the cotton belt of Gujarat, 23 km south of Capital Gandhinagar, 552 km north of Mumbai and 96 km from the Gulf of Cambay. It has excellent connectivity through air, road and rail links with Mumbai and Delhi. The population within the Ahmedabad Municipal Corporation (AMC) area is growing at 2.5% per year and that at Ahmedabad Urban Development Authority (AUDA) area is growing at 3.62% per year. The increase in population within a given area/region results in denser settlements which in turn lead to generation of higher number of trips using various modes.

Traffic crashes affect everyone. According to Cafiso, Lamm and La Cava, in the millions of crashes occurring worldwide each year, more than 500,000 people are killed and more than 15 million are injured. This corresponds to one crash-related death every minute. In Ahmedabad according to the research, cars and two-wheelers posed highest risk of accidents among road users. Both segments were found involved in 56% (28% each) of total road accidents. Moreover, two-wheelers were most affected—having been involved in 53% of fatal accidents and 47% of serious accidents. The study mentions that only 22% of the total road accidents get reported to police.

When signal changes from green to yellow at a signalized intersection, often drivers become skeptical, whether to cross the intersection or stop without entering the intersection. Improper decision might lead to right angle collision or rear end collision. The area in which the drivers are skeptical is termed as dilemma zone or indecision zone. Most of the studies in the literature have investigated the dilemma zone driving behaviour in homogeneous traffic conditions, but traffic in developing countries like India is heterogeneous containing various vehicle types, where vehicles vary in their physical dimensions and dynamic characteristics.

In a report compiled by Arrive Alive, the US Department of Transportation estimated that as much as 43% of motor accidents happen at intersections or are 'intersection-related'. Types of intersection-related crashes are listed as follows:

- Rear-end crashes – often occurring because a following driver is distracted and does not realize the lead driver has stopped.
- Side impact collisions or “T-bones”. These types of accidents typically involve a driver on one side running a red light, be it intentionally or while trying to make it through an intersection before a yellow light turns red.
- Side-swipe collisions where one or more vehicles are turning.
- Collisions between oncoming vehicles, particularly when one is turning across traffic.
- Collisions into vulnerable road user such as pedestrians and cyclists while turning.

As the signal changes from green to yellow, vehicles travelling at high speeds to clear the intersection are often caught in a zone where they have to decide, whether to cross or stop at the intersection, which is termed as dilemma zone. There are two types of dilemma zones well known in the literature namely, type I and type II dilemma zone. An area where a driver can neither safely pass through the intersection nor stop comfortably prior to the stop line, when confronted with a yellow signal is termed as type I dilemma zone. This was first referred in literature by Gazis, Herman, & Maradudin (1960). This type of dilemma zone is attributed to the improper signal timings. Type II dilemma zone was first recognized in a committee report produced by the southern section of ITE in 1974 (Zhang et al. 2014) And It is an area where the driver is indecisive to stop or cross, when confronted with a yellow signal and is attributed to the complications in driver decision making process. It is also called Indecisive Zone or Option Zone (Abbas et al. 2014). Type I dilemma zone can be eliminated by providing sufficient yellow duration, but the indecisive zone or type II dilemma zone is associated with the driver's decision making behaviour.

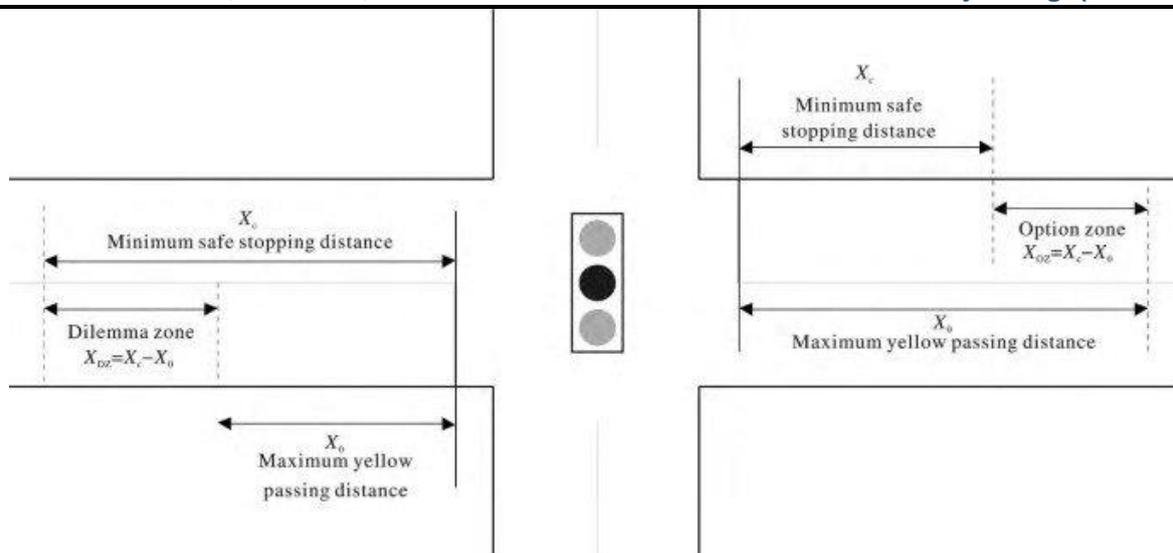


Fig 1.1 Type-I and type-II Dilemma zones

II. LITERATURE REVIEW

Yiheng Feng, K. Larry Head, and Wanjing Ma^[1] proposed an analytical model for estimating number of vehicles in the dilemma zone (NVDZ) on the basis of signal timing, geometry, traffic demand, and driving characteristics. In this paper, author assumes that only through movement vehicles may be in the dilemma zone is reasonable. Turning vehicles will be required to slow down when they approach an intersection regardless of the status of the signal. As a result, no left-turn phases are included in the signal setting formulation. Through application of Robertson's platoon dispersion model, the proposed model calculates the flow rate in the dilemma zone area at yellow onset as well as queue lengths under a discrete time horizon. A VISSIM-based microscopic simulation is then calibrated to validate the NVDZ calculation. The mathematical framework for signal optimization is implemented. Most of the current signal optimization methodologies do not consider safety measures such as NVDZ to be an objective. Delay and NVDZ are formulated as a multi-objective optimization problem addressing efficiency and safety together. Examples show that delay and NVDZ are competing objectives and cannot be optimized at the same time. Uniform arrival at the upstream intersection is assumed in this paper. The stochastic nature of the arrival patterns at entrance links may result in different arrival types at the downstream intersection. As a result, the value of NVDZ may vary with different arrival types.

Fen Wang, Keshuang Tang, Yanqing Xuc, Keping Li^[2] The objective of this paper is to empirically Assessment of drivers' decision zones at the onset of flashing green and yellow indication at rural high-speed intersections in China. In this paper, approaches at three typical high-speed intersections located in a rural highway were selected for data collection. At each selected approach, two high-resolution video cameras were set on the nearby tall buildings. One camera was used to cover the upstream area of the approach and the other camera was used to record the signal states. The two cameras were then synchronized temporally and spatially. Video surveys were undertaken under sunny weather conditions on 5 normal weekdays. In this paper, the approach speed v is defined as the instantaneous speed at the onset of flashing green or yellow, dependent upon the reference time point in the measurement of behavioral parameters. τ is defined as the elapsed time from the instant when the flashing green or yellow signal begins to the instant when the subject vehicle starts a continuous and remarkable deceleration process, i.e., brake response time defined in the research by Gates and Noyce (2010) and Gates et al. (2012). a_1 is defined as the 85th percentile value of all the observed instantaneous deceleration rates from the flashing green onset or the yellow onset to the moment when the subject vehicle completely stopped. Similarly, a_2 is defined as the 85th percentile value of all the instantaneous acceleration rates from the flashing green onset or yellow onset to the moment when the subject vehicle passed the stop-line. Then as shown in Fig 2.1, the S-D diagram is plotted to show what a driver can possibly do for a given distance and speed at the onset of flashing green or yellow. Further all the field data were plotted in the A-D plot. There are positive and negative values for both A and D. Major finding of this paper is the installation of flashing green helps to reduce the dilemma zone according to the A-D diagram. Although it is a more complicated method based on the calculated required acceleration and required deceleration. However, this diagram could reflect the drivers' response to the change of signal.

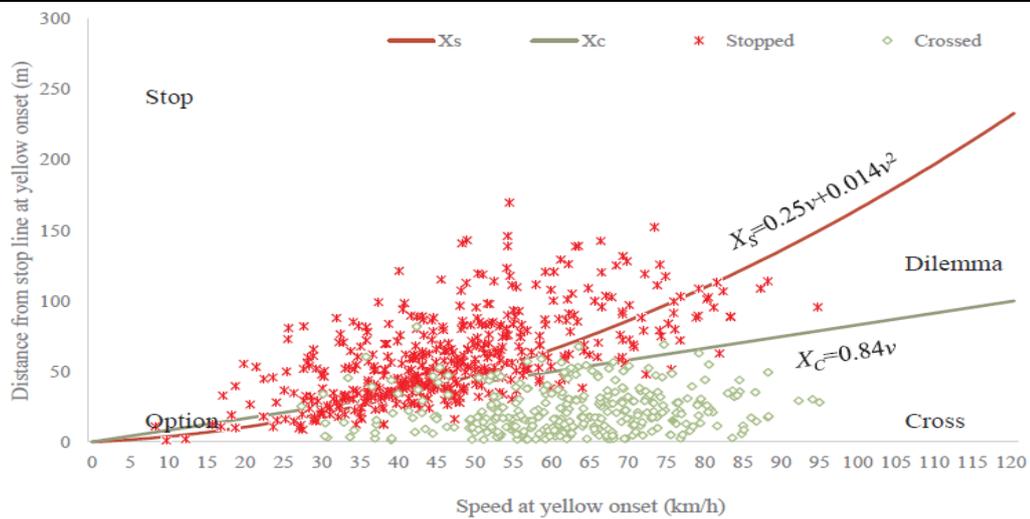


Fig 2.1 Speed-Distance diagram

Huilin Zhang; Lin Cheng; Qiang Tu; and Qiaozhen Wang^[3] took two aspects of dynamic nature are proposed. One of which is based on vehicles' characteristics and the other one is based on time with a following car considered. The relationship between dilemma zone and vehicles is illustrated in the form of a graph based on the definition of DZ. Then Linear car following models have been used to analyze the time dynamicity of DZ, which plays an important role in the prediction of DZ and guiding vehicle to avoid DZ in advance. Author divides vehicles into two groups: cars and trucks according to the different vehicle lengths and decelerations. To get the real parameters, they do a filed survey at a suburb signalized intersection in Nanjing, China. Vehicle speed was measured by laser velocimeter, and decelerations were measured by video method by width and length.

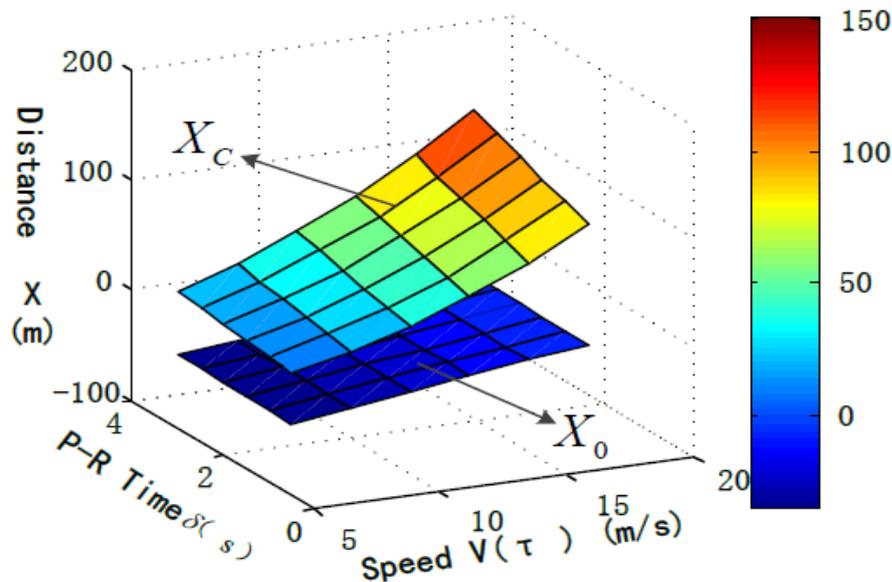


Fig 2.2 3D plot between Speed, P-R Time and DZ Based on cars

Mingmin Wua, Wanjing Maa, Li Lia^[4] conducts a comprehensive evaluation of effects of optimization objectives for signal coordination at two coordinated signalized intersections. Microscopic traffic simulation software, VISSIM, was used to represent the stochastic variation of traffic flow. The results indicate that the traffic flow fluctuation, the optimization objectives, and traffic demand level have significant impacts on dilemma zone distribution. Compared with length of dilemma zone, the number of vehicles in dilemma zone is more sensitive to the signal coordination. The method to avoid dilemma zone is also proposed based on simulation results. Major conclusions of this paper is:

1. There will be different travel time distributions with different flows. When the flow is not high, the travel time distribution is similar with each other. The non-stopped travel time distribution follows normal distribution and the non-stopped vehicles are more than stopped vehicles with a high proportion. Moreover, the proportion of non-stopped vehicles and stopped vehicles does not have a big variation. When the flow is high, the travel time distribution changes to a situation with more stopped vehicles. At the same time, the peak of non-stopped vehicles becomes lower.
2. The amount of vehicles in dilemma zone is also affected by flow. More flow will lead to more vehicles in dilemma zone with the same offset. And the amount increases with a greater rate under 0.5 times saturation flow.
3. The proper offset decreases the number of vehicles in dilemma zone effectively. Especially, the number of vehicles in dilemma zone keep a high value when the flow is higher than 3500veh/h.

Bharat K Pathivada, Vedagiri Perumal^[5] investigated the driver behavior by videotaping 398 driver responses at two signalized intersection approaches with different yellow durations. Binary logistic regression model is developed to represent the driver behavior in mixed traffic conditions. Vehicle type, which is a characteristic of mixed traffic conditions is found to have a significant impact on the driver's decision process along with the vehicle speed, distance from the stop line and duration of yellow signal. Data is collected at two signalized intersections approaches by video recording the driver's decision to stop or cross the intersection when confronted with a yellow signal. Video data was collected for four non-peak hours at each location. Three high definition video cameras, which can record at 30 frames per second, were used to record the traffic data. Video cameras were placed at the higher points so that it could cover 100-150m length of the desired approach. Traffic cones were placed at 10m intervals along the roadway as reference points for video benchmarking and reference line generation as shown in Fig 2.3. As a result of this paper, only 35.5% of the drivers out of the 398 observations were found to stop at the intersection, indicating the aggressive behavior of the Indian drivers. Here Binary logit model has been developed to describe the decision behaviour of the driver at the onset of yellow. The developed model has been validated using 15% of the extracted data, which shows the prediction accuracy of the model to be 83.3%. It is observed that the probability of stopping decreased with the increase in the approaching vehicle speeds and increase in yellow duration at the signal. All vehicle types were found to continue through the intersection, if their distance to the stop line was less than 30m at the onset of the yellow signal. Vehicle type, which is a characteristic of mixed traffic conditions, had a statistically significant effect on the stopping probability of the drivers.

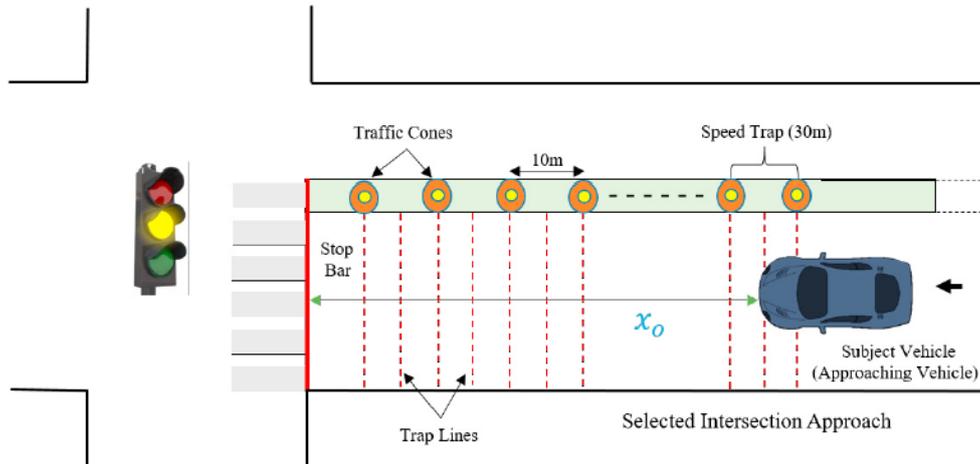


Fig 2.3 Data collection and extraction at selected intersection approach

Heikki Summala^[6] review on driver brake reaction times (RTs), Green (2000) rightly criticizes attempts to seek a canonical brake RT, and proposes to determine expected brake RT for specific situations. However, based on his analysis, he presents a series of values for expected, unexpected, and surprise situations that appear to generalize over a variety of different driver tasks and traffic situations without sufficient concern for urgency or criticality of the situations. This sampling problem may lead easily to biased and somewhat arbitrary estimates. Thus, instead of 1.25 sec for “unexpected” situations, the median yellow response time for the critical conditions (at short time-to-stop-line) is rather below 1.0 sec, and instead of 1.5 sec mean brake RT for surprise situations, available on-road data suggest that in fairly urgent situations—at time-to-collision of about 4.0 sec—unaltered drivers are able to react to an obstacle by braking at an average latency of 1.0 to 1.3 sec, depending on site. More emphasis should be given to analyzing (and producing) real-life data on driver reactions as a function of situational and driver-centered variables, and of criticality. In his review, Green (2000) examines the effects of what he assumes to be the five principal variables on RTs: expectation, urgency, age and gender, and cognitive load. His main conclusion is that driver expectations are the most important variable affecting RTs, by a factor of 2, and RTs are modulated somewhat by other factors like driver age and gender, cognitive load, and urgency. However, somewhat against criticism of canonical value, he proposes a series of values to be used in expected, unexpected, and surprise situations.

III. CONCLUSION

This commentary suggests that Green's (2000) analysis generalizes over a variety of different driver tasks and traffic situations in a way that leads to biased estimates of unaltered drivers' brake RTs. It is obvious that to get general central-tendency measures for drivers' RTs, we cannot make generalizations over situations where drivers have no need to respond quickly. We may hypothesize that drivers who concentrate on the driving task, avoid sharing attention, and find a situation urgent enough to respond by braking may well do it at the average latency of about 1 sec in unexpected and even surprise situations. However, when we add distraction, low arousal level, fatigue, temporary attentional lapses, old age, neurological diseases, and drugs, all of which are present in traffic, we get slow reactions and skewed RT distributions even in urgent situations.

The installation of flashing green helps to reduce the dilemma zone according to the A-D diagram. Although it is a more complicated method based on the calculated required acceleration and required deceleration. However, this diagram could reflect the drivers' response to the change of signal.

In order to obtain relevant information of DZ and adjust running status of vehicles to avoid DZ in advance, this paper studies the relationship between DZ and time on condition that the leader car exists, which makes much more sense to improving the security of intersections. However, from the derivation of the formula if you want to draw the relationship between DZ and time, that there is a need for a vehicle detection system which can provide vehicle speed and position information at every moment. So it is higher requirement of the road facilities needed.

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