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Driving cycle analysis to identify intersection influence zone for urban intersections under heterogeneous traffic condition

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ABSTRACT

A driving cycle is a speed-time profile which forms the basis of measurements of vehicle performance and characteristics. Vehicle performance varies in different conditions of temperature, altitude, road geometry and traffic. Driving cycle can be analysed for improving vehicle fuel utilisation and reducing emission level by changing driving patterns. It achieves through traffic engineering and management including road alterations and traffic signal control. At intersections, acceleration and deceleration activities of vehicles occur at high frequency. Driving through an intersection evokes stopping or slowing of vehicles, which results sharp acceleration and promotes high emissions. The methodology adopted in present study is to analyse driving cycle characteristics for five intersections of Vadodara city. Driving cycle profile has been collected to identify the intersection influence zone. Intersection influence zone is the location from which the vehicle forcefully involves under the activity of deceleration, stop and acceleration. It doesn't have choice to move at desire speed, so it is the zone of high pollution, which needs implementation of control strategies to minimise the emissions.

1. Introduction

Vehicular population has placed environmental stress on urban area through vehicular exhaust emissions (Padam & Singh, 2004). Emissions depend on the driving activity in different situations including speed, acceleration and deceleration, idling-stop and maximum speed (Pandian, Gokhale, & Kumar Ghoshal, 2009). In order to fulfil efficient measures for controlling and adapting vehicles emissions, driving cycle is the important concept used to develop emission control strategies (Yu, Wang, & Shi, 2010). Driving cycles are used for many goals like emission estimation, rate of fuel consumption and traffic engineering purpose (Andre, 2004; Barlow, Latham, McCrae, & Boulter, 2009; Galgamuwa, Perera, & Bandara, 2015; Seers, Nachin, & Glaus, 2015; Tamsanya, Chungpaibulpattana, & Atthajariyakul, 2006). The driving pattern of vehicle states the fluctuation in vehicle speed over period of time. Vehicle has experience this driving pattern repetitively along the journey. This pattern is called the 'Driving Cycle' (Tamsanya, Chungpaibulpatana, & Limmeechokchai, 2009). The driving cycle is a profile of either speed versus time or speed versus distance (Galgamuwa et al., 2015). It is a sequence of data points, represents speed of vehicle at given time interval (Galgamuwa et al., 2015). Profile of driving cycle depends on characteristics of individual vehicles, driver's behavior, geometrical aspects of road, traffic volume and traffic control devices (Mudgal, 2011). Driving cycle is a series of vehicle operating states; idle, acceleration, deceleration and cruise (Arun, Mahesh, Ramadurai, & Shiva Nagendra, 2017; Nesamani & Subramanian, 2011). Driving cycle profile for actual traffic condition can be collected from test vehicle driving in heterogeneous traffic condition, which represents actual traffic conditions (Bokare & Maurya, 2012; Brady & O'Mahony, 2013).

In signalised intersection, driver has to follow and maintain the speed according to preceding vehicle when it approaches intersection. It starts decelerating from the desire speed and further comes to stop position under influence of red signal phase. Stop position promotes acceleration of vehicle to achieve again its desire speed. Sequence of deceleration, idle and acceleration mode of vehicle occur at signalised intersection due to phasing of signal cycle and traffic influence. The focus of the study is to find out the location from which deceleration starts and acceleration ends at the intersection. The stretch of these two locations is known as intersection influence zone. Present study highlights driving activity at signalised intersection for different modes of vehicle to identify influence zone of intersection. Driving cycle profile has been collected in peak period for five intersections of Vadodara city of Gujarat state, India. Study area consists of around 90–92% of vehicle

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composition of two wheeler, car and auto rickshaw, so these three modes have been taken for data collection to know mode wise speed characteristics.

The main objective of the current research is to identify intersection influence zone for signalised and rotary intersection by three modes of vehicle. Intersection influence zone consists of driving activities; acceleration, idle and deceleration. Percentage time in acceleration, deceleration and idle have been calculated for influence zone. Speed acceleration frequency matrix is prepared to know driving parameters characteristics in detail. A code has been developed to prepare speed acceleration frequency matrix. Driving parameters are compared for three modes of vehicles; Auto rickshaw, bike and car.

Li, Boriboonsomsin, Wu, Zhang, and Barth, 2009 have proposed method to analyse the intersection influence effect on vehicle energy and emissions essential for evaluating the effect of traffic signal control. Sanghpriya, Kamble, Mathew, and Sharma, 2009 explained methodology for construction of driving cycle using micro- trip approach from real world traffic data. They considered driving parameters of speed – time profile like; average speed, percentage acceleration, percentage deceleration and percentage idle – cruise. Fotouhi and Montazeri-Gh (2013) have also discussed the method for car driving cycle development for Tehran city based on data clustering. Nesamani and Subramanian (2011) used GPS (Global Positioning System) for knowing driving characteristics of intra city buses. The study explained that higher percentage of travel time is spent in idle mode while analyzing driving data of real traffic condition. Seedam, Satiennam, Radpukdee, and Satiennam, 2015 have developed on-road driving pattern for driving cycle of motorcycle for Khon Kaen city, Thailand. The results are validated through collected data of speed profile. Knez, Muneer, Jereb, and Cullinane, 2014 estimated driving pattern in the Slovenian city of Celje. The urban driving cycle for small city is estimated and compared with other European cities. Average speed is taken for the measurement.

2. Study area and data collection

2.1. Study area

Vadodara, the second name Baroda is a city holds third position after Ahmedabad and Surat in overall development. Old Padra Road of the city faces hazards traffic problem almost every day. To understand influence of traffic on vehicle speed, data has been collected on corridor of Old Padra road. Velocity box (V-box) apparatus was mounted on vehicle to get speed profile of existing traffic condition. It is GPS based instrument gives the speed value of at 1 Hz frequency (data recording once a second) (Bokare & Kumar Maurya, 2013). Data has been collected for three modes of vehicles; Auto rickshaw, bike and car in peak hour period. Fig. 1 shows location of intersections from the starting point of Akshar chowk to end point Genda circle. Performance box stores data of driving cycle in form of speed verses time and speed verses distance.

Table 1
Distance of intersections from Akshar Chowk to Genda circle.

Corridor	Distance (km)	Nomenclature
Akshar chowk	0.0	SP
Vasna circle	1.6	SI-1
Havmore circle	2.2	SI-2
Malhar circle	2.4	SI-3
Chakli circle	2.9	RI
Ambedkar circle	3.2	SI-4
Genda circle	4.3	EP

In Table 1 the distance of intersections from the reference point SP is denoted. SI-1, SI-2 and SI-3 are four legged signalised intersections, whereas RI is a rotary intersection. SI-4 is three legged signalised intersection. Instrument mounted on car to get speed profile of the intersection is shown in Fig. 2. Fig. 3 shows collected speed – distance plot of driving cycle. It is clearly seen that the profile of driving cycle pattern suddenly dropped down before the intersection and again it comes to the acceleration phase near the intersection point.

3. Methodology and analysis

Driving cycle collected from real world data represents characteristics of heterogeneous traffic condition in form of acceleration and deceleration. Methodology for analyses of driving cycle to find influence zone consists of data collection, data division, parameter calculation and mode wise comparison of parameters for influence zone. Fig. 4 shows flow chart of methodology to identify intersection influence zone based on speed – time profile. The profile of driving cycle is divided at upstream and downstream of intersection for finding the stretch of the influence. The location at which the deceleration of vehicle starts till the location of the vehicle at the acceleration ends are marked and indicated as stretch of intersection influence zone. The influence zone is identified by comparing speed-time trajectory and distance-time trajectory. Important driving parameters namely acceleration, deceleration and idle are calculated for influence zone. Parameters are studied in details by preparing speed acceleration frequency matrix. In this matrix the acceleration and speed is divided in to range. The procedure is repeated for three modes of vehicles; auto rickshaw, bike and car.

As per the methodology discussed earlier, data is analyzed and locations have been identified. The driving parameters are calculated for the segment of intersections. Driving parameters; percentage time in acceleration, deceleration, and idle are calculated for the stretch of the marked influence zone.

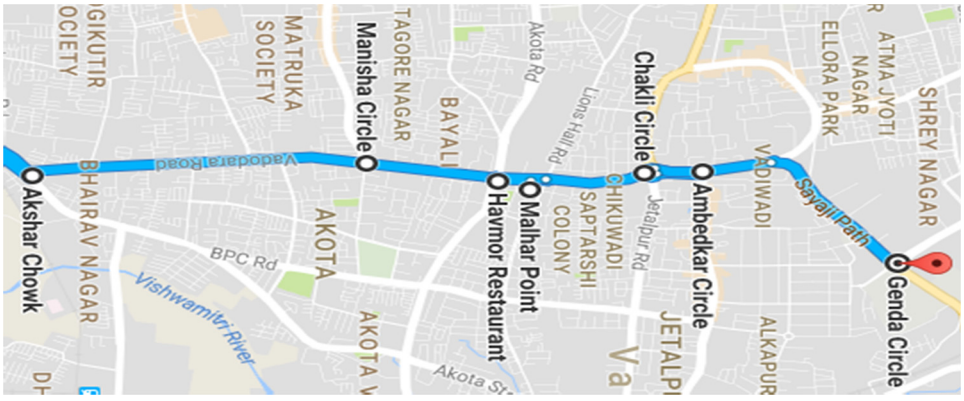

Fig. 1. Location of intersections between Akshar Chowk to Genda circle.