Clustering of Vehicles by Performance Characteristics for Indian Multi-Lane Highways

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Abstract— Vehicle type plays an important role in the accident occurrence, lane changing process and capacity analysis. In heterogeneous traffic, like Indian roads, vehicle interaction is high due to different types of vehicles with difference in speed. Sizes of vehicle-type are same in existing vehicle classification. But, the performance characteristics of vehicle types are different. Grouping the vehicles based on performance characteristics and vehicle configuration is needed for multi-lane highways. The present study is an attempt to identify and group the same performance characteristics vehicles using dynamic cluster based on free-flow speed and Vehicle configuration. Classified traffic volume and spot-speed study have been carried out for a four lane divided highway (NH7 – Virudhunagar to Madurai stretch, Tamilnadu) in India. The road stretch has been chosen as far as away from the city influence to experience the free flow conditions. Considering only free-flow speed, Euclidean lengths for each existing vehicles types have been calculated. Based on Euclidean lengths, vehicles are classified into five groups. This five groups are further modified as eight groups considering the vehicle configuration also. Traffic composition and standard deviation of speeds for new vehicle types have been obtained as the performance characteristics.

Key words: Euclidean Lengths, Free-Flow Speed, Grouping of Vehicles, Heterogeneous Traffic

I. INTRODUCTION

Vehicle type plays an important role in the accident occurrence, lane changing process and capacity analysis. Dinu R. R. and A. Veeraragavan (2011) developed a random parameter model to predict accident frequencies on two-lane undivided rural highway segments. The factors considered in the model are variability among vehicle types and variability in driver behavior. Satish Chandra and Shalinee Shukla (2012) evaluated the acceleration and overtaking characteristics of different types of vehicles (Car, Two wheeler, Heavy vehicle, Auto rickshaw and Light Commercial Vehicle) on four-lane divided highways. Rong Jian, Liu Xiaoming and Ren Futian classified the vehicles for expressway capacity analysis in China, because the existing vehicle classification causes some problems, such as the vehicle-types whose sizes are the same have different performance characteristics. In heterogeneous traffic, like Indian roads, vehicles interaction is high due to different types of vehicles with difference in speed. Sizes of vehicle-type are same in existing vehicle classification (e.g., Government bus and Private bus). But, the performance characteristics of vehicle types are different. Identifying and grouping the same performance characteristics vehicles based on some factors is needed. The present study is an attempt to identify and group the same performance characteristics vehicles using dynamic cluster based on Free-flow speed and Vehicle configuration. Free-flow speed can measure the performance characteristics of vehicles, because it is the spot speed at which the vehicle travels under a free condition. It is only related with the operational characteristics of vehicles and driving habits of drivers.

II. OBJECTIVE

To group the same performance characteristic vehicles for Indian multi-lane highways using dynamic cluster based on free-flow speed and vehicle configuration.

III. STUDY CORRIDOR AND DATA COLLECTION

The study corridor is Virudhunagar to Madurai stretch (Figure 1), four lane divided rural highway (NH7), in India.

Fig. 1: A view of study corridor

Classified traffic count and speed data have been carried in the road stretch for the both directions, North to South (Madurai to Virudhunagar) and South to North (Virudhunagar to Madurai). Data has been collected manually for one day with 15min intervals in the year 2013. The existing vehicle types are given in the Table 1. The traffic volume & speed data collected in field were analyzed to identify the same performance characteristics vehicles.

Type No.	Vehicle Type Name	Type No.	Vehicle Type Name
1	Motorized Two Wheeler	8	Light Commercial Vehicle
2	Auto Rickshaw	9	2-Axle Truck
3	Passenger Car	10	3-Axle Truck
4	Mini bus	11	Multi Axle Truck
5	Government Bus	12	Tractor
6	School/College Bus	13	Tractor with Trailer
7	Private Bus	14	Bicycle

Table 1: Types of vehicles before grouping

The total number of vehicle travelled form Madurai to Virudhunagar was 7024 and about 40% of the vehicle travelled was Passenger car. The total number of vehicle travelled form Madurai to Virudhunagar was 7002 and nearly 39% of the vehicle travelled was Passenger car.

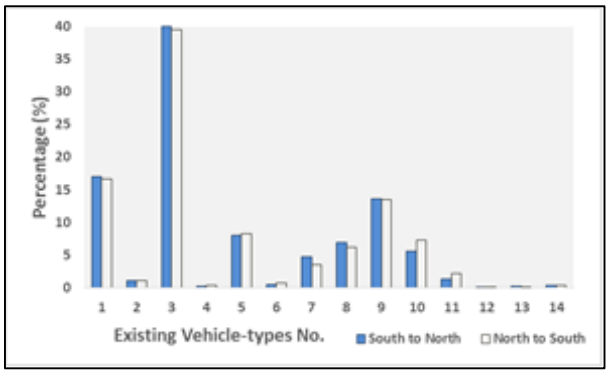

Fig. 2: Existing Vehicles-types Composition

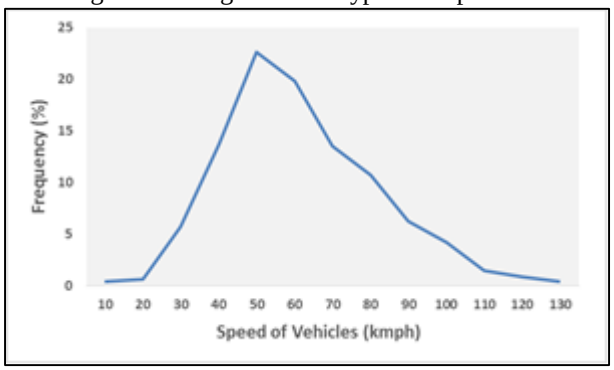

Fig. 3: Frequency Curve for speed of vehicles

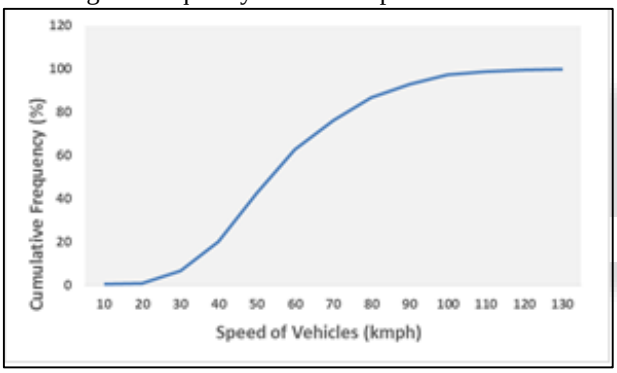

Fig. 4: Cumulative frequency Curve for speed of vehicles

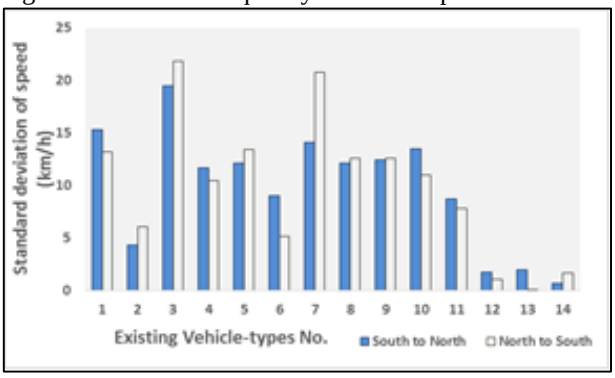

Fig. 5: Standard deviation of speeds of existing vehicle-types

Traffic composition of existing vehicle classification is shown in figure 2 as percentage. It is observed that the maximum number of vehicles is travelling in the speed range of 40kmph to 80kmph (Figure 3) and the 85th percentile speed is 90kmph (Figure 4). Standard deviation of speeds of existing vehicle-types is shown in figure 5.

IV. CLUSTERING OF VEHICLES

The Euclidean Lengths calculated using Equation (1) are used to measure the variances of performance characteristics between various Groups [1]. In mixed traffic, medium vehicle always occupies the highest percentage (40% of the vehicles are Passenger car), so passenger car is selected as the standard vehicle-type.

$$R_i = \sqrt{(x_i - x_0)^2} \qquad (1)$$

Where,

R_i = Euclidean Length between average free-flow speed of vehicle-type *i* and passenger car;

x_i = Average free-flow speed of vehicle-type *i*;

x_0 = Average free-flow speed of passenger car.

Euclidean lengths for each existing vehicles types have been calculated (Figure 6). Vehicles are classified into five groups from obtained Euclidean lengths with scale 15.

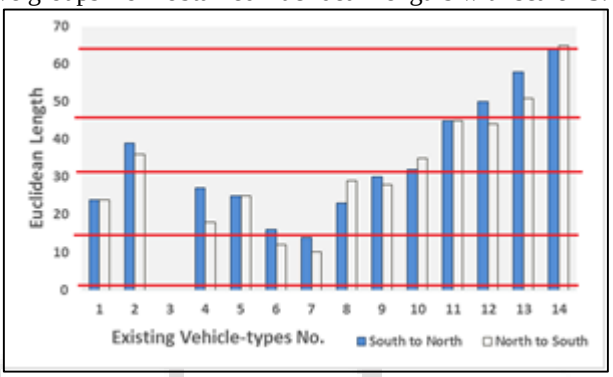

Fig. 6: Euclidean lengths of each Vehicle-type

Result of the clustered new vehicle types based on free-flow speed are given in the Table 2. The names of this vehicle groups are A1, A2, A3, A4 and A5. Motorized two wheeler, Auto Rickshaw and Bicycle are in group A3, A4, A5 respectively with difference in configuration. Hence, the vehicle types are classified into eight groups as in the Table 3 based on free-flow speed and vehicle configuration.

New Vehicle-Type No.	Existing Vehicle Type No. & Name
A1	3 - Passenger Car
A2	6 - School/College Bus 7 – Private Bus
A3	1 - Motorized Two Wheeler 4 - Mini bus 5 - Government Bus 8 - Light Commercial Vehicle 9 – Two -Axle Truck
A4	2 - Auto Rickshaw 10 - Three-Axle Truck 11 - Multi Axle Truck
A5	12 – Tractor 13 - Tractor with Trailer 14 – Bicycle

Table 2: Result of Clustering using free-flow speed

New Vehicle-Type No.	Existing Vehicle Type No. & Name
B1	3 - Passenger Car
B2	6 - School/College Bus 7 – Private Bus
B3	4 - Mini bus 5 - Government Bus 8 - Light Commercial Vehicle

	9 – Two -Axle Truck
B4	10 - Three-Axle Truck 11 - Multi Axle Truck
B5	12 – Tractor 13 - Tractor with Trailer
B6	2 - Auto Rickshaw
B7	1 - Motorized Two Wheeler
B8	14 – Bicycle

Table 3: Clustering using free-flow speed & Vehicle Configuration

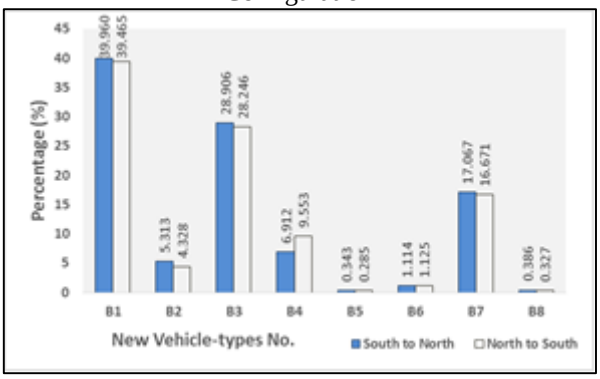

Fig. 7: New Vehicles-types Composition

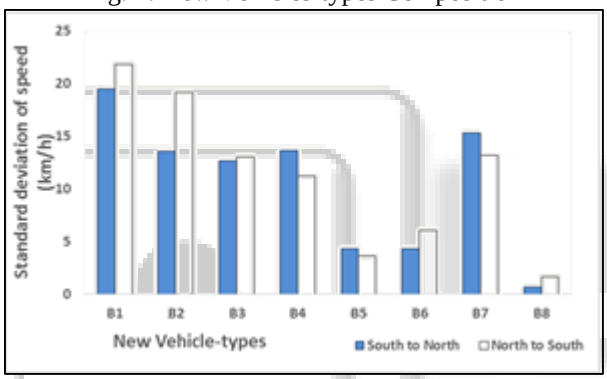

Fig. 8: Standard deviation of speeds of new vehicle-types

Traffic composition of new vehicle classification is shown in figure 7 as percentage. Standard deviation of speeds of new vehicle-types is shown in figure 8. In the new vehicle types, the deviation in the composition and speed is very less comparatively.

V. Conclusion

Same performance characteristics vehicles are identified and clustered for the four lane divided highway. Dynamic cluster method is used for clustering. The clustered new vehicle-types are eight. Traffic composition and standard deviation of speeds are obtained as the characteristics of new vehicle groups.

Motorized two wheeler and Bicycle are two groups in the eight new groups. About 17% of vehicles are in this two groups. This two group vehicles are mostly use shoulder lane or paved shoulder for their movement in four lane divided highways. These two group of vehicles are mostly not involving in the overtaking or lane changing maneuvers. Even though, these vehicles are influencing the flow of other vehicles.

In this study, Speed of vehicles have been calculated manually. Instead of collecting manual data, video capturing may give more accurate result and speed for all vehicles can be obtained. Six-lane highways vehicles also can be included for this classification.

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