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Analysis of the Effect of Variable Lateral Gap Maintaining Behavior of Vehicles on Traffic Flow Modeling

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Abstract

Vehicular interaction between different types of vehicles, in both the lateral and longitudinal directions, significantly affects the heterogeneous traffic flow modeling. From the field data it has been observed that the drivers vary gaps based on the changing traffic conditions. This variable gap maintaining behavior has been characterized using macroscopic traffic characteristic called area occupancy. Variable gaps are explained through effective vehicle width and it is found to be influenced by various factors. In this study, variable gap maintaining behavior is modeled using the concept of cellular automata (CA), with the help of a modified cell structure. Cell width in the modified cell structure has been varied corresponding to the observed variation in the effective vehicle width. It was found that the results obtained from the model incorporated with the variable gap maintaining behavior are significantly different from that of the uniform-cell-width based CA model. The effect is more significant for urban traffic conditions due to the presence of two-wheelers and three-wheelers.

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Keywords: Cellular automata; Heterogeneous traffic; Lateral gap; Variable cell width;Cell structure.

1. Introduction

Wide ranging physical dimensions, weight, and other dynamic characteristics of vehicles characterize the heterogeneous traffic observed in developing countries like India. The driver, under these conditions, can utilize any space available on the road without any lane discipline. When different types of vehicles share the same road space without any lane discipline, the extent of vehicular interactions varies widely with the variation in traffic mix and

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traffic conditions. It also generates significant level of friction or frictional clearance between the vehicles moving side-by-side in the traffic stream. This frictional clearance is expressed in terms of lateral gaps maintained by vehicles. The lateral gap may vary depending on the type of vehicle, vehicle size, speed, area occupancy, etc. Under heterogeneous traffic conditions, at higher traffic volumes, a large proportion of motorized two-wheelers and bicycles are able to move with speeds closer to their free speeds because of their ability in utilizing the smaller gaps in the traffic stream. Modeling these traffic conditions require systematic study of all the relevant characteristics of traffic, with enough data support. From limited field observations, Pal and Mallikarjuna [1] have shown the variation of the average gaps maintained by vehicles with respect to area-occupancy. These relationships are valid for only specific traffic conditions. There is a need to extend these relationships for studying different traffic conditions prevalent on the roads. It is also necessary to incorporate this variable gap maintaining behavior in traffic flow models.

Cellular Automata concept is being widely used to model the heterogeneous traffic streams. CA model used for homogeneous traffic requires modifications to the CA structure as well as updating procedures in both lateral and longitudinal directions. To model no lane-discipline which can be attributed to the driver discomfort as well as due to the presence of small sized vehicles, the present concept of lanes may not be useful. It is necessary to include lateral gaps at different traffic conditions in addition to actual vehicle width while deciding the CA structure. The cell width must be decided in such a way that the small vehicles such as motorized two wheelers and three wheelers are represented appropriately. The cell structure must incorporate the variable gap maintaining behavior of different vehicles under different traffic conditions. Fig. 1 and 2 show the traffic conditions at different occupancy levels over a 13m wide road located in Motibagh, Delhi, India, at 14.30 hrs and 14.40 hrs, respectively. It is clear from these figures that more number of vehicles can move on the same road section at a different occupancy level.

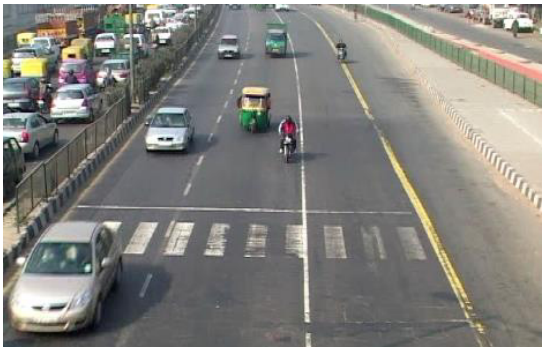

Fig. 1. Road section with less occupancy.

Fig. 2. Road section with high occupancy.

In this paper, variable gap maintaining behavior of vehicles is modeled using CA concept with a modified cell structure. Cell widths have been varied corresponding to the variation in the lateral gaps observed in the field data. The observed variation in the lateral gaps has been captured and incorporated in the model using macroscopic characteristic called area occupancy [2]. Area occupancy is a variant of occupancy that is commonly used in traffic flow theory. It expresses for how long a particular size of the vehicle is moving on a certain area of the road. Whereas, occupancy is the percentage time the road section is occupied by a vehicle over a given period of time. Area Occupancy can be measured over time and over space. In this study, temporal area occupancy is used for the analysis of gap maintaining behaviour and is termed as area occupancy throughout this paper. Effect of variable gap maintaining behavior has been studied using flow-occupancy relationships and it has been found that the reduced lateral gaps at higher occupancy levels significantly affect the resulting flow values. The effect of the variable gap maintaining behavior is more predominant in urban traffic scenarios due to the presence of smaller vehicles such as two-wheelers and three-wheelers.

This paper is organized into five major sections. In the next section background literature is presented. Section 3 describes the data collection methodology and the process of determining the variable cell width. Section 4 deals with the description and validation of the CA based simulation model. Summary and conclusions are presented in last section.