ANALYSIS AND MODELING OF HETEROGENEOUS TRAFFIC

By

CHUNCHU MALLIKARJUNA

A Thesis Submitted
in fulfillment of the requirement
for the degree of

DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

New Delhi-110016, INDIA

August-2007

CERTIFICATE

This is to certify the thesis entitled "**Analysis and Modeling of Heterogeneous Traffic**" being submitted by Mr. Ch. Mallikarjuna to the Indian Institute of Technology, Delhi, India, for the award of the degree of **DOCTOR OF PHILOSOPHY**, is a record of original bonafide research work carried out by him. Mr. Mallikarjuna has worked under my guidance and supervision.

To the best of my knowledge, the thesis has reached the requisite standard. The material contained in this thesis has not been submitted, in part or in full to any other University or Institute for the award of any degree or diploma.

(Dr. Kalaga Ramachandra Rao)
Assistant Professor
Department of Civil Engineering
Indian Institute of Technology Delhi
New Delhi, India

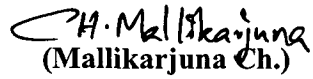
ACKNOWLEDGEMENTS

I consider it my privilege to be working under the guidance of Dr. Kalaga Ramachandra Rao, Assistant Professor, Civil Engineering Department, IIT Delhi. He had been a pillar of strength for me throughout the period of doctoral program and in realization of this thesis.

My special thanks to SRC members - Prof. A. K. Nagpal (Chairman), Prof. G. Venkatappa Rao, and Prof. S. G. Deshmukh - for their invaluable suggestions during different stages of my research work. I also thank Dr. Geetam Tiwari, Associate Professor and Dr. G. V. Ramana, Associate Professor, for their encouragement and support throughout my research work.

My sincere gratitude to friends Hanumantha Rao, Ravindra Babu, Ravi Shankar, Shiva, Sudhakar, Srihari, Amardeep Singh, Bulu Pradhan, Kondrai Vendan, Ramana Reddy, Satish, Phanindra, and Ravi who had made my stay in IIT Delhi comfortable. They also have been constant source of inspiration for me to draw strength from. My special thanks to my colleagues Arvind Kumar Jain, Mukti Advani, Shriram and Sarma, for the thought-provoking professional discussions we had, as also for some lighter moments we shared.

The time I spent with my niece Geetika (Chinnu) had always imbued fresh energy in me to get back to work reinvigorated. Also, my word of thanks to my father, brother, and other family members for their constant encouragement and support. Last but not the least, I would like to place on record my appreciation for my better half Anusha for her unrelenting support and sacrifice, without which it would not have been possible for me to complete this thesis.



(Mallikarjuna Ch.)

Abstract

Rapidly growing traffic in both urban and rural areas has resulted in a demand for better management of existing roads as also higher investments on new infrastructure. In this scenario, traffic management, which is cheaper of the two options, is emerging as an important area that requires thorough understanding of traffic behavior. The composition and associated no lane-discipline behavior of the heterogeneous traffic, observed in countries like India, make it difficult in understanding as well as in modeling of such traffic. Understanding the real traffic behavior requires some observable traffic characteristics. In the past, though several researchers have tried to come up with a successful traffic model, there was no comprehensive methodology, which encompasses these important aspects of traffic modeling.

In this work, an attempt is made to analyze and model the heterogeneous traffic behavior observed on mid-block sections of urban and rural roads. In doings so, three important objectives namely, choosing traffic characteristics that are useful in describing heterogeneous traffic, developing a Cellular Automata (CA) based traffic model, and utilizing a Video Image Processing (VIP) based data collection methodology, are concentrated upon.

Several macroscopic traffic characteristics are analyzed for their suitability in describing the heterogeneous traffic. Important characteristics such as flow in absolute number of vehicles and density are found to be inadequate in describing this traffic. A new macroscopic traffic characteristic called 'area occupancy' has been proposed in this study. Area occupancy is formulated as a function of vehicle area and speed and found to be more suitable in describing the heterogeneous traffic. When more trucks and two

wheelers (TW) are present in the traffic stream, area occupancy is more significant in describing the traffic behavior. This is proved with the help of data collected on National Highway (NH)-1, where significant truck volume is present. CA model, which is useful in modeling complex systems, is modified to study the heterogeneous traffic. CA lattice structure has been modified to incorporate heterogeneous traffic characteristics and to model no lane-discipline. Both longitudinal and lateral movement rules, specific to heterogeneous traffic, are developed in this work. A VIP based data collection methodology, which is capable of capturing trajectories of even small sized vehicles such as two-wheelers, has been utilized in this work. Several microscopic characteristics such as lateral and longitudinal gaps are also measured using this new technique. To effectively utilize the lateral gaps maintained by different vehicles under different traffic conditions, we have evaluated different relationships between these lateral gaps and various macroscopic traffic characteristics. Area occupancy and majority vehicle type in a particular vehicle combination are found to be effective in describing the lateral gap-maintaining behavior of that combination.

Modified Knospe's Brake Light (BL) model has been used for vehicle updating in longitudinal direction. A simulation model has been developed using the modified CA methodology on JAVA platform. Sensitivity analyses are carried out to know the effect of different CA parameters on the model output. This model has been validated using flow-occupancy relationship obtained from the field as well as simulation. The validation is done using two data sets; one related to the urban traffic and the other in the context of rural traffic. Observed and simulated flows are compared and correlation coefficients are 0.74 and 0.9 in case of urban and rural traffic respectively. The key result of the analysis is the emergence of new common vehicle unit 'Cell' to express the

heterogeneous traffic flow in terms of homogeneous traffic, which is found to be a better alternative than Passenger Car Equivalent in explaining the global flow-global occupancy relationship obtained from the CA model. Global measurements obtained from the modified CA model can be used to correlate the heterogeneous traffic in terms of cells to homogeneous traffic.

CONTENTS