Flow Characteristics of Heterogeneous Traffic with and without Adherence to Lane Following

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Introduction

- Homogeneous traffic
  - Lane-following
  - Disciplined movement

- Heterogeneous traffic
  - Highly varying static and dynamic characteristics
  - Difficult to impose lane discipline
  - Vehicles occupy any lateral position on the available road space

- Growth of vehicular traffic has resulted in low speeds, excess travel times, delays and safety-related traffic problems
Motivation

- Different types of vehicles moving on the same road may enjoy different levels of service (e.g. Two wheelers)
- Complex traffic scenario poses a serious challenge to traffic planners and engineers
- Solutions can be obtained through systematic study of relevant characteristics of mixed traffic
Objectives

- To compare the lane following and non-lane following characteristics of heterogeneous traffic for different lane facility types (two-, three- and four-lane)

- To compare the capacities and speeds of different lane facility types by varying composition, flow levels and lane widths
Literature Review

- Different simulation models were developed for heterogeneous traffic conditions (Oketch (2000), Cho & Wu (2004), Arasan & Koshy (2005), Mallikarjuna & Rao (2007), Dey et al. (2008))

- Limited work were done for comparing capacities of different lane facility types - heterogeneous traffic system follow lane discipline (Chandra & Kumar (2003), Arasan et al. (2009), Thomas et al. (2011), Gowri et al. (2012))

- This work is a further attempt in this direction; it compares the capacities of lane following and non-lane following scenarios through simulation models
Development of Simulation Model

- On most Indian roads, vehicles move freely based on availability of space and ignore lane discipline
- Smaller vehicles often weave through gaps between larger vehicles
- These features of traffic flow and wide variations in vehicular characteristics are incorporated in the developed simulation model (Gowri et al., 2009; Gowri, 2011).
- This model is intended to simulate the heterogeneous traffic flow at mid-block section (two lanes) of an urban street.
Logics used in Simulation Model

- Logics in simulation model for non-lane following scenario
  - Vehicle Generation
  - Vehicle Placement
  - Vehicle Movement

- Object Oriented Programming concepts

- Implemented in C++ programming language (Gowri et al., 2009)
Vehicle Generation

• Vehicle enter the system based on time interval (time gap distribution)

• Time gap distributions for different categories based on lead-lag vehicle (e.g. TW-TW, TW-Car, etc.) are given as input to the simulation model

• Generated vehicle is assigned a free speed as per the normal distribution based on field data

• Type of vehicle is assigned based on traffic composition observed in field
Vehicle Placement

- Vehicle placement is based on availability of transverse and longitudinal spaces.
- Vehicle looks for spaces from right edge to left edge of the road stretch.
- If spaces are sufficient, vehicle will be placed on the road stretch.
- If not, it reduces its speed to that of its leader (car following rule).
Vehicle Movement

- If there is no slow vehicle in front of it, vehicle accelerates up to its free speed.
- If not, overtaking logic is invoked
- Overtaking vehicle looks for availability of transverse and longitudinal spaces on the right/left side of the overtaken vehicle
- If spacings are inadequate on both the sides, car following logic is involved
Modifications to the Simulation Program

- In order to simulate lane following by vehicles and to accommodate multiple lane scenarios, program was modified appropriately

- Lane following scenario
  - Vehicles are placed in such a way that centre line of the vehicle and centre line of the lane match.
  - Overtaking is allowed but movements between lanes are not allowed.
  - Vehicles are allowed to overtake from the left as well as right

- Increase in lane widths to reflect multiple lanes (three and four) were incorporated
Data Collection

Ashok Nagar Mid-block Section, Chennai

- Road width – 8.2 m
- Total volume – 4000 veh/h
- Two Wheeler composition is dominant (70%)
Model Validation

- Parameter used for validation – Speeds of different types of vehicles

- Speeds of vehicles for one hour peak period is obtained from field and simulation model

- Simulated values are not statistically different from observed values, indicating the validity of the developed model
Model Application

• Study of influence of lane discipline on speed-flow relationships by varying
  ▪ Compositions
  ▪ Flow levels [500 veh/h to capacity (simulation model)]
  ▪ Number of lanes (two, three and four lanes)

• Different compositions used:
  ▪ Composition 1 - 70% TW and 19% cars
  ▪ Composition 2 - 19% TW and 70% cars
  ▪ Composition 3 - 45% TW and 44% cars
Composition 1 (TW Dominant)

- Capacities (in veh/h) are higher in the traffic stream for both lane following and non-lane following cases.

- Due to high seepage (between other vehicles) of two wheelers due to their smaller size and higher manoeuverability.
Composition 2 (Car Dominant)

- Capacities (veh/h) are lesser in the traffic stream compared to that of two wheeler dominant composition.
- Due to the presence of higher proportion of cars vis-a-vis two wheelers.
Composition 3 (TW and Car almost equal)

- Capacities (in veh/h) are generally higher than car dominant composition (Composition 2) and lesser than two wheeler dominant composition (Composition 1)
Capacity difference between Lane Following (LF) and Non-Lane Following (NLF) for various lane widths and compositions

<table>
<thead>
<tr>
<th>Lane Width</th>
<th>Composition 1 (70% TW, 19% Cars)</th>
<th>Composition 2 (19% TW, 70% Cars)</th>
<th>Composition 3 (44% TW, 45% Cars)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity PCU/h (veh/h)</td>
<td>Capacity PCU/h (veh/h)</td>
<td>Capacity PCU/h (veh/h)</td>
</tr>
<tr>
<td></td>
<td>NLF</td>
<td>LF</td>
<td>Diff.</td>
</tr>
<tr>
<td>Two-lane road</td>
<td>6343 (7356)</td>
<td>5067 (5876)</td>
<td>1276 (1480)</td>
</tr>
<tr>
<td>Three-lane road</td>
<td>8839 (10250)</td>
<td>5962 (6914)</td>
<td>2877 (3336)</td>
</tr>
<tr>
<td>Four-lane road</td>
<td>11101 (12873)</td>
<td>9082 (10532)</td>
<td>2019 (2341)</td>
</tr>
</tbody>
</table>
Comparison of stream speeds (at capacities) of Lane Following and Non-Lane Following cases for various lane widths and compositions

<table>
<thead>
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<th>Composition 2 (19% TW, 70% Cars)</th>
<th>Composition 3 (44% TW, 45% Cars)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Speed km/h</td>
<td>Speed km/h</td>
<td>Speed km/h</td>
</tr>
<tr>
<td></td>
<td>NLF  LF  Diff.</td>
<td>NLF  LF  Diff.</td>
<td>NLF  LF  Diff.</td>
</tr>
<tr>
<td>Two- lane road</td>
<td>31  24  7</td>
<td>31.4 24.5 6.9</td>
<td>31  24  7</td>
</tr>
<tr>
<td>Three- lane road</td>
<td>32  25  7</td>
<td>32  23.6 8.4</td>
<td>32  24  8</td>
</tr>
<tr>
<td>Four- lane road</td>
<td>29  24  5</td>
<td>32  24.8 7.2</td>
<td>29  24  5</td>
</tr>
</tbody>
</table>
Conclusions

- This study focuses on comparison of capacities and corresponding speeds under heterogeneous traffic with and without lane adherence for various combinations of vehicular compositions.

- An existing microscopic traffic simulation model was used.

- Simulation runs were carried out for various combinations of vehicular composition, volume levels, number of lanes and lane following/non-lane following scenarios.
Conclusions (contd..)

- Non-adherence to lanes results in higher mid-block capacities vis-à-vis the case of lane following

- Capacity decreases with the increase in the cars in the total composition when it is measured in veh/h but increases with increase in cars when it is measured in PCU/h, for both lane following and non-lane following cases, in all the road cases, i.e. two, three and four lanes

- While these findings point to higher capacities for non-lane following cases, the issue of compromise on safety must be kept in mind
Conclusions (contd..)

- More case studies and further scenario analysis need to be conducted to generalize the findings

- The present work can be extended to include both mid-block and intersection to form a linear section, which would serve as measure of performance of traffic flow on a road corridor
Acknowledgement

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References


