The adaptability of microsimulation models to chaotic traffic environments

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In this paper, the capability of microsimulation models for representing real-world traffic conditions, encountered in ‘chaotic traffic environments’ of developing countries, is analysed. For this exercise, two suites are used: VISSIM and DRACULA.

INTRODUCTION

Over the past few years, microsimulation modelling has become an important tool for discussing transport proposals between both transport professionals and decision-takers. The existing microsimulation packages have been developed for what it can be considered a ‘well-behaved’ environment, which can be defined as having the following characteristics:

- High standards in road users’ traffic education;
- Relatively low proportions of public transport vehicles, which comply with bus stop sites and pre-arranged bus frequencies;
- Good infrastructure provision for pedestrians and cyclists;
- Sophisticated traffic control devices; and
- Well designed junctions where ‘atypical’ layouts are uncommon.

As it has occurred with macrosimulation models, microsimulation modelling will soon be part of the transportation planning framework in less developed countries. However, the traffic environment encountered on many cities in developing countries may be quite different from those listed above. Thus, current microsimulation models may need to be enhanced in their capability to cope with the most relevant characteristics discussed herein. In this paper, we review the main characteristics of two of the microsimulation packages used in the UK, namely VISSIM and DRACULA, and an analysis of their flexibility for adaptation to ‘chaotic traffic conditions’, such as those encountered in cities from developing countries, is carried out, highlighting models’ strengths and limitations. For the analysis, a typical chaotic network from a third world city has been taken.

MICROSIMULATION MODELS CAPABILITY OF ADAPTATION TO EXTREME TRAFFIC ENVIRONMENTS

The microsimulation principles in VISSIM are based on a ‘psycho-physical’ car-following model based on the work of Wiedemann (1974), whereas DRACULA uses a ‘more conventional’ car-following model. These microsimulation models have been used for representing the traffic conditions on a small-scale network in La Paz City, where it is common to have disorganised traffic conditions.

Figures 1 and 2 highlight some of the traffic conditions encountered at the study area. The main atypical geometric and traffic conditions encountered in La Paz can be listed as follows: atypical junction layout; lane indiscipline; aggressive driving behaviour; and lane indiscipline. From the analysis of the case study, conclusions are drawn out which highlight the main advantages and disadvantages of the microsimulation models for representing the ‘real world’ of less developed traffic environments.

Figures 1 and 2 (over) show some of the traffic conditions encountered at the study area. The main atypical geometric and traffic conditions encountered in La Paz can be listed as follows: atypical junction layout; lane indiscipline; aggressive driving behaviour; and lane indiscipline.
user classes, namely cars and HGVs.

As it is known, model calibration is perhaps the most important stage in model building, which will ensure that a model is a valid representation of the ‘real-world’, but parameters calibration for a microsimulation model may require sophisticated techniques which are not normally available in developing countries (see for example Fellendorf, 1997). Thus for the calibration process, only aggregated information on journey times and exit flow rates at the main modelled junction were used.

Table 1 shows a comparison of modelled and observed journey times for two routes within the study network. From this Table, it can be seen that VISSIM models journey times within a 10% difference from observed values. On the other hand, DRACULA provides slightly higher journey times than VISSIM for all cases. Reducing link speeds on the DRACULA model generated excessive queues; thus, it was decided to keep the high journey times.

Observed exit flows from all arms at the main modelled junction were also used in order to verify modelled demand levels and, thus, the model’s representation of capacity at the junction. With this verification, both models were considered as validated. However, in order to ensure a true representation of the real-world, additional survey work was undertaken at the study junction, by which queue lengths and transit dwell times were observed during three days on the AM peak period. Tables 2 and 3 show a comparison between modelled and observed queue lengths and transit dwell times respectively.

From Table 2 it can be seen that, on Av. del Ejercito, DRACULA overestimates queue lengths, and thus junction delays, by a high proportion. It was observed that this model behaviour was a result of an unreal representation of exit flows on that arm due to the way in which DRACULA models junction layout.

Drivers’ aggressiveness, typical in the La Paz traffic environment, has not been accurately represented by DRACULA for vehicles coming from Av. del Ejercito and entering to Av. Federico Suazo. In the real world, these vehicles can squeeze through any available space in order to make the turn. In DRACULA, vehicles flow on arranged traffic streams on the available lanes, which does not occur in practice in La Paz. On the other hand, VISSIM allows specification of road width, which is used to allow more than one traffic stream on a given lane. In addition, VISSIM allows vehicles to overtake on either the left or the right-side lane, which can increase traffic throughput significantly.

On J.J. Perez road, traffic flow follows arranged streams on every lane. Thus, queue length values modelled by DRACULA and VISSIM are similar to those observed on site.

From Table 3 it can be seen that transit dwell time is well represented by both models, with a slightly higher than observed values simulated by DRACULA.

In order to assess the models’ capability of adaptation to extreme traffic environments, five parameters were analysed: capability for modelling ‘unusual’ driver behaviour; capability for modelling vehicle characteristics; capability for modelling atypical public transport; capability for modelling unusual geometric layouts; capability for modelling lane indiscipline.

What follows is an analysis of the ability of VISSIM and DRACULA for modelling the unusual traffic conditions encountered in the network under study.
the possibility of having more than one stream of vehicles where enough space is available. On the other hand, DRACULA assumes that a lane is just for one traffic stream, regardless of its width.

The existence of high gradients on links can affect vehicular speeds. Whilst VISSIM allows the introduction of link gradient for reducing vehicles’ acceleration capability, DRACULA does not consider this parameter for modelling vehicle performance on a link. Link gradient was proved to be important in modelling heavy goods vehicles’ traffic behaviour within the study network, as many of the links had a significantly high gradient, which obviously defines the way on which vehicles perform.

**Lane discipline**

Whilst lane indiscipline is seldom found on most ‘well-behaved’ traffic environments, it can be a common practice on ‘ill-behaved’ traffic environments. For example, lane choice for turning movements does not normally follow rules given by road markings or traffic regulations.

VISSIM is able to model vehicles’ lane discipline for various traffic environments, as it allows the modeller to define the position that vehicles take on a lane under free driving conditions, and to model the possibility for overtaking either on the left lane or the right lane within a link. This characteristic was very useful for a better representation of the real-world traffic conditions at the study area.

DRACULA assumes that traffic behaviour is lane-disciplined, with all overtaking happening on the faster lanes (offside lanes).

In summary, lane indiscipline observed at the junction under study has been shown to be better represented by VISSIM as it provided a lot more tools for the chaotic traffic conditions.

**Driver behaviour**

In microsimulation models, driver behaviour is represented by two main parameters: driver’s reaction time and critical gap acceptance time.

The driver’s reaction time represents the perceptual-motor manoeuvre carried out by the driver of a vehicle when following another vehicle: perception to a stimulus, decision-making and control. This process is considered to take around one second. There was no reason to believe that driver’s reaction time would be different between one traffic environment to another. Nevertheless, should the analyst consider that this parameter needs to be represented accurately, it is always possible to test different values during the calibration stage, or in the worst case, measure it.

Gap acceptance time is perhaps the single most important parameter which needs to be represented in an accurate manner if driving conditions on junctions with a priority rule are to be correctly modelled. This parameter is certainly different in third world cities, where the driver can be much more aggressive, or less polite, than in Europe or North America. A careful analysis of the appropriate gap acceptance values to be used in model building needs to be carried out by the modeller.

VISSIM models driver’s gap acceptance by defining a ‘minimum gap time’ and a ‘minimum headway distance’. Both are fixed by junction and vehicle type, and may depend on junction geometry. On the other hand, DRACULA uses two gap acceptance times: ‘minimum acceptable gap’ and ‘reduced acceptable gap’; this approach means that the gap acceptance time can be variable according to the minor road vehicle’s waiting time (the longer the driver waits for a gap the critical gap acceptance time is reduced).

Setting the gap acceptance parameter as variable might be useful when the major road carries a high traffic volume, which otherwise could lead to high queues on the minor road. The reduced gap acceptance time in DRACULA can somehow simulate the driver’s aggressiveness encountered on many chaotic traffic conditions, or just when the waiting time becomes too long.

The capability of setting the gap acceptance as variable can be considered as an advantage provided by DRACULA,
when modelling congested networks in chaotic traffic environments.

Public transport and bus stops
The public transport system of many third world cities is characterised by having:
1) A high number of routes on main corridors;
2) Indiscriminate stops at various sites on a road section;
3) Atypical transit vehicles; and
4) Long dwell times.

The first characteristic means that networks are distinctive in that they have a high proportion of public transport vehicles, which may account for more than half of total traffic. The second characteristic is critical as it can reduce link and junction capacity on road sections where high levels of transit routes are encountered. The third characteristic refers to the fact that low capacity vehicles may be used as transit vehicles, which can include taxi-type vehicles (with a capacity of up to four passengers) or non motorised vehicles. Finally, the fourth characteristic is due to the door types of low capacity vehicles, which can lead to lengthy boarding and unboarding times.

The test models have shown that VISSIM offers more flexibility for modelling the atypical transit vehicle types encountered in La Paz, as it has the advantage of incorporating almost any vehicle type with specification of width, length and axle’s location. In addition, VISSIM’s ability to include the number of passengers on the bus, which is related to the number of passengers that can board the transit vehicle and the effect of deboarding passengers on dwell time, have shown to be useful for representing La Paz transit behaviour more realistically.

A bus stop in DRACULA is defined as a point on the road, and only one bus at a time can stop on it. On the contrary, VISSIM allows the definition of bus stop length on which more than one vehicle can stop. The fact that transit vehicles have indefinite capacity can be considered as a drawback in DRACULA as it means that one bus can stop for an excessively long period of time.

Neither VISSIM nor DRACULA can deal with double-parking at bus stops, which may be very common on deregulated transport systems like the one in La Paz City. In addition, the characteristic of buses stopping randomly on any point of the road can be very difficult to model with both packages, as they need bus stops to be defined explicitly.

VISSIM and DRACULA have similar capabilities for simulation of transit routes and their characteristics with great detail. However, VISSIM’s ability to incorporate a desired speed for transit vehicles, as well as the introduction of ‘reduced speed areas’ and ‘desired speed changes’, can be useful when modelling the different performance of transit vehicles within the network.

The modelling of bus stops on links around the junction under study has proved to be difficult, because of the fact that buses could stop at almost any point on the link. In order to model this atypical behaviour, a survey was carried out for establishing the frequency of stops by route and the main stopping points, and these data were introduced in the models. The exercise showed that both VISSIM and DRACULA were able to simulate this unconventional transit behaviour to an ‘acceptable degree’.

CONCLUSIONS
The atypical geometry encountered in the study network was better represented by VISSIM than by DRACULA, as the first model uses ‘connectors’ for linking entry lanes with exit lanes within a junction. In DRACULA, junction layout is worked out from the number of entry an exit lanes, which can lead to an unreal representation of junction geometry for atypical layouts.

VISSIM allowed a closer real-world representation of traffic behaviour as this suite incorporates parameters that allow a free vehicle to overtake, either on the left side lane or the right side lane. In addition, VISSIM models the formation of more than one traffic stream on a single lane when there is enough lane width. In DRACULA, overtaking is carried out on the faster lane only and lane width is not considered as a factor for increasing road capacity.

Gap acceptance and driver’s reaction time, which can be considered as the main driver behaviour parameters, are quite flexible in both VISSIM and DRACULA. However, the availability of a ‘reduced gap acceptance time’ parameter, for high waiting times, may be considered as an advantage provided by DRACULA.

For bus stops modelling, VISSIM allows the stop’s length to be defined, which is important for representing the fact that more than one vehicle can stop at a single bus stop. In DRACULA, at every bus stop just one vehicle can stop at a time, which is not the case encountered on most deregulated public transport systems.

Finally, it is important to mention that the vehicle-pedestrian interaction away from junctions cannot be modelled in detail by any of the models analysed in this study. However, it was realised that DRACULA offers some tools for including this interaction at signalised junctions, by incorporating a pedestrian gap acceptance parameter. VISSIM, as in version 3.7, does not offer this utility.

REFERENCES

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