The accuracy of traffic microsimulation modelling

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Abstract

Previous work at University College Cork into the use and evaluation of microsimulation models suggested they are generally suitable for the examination of alternative urban traffic management proposals but that there is little independent validation of the accuracy of microsimulation. In particular, there appeared to be difficulties in comparing the modelled and actual queue lengths. This paper describes a study into the evaluation and accuracy of urban traffic microsimulation models. This involved a review of the available information and the construction of four Pyramics microsimulation models for the road network adjacent to University College Cork. Recommendations are made on queue length validation and on improvements to microsimulation modelling.
Keywords: microsimulation accuracy, Paramics, evaluation, traffic modelling.

1 Introduction

This paper evaluates the accuracy of microsimulation modelling of congested urban networks using the Paramics software package. The University College Cork area road network was modelled as a whole, involving route choice, and also modelled in three separate sections (corridor models) not involving route choice to determine the effects of route choice on model accuracy. The various evaluation criteria used for model validation and the suitability of these criteria for the development of accurate microsimulation models are first described. Recommendations are made on improvements to Paramics and on microsimulation in general and also on the evaluation criteria used for model validation.

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2 Evaluation procedure

As in a previous work at University College Cork [2], the proposed method of evaluation of the accuracy of microsimulation modelling was the presentation of the results of modelling exercises without bias on the part of the modeller leading to an objective evaluation. Based on the available information on microsimulation evaluation and on data collection requirements, it was decided that the principal headings to be used for the evaluation of the accuracy of the microsimulation models should be:

- Traffic Flows
- Journey Times
- Queue Lengths

Typically, model validation is based on these three criteria. Using all three criteria gives a higher degree of validation than if just traffic flows are used. The results from the validation of the UCC models to these three criteria was then used to compare the accuracy of corridor models with a single model involving route choice which covered the same area.

3 Evaluation criteria

After a detailed investigation into evaluation criteria, the authors decided to use the traffic flow and journey time criteria set by the UK Design Manual for Roads and Bridges [1] shown in Table 1, as they were considered the most appropriate for this work.

Table 1: DMRB acceptability guidelines for validation criteria [1].

Criteria and measures	Acceptability guideline
<u>Assigned hourly flows compared with observed flows –</u>	
1. Individual flows within 15% for flows 700-2700 vph	)
2. Individual flows within 100 vph for flows < 700 vph	) > 85% of cases
3. Individual flows within 400 vph for flows > 2700 vph	)
4. Total screenline flows (normally > 5 links) to be within 5%	All (or nearly all) screenlines
5. GEH statistic	
(i) individual flows: GEH < 5	> 85% of cases
(ii) screenline totals: GEH < 4	All (or nearly all) screenlines
<u>Modelled journey times compared with observed times</u>	
6. Times within 15% (or 1 minute if higher)	> 85% of routes

It is important to note that other criteria and measures could have been used, but, for example, the authors were of the opinion that the more stringent criteria suggested by Transport for London [3] would be very difficult to achieve without major model adjustments, which are undesirable. Also, no generally used guidelines are available on acceptable validation values for queue lengths and the authors consider this to be a major drawback. The authors evaluated queue lengths using a criteria suggested by "SIAS" [4] shown in Table 2 and by that suggested by Choa [5], that *the average simulated queue length should be 80% to 120% of the average observed queue length*, in an attempt to establish suitable criteria for model validation.

Table 2: A "SIAS" criteria for queue length validation [4].

Number of observed vehicles	Number of modelled vehicles
0-10	+/- 5
11-20	+/- 7
21-30	+/- 10
> 30	+/- 15

4 Modelling work

4.1 Development of the UCC models

Previous work at University College Cork [2] had concluded that:

i) Paramics can be taken as a generic microsimulation model, and that
ii) Microsimulation models developed in the UK are transferable to Irish traffic conditions.

Consequently, it was decided to develop new microsimulation models for the road network around University College Cork (UCC) for the evaluation of traffic microsimulation modelling using Paramics. The advantages associated with developing local models included:

- detailed knowledge of the study network
- more convenient data collection
- subsequent monitoring of traffic conditions is feasible

The main UCC campus occupies 12 hectares overlooking the River Lee in the western suburbs of Cork City. The main campus is bounded by Donovan's Road on the east, College Road on the south, by Gaol Walk on the west and Western Road to the north. Vehicular access is on College Road and Gaol Walk and there are numerous pedestrian accesses. The university is a major attractor of commuter traffic. The surrounding streets and roads are primarily residential with a high proportion of rented student accommodation. The road network surrounding UCC is particularly busy and carries a significant amount of commuter traffic into the centre of Cork City.

Four Paramics models were developed to model the road network surrounding UCC. The UCC Area Route Choice Model modelled the entire road network surrounding UCC, therefore involving route choice. The road network was also broken down into three separate line networks which were developed as three separate corridor models, therefore eliminating route choice. The three Corridors modelled were:

- Corridor A – Gaol Walk
- Corridor B – College Road
- Corridor C – Wilton Road / Western Road

The Corridor A model comprised Highfield Avenue and Gaol Walk. Two major roads, College Road and Western Road, intersect this corridor. There is a cross roads where Highfield Avenue and Gaol Walk meet College Road and a T-junction where Gaol Walk meets Western Road. In all, the Corridor A Paramics model included five junctions, two of which are signal controlled, making it the smallest of the three corridor models.

The Corridor B model included Model Farm Road, Donovans Road and most of College Road. Only one major road, Wilton Road, intersects this corridor, but it is intersected by a number of minor roads. This model included a total of twelve junctions, two of which are signal controlled.

Wilton Road and Western Road formed Corridor C. It is intersected by a number of other major roads, including Model Farm Road and Carrigrohane Road. This corridor model included eight junctions, five of which are signal controlled.

As is common when microsimulation models are being constructed, no appropriate origin / destination data and little reliable traffic volume information was available. The input traffic data used was mainly obtained from morning peak hour (8am to 9am) junction surveys carried out by University College Cork students under the authors' direction during October and November 2004.

Microsoft Excel was used to develop the O-D matrices for the UCC models. Using the traffic survey data, a separate spreadsheet was created for each zone and the traffic entering at that particular zone was then assigned a specific route and exit zone. This was carried out for each zone until the total assigned traffic entering and exiting at each zone was within 5% of the actual total traffic entering and exiting at each zone as obtained from the traffic counts. These individual spreadsheets were then combined to produce an O-D matrix for the area. The figure of 5% was used following discussions with SIAS Transport Planners, the creators of Paramics and with Arup Engineering Consultants Cork. It was considered that 5% gives sufficient leeway to balance the numbers of vehicles entering and exiting the network without compromising the accuracy of the initial input O-D matrix.

4.2 Modelling results

The DMRB [1] traffic flow criteria shown in Table 1 were satisfied for all the UCC models with the accuracy decreasing with an increase in model size. For example, the smallest model developed, the Gaol Walk Corridor Model (Corridor A), satisfied the DMRB criteria for 97% of the turning counts, while the largest of the models developed, the UCC Area Route Choice Model, satisfied the DMRB criteria for 85.1% of the turning counts.

The DMRB [1] journey time criteria was met for both the Gaol Walk and College Road Corridor Models (Corridors A and B), but was not satisfied for the Wilton Road / Western Road Corridor Model (Corridor C) or for the UCC Area Route Choice Model. This shows that although the traffic flow criteria were satisfied for all models, it does not necessarily follow that the journey time criteria are satisfied.

A possible reason for the Corridor C Model and the UCC Area Route Choice Model failing to meet the journey time criteria could be insufficient journey time surveys. The comparisons of observed journey times with modelled journey times were carried out for routes between the main origin/destination zones in each of the Paramics models developed**.** The average of 5 or 6 journey time runs was taken and compared with the modelled journey times. In the case of the Corridor C Model, the journey time criteria were satisfied in 83% of cases, just outside the required 85%. As there was a large variation between some of the journey time runs, the authors were of the opinion that more journey time runs should have been carried out in order to determine whether closer agreement with the modelled journey times could be obtained. However, there were large variations in the actual journey times due to incidents in the traffic flow such as illegally parked delivery vehicles, road works, etc., which occurred mainly on Western Road and Wilton Road.

The majority of modelled queues in each of the models developed, satisfied the “SIAS” criteria shown in Table 2 and this criteria is deemed by the authors to be the most appropriate criteria for queue length validation where short queues are concerned (average queues < 50 vehicles). In most of the cases where the modelled queue lengths failed to meet the “SIAS” criteria, the authors found that the Paramics program did not replicate the actual traffic conditions. For example, at Gaol Cross, many cars ignored the painted traffic island on the Western Road inbound approach to this junction and queued on the traffic island, therefore increasing the queuing on this lane and reducing the queuing on the other lane, the opposite to what occurs in the model.

As indicated by the above results, the Corridor A and Coridor B Paramics models can be considered validated traffic models, but not the Corridor C model or the UCC Area Route Choice model. After numerous attempts at calibrating the later two models, it was concluded that little further improvement could be obtained with the available data. It was decided that it was preferable to accept the models for the scenario that appeared to give the best representation of the actual traffic conditions based on visual inspection. With more calibration, these models might be able to satisfy all the evaluation criteria but this was considered unsatisfactory. Further model calibration was attempted following additional on-site traffic counts, queue length surveys and journey time surveys but the models could not be validated.

5 Discussion

5.1 Model input

The importance of the input to microsimulation models cannot be overstressed. The calibration of a microsimulation model to accurately represent actual conditions becomes a wasted exercise if there are inaccuracies in the site measurements. A model cannot be more accurate than the accuracy of the input data. The input data used in this work was collected with the model outputs from the finished models in mind. For example, as Paramics gives turning counts as well as link counts at each junction, the authors specified that turning counts should be carried out at each junction in the modelled area to validate the models for traffic flow. Using turning counts for model validation, as opposed to link counts, is a more accurate check because of the additional number of counts involved. More accurate models should result from prior knowledge of the software to be used to ensure the collection of suitable input data for the microsimulation models. This collection of suitable input data combined with the amendment of certain aspects of the input settings to microsimulation models would result in more accurate models. In order to more accurately represent the traffic conditions, the authors recommend the following model input amendments for Paramics and other microsimulation software packages:

- The inclusion of an urban traffic control signal optimisation system
- The improvement of driver/vehicle behaviour input
- Improvement of traffic island modelling

The O-D matrices used for initial model development were estimated by the authors. This might be the reason why it was necessary to make adjustments to the O-D matrix once it was entered in the model in order to achieve more favourable queue length comparisons. The only way of finding the answer would be to use an ‘ideal’ O-D matrix and then compare the observed with the modelled average queue lengths. This would be an exact O-D matrix for the area, developed from O-D surveys for all vehicles entering and exiting the network at all zones and turning counts at all junctions for the am peak hour. This was not possible due to a lack of resources and it would also cause severe disruption to traffic. Therefore, the authors are of the opinion that adjusting the O-D matrices to achieve more comparable queue lengths is acceptable once the traffic flow criteria set out by the DMRB [1] are met.

5.2 Model output

As regards the model output in Paramics, the authors found that the Statistics Module (Version 2004.2) needed further improvement for both the queuing and the journey time outputs. The authors are of the opinion that the current way in which Paramics records a queue is inappropriate. During the site surveys it was found impossible to measure the gaps between vehicles and the speeds of vehicles. It was decided that it was best left to the surveyors to judge if a vehicle was in a queued state, and to record the number of vehicles on each approach at the start of green. This is why the authors took a similar approach when extracting the queue lengths from the model, rather than using the output from the Paramics Statistics Module. This is an area that obviously needs improvement as the approach the authors took was extremely time consuming. It is also recommended that the average journey time taken for each of the possible routes between, for example, Zone A and Zone B should be available from the Statistics Module. This would permit a more comprehensive journey time validation.

5.3 Corridor versus route choice models

The authors concluded that the development of a number of corridor models was better than a single route choice model. The reasons for this were:

- Simpler O-D matrix development for corridor models
- More realistic results for corridor models
- Less time and effort to calibrate corridor models

It was found that while a single route choice model may be more impressive in terms of presentation, there can be no doubt that a small number of corridor models covering an area are better in terms of both time spent and accuracy obtained. However, the proposed use of the model dictates whether a route choice model is required or whether a number of corridor models will be sufficient to model an area. In the majority of cases, in order to determine the impact of a measure such as the introduction of a traffic island, speed ramps or a bus lane will have on an area, a model of the entire area under investigation will be required, therefore incorporating route choice. It is therefore important that a modeller has sufficient data and knowledge to be able to develop a route choice model for an area that meets all validation criteria for an accurate model; otherwise a number of corridor models may be more appropriate.

5.4 Choice of evaluation criteria

The criteria that modellers choose to validate their models are a grey area in microsimulation modelling. As there are no generally accepted criteria by which modellers must validate their models, they are often free to choose criteria that best suit them, and so question marks arise as to the accuracy of the models. As previously stated, the widely used UK DMRB criteria [1] for the validation of microsimulation models based on comparisons between observed and modelled traffic flows and journey times appear appropriate, while the Transport for London criteria [3] is considered very difficult to achieve without major model adjustment which is undesirable.

However, no DMRB criteria exist for queue length validation which is considered a major omission. Based on this work, it appears that the actual queuing conditions may not be adequately represented in models. The authors are of the opinion that there is a need for the establishment an acceptable queue length validation criteria, rather than individuals choosing a queue length validation criteria that suits them.

The authors evaluated queue lengths using both the "SIAS" criteria (Table 2) and that of Choa [5] and came to the conclusion that the absolute difference method suggested by "SIAS" is suitable for low values of average queue lengths (< 50 vehicles) and that the percentage difference method used by Choa [5] is suitable for high values of average queue lengths (> 50 vehicles). An appropriate solution is for an absolute difference at low values and a percentage difference at high values such as the criteria suggested by the anonymous CB [6]:

observed average queue < 10 vehicles: modelled average queue +/- 4 vehicles
observed average queue 10-30 vehicles: modelled average queue +/- 6 vehicles
observed average queue 30-50 vehicles: modelled average queue +/- 10 vehicles
observed average queue 50-100 vehicles: modelled average queue +/-15 vehicles

Ideally, for a model to be considered validated, all three evaluation criteria (traffic flow, journey time and queue lengths) should be met. However, the only way of really investigating the accuracy of microsimulation modelling, would be for 'Before and After' comparison studies to be carried out in situations where microsimulation was used to model significant changes in traffic systems. Surprisingly, the authors were unable to locate any such studies.

5.5 General

Microsimulation models are user friendly in terms of model construction, model editing and results extraction. Model construction in programs such as Paramics and Vissim is more user friendly than in macroscopic programs such as Saturn and Trips due to the graphical user interface. The authors consider that microsimulation modelling to be within reach of less experienced traffic modellers, as regards being able to code and run a model, particularly corridor models, but not so accessible for the larger route choice models where they may lack the experience necessary to properly calibrate and interpret model results. The publication of calibration guides to microsimulation for each modelling software package, such as *The Microsimulation Consultancy Good Practice Guide* [7] recently issued for Paramics, would provide modellers with recommended calibration methods. This would improve confidence in microsimulation models, as microsimulation modelling is much more dependent on the integrity of the modeller than macroscopic models, particularly in the case of a model incorporating route choice. This is due to the larger number of different settings available to the modeller in microsimulation models that can be changed from their default values to best represent the actual conditions.

6 Conclusion

The authors are of the opinion that traffic microsimulation models can provide an excellent option for the evaluation of urban traffic management and development proposals. However, there is a need for:

- detailed calibration guides for all microsimulation modelling packages.
- the development of agreed standard validation criteria, including queue length criteria.
- improvements to the input and output in the existing commercially available models in order to more accurately represent real life conditions.

These would greatly improve the acceptance of microsimulation modelling by traffic modellers and users of the model outputs.

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