



Working Paper

Workshop report: Microsimulation

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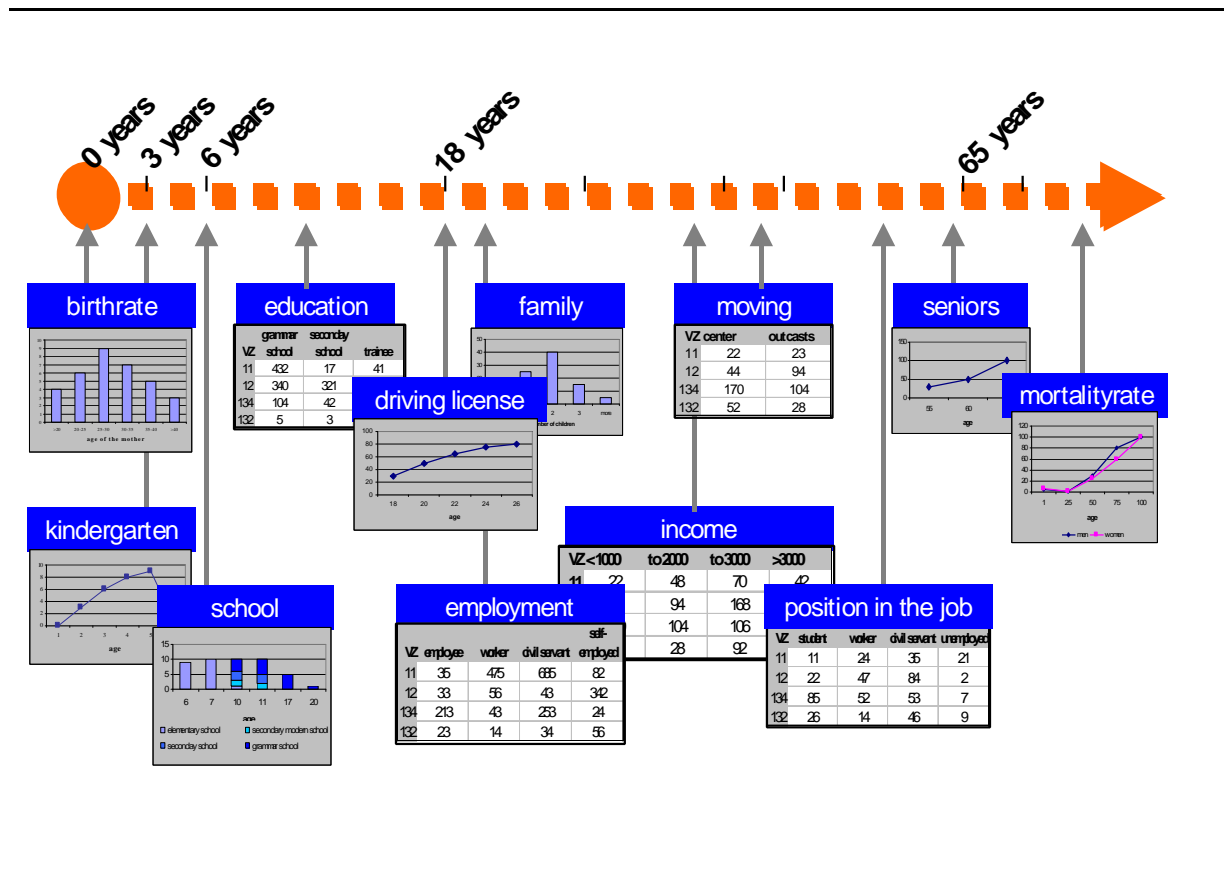
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Workshop report: Microsimulation

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Draft – Workshop report

Microsimulation

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ABSTRACT

This report presents the main results from the Microsimulation workshop of the 9th International Conference on Travel Behaviour Research at Goldcoast, Australia. The focus is on the issues of modules and scale, consistency and relaxation and trust building. The report closes with a suggestion for an expanded type of data archive as tool to encourage comparative work and with a suggestion to standardise a minimum set of modules to allow an easier exchange of work.

KEYWORDS

IATBR – Goldcoast, 2000 - Microsimulation - Workshop

Figure on the title page:

Overview of the modelling approach of Dörnemann (2000) (Figure 1)

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1 BACKGROUND

Simulation is a useful tool in cases where analytical solutions are not available. In micro-simulations each participating entity is resolved as an individual object. A natural level of microscopic resolution for travel behaviour research is the individual traveller.

In the last couple of years, in particular since the last IATBR conference in Austin (Axhausen and Pendyala, 1997), we have seen a growing acceptance of micro-simulation methods for travel research. Some of the reasons for this are:

- Conceptual appeal of starting from "first principles" as much as possible
- Move of programming languages away from "numerical analysis" towards object-orientation, which allows straightforward coding of individuals and "rule-based" behavioural rules for the individual traveller
- Availability of ever faster computers and mass storage
- Natural fit of object-oriented rule-based code with parallel computers, thus giving the perspective of nearly limitless computational resources for many current problems

All papers presented at the workshop are predicated on the premise that these trends will continue.

The discussion in the workshop was based on a set of seven papers which were presented during its first half. The paper by Miller and Salvini (2000) gave the ideas presented three years ago for their ILUTE model (Miller and Salvini, 1997) concrete form. It discussed the design problems of a joint travel and land use simulation models and highlighted in particular the difficulties of integrating different time scales and of describing the search and market clearing mechanisms. Less ambitious in scope, but operational were the models presented in the following four papers. Bhat and Misra (2000) developed a consistent disaggregate modelling framework for the activity participation of non-workers, including their location, mode and time-of-day choice. Kulkarni's and McNally's (2000) work

addressed the same problem of the generation of activity patterns for later execution within a simulation of traffic flow or better spatial movements. Esser and Nagel demonstrated an operational version of integrating trip generation and traffic flow, using extremely simplified models for both. They compared their results with Portland field data and with Portland emme/2 study results and found surprisingly few differences. Dörnemann's (2000) model of activity performance developed for the city of Berlin implements a complex rule-based approach to choose consistently the attributes of given activity chains. The scale and detail of the model were noticeable and its use for policy analysis. The final two papers had a narrower focus with Mahmassani and Abdelghany (2000) integrating activity chain execution with route choice and Liu, Cruz da Silva and da Maia Seco (2000) combining vehicular and pedestrian flow simulations.

The intensive discussion identified a series of issues, which it tried to clarify. The discussion closed with an attempt to identify research issue for the immediate future.

2 METHODOLOGICAL ISSUES

2.1 Modules

Micro-simulation models in transport and land use seem to have natural breakpoints. These have not specifically been designed, but they have evolved over many years of practical experience. In a figure together with typical scales and objects these look as follows:

Figure 1 Breakpoints in simulation systems

Module	Typical time scale	Typical spatial scale	Typical entity
Traffic flow	1 sec	1 meter	Intersection
Route choice	¼ hour	100 meter	City
Demand generation	1 hour	1 km	City
Land use	1 year	10 km	Region
Economy	1 year	100 km	Country

In the past, due to resource limitations, these modules were mostly used in isolation, although it was clear to most people that interactions take place. For example, land use patterns influence demand which influence land use decisions such as commercial location choice.

In consequence, what we have seen in the past is that models expand over more and more of these scales. The following figure shows how some current models stretch over these scales; arrows indicate current research and implementation activity.

Figure 2 Scope of some existing micro-simulation approaches

System	Traffic flow	Route choice	Demand generation	Land use	Economics
ORIENT/RV	■ ■ ■ ■ ■ ■ ■ ■				
DYNASMART	■ ■ ■ ■ ■ ■ ■ ■ >				
UrbanSim		< ■ ■ ■ ■ ■ ■ ■ ■		■ ■ ■ ■ ■ ■ ■ ■	
ILUTE		< ■ ■ ■ ■ ■ ■ ■ ■		■ ■ ■ ■ ■ ■ ■ ■	
TRANSIMS	■ ■ ■ ■ ■ ■ ■ ■ ■ ■ >				

2.2 Scales

As seen above, all models have scale cut-offs somewhere. For the foreseeable future, it will not be possible to cover all scales from traffic flow to macro-economics within one simulation model. For that reason alone, models have to deal with the corresponding cut-offs. Obviously, each model has two of them: One towards the small scale, and one towards the large scale. At each end, a solution needs to be found:

- **Small scale:** The method here is sometimes called parameterisation. In essence, one uses aggregated models of the dynamics at the smaller scale. For example, in assignment, or route choice respectively one typically uses a link-flow relation as a parameterisation of the dynamics of traffic flow. As is well known, this particular parameterisation does not represent certain aspects of the true dynamics, but this is accepted for the sake of speed and simplicity.
- **Large scale cut-off.** This is commonly referred to as "externalities" described by exogenous variables. Such externalities need to be specified; for time-dependent models they typically have to be specified for each time-step of the simulation run. The process of coupling the model of interest with a further model which forecast, estimates or calculates these exogenous variables is called endogenising the externalities. Again, in most cases, this is not done for the sake of speed and simplicity, especially as many exogenous variables are specified by different policy analysts, e.g. land use planning, forecasts of populations, economic growths.

Another question regarding scales is which scale is necessary to answer which question. There is wide-spread intuition but currently little hard knowledge. Rules-of-thumb, such as to include one level of resolution below the level of interest, are just rule-of-thumb.

2.3 Consistency and relaxation

Modules need to be consistent between each other. For example, route choice will take into account congestion, which in turn depends on route choice. If the congestion encountered during travel execution is not consistent with the congestion assumed during decision-making, then another route may be chosen in the future, meaning that we have a transient situation.

The typical solution to deal with this problem, lacking a better method, is relaxation: Guess a route choice, compute resulting congestion, adjust route choice, etc. This is a typical method also of, say, numerical analysis; but much less is known about things like stability and efficiency in the context of object-oriented simulation methods than in numerical analysis.

An interesting observation is the following: At the smaller scales, it may be possible to wait until transients have died out and obtain a useful result, for example, this is what most Dynamic Traffic Assignment (DTA) models currently do. This result is similar to, albeit not exactly the same as, equilibrium. Its usefulness depends on uniqueness, which is an open issue in this context. In larger-scale models however, such as for land use and housing, this will lead to a meaningless result: Reality here is always in a transient.

This implies an often-used short-cut in the computations: Instead of simulating housing market, route decisions, and traffic flow on a continuous day-by-day basis, it is possible to run the route decision/traffic flow part only every once and then, starting from scratch and relaxing towards consistency. Only this makes it possible to use longer time steps, say weeks or quarters, in the land use/housing models.

2.4 Trust building and quality control

It actually was a recurrent theme through many of the workshops at the conference that the validity of the results needs to be tested and demonstrated to the users. In micro-simulations, this problem is even more difficult than in some other situations because of:

- Results which can be compared to field data are emergent. As a result, there is currently no method which allows to calibrate jointly all parameters due to the enormous computational burden this would imply.
- In addition, the emergent results are stochastic, which implies many things simultaneously: (1) In order to obtain a characteristic value of the results (say the mean), one needs to make several runs. (2) Reality is also stochastic, which means we have to

compare two distributions (3) We do not just want to be right on the means, but also on the variability or even better the form of the distribution.

There was some agreement that because of the complexity of the issue it might be useful to push towards real world test scenarios. This way, the issues have a chance to be resolved over real-world scenarios. The underlying assumptions here are: (1) It is unclear if concentrated research into the general question would come up with useful answers within the near future. (2) The problem also exists outside transportation and so progress can be expected from other groups. (3) Possibly, some of the questions are less vexing in practice than in theory. (4) There are probably certain measures of stochasticity that will be better accepted by practitioners than others, and it may be worthwhile to find those before embarking on a more theoretical research agenda.

3 DATA ISSUES

Micro-simulation methods depend on a large amount of data. For example, in principle one could employ the demographic and behavioural characteristics of each traveller, the exact lay-out and properties of each road, the timing of each traffic signal, etc.

Data availability has become much better over the recent years with the introduction of spatial information systems and the switch of planning organisations to computerised methods. For the future, we expect a virtual explosion of data availability with the introduction of Intelligent Transportation Systems and the increasing use of mobile communication devices by the population. In addition, commercial providers will enter the field supplying further data items, such as purchasing power, consumption habits, which were not available in the past.

This means that the issue here changes from a situation of limitation to a situation of over-supply; and the new challenge will be to sort the incoming data and separate relevant from irrelevant or even faulty information.

In addition, some still-needed data will still be missing, or will always be missing for example because of privacy issues. In such cases, it will be imperative to develop synthetic methods for data generation. Such methods are for example synthetic population generators, or the widely accepted approach that a survey from a sample is taken as representative to a whole population. Similarly, it might be possible to derive, say, short-cut approaches to generate the traffic control approach for each intersection from a representative sample of actually known junctions. In this process, it will also

become imperative to develop methods which clearly label the sources of data (e.g. random, synthetic, survey, field, ...), and which ensure that these labels remain consistent even through data entry errors.

4 FUTURE DIRECTIONS - A RESEARCH AGENDA

Our future directions extrapolate from the issues. Currently, a large part of the problem seems to be with the implementation which is not a research problem as such. A second major problem is relaxation stability, i.e. are results robust under changes of initial conditions and/or modification of rules. A third major problem, as mentioned above, is that it is unclear which scales need to be included for particular questions. It seems, however, that on these questions it is currently possible to make progress within the existing research groups. In the following are two issues which need collaboration across the community in order to happen.

4.1 Real world scenarios

Data archives allow the refinement of modelling approaches through the repeated examination of the same data or problem (Lievesley, 1998). The same logic applies to micro-simulation models of travel and land use. The problem is that a variety of data types, including spatial and network data, would have to be collected and documented. Still, the investment would be worthwhile. Short of a formal archive, the research community should be more open in sharing data, in particular of before and after - comparisons, as such would allow the systematic test of model sensitivity and performance as traditionally done in other areas if large scale modelling, such as meteorology.

In addition, planning organisations could invite blind comparison test, where scenarios including validation data for the current situation are made available and traffic after some major infrastructure change is to be predicted ahead of time.

4.2 Module interchangeability

The purpose of all real world large scale testing should be to improve models. Since the models are so complex that it is not possible to accord wrong predictions one-to-one to certain model properties, and

also because only very few research groups which will work on all scales simultaneously, it will become imperative to be able to interchange modules. For example, it should be possible to replace an existing demand generation module and with one from another group.

There was agreement that formal software interface specifications here are probably not a productive solution. It may, however, be of use to define common sets of data items that all groups use. For example, routes can be defined as a sequence of nodes or as a sequence of links; deciding on one or the other in the long run will save enormously in terms of module interchangeability.

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