Microsimulation of Land Use and Transport in Cities


Model levels

Microsimulation

Theory

Microsimulation is the reproduction of a macro process by many micro events.

Events:

The basic building block of microsimulation is the event.

No deterministic assertions (that are valid with certainty) can be made about events, only probabilistic assertions (that are valid with probability) are possible.

Microsimulation

The method of microsimulation consists of generating a sequence of events as a function of their probability of occurrence.

To generate an event, a lottery is drawn the result of which is one of the possible outcomes of the event and subject to their probability. This is why microsimulation is also called Monte-Carlo simulation.

Another term for microsimulation models is agent-based models (ABM). Cellular automata (CA) models are raster-based models of transitions of raster cells based on neighbourhood properties.

Microsimulation

There are two types of events:

- Transitions are changes of an individual or object from one state to another subject to transition probabilities (e.g. ageing of persons or buildings).
- Choices are selections between alternatives by an individual as a function of their perceived utility (e.g. modal choice, residential location).

If the causal chain behind choices is of no interest, also choices are modelled as transitions (e.g. birth, marriage, divorce).

Microsimulation

The lottery consists of the mapping of a random number between 0 and 1 to the vector of cumulated probabilities of possible outcomes of the event.

Example:

An event has three possible outcomes with probabilities 0.3, 0.5 and 0.2. If the random number 0.74 is drawn, Outcome 2 is the event.
Random number generators

Random number generator

Pseudo random number generator

Micro database

Buildings

Residential buildings (micro location)
- Dwellings (type, size, quality)
Nonresidential buildings (micro location)
- floorspace (industrial, retail, offices)

Households/Businesses

Households (micro location)
- Households (size, income, cars)
- Persons (age, sex, education, job)
Businesses (micro location)
- Firms (industry, size, vehicles)
- Employment (skill)

Spatial disaggregation

(2) Allocation of zone data to raster cells
The data elements are allocated to raster cells by Monte-Carlo simulation according to their density.

Spatial disaggregation

100 x 100 m raster cells

Synthetic micro data

Microsimulation models require micro data.
In reality micro data are rarely available or where available cannot be used because of privacy concerns.
Synthetic micro data are micro data generated from available spatially aggregate data with which they are consistent in all known attribute distributions.
Microsimulation models can be operated with synthetic micro data instead of real micro data.
The ILUMASS Project (2001-2006)

The project ILUMASS (Integrated Land-Use Modelling and Transport Systems Simulation) embedded a microscopic dynamic simulation model of urban traffic flows into a comprehensive model system incorporating both changes of land use and the resulting changes in transport demand as well as their environmental impacts.

For testing the land use submodels, the transport and environmental submodels were replaced by the aggregate transport model of the IRPUD model and simpler environmental impact models (= reduced ILUMASS model).
Model dimensions

- 1.2 million households
- 2.6 million persons
- 1.2 million dwellings
- 80,000 firms
- 92,000 industrial sites
- 8,400 public transport links
- 848 public transport lines
- 13,000 road links
- 246/54 internal/external zones
- 209,000 raster cells
- 30 simulation periods (years)
- 90 minutes computing time

Micro data

Travel flows

Link loads
Microsimulation

New activity-based microsimulation models improve urban simulation models:

- **Lifestyles** can be represented, i.e. households and individuals can be disaggregated to the agent level.
- **Environmental impacts** and feedback can be modelled with the required spatial resolution.
- **Population** and **employment** can be represented by their decision making units, i.e. households and firms.
- **Microlocations** can be represented. Households affected by environmental impacts can be localised.

However ...

To date, no full-scale microsimulation model of urban land use, transport and environment has become operational. There are still unresolved problems regarding the **interfaces** between the submodels. The feedback between transport and environmental quality and location has not yet been implemented. Serious problems of **calibration**, **instability** and random fluctuations have not yet been solved. The **computing time** for existing models is calculated in terms of **weeks** or **days**, not **hours**.

Limits of microsimulation

There are **ultimate limits** to increasing the substantive, spatial and temporal resolution of behavioural models:

- There are **theoretical limits** when the number of processes simulated is too small to yield reliable results.
- There are **empirical limits** when the marginal costs of obtaining micro data are larger than their added value.
- There are **practical limits** when the computing time of the models exceeds the duration of the modelled processes.
- There are **ethical limits** to the collection of data about private lives for purposes of research.

How much micro is enough?

There seems to be little consideration of the benefits and costs of microsimulation:

- Where is microsimulation really needed?
- What is the price for microsimulation?
- Would a more aggregate model do?

For spatial planning models, the answer to these questions depends on the planning task at hand.

Conclusion

These considerations lead to a reassessment of the hypothesis that in the future all spatial modelling will be microscopic and agent-based.

Under constraints of **data collection** and of **computing time**, there is for each planning problem an optimum level of **conceptual**, **spatial** and **temporal resolution**.

This suggests to work towards a **theory** of balanced **multi-level models** which are as **complex** as necessary for the planning task at hand and — to quote Albert Einstein — "as simple as possible but no simpler".

More information


More information on the development of the ILLUMASS model can be found at http://www.spiekermann-wegener.de/mod/illumassmod_e.htm.

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