Employing agents to develop integrated urban models - numerical results from residential mobility experiments

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1. Introduction

Judging from the recent number of publications, conference-proceedings, and research projects, multi-agent systems seem to become a highly popular technique to develop urban simulation models (Batty, 2005). To give an indication of this popularity, the following list is a selection of agent-based models only addressing residential mobility: sprawlSim, Obeus, Abloom, the Bathurst-model, Diappi's gentrification model, Mabel, Sypria, etc. In spite of this popularity, none of the listed models appears to actually exploit the full potential of multi-agent systems. Such a system in effect allows modelling (spatial) behaviour at the level of individual decision-makers with each decision-maker pursuing own goals, exhibiting a unique lifestyle and life-course, based on a personal cognitive representation of his/her environment, perceiving and learning this environment on the basis of own experiences, being part of a self-selected social network, interacting with other agents according to own standards, etc.

The listed models at best only start to explore this potential, mostly adopting not more than one of these behavioural concepts. This paper, on the other hand, presents a model explicitly addressing this potential, developed around a framework integrating all of the above concepts. As a test case, this framework is implemented to model processes underlying residential mobility, simulating moving behaviour of students in Eindhoven, a medium sized town in the Netherlands. The particular focus of this paper is to illustrate the potential of the multi-agent approach using numerical results of the student-test-case.

2. Model framework

The model is a microsimulation model developed to simulate residential choice behaviour of students. Basically, there are two types of agents: students and landlords: students search for rooms to rent and landlords offer rooms for rent. Both students and landlords entertain a particular lifestyle made explicit through their preferences. Over time, their lifestyle may change; either because of changes in the life-course -a student might, for instance, meet a partner with whom he/she wants to live together- or because of changes in the living environment –for instance, cheaper and better housing might become available. Both types of change might cause a discrepancy between the current place of residence and the preferences of the student, so that he/she starts to consider moving.

Students will try to anticipate these changes by continuously evaluating whether it would be more beneficial to move or to stay in their current place of residence. This evaluation is based on the cognitive knowledge of the student regarding his/her housing-market, such as knowledge about the availability of particular room-types, the price-level of these types, the location, etc. Given that most students only move a limited number of times during their student-career, this knowledge will evidently be rather limited. Students will thus have to search to increase this knowledge, either by consulting information sources such as newspapers or Internet sites, or by relying on social networks. Once promising offers are found, students will visit some for inspection, to then finally negotiate, in agreement with possible fellow roommates, with the landlord over a price at which to rent a particular room.

In the presented model, cognitive knowledge is structured in Decision Tables and the decision-making process is structured in Decision Trees. In order to make a decision, agents evaluate all actions available to them in that situation, relying on their knowledge at that moment in time, to select the action maximizing expected lifetime utility. The result is an artificial society displaying real-life phenomena such as the emergence of a housing ladder (Goetgeluk, 1997), sub-market competition (Alhashimi and Dwyer, 2004), substitution of housing preferences (Oskamp, 1997), residential sorting (Dieleman and Mulder, 2002), etc.

A returning critique regarding agent-based systems concerns validation: the large number of parameters renders it quasi impossible to rely on conventional calibration techniques (Batty and Torrens, 2005). We argue that though this might indeed be an issue when it comes to the reliability of micro behaviour, regularities emerging on macro and even meso level do resemble regularities pointed at in empirical research. Numerical experiments will illustrate this resemblance.

3. Model experiments and numerical results

The presented model is developed, implemented and tested incrementally, increasing the number of integrated behavioural concepts step by step –starting with the simplest scenario of a perfectly rational agent residing in a stationary housing-market, to end with pro-active approximately rational agents residing in a non-stationary interactive housing-market. With this approach, we not only strive for transparency and readability, introducing new concepts step by step, but also for a first validation, in that we begin with a simple scenario with a maximum number of constraints but a minimum number of potential interferences, and gradually add more complexity (and thus uncertainty).

With each step, not only the implemented behaviour, but also the phenomena emerging out of this behaviour come closer to reality. To illustrate this, two classes of experiments are run for each scenario, the first one to assess the phenomena emerging out the agents' behaviour, and the second to assess the value of the model as a planning decision support tool.

In the behaviour-class, results are recorded on the level of the whole population, illustrating for instance average movement patterns; on the level of particular agent-profiles, illustrating for instance the impact of socio-cultural features on location choice;

and on the level of the individual agent, illustrating for instance the degree to which the life-course of this agent defines his/her moving behaviour.

In the planning-support class, results are recorded as to comply with current residential-mobility indicators, such as, vacancy rate, turnover rate, satisfaction level of residents, the period it takes to rent out a room, etc. By adjusting the model parameters, a decision-maker can then assess planning proposals by measuring the impact of these proposals on the above indicators.

4. References

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