

Comparison of Agent-Based and Population Based Simulations of Displacement of Crime^{*}

(extended abstract)

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Within Criminology one of the main research interests is the emergence of so-called criminal hot spots. These hot spots are places where many crimes occur. After a while the criminal activities shift to another location, for example, because the police has changed its policy and increased the numbers of officers at the hot spot. Another reason may be that the passers by move away, when a certain location gets a bad reputation. Such a shift between locations is called the displacement of crime. The reputation of specific locations in a city is an important factor in the spatio-temporal distribution and dynamics of crime. For example, it may be expected that the amount of assaults that take place at a certain location affect the reputation of this location. Similarly, the reputation of a location affects the attractiveness of that location for certain types of individuals. For instance, a location that is known for its high crime rates will attract police officers, whereas most citizens will be more likely to avoid it. As a result, the amount of criminal activity at such a location will decrease, which will affect its reputation again.

The classical approaches to simulation of processes in which groups of larger numbers of agents and their interaction are involved are population-based: a number of groups is distinguished (populations) and each of these populations is represented by a numerical variable indicating their number or density (within a given area or location) at a certain time point. The simulation model takes the form of a system of difference or differential equations expressing temporal relationships for the dynamics of these variables. Well-known classical examples of such population-based models are systems of difference or differential equations for predator-prey dynamics (e.g., [8], [11], [12], [9], [4]) and the dynamics of epidemics (e.g., [7], [4] [1], [6]). Such models can be studied by simulation and by using analysis techniques from mathematics and dynamical systems theory.

From the more recently developed agent system area it is often taken as a presupposition that simulations based on individual agents are a more natural or faithful way of modelling, and thus will provide better results (e.g., [5], [10], [2]). Although for larger numbers of agents such agent-based modelling approaches are more expensive computationally than population-based modelling approaches, such a presupposition may provide a justification of preferring their use over population-based modelling approaches, in spite of the computational disadvantages. However, for larger numbers of agents (in the limit), agent-based simulations may equally well approximate population-based simulations. In such cases agent-based simulations just can be replaced by population-based simulations.

In the full version of this paper, for the application area of crime displacement these considerations are explored in more detail. Comparative simulation experiments have been conducted based on different simulation models, both agent-based (for different numbers of agents), and population-based. Using mathematical analysis, and confirmed by the simulation results, the population-based model was shown to

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end up in an equilibrium for one variant of the model. The parameter settings for these simulations have been determined in cooperation with criminologists. The simulation results for the agent-based model using the same parameter settings show an identical trend to the population-based model except for some minor deviations that can be attributed to the fact that the agent-based model is discrete, as confirmed by the formal evaluation. This provides support for the idea that population-based models approximate agent-based models for larger populations. The computation time of the population-based model was shown to be much lower than the computation time of the agent-based model.

The results reported in this paper are not completely in accordance with the results reported in [3]. In the results using an agent-based model reported in that paper, cyclic patterns were observed whereby there is a continuous movement. As already stated before, this paper shows that the population of agents at the various locations stabilises over time. The difference can be attributed to the fact that in [3] all agents decide where to move to based upon the attractiveness of locations, whereas in the case of the models presented in this paper only a subset of the agents move. The results can however be reproduced using the model presented in this paper as well by using $\eta = 1$ (i.e. the speed factor) and $\Delta t = 1$. Determining what settings are most realistic in real life is future work.

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