GeoInformatics · Practical 3

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This practical extends the principles of agent-based modelling (ABM) to the spatial dimension. It combines the demographic model developed in practical 2 with the urban model from practical 1. You might wish first to read what is required by way of assessment (one report for practical 2 and 3 — see separate document).

1 Spatial demography: coupling ABM and CA

The CA developed in practical 1 assumes a constant urban growth (limited only by the size of the world). Evidently, urban growth happens because of specific drivers, not for the sake of growth. The number of people choosing to reside in the area is one of these drivers. The CA therefore needs to be adapted so urban development occur when there is an increasing demand for more residences. Conversely, a number of the agents' behaviour rules needs to be changed so a relation to land use is included.

Starting with a simple coupling, let's assume that one cell can only be occupied by one agent only. Let's also assume that the young agents locate at their parents residence, not consuming any space. When they turn mature, they search for an empty urban cell. If there is no more available urban cell, the unsatisfied agent leaves the region. Note that this new rule changes the nature of the emigration process. Emigration was previously a given figure (exogenous variable) but now is an output (endogenous variable). Conversely, immigration stays exogenous but will only be met if there is enough empty cells to accommodate the incomers.

At this stage, only two of the CA rules are adapted. First, a new developed cell becomes established as soon as it is occupied by an agent. Second, available cells are newly developed following an overall level of demand. The probability of being built is dependant on the ratio between the total population and the total number of urban cells, and should be $1 - \frac{C}{P(1+S)}$ (where C is total city capacity, P is total city population and S is a surplus factor, to allow a certain level of surplus housing). This has an intuitive rationale: if there are very few available properties, developers may be tempted to built more residences because they are pretty certain to sell it. Conversely, if there is lots of empty properties, the probability for someone to move in a new property is virtually null.

TASKS:
(1) Modify the CA "established" and "new development" rules.

> **HINT:** It is probably a good idea to write down precise rules for what you want to accomplish before modifying the code. Do not allow redevelopment at this stage!

(2) Run the model and observe. Verify that different values for the surplus factor affect the ratio of capacity and population on the graph.

2 Spatial demography: advanced coupling

Urban areas are, in the real world, characterised by different densities. The "one cell — one agent" link is thus unrealistic. Moreover, we have yet said nothing about the regeneration. If buildings are to be demolished at some point in time, their inhabitants should be expelled (relocated). Also, regeneration usually occurs when there is a lack of space in a neighbourhood and planning decisions have been made to increase its density. Finally, available cells should be released by planning policy when the urban areas lack space to accommodate its population. It is unrealistic to claim that a city grows endlessly at its fringe, especially when the area empties of its population. In this case, the planners might want to stop urban expansion altogether so vacated accommodations in the centre are reoccupied.

TASKS:
(3) Change the maximum capacity in the model.score, to allow more than 1 agent per cell
(4) Add a redevelopment rule, which is triggered when the cell is old, and local density is high.

> **HINT:** Make sure you use the "redevelop()" function for the transition from Old to Available land; this will evict all of the agents living in that cell, and rebuild it with a higher capacity

(5) Run the model and compare outputs.

3 Spatial demography: location preferences

Urban dynamics is largely influenced by people location choices. It is logical, therefore, to consider location preferences. Let's assume that mature agents seek neighbourhoods with high population densities whilst old agents only few people around them.

TASKS:
(6) Modify Mature and Old so that they return useful values for their evaluation of each cell, to reflect their location preferences.

> **HINT:** You can query cells for their neighbourhood density. You should then create an evaluation based on this. It will probably be easiest if your evaluation function always returns between 0 and 1

(7) Add additional code for each of these agents that evaluates their current cell each turn, and moves if it is lower than a certain value.
(8) run the model and observe.