Housing – Multiple Factors

Description:

It is commonly observed that the price of houses is primarily affected by two factors: (i) the price of other houses in the neighbourhood, and (ii) the householder's economic status. If a house is in a neighbourhood with higher (lower) average prices, its price tends to increase (decrease), and higher (lower)-income owners tend to raise (lower) the price of their houses over time. LeftMove.com are interested in how to accurately evaluate house prices, and if this can be done in a predictive manner, given a current set of prices and a demographic of owners. They have seen some results of simple models and are interested in understanding if and how they can be applied in more realistic situations. In particular, they are hoping to determine how such models work when individuals have preferences not only for their house value to match their income, but also to live in communities with shared qualities, such as religion or political opinion. They are also interested in what the model can tell them about the (physical) range over which neighbourhoods can affect house prices.

Aims:

LeftMove.com wish to understand some/all of the following:

- Can the model treat people valuing not only prices matching their income, but also other properties of neighbourhoods?
- If so, what does it tell us about the effects of these extra factors on house prices and the formation of neighbourhoods with common properties?
- What are the effects of changing the size of neighbourhoods, i.e., the range over which house prices are affected by others?
- Is there any real-world data that the model can be benchmarked against? In particular, is it possible to determine reasonable values for any of the parameters?

An initial model:

Environment:

A two-dimensional lattice (say $n \times m$), where each site, x, represents a house with a value $V^t(x)$ at time t

Agents:

A set of householders (say one for each house) who have income (or affluence) $A^t(x)$, which can take one of the values $p, m, r \in [0, 1]$, with $p < m < r$ (poor, middle, rich), e.g., $r = 1$, $m = 0.5$, $p = 0.1$.

Algorithm:

The motivation for the model is that people want to live in accommodation that matches well with their income. House prices are affected by both the income of the owner and the value of nearby houses.

For an arbitrary state, one update of the system consists of the following steps, performed in parallel for all houses and householders:

1. **Update house prices:** the price of the house at site x evolves from time t to time $t+1$ via

$$V^{t+1}(x) = A^t(x) + \lambda \frac{\sum_{y \in \mathcal{N}(x)} V^t(y)}{\#\mathcal{N}(x)}$$

   where $\mathcal{N}(x) = \{y : \max(|x_1 - y_1|, |x_2 - y_2|) \leq 2\}$ is the square neighbourhood of radius 2 centred at x, and $\#\mathcal{N}$ is the number of elements of $\mathcal{N}$ (normally 25, lower near the boundary of the domain).

2. **Propose a move:** randomly choose a pair of agents. Denote their locations as x and y. Compute the relative match of house prices and incomes before and after swapping the two agents:

$$\delta(x, y) := (A^t(x) - V^t(x))^2 + (A^t(y) - V^t(y))^2 - (A^t(x) - V^t(y))^2 - (A^t(y) - V^t(x))^2.$$

   where $|I|$ denotes the number of people in the set I.

3. **Update locations:** if $\delta > 0$ swap the agents at x and y, otherwise do nothing.

Reference:

'A Spatially Extended Model for Residential Segregation', Antonio Aguilera and Edgardo Ugalde, Discrete Dynamics in Nature and Society, **2007**, 48589, 2007.