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An approach to allocate households agents in a MAS model for the urban simulation

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Land use zoning Shopsim Income Allocation

1.Introduction

A number of published studies [1] [2] have demonstrated that multi-agent system (MAS) models can provide a detailed, decentralized and dynamic view of urban system, and can serve as a virtual laboratory for urban planning policies. These studies share the common view of that heterogeneity of agents result in different individual preferences and thus have a significant effect on model outcomes, usually measured by aggregate patterns of clustering.

However, most of these studies are based on assumptions that the household agents are distributed uniformly or randomly and the heterogeneity of agents are resulting from the difference of social-economic attributes such as education, income, etc. This kind of assumptions neglect that the spatial distribution of households are affected by urban planning regulations such as zoning constraints and pay no attention to the interdependence of households' spatial distribution and their social-economic attributes. The assumptions limit the usefulness of these models for investigating the concerned urban phenomena through individual-level interaction. This paper is attempting to allocate household agents in simulation space while considering the land use zoning constrains.

2.Method

The Shopsim [3], which we developed to explore the use of MAS for analyzing the potential impact of the downtown regeneration policies, specially the planning regulations concerning the development of large-scale shopping centers (B-shop) through simulating shopping spatial market share of the downtown and B-shops. This system consists of various autonomous agents (planner, developer, shop, household) who interact with each other acting in a virtual urban space represented by cells. In order to enable the household agent's shop-choice decision-making process more reasonable for analyzing shop spatial market share we modified the household agents' attributes and the way to allocate household. Household agents are grouped in to three income types. The income attributes of household not only will affect their shop-choice preference, but also their spatial location. And what is more, the distribution of household agents in the virtual urban space display the general population density character of the city, in other words, the density is higher in the center than in the outer area of the city.

3. Factors affecting spatial distribution

3.1 Income types of household agents

The number of household agent is assumed has been known and is set by users in the Shopsim. Household agents are group into three income levels in the Shopsim, denoted respectively by the Rich, the Middle and the Poor. The sum of ratios equals to 1. It is assumed that there are three kinds of spatial pattern by income types: Well-Mixed, Inner-Higher and Outer-Higher. Well-Mixed pattern represents an ideal distribution pattern that households of different income mix with each other. Inner-Higher and Outer-Higher pattern is defined according to the Rich distribution. The former means that the Rich household agents intend to live in the downtown area, and the later vice versa. Users of the Shopsim can adjust the ratios of different income-types, select the location pattern by household income types for the simulation。

3.2 Land use zoning constraints

The zoning constraints on household spatial distribution are put into effect through two critical variables: HSP, HFAR.

The variable HSP means the probability of a cell to be selected to hold households. The HSP is a representation of housing-use ratio in each kind of zoning types in real world and its value is designed based on existing study [4].

The variable of HFAR means the maximum number of household agents on a cell, or the household-capacity of a cell. The value of HFAR for each cell in Urban Planning Area (UPA) is designed form the maximum floor area ratio (Max. FAR) of the zoning type that cell belongs to.

In order to let household agents' distribution obey the general population density pattern of the cities, it is assumed the value of HSR and HFAR of cells in the downtown is higher than other cells belonging to UPA (Table-1). The HSR of cells in Urbanization Control Area (UCA) is set as 50% and the HFAR is either 1 or 0 with equal probability randomly.

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Table-1. The zoning constrains related variables for the UPA

No.	Land use zoning	Downtown		Out-Downtown	
		HSR (%)	HFAR (%)	HSR (%)	HFAR (%)
1	1st low-rise exclusive residential district	100	2	100	2
2	2nd low-rise exclusive residential district	100	2	100	2
3	1st mid-high-rise exclusive residential district	100	3	100	3
4	2nd mid-high-rise exclusive residential district	100	3	100	3
5	1st residential district	90	4	90	4
6	2nd residential district	90	4	90	4
7	Quasi-residential district	80	4	80	4
8	Neighborhood commercial district	70	4	70	4
9	Commercial district	50	10	50	10
10	Quasi-industrial district	70	4	70	4
11	Industrial district	30	4	30	4
12	Exclusive industrial district	0	0	0	0

4. Allocation model of household agents

The process to allocate household agents is one of important components of the initialization of the Shopsim. It is performed after setting up urban space (urban planning area and land use zoning) using a cellular automata model, which set up the physical acting space for the households. To set about initializing the Shopsim, users should decide the external variables' values, including the number, the income ratios and income-location pattern of households. The Figure-1 demonstrates the relationship between objects in the process.

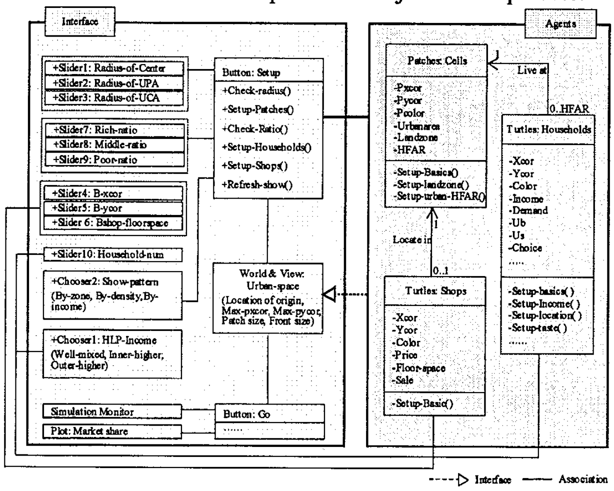


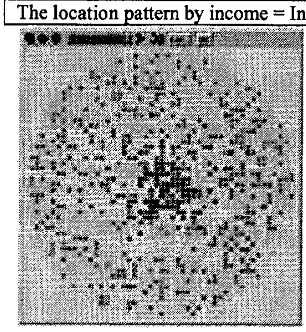
Figure-1. The class diagram for allocation in Shopsim

5. Simulation results relating to households allocation

Our model has been implemented in Net Logo (http://ccl.northwestern.edu/). Simulation results are produced based on following basic inputs (Table-2). The Figure-2 shows the household agent spatial distribution. The Figure-3 exhibits the spatial market shares of the downtown shops and B-shop.

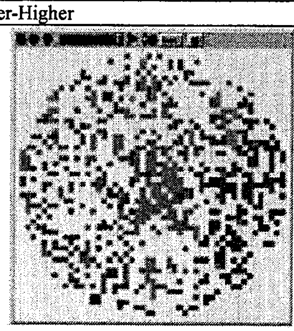
Table-2. Basic parameters for the initialization

Radius-of -Center = 5	The B-shop position = (13, -4)
Radius-of-UPA = 20	Households-Num = 2000
Radius-of -UCA = 25	Rich: Middle: Poor = 0.2: 0.6: 0.2
The location pattern by income = Inner-Higher	



■ The Rich ▩ The Middle
□ The Poor ▣ The urban space

Figure-2. The spatial distribution of household agents



■ The share of the B-shop
▩ The share of the Downtown

Figure-3. The spatial pattern of shopping spatial market shares

6. Conclusion

In order to enable the simulation results of the Shopsim come closer to reality, which is developed for exploring the impacts of large-scale shopping on the local city center under certain planning regulations, we modified the household agents' attributes and their allocation by considering zoning constraints and location pattern by income.

We believe the work report here is a step forward towards generating a more realistic simulation environment for the Shopsim, and maybe looked as a good reference for urban simulation models. But we realize that more effort needs to be made to improve the quality and accuracy of the Shopsim. In our future research, we plan to add dynamic location process of household in respond to urban planning conditions change and the building of a large-scale shopping center.

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