The Formation of Agent cells according to Diversity of the Ratio and the Familiarity of Agent cells

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***Abstract*—The familiarity between the five kinds of land use agents is set up, and it supposes that the agent acts corresponding to the familiarity. The characteristics of the form are explained if the number of agents according the kind varies. Cellular Automata is applied as a method. The degree of satisfaction based on the familiarity was set up as an evaluation index of the distribution form of the agents. It became evident that the distribution form of the agents and the degree of satisfaction was different according the difference in the composition ratio of the agent.**

I. Introduction

The land use plan of the city is based on the zoning system in Japan. This system is the institution which regulates a land use to a certain land area. On the other hand, there is a way on which a land use of one site is planned by the conformity with its circumference area. In other words, the zoning institution is a land use planning system in the macroscopic view, but the latter is a system in the microscopic view.

On this study, it is supposed that a site ; a land agent or an agent, moves to the suitable place according the conformity with the land use of its circumference. And it is considered that what kind of form the agents make by the simulation of cellular automata.

The author's previous research established four kinds of agents and three kinds of strategy, and considered what kind of form the agents made, when each agent acted in accordance with each strategy by the cellular automata simulation [1]. The component ratio of agents was equal each other to the four land use kinds on the previous research. This research examines the case that the component ratio is different according the different land use.

There are the following previous researches about the simulation of city form by the cellular automata. Joshua M. Epstein introduces the fundamental model of the multi agent about the artificial society [2]. Takizawa et al. sets up three kinds of land use; residential area, business area and commercial area, and simulates the formation of that land use by the economical model [3]. Watanabe et al. establishes the factors of urbanization as the parameters, and simulates the growing form of urbanization, and compares it with the real city [4]. Asayama prospects quantity of built land based on the actual population growth, and the city form according the additional built land [5].

The principal object of the above previous researches is to prospect the form of city according the growth of the city. On the other hand, this research simulates a rearrangement by the degree of satisfaction of the built land under the condition of constant of the city scale.

II. The method of simulation

An area is divided into the lattice grid. One grid or one cell is called a land use agent or an agent cell or an agent. Then, the movement of the land use agent is simulated by the cellular automata.

A. The kind of the agent cell

The following five kinds of agent are taken; the residential agent, the commercial agent, the industrial agent, the green agent and the vacant agent.

B. Familiarity between the agent cells

The familiarity means appropriateness between the agents. It establishes as follows;

f_{ij} : familiarity of agent i toward agent j (1)

The familiarity takes [+1,-1]; the plus number is good familiarity, the minus number is bad familiarity, and zero is a neutral familiarity. The familiarity between the agents takes +1 or -1 except 0 on this research. The familiarity between the same kind agents takes +1 or -1, and the familiarity between the different kind agents takes +1 or -1 too. Then, the combinations of the familiarity are four kinds. A residential agent, a commercial agent, an industrial agent and a green agent have one of them. As for the vacant agent, its familiarity takes zero to any agent. In other words, a residential agent, a commercial agent, an industrial agent and a green agent acts as an active agent, but a vacant agent never moves by itself. The familiarity of the agent is indicated in the figure 1.

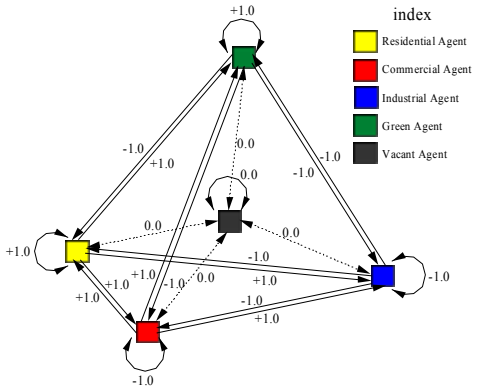

Fig. 1 Degree of Familiarity between Agents

C. The satisfaction of an agent cell

The satisfaction of an agent toward another agent is as follows. It is reduced by the square of the distance.

$$s_{ij}=f_{ij}/r_{ij}^2 \quad (2)$$

s_{ij} : satisfaction of agent i toward agent j
f_{ij} : familiarity of agent i toward agent j
r_{ij} : straight distance between agent i and agent j
One unit of distance is one side length of one cell.

The satisfaction of an agent toward its neighborhood agents is as follows.

$$S_i=\sum_j s_{ij} \quad (3)$$

S_i : satisfaction of an agent i
j : any agent j in neighborhood of agent i

D. The strategy of the agent cell

Egoism strategy is taken.

Egoism: if the own satisfaction improves by being replaced another agent, then the agent and another one exchanges, figure 2.

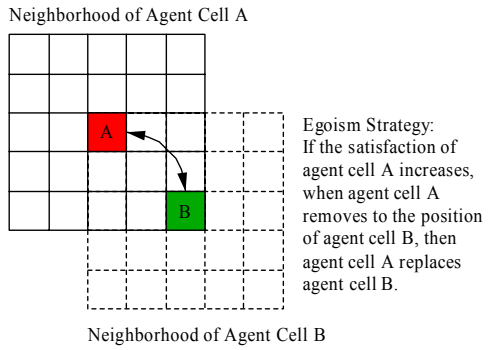

Fig.2 Egoism Strategy

E. The ratio of the agent cell to whole cells

Concerning the residence, the commerce, the industry and the green, the following two kinds of ratio were taken;

a) 2%, 4%, 8%, 16%, totals 30%
b) 4%, 8%, 16%, 32%, totals 60%
Other cells are vacant agents.

F. The neighborhood of agent cell

The neighborhood is the area where one agent can move at a time and influenced from other agents. Concerning the size of neighborhood; figure 3, the area surrounded by one cell width is called the first neighborhood and the area surrounded by two cells width is called the second neighborhood. Therefore, the area surrounded by n cells width is the n'th neighborhood.

The simulation was done about five kinds of neighborhood size; from the first neighborhood to the fifth neighborhood.

G. The form and size of the simulation area

The area of the simulation is a square grid composed of 50 cells one side. Therefore, the total is 50×50=2500 cells.

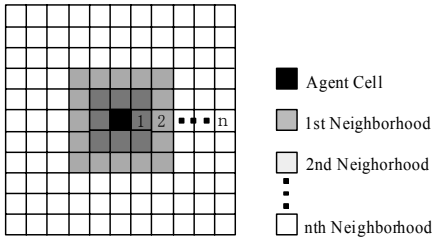

Fig. 3 Neighborhood Size

H. The repetition of calculation

The calculation repeated 1000 times.

I. How to choose an agent cell

Every agent was chosen at random order.

J. Initial distribution of agent cells

Every agent was arranged at random at first.

III. The result and analysis of the simulation

The result of the simulation is shown in figure 4 and 9.

And, mean of satisfaction of every agent is shown at figure 5 to 8 and figure 10 to 13.

A. Regarding the agent cell composition ratio; 2%, 4%, 8% and 16%

a) The distribution form of the agent cells; figure 4.

A difference of the distribution form according the difference of the familiarity and the composition ratio appears remarkably. In other words, the residential agents and the green agents make clusters, the commercial agents disperse on the whole of the area, and the industrial agents disperse outside the residential cluster and the green cluster.

b) The mean of satisfaction of every agent; figure 5 to 8.

The mean of satisfaction changes according the difference of ratio of the agents.

- On the case of the residential agents (16%) the commercial agents (8%) the industrial agents (4%) and the green agents (2%), the mean of satisfaction increase rapidly until about a calculated repetition 100 times. After that, it almost becomes steady condition. And as the neighborhood size is bigger, the mean of satisfaction is higher.
- On the case of the residential agents (2%) the commercial agents (16%) the industrial agents (8%) and the green agents (4%), the mean of satisfaction increase rapidly at the early stages of the calculated repetition. After that, it becomes steady within about the satisfaction range 0.2. And as the neighborhood size is smaller, the mean of satisfaction is higher.
- On the case of the residential agents (4%) the commercial agents (2%) the industrial agents (16%) and the green agents (8%), the mean of satisfaction increase rapidly until about a calculated repetition 100 times. After that, as for the neighborhood size 1, it almost becomes steady. But, as for other neighborhood sizes, it changes within about the satisfaction range 0.5 until about a calculated repetition 500 times. After that, it becomes little change; about 0.2 range.

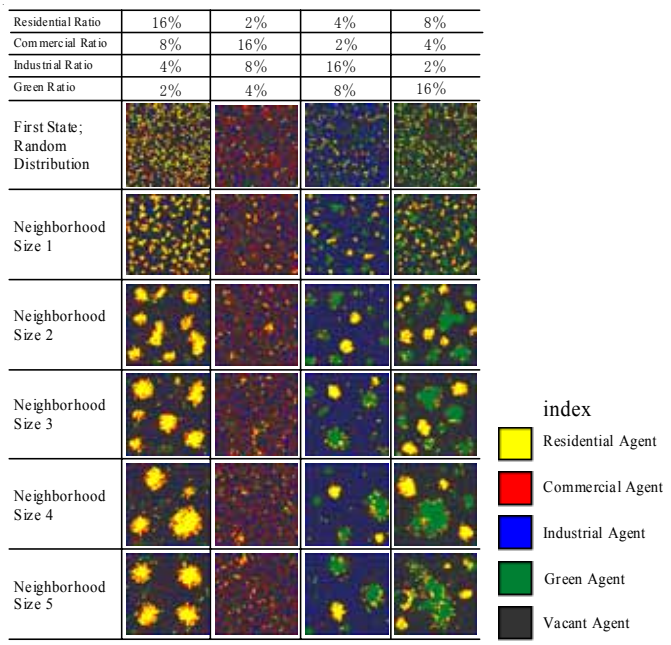

Fig.4 Distribution Form of the Agents; 2%, 4%, 8% 16%

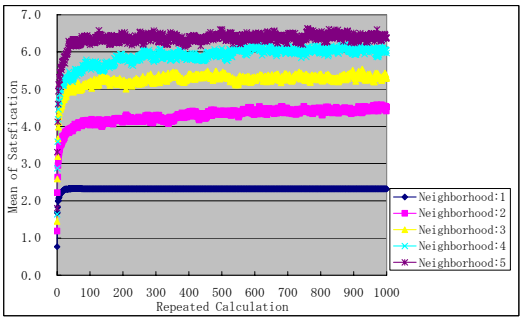

Fig.5 Mean of Satisfaction; Residence (16%), Commerce (8%), Industry (4%), Green (2%)

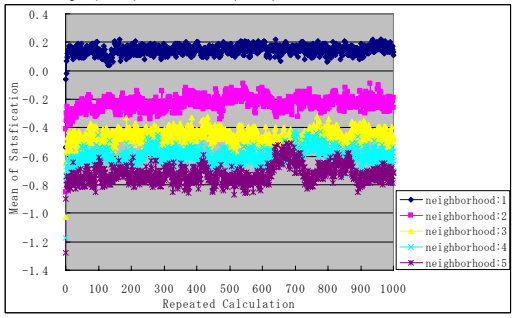

Fig.6 Mean of Satisfaction; Residence (2%), Commerce (16%), Industry (8%), Green (4%)

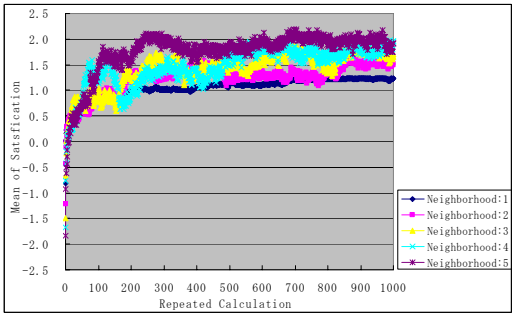

Fig.7 Mean of Satisfaction; Residence (4%), Commerce (2%), Industry (16%), Green (8%)

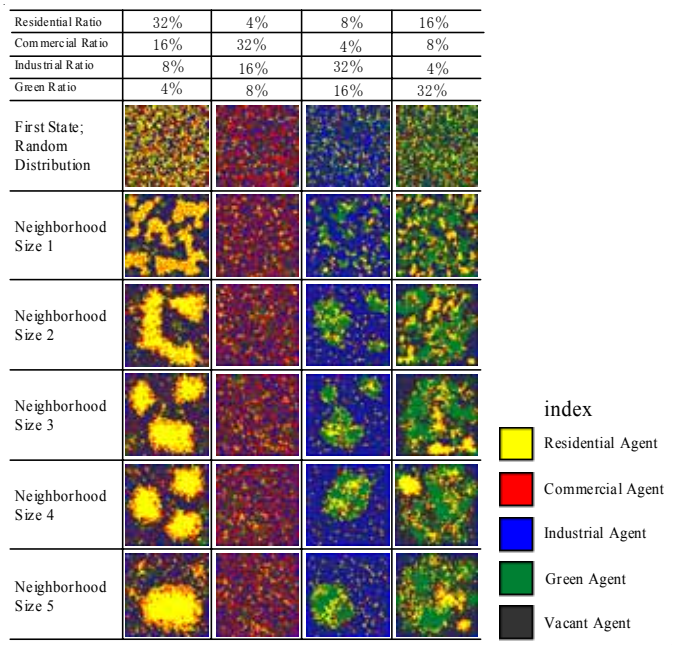

Fig.9 Distribution Form of the Agents; 4%, 8%, 16 % 32%

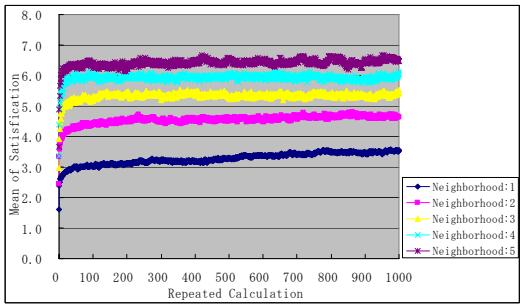

Fig.10 Mean of Satisfaction; Residence (32%), Commerce (16%), Industry (8%), Green (4%)

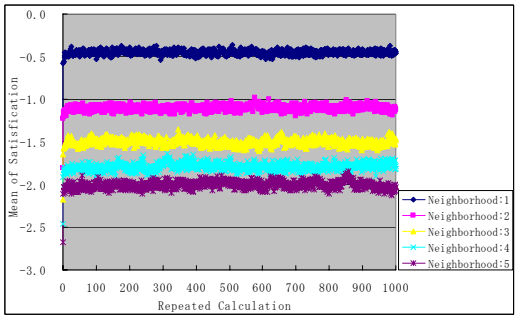

Fig.11 Mean of Satisfaction; Residence (4%), Commerce (32%), Industry (16%), Green (8%)

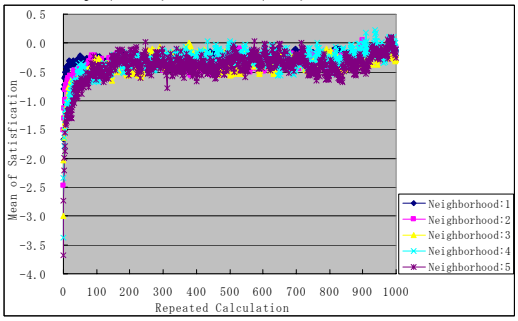

Fig.12 Mean of Satisfaction; Residence (8%), Commerce (4%), Industry (32%), Green (16%)

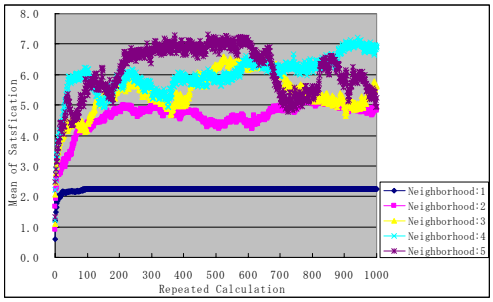

Fig.8 Mean of Satisfaction; Residence (8%), Commerce (4%), Industry (2%), Green (16%)

- On the case of the residential agents (8%) the commercial agents (4%) the industrial agents (2%) and the green agents (16%), the mean of satisfaction increases rapidly at the early stages of the calculated repetition. After that, as for the neighborhood size 1, it becomes steady. But other neighborhood sizes do not become steady. The change of the neighborhood size 3 and 4 is especially big.

B. Regarding the agent cell composition ratio; 4%, 8%, 16% and 32%

a) The distribution form of the agent cells; figure 9.

The characteristics are fundamentally as same as the previous case. But, a degree of mixture with the residential agents and the green agent rises.

b) The mean of every agent cell; figure 10 to 13.

As well as the previous clause, the mean of satisfaction changes according the difference of ratio of the agents.

- On the case of the residential agents (32%) the commercial agents (16%), the industrial agents (8%) and the green agents (4%), the mean of satisfaction increase rapidly until about a calculated repetition 100 times. After that, it almost becomes steady condition. And as the neighborhood size is bigger, the mean of satisfaction is higher.

- On the case of the residential agents (4%) the commercial agents (32%) the industrial agents (16%) and the green agents (8%), the mean of satisfaction increases rapidly at the early stage of the calculated repetition. After that, it almost becomes steady. And as the neighborhood size is smaller, the mean of satisfaction is higher.

- On the case of the residential agents (8%) the commercial agents (4%) the industrial agents (32%) and the green agents (16%), the mean of satisfaction increases rapidly until about a repeated calculation 100 times. After that, it becomes steady within about the changing range 0.5.

- On the case of the residential agents (8%) the commercial agents (4%) the industrial agents (32%) and the green agents (16%), the mean of satisfaction increases rapidly at the early stage of the repeated calculation. After that, the neighborhood size 1 and 2 become steady within about the changing range 0.2, and other neighborhood sizes become steady within about the changing range 1.0.

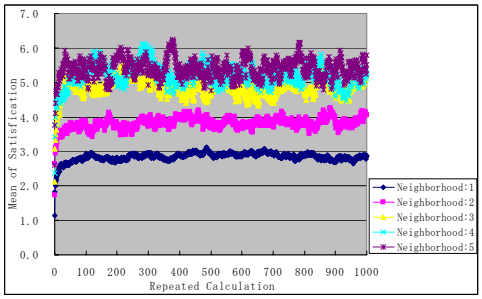

Fig.13 Means of Satisfaction; Residence (16%), Commercial (8%), Industrial (4%), Green (32%)

IV. Conclusion

This research set up a familiarity between the agent cells about five kinds of agent cells.

And the form of the agent was examined by the simulation of cellular automata according the change of the familiarity and the composition ratio of the agent cells.

The following characteristics became clear as that result.

a) The difference of the distribution form of agents becomes remarkable according the difference of the familiarity and the composition ratio of the agent cells.

b) The satisfaction of the agent cell changes according the composition ratio of the agent cells.

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