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GIS-Based Microsimulation System for Urban Landuse Policy Analysis

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1. Introduction

In order to simulate changes in urban landuse and to forecast the influences of new measures on the block level, there is a need to develop a micro landuse system that can represent the changes of individual buildings including usage, area, height, floor area ratio, etc. Miyamoto et al. (1998) developed a model of detailed physical landuse patterns to represent the changes in building types and use by block. This model does not consider the possibility of lots merging. Another system has been suggested to simulate space use in downtown planning (Kaneda, 1998). Although this system has a graphical interface that shows the simulation result, the urban patterns that it can handle are limited to chess-board-like patterns. In this research, a landuse forecasting model is implemented on a PC using object-oriented GIS concepts. It is assumed that the total quantities of urban activities in a zone are known. Then, these quantities are allocated to lots according to the probability of change of the landuse and based on the attributes of these lots. The possibility of merging adjacent lots is also considered.

2. MIcro LandUse Simulation System (MILUSS)

The flow of the MIcro LandUse Simulation System (MILUSS) developed in this research is as follows: (1) Input lots and buildings' GIS data, and total floor areas to be allocated for each landuse. (2) Create lot' s neighborhood information. (3) Perform lot merging based on the probability of merging and using Monte Carlo simulation, then update lots' data. (4) Calculate the utility and the probability of each landuse for all lots. (5) Sort lots according to each landuse probability. (6) Allocate the total demand for floor area of each activity (building type) to the lots in order using Monte Carlo simulation. (7) In case that a change in a lot's landuse occurred that involves a change in the structure on the lot, a new *Building* object is created, and the floor areas to be allocated are updated. (8) The allocation process is complete when all the demands for all activities are allocated, or when all the available lots in the zone are allocated. In the later case, the information about the remaining demand that could not be allocated is fed-back to the macro model. (9) After the end of the allocation process, GIS data of lots and buildings are saved. (10) The simulation results are displayed in 2D and 3D.

The software is developed using Visual Basic, and the GIS functions are implemented using MapObjects. The object-oriented model of MapObjects allows the state and behavior of an object to be modeled as attributes and methods, respectively, which greatly facilitates the reuse and extension of objects. In addition, a special function has been developed in the GIS simulation software that creates the basic shapes of buildings by extrusion, and uses other attributes, such as the type of the roof, to add more details to the 3D buildings' model parametrically using VRML.

3. Case study

The study area is at a sub-center about 10 min. from the CBD of Nagoya City. It is a commercial and mixed-use area of about 50 ha including 1173 lots. Attributes of lots and buildings were attached to GIS maps for the years of 1991 and 1997. Fig.1 shows the zoning regulations, the lots' distribution, and the present buildings' distribution of the study area.

Keywords: GIS, Microsimulation, Landuse

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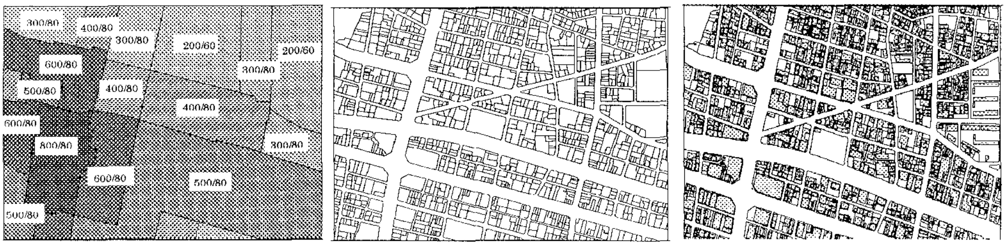

(a) Zoning Regulations　　(b) Lots' Distribution　　(c) Buildings' Distribution

Fig.1 Area of the Case Study

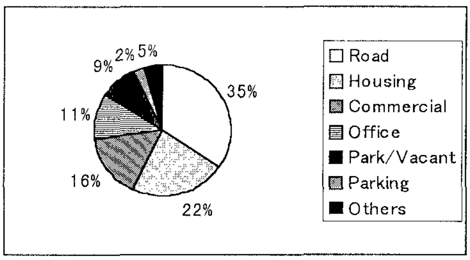

Fig.2 Land Areas Percentage of Each Landuse Type

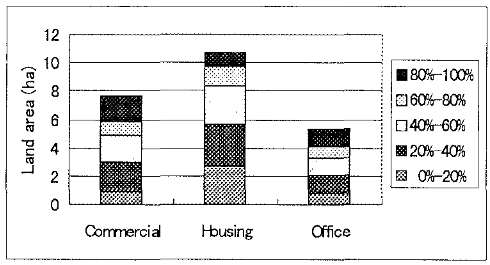

Fig.3 Used Percentage of Max. Floor Area Ratio

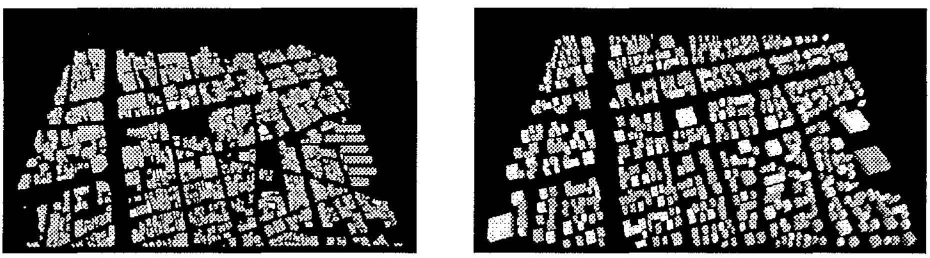

Fig.4 Present Landuse (left) and Simulation Results (right)

The two numbers on each zone in Fig. 1(a) are the percentages of the floor area ratio and the building-to-land ratio. Fig. 2 shows the land areas percentage of each landuse type. Fig. 3 shows the land areas with respect to the used percentage of the maximum floor area ratio. It is clear from Figs.3 that a large part of the floor areas of the housing use is in low-rise buildings, and that the used percentage of the maximum floor area ratio is generally small.

Fig.4 shows the present landuse and an example of the measures that can be simulated with the system. This measure is about improving the urban environment by imposing a new regulation that aims to decrease the building-to-land ratio in order to increase the open space between buildings.

6. Summary and future work

The prototype simulation system is innovative in that it allows for the dynamic manipulation of the topology of the polygons representing lots and buildings. Future work includes considering the effect of the age of buildings on the redevelopment process, and the effects of setback regulations on the landscape.

References: Kaneda, T. (1998). A System Design of Space Use Simulator for Downtown Planning, Proceedings of the Annual Meeting of Japan Architects Association (in Japanese). Miyamoto, K. et al. (1998). A model of Detailed Physical Landuse Patterns for Environmental Considerations, Paper submitted to the 8th World Conference on Transport Research, Antwerp, Belgium.