A Method to Model Neighborhood Interactions in Geo-simulation of Urbanization Processes

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(1) Objective: Understanding and calibration of neighborhood interactions for cellular automata-based geo-simulation models of urbanization processes is complex. This research aims to assist modelers in the implementation and quantification of neighborhood interactions in geo-simulation of urbanization processes.

(2) Methods: Based on the theory of Tobler's first law of geography, Reilly's law of retail gravitation as well as logistic regression approach, an integrated model is proposed. In this model, the contribution of one cell with land use k in the neighborhood on the conversion of the developable cell i to land use j for next stage is described as f_{kj}:

$$f_{kj} = G_{kj}\frac{A_k}{d_{ki}^2}$$

Where, A_k area of the cell with land use k; d_{ki} the distance from the cell to the developable cell i; G_{kj} the effect coefficient of land use k on the transition of the developable cell i to land use j. The neighborhood effect to the probability P_i of conversion of a cell is described as a function of a set of aggregated contribution F_{kj} of different land use types:

$$Log(\frac{p_j}{1-p_j}) = \beta_{0j} + \sum_k \beta_{kj}F_{kj} = \beta_{0j} + \sum_k \beta_{kj}G_{kj}\sum_m \frac{A_k}{d_{kmi}^2}I_{km}$$

Where, m is the total number of cells in the neighbourhood. The goodness of fit of this regression model is evaluated using PCP (Percentage Correctly Predicted) and ROC (Relative Operating Characteristic).

(3) Originality: No such model is found to be used in spatial model of urbanization processes. It simplifies the calibration processes.

(4) Results: The regression results (high PCP: >84%, and ROC: >0.91) indicate that this method can grasp the main characteristics of neighbourhood effect in urbanization processes. We simulate urban growth of the Tokyo metropolitan area from 1984 to 1994 using this model constrained by land condition, land use zoning plan and transportation network and assess the result of simulation using fractal dimension. The assessment results through comparing the simulated urban land use with corresponding reality of the Tokyo metropolitan area using fractal dimension confirm the usefulness of this model.

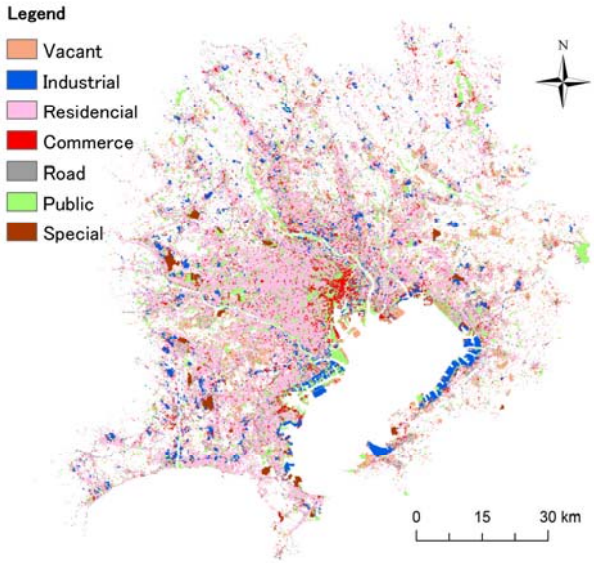

Figure 1: Simulated urban land-use map of the metropolitan in 1994

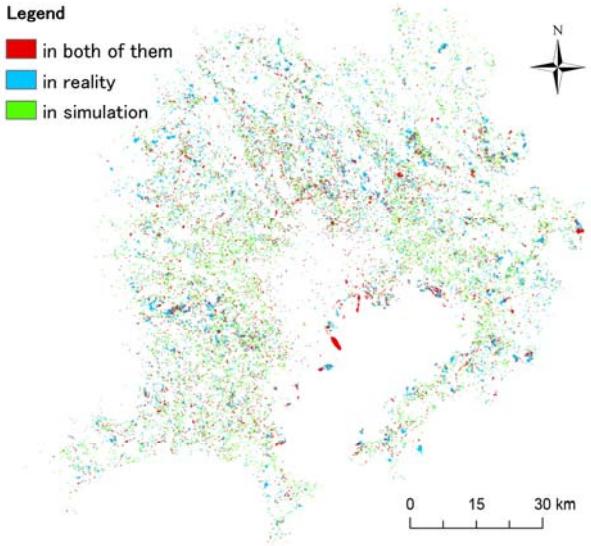

Figure 2: Comparison of simulation with reality