Early warning systems for detecting illegal development in fast growing regions

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1. Introduction

Illegal development which usually occurs during the period of rapid urban growth refers to the construction without permits and authorized blueprints. Although the reasons for illegal development are complex, a number of factors can be identified for explaining the mechanism of such development. The causes of illegal development may be attributed to unbalanced regional economic growth and development, ineffective legislation and city administration, lack of available sites and parcels for individual housing with basic utility provision, postponement of demolition of illegally constructed houses at the beginning of construction (Zegarac 1999; Zhao 2011).

Recent years have witnessed the fast development of various bottom-up simulation models for predicting land use change trajectories and exploring possible development options. Particularly, a family of cellular automata (CA) have been developed, including SLEUTH (Clarke et al. 1997), GeoSOS (Li et al. 2011), and CLUE-S (Verburg et al. 2002). Although there is a growing trend of using agent-based models, CA have been considered to be convenient and well defined in terms of model structures and model calibration. Compared with agent-based models, CA are more effective for simulating geographical phenomena under some situations.

This paper will present a multi-model approach by integrating CA and artificial neural networks (ANN) for improving the predictability of EWS. CA will be used to simulate illegal development in future years. ANN are also incorporated to improve the simulation performance because the development is an extremely nonlinear process. Moreover, handheld GPS (global positioning systems) with high-precision will be utilized to provide empirical information to train and validate the EWS.

2. Early warning of illegal development by integrating cellular automata and neural networks

The integration of CA and ANN is to provide the complementary information which is crucial for the early warning of illegal development (Figure 1). A logistic-CA is directly used to simulate the patterns and processes of urban development. ANN is also developed to improve the accuracy of warning illegal development. Since the ANN model is only calibrated by using one year of high-resolution data, it cannot directly simulate illegal development for future years. Instead, a logistic-CA which is a process model will be

utilized to obtain the total amounts of predicted illegal development for various years. These amounts of illegal development are then treated as the constraints of ANN so that this model can predict the patterns of illegal development for these years. The combination of these two models is to improve the accuracy of identifying potential illegal development for the EWS. The following section will describe the details of the proposed methodology (Figure 1).
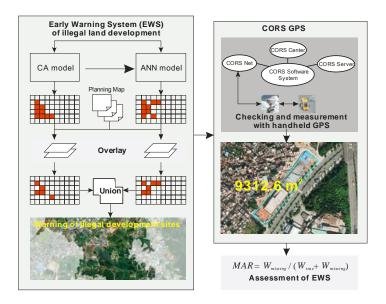

Fig. 1 Early Warning System (EWS) for predicting illegal development by integrating cellular automata (CA) and neural networks (ANN)

3. Conclusion

The warnings of illegal development can be obtained more accurately by combined use of CA and ANN models. Any illegal development sites predicted from either of these two models in future years will be considered as the warnings. Empirical data about illegal development can be obtained from temporal remote sensing data, such as TM and SPOT satellite images. The GPS which is based on Continuous Operational Reference System (CORS) provides a powerful tool to verify the warning results with detailed and accurate geometric information. The warnings yield the target areas for GPS to verify and thus significantly reduce the labour costs.

In this study, the traditional concept about accuracy may not be applied to this proposed system. It is because the ultimate goal is not just to predict illegal development accurately, but rather to implement protection measures and legislation in the target areas. This needs to identify the potential sites which may have a chance to develop illegally as many as possible. Compared with missing alarms, over-alarms or false-alarms of illegal development may not be a serious problem because ground checking can be carried out to verify or correct the prediction errors.

7. References

Zegarac, Z., 1999. Illegal construction in Belgrade and the prospects for urban development planning. Cities 16, 365-370.

Zhao, P., 2011. Managing urban growth in a transforming China: Evidence from Beijing. Land Use Policy 28, 96-109.