Land Use Change Modelling Using Markov Chain and Neural Network: Potentialities and Limitations

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1. Introduction

Many well-developed techniques for land use change modelling exist. Most of land use change models share a similar model framework, which includes three model components: The first component, dealing with the temporal part (or non-spatial component), is to predict the area changes of each land use in an aggregated level; the second component, dealing with the spatial part, is to model the transition potential at an individual pixel level; the third component is to assign the predicted amount of land use to each pixel based on its transition potential. The technique that combines Markov Chain (as the first model component) and Neural Network (as the second model component) enjoys popularity within land use/cover change modelling domain and becomes available in commercial GIS software, due to its capabilities of modelling complex systems.

This study explored the combined use of Markov Chain and Neural Network (MC_NN) for land use modelling at a specific scale. It aimed to assess its predictive performance and potentials for simulating future land use.

2. Data and Methodology

The study area is at North Norfolk, UK. Three dates of land use data represent 1930s, 1960s and 2000, first two of which were digitized from land use maps and the last is a satellite-derived data. Field visits were made to assess the 2000 data which was served as true/reference data for validation.

Considering that the existing errors within the land use dataset might distort to some extent the directly derived Markov matrix, two other approaches, a heuristic approach by optimisation and an 'arbitrary interference' approach were also tried to improve Markov matrix.

The NN implemented is called multi-layer feed-forward neural network or multi-layer perceptron (MLP), which is one of the most popular NN architecture.

By assuming that pixels with highest change potentials will change, changes predicted from NN were allocated.

Validation of the model was carried out by not only assessing overall accuracy but also the accuracy at changed area level. In addition to that, by looking into the accuracy at component level, each component's strengths and disadvantages within the MC_NN model were evaluated and thus, a complete image of its predictive performance as well as the ability of simulating future land use was formed.

3. Results

The results showed at a fine spatial scale and mid-term prediction problem, the accuracy of MC_NN technique at overall level is acceptable (indicated by a Kappa index of 60%), but the predictive ability at changed area level is weak (indicated by a Kappa index of 20.6%).

The model could be used directly for making a plausible land use scenario. By modifying land change potentials under different planning or management strategies, more alternative scenarios could be made.

The study showed the potential of the MC_NN technique for land use change modeling as it is easy to use and not data demanding.

Considering the specialty of the dataset, more case studies covering a range of scales were required to validate the MC_NN technique.

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