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Why Does Dynamic Neighbourhood Configuration Matter in CA-Based Models?

An exploratory approach for Luxembourg's cross-border area

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Abstract: Cellular Automata (CA) based modelling is rapidly emerging as a powerful technique to model complex systems in a wide range of applications. The neighbourhood configuration is one of the key components of CA models. Static neighbourhood configuration (*SNC*) has been used for a long time in various applications. However the efficiency of a CA model is highly influenced by its *SNC* and cell size. Recently, a few number of researchers working in land change science have proposed a large neighbourhood configuration (e.g., 10×10 Moore neighbourhood instead of the commonly used 3×3 Moore neighbourhood). The large neighbourhood configuration has shown its benefit, to a certain extent, in CA models used for urban sprawl, disease or virus spread among other applications. However, it seems that each research study proposed intuitively its own scale of the neighbourhood. An appropriate neighbourhood configuration for raster-based CA models remains to be defined. To our knowledge, this paper is the first to propose a dynamic neighbourhood configuration (*DNC*) within a raster CA model that is based on border effects, accessibility and housing prices since they are most determinant for urban changes in cross-border areas. The *DNC* is based on the *k*-nearest neighbors approach and it includes the whole CA grid; it is dynamic and specific to each spatial unit. Two cells are neighbours if they are separated by cells whose states favour the land-use transition between them and they are similar (with respect to the Euclidean distance measure) with regard to given determinant factors. This is a possible solution to overcome the scale sensitivity of the standard *SNC* in raster-based CA models. The aim of this paper is to briefly review the different *SNC* and *DNC* previously used in CA. In addition, this paper proposes a new *DNC* for urban modelling in the Luxembourg cross-border area. We compare and assess the new *DNC* to standard *SNC* based on well-known evaluation metrics, the relative operating characteristics (*ROC*) and percent correct change (*PCM*). The results show that the new *DNC* produces realistic spatial patterns similar to reference land-use maps and that it is superior to the *SNC*. This paper also addresses some critical issues in developing *DNC* such as simplicity, flexibility, extendibility and efficiency. Finally, we discuss some future research directions toward the successful implementation of a *DNC* in raster-based CA models.

***Keywords**:* Land use change; spatial modelling; complex systems; cellular automata; neighbourhood configuration.