**Simulating large-scale urban land-use patterns and dynamics using the U-Net deep learning architecture**

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# **Abstract**

Cellular automata (CA) models are widely used to simulate real-world urban dynamics, but many studies have oversimplified the spatial complexity of the driving factors in the process of objectifying urban transition functions and abstracting urban development rules. Advances in deep learning technology enable complex urban spatial patterns and dynamics to be captured. In this study, we selected the U-Net deep learning algorithm to assimilate historical urban development, describe the pattern-extraction process, validate the model against a reference map, and apply the model to predict urban layouts for 2030 in the North China Plain. The results showed that: 1) U-Net can gradually abstract high-level spatial features and refine those patterns into precise urban development shapes, 2) the Figure of Merit (FoM) of the simulation map was close to those of previous studies that went through a lengthy calibration process, and 3) the landscape patterns of the simulation and reference maps were well aligned. U-Net was able to learn complex urban development patterns such as gravity effects and linear development, which can complement CA models to integrate spatial features to project future urban development.

**Keywords:** Deep Learning; Urban expansion simulation; Cellular automata; Spatial pattern