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

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# **Abstract**

Accurate predictions of land-use change are important for supporting planning. Cellular automata (CA) models are widely used to simulate real-world urban land-use change but accurately modelling complex spatial urban patterns and dynamics can be challenging due to the high degree of subjectivity involved in CA model parameterisation. Advances in deep learning enable complex spatial patterns such as urban development to be learned and simulated. In this study, we used the U-Net deep learning algorithm to capture historical urban development and simulate future patterns for the North China Plain, one of the most rapidly urbanizing regions on the planet. We validated the model against a reference map for 2018 then applied it in predicting patterns of urban expansion for 2030. The results showed that U-Net can accurately predict urban land-use and mimic real-world spatial patterns with very low requirement for model parameterization and forcing data. Visual inspection of the outputs revealed that U-Net was able to automatically learn complex urban development patterns and processes such as neighbourhood influence, the gravity effects of large cities, and the tendency for linear development. Deep learning architectures such as U-Net provide a new parameter-free way to accurately capture and simulate spatial features in projections of future urban development and land-use change.

**Keywords:** Deep Learning; urban expansion simulation; cellular automata; spatial pattern

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