Abstract Article

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Hybrid GeoAI Utilizing DQN-Driven Adaptive Fusion Approach for Approximate Polygon Regularisation of Rasterised Building Footprints

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Abstract

Accurate regularisation of building footprints is a fundamental requirement for urban analytics, geographic information systems, and large-scale spatial modelling. Traditional regularisation methods directly depends on explicit vector geometry which are not available in rasterised datasets rendering polygon-level regularisation ill-posed in raster space. In this study, a hybrid GeoAI framework, a high dimensional building footprint regularisation is proposed from rasterised data as an approximate polygon recovery problem that integrates deep instance segmentation with discrete-action reinforcement learning for adaptive geometric regularisation. Initially building masks are generated using Mask R-CNN and refined using three complementary raster-domain regularisers: RANSAC Thresholding (RT), Rectangular Regularisation (RR), and Fuzzy Edge Refinement (FER). A Deep Q-Network (DQN) learns to adaptively fuse these regularisers based on geometric state descriptors and CNN-based contextual embeddings which allows regularisations strength to differ according to urban morphology. The experiments were conducted across eight U.S. states using large-scale rasterised building datasets demonstrating consistent improvements in boundary fidelity, achieving a mean Intersection-over-Union (IoU) of 74.9%, corresponding to a 7.1% gain over the Mask R-CNN baseline. GPU acceleration enables 17.6× reduction in inference time, supporting scalable regional analysis resulting an effective mechanism for approximating polygon-level regularisation objectives within raster space.