Automated versus Hybrid Street Network Modelling for network Analysis: A Comparative Case Study of Nicosia, Cyprus

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Introduction

Urban spatial models, particularly street network analyses, are vital tools in planning and managing cities. Methods like network analysis use street geometry to interpret movement, accessibility, and urban structure. However, these models often rely on extensive, high-quality data, which is difficult to obtain in data-scarce regions. Manual preprocessing of network data is time-consuming and often inconsistent. Automated workflows offer a promising alternative but remain underexplored in challenging urban contexts.

Problem

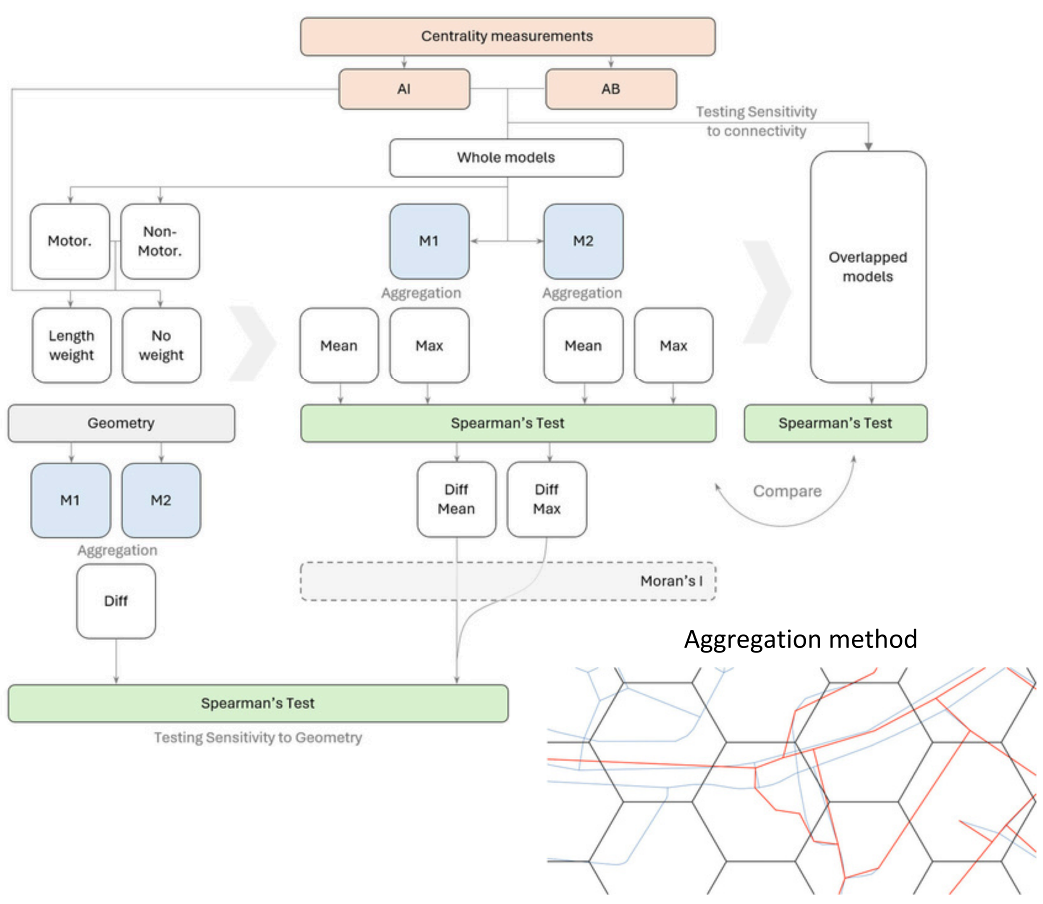
Manual modelling in spatial analysis struggles in regions with limited or fragmented spatial data. It is slow, subjective, and hard to reproduce, especially across large or complex urban areas. This undermines the scalability and reliability of evidence-based urban planning. While open-source and automated tools exist, their effectiveness in low-data environments has not been thoroughly validated. A systematic comparison with manual methods is needed to understand their potential and limitations.

Aim

This study aims to assess whether automated, open-source workflows can reliably replicate or approximate the results of hybrid/manual street network modelling. Using Nicosia, Cyprus, a context marked by limited data, the research evaluates both modelling approaches using centrality and accessibility metrics. The study seeks to identify where automated models align or diverge from manual ones. It also explores how differences in network preprocessing affect planning- relevant outputs. Ultimately, it aims to guide scalable, reproducible modelling practices in data-scarce environments.

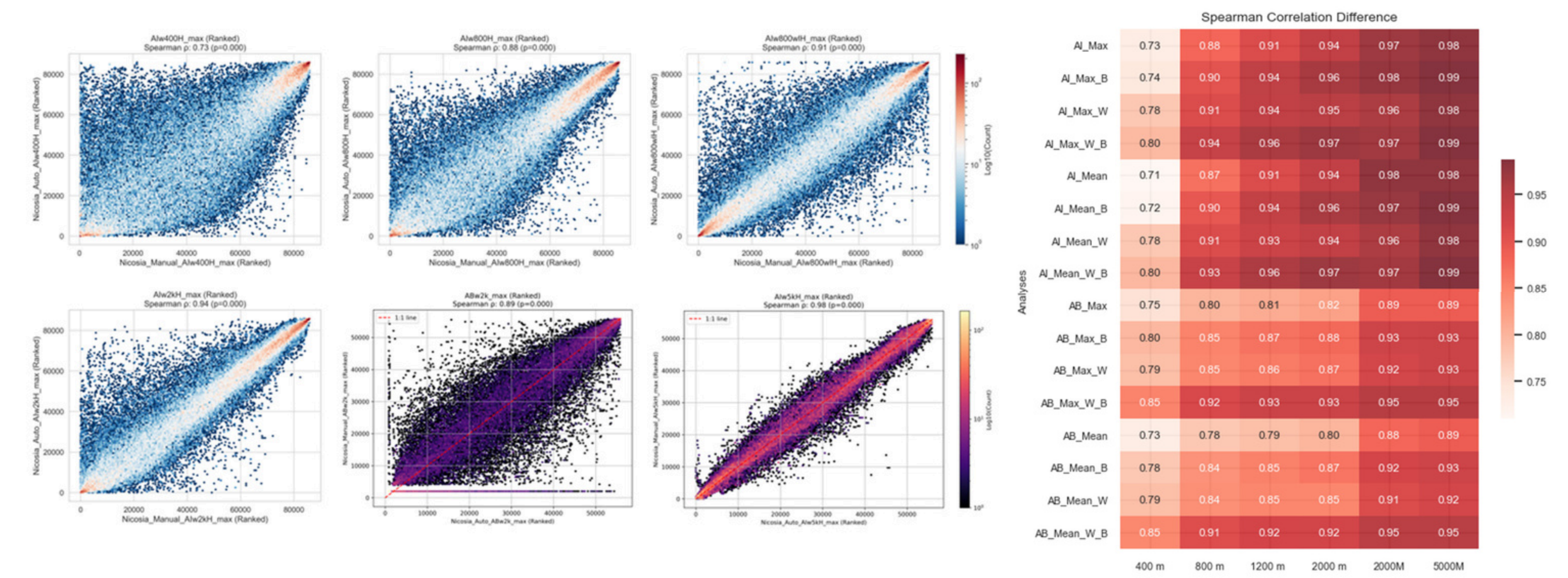
Methodology

The study compares two workflows: a hybrid model combining automated and manual preprocessing, and a fully automated model built using open-source tools. Both were applied to motorised and non-motorised networks in Nicosia, analysing centrality (integration and betweenness) and accessibility (reach and attraction distance) using the Place Syntax Tool. Centrality results were aggregated to hexagonal grids and compared statistically using Spearman correlations and Moran's I. Accessibility results were evaluated through Bland–Altman analysis and kernel density plots. Additional geometric and sensitivity analyses helped explain divergences between the models.



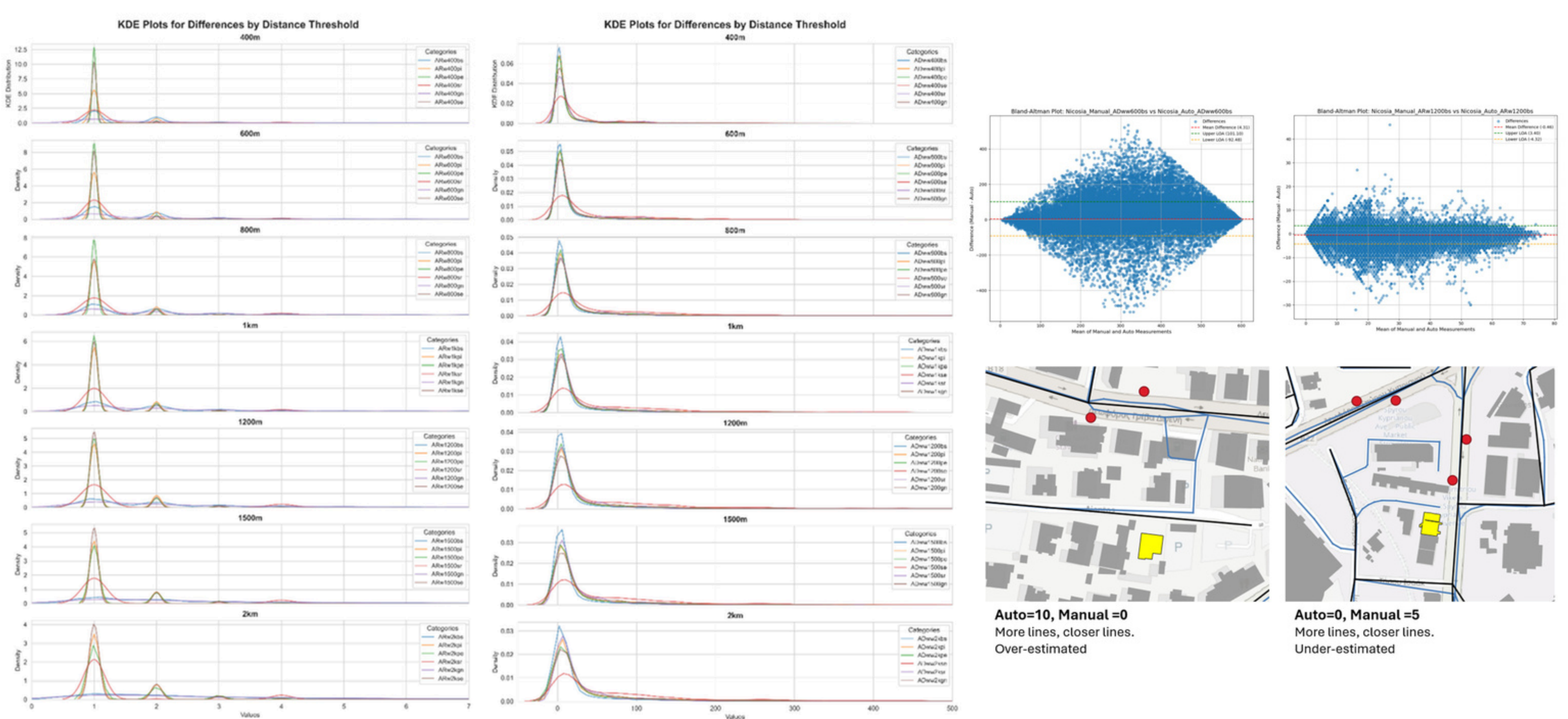
Centrality Measurements

Centrality results from both models show strong overall agreement, especially for angular integration at larger radii (ρ ≈ 0.98 at 5000 m). Agreement weakens at smaller scales, particularly for angular betweenness, due to sensitivity to fine geometric differences. Weighting by segment length improves correlation for both metrics across all scales. Differences in rank values are spatially clustered, not random, suggesting systematic variation in local topology. Overall, the automated model performs well at capturing city-scale centrality patterns but shows divergence at the neighborhood scale.



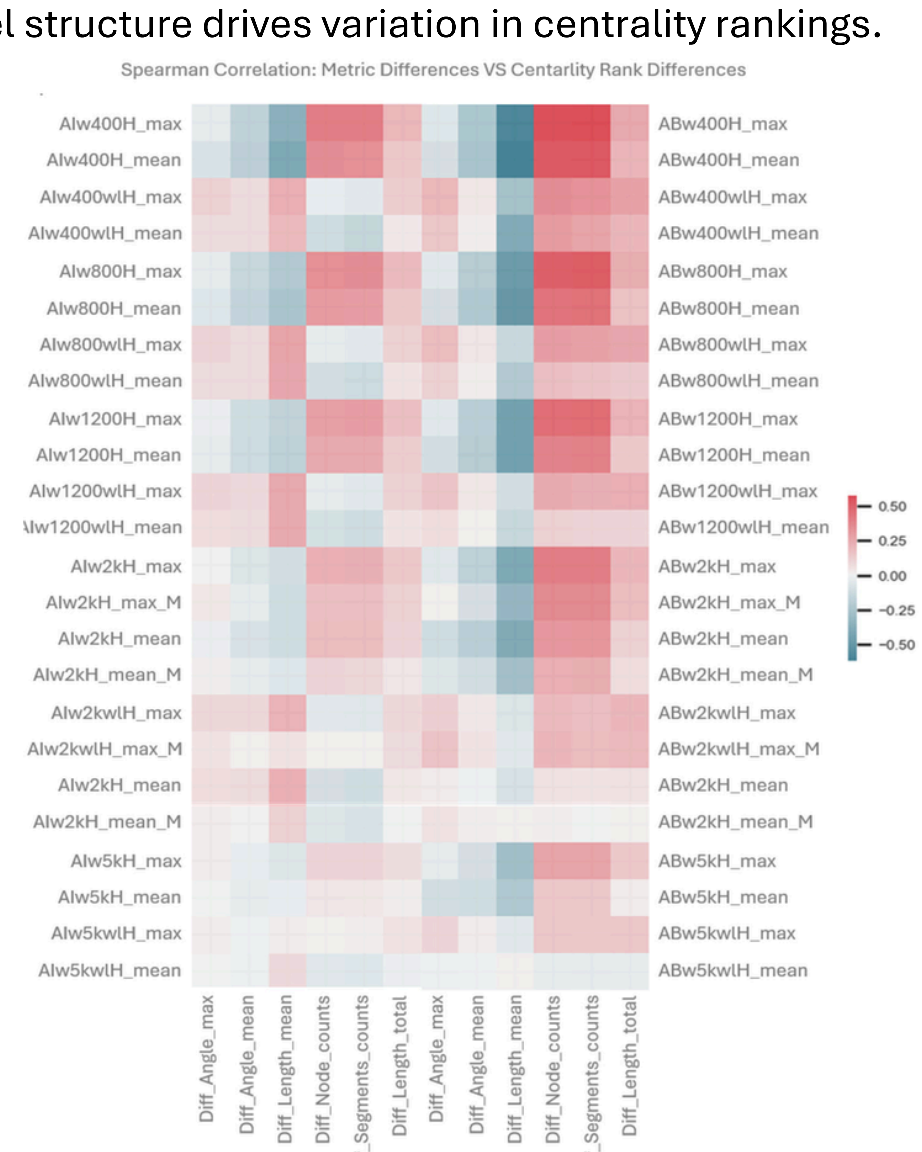
Accessibility Measurements

Reach metrics between the two models are closely aligned at short distances but diverge with increasing radius. The automated model often shows higher accessibility due to its inclusion of more micro-paths. Discrepancies are most pronounced for destinations like bus stops and green areas at larger scales. Despite some variance, about 95% of values remain within a similar range, indicating broad consistency. KDE plots and Bland–Altman analysis reveal that while average differences are small, distribution spreads widen with scale.



Metric Characteristics

The manual model contains more total segments and greater overall network length, reflecting detailed coverage. In contrast, the automated model generates fewer but denser segments per cell, emphasizing localised connectivity. Despite its shorter global length, the automated network matches spatial coverage in shared areas. Local differences in node density and angular geometry strongly influence betweenness metrics. This shows that model structure drives variation in centrality rankings.



Conclusion

Automated street network models can effectively replicate manual modelling results for large-scale spatial analysis, especially for integration metrics. However, local-scale differences highlight the importance of preprocessing and network structure. With refinement, automated workflows offer a scalable and reliable solution for urban analysis in data-scarce environments.

TWIN2EXPAND

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