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Abstract

Fractal and Network-based analysis of historic and modern street patterns across European cities

Tutor/Correlator
Prof. Luca S. D'Acci
Prof. Giancarlo Cotella

Candidate
Anara Kulzhanova

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Testo abstract (4000 caratteri max) (Century Gothic 11, interlinea 16 pt). Usare lo stile "Testo Abstract".

Abstract

In urban studies, historic districts are often portrayed as inherently walkable because their street networks emerged through organic development rather than planned design. These areas typically feature frequent intersections, richer route choice, and more engaging streetscapes than the larger blocks and regular alignments characteristic of many modern planned districts. Such interpretations often rely on the idea that historic areas possess a form of geometric complexity described as "fractal-like", yet this characteristic has rarely been evaluated systematically or directly linked to measurable street-network indicators.

This thesis addresses this gap by examining whether differences in geometric complexity and street network structure correspond to the walkability-related properties commonly attributed to fractal-like street form. The analysis, therefore, focuses on whether fractal dimension, as a quantitative measure of this complexity, captures variations in street morphology and how it correlates with key topological indicators of street-network configuration.

The study covers 100 European cities, each represented by a pair of contrasting districts: an organically evolved historic core and a typical planned modern extension. Geometric complexity is measured using fractal dimension and two indicators of street grain: intersection density (nodes per km^2) and average segment length. Network structure is assessed using graph-based indicators, including meshedness (redundancy of alternative paths), reachability index (number of intersections accessible within 600m), route straightness (deviation from a straight line), and harmonic mean shortest path length (average minimum travel distance).

The results show that historic areas generally exhibit a higher fractal dimension ($\widetilde{D} \approx 1.5$, SD = 0.07) than modern districts ($\widetilde{D} \approx 1.4$, SD = 0.07), reflecting their more irregular and compact street structure. This difference is accompanied by denser intersections (103 vs 87 per km^2), shorter average street lengths (78 vs 88 m), and roughly 20% higher local reachability. However, both morphologies display similar route straightness and shortest-path metrics, indicating that global-scale connectivity is less sensitive to underlying geometric variation.

These findings demonstrate that fractal dimension captures consistent variations in both geometric and topological properties of street networks across contrasting urban morphologies. By linking fractal geometry with network-based measures, the research provides an empirically grounded framework for examining street-network structure and clarifying the morphological foundations of walkability in different urban contexts.

Keywords: street-network morphology, fractal dimension, topological indicators, walkability, urban form.

For info:
s310499@studenti.polito.it