What Makes London Work Like London?

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Urban Environments
How do Cities Behave?

[SpaceSyntax]
What are the Good Features?

Paris?

London?

New York?

Hong Kong?

Moscow?
Virtual Cities

What Makes London Work Like London?

AlHalawani et al., SGP 2014

[Bao et al., Siggraph 2013]

1 of 10 initial good layouts

portal graph

AlHalawani et al., SGP 2014

What Makes London Work Like London?
‘Virtual Urbanity’
Street Network Analysis

Street network descriptors
Related Work

Urban Analysis

Walters & Brown 2004

Southworth & Ben-Joseph 2003

Moughtin 1992

Gerling & Kellett 2005
Analysis Framework

input map data

parsed OSM

Feature analysis

City Classification

Extract street-network features
Data Gathering

- 10 cities
- 3 scales
  - $\{0.25km^2, 1km^2, 4km^2\}$
- 100 samples

Beijing, Camp Durant, Cardiff, London, Los Angeles, Moscow, New York, Paris, Toronto, Vienna
Encoding Street Networks

Maps in XML format as ‘.osm’ files

ReadOSM

Set of nodes
\[ V = \{ v_1, v_2, \ldots, v_N \} \]

Set of edges
\[ E = \{ e_{ij} \}, \quad e_{ij} = \overline{v_i v_j} \]

Graph
\[ G = \{ V, E \} \]
Parsed Street Data
What Makes London Work Like London?

Algorithm

input map data

parsed OSM

Feature analysis

City Classification

Extract street-network features
Street Network Analysis

Topological features
- Valence
- Street density
- Connectivity index
- Intersection density
- 4-way crossing ratio

Geometric features
- Total street length
- Average street length
- Transportation convenience
- Redundancy
- Metric reach
- Travel distance histogram
Street Network Analysis

**Topological features**
- Valence
- Street density
- Connectivity index
- Intersection density
- 4-way crossing ratio

**Geometric features**
- Total street length
- Average street length
- Transportation convenience
- Redundancy
- Metric reach
- Travel distance histogram
Topological Features

- **Valence** (of a junction)
  - dead end \( t_v = 1 \)
  - T-junction \( t_v = 3 \)
  - 4-way crossing \( t_v = 4 \)
  - others \( t_v > 4 \)
Topological Features

Nodes with valence = 1
Topological Features

• Street density
  – # streets per unit area

• Intersection density
  – # intersection per unit area \( (t_v > 2) \)

• 4-way crossing ratio
Topological Features

• Connectivity index
  – how well is a network connected?
Street Network Analysis

Topological features

- Valence
- Street density
- Connectivity index
- Intersection density
- 4-way crossing ratio

Geometric features

- Total street length
- Average street length
- Transportation convenience
- Redundancy
- Metric reach
- Travel distance histogram
Geometric Features

- Total street length
- Average street length
Geometric Features

Transportation convenience
Geometric Features

Redundancy \((g_r)\)
Geometric Features

Metric reach (think geodesic fan)
Geometric Features

Travel distance histogram *(think shape distribution)*
Bag of Features
Analysis and Classification

- Input map data
- Feature analysis
- City Classification
- Extract street-network features

parsed OSM

AlHalawani et al., SGP 2014
Good Features

Inter-city classification

• learn (using SVM) to learn relative weights for the descriptors

- 4-way crossing proportion
- connectivity index
- # valence 4
- # valence 3
- number of blocks
Good Features

Intra-city classification

- node density
- street density
- # valence 3
- # valence 4
- total street length
Classify

input map data

parsed OSM

Feature analysis

embedding + clustering

City Classification

Extract street-network features

AlHalawani et al., SGP 2014
City Classification

Support Vector Machine (SVM)
- Linear
- Radial Basis Function

Discriminative Analysis (DA)
- Linear
- Quadratic
## Inter Classification

<table>
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<th>SVM</th>
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<th>LDA</th>
<th>QDA</th>
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<td>Vienna and others</td>
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Precision-Recall

Classification using all versus selected features

using all features

using selected features
## Confusion Matrix

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<th>Paris</th>
<th>New York</th>
<th>London</th>
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<th>Toronto</th>
<th>Vienna</th>
<th>Moscow</th>
<th>LA</th>
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</tbody>
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What Makes London Work Like London?
What is a Good Scale?

0.25km²

1km²

4km²
Comparison with Image Features
Comparison with Image Features

• GIST features

• 20-40% performance loss
Applications
City Retrieval

What Makes London Work Like London?
City Retrieval

AlHalawani et al., SGP 2014

What Makes London Work Like London?
Synthetic City Generation

\[ \text{target} \rightarrow \text{Synthesis Algorithm} \rightarrow \text{Synthesized layout} \]

\[ + \hat{f}(L) = \{ t_{val}, \ldots \} \]
Existing Algorithm?

[Averkiou et al., Eurographics 2014]
Synthetic City Generation
Synthetic City Generation
Limitations

- road width, car/population density
- speed restrictions
- one-way roads
- supervised method
Conclusion

Topological and geometric features
  – local and statistical

Classification (10 cities, 100 maps, 3 scales)
  – feature importance: inter and intra city

Applications
List of accepted papers and workshops for AAG2014 now available

Registration for AAG2014 now open

Advances in Architectural Geometry 2014

Geometry lies at the core of the architectural design process. It is omnipresent, from the initial form-finding stages to the final construction. Modern geometric computing provides a variety of tools for the efficient design, analysis, and manufacturing of complex shapes. On the one hand this opens up new horizons for architecture. On the other hand, the architectural context also poses new problems to geometry. Around these problems the research area of architectural geometry has emerged. It is located at the common border of applied geometry and architecture.

Advances in Architectural Geometry / AAG is a symposium where both the initial and final work linked to new geometrical developments is presented. This symposium aims to gather the diverse components of the contemporary architectural design and to establish the building envelope towards free form and respond to the multiple current demands in design. It involves architects, engineers, mathematicians, software designers and constructors. We aim at connecting research from architectural and engineering practices, academia and industry. AAG has become a reference in the professional field and is supported by the key organisations of the most renowned architecture design and engineering offices and construction companies.

The current edition, the fourth, will be held in London from the 18th to 21st of September 2014.

Conference dates: 18-19, 2014
Workshops: September 18-21, 2014

The symposium consists of two days of presentations of accepted papers, followed by two days of hands-on workshops, allowing participants, teachers, students and professionals to learn and experiment with new technologies and practices reflected in the themes tackled during the symposium.

[Link to the 2018 conference] [Link to the 2010 conference] [Link to the 2012 conference]
Thank You

(code + data available)