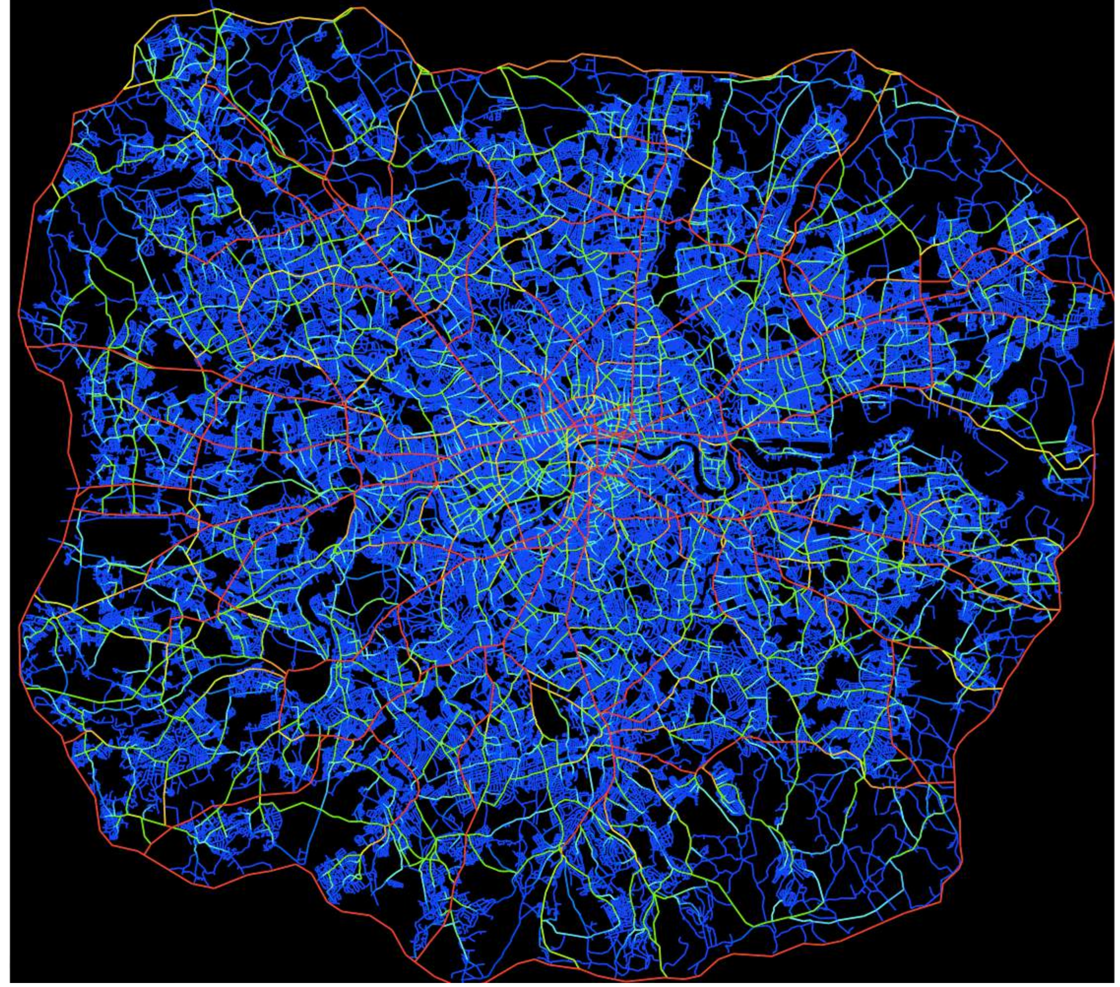


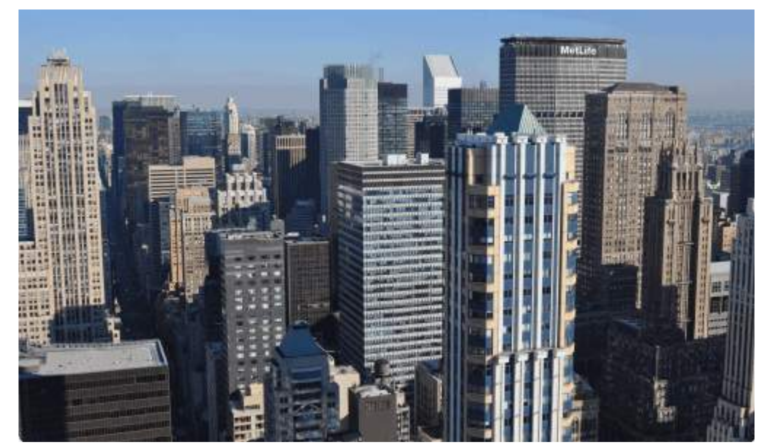
What Makes London Work Like London?

Sawsan Al-Halawani *Yongliang Yang* *Peter Wonka* *Niloy J. Mitra*

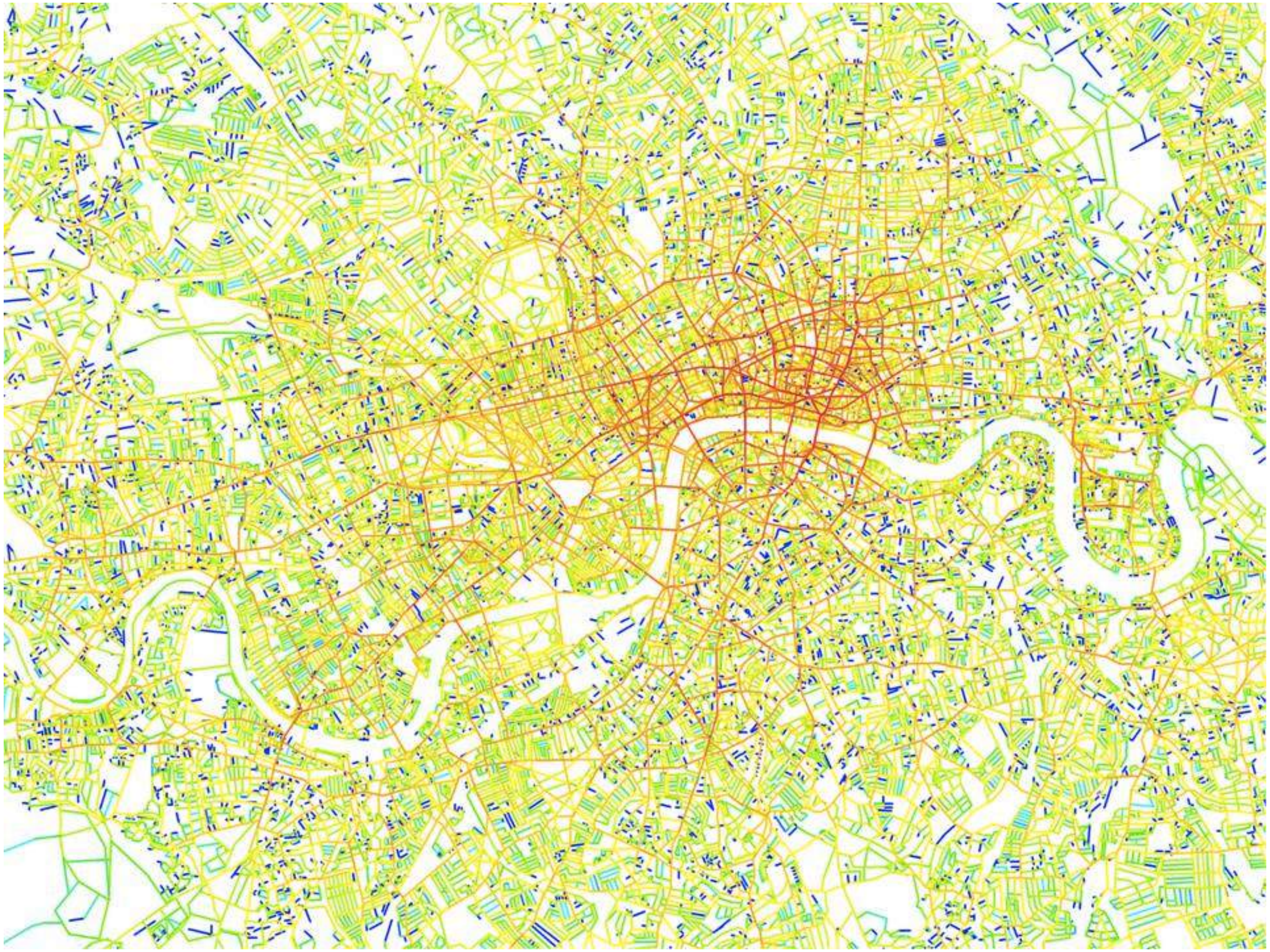
KAUST

UCL

Urban Environments



How do Cities Behave?



[SpaceSyntax]

What are the Good Features?

Paris?

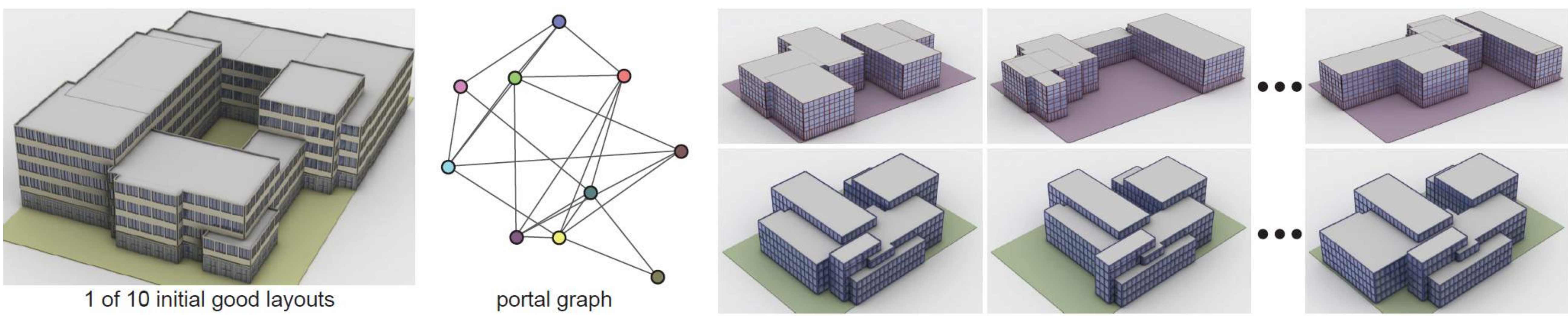
New York?

London?

Hong Kong?

Moscow?

Virtual Cities



[Bao et al., Siggraph 2013]

‘Virtual Urbanity’

[Bakolas ’07]

Environment and Planning B: Planning and Design 2008, volume 35, pages 881 – 901

doi:10.1068/b33088

The connectivity of streets: reach and directional distance

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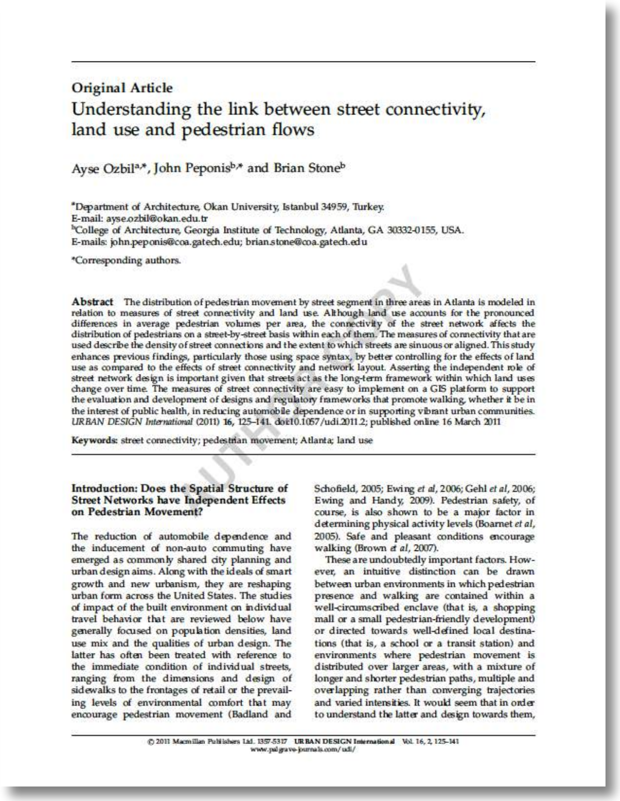
Received 26 July 2006; in revised form 3 April 2007

Abstract. We introduce two measures of connectivity that are applicable to standard GIS-based representations of street networks. The *reach* of a point measures the total street length covered by all paths extending out from that point that are no longer than a given threshold value. The *directional distance* of a street network from a point is measured according to the minimum number of direction changes required to reach any part of the network from that point, consistent with typical measures used in space syntax. However, our measure of directional distance requires no prior commitment as to the relational elements that make up the network. Any part of the network which is accessible from a point without a change of direction greater than a given threshold angle is treated as a single directional element for the purposes of computation. Street segments are characterized by the reach and directional distance of their midpoints. Networks are characterized by the average directional distance of the corresponding street segments. The measures render explicit the interplay between metric and topological properties of networks. Preliminary studies show that the measures discriminate well between different morphologies of street networks. When used to compare urban morphologies they are well correlated with standard measures used in the literature, with the added advantage that they can discriminate between street segments within the same urban area. Using field observations we also show that the measures can be used to model the effect of spatial configuration upon movement in ways which compare favorably to standard space syntax.

Introduction

In the most general sense, connectivity is about relatedness. In this paper we discuss the specific form of relatedness that arises according to the structure of street networks. We do not limit the idea of connectivity to some local measure, such as the number of intersections along a street, or the number of streets that come together at an intersection; these are best denoted by the term ‘degree’, as it pertains to the node of a graph representing relationships between elements. The aims of this paper are twofold. First, to introduce measures of street connectivity that can be computed on the basis of standard GIS representations of street networks, such as the street centerline maps that are readily available for all cities in the US. Second, to rethink some of the measures of street connectivity associated with space syntax in a way which takes into account recent advances in the field, as well as criticisms raised by authors who have discussed space syntax in this journal in recent years. In addressing these aims we set the foundations for future research aimed at testing theoretical hypotheses. This paper is focused upon the definition and clarification of descriptive concepts and their computational implications. Still, we present the results of a pilot field study indicating that the new measures postdict the distribution of pedestrian movement as well as standard syntactic measures. We also discuss the relationship of the new measures to standard morphological measures used in the literature.

[Peponis et al. ’07]



Original Article

Understanding the link between street connectivity, land use and pedestrian flows

Ayse Ozbil[a,*], John Peponis[b,*] and Brian Stone[b]

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[b]College of Architecture, Georgia Institute of Technology, Atlanta, GA 30332-0155, USA.
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*Corresponding authors.

Abstract The distribution of pedestrian movement by street segment in three areas in Atlanta is modeled in relation to measures of street connectivity and land use. Although land use accounts for the pronounced differences in average pedestrian volumes per area, the connectivity of the street network affects the distribution of pedestrians on a street-by-street basis within each of them. The measures of connectivity that are used describe the density of street connections and the extent to which streets are sinuous or aligned. This study enhances previous findings, particularly those using space syntax, by better controlling for the effects of land use as compared to the effects of street connectivity and network layout. Asserting the independent role of street network design is important given that streets act as the long-term framework within which land uses change over time. The measures of street connectivity are easy to implement on a GIS platform to support the evaluation and development of designs and regulatory frameworks that promote walking, whether it be in the interest of public health, in reducing automobile dependence or in supporting vibrant urban communities.
URBAN DESIGN International (2011) **16**, 125–141. doi:10.1057/udi.2011.2; published online 16 March 2011

Keywords: street connectivity; pedestrian movement; Atlanta; land use

Introduction: Does the Spatial Structure of Street Networks have Independent Effects on Pedestrian Movement?

The reduction of automobile dependence and the inducement of non-auto commuting have emerged as commonly shared city planning and urban design aims. Along with the ideals of smart growth and new urbanism, they are reshaping urban form across the United States. The studies of impact of the built environment on individual travel behavior that are reviewed below have generally focused on population densities, land use mix and the qualities of urban design. The latter has often been treated with reference to the immediate condition of individual streets, ranging from the dimensions and design of sidewalks to the frontages of retail or the prevailing levels of environmental comfort that may encourage pedestrian movement (Badland and Schofield, 2005; Ewing *et al*, 2006; Gehl *et al*, 2006; Ewing and Handy, 2009). Pedestrian safety, of course, is also shown to be a major factor in determining physical activity levels (Boarnet *et al*, 2005). Safe and pleasant conditions encourage walking (Brown *et al*, 2007).

These are undoubtedly important factors. However, an intuitive distinction can be drawn between urban environments in which pedestrian presence and walking are contained within a well-circumscribed enclave (that is, a shopping mall or a small pedestrian-friendly development) or directed towards well-defined local destinations (that is, a school or a transit station) and environments where pedestrian movement is distributed over larger areas, with a mixture of longer and shorter pedestrian paths, multiple and overlapping rather than converging trajectories and varied intensities. It would seem that in order to understand the latter and design towards them,

 URBAN DESIGN International Vol. 16, 2, 125–141
www.palgrave-journals.com/udi/

[Ozbil et al. ’11]

What Makes Paris Look like Paris?

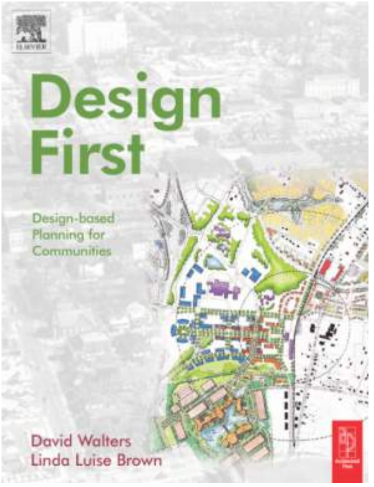
[Doerch et al. ’12]

Street Network Analysis

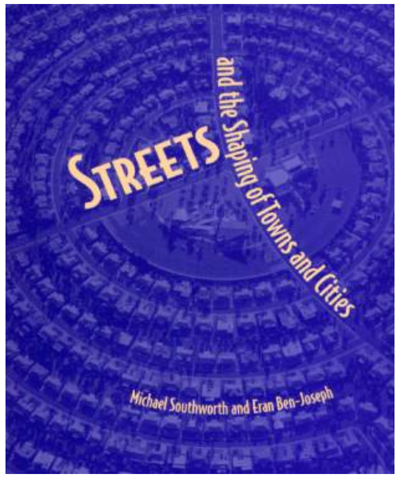
Street network descriptors

Related Work

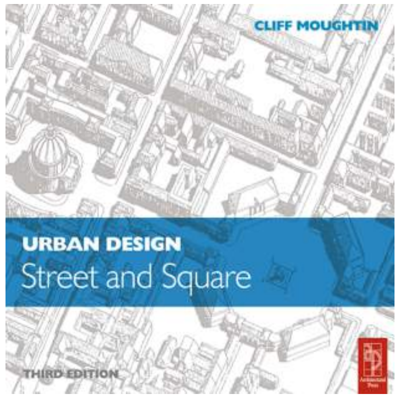
Urban Analysis



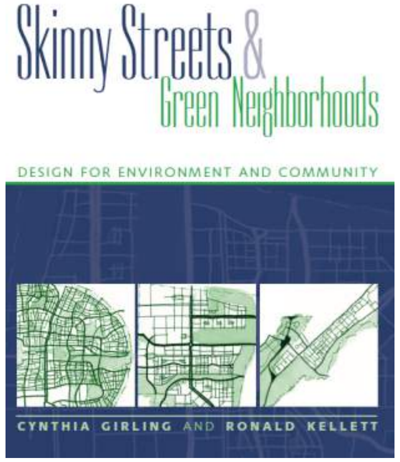
Walters & Brown 2004



Southworth & Ben-Joseph 2003

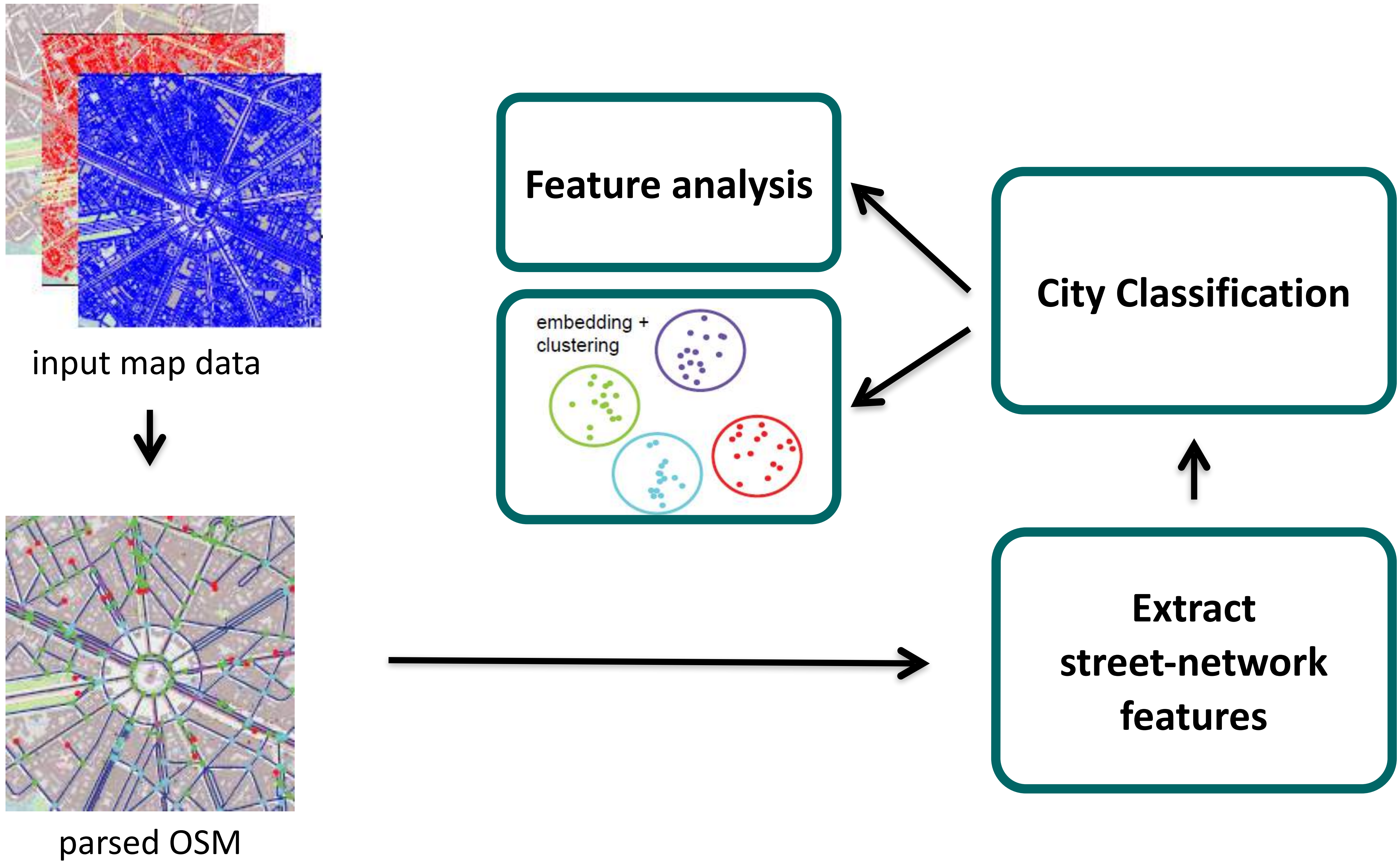


Moughtin 1992

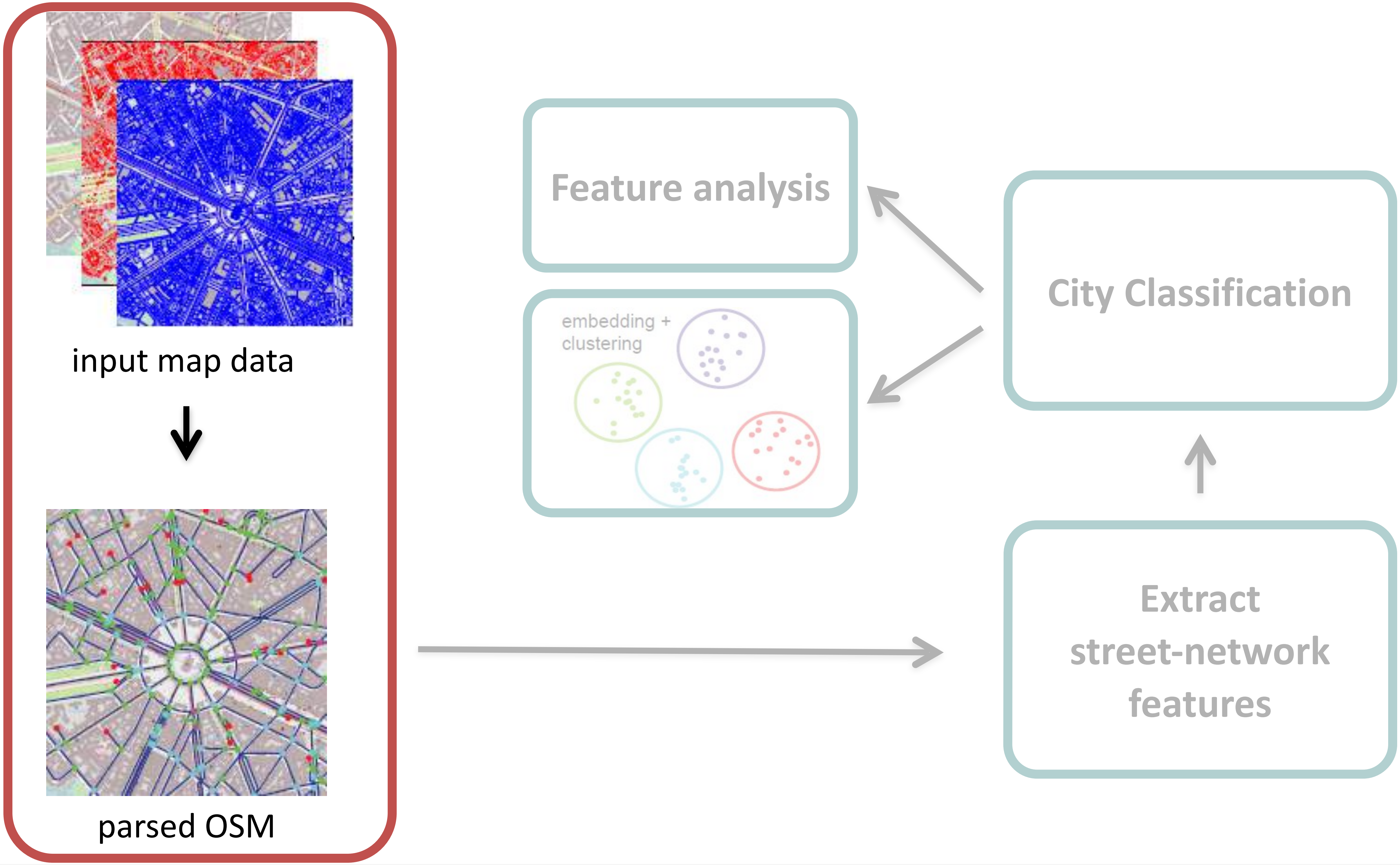


Gerling & Kellett 2005

Analysis Framework

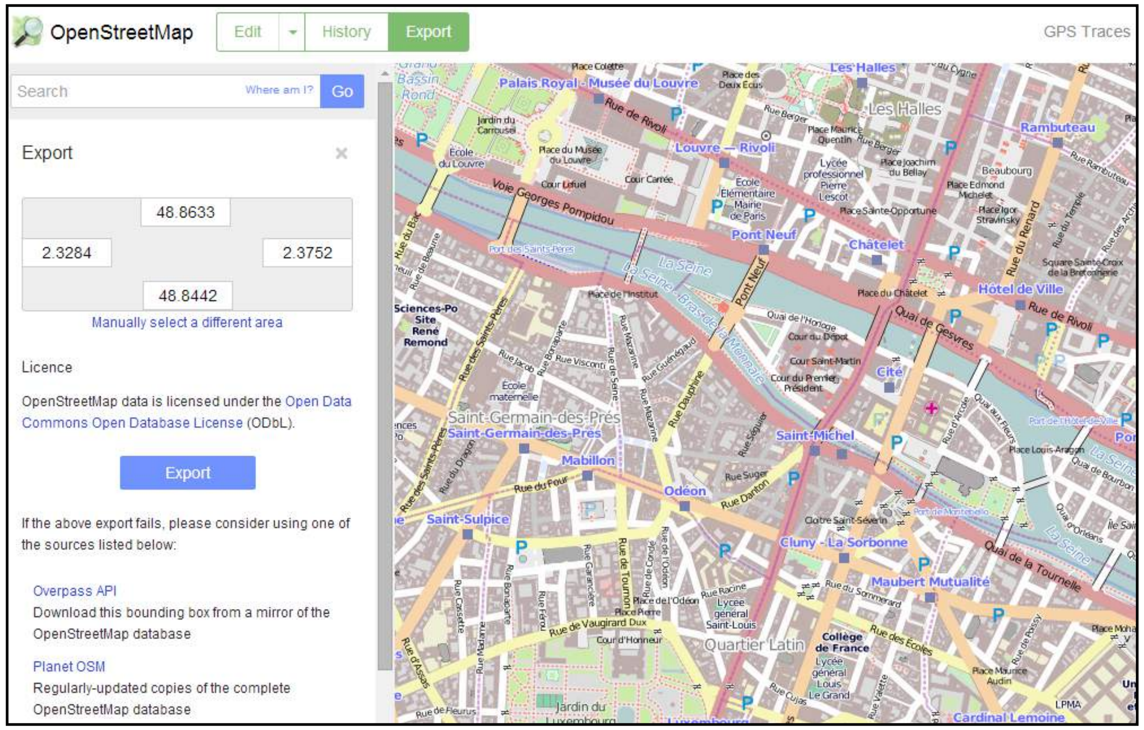


Analysis Framework



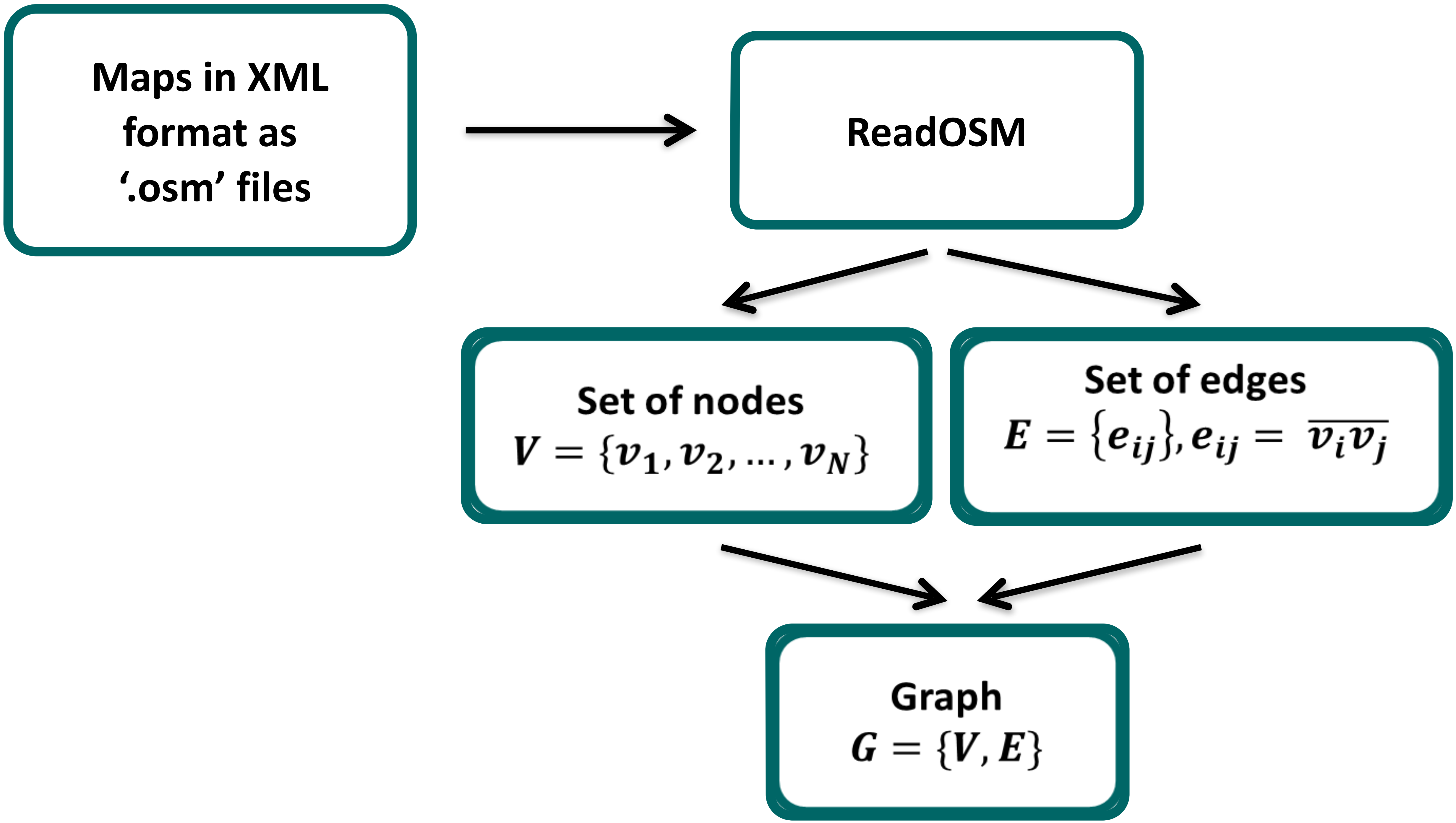
Data Gathering

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

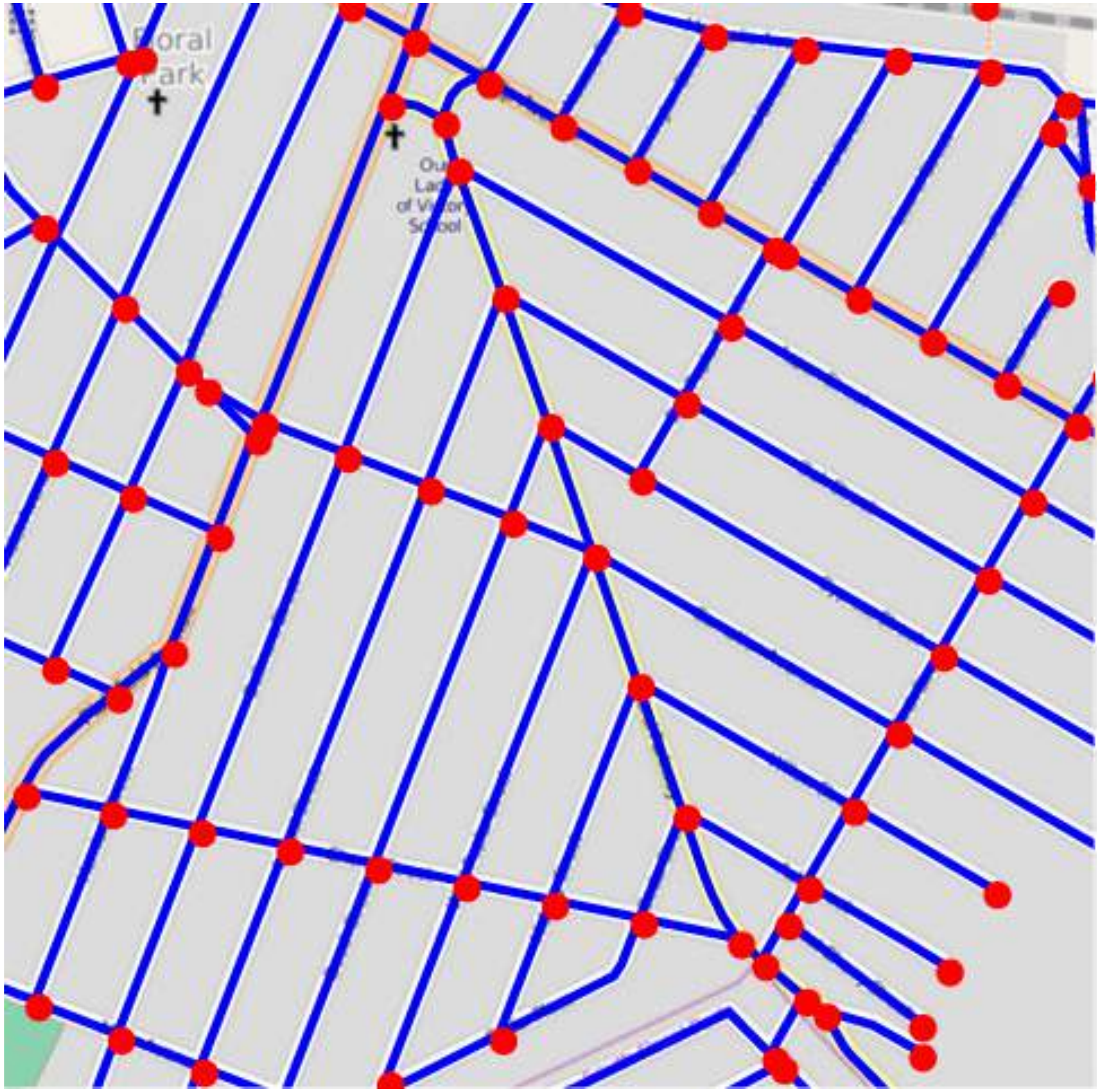


Beijing, Camp Durant, Cardiff, London, Los Angeles, Moscow, New York, Paris, Toronto, Vienna

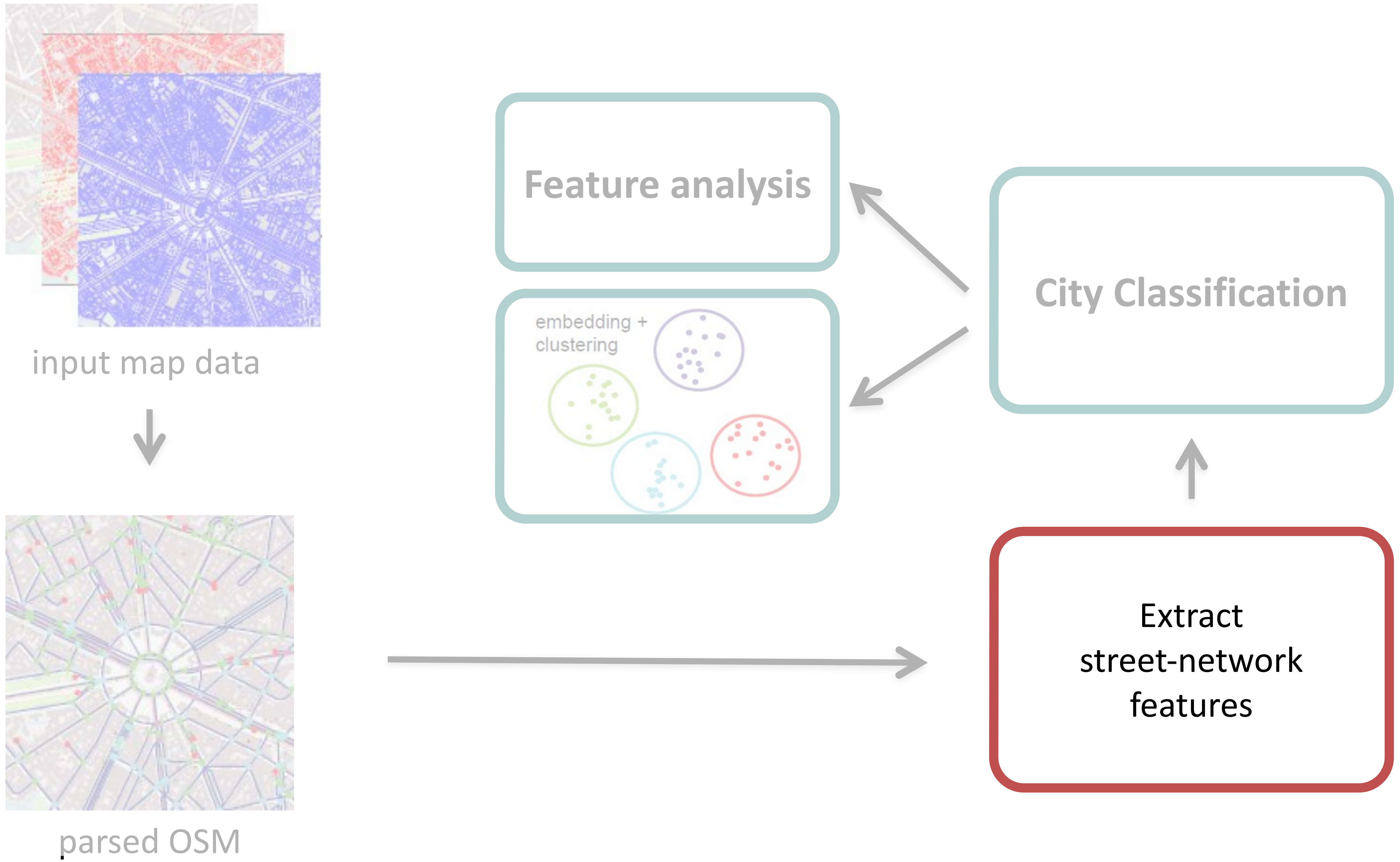
Encoding Street Networks



Parsed Street Data



Algorithm


input map data
parsed OSM
Feature analysis
embedding +
clustering
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

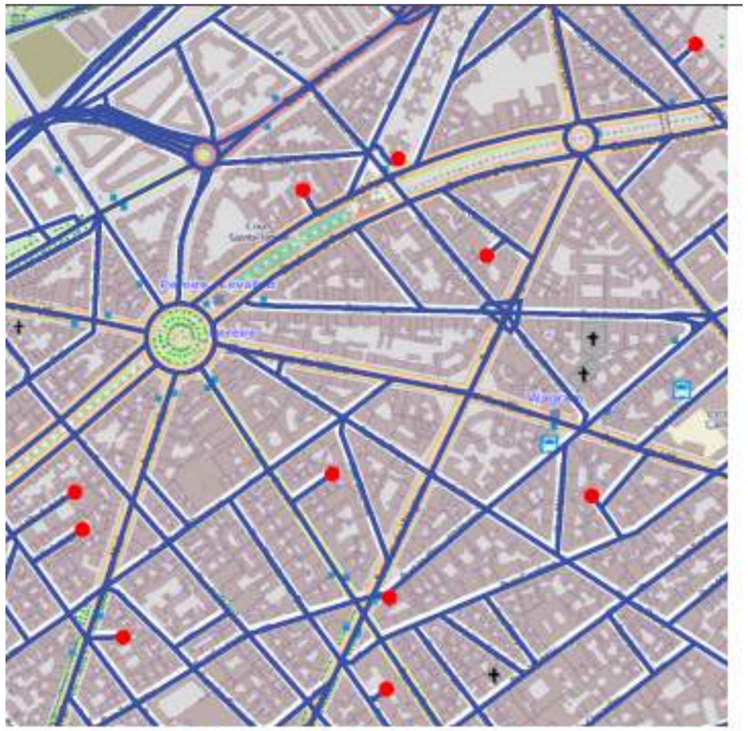
Street Network Analysis

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

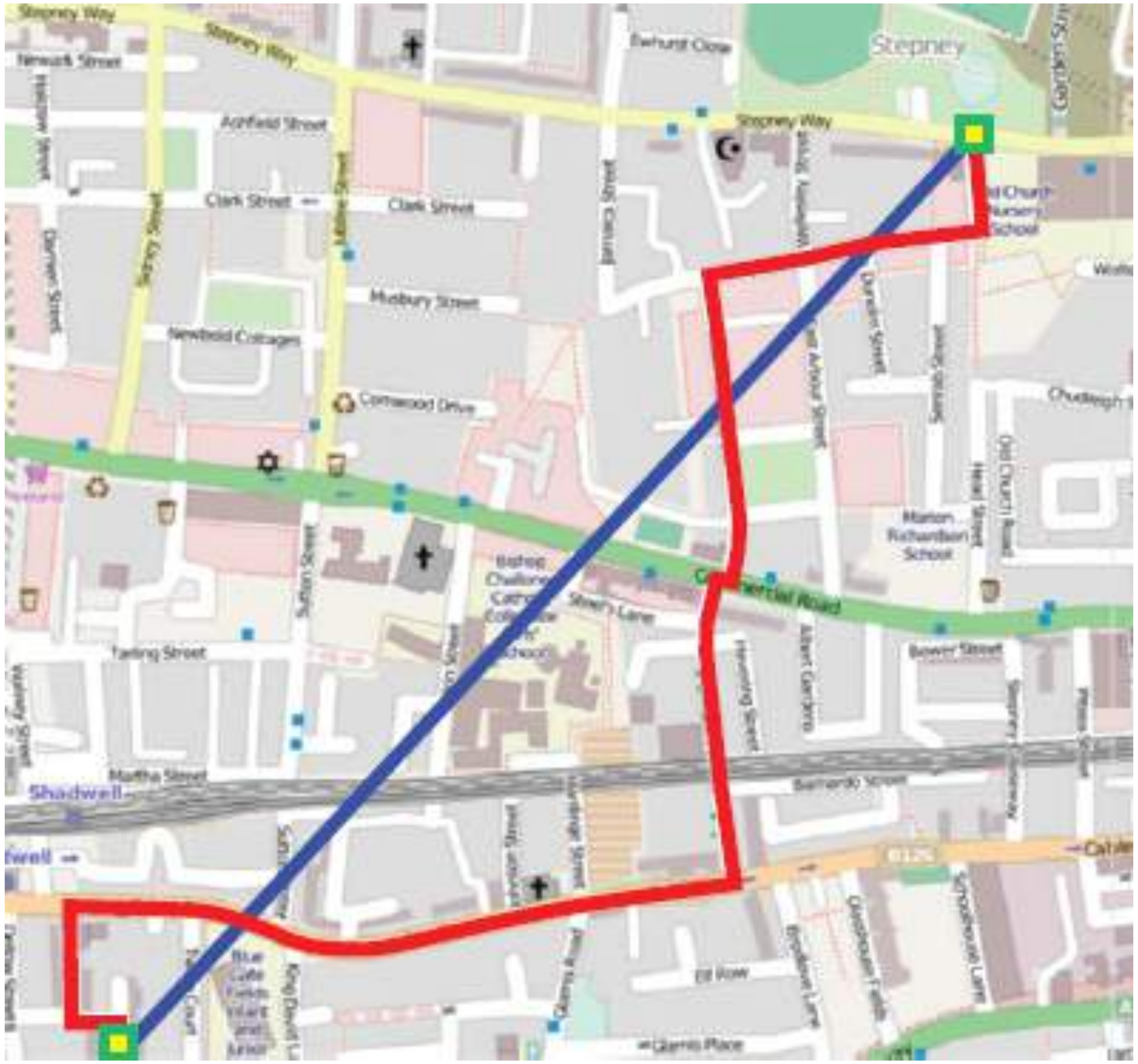
Geometric Features

- **Total street length**

- **Average street length**

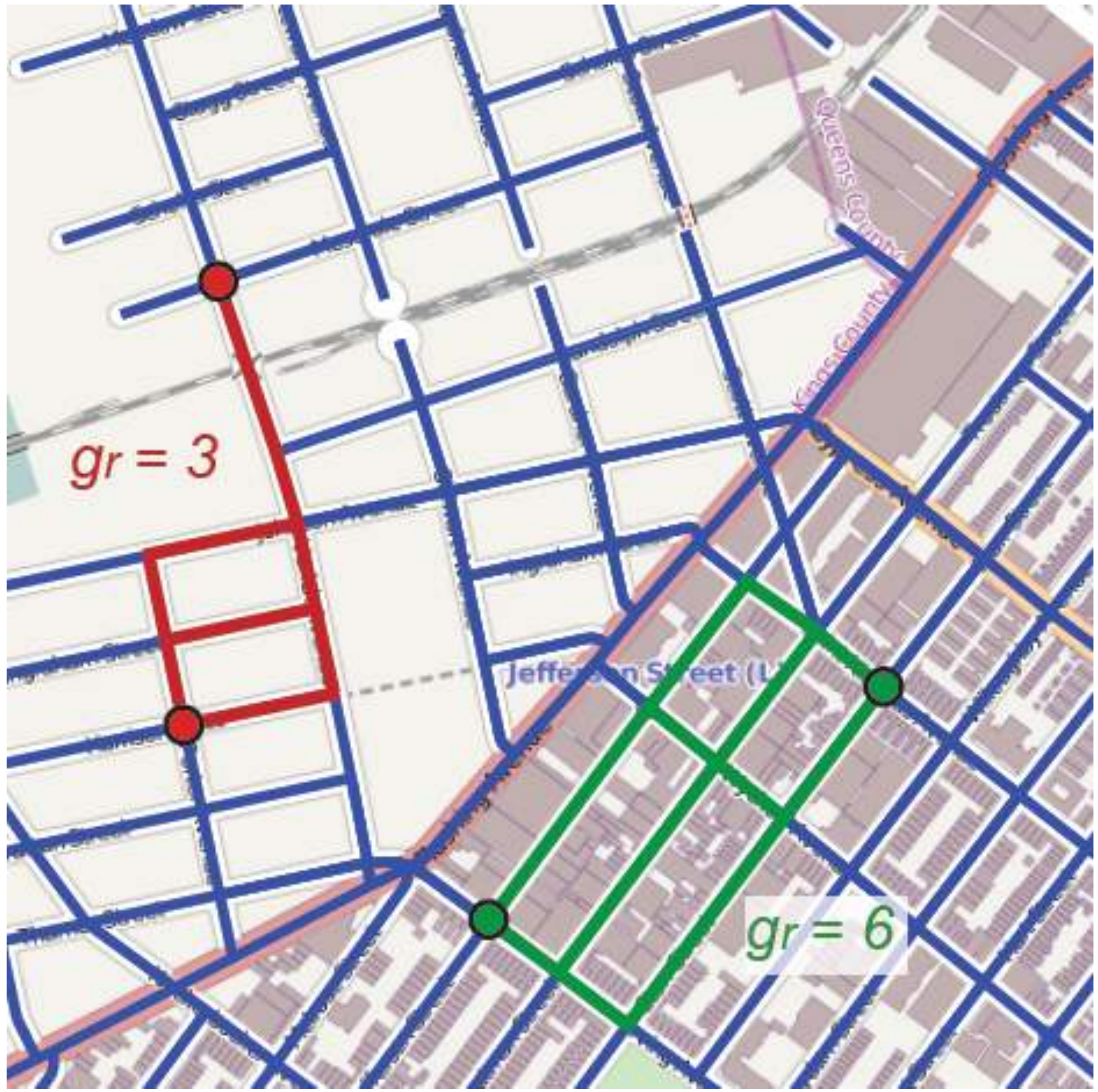
Geometric Features

Transportation convenience



Geometric Features

Redundancy (g_r)

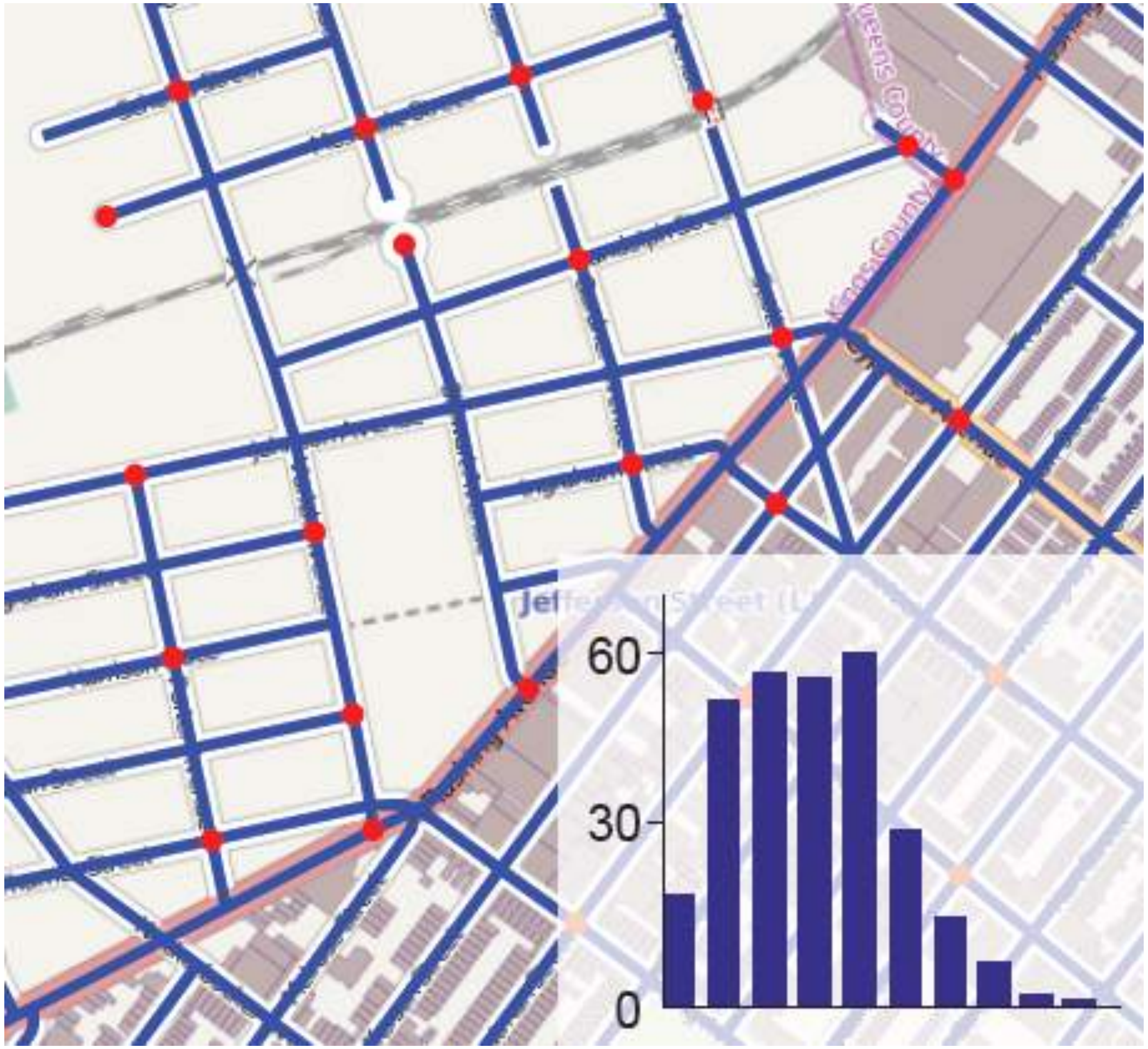


Geometric Features

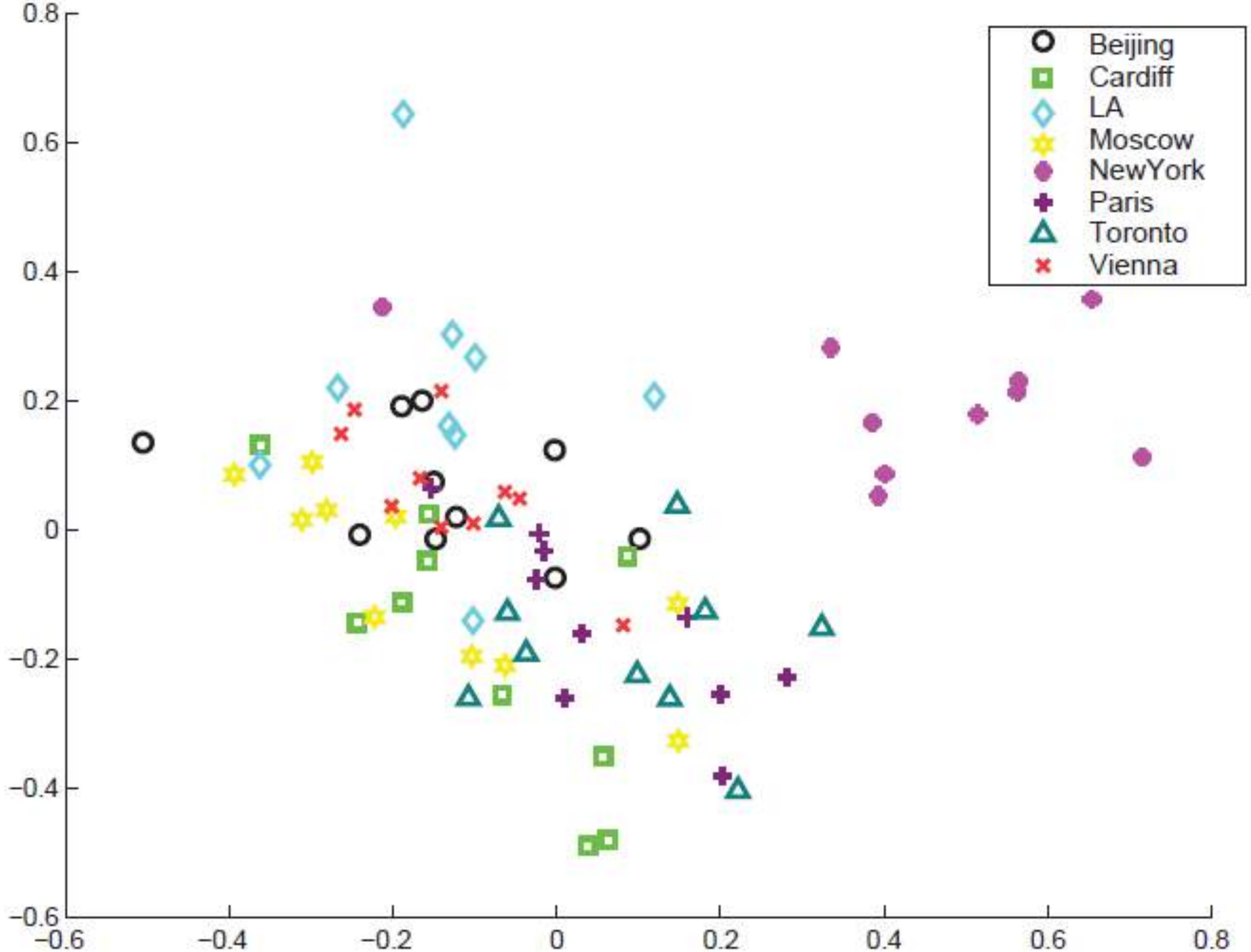
Metric reach *(think geodesic fan)*

Geometric Features

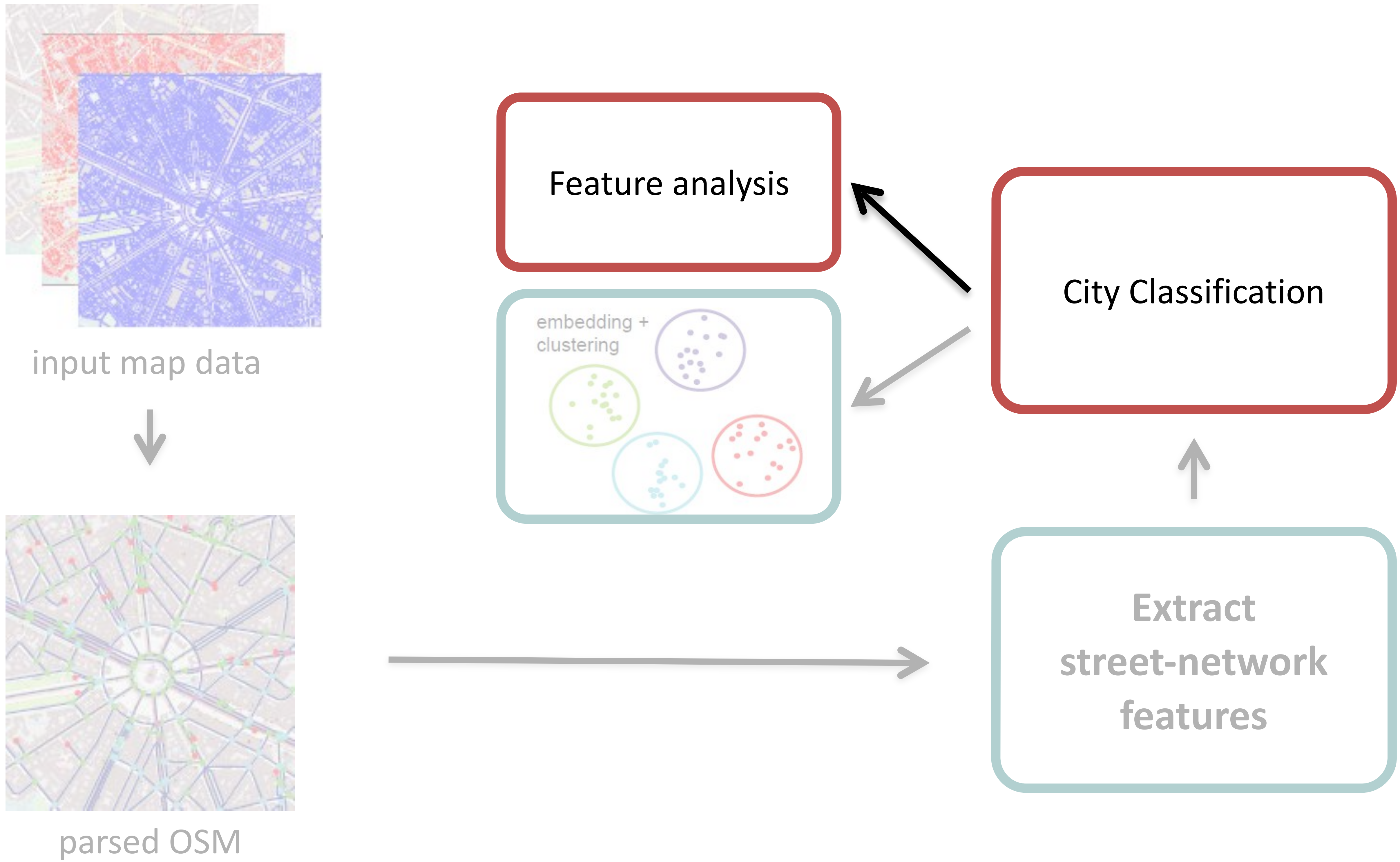
Travel distance histogram *(think shape distribution)*



Bag of Features



Analysis and Classification



Good Features

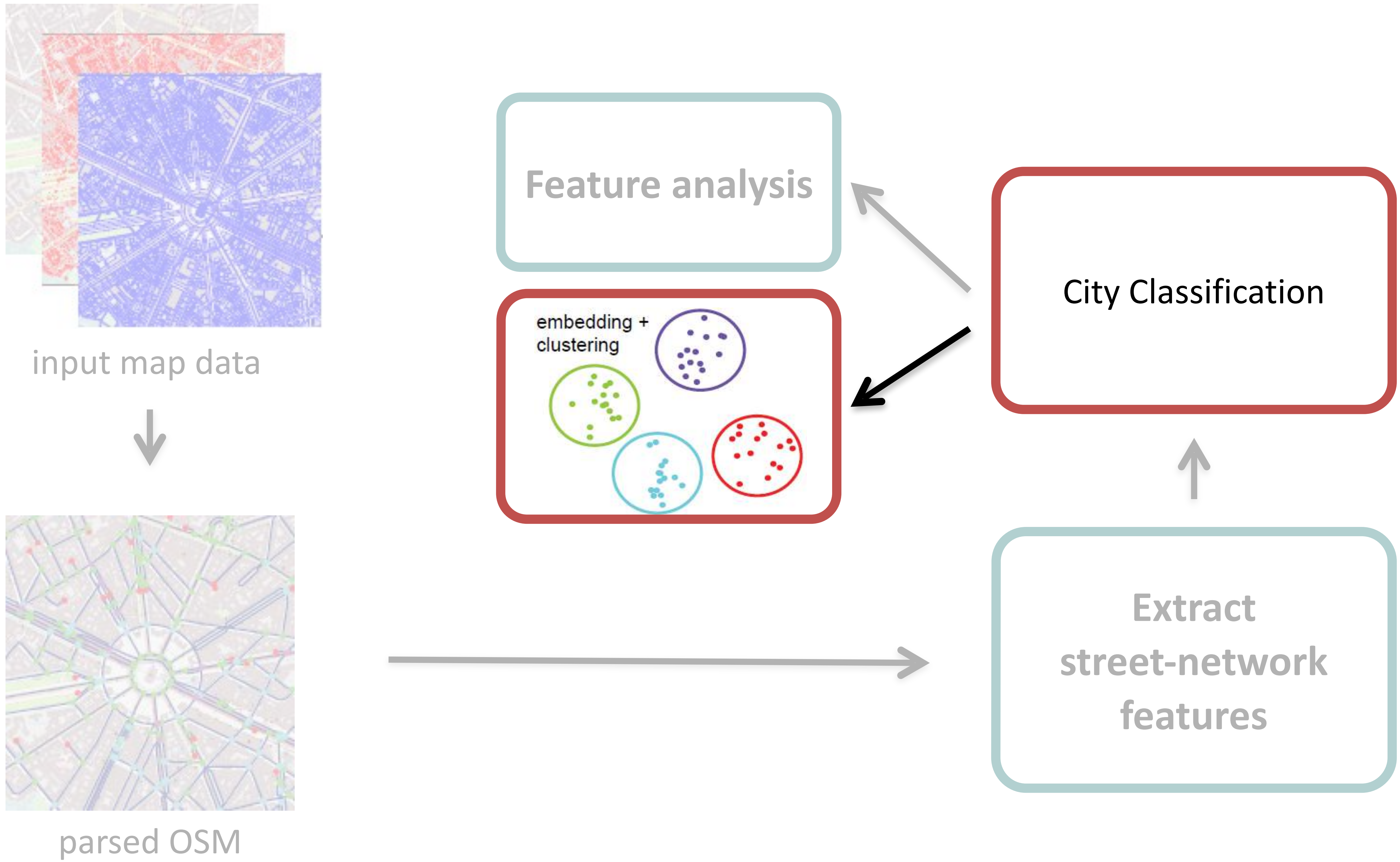
Inter-city classification

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

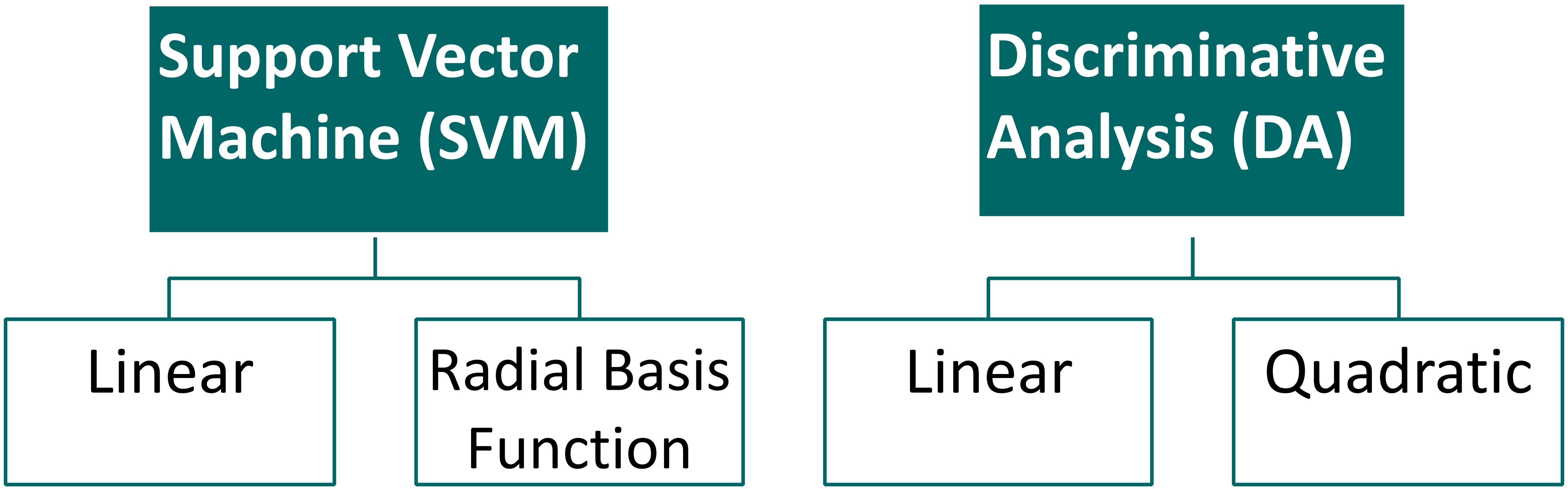
Good Features

Intra-city classification

Classification



City Classification

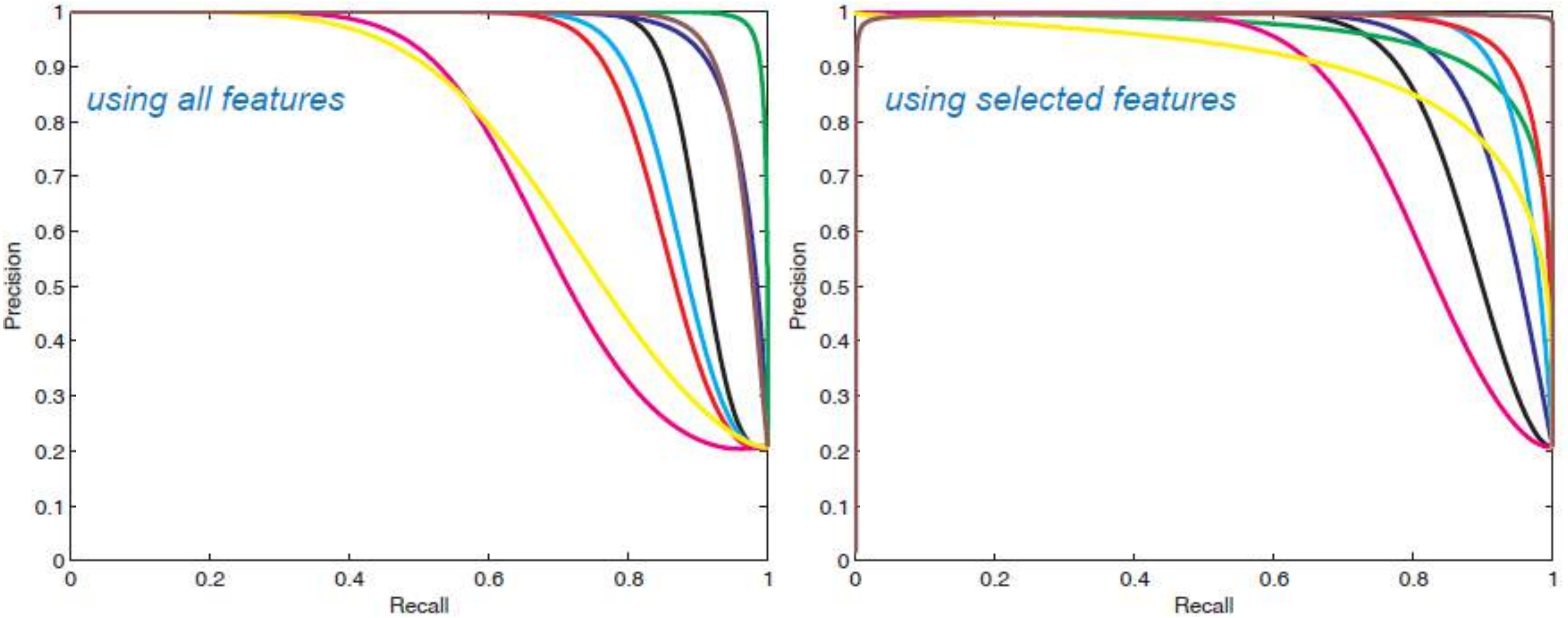


Inter Classification

classification type	SVML	SVMR	LDA	QDA
multi-class	35.8	41.7	47.3	53.4
Beijing and others	90.2	90.6	88.7	76.0
Camp Durant and others	90.2	91.1	88.8	89.9
Cardiff and others	91.1	91.3	83.8	84.1
LA and others	88.8	89.0	82.0	83.0
London and others	90.8	91.2	86.6	88.4
Moscow and others	89.3	89.1	80.3	83.7
NY and others	93.6	94.7	90.7	90.5
Paris and others	92.9	93.2	87.2	89.4
Toronto and others	89.0	89.1	67.9	66.2
Vienna and others	90.0	90.0	74.6	74.0

Precision-Recall

Classification using all versus selected features



Confusion Matrix

What is a Good Scale?

$0.25km^2$

$1km^2$

$4km^2$

Comparison with Image Features

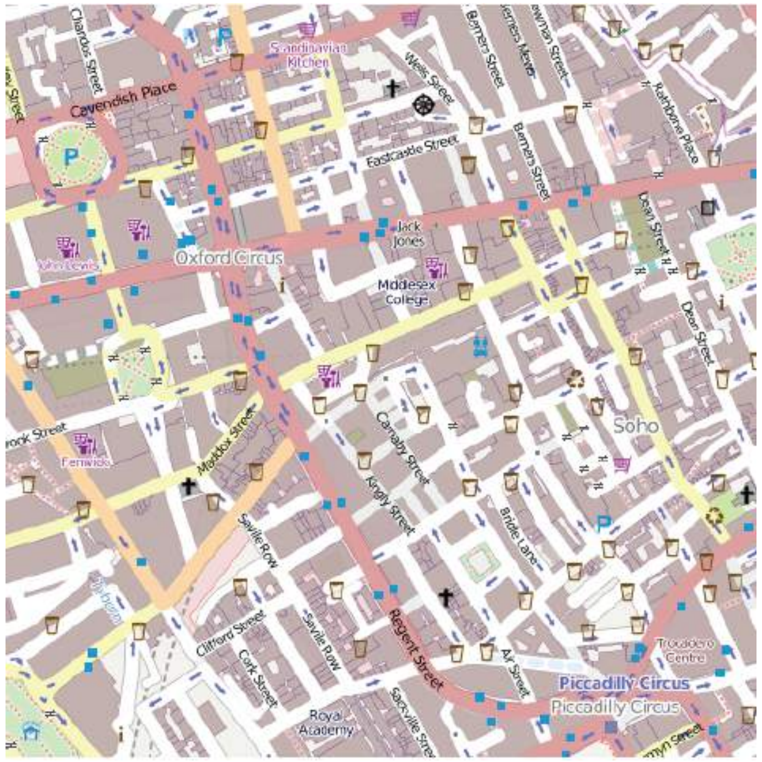
Comparison with Image Features

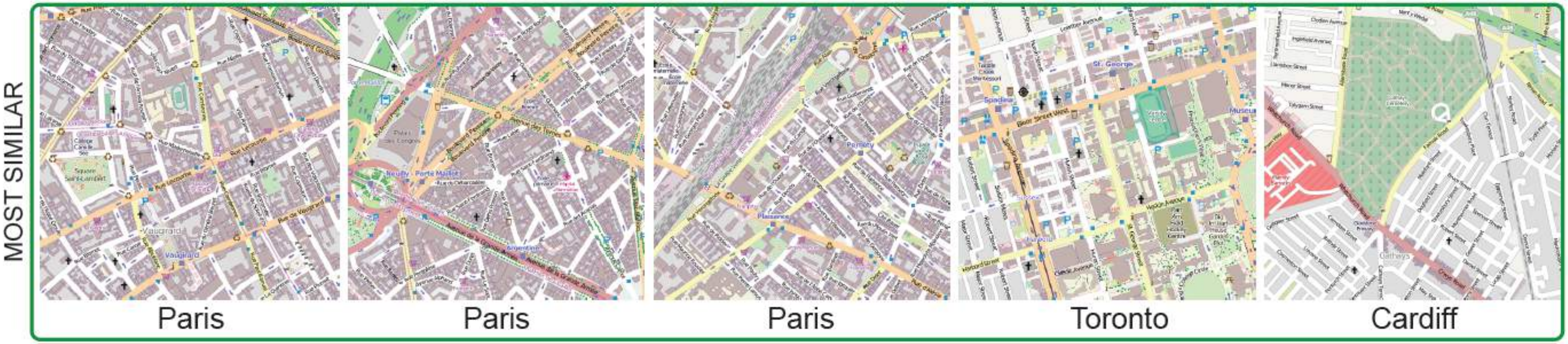
- GIST features

- 20-40% performance loss

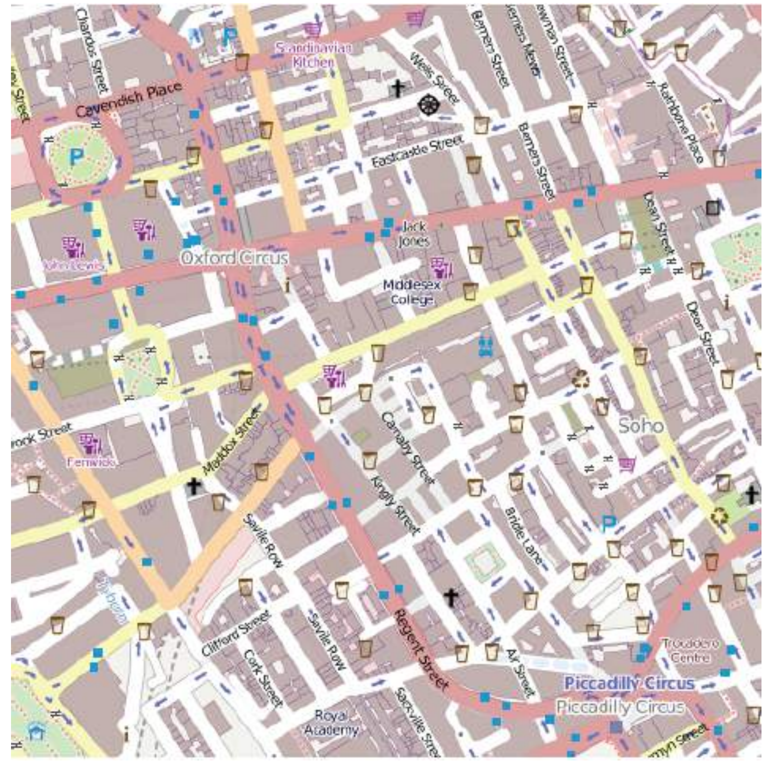
Applications

City Retrieval

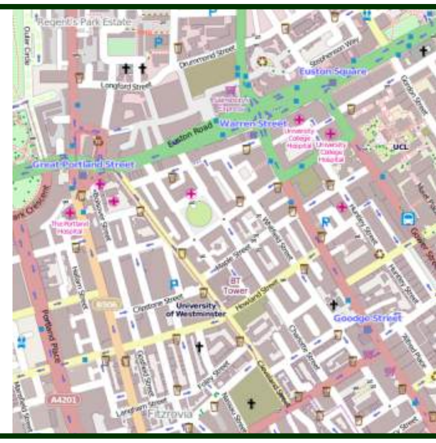




City Retrieval



Synthetic City Generation



$+ \quad \vec{f}(L) = \{t_{val}, \dots\}$

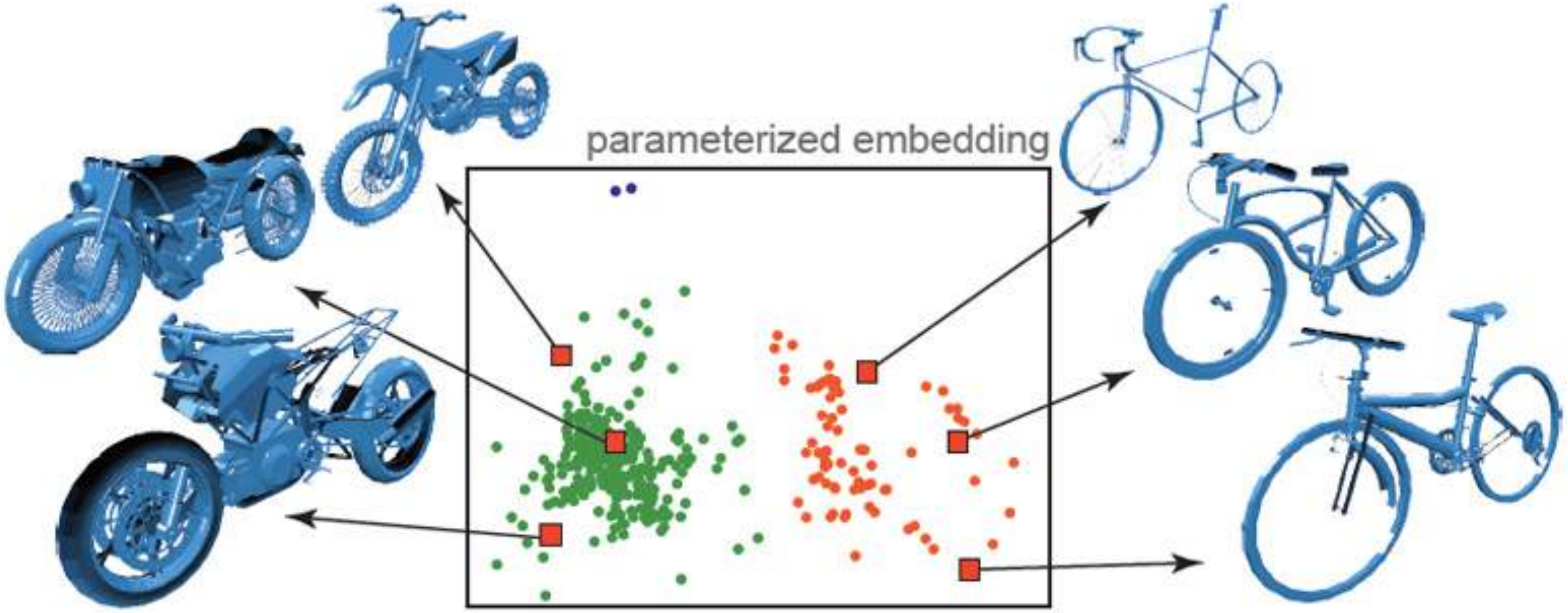
target

input

Synthesis Algorithm

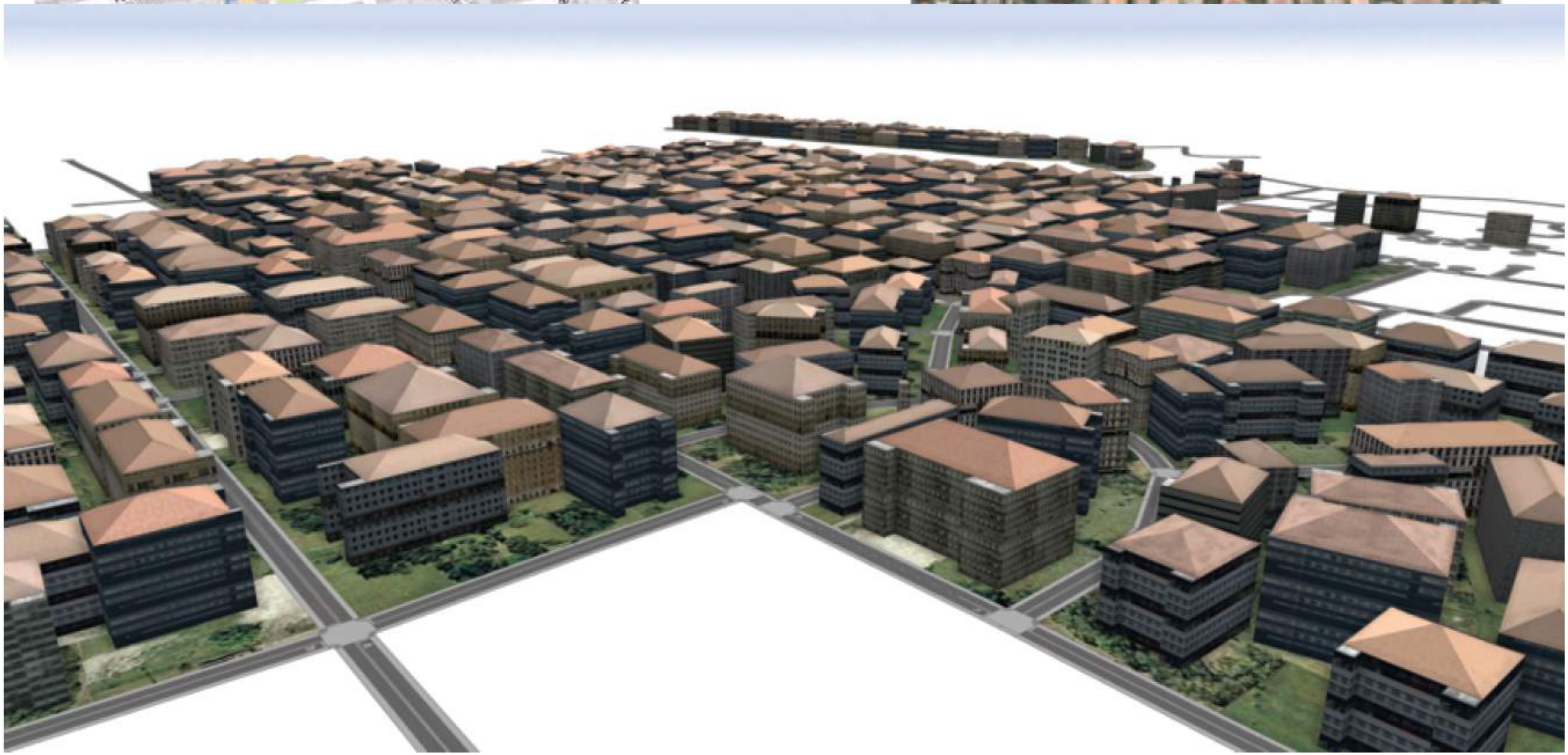
Synthesized layout

Existing Algorithm?



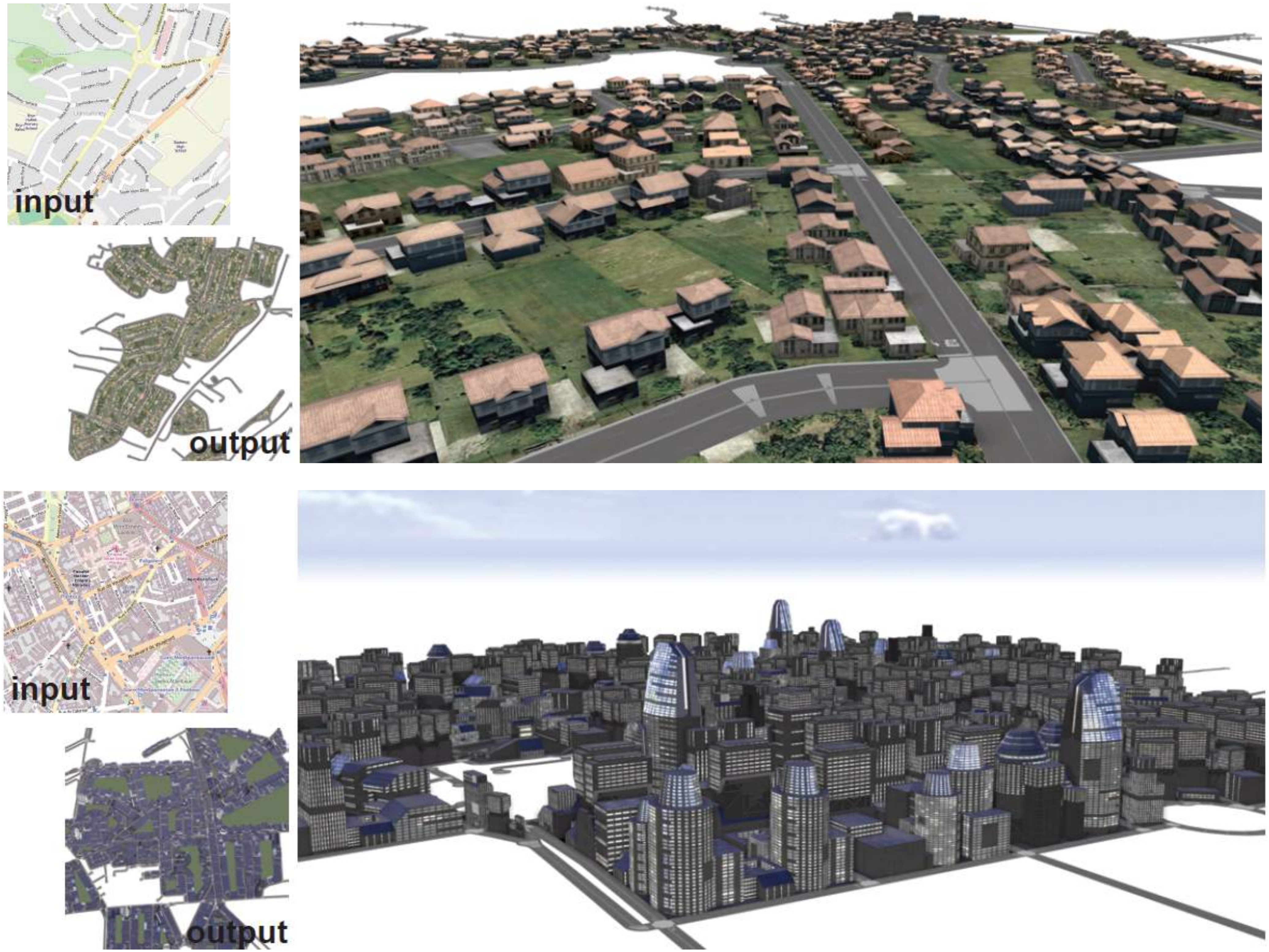
[Averkiou et al., Eurographics 2014]

Synthetic City Generation



AlHalawani et al., SGP 2014

Synthetic City Generation



AlHalawani et al., SGP 2014

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

AAG 2014

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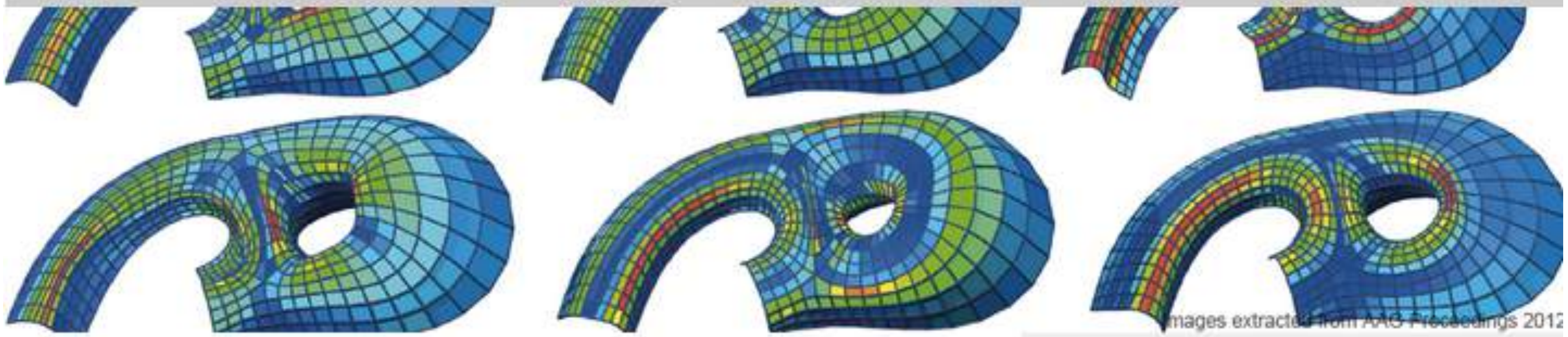

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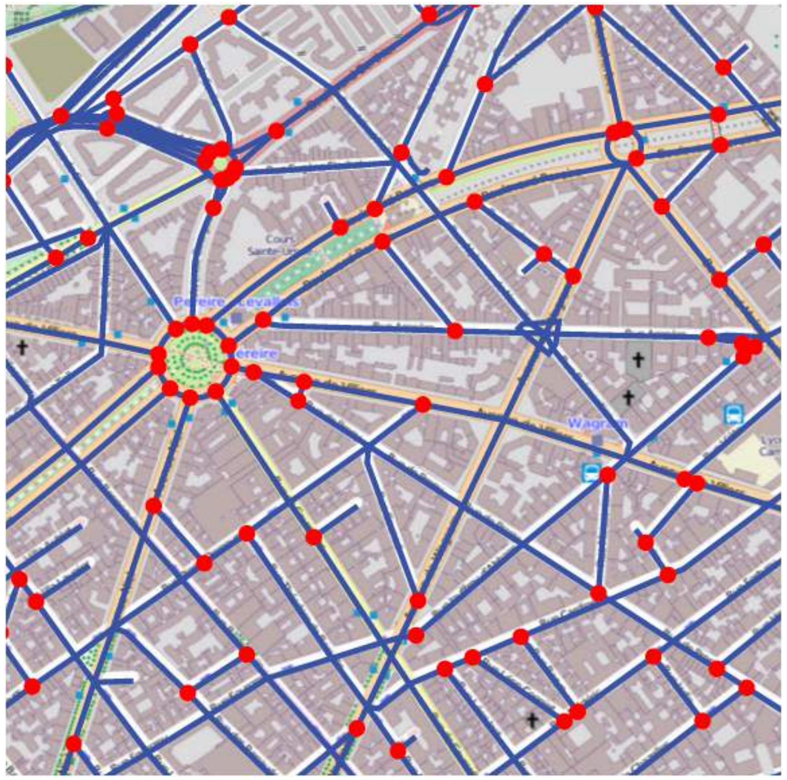
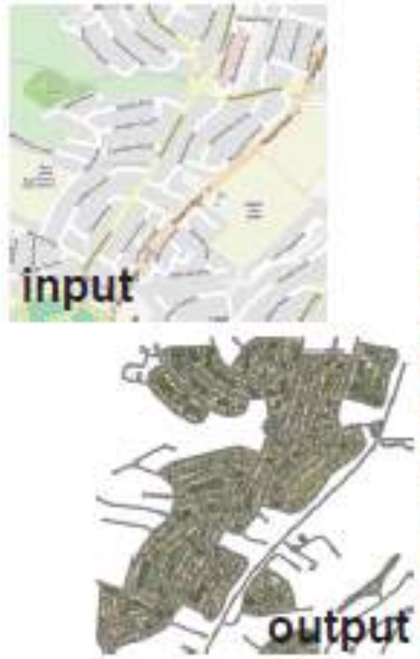
Thank You





http://geometry.cs.ucl.ac.uk/projects/2014/whatMakesLondon/

(code + data available)