# Spatial Signatures
## *Dynamically building the built environment*

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Abstract: Blah blah blah

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## 1. Introduction

Fleischmann et al. (2020a) is king.

## 2. (Urban) form and function

Research studying urban form has a long tradition (Geddes, 1915, Trewartha, 1934), whilst urban morphology as an independent area of research has established in the 1960s. It originated independently in geography (Conzen, 1960) and architecture (Muratori, 1959), reflecting its inherently multi-disciplinary nature, which was later reinforced by the inclusion of socio-economic component in works of Panerai et al. (1997). The original methods are predominantly qualitative, and this tendency persists (Dibble, 2016). First notable quantitative approaches date to the late 1980s and 1990s, reflecting advancements in computer science and newly available data capturing built environment. Two strains of research have emerged, one based on cartographic (vector) representation of the urban environment, assessing its boundaries (Batty and Longley, 1987), street networks (Hillier, 1996, Porta et al., 2006) and other elements (Pivo, 1993). The other one based on earth observation exploiting remotely sensed data to capture the change of footprints of urban areas (Howarth and Boasson, 1983) or classification of land cover (European Environment Agency, 1990).

The distinction between two approaches based on their primary source of data can also be applied to the recent literature reflecting the state of the art of characterization of urban form. A quantitative branch of urban morphology, or urban morphometrics, working predominantly with vector representation of elements of urban form has rapidly grown and offers an abundant selection of measurable characters describing different aspects of form (Fleischmann et al., 2020b). Methods focusing on a single aspect (Porta et al., 2006) were replaced by others aiming to better reflect the complexity of urban form by combining multiple morphometric characters into a single model, often leading to a classification of some sort (Song and Knaap, 2007). The focus on classification is becoming more present in recent years, starting from small-scale studies classifying blocks and streets (Gil et al., 2012) to larger areas and higher granularity (Schirmer and Axhausen, 2015, Araldi and Fusco, 2019, Bobkova et al., 2019, Dibble et al., 2019, Jochem et al., 2020).

In parallel, advancements in remote sensing led to a range of classification frameworks based on various conceptualizations of the urban fabric. However, there is one significant difference between classification derived via morphometric characterization and the one of remote sensing origin. Where the former is mostly unsupervised (Araldi and Fusco, 2019, Schirmer and Axhausen, 2015), the latter tends towards supervised techniques, capturing classes defined prior to the analysis (Pauleit and Duhme, 2000). Two most prominent classification models used as an input (i.e. training set) are Local Climate Zones (Stewart and Oke, 2012) defining ten built-form types and seven land cover types, used by Koc et al. (2017) or Taubenböck et al. (2020), and Urban Structural Type, a generic typology based on the notion of internal homogeneity of types (Lehner and Blaschke, 2019).

However, all the methods above have certain limits, mostly related to detail, comprehensiveness and scalability, lacking at least on them. Detail reflects spatial granularity of resulting classification, where more granular, i.e. more detailed, unit has the ability to capture smaller nuances of the urban environment and better reflect local characters or a place. Methods based on a unit which can be further subdivided (Dibble et al., 2019, Jochem et al., 2020, Araldi and Fusco, 2019, Gil et al., 2012), therefore does not ensure internal homogeneity, can result in classes driven by the heterogeneity instead of the unit instead of the actual pattern of urban form. Comprehensiveness refers to the number of characters (variables) used in the classification procedure. Small sets of characters as in Bobkova et al. (2019) or Serra et al. (2018) are prone to a selection bias and will less likely reflect the complexity of the urban environment. Finally, scalability reflects the ability of the proposed method to scale up to large extents of metropolitan areas or national-level studies. While some works illustrate such a potential (Jochem et al., 2020, Schirmer and Axhausen, 2015, Bobkova et al., 2019, Araldi and Fusco, 2019), others which may overcome other issues are less likely to scale from their original limits (Dibble et al., 2019). Furthermore, computational scalability can be limited by data availability. Methods dependent on a high amount of detailed vector data (Bobkova et al., 2019) can be hardly applied in other contexts where such input is not available.

# 3. Spatial Signatures

## 3.1 *Definition*

## 3.2 *Building blocks: the Enclosed Tesselation*

This section proposes a novel and theoretically-informed delineation of space to support the development of spatial signatures. Since spatial signatures are conceptualised as highly granular in space, considering the ideal unit of analysis at which to measure them is of utmost importance.

An ideal unit of analysis for spatial signatures will partition space into consistent blocks of built *and* lived environment. In other words, a successful candidate will need to meet the following XXX characteristics:

## 3.3 *Embedding form and funtion into Spatial Signatures*

# 4. Illustration

# 5. Conclusions

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