Characterisation of space in Great Britain using the Spatial Signatures model

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ABSTRACT

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Background & Summary

(700 words maximum) An overview of the study design, the assay(s) performed, and the created data, including any background information needed to put this study in the context of previous work and the literature. The section should also briefly outline the broader goals that motivated the creation of this dataset and the potential reuse value. We also encourage authors to include a figure that provides a schematic overview of the study and assay(s) design. The Background & Summary should not include subheadings. This section and the other main body sections of the manuscript should include citations to the literature as needed.

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Methods

The Methods should include detailed text describing any steps or procedures used in producing the data, including full descriptions of the experimental design, data acquisition assays, and any computational processing (e.g. normalization, image feature extraction). See the detailed section in our submission guidelines for advice on writing a transparent and reproducible methods section. Related methods should be grouped under corresponding subheadings where possible, and methods should be described in enough detail to allow other researchers to interpret and repeat, if required, the full study. Specific data outputs should be explicitly referenced via data citation (see Data Records and Citing Data, below).

Authors should cite previous descriptions of the methods under use, but ideally the method descriptions should be complete enough for others to understand and reproduce the methods and processing steps without referring to associated publications. There is no limit to the length of the Methods section. Subheadings should not be numbered.

Subsection

Example text under a subsection. Bulleted lists may be used where appropriate, e.g.

- First item
- Second item

Third-level section

Topical subheadings are allowed.

The method of identification of spatial signatures consists of three top level steps. First, we need to delineate spatial unit of analysis, one that reflects the structure of urban phenomena on a very granular level. Then we charactercterise each of them according to the form and function capturing the nature of each unit and its spatial context. Finally, we use cluster analysis to derive a typology of our spatial units that, once combined into contiguous areas, forms a typology of spatial signatures.

Spatial unit

The first major methodological decision needs to be taken on the definition of the spatial unit. As mentioned, it needs to reflect space in a granular manner and we argue that it should fulfil three conditions. First, it should be *indivisible*, meaning that when such a unit would be subdivided into smaller parts, none of them would be enough to capture the nature of spatial signature. Second, it needs to be *internally consistent* - it should always reflect only a single signature type. Last, it should be geographically *exhaustive*, covering entirety of the study area.

Spatial units used in literature can be split into three groups. One is using administrative boundaries like city regions, wards or census output areas, that are convenient to obatain and can be easily linked to auxiliarry data. However, those rarely reflect the morphological composition of urban space and in some cases may even “obscure morphologic reality” REF Taubenbock 2019. At the same time, most of them are divisible and larger units are not alwyas internally consistent. Another group is based on arbitrary uniform grids linked either to spatial indexing method like H3 REF or OS National Grid REF, or to anciliarry data of remote sensing or other origins like a WorldPop grid REF. The issue is that grids cannot be considered internally consistent as they have no relation to the real-life spatial pattern. Finally, urban morphology tends to use morphological elements as street segments REF, blocks REF buildings or plots as a unit of analysis. Some of those could be seen as indivisible and internally consistent but since they are largely based on built-up fabric, they are not exhaustive. When there is no builiding or street, there is no spatial unit to work with. Plots could be theoretically considered as exhaustive, consistent and indivisible but there is no accepted conceptual definition and unified geometric representation (REF Kropf).

We are, therefore, proposing an application of an alternative spatial unit called *enclosed tessellation cell* (ETC), defined as:

A characterisation of space based on form and function designed to understand urban environments

ETC follows the morphological tradition in a sense that is it based on the physical elements of an enviroment but overcomes the drawbacks of conventionally used units. Its geometry is generated in three steps illustrated on a Figure 2. First, a set of features representing physical barriers subdividing space, in our case composed of street network, railways, rivers and a coastline, is combined together, generating a layer of boundaries. These then partition space into smaller enclosed geometries called *enclosures*, which can be very granular or very coarse depending on the geographic context. In dense city centres where a single enclosure represent a single block is a high frequency of small enclosures, while in the countryside, we can observe very few large enclosures as their delimiters are far away from each other. Enclosures are then combined with building footprints, posing as anchors in the space and are subdivided into enclosed tessellation cells using the morphological tessellation algorithm REF, a polygon-based adaptation of Voronoi tessellation. Resulting geometries are indivisible as they contain, at most, a single achor building, internally consistent due to their granularity and link to morphological elements composing urban fabric, and geogrpahically exhasutive as they cover entire area limited by specified boundaries.

In the case of classification of Great Britain, street networks are extracted from OS Open Roads datasets (REF) representing simplified road centrelines cleaned of road segments under the ground. Railways are retrieved from OS OpenMap - Local ("RailwayTrack" layer) which captures surfance railway tracks. Rivers are extracted from OS OpenRivers (REF) representing river network of GB as centrelines, and a coastline is retrieved from OS Strategi® (2016) REF, capturing coastline as a continous line geometry. Building geometry is extracted, again, from OS OpenMap - Local ("Building" layer) and represents generalised building footprint polygons. Note that the dataset does not distinguish between individual buildings when they are adajcent (e.g. perimeter block composed of multiple buildings is represent by a single polygon).

Data Records

The Data Records section should be used to explain each data record associated with this work, including the repository where this information is stored, and to provide an overview of the data files and their formats. Each external data record should be cited numerically in the text of this section, for example[2], and included in the main reference list as described below. A data citation should also be placed in the subsection of the Methods containing the data-collection or analytical procedure(s) used to derive the corresponding record. Providing a direct link to the dataset may also be helpful to readers (https://doi.org/10.6084/m9.figshare.853801).

Tables should be used to support the data records, and should clearly indicate the samples and subjects (study inputs), their provenance, and the experimental manipulations performed on each (please see ’Tables’ below). They should also specify the data output resulting from each data-collection or analytical step, should these form part of the archived record.

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Acknowledgements should be brief, and should not include thanks to anonymous referees and editors, or effusive comments. Grant or contribution numbers may be acknowledged.

Author contributions statement

Must include all authors, identified by initials, for example: A.A. conceived the experiment(s), A.A. and B.A. conducted the experiment(s), C.A. and D.A. analysed the results. All authors reviewed the manuscript.

Competing interests

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The corresponding author is responsible for providing a competing interests statement on behalf of all authors of the paper. This statement must be included in the submitted article file.

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Figures, tables, and their legends, should be included at the end of the document. Figures and tables can be referenced in LaTeX using the ref command, e.g. Figure 1 and Table 1.

Authors are encouraged to provide one or more tables that provide basic information on the main 'inputs' to the study (e.g. samples, participants, or information sources) and the main data outputs of the study. Tables in the manuscript should generally not be used to present primary data (i.e. measurements). Tables containing primary data should be submitted to an appropriate data repository.

Tables may be provided within the LaTeX document or as separate files (tab-delimited text or Excel files). Legends, where needed, should be included here. Generally, a Data Descriptor should have fewer than ten Tables, but more may be allowed when needed. Tables may be of any size, but only Tables which fit onto a single printed page will be included in the PDF version of the article (up to a maximum of three).

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Figure 1. Legend (350 words max). Example legend text.

Condition	n	p
A	5	0.1
B	10	0.01

Table 1. Legend (350 words max). Example legend text.

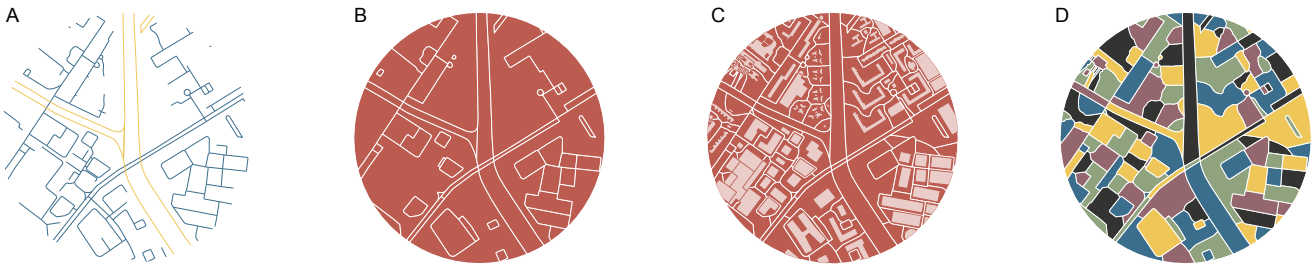

Figure 2. Diagram illustrating the sequential steps leading to the delineation of enclosed tessellation. From a series of enclosing components, where blue are streets and yellow river banks (A), to enclosures (B), incorporation of buildings as anchors (C) to final tessellation cells (D).