A Natural Definition for the Boundaries of Cities

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Our society is witnessing a transition from rural to urban environments. To respond to the challenges that this transition imposes upon us, we need to be able to understand urban environments and to observe and quantify the phenomena that happen upon them. This is producing a new wave of multi-disciplinar studies that aim at producing the methodologies and tools to understand both the physical component of cities and their social dynamics.

Despite these efforts to produce objective descriptions of our settlements, researchers have been constrained by a fundamental question, what is a city. This is one of the most primary questions that an urban science must be able to answer, since without this definition we will not be able to advance in our understanding.

We need to be able to procure objective and comparable definitions for the boundaries of our cities such that they allow to construct studies that span several countries. Numerous articles [1, 2] have already shown how varying definitions of cities affect the measurements taken upon them, even leading to contradictory results [3]. What constitutes a city is influenced by its cultural context, and the current boundaries delineated by administrative bodies are affected by historical or political reasons. This differing criteria used among different countries due to cultural specificities forbid large scale studies and hinder the evolution of our research field.

A city is not a single object. A city behaves differently depending on what sort of phenomena we try to measure. Accordingly, several definitions for its limits should coexist. Our approach focus on the understanding of cities as dense continuous urban cores. This is the smallest of all possible definitions, and future work should find new methodologies to define functional areas, or other regional aggregates.

We present in this paper a simple procedure to create a natural definition for the limits of urban environments. This boundary is created through the observation of an intrinsic property of the system, its fractal dimension. By obtaining the percolation at several thresholds we obtain different partitions of the system, which are then compared by their average fractal dimension, choosing the threshold that maximises it. In order to improve the results, the hierarchical index proposed in [4] is applied which summarises the percolation process before applying these thresholding procedure. This methodology is an improvement of a previous effort in order to adapt it to the global dataset of population [5]. We intend to simultaneously give an answer to what is a city and to create a dataset that is accessible for the wider research community. We hope that this can become a useful

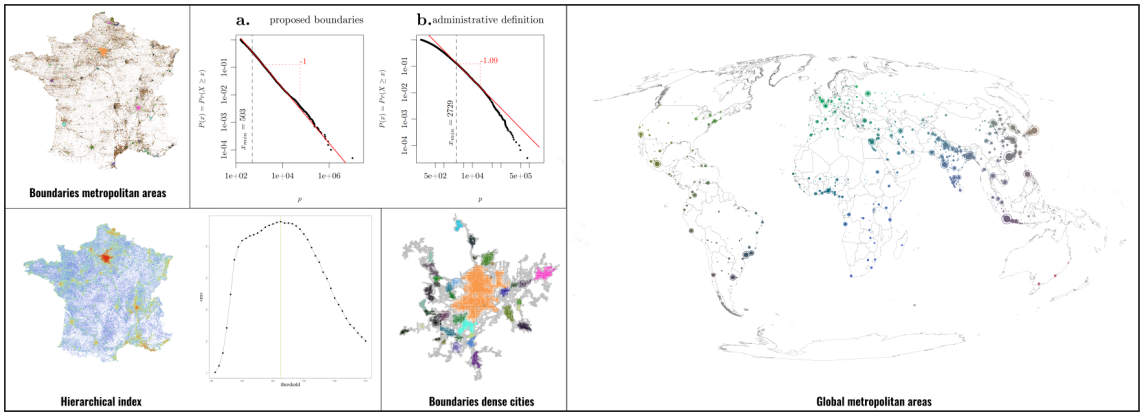

Figure 1: Results of our approach, showing the two types of definitions for cities that can be obtained, and that we are producing a global unified and coherent definition for urban settlements.

resource for the research community and with that intent our dataset will be made available at an open repository for the wider scientific community.

The definition stems from understanding cities as dense and continuous urban fabric. Therefore its aim is not to cover every possible conceptual construct of what is a city, and other definitions must be created to produce sets of functional areas to respond in an adequate manner to different types of studies. We offer two complementary definitions, the metropolitan area and the dense core of cities.

We have shown with a simple example how the boundaries produced are better behaved than the current administrative limits. We can see how Zipf's law shows an exponent closer to -1 ($\alpha = -2.01$ against $\alpha = -2.09$), while simultaneously covering a larger range of the sample space ($x_{min} = 574$ against $x_{min} = 2729$). Furthermore, as shown in the corresponding Figure (Fig.1) the whole set of boundaries follows the same distribution very closely, while the administrative ones diverge at both the larger and smaller elements. This is expected to augment the quality and precision of any measurement taken upon this newly created set of boundaries.

References

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