Reading Cities through their Lines: How to describe road networks structures.

Claire Lagesse*†[1] and Stéphane Douady[2]

[1]TheMa – CNRS : UMR6049, Université de Franche-Comté – Université de Franche-Comté 32 rue Mégevand 25030 Besançon Cedex, France

[2]Matière et Systèmes Complexes (MSC) – Université Paris VII - Paris Diderot, CNRS : UMR7057 – Université Paris Diderot, Bât. Condorcet, case postale 7056, 10 rue Alice Domon et Léonie Duquet, 75205 PARIS Cedex 13, France

Abstract

City road networks have been extensively studied for their social significance or to quantify their connections and centralities, but only small subsets are usually considered and their geographical origin is most of the time forgotten. This work, at the intersection between social sciences and complex system sciences, focuses on the geographical and geometrical aspects of the road network skeleton. Following on the work on space syntax and successors, we build an extended geographical object called the *way,* by pairing edges at each node of the road network graph. The *way* is constructed by local geographical rules, independently from the order in which the network is read. The resulting object is multi-scale, from the single edge to the largest *way* extending over the whole studied zone.
This last property allows to make stable computations on as large as wanted geographical zones. The indicators computed on the ways gain the valuable property to become robust against zoning. Using the way as the graph element also reduce the number of elements, less time consuming to compute. Further than the most used topological ones, as the Degree, Closeness and the Betweenness, we will focus on the geographical indicators, as simply the Length, and present some new ones. For instance, the *spacing* indicator highlights the spatial density of the graph, or the *orthogonality* indicator stress how (geometrically) the ways are connected one to each other. Road networks structures, their richness and heterogeneity, will thus be highlighted both with complex networks long-established indicators and new ones came out from interdisciplinary discussions.

Another emergent property of computing indicators on ways, stable multi-scale elements, is that many of them becomes strongly correlated, or redundant. After a systemic analyze we will present those that give the most relevant and non-redundant information, and the easiest to compute. For instance, an indicator which is local to each way (as the Degree), and thus directly computed, appear to be equivalent of an heavy non-local indicator as the Betweenness. The small differences between two correlated indicators can also turn out to be very meaningful. For instance, the *servicing degree* which is the difference between the degree and the edges connection number, allows the identification of different kinds of connections (in X or in T) in the road network. Similarly, the difference between the closeness, computed using the topological distance, unweighted, and the same one weighted by the way

*Speaker

†Corresponding author: claire.lagesse@univ-fcomte.fr

length can reveal differences in urban structure.

Large scale examples (Paris, Bruxelles, New York, London, Teheran) will illustrate how these indicators computed on the ways are revealing the city structure. In particular the stability through zoning also implies stability through time (which can be considered as a more complex zone variation). It is then possible to read the history of cities, through the lines of their road networks, including major events as the impact of piercings.
In summary, the *way* appears to have unique spatial properties, revealing parallels between global and local analyses. We will explain how this complex object, built upon appropriate parametrization, allows us to carry out deep analysis of spatial networks, independent from their size and borders. The obtained results have shown their relevance for urban planners, as they match their way of reading cities. The new indicators expand their possibility of analyses. It allows to link quantitative and qualitative approaches and fosters multidisciplinary discussions.