

Complementarity of generative models for road networks

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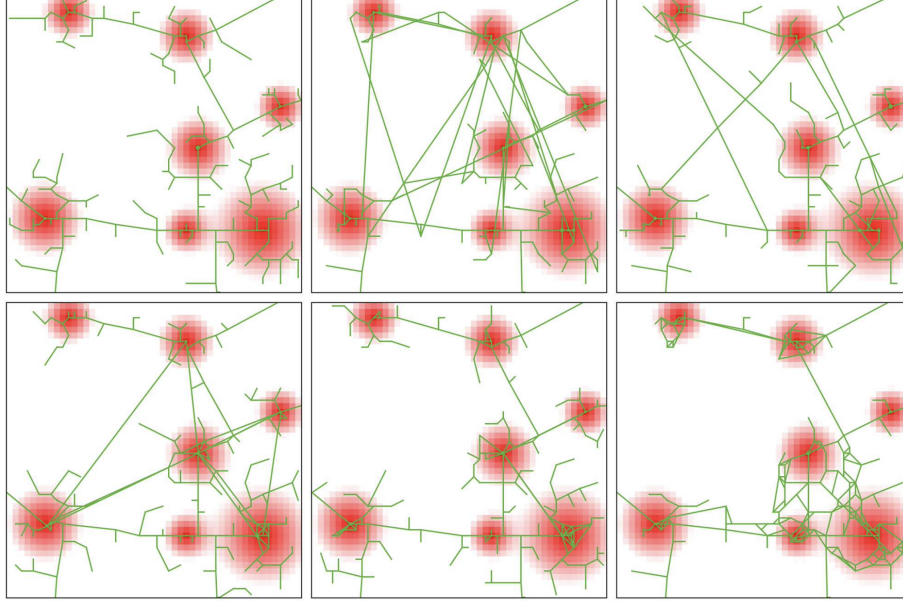
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1 Introduction

Territorial systems are complex in the sense that they span across multiple dimensions, and are produced by various agents at different spatial and temporal scales [Batty, 2007]. They are furthermore adaptive and self-organised, as witnesses the resilience of co-evolving city systems on long time scales [Pumain, 2021]. Among the built environment, environmental, and social components, one crucial driver of spatial structure and dynamics of these territorial systems are transportation infrastructure networks, and more particularly road networks. They irrigate territories by distributing accessibility, and their topology and hierarchy often shapes spatial interactions and thus urban and land-use dynamics [Wegener and Fürst, 2004]. Strong effects of path-dependance furthermore highlights the role of these networks [Ribeill, 1985].

Although accessibility is nowadays strongly multimodal [Cats and Birch, 2021], road networks have been the dominant transportation infrastructure in urban systems over long historical periods [Verdier and Bretagnolle, 2007], and they still are an important aspect of both urban form at the microscopic scale and accessibility at the mesoscopic and macroscopic scales. Understanding the link between underlying processes driving the growth of road networks and their shape is an important subject, towards potential application to sustainable planning.

Generative processes for road networks are multiple: for example a combination of self-organisation and top-down planning may leave a significant signature in topological features of these networks [Barthelemy et al., 2013]. In order to explain such evolution and in some cases reproduce existing networks, multiple simulation models have been introduced in the literature by different disciplines. These span across a broad spectrum, from data-driven models to parsimonious stylised models. [Xie and Levinson, 2009] propose a broad survey of such models, including economics, transport geography, transport planning and network science. The diversity of processes taken into account can range



from economics of investment [Xie and Levinson, 2011], to negotiations between planning stakeholders [Raimbault and Le Néchet, 2021], full top-down planning [Szell et al., 2021], self-organisation through morphogenesis [Tirico et al., 2018], or local optimisation [Barthélemy and Flammini, 2009], among others.

Most of these models include empirically documented processes, and have been validated against stylised facts such as hierarchical organisation of the network or the distribution of network measures, and also often compared against existing networks with reasonable success. However, to what extent these processes and models are complementary remains an open question. We propose in this paper a systematic benchmark of several road network growth models, to clarify the necessity of considering such diverse models.

2 Road network growth models

[Raimbault, 2020] [Raimbault, 2019] [Louf et al., 2013] [Raimbault, 2018]

3 Results

3.1 Data

3.2 Implementation

3.3 Exploration

4 Discussion

[Molinero and Hernando, 2020]

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