Building simulation models coupling territorial and network dynamics at the interface of disciplines and scales

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Interactions between transportation networks and the dynamics of land-use are crucial to take into account when planning and managing sustainable urban environments. A quantitative understanding of such processes using models has been proposed by several disciplines, including Land-use Transport Interaction models or economic models of transport network growth. A co-evolution approach (in terms of circular causal relations) to modelling interactions between transportation networks and territories can be proposed, to simulate the dynamics of territories on long time scales. Such a viewpoint has however not been extensively explored, as the question is by nature interdisciplinary and at the interface of spatial and temporal scales.

The purpose of this communication is to synthesise results obtained with simple agent-based and simulation models at different scales and integrating paradigms from different disciplines, from planning to transport geography, urban geography, physics and economics. These models have the common feature of strongly coupling territorial and transportation network dynamics.

A first model at the scale of the urban area explores the coupling between a population density generation model based on aggregation-diffusion processes with multiple network growth heuristics. This co-evolution model capture in practice the growth of urban form, and multiple dynamical regimes between population and road networks. It is calibrated on empirical morphological and network measures computed on spatial windows covering Europe.

We then develop a family of models at the macroscopic scale to simulate systems of cities, and more particularly the co-evolution of cities and interurban transportation networks. Building on dynamical models developed in the frame of Pumain's evolutionary urban theory, this allows investigating self-reinforcement processes between urban and network hierarchies. We show in particular that these models are effectively capturing a diversity of co-evolution regimes (in the sense of a circular causation) between the properties of network and cities.

We finally describe an agent-based model at the metropolitan scale including more complex mechanisms for coupling, in particular a governance process for the growth of the transport network based on game theory, coupled to a Lowry model for land-use dynamics. This model is applied and calibrated on the case study of Pearl River Delta, China.

This synthesis emphasises the role of simulation models in the production of knowledge. Indeed, most results are obtained through the systematic exploration of models and the application of new model validation methods provided by the OpenMOLE platform. Such systematic explorations enable the testing of hypothesis, and clarify theory building when linked to empirical data and stylised facts. This also facilitates a modular approach to modeling, and thus the coupling of concepts and processes from different disciplines.