

A conceptual representation for modelling the synchronization process of complex road networks

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The conceptual representation of complex road networks goes beyond the established dualism of spatio-temporal database structures in GIS (e.g. raster versus vector, continuous versus discrete view of time) and moves further towards a more topological structure where a synchronization process affects the probability of linking the nodes of a complex network [1]. Predicting whether dense traffic will congest involves issues with respect to this synchronization process. In particular, Manson [2] provides an interesting effort at describing the evolution of complexity research and its application in the geographical domain.

Synchronization is a process wherein complex road networks adjust a given property of their motion due a suitable coupling of their structures (i.e. nodes and links) to an external forcing driven by the behavior of the same networks [3]. It challenges the development of new methods in complex road networks to support real-time transportation analytics for discovering patterns in traffic networks and revealing new insights to decision making.

Most of the existing representations developed in the transportation domain are graph-based networks where nodes and links are used to represent the topological and geometric properties of the intersections and the roads of a network [4, 5]. In the primal graph-based networks, intersections are represented by nodes and roads are represented by links [6]. This representation has been very useful to understand the connectivity between roads through representing the distance of their consecutive links. Conversely, in the dual graph-based networks, the roads are represented by nodes and intersections are represented by links [7]. This representation has played an important role in the computation of the accessibility and integration within road networks. In both representations, statistical properties, such as centrality measures, clustering or cellular structure, have been used to analyze patterns in traffic networks [8, 9, 10]. However, these properties only provide a snapshot of the behavior of a road network rather than its dynamic synchronization behavior [11].

In this poster presentation, we demonstrate how the coupling of a topological structure to its behavior is achieved using a large graph-based representation where nodes are all the intersections found within a complex road network as well as links represent the synchronization between these nodes (i.e. intersections). The synchronization properties are coupled to the links for modeling the motion of vehicles between the intersections. The research challenge is twofold:

- The organization of intersections is not completely represented by a unique hierarchy, but by a set of several hierarchical levels that appear at different topological scales [12]. For example, intersections might be the location of highway exists or traffic lights.
- Highly densely connected sets of nodes synchronizes more easily that those with sparse connections. Therefore, for complex road networks with poor connectivity, starting from random initial measures, those highly interconnected nodes forming local clusters will synchronize first. This can be illustrated by the principle which 20 percent of roads accommodate 80 percent of traffic flow (20/80) [9].

Our approach differs from previous work in proposing synchronization for representing the dynamic behavior of a complex road network because it is the whole process which will reveal the topological structure at different scales.

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