Optimization-based clustering of urban networks through snake segmentation

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Abstract

Traffic congestion appears with different shapes and patterns and might propagate in particular directions varying from day to day. Research on congestion propagation and spreading in large urban networks still remains challenging due to unpredictability of travel behaviours and high complexity of accurate physical modelling. However, describing the main pockets of congestion in a city with small number of clusters is conceivable, thanks to the spatial correlation of congestion in adjacent roads and its spatiotemporal finite propagation speed. Hence, finding a clustering method to identify homogeneous regions in heterogeneous networks not only allows us to model spatiotemporal growth of congestion but also is crucial for real-time traffic control schemes specifically hierarchical perimeter control approaches. In this work, an optimization-based partitioning mechanism, which utilizes robust components in the network, is used to obtain connected clusters with low variances and reasonable sizes. Firstly, a sequence of links called 'snake' is created by adding new adjacent links iteratively based on their similarity to join previously added links. In this way, the corresponding snake grows in a way that has the highest possible homogeneity. Based on robust behaviour observed in sub-regions with different level of congestion, we come up with the idea to define similarities between components and identify snakes that represent the same local components. The similarities are computed in a way that put more weight on adjacent local components and facilitate compact shaped clusters. Finally, to find clusters with high intra similarity and low inter similarity, Symmetric Nonnegative Matrix Factorization (SNMF) framework is utilized to assigned links to proper clusters. SNMF reveals the hidden clusters in similarity-based graph representation of nonlinear datasets.The proposed clustering framework is applied in a medium network based on micro-simulation data and the promising obtained results reveal the ability of finding directional congestion within a cluster, robustness with respect to parameters' calibration and its good performance for networks with low connectivity and missing data.

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