Non-local APA: An intuitive PageRank-based centrality model for urban street networks

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Abstract

Most of the world's population now live in cities and with urbanization expected to increase in the near future, the study and understanding of the structure and dynamics of cities is an important problem [1,2]. Many of the processes that occur in cities can be understood using networks and thus, determining the most important or central nodes in urban networks is a key issue. This is certainly true in the urban street network domain where researchers have been applying centrality measures to help identify and better understand the structure of important locations in an urban area [3,4].

Interestingly though, most studies over the years have focused on the closeness, betweenness and straightness centrality measures with less attention being paid to the PageRank centrality measure (originally invented to rank web pages) despite its popularity and use in a wide range of applications including biology, chemistry, sports, and social networks to name a few [5]. In fact, it was only relatively recently that Agryzkov et al. [6] adapted the PageRank model (called the APA model) to rank intersections (nodes) of an urban street network by considering both the structure of the street network and external information associated with the nodes (such as the presence of shops, restaurants, or tourist attractions). In a similar way to the PageRank model, the APA model can be interpreted using the notion of a random walker who moves around the street network and in the long run, the proportion of time the random walker spends at a given intersection is a measure of its relative importance.

Even though the APA model appears promising, a fundamental concern exists with the model and that is the notion of teleportation (which stems from the PageRank model) because it means the random walker is equally likely to jump or 'teleport' to any intersection in the street network, regardless of how far away it is. This has motivated us to develop a new centrality model that overcomes this counterintuitive idea, by modifying the jumping probabilities so that the random walker is more inclined to jump to a nearby intersection than a distant intersection. We accomplish this by exploiting recent advances in non-local random walks which allow a random walker to jump to any node in the network (not just adjacent nodes) with probabilities that depend on the distance separating the nodes [7,8].

Therefore, the aim our talk is three-fold. First, to present the development of the proposed model, which we call the *non-local APA* model. Second, to present some experimental results on a real-world urban street network that demonstrate the intuitiveness of the model. And third, to highlight potentially powerful applications of the model for studying urban environments, such as human mobility prediction and spatial characteristics of socio-economic activities.

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