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Transit accessibility: A new definition of transit connectors

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ABSTRACT

Transit accessibility is a key determinant in explaining transit use and promoting transit policies. The improvement of transit access conditions is deemed to improve the overall quality of the transit service, the user experience, and ultimately, the transit ridership. In transport modeling, however, transit accessibility is still modeled in a very crude manner based on centroid connectors. This approach does not render actual walking conditions as encountered by transit users. The current paper proposes a new definition of transit access for transport modeling purposes. In contrast to current practice which is based on centroid connectors, this new definition uses high resolution spatial data to model actual access and egress conditions to and from transit facilities. The new approach relies on the spatial distribution of potential transit users and their probability of using transit facilities. Two automatic methods have been developed: selection of accessible transit facilities on the basis of their proximity and computation of the length of connectors using distance decay functions.

Results from the urban area of Lyon, France, show the significant contribution of the new definition. In comparison to the standard method, the new definition is found to improve main transit modeling outcomes and to better reproduce observed data. This new method can assist transport planners and public authorities to evaluate transit policies more accurately and instruct more appropriately policy makers.

1. Introduction

Public authorities often set transit accessibility as a vital target in promoting transit use and endorsing transit policies. The improvement of transit access conditions and especially walking conditions is deemed to improve the overall quality of the transit service, the door-to-door user experience and ultimately, the transit share (Brons et al., 2009). In this context, transit accessibility or transit access refers to the ease, in terms of proximity in distance or time, with which residents and workers can reach transit facilities. There is a profuse literature on the relationship between transit use and transit access conditions (Cervero and Kockelman, 1997; Daniels and Mulley, 2013; El-Geneidy et al., 2014; Ewing and Cervero, 2001; O'Sullivan and Morrall, 1996). These studies show that short access times encourage transit use and that long access times, in contrast, disadvantage transit ridership. In fact, from an economic perspective, walking to or from transit facilities is considered as a disutility or a cost associated with the consumption of the travel service (Domencich and McFadden, 1975). Therefore, the higher the cost, the lower the demand. Accounting for transit accessibility is therefore an important issue in modeling and appraising transit policies.

In transport modeling, however, access to transit facilities is still modeled in a very approximate manner based on centroid

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connectors (Ortúzar and Willumsen, 2011). Local access conditions are often overlooked and walking to and from transit facilities is simply modeled by direct links called centroid connectors. Centroid connectors attach zone centroids to transit stops and model transit access and egress by the resultant direct links. In fact, in the majority of transport models (whether they are aggregate or disaggregate), all trip origins and destinations are aggregated into traffic analysis zones (TAZ). The entire information lying inside a zone is summarized by a single point called zone centroid. This aggregation process results in a loss of information about access and egress conditions. As a result, transit access is modeled by centroid connectors without considering the effects of local characteristics on walking conditions and especially on walking times. Centroid connectors often connect zone centroids to the nearest transit facilities. The corresponding walking time is, also, often directly deduced from the length of the connector. This definition, which is still widely used by both, practitioners and researchers, does not necessarily take account of local access conditions encountered by transit users and still less of users' practices and behaviors (Bonnel, 2004). Consequently, the standard definition of centroid connectors may bias the main modeling results and ultimately, the policy decision.

In this paper, we shall describe a new method for modeling transit access. The method is made possible by the increasing availability of detailed spatial data. It relies on detailed estimations of walking distances to and from transit stops using fine-grained spatial data and distance decay functions. The method is also automatic and needs no major intervention from the modeler. Contrary to the standard method, the resulting transit connectors are less affected by the aggregation bias and, in particular, the geographic position of the zone centroids.

2. Background

While there is a plentiful literature on how transit access influences transit use (Alshalalfah and Shalaby, 2007; Cervero and Seskin, 1995; Dill, 2003; Hsiao et al., 1997; Zhao et al., 2003), it is surprisingly sparse when it comes to transposing this influence to the definition of transit access for transport modeling purposes. Few studies have addressed the problem of defining zone connectors and even fewer have dealt with the special case of transit connectors. The major literature we have found deals with private car connectors (Chang et al., 2002; Daganzo, 1980a; Friedrich and Galster, 2009; Leurent et al., 2011; Sean Qian and Zhang, 2012), while little research has focused on transit connectors (Tamblay et al., 2016). Car connectors definition has been found to impact the main modeling results. In this line, transit connectors have not been directly addressed and are tacitly assumed to be similar to car connectors. Yet transit connectors differ from private car connectors in a number of respects. Unlike car connectors, the travel time on transit connectors is a significant component of the total journey travel time. Walking speeds on transit connectors are very much slower than driving speeds on car connectors. Transit connectors are also constrained and highly sensitive to the choice of connection nodes. The only possible connection nodes are the available and accessible transit stopping points. Finally, in transport modeling, walking time is often penalized since it is considered to be unpleasant by transit users (Abrantes and Wardman, 2011; Wardman, 2001). A penalty coefficient or a time multiplier, often greater than 2, is applied to access and egress times. Consequently, transit connectors seem to have a wider impact on modeling results than car connectors.

The literature shows that both the travel times and connection nodes of car connectors have a significant impact on modeling outcomes (Chang et al., 2002; Friedrich and Galster, 2009; Sean Qian and Zhang, 2012). Chang et al. (2002) have shown that zone centroid placement method and thus the travel time associated with centroid connectors impacts the assignment results. After testing different configurations of car connectors in a regional transport model, they concluded that using fine-grained data to define car connectors significantly improves the quality of the model. In another paper, Sean Qian et al. (2012) have investigated the impact of randomly selecting connection nodes and their number on traffic assignment results. They found that random selection of nodes results in significantly unstable estimated traffic volumes and travel times, and that adding more connectors does not necessarily reduce these instabilities. On the contrary, this caused fictitious network fluidity, since certain non-existent routes can be used to bypass congested parts of the network. Contrariwise, reducing the number of connectors may create fictitious congestion. Defining connector travel times and connection nodes is therefore not straightforward.

The standard definition of connectors inevitably seems to have an impact on transport modeling. Since these effects are largely due to the spatial aggregation problem, some studies have set out to reduce this impact by using land use characteristics of city blocks inside zones and their remoteness from transit facilities to infer averaged walking distances (Tamblay et al., 2016). Other studies have managed to get rid of this bias by using a continuous representation of space (Daganzo, 1980a, 1980b). Other researchers have tried to avoid the same bias by developing a totally disaggregated approach using detailed surveys where the exact origins and destinations of trips are known (Chapleau and de Cea, 1983); or to reduce the magnitude of this bias by refining the zoning system, especially during the assignment (Mann, 2002). Another approach is to keep the initial zonal aggregation and reduce its impact, and more specifically the impact of the connectors, by introducing a probabilistic network access function (Leurent et al., 2011) or by combining a microscopic and a macroscopic transport models (Friedrich and Galster, 2009). Nowadays, micro-simulation approaches can get rid, to some extent, of this spatial aggregation bias and model more suitably access and egress conditions. Agent-Based Models (ABM) are an example of these approaches where access and egress conditions of agents can be characterized. However, these models are rarely implemented in real case studies, or used to assess urban policies in operational conditions mainly because of their complexity, data requirement and incompatibility with operational constraints. Furthermore, some of these methods (ABM, in particular) require precise data located at the x-y coordinates. This requirement is not always met regarding privacy concerns. Finally, transport models, like four step models (FSM), that rely on spatial zoning are still widely used as an urban planning tool, a modeling framework and a policy-decision aid tool.

As a result of this situation, operational transport models have no alternative but to use some 'rules of thumb' to fill this methodological gap (Cambridge Systematics, Inc and AECOM Consult, 2007; WATS, 2008). These rules are often drawn from the