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The influence of assignment criteria for the solution of dynamic travel demand estimation

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Abstract

This study deals with an investigation of the influence of several assignment criteria, combined with a different set of information about traffic conditions, on the efficacy and stability of the solution of the off-line dynamic demand estimation problem. Motivations of such investigation derive from the need to better reproduce the real users' behaviors during the demand estimation and benefit from the extensive information, which is provided by traffic monitoring systems that collect advanced traffic data ubiquitously distributed on the network. Several synthetic experiments have been conducted on a test network, obtaining interesting results about the common adoption of dynamic user equilibrium and about the possibility to introduce new types of information during the optimization.

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1. Introduction

This work deals with the off-line estimation of OD matrices for a within day dynamic framework, and specifically it investigates the impact of assignment criteria, combined with several information on traffic regime,

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during the estimation.

Different approaches exist in the literature to solve the dynamic OD matrices estimation problem. For a review of early contributions, the reader is referred to Balakrishna et al. (2005), whilst in Toledo et al. (2015) more recent research attempts can be found.

The bi-level approaches are the main ones considered in this paper. In such cases, the upper-level problem consists of the adjustment of a starting demand using traffic measurements. These traffic measurements are in turn linked to the dynamic demand and this link is generated through the Dynamic Traffic Assignment (DTA) problem at the lower level.

As reported in Antoniou et al. (2015), relevant topics faced in literature about dynamic demand estimation deal with 1) non-linearity of the relation between ODs and traffic measurements; 2) high indeterminateness of the problem due to the dimension of the unknowns; 3) selection of traffic flow measurements to be adopted during the optimization. Respect to the latter point, Balakrishna (2006) and Cipriani et al. (2011; 2014) accurately investigated the role of link counts, speeds and occupancy; several authors adopted probe data from vehicle equipped by AVI tags (Dixon and Rilett, 2002; Eisenman and List, 2004; Antoniou et al., 2004; Zhou and Mahmassani, 2006; Caceres et al., 2007, Barcelò et al., 2012; Mitsakis et al., 2013; Cipriani et al., 2014). Also the influence of aggregated demand information derived by commonly adopted demand models, such as traffic emissions and attractions by zones, or the reliability of the starting demand matrix have played an important role in some literature (Iannò and Postorino, 2002; Cipriani et al., 2014; Cantelmo et al. 2014a-b, 2015).

Less often the impact of the assignment criteria (i.e. the type of DTA), combined with the traffic measurements adopted in the optimization, has been investigated: this is the aim of the paper.

The common approach to solve the DTA, required at the lower level of the demand estimation, is to follow a Dynamic User Equilibrium (DUE) principle in case of congested networks, while Dynamic Network Loading (DNL) is usually adopted for not congested networks or for networks without path's options. However, despite the DUE has the advantage of smoothing out the inherent stochasticity of route choice through the iterative process needed to search for the equilibrium, the concept behind is a modelling construct that makes sense under specific hypotheses: 1) travelers are assumed to choose O-D routes that require minimum disutility; 2) travelers are assumed to know, and accurately perceive, travel times throughout the network; 3) O-D flows and roadway characteristics are assumed to be fixed and known (Chiu et al., 2001). If the modeling time horizon is not long enough or if advanced traveler information and management systems suggest a route option to inexperienced road users, the equilibrium principle can hardly be reached.

Several synthetic experiments have been conducted on a test network consisting of 22 nodes (14 are signalized intersections), 68 links, 6 traffic zones, a whole planning horizon of 35 minutes discretized into 5 minutes intervals. Specifically, these experiments consider:

- The Dynasmart model (Jayakrishnan et al., 1994) to solve the DTA;
- Different assignment criteria for the DTA, specifically 1) Dynamic Network Loading (DNL), 2) Dynamic User Equilibrium (DUE) approach, 3) System Optimum (SO) approach, 4) different percentages of users that follow DUE or SO, 5) different percentages of users that follow the previous approaches with users following always the same path ("unresponsive users"). These different DTA options allow mimicking possible behaviors of users, even in presence of information and control systems on the network;
- Different combinations of traffic measurements inside the objective function of the dynamic travel demand estimation, also proposing the adoption of new traffic measurements with respect to those commonly reported in literature;
- The Simultaneous Perturbation Stochastic Approximation, Asymmetric Design, Polynomial Interpolation (SPSA AD-PI, Cipriani et al. 2010, 2011) method to solve the off-line estimation of dynamic OD matrices.

This paper contains four sections including this introduction: Section 2 deals with the formulation of the off-line dynamic demand estimation and the method adopted to solve it. Section 3 presents the experimental design and the results obtained on the adopted test network. Conclusions follow in Section 4.