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Dissuasive queues in the time dependent traffic assignment problem

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Abstract

In this study, variables of arc travel-time functions and traffic performance indicators for real networks are related in order to delve into the validity and representativeness of these variables on flow propagation models. A methodology for estimating performance indicators, for the analysis of travel patterns in time-dependent networks, is suggested. Also, an analysis of data from a congested network with daily travelers is presented. Finally, a queue length variable is incorporated in the time-dependent traffic assignment problem; and a suitable travel-time function from the traffic flow theory that can be applied to arcs of signalized and un-signalized arteries, is introduced.

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1. Introduction

The traffic assignment models are a great resource to estimate travel patterns in a transportation system, discover performance indicators, and define mobility and accessibility variables. Performance indicators are used to identify emergent properties and distinguish problems and externalities that need to be solved. Traffic management actions supported on information technology and intelligent transportation systems are very important for traveler's route choice and could have a deterrent effect.

Time-dependent traffic assignment models (TDTA) and dynamic traffic assignment models (DTA) include variables which can be used to calculate impacts on pollution, delays and fuel consumption, on urban networks.

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These models, used with intelligent transportation systems, can also be a guide to regulate traffic operative and tactical decisions. The difference between TDTA and DTA models is the resolution of the time interval.

A user equilibrium traffic assignment (UEA) model uses flow-dependent arc time functions (ATF) to obtain travel patterns on congested networks, assuming that travel itineraries last one time interval. This model estimates flow and allows to identify congested arcs, but it does not consider the role of queues on route choice. On the contrary, a TDTA model can give detailed information about traffic progress, propagation of densification waves, queues generation, etc. A traffic problem can be analyzed according to the specificity of performance indicators, which are classified as follows:

- Microscopic indicators, which focus on individual vehicle.
- Mesoscopic indicators, which consider the queue process and turning flow in intersections.
- Macroscopic indicators, which are based on travel patterns and flow propagation estimation in a time period.

Although research on modeling and algorithms for TDTA problems has been developed for three decades, there is a gap on: analytical treatments of flow dynamics, the relationship between the dynamic variables, and the flow behavior in an individual arc belonging to a route chosen by travelers and its spread through the network.

Several studies and papers extensively discuss the DTA problem, its modeling, solution and testing on networks, with both analytical and simulation approaches. However, research must go deeper into this subject, especially on matter of time-dependent travel functions which describe flow propagation on networks.

Researchers agree on the properties of ATF if the network is loaded with static user equilibrium, because the results closely represent the user behavior. On the contrary, in time-dependent traffic assignment modeling, functional forms of time-dependent variables have yet to be studied as well as their properties and relationship with the flow-dependent arc travel time functions (time dependent arc travel time function, TDATF).

Road systems include roads and intersections, topologically expressed like arcs and nodes, where trips are daily loaded. Most of them are regular trips, with the same origin-destination (O-D) pair everyday on paths chosen according to the user's experience. Everyday users know the alternative routes behavior. Travelers could be persuaded to change their routes, if they have information about congestion, bottlenecks and queues. In fact, free open access traffic applications (APP) are becoming widespread (i.e. several application, based on Google Maps, give real time traffic information to users).

Through this study, the TDTA problem is studied by means of analytical and macroscopic approaches. Performance indicators for time-dependent networks are defined and calculated in order to examine and assess the resolution and accuracy of ATF so they are adequate to DTA. This is a current and in progress topic.

We provide a framework for analyzing performance of congested networks (with daily travelers), by means the use of a GPS app and traffic analysis based on the Manual of Transportation Engineering Studies (Schroeder, Findley, Hummer, & Foyle, 2010), and displaying it by using free-access resources. We propose a methodology for obtaining, processing and estimating performance indicators, which contributes to DTA modelling.

This paper has three parts. The first one presents the description, characteristic parameters and variables of dynamic arc time function (DATF) models for DTA. The second part explains the methodology applied to calculate and show traffic behavior on congested time-dependent networks; here, a case study is presented. In the last part, a discussion about the need of extending the TDATF for DTA is included.

2. Dynamic network loading models for DTA

Nomenclature(Nie & Zhang, 2005[a])

$\mathbf{u}(t)$ Entrance flow rate on arc at time *t*

$\mathbf{v}(t)$ Exit flow rate on arc at time *t*

$\mathbf{x}(t)$ Flow rate on arc at time *t* or number of vehicles on arc at time *t*

$\tau(t)$ Travel time on arc at time *t*

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