Simulation Modelling Practice and Theory 53 (2015) 139–148

Contents lists available at ScienceDirect

Simulation Modelling Practice and Theory

journal homepage: www.elsevier.com/locate/simpat

Microscopic simulation evaluation method on access traffic operation

Yuchuan Du [a,*], Cong Zhao [a,1], Xi Zhang [b,2], Lijun Sun [a,3]

[a] Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, Shanghai 201804, China
[b] California Department of Transportation, 111 Grand Ave., Oakland, CA 94612, United States

ARTICLE INFO

Article history:
Received 4 November 2014
Received in revised form 30 January 2015
Accepted 6 February 2015
Available online 25 February 2015

Keywords:
Traffic simulation
Access management
Operation optimization

ABSTRACT

Cities around the world have long been plagued by traffic congestions. The access to public buildings, such as parking structures, hospitals, schools, hotels is the main bottleneck that frequently causes traffic backups and accidents. One of the major access management strategies is the optimization of traffic operations adjacent to the access point. However, there is not a scientific model to evaluate access management. It is of great importance that a systematic and unbiased evaluation system is established to gauge the effectiveness and safety of traffic optimization around the access point. This study established a microscopic simulation evaluation index system on access traffic optimization, and obtained the required parameters by VISSIM simulations. A comprehensive evaluation method was established by combining an analytic hierarchy process (AHP) to determine the level and index weights with gray relational analysis (GRA). We applied our evaluation method to the building park entrance of Tongji University in China and the road near the entrance was suffering terrible traffic congestions. We acquired the relatively best traffic organization scheme in both efficiency and safety aspects through this method. The results show that it is suitable for the design and optimization of traffic organization to ease traffic congestion. This method, not only considered experts' experience, but also appropriately reduced the uncertainties of human involvement during the evaluation process and improved the applicability of our method.

1. Introduction

Cities around the world have long been plagued by traffic congestions [1–3]. The access of public buildings, such as parking structures, hospitals, schools, hotels is the main bottleneck that frequently causes traffic backups and accidents [4]. Access Management (AM) has been applied to solve the ubiquitous traffic congestion problem. Good AM balances site access needs with the need to provide safe and efficient use of the transportation network by specifying acceptable spacing and combinations of access connections for a given property [5,6]. Access Management will continue to improve traffic safety and operations when implemented appropriately [7]. One of the major access management strategies is the optimization

* Corresponding author. Tel.: +86 21 6958 5712.
E-mail addresses: ycdu@tongji.edu.cn (Y. Du), zhc_tongji@163.com (C. Zhao), xi.zhang@dot.ca.gov (X. Zhang), ljsun@tongji.edu.cn (L. Sun).
[1] Tel.: +86 21 6958 8634.
[2] Tel.: +1 510 622 5929.
[3] Tel.: +86 21 6958 5705.

http://dx.doi.org/10.1016/j.simpat.2015.02.004
1569-190X/

of traffic operations adjacent to the access point. However, evaluation methods on access traffic optimization are far from perfect.

When the access to a public building is designed, engineers usually only consider the entrance width and determine it by queuing theories per the population density of public buildings [8]. On the other hand, past research efforts focused on service time and capacity of the entrance and exit only [4]. However, the effects of different traffic operation strategies (e.g. right-in-right-out (RIRO), signalized access control, etc.) on traffic flows, though important, lack proper analysis and study. Therefore, it is crucial that a systematic and unbiased evaluation system is established to gauge the effectiveness of traffic optimization around the access point. With such an evaluation method, the access point and its adjacent roadway network can be fully optimized.

With the advance of information technology and driver behavior theory, microscopic simulation has become a useful tool for transportation engineers to solve complicated traffic design and management issues [9]. Traffic designers always make use of the simulation-before-construction approach that allows them to study the effects of different organization methods [10]. VISSIM is one of the most popular simulation tools which can provide a realistic representation of traffic flow of cars, trucks, buses and trams [11]. The output of VISSIM consists of comprehensive parameters to evaluate operating efficiency, safety, environment and comfort, etc. VISSIM can be used to evaluate traffic policy, transit facilities and traffic operations [12–15]. The microscopic simulation model has been used to evaluate the operational impacts of different left-turn treatments at mid-block intersections on different classes of roadway facilities [16]. This study will use VISSIM to evaluate the effects of traffic operation schemes around access points.

The surrogate safety assessment model (SSAM) is a model for analysis of conflict recognition based on a grid developed by the US Federal Highway Administration [17]. It is designed to perform statistical analysis of vehicle trajectory data output from microscopic traffic simulation models such as VISSIM [18]. SSAM computes a number of surrogate measures of safety for each conflict that is identified in the trajectory data and then computes summaries (mean, max, etc.) of each surrogate measure.

Since there are many output parameters from microscopic simulation, a comprehensive evaluation method is necessary to scientifically combine the relevant parameters and provide a uniform assessment of the optimization strategy. Weighting the index vectors is an issue of great concern to each normalization-based method. Many efforts have done in the creation of an acceptable set of weights and much more efforts are still needed [19,20]. This study selects the Analytic Hierarchy Process (AHP) to determine the index weights, which is a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales [21].

Researchers worldwide have studied data envelopment analysis method, fuzzy comprehensive evaluation method, neural network method, and Grey Relational Analysis (GRA) [22]. These methods have their own merits. The latest trend in research is to improve their effectiveness by picking and combining them with each other [23]. This paper also follows this trend. This study selected GRA as the comprehensive evaluation method. Grey system theory was invented by Deng in the People's Republic of China [24]. It provides a method for abstract system that the information is limited, incomplete and uncertain. Grey model is the key of grey system and focuses on building a differential model from limited data sets and it has been successfully used in many engineering areas [25,26]. Grey system theory generally copes with systems or objects that have well defined external boundaries but internal uncertainty or vagueness, whereas conversely fuzzy mathematics deals with systems or objects that have not well-defined boundaries but well-defined interior [27]. GRA is a comprehensive evaluation method, which is based on the concept of grey relational space, one of the elements of grey system theory [28]. The philosophy of GRA is to find a mathematical way to analysis the correlation between the series that compose a set space. Presently, GRA is primarily applied in Chinese speaking areas, and hardly known in western countries [29–31].

The primary goal of this study is to find an evaluation method for microscopic simulation on access traffic operation. Around the goal, the rest of the paper is organized as follows. First, we discuss the selection of evaluation index and establish an index system for microscopic simulation. Second, we calculate the index weight according to Analytic Hierarchy Process (AHP) for comprehensive analysis. Third, we develop the comprehensive evaluation method by combining GRA and AHP. Finally, we acquire required output parameters from VISSIM and tested our evaluation method.

2. Methodology and procedure

2.1. Index selection principles

It has a significant impact on the final evaluation results whether the selection and establishment of the index system is scientific, reasonable, and reflecting user needs. The selection of the evaluation index should follow these principles:

(a) **Objective:** The index system should be suitable for the evaluation activities and the essential characteristics, structure, and elements of the evaluation items should be objectively described.
(b) **Scientific:** A prerequisite for accurate and reasonable results is that the index system is scientific in nature; it should be able to objectively reflect the characteristics of evaluation items and minimize subjective judgments.
(c) **Independent:** To avoid deviations in correlation, selection of the evaluation index should be as simple as possible, clearly defined, and independent.