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Graded-information feedback strategy in two-route systems under ATIS

Jianqiang Wang*, Huimin Niu

School of Traffic and Transportation, Lanzhou Jiaotong University, Lanzhou, Gansu, China

Abstract: In consideration of the constraint of the advanced traveler information systems (ATIS) detecting accuracy and the time delay of information feedback systems, a novel approach named graded-information feedback strategy is proposed and applied into a two-route scenario. The approach adopts the fuzzy C-means clustering algorithm to classify road traffic conditions based on flux, mean velocity, and density. Then, each cluster centre is fixed on. Furthermore, real-time traffic conditions on each route could be judged by the preceding cluster centers. Results of judgment would be displayed on variable message signs to guide the successors at the entrance to make reasonable route-choices. Meanwhile, a cellular automaton model is adopted to investigate the correlation between efficiency of two-route systems, number of clustering, and travelers' route choice behavior. Compared with the conventional strategies, the simulation shows that the innovative information feedback strategy can evidently improve utilization efficiency of road networks.

Key words: traffic flow; graded-information feedback; two-route; fuzzy cluster; cellular automaton model

1 Introduction

In recent years, there has been a growing interest in design and deployment of advanced traveler information systems (ATIS). As key part of ATIS, information feedback strategies have attracted great interest of transportation scholars (Eran et al. 2013a; Cristea et al. 2014; Eran et al. 2013b). The road service efficiency can be greatly improved by means of an applicable information feedback strategy. Although people are full of expectation of ATIS, traffic condition would become more serious if an inappropriate information feedback strategy is adopted. It is an essential task in the field of road traffic to find an optimal and efficient information feedback strategy (Wahle et al. 2002; Zhao et al. 2013).

Thus, several conventional information feedback strategies have been proposed. These strategies mainly consist of three types: travel time feedback strategy (TTFS) (Wahle et al. 2000), mean velocity feed-

* **Corresponding author**: Jianqiang Wang, Doctoral Student, Lecturer.
E-mail: xinxiwjq@126.com.

back strategy (MVFS) (Lee et al. 2001) and congestion coefficient feedback strategy (CCFS) (Wang et al. 2005). It has been proven that MVFS is more effective than TTFS, which is a lag effect approach and is impossible to provide travelers with the current situation of each route. Meanwhile, CCFS is more effective than MVFS, the core of which is to define the congestion coefficient creatively. Regardless of the fact that CCFS promotes the efficiency of the road networks, it needs higher detection precision and more computing resources of ATIS to compute the congestion coefficient. Based on three strategies above, Dong et al. (2010a; 2010b; 2010c) put forward to a corresponding angle feedback strategy (CAFS), a vehicle number feedback strategy (VNFS) and a prediction feedback strategy (PFS). Chen et al. (2012a; 2012b; 2012c) put forward to a vehicle's length feedback strategy (VLFS), time flux feedback strategy (TFFS), and an exponential function feedback strategy (EFFS). Tobita and Nagatani (Tobita et al. 2012) put forward to a tour-time feedback strategy.

These information feedback strategies adopted various traffic flow feedback factors to improve the capacity and performance of road networks to some extent. In order to make research work more conveniently, it is commonly assumed that ATIS can acquire real-time and precise traffic information. In practice, traffic information is gathered from each vehicle, and is transmitted to traffic center to be processed, and then is distributed to each road user. As a result of the above whole process, the delay of feedback information will be inevitable. In addition, traffic information is restricted to the level of ATIS detecting accuracy, and impracticable to provide completely precise information.

Furthermore, Meneguzzer and Olivieri (2013) studied the day-to-day route choice dynamics in a simple three-route network with limited feedback information. Hino and Nagatani (2014) studied the traffic behavior in the case which has a bottleneck on a route in the two-route traffic system with real-time information. Shiftan et al. (2011) evaluated the potential benefits from pre-trip travel time information provision by gaining insights into and better understanding of the factors affecting the route-choice behavior of travelers. Elia and Shiftan (2010) pointed out that travelers made route-choice relying on both real-time information and their historical experience. Bekhor and Albert (2014) demonstrated that certain sensation seeking domains alongside traditional variables played an important role in route choice behavior with pre-trip travel time information.

The above researches reveal the complex relationship between route-choice behavior and real-time feedback information. But, it is a conventional presumption which is commonly called the maximum utility theory in the former information feedback strategies that travelers would always choose the shortest-time cost one of the routes according to feedback information. As a matter of fact, detailed and precise feedback information is not required because travelers usually take feedback information only as reference.

Consequently, it is a reasonable and practical approach to provide road users with graded-information to minimize their personal travel time, which is qualitative based on numerical information about the traffic conditions. Both delay of information processing and detection error of ATIS are ignored in the graded-information. The discrete choice model is adopted to imitate traveler's route-choice behavior instead of the maximum utility theory. Of course, the emphasis of this study is on the graded method of traffic information and performance analysis of the graded-information feedback strategy (GIFS) in two-route scenario.

The remainder of this paper is arranged as follows. In section 2, the VDR model and a two-route scenario are briefly introduced, and then graded-information rules on the basis of fuzzy C-means clustering algorithm are depicted in detail. In section 3, factual simulation results are presented and results are discussed on the comparison of TTFS. In the last section, we make conclusions and suggestions.

2 Graded-information feedback strategies

2.1 VDR mechanism

Compared with the NS mechanism, which is the most popular and simplest cellar automaton model to investigate the traffic flow, the VDR mechanism is a more