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Guidance compliance behaviors of drivers under different information release modes on VMS

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ABSTRACT

Driver's guidance compliance behavior, which is a crucial link in Intelligent Traffic Guidance Systems (ITGS), has a direct impact on guidance effect. Based on State, Operator, and Result (SOAR), which was a cognitive architecture, the traffic compliance agent was designed and elaborated in detail. In the paper, working memory (WM), long-term memory (LTM), operator selection, impasse solving, expected travel time determination, and chunking rule generation were described with the consideration of practical situations. Finally, two simulations with different information release modes were carried out under the same given condition, one was based on real-time flow statistics (M1), and the other was based on flow forecasting (M2). Through analyzing the changes of drivers' compliance rates and vehicles' lane-changing times under Variable Message Sign (VMS), M2 was proven to be more effective in alleviating traffic jam in the morning and evening peak periods and bring a higher compliance rate. This study laid a foundation for selecting the release modes of guidance information in both theory and practice.

1. Introduction

Among the various means and methods involved in Intelligent Transportation System (ITS), traffic guidance is one of the traffic management methods that can truly increase traffic performance and ensure traffic safety. Traffic guidance can help drivers make better decisions in travel choice and release their anxiety and stress during trips. The guidance compliance rate, which reflects driver's behavior toward traffic guidance information, should be taken into consideration in designing traffic guidance systems. In previous studies, drivers are generally assumed to make trips with 100% compliance rate, or a certain rate set by system [13,47,50,54]. In addition, these studies indicate that drivers regard expected utility as goals, who are allocated to the road network by using the user equilibrium approach [1,27,39]. However, these assumptions are not true in practice. Many other surveys have proven that the true compliance rate significantly deviates from the assumptions, and the conclusions challenge the conventional rate treatment process [1,27,39]. Many scholars have realized that the compliance rate of groups must be studied from the perspective of individual guidance compliance behaviors; hence, three primary methods have been developed in literature: survey [18,45], experiment [1,51], and simulation model [2,48].

Unlike traffic control signal, the guidance information released by Variable Message Sign (VMS) is just a kind of suggestion message, and it has no mandatory effect on drivers. So drivers can choose to comply with the VMS or not, which closely depends on their characteristics, their familiarity with road network, the content, the display form and release mode

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of information, their perception and comprehension of information, even their mood when they see VMS. And the dependencies vary gradually with driver's acceptation and adaption of VMS [3,7,10,26,28,29]. Among these factors, information release mode has a significant impact on drivers' guidance compliance behavior. The modes based on real-time statistic and traffic flow forecasting are the two most common ones. The aim of this research is to study the effects of the two information release modes on drivers' guidance compliance behaviors and find a better mode.

Compliance rate is used to represent drivers' degree of compliance with traffic information. The rate is the proportion of drivers who select the suggested roads of traffic information just because of the existing of information, and it reflects the effects of guidance information on drivers' compliance behavior. In this paper, the suggested path of information is the dynamic shortest path, i.e., the path costs the shortest time from current position to destination under the current traffic condition shown on VMS.

The remainder of the paper is organized as follows. Section 2 reviews the researches of drivers' guidance compliance behaviors. Section 3 introduces the State, Operator and Result (SOAR) architecture and analyzes its applicability. Section 4 describes the information release modes and SOAR based agent design of guidance compliance behaviors. Section 5 analyzes the simulation results and discusses the validities of simulation model and information release modes. Finally, the suggestions for practical use and future researches are given in conclusion.

2. Literature review

Bonsall et al. [8] investigated 100 drivers with vehicle-mounted guidance systems and found that 70% of them comply with the guidance system when they were familiar with the road network, while up to 90% when they were not. Cummings [12] surveyed 20 VMS systems in Europe and found that only 4–7% of the drivers obeyed the system in normal conditions, while 13% in special circumstances. Moreover, 5% of the drivers did not understand the VMS information and over 10% misunderstood it. Tarry et al. [46] monitored the VMS along the road network near Birmingham, UK, and found that 27–40% of the drivers obeyed the guidance when the VMS showed that an accident happened in front, but only 2–5% obeyed it when the VMS just notified the drivers of the traffic jams without reporting the cause [43]. Swann et al. [45] investigated the VMS near the estuary district in Forth of Scotland and found that 16% of the drivers diverted to the recommended path when the VMS showed traffic jams happened in front roads. Erke et al. [18] conducted a spot field investigation on two motorways and found that about 20% followed the recommendations of VMS, but 100% when the VMS showed that the road ahead was closed. Zhou et al. [58] analyzed 497 valid questionnaires about individual guidance compliance decisions in Beijing and found that the percentages of the drivers who *would change path*, *may change path*, *would not change path*, and *does not know what to do* were 16.9%, 65.4%, 11.5% and 6.2%, respectively. Chen [9] and Mo et al. [53] studied the parking guidance systems in Nanjing and Shanghai, and concluded that the behaviors of drivers in seeking guidance information as well as in understanding and complying with the information varied very much when the personal properties, travel characteristics, and the factors considered in selecting parking space were different among drivers. The abovementioned studies show the compliance rate is normally low. The main reasons are as follows: (1) there is no need for guidance information as drivers are already familiar with the roads; (2) drivers do not notice the information; (3) drivers do not understand the information; (4) drivers do not believe the information; (5) the information is received after drivers have already chosen a path, and (6) the readable distance of VMS is too short to read, leading to information missing [8,12,18,45,46].

The method based on experimentation is adopted to identify the laws of behavior and find the behavior influencing measures by analyzing drivers' responses to different experimental conditions. Allen et al. [4] allowed drivers to experiment with different origins and destinations (O–D) and different congestion degrees. Their results showed that drivers' compliance rate was high (beyond 70%) when they used route guidance mode. This experiment did not consider the recommended path would congest and then influence the guidance compliance behavior, which was actually very common in practice. Srinivasan et al. [44] adopted the Designer Workbench model of Corypheaus Corporation to create a software for developing experimental environments, in which different display approaches for guidance information were used to test their effectiveness based on the responses of 10 participants. They found that the approach with the highest compliance rate was the one using the countdown progress bar to show the distance between the current location and the front intersection. Chen et al. [11] allowed 99 participants to join a 20-day experiment on a road network simulated by a computer and found that the factors affecting drivers' guidance compliance behavior were the characteristics of guidance information (whether the information showed the recommended path, whether the road was connected or close to a highway, etc.), drivers' characteristics such as age, gender and education degree, and whether the information provided the reason for accidents or congestion. Wochinger et al. [51] found that drivers preferred different display modes and seemed to be more willing to comply with their favorite one. Adler [1] divided 80 participants into 4 groups with 2-factor measurement experiments. The measurements were repeated 15 times per person in one simulated road network. The results showed that the guidance compliance rates of drivers unfamiliar with the road network were higher than those familiar with it, it was because familiar ones derived little benefit from the provided information.

With the rapid development of computer technology, simulation models have been applied to study drivers' guidance compliance behaviors and has obtained certain results. For example, Lu et al. [37] proposed a complexity model of guidance compliance rate based on a traffic assignment Logit model to analyze the rate changing properties. Huang et al. [21] proposed a stochastic-user equilibrium model to study the changing processes of compliance rate in Advanced Traveler