Dynamic Guidance Sign Design for Passenger Transfer in City Railway Hubs

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Dynamic Guidance Sign Design for Passenger Transfer in City Railway Hubs

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Abstract. The congestion state models are established for three traffic modes of city railway hubs. According to visual and psychological characteristics of passengers, a new dynamic guidance sign system is designed to release transfer information. The identification and continuity level of information on guidance signs are evaluated to make the design more reasonable. The research would provide a new design and evaluation method for transfer information guidance system in city railway hubs.

1. Introduction

With the development of economy, the carrying capacity of railway increased, which required rapid grooming for passengers in city railway hubs [1-2]. However, in many domestic railway hubs, the defective design of guidance signs caused great inconvenience for transfer behaviors. Studies on guidance sign design of city railway hubs mainly focus on the line shape of access channel, but little has been done on the size and subsidiary facilities in exit channel. As the contents and formation of guidance signs are puzzling with non-uniform standards, departing passengers tend to be stranded, which cause a decreased operation efficiency of hubs [3].

In this case, a new method of dynamic guidance sign design was proposed to face the challenge and improve the performance of information guidance system for transfer passengers.

2. Congestion State Models for Various Transfer Modes

Bus, subway and taxi are three of the most important transfer modes for departing passengers in city railway hubs. The operation condition is mainly influenced by departure frequency, fare, loading rate, level of other service and so on [4].

Assume that the number of arriving passengers at current time is N_t, the proportion of passengers transferring by bus, subway and taxi are η_1, η_2 and η_3 respectively. In order to reflect the real-time operation condition of transfer modes, a group of congestion degree models were set up by comparing the number of arriving passengers with carrying capacity for various transfer modes.

2.1 Congestion State Model for Bus

Bus transfer site for hubs include originating station and passing station. Then buses can be classified into originating bus and passing bus, the condition of which must be described respectively. As the loading rate of bus is defined, the congestion state model is as below:

$$C_B = \frac{N_t \eta_1}{\frac{\Delta T}{\Delta t_1} n_1 Q_B + \frac{\Delta T}{\Delta t_2} n_2 (1-\alpha) Q_B} \tag{1}$$

Where, C_B is noted as the loading rate of bus at current time; ΔT is the time interval of information updates on guidance signs; Δt_1 and Δt_2 are the departure interval for originating bus and passing bus respectively; n_1 and n_2 are the number of bus lines for them respectively; α is the average loading rate of passing bus at current time, which can be tested by automatic vehicle monitoring system for urban public transport; Q_B is the maximum number of loading passengers for one bus.

2.2 Congestion Degree Model for Subway

For subway, the congestion state model is described as follows:

$$C_S = \frac{N_t \eta_2 (1+\beta)}{\frac{\Delta T}{\Delta t_3} n_3 Q_S} \tag{2}$$

Where, C_S is noted as the loading rate of subway at current time; Q_S is the maximum number of loading passengers for one subway train; n_3 is the number of subway lines; β is the allocation coefficient of subway for nearby resident trip; Δt_3 is the departure interval of subway.

2.3 Congestion Degree Model for Taxi

As taxi arrive at transfer site with no regularity, passengers wait for taxi with a sense of tolerance. Suppose there is a tolerance limit of waiting time, over which the operation condition of taxi would be considered as congested, the congestion state model is established, as shown in equation (3).

$$C_T = \frac{N_t \eta_3}{\xi a t_g Q_T} \tag{3}$$

Where, C_T is noted as the loading rate of taxi at current time; a is the average arrival rate (leaving rate) of taxi; t_g is the passenger tolerance limit of waiting time; Q_T is the maximum number of loading passengers for one taxi during the rush hour; ξ is the correction coefficient for taxi, which is set as 1, 0.8 and 0.6 respectively during three periods of time such as 7:00~11:00, 11:00~20:00 and 20:00~7:00 next day.

3. Release of Dynamic Guidance Information

The basic philosophy of transfer information release is put forward. According to passenger transfer demand, the transfer information on guidance signs in exit channel is selected. Based on a learning concept, the performance of identification and continuity of information is taken into account. Base on the visual and psychological characteristics of passengers, LED guidance signs with different colors will be applied to release the abstract operation condition information, including dynamic congestion state information and other basic information for various transfer modes.

3.1 Design of Dynamic Guidance Signs with Congestion State Information

As the carrying capacity of bus is low, passengers with baggage tend to transfer by a more convenient mode such as subway or taxi instead of bus. Thus, the upper limit of congestion degree is relatively small. While for subway with a great carrying capacity, the upper limit is larger. Although taxi service is flexible and convenient, passengers seldom waited very long but would switch to other modes, so a large upper limit is not suitable [5-6]. The congestion degree, congestion state and displayed color of information on guidance signs are listed in Table 1.

Table 1. Congestion degree of transfer modes and displayed color of information.

Congestion degree	Congestion state	Displayed color
Above 1.5	Severely crowded	Red
1.2～1.5	Crowded	Orange
1.0～1.2	Slightly crowded	Yellow
0.9～1.0	Almost crowded	Yellow-green
Below 0.9	Free	Green

After reading the dynamic congestion information on guidance signs, passengers choose transfer mode according to their own value orientation. The dynamic information includes title and iron of transfer mode, scrollbar reflecting crowding indication, walking direction and so on[7], which is shown in figure 1.

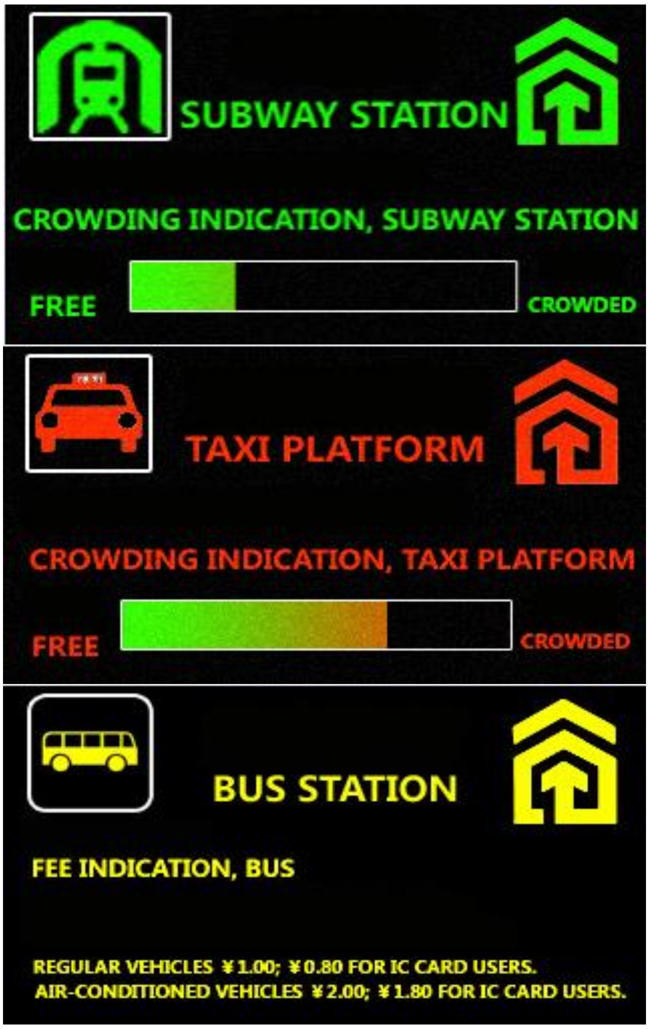

Figure 1. Congestion state information on dynamic guidance signs.

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3.2 Design of Dynamic Guidance Signs with Basic Transfer Information
Basic guidance information includes fare, transfer lines, added service, time, weather conditions and some kindly reminders [8]. The real-time information on LED display board refreshes regularly. According to relevant survey, 70% of passengers accept week information easily while only 30% of them prefer date information. Thus it is necessary to release time information by week instead of date to ensure the reliability and integrity of information.

Figure 2. Basic transfer information on dynamic guidance signs.

4. Performance Evaluation of Transfer Information Guidance System
The performance of transfer guidance system is measured by identification and continuity level of information.

4.1 Identification Level of Transfer Information
The identification level of information shows whether the information can be found and understood exactly by passengers in the shortest time. It is measured by the average time for passengers to recognize information [9-10], as shown in equation (4).

$$T = (T_1 + T_2) / N \quad (4)$$

Where, T is noted as the average time to recognize information; N is the total number of transfer guidance signs; T_1 is the time to seek for dynamic information, which is consist of refresh time of information, reaction time and sight moving time of passengers; T_2 is the time to understand the meaning of information, which can be calculated as follows:

$$T_2 = D/V \tag{5}$$

Where, *D* refers to the amount of information of a single guidance sign; *V* is the understanding rate of information for a walking passenger, which is taken as 150 unit / minute.

4.2 Continuity Level of Transfer Information

When Passengers receive useful information on a guidance sign but cannot find the next one, they may feel panic. With the loss of information, the sense of panic may grow stronger. In this case, it is necessary to evaluate the continuity level of information on guidance signs, as shown in Equation(6).

$$C = 1 - \sum_{ij} L_{vij} / \sum_{i} L_{ri} \tag{6}$$

Where, *C* is the continuity level of information on guidance signs; L_{ri} is the length of transfer path *i*; L_{vij} is the information loss space of gap *j* between two guidance signs along transfer path *i*, which is expressed as follows:

$$L_{vij} = L_j - L_c \tag{7}$$

Where, L_j is the length of gap *j* between two guidance signs; L_c is the maximum identification distance for passengers to recognize the title or icon on guidance signs and decide to seek for detailed information on next sign or not.

5. Conclusion

For higher operation efficiency of city railway hubs, a reasonable transfer guidance system is essential for departing passengers. A new dynamic guidance sign system is designed by congestion state models of various transfer modes. The performance of this system is evaluated by identification and continuity level of information. The research would provide a new design and evaluation method for transfer information guidance system in city railway hubs.

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