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Intelligent Optimization Design of APP Display Interface for Intelligent Transportation

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The improvement of socio-economic conditions in China, and the increasing amount of urbanization and roadway construction have made the road traffic environment increasingly complex. Intelligent transportation application (APP) software plays an important role in alleviating traffic pressure and improving the efficiency of public transportation. The scale of the transportation system is huge and the travel needs of the masses are also diverse. The current APP display interface in intelligent transportation still has some defects in terms of function realization and user experience. To meet different user needs and improve user experience, in this study, in-depth research was conducted on the intelligent optimization design of APP display interface in intelligent transportation, analyzed functional requirement from the aspects of travel route planning, traffic information query and vehicle condition detection and optimized the design of APP display interface based on design principles such as ease-of-use and consistency. To determine the effectiveness of the proposed display interface, this article conducted experimental analysis from two aspects: performance testing and owner satisfaction testing. The results of the satisfaction testing showed that users who were very satisfied with the visual design effect, usability and interaction effect of the display interface of the intelligent transportation APP were 21.44%, 19.67% and 20.58%, respectively. The experimental results indicated that the intelligent optimization design of the APP display interface in intelligent transportation can effectively meet user needs, improving their experience and satisfaction.

Keywords: display interface design, intelligent transportation, intelligent optimization, application performance, traffic information data

1. INTRODUCTION

With the development of urban road construction, the transportation environment is becoming increasingly complex [1]. Technological advancements have led to the improvement of intelligent transportation. Intelligent transportation involves the comprehensive informatization of transportation infrastructure and transportation tools, and plays an important role in improving traffic safety and travel efficiency [2–3]. However, the current APP display interface in intelligent transportation still lacks flexibility and has certain usage limitations. With the increase in the frequency of personal transportation trips by the masses, the personalized and functional requirements of the APP display interface have significantly increased. From the perspective of user experience and actual travel needs, intelligent optimization design and analysis of the intelligent and interactive APP display interface design concept are of great practical value for improving user experience and promoting personalized and intelligent development of transportation services.

Against the backdrop of increasing demand for personal transportation, the application and research of intelligent transportation APP have gradually become the focus of attention of many scholars. Considering various problems

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in each layer and its crowd intelligence solutions, Chandra (2020) proposed a layered intelligent transportation system APP architecture and emphasized the importance of intelligent transportation technology and its applicability to the sustainable development of future transportation infrastructure [4]. Boucher (2019) believed that as traffic congestion and environmental pollution issues increased, the use of mobile APP related to the concept of transportation roads increased. Intelligent transportation APP technology played a crucial role in improving transportation safety and efficiency [5]. Do Vale et al. (2021) considered that the vehicle network APP was key to supporting the advanced intelligent transportation system. He developed a new framework for the intelligent transportation APP driver using the fifth-generation mobile communication technology network slice, and introduced the architecture of the proposed solution and the design algorithm of heterogeneous traffic in the dynamic vehicle environment. Simulation was conducted in actual vehicle scenarios. The results showed that, compared with the most advanced methods, the performance of the intelligent transportation APP network based on the fifth-generation mobile communication technology network slicing was significantly improved [6]. Woodward and Kliestik (2021) explored the application of intelligent transportation APP in intelligent sustainable urban transportation system. They used data from various transportation associations and competitions to analyze and estimate how networked and autonomous vehicle can pass the traffic data management, route analysis and navigation decisions of intelligent transportation APP. The results showed that intelligent transportation APP was a feasible means of reducing traffic accidents [7]. To date, intelligent transportation APP has made good progress, but with the expansion of traffic road construction, the display interface of intelligent transportation APP also needs to be adequately improved and optimized. Previous research did not take into account the ease-of-use and function problem of the display interface.

The development of science and technology has led to the improvement of the design of the display interface of intelligent vehicle APP. Gade (2019) proposed an intelligent traffic management mobile application based on Internet of Things (IoT) sensors, image processing, geographic information technology and data analysis, and discussed its interface intelligent optimization design, including speakers, display views, etc. Compared with traditional traffic management systems, this application was not only easy to install and use, but could also provide efficient and real-time traffic data analysis [8]. Based on the new generation of information technology such as microservices, Xuan et al. (2021) proposed the design and implementation scheme of smart travel APP for urban rail transit, designed and described the display interface and technical architecture of smart travel APP, realized functions such as station information, line details and travel path planning, and provided convenient and high-quality mobile application services for passengers [9]. With the assistance of science and technology, the display interface of intelligent transportation APP has further developed, although most studies have not provided more effective guidance for the intelligent optimization design of the display interface based on the actual travel needs of users.

To improve user experience and the application value of intelligent transportation APP, in this study, in-depth research was conducted on the display interface of the APP in intelligent transportation. From the perspective of design requirements and principles, intelligent optimization design is implemented and its effectiveness is verified in terms of: 1) performance testing, and 2) owner satisfaction testing. In regard to practical application, the intelligent transportation APP display interface proposed in this study can provide users with efficient services and accurate traffic data, as well as improve user satisfaction and promote the development of safe and efficient intelligent vehicles.

2. INTELLIGENT OPTIMIZATION DESIGN

2.1 Design Requirements

According to the transportation and travel conditions in real life, an intelligent transportation APP should meet three main user needs: travel route planning, traffic and road condition information, and vehicle condition detection.

2.1.1 Travel Route Planning

People mainly use APP to plan their travel paths when driving, so the APP display interface must have precise path planning, navigation and other functions and the ability to update the road conditions in real time. With the development of urban land and road construction, the number of vehicles on the road has rapidly increased and people's demand for reasonable and efficient arrangement of personal travel schedules is also constantly increasing [10]. When planning the driver's work and daily travel routes, the design of an intelligent transportation APP display interface needs to take into account not only the driver's travel route planning for activities such as shopping and fitness, but also other needs closely related to travel route planning [11–12].

2.1.2 Traffic Information Query

Besides travel path planning, the intelligent transportation APP display interface also needs to provide users with corresponding query services to obtain traffic information. For example, users need to obtain real-time road traffic conditions such as road congestion, vehicle speed restrictions, traffic accidents, etc. through the APP, to provide them with the optimal travel mode. Due to the interconnection of intelligent transportation systems, traffic information has become increasingly complex [13–14]. Especially in some large transportation hubs, due to high traffic volume and complex pedestrian flow, it becomes very difficult for users to understand traffic information, thereby inconveniencing them unnecessarily [15–16]. Therefore, an intelligent transportation APP display interface should provide users with comprehensive and diversified traffic information query services. Users can input or query the starting and destination locations on the display interface to obtain corresponding road condition information [17–18].

2.1.3 Vehicle Condition Detection

Vehicle condition detection plays an important role in ensuring traffic safety before and during travel. In general, vehicle condition detection includes the detection of vehicle body power, vehicle speed and mileage. In intelligent transportation, the analysis of big data is needed to enable users to obtain real-time information on the running status of vehicles [19]. Also, the display interface of the intelligent transportation APP needs to visually and comprehensively display the vehicle's condition to drivers, so that when abnormal conditions occur, the vehicle can be promptly handled to ensure driver safety.

2.2 Design Principles

(1) Easy usability principle: Easy usability refers to a user-centric approach that reduces the cognitive load on users, enabling them to easily use interface functions and perform interactive interface operations. In the process of intelligent optimization design, it is necessary to consider the easy-of-use of the display interface, integrate service modules of the same functional type, reduce user operations and strive to enable each user to independently understand and implement interface functional operations.

(2) Consistency principle: The APP should not only align with the user's understanding of transportation, but should also be consistent with the user's usage habits. For example, when designing display interface icons and text, certain standards should be followed. Adherence to the principle of consistency in the design of the display interface can improve the visual effect of the interface and the user experience.

(3) The principle of interactivity: The principle of interactivity refers to the fact that the design of the display interface of an intelligent transportation APP needs to consider the actual operation of the user. If some operations on the interface cannot be directly expressed, then some prompts should be provided in the program to enable users to interact better. When designing, it is important to minimize user input by, for instance, automatically saving user input information. Furthermore, it is necessary to keep the global navigation bar unchanged as much as possible, as global navigation can reduce the jumping between web pages, which is very helpful for storing information. Therefore, in the intelligent optimization design of the APP display interface, global navigation should be set according to the attributes of the functional services.

(4) Rationality principle: Rationality refers to whether the overall layout of the display interface is reasonable. Generally speaking, the midpoint of the diagonal line of the interface is the location where users can directly see it. Therefore, the most important functional services provided by the APP should be positioned where users can easily see and click the required service, making it easier for users to operate the APP system.

(5) The principle of aesthetics and coordination: Design elements create the first impression that the APP display interface gives users, and the visual effect of the overall elements needs to be highlighted in the display interface design. Also, when designing the display interface of intelligent transportation APP, full consideration should be given to the characteristics of the user group. Generally speaking, drivers use the intelligent transportation APP so that their travel demands can be met. Therefore, when designing the display interface, it is necessary to combine environmental factors and take into account the users' usage environment. In terms of interface visual design, colors should be intuitive but not have strong visual impact [20]. This not only effectively meets the basic aesthetic needs of users, but also facilitates the display of traffic information.

2.3 Design Implementation

2.3.1 Display Interface

The intelligent optimization design of the APP display interface in intelligent transportation was based on the analysis and application of design requirements and principles. This APP display interface is shown in Figure 1.

Figure 1 shows that the display interface of the intelligent transportation APP consists of: a personal center, additional functional service modules, input and query services, real-time vehicle status services, traffic information and path planning services.

(1) Personal center

The personal center is the user information center of the intelligent transportation APP. When users log in for the first time, they need to confirm their identity through the personal center. Users can choose to use their mobile phone number or WeChat to verify their login details. After successful identity confirmation and login verification, they can enter the APP display interface. After logging in, users can choose to bind to their local account. After binding, when the user reenters the display interface, they can automatically jump to the corresponding page without repeating identity confirmation and login verification.

(2) More functional service modules

The home screen of the APP display proposed in this paper includes four main services: input and query services, real-time vehicle status services, traffic information services and path planning services and its expansion services are concentrated on additional functional service modules for display such as vehicle health management, route collection and viewing, etc. Vehicle health management can provide users with services such as vehicle inspection and modification of vehicle information. Route collection and viewing can provide collection and viewing functions for places that users frequently enter and exit, making it convenient for users to query and save time.

(3) Input and query services

Input and query services can satisfy the diverse travel needs of different users. Users only need to enter the desired location in the box, and the APP display interface can provide them

Figure 1 APP display interface in intelligent transportation.

with information about their destination point as well local facilities such as food outlets, hotels, banks and other related information. Also, input and query services can combine user travel data to intelligently guide users to their intended destinations, providing them with scientifically-based and objective travel recommendations.

(4) Real time vehicle status service

The display interface of the intelligent transportation APP is interconnected within the vehicle control system. The collected travel time, mileage, tire pressure and other raw data are transmitted to the vehicle control terminal that analyzes the status of the vehicle and then transmits it to the server via the wireless network. Therefore, the user can see the real-time status of the vehicle on the display interface of the APP. Moreover, users can selectively set the real-time information of vehicle status to the top according to their actual needs, so that they can observe it in real time when driving.

(5) Traffic information and path planning services

Due to the close connection between traffic information and path planning, to ensure ease of use, the two services are combined to form a functional module. Traffic information and path planning services mainly analyze traffic information, plan the optimal path for the destination input by users and query traffic information for feasible paths.

In the path planning of the intelligent transportation APP, assuming D_x represents the distance from a certain node to the target node, if the current vehicle is on the node in map coordinate (m_0, n_0), the distance from this node to the destination node is represented as D_0. If there are three nodes in the feasible path list planned by the APP, namely (m_1, n_1), (m_2, n_2), (m_3, n_3), their distances to the target point are D_1, D_2, D_3, respectively. If other nodes are selected, the distance between the node and the target node is [21]:

$$\Delta D_x = D_x - D_0 \tag{1}$$

The reference point for defining the amount of distance change is:

$$H = \Sigma|\Delta D_n| \tag{2}$$

Redefining the direction function as D_f, the i-node (m_i, n_i) direction function is calculated as [22]:

$$D_{fi} = \frac{H - \Delta D_n}{\Sigma|H - \Delta D_n|} \tag{3}$$

where n represents the next node that can be selected. After introducing the direction function, the migration probability function for APP path selection is modified to:

$$T_i^2(p) - \begin{cases} \frac{\delta_{0h}^u(p)\cdot\mu_{0h}^v(p)}{\frac{\Sigma_{s\in a_k}\delta_{0h}^u(p)\cdot\mu_{0h}^v(p)}{1+s_0}} + s_0 D_{fi}, & i \in a_k \\ 0, & otherwise \end{cases} \tag{4}$$

In the path planning of intelligent transportation APP, the updates after each iteration also have a strong impact on the final path planning results.

Furthermore, the APP display interface can be combined with map functions and accurate local weather real-time and predicted data provided by third-party meteorological departments to transmit information on traffic and road conditions in the area entered by the users' vehicles.

2.3.2 Technical Architecture

The technical architecture of the intelligent transportation APP display interface is shown in Figure 2.

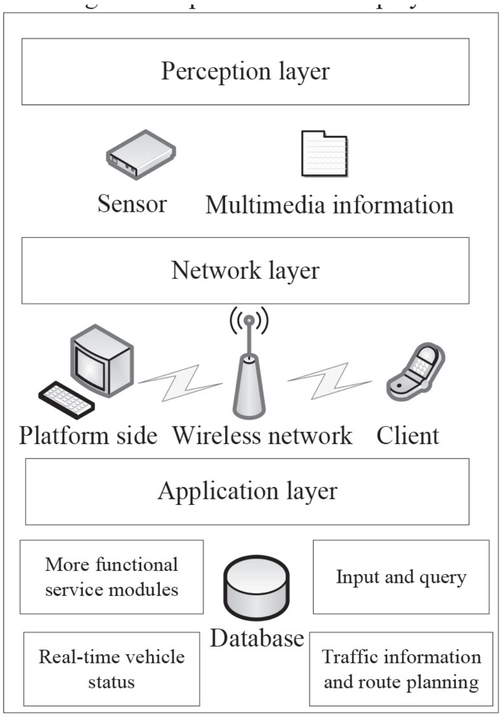

Figure 2 Technical architecture of intelligent transportation APP display interface.

Table 1 User information data structure.

Field name	Describe	Field type	Field length	Is it empty?	Primary key or not?
User-identity	User's identity	Int	20	N	Y
Name	Nickname	Varchar	50	N	N
Profile-wechat	WeChat number	Varchar	50	N	N
Phone-number	Phone number	Varchar	16	N	N
Available-status	Available status	Int	10	N	N
User-type	Customer type	Varchar	20	N	N
Create-time	Creation time	Varchar	8	N	N

(1) Perception layer: The main function of the perception layer is to perceive and collect data information, which is mainly achieved through sensors and multimedia information. Besides, in the technical architecture, the perception layer can utilize short range transmission, self-organizing networks and other methods to achieve the transmission and processing of information data in the APP display interface functional module.

(2) Network layer: The network layer is a bridge that connects the perception layer and application layer of the intelligent transportation APP display interface technology architecture. It consists of a platform side, wireless network and user side. In the network layer, the information on the platform end is transmitted to the user end through wireless networks. The platform end comprises user administrators and information centers, while the user end consists of general users and login users.

(3) Application layer: The application layer is connected to the APP display interface, providing users with rich and specific services. The main service functions displayed in the display interface include more functional service modules, input and query services, real-time vehicle status services, traffic information and path planning services. The database contains data that all logged-in users can access simultaneously. The data in this database can be shared and users can use the database in different ways through interfaces on the mobile end. According to its main functions, the structure of some data tables is shown in Tables 1, 2 and 3.

The columns in Table 1 show user identity, user nickname, WeChat number, mobile number, available status, user type and creation time. Among them, all fields cannot be empty and the user identity is the primary key in the user information table.

In Table 2, the columns for vehicle information comprise license plate number, vehicle type, vehicle production date, vehicle engine number, vehicle maintenance date, tire pressure status and correction time. All fields cannot be empty and the license plate number is the primary key in the vehicle information table.

The road condition information table is an important means of recording the road conditions within the target travel range of vehicles. As seen in Table 3, the road condition

Table 2 Vehicle information data sheet structure.

Field name	Describe	Field type	Field length	Is it empty?	Primary key or not?
Car-code	License plate number	Int	20	N	Y
Car-model	Model	Varchar	50	N	N
Car-manufacture	Date of manufacture	Varchar	50	N	N
Car-engine	Engine number	Varchar	50	N	N
Car-maintenance	Maintenance date	Varchar	8	N	N
Car-tire	Tire pressure status	Varchar	50	N	N
Modification-time	Modification time	Varchar	8	N	N

Table 3 Road information data structure.

Field name	Describe	Field type	Field length	Is it empty?	Primary key or not?
Road-category	Road category	Varchar	50	N	N
Road-name	Road name	Varchar	50	N	Y
Road-describe	Road describe	Varchar	2000	N	N
Road-picture	Road picture	Varchar	5000	N	N
Notes	Road condition information notes	Varchar	5000	N	N

Table 4 Software and hardware environment for experimental testing.

Attribute	Item	Specifications
Hardware	Client	Advanced risc machine Cortex-A9 Dual-core, processor main frequency 1.6 Gigahertz
	Server	Intel 4-core 2.8 Gigabyte processor
	Network	Internet
Software	Android system development environment	Android studio 2.2
	Operating system	Community enterprise operating system 7.3

information table fields include road type, road name, road description, road image and road condition information remarks. Here, all fields cannot be empty and the road name is the primary key in the road condition information table.

3. INTELLIGENT TRANSPORTATION APP DISPLAY INTERFACE EXPERIMENT

In this study, the effectiveness of intelligent optimization design for APP display interface in intelligent transportation was tested. The testing was conducted in two phases: APP performance testing and car owner satisfaction testing. The software and hardware environment for the experimental testing is shown in Table 4:

3.1 APP Performance Testing

APP performance testing was conducted for the main functional services of the APP display interface in intelligent transportation. For this study, members of the local community were used for the testing of APP. Their traffic travel data for the past three months was collected to create a test case set. Using randomly-selected test cases, the intelligent transportation APP input and query service, real-time vehicle status service and traffic information and path planning service were tested to evaluate the performance of the APP display interface.

(1) Input and query service testing

The input and query services aim to meet the different travel needs of different users and provide them with diversified transportation services. The intelligent transportation APP display interface needs to provide precise location information for user input or query instructions and push diverse peripheral data to provide objective suggestions and predictions for user travel. For this study, eight users from the local community were randomly selected. All of them had previously used the same transportation application and their search records in their transportation travel data were used as test cases. The accuracy of command search and the amount of information provided on the display interface of the intelligent transportation APP were tested and compared with the transportation application programs previously used by community users. The number of tests was set to 10 and the final results were averaged, yielding the results shown in Figure 3.

As seen in Figure 3, compared to the previous APP used by the user, the accuracy of command search and the quantity of information provided on the display interface of the intelligent transportation APP are relatively ideal. In Figure 3A, the average search accuracy test results of the APP instructions reach 91.89%, while the average search accuracy test results of the APP instructions previously used by users are only 85.11%. In Figure 3B, the average number of information

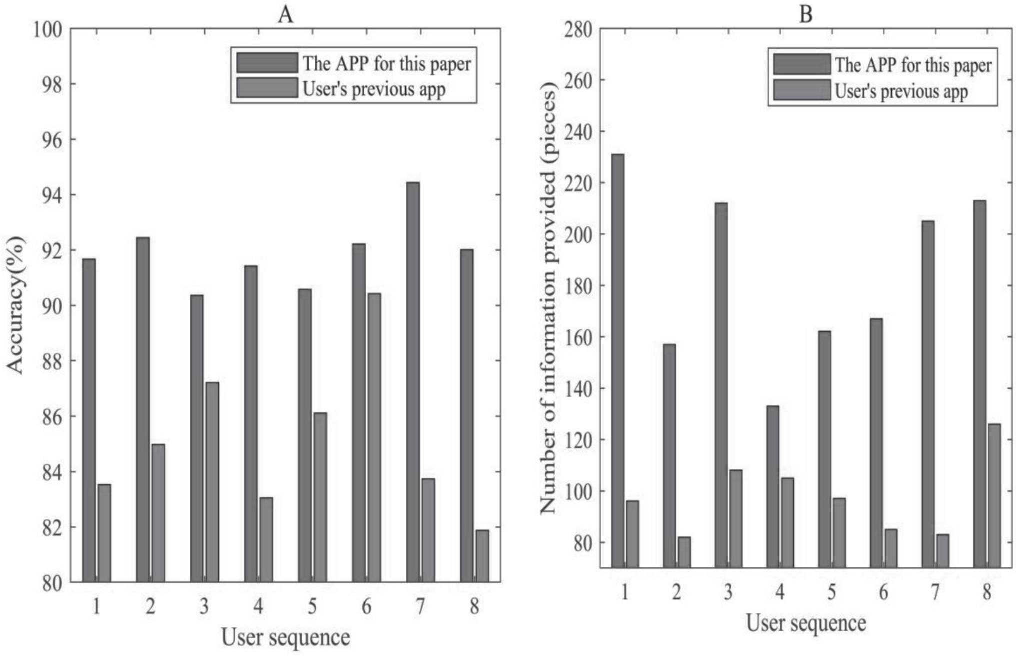

Figure 3 Input and query service test results. (A) shows the accuracy results of instruction search. (B) provides quantitative results for information provision.

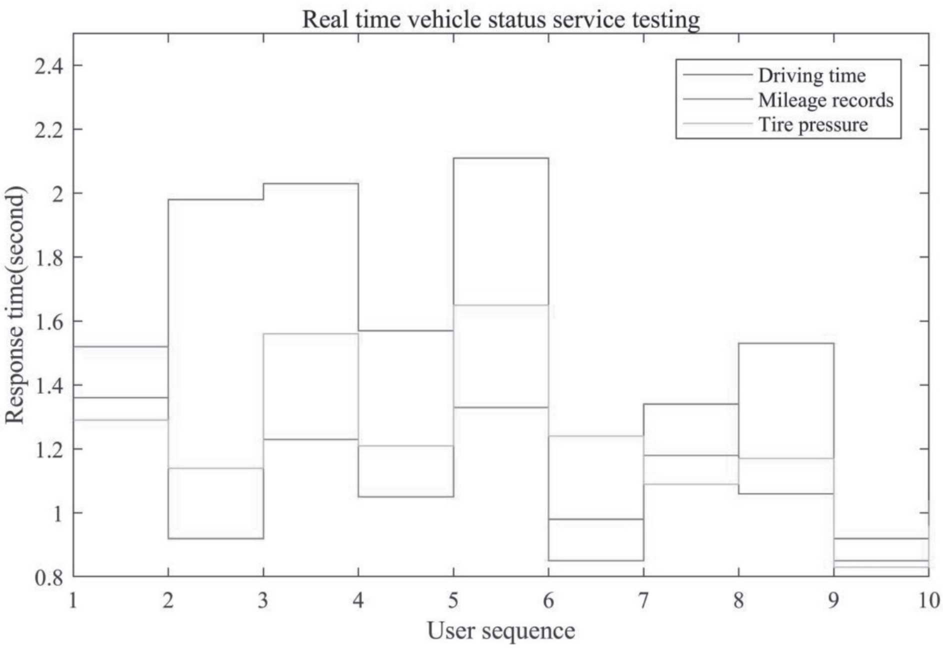

Figure 4 Real-time vehicle status service test results.

items provided by the APP under different user test cases reached 185, while the average number of information items provided by the APP previously used by the user under different user test cases was only about 98.

(2) Real time vehicle status service testing

The intelligent transportation APP display interface needs to display the original data transmission of vehicle status such as driving time, mileage record, tire pressure, etc. The real-time response of vehicle status service instructions has a significant effect on the use experience of the APP display interface. Therefore, in this study, 10 users were randomly selected and their driving times, mileage records and tire pressure commands were used as test cases. They were used as real-time vehicle status service commands to test the intelligent transportation APP. The command response times are shown in Figure 4.

Figure 4 shows a comparison of the mileage records and tire pressure command response times of 10 user test cases. The results show that the response time for driving time, mileage records and tire pressure commands do not exceed 3 seconds. Among them, the average response time test for driving time instructions was about 1.43 seconds. The average response time test for mileage recording instructions was 1.15 seconds. The average test response time for tire pressure

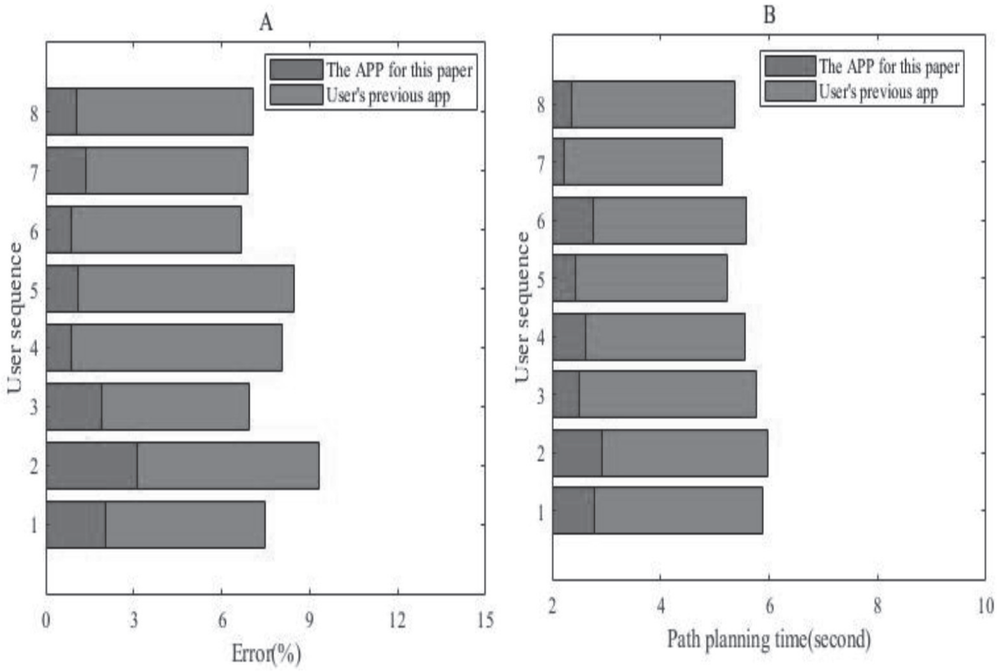

Figure 5 Test results of traffic information and path planning services. (A) shows the error test results. (B) shows the test results of path planning time.

commands was approximately 1.21 seconds. The response time difference among the three types of commands was not significant, indicating that the display interface of the intelligent transportation APP proposed in this paper was not easily affected by the command category in real-time vehicle status service operation and it had relatively ideal performance in terms of efficiency.

(3) Traffic information and path planning service testing

Traffic information and path planning services need to be quickly and accurately available to users. In this study, eight users from the local community were randomly selected to test the input and query service. Their historical navigation data was used to test the prediction error of road condition information and the optimal path planning time on the display interface of the intelligent transportation APP in this article. It was also compared with the transportation application programs previously used by the users. Ten tests were conducted and the average of the total results was calculated. These are displayed in Figure 5.

As shown in Figure 5, there are significant differences in the results of error testing and path planning time testing between the two types of APP. In Figure 5A, the average information prediction error of the APP in this article under different user test cases is 1.54%, while the average information prediction error of the transportation APP previously used by the user under different user test cases is 6.07%. In Figure 5B, the average path planning time test for the APP is 2.58 seconds, while the average planning time test for the transportation APP previously used by the user is 2.99 seconds. The test results for traffic information and path planning services under intelligent optimization design, show that the display interface of the intelligent transportation APP proposed in this study has significant advantages in terms of information prediction accuracy and path planning efficiency.

3.2 Vehicle Owner Satisfaction Test

The car owner satisfaction test targeted community users who evaluated the visual design, and the usability and interaction effects of the intelligent transportation APP display interface proposed in this study. The evaluation range was measured on a scale of 1to 5 and it was expressed from high to low as: very satisfied, satisfied, average, dissatisfied, very dissatisfied. The percentage of people and their ratings are shown in Figure 6.

Figure 6 shows the percentage of people who were very satisfied, satisfied, average, dissatisfied and very dissatisfied with the visual design, usability and interaction features of the intelligent transportation APP display interface. Of the participants, 21.44% were very satisfied with the visual design effect of the display interface of the APP, and 36.05% were satisfied. Regarding participants' evaluation of the usability of the APP display interface, 19.67% were very satisfied, and 33.42% were satisfied. respectively. In the evaluation of interaction effects, 20.58% of users were very satisfied, and 35.44% were satisfied.

4. CONCLUSIONS

With the development of construction in the road traffic environment, people's demand for transportation is also constantly changing. As a new type of transportation mode, intelligent transportation APP can achieve the sharing and real-time processing of traffic data through information technology and intelligent means, improving traffic efficiency and safety. The display interface has a significant impact on the effective functioning of the APP. To improve the user experience and promote the wider application of the APP, this study explored its functions and user needs and

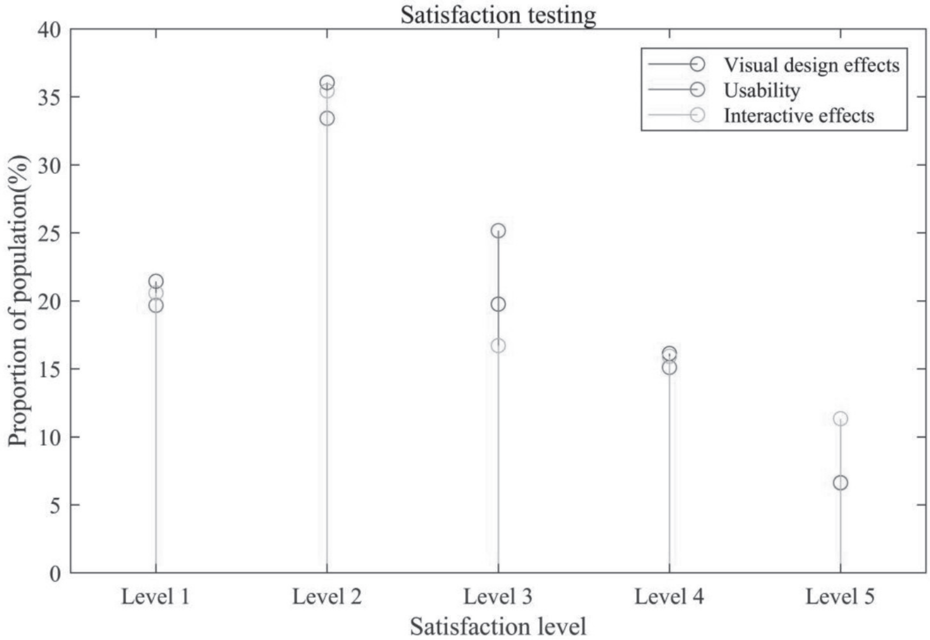

Figure 6 Car owner satisfaction test results.

intelligently optimized its display interface. This not only achieved efficient and diverse services, but also improved the visual design effect, usability and interaction effect of the display interface, meeting the needs of different users. Although the intelligent optimization design analysis of the APP display interface in intelligent transportation played a certain and significant role in promoting the application and development of intelligent transportation, there were still some areas that needed to be improved. Future research will undoubtedly improve the display interface design of intelligent transportation APP from the perspective of functional expansion, so as to promote the intelligent and sustainable development of transportation construction work.

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