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A scheme to increase the speed at which special vehicles enter the expressway

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특수차량의 고속도로 진입 속도를 향상시키기 위한 방안

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Abstract Expressway is the main link in promoting the national economic development, which plays a vital part in improving the regional economy and people's living standards, therefore, it is of great significance to accelerate the construction of expressways. However, because it is difficult for the existing system to identify the information of special vehicles quickly, leading to the cumbersome flow of special vehicles passing through the toll station of expressways [1], which brings a certain burden to the work of expressway administrators. The surge in the number of private cars also increased the traffic pressure of toll stations, especially the free expressways traffic policy implemented by the State during holidays, resulting in more frequent traffic jams at high-speed intersections. According to this situation, a intelligent system was created to ameliorate the difficult situation of special vehicle identification on expressways, reduce the congestion at high-speed intersections, and improve the efficiency of staff by data-based means.

Key Words : Special vehicles, Toll station, Inspection system, Intelligent system, Service blueprint

요 약 도로는 국가경제발전의 주요한 일환으로서 지역 내 경제 및 인민생활 수준을 제고하는데 중요한 역할을 발휘한다. 그래서 고속도로 건설의 가속화는 중요한 의미가 있다. 그러나 기존 시스템이 특수차량의 정보를 빠르게 식별하지 못해 특수차량이 고속도로 요금소를 통과할 때 절차가 까다로워 고속도로 관리인의 업무에 일정한 부담을 주었으며, 자가용의 급증은 고속도로 요금소 통행 압력을 다시 한 번 높인다. 특히 명절에 본 연구는 이러한 현황에 기초하여, 데이터화 수단을 이용한 인텔리전스 시스템을 구축하여 고속도로 특수 차량 식별이 어려운 상황을 개선하고, 고속도로 진입로의 혼잡을 줄여 작업자의 효율성을 높이는 방안을 제시한다.

주제어 : 특수 차량, 톨게이트, 사찰 시스템, 지능화 시스템, 서비스 청사진

1. Introduction

In the process of continuous social and economic development, the mileage of expressways in use in China has exceeded 140,000 kilometers, effectively realizing the development from

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scratch, from backwardness to modernization. Based on the promotion of information technology, the current expressway is more in pursuit of high-level requirements of humanization and intelligence. Under the background that expressways have improved the quality of people's life, they also have brought some troubles to the toll station personnel [2]. The surge in the number of private cars has led to the increasing traffic pressure of toll stations on expressways, especially during holidays when the state issues toll free policies for expressways that benefit the public, which makes the problem more serious. The workload of check-in personnel is constantly on the rise, and there is a lack of supervision system for illegal acts such as counterfeiting, forgery and fake plate, resulting in national economic losses. In addition, a large amount of information for special situations has to be registered and recorded manually, and it is stipulated in the regulations on the management of toll stations that the check-in personnel should record the equipment damage or replacement in detail, also the information of new check-in personnel has to be recorded if any, which all have to be realized by the check-in personnel and significantly improve their work pressure [3]. In order to realize the unified management of special vehicles and private cars, and advocate unmanned service, the expressway toll station allows various vehicles to pass via automatic payment by virtue of intelligent management system, so that the unblocked traffic on the freeway is ensured and the status quo of traffic jams bettered. How to improve the management efficiency of expressway toll station, ensure the maximum traffic capacity and reduce the work intensity of check-in personnel has become a major problem to be solved.

In this paper, the development status of the expressway toll station inspection system is analyzed and verified through the model and case study of toll station and the interview of toll station employees. An intelligent toll station inspection system is proposed based on it. After that, the service design of the intelligent toll station inspection system is realized, mainly including software module and data security design, and the tracking of toll station inspection video is set up[4]. Finally, the performance analysis of the inspection system is carried out. The intelligent system of expressway toll station inspection can improve the management of toll station and create greater social and economic benefits for expressway management and operation.

2. The status quo of vehicles passing through toll stations on expressways

2.1 Development status of expressway

Expressways have brought a lot of convenience to the public thesedays while expressway intersections have been extended to many small cities and towns [5]. As is known to all, the rapid development of infrastructure, especially the rapid development of expressways, has greatly improved the traffic capacity and transportation efficiency of highways, and promoted the sustainable and healthy economic and social development of China. By the end of 2018, the total mileage of expressways in China has exceeded 142,600 kilometers, ranking first in the world, covering nearly 98% of cities and prefecture-level administrative centers with a population above 200,000. Therefore, the first choice of convenient and fast transportation for vehicles is the expressway. Whether it's military vehicles or special vehicles, they will choose expressways to carry out their tasks [6].

2.2 The status quo of expressway toll station system

Currently, manual passageways and ETC automatic payment passageways are installed respectively at expressway toll stations in China. ETC has not been popularized and widely used, manual passageways are the major passageway of expressway roll stations at present. However, the task of expressway staff becomes heavier and heavier as the number of private cars increases day and day. In the process of toll charge, there are situation of faking official vehicles [7]. It costs a lot of time to register and verify vehicle traffic, which brings about traffic jams directly, thus, it is extremely urgent to improve the efficiency of toll stations.

2.3 Check-in personnel and negative emotions

When the check-in personnel at the toll station of the expressway encounter special vehicles, for example, military vehicles, fire trucks, police cars, and so on, without an identification method at in the process of passing, and it can only be confirmed through registration and reporting. At this stage, since there are many private cars temporarily using fake plates in order to evade the toll, when the check-in personnel can't confirm it quickly, the long waiting time results in negative emotions on both sides [8]. On the one hand, tasks need to be carried out quickly, on the other hand, they need to be responsible for their work, which means that unnecessary trouble could arise. Therefore, we need to shorten the passing time and improve the passing efficiency for special vehicles, making sure that the relevant confirmation information can be received by the expressway toll station without wasting time.

3. Service Design

3.1 Service overview

In view of the previous cases and studies related to the intelligentization of expressway toll stations, the corresponding system mode and intelligent toll charge are formulated to solve the problems in the expressway toll station system and the problems of counterfeit license plates, card swipe and toll evasion in the expressway toll station system, indicating the effectiveness of the designed system [9]. However, due to the user's lack of understanding of the relevant system, special vehicles passing through the toll station cannot be identified, which requires manual recording and reporting to the leader at the same time. Since it cannot be determined whether the special vehicles need not to be charged for the passage at once, the waste of the passage time and delay of important issued could occur. The failure of in-place inspection on the special vehicles by the toll station personnel may result in related problems. Therefore, it is necessary to design the service of the inspection system [10] and apply the intelligent system to improve the inspection of expressway intersections.

3.2 User interviews of staff

The survey was carried out on the personnel of the toll stations on a voluntary basis. This survey is conducted by means of interview, telephone and WeChat, and the questionnaire survey is designed by myself by ourselves with reference to relevant literature. The contents of the survey include the current use of the system, self knowledge base of the personnel, inadequate monitoring, and the requirements for the intelligent inspection system, etc. [11], as shown in Table 1.

Table 1. Key questions of interview

Key questionnaire	Key questions
Headaches in the work of expressway toll station check-in personnel	1. Do you feel the work procedure complicated 2. Whether materials can be uploaded in time 3. Unable to check and control card change

Existing vehicle detection system	1. Is it often that illegal vehicles cannot be locked on? 2. Unable to receive information in time to deal with illegal vehicles 3.Monitoring difficulties
Special vehicles	1. Government vehicles cannot be identified quickly 2. Are they often big delays if reporting manually
Toll payment of vehicle owners	1. Is manual payment convenient? 2. Is there wrong toll deduction by the intelligent system

The results of the survey are analyzed, sorted out and summarized according to the accuracy of the answers. Evaluation is conducted by relevant experts prior to the use the content, and then it was improved and modified, with a credibility of 0.9. The questionnaire has been carried out on a total of 15 expressway intersection personnel, and 15 of them have fed back towards it. Through the interviews with, the survey of telephone and WeChat onto check-in personnel at the toll stations, the data below has been collected Table 2.

Table 2. Staff Service Vehicle

Problem	% (Number of persons)
Unable to upload in time	0.6% (1)
Card change cannot be checked and controlled	46% (7)
Illegal vehicles cannot be locked on	86% (13)
Processing illegal vehicles with information	53% (8)
Monitoring difficulties	0% (0)
Difficulties in identifying government vehicles	66% (10)
Convenient payment	13% (2)
Wrong toll deduction by the intelligent system	0% (0)
Complicated manual registration and reporting for special vehicles	60% (9)

According to these data, it is obvious that when a vehicle reaches the toll station, 86% staff cannot judge a criminal vehicle, while 60% staff think the procedure is so complicated that it almost delays time and affects efficiency when special vehicle is passing. If staff fail to deal with toll of special vehicles, there will be a traffic jam. So it is a must to solve the problem, realize a quick pass of special vehicles, and prevent the traffic jam happening.

3.3 Access the survey

We conducted a questionnaire survey and interviews on the traffic situation of special official vehicles used by various departments, and made statistics on the driving history on expressways and emergency situations of official vehicles of special departments, and got departments corresponding responses to the problems affecting the efficiency of the department. We resorted to the fire brigade, hospitals, the public security traffic department for the survey (in Table 3).

Table 3. Results of visits to drivers by various

Motor vehicle driver	Interview results
Fire truck driver	At this stage, EDC is adopted to quickly pass through expressway intersections, and the toll fees are submitted by the department all together.
Military vehicle driver	Soldier communication, confirmation and reporting is adopted for military vehicles to through expressway intersections, and procedures are handled uniformly to ensure the smooth passage. All other vehicles shall wait or change to other intersections for passage.
Military vehicle driver	Present certificates and vehicle license plate registration.
Government official vehicles	At this stage, EDC is adopted to quickly pass through expressway intersections, and the toll fees are deducted automatically.

Through investigation into each department, for more convenient passing, vehicles of some departments are equipped with etc on their own, and they reimburse the deduction to the finance independently. On the contrary, special vehicles of other departments still report for a record. Anyway, there is no an effective option to deal with the toll when special vehicles pass the toll station.

3.4 User population

There are many types of vehicles passing through toll stations. This paper focuses on special vehicles except ordinary vehicles. When these vehicles pass through toll stations, no toll is charged in accordance with the stipulation of Chinese laws, and determination needs to be made on the spot. As shown in Table 4.

Table 4. main vehicle

Vehicles	Where they belong
Military vehicles	The army
Fire trucks	Emergency Force
Police cars	Public security bureau
Ambulances	Hospitals
Official vehicles	Local governments

3.5 User journey map export

The time and effort spent on the inspection when the special vehicle passes through the expressway intersection before the system is connected to the data of various departments is huge, while great improvement has been made through the application of the intelligent system. With such improvement, the detailed information of the vehicle can be displayed in one step, and there is no more need to register and report back the information and forth [12]. A lot of unnecessary troubles are saved in the whole process and the specific conditions and pain points are as shown in Fig. 1.

The customer journey map is divided into three stages: in front of the toll gate, identify vehicle information and release. It can be found through the customer journey map that if a vehicle parks in front of the toll gate and fails to be identified as a special vehicle, further reporting by the check-in personnel is required and it can not be released until receiving the confirmation from the superior department. As a result, there will be an increase of workload and negative impacts on both sides to different degrees. The personnel will also be affected emotionally, leaving them with less energy to complete their own tasks, and even worse if there is an emergency.

Through the identification of the inspection system, special vehicles can be quickly identified in the system. The system will automatically lift the stop bar for release, which requires neither reporting and registration, nor the approval of

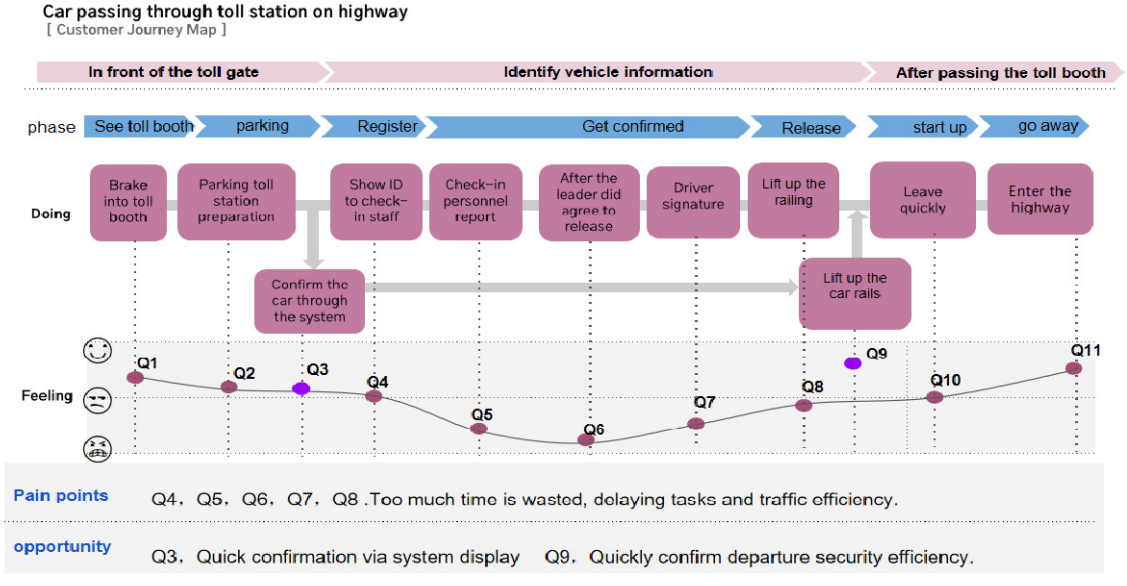

Fig. 1. Special Vehicle User Journey Map

the superior leader, and greatly reduces the workload of the personnel in the two departments. As the passing time is shortened, the personnel will not be affected emotionally, the labor time is reduced, and the work efficiency is improved.

3.6 Analysis and comparison of existing systems

The traditional check-in system of expressway toll station can use the check-in inspection to find problems and realize standardized management. However, work intensity of the traditional system is very high and the management efficiency rather low, which may cause the missing of special cases records due to the negligence of personnel, etc. [13]. In addition, the incompetence of current system inspection can lead to the exile of criminal vehicles. As an important part of the overall traffic system, more attention should be paid to expressway inspection, especially when the system cannot correctly identify the criminal vehicles [14], and the check-in personnel have no basis of timely evidence. In addition, the situation that special vehicles cannot be identified and need to be registered and reported manually level by level seriously affects the efficiency and increase the burden of check-in personnel [15].

Centralized monitoring system is set up too [16], intelligent inspection system distinguishes the authenticity of a special vehicle through linking up with vehicle management system and expressway charging system of departments, omits the steps of registration and reporting for verification, and prevents some certain vehicles from pretending to be special vehicles for the evasion of payment. Moreover, it can distinguish synchronously with the classification of private cars, and improve the traffic jam condition of expressway toll stations while increasing throughput efficiency.

3.7 Overall framework of the inspection system

The intelligent inspection system is deployed in the road section center, provincial center and toll stations, and the information interaction and linkage platform is established in combination with each system [17]. The system mainly consists of toll station system, intelligent data inspection system, management website, lane system and so on. Fig. 2 shows the framework of the intelligent inspection system.

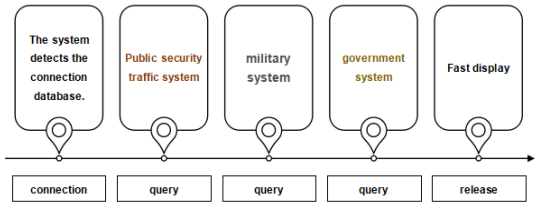

Fig. 2. Framework of the intelligent inspection system

4. Use of inspection system services

4.1 Improve the inspection efficiency at expressway intersections

Traditional inspection can only be carried out for a certain period of time, by a certain toll station personnel on passing vehicles, but the intelligent inspection system will not be limited by the location and time. Instead, it can query and compare vehicle information anytime and anywhere, and achieve the data inspection for the whole period of time and the whole road section. The intelligent system can also be adopted to screen the vehicles that evade tolls, select the vehicles by information query, and verify the inspection data with video and pictures.

As the screening and filtering of the matching data can be realized with computer comparison, the number of vehicles can be reduced and the work efficiency improved. It is stated by to the personnel of toll station that after the adoption

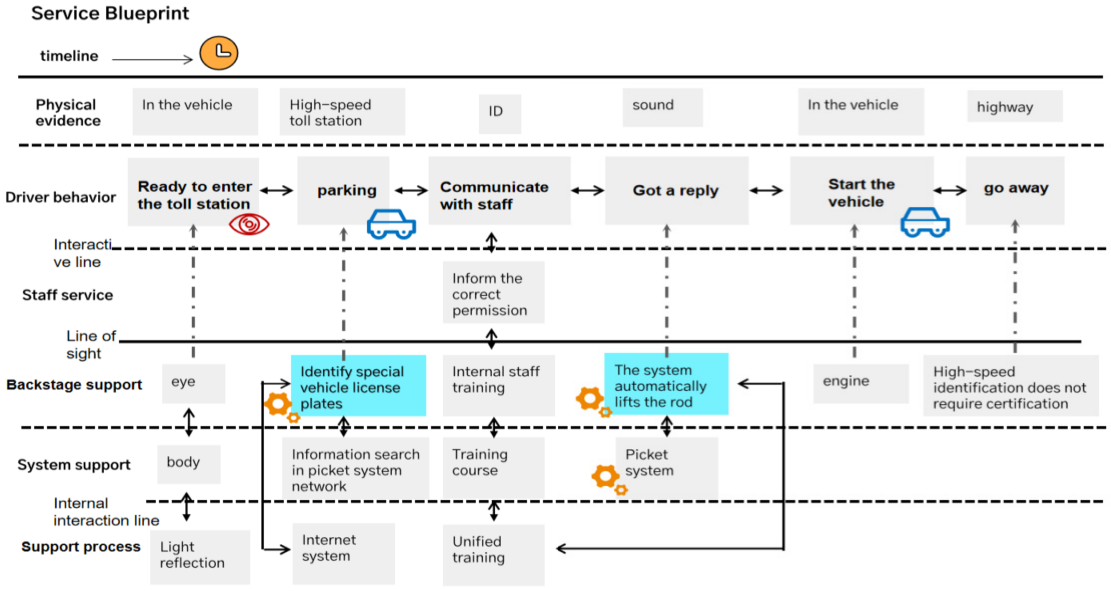

Fig. 3. Service blueprint after system improvement

of the intelligent inspection system, the inspection efficiency of the whole station has been improved, the team construction has been strengthened, the abilities of personnel have been brought into full play, and the system has achieved a good performance in general [18].

4.2 Eliminate crimes and shorten charging time

Through the adoption of the intelligent inspection system, the interference of inspectors to the charging personnel's sense of supervision can be avoided, and fairness and justice can be ensured through data comparison on computer, no inspection gap can be neglected. By learning from different cases, the expressway management personnel can improve their ability to deal with various special situations, be alert to key vehicles, and improve the pertinence of inspection work, so as to enhance the performance of daily management and the management level of the expressway.

4.3 Comparison with current charging mode

Special vehicles can only use manual passageways when passing through the expressway toll station at present, and can't pass through it smoothly until the registration and examination are ratified, which is not beneficial to smooth traffic flow. The inspection system can identify vehicle information intelligently, and distinguish special vehicles automatically when they pass through the toll station. It not only reduces the workload of staff greatly, but also reaches the goal of increasing throughput efficiency.

4.4 service blueprint

when laying out the service blueprint, it can be clearly seen that when special vehicles pass through the expressway intersections, the toll station personnel do not have too complicated procedures to go through, and mechanization with convenience and efficiency can be realized by means of the inspection system as shown in Fig. 3. From the situation of the service blueprint, it is necessary to realize the integration of the

system, improve the vacancy of the system, realize intelligence, reduce the workload of the staff, improve work efficiency and traffic jam of the expressway.

5. Conclusion

It is a long-term and complex task to improve the elimination of evasion passage and criminal arrest on expressways. Through the sound summarizing and analysis of the system data, the study on the tracks and laws of special and criminal vehicles, an information-based inspection system of the whole road network and the whole expressway is created to solve the passage problems of special vehicles. Due to cumbersome procedures for special vehicles to pass through a toll station, it leads to the subsequent retention of ordinary vehicles, and results in the wastage of time and energy on both sides of staff and passers-by. In view of the status quo, it is of practical significance to some extent to establish an intelligent data inspection system. The intelligent data inspection system can effectively identify abnormal license plates through flow inspection and anomaly analysis inspection, and realize the comprehensive recognition of criminal vehicles and special vehicles based on the lane scene, so as to improve the efficiency, make the criminal vehicles nowhere to escape and the passage of special vehicles convenient and fast. The scientific, refined and standardized management of expressway crime inspection should be carried out. The extensive use of the inspection system in the inspection work of expressways has obviously enhanced the ability to plug leaks and increase revenue of expressways, while the intelligent operation order of expressways has also been improved.

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