Application analysis and development countermeasures of intelligent parking in smart city development

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Keywords: Smart City, Smart Traffic.

Abstract: In order to solve the problem of urban development and achieve sustainable urban development, the construction of smart city has become the development trend in the world. Smart traffic is the most intuitive and valuable display of smart city construction. With the rapid growth of car ownership, the problem of urban parking becomes more and more prominent. The traditional transportation infrastructure has been unable to adapt to the needs of modern society, and there is no spare land for the construction of new parking lots, which causes severe parking problems, residents travel difficulties, traffic jams, environmental deterioration and other problems and affects the normal development and function of the city. The intelligent parking system based on the Internet of Things has become the optimal solution of intelligent transportation to solve the parking problem. In this paper, the application of intelligent parking examples to illustrate the improvement of intelligent parking in the city, at the same time, this research analysis of the current development of intelligent parking problems and put forward possible improvement measures. It is expected that this paper can promote the development of intelligent traffic industry and alleviate the current parking contradiction.

1. Introduction

Nowadays, China's economy is developing rapidly. The urbanization rate of China is increasing year by year, and the number of people and cars in cities is also rising. At the same time, the pressure of urban traffic is growing with each passing day. Road congestion, driving difficulties and other problems are becoming more and more prominent. Therefore, it is urgent to establish and improve the urban intelligent transportation system. According to the Ministry of Public Security, by June 2021, there were 384 million motor vehicles in China, including 292 million cars. The number of new energy vehicles was 6.03 million, accounting for 2.06 percent of the total. By region, as of the end of June, 74 cities across the country had more than 1 million vehicles, 33 cities had more than 2 million vehicles, and 18 cities had more than 3 million vehicles [1]. However, the increasing cars make the parking problem serious in China. The parking problem cannot be solved simply by increasing the supply of parking space. The government clearly points out that the construction of urban parking facilities should be gradually strengthened from the 13th Five-Year Plan. In July 2019, the Ministry of Transport issued the *Outline of The Development Plan for Digital Transport*, which clearly stated that it would promote the application of new transport formats such as Internet of vehicles, smart parking, smart buses, ride-hailing and bike-sharing, and promote the in-depth integration of advanced information technology with transport and develop a modern data-driven transport system [2].

With the application of mature technologies such as Internet of Things, Cloud Computing and Mobile Internet in the construction of intelligent transportation system, intelligent parking system has been rapidly developed, but there are many non-technical problems in the practical application of intelligent parking system. This paper would summarize the main problems in the development

process of intelligent parking system and put forward reasonable and effective suggestions for possible improvement.

2. Theoretical Basis of Intelligent Parking

With the rapid development of information technology and the support of related policies, the construction of China's smart city is in a stage of vigorous development, and it has gradually developed from concept to practice. Among them, the smart parking system has gradually entered people's field of vision. This system was first proposed by Teodorovi and other scholars in 2005. Their paper outlined the basic concepts of parking reservation system and parking revenue management system, and proposed an intelligent parking space inventory control system based on fuzzy logic and integer programming technology. The unique feature of this method is that the rules are derived from a set of selected examples under the premise of known arrival patterns [3]. In 2012, Giuffrè and other scholars discussed the conceptual architecture of IPA (Intelligent Parking Assistant), which aims to overcome the parking management problems and become the leading paradigm of smart cities, and proposed to incorporate mobile payment methods into the system [4]. With the development of the Internet of Things, a number of technologies for intelligent parking have been upgraded and the technology tends to be improved. In 2017, DongYurong and other scholars proposed a intelligent parking system based on narrowband Internet of Things. The system updates parking information in real time through NB-lot modules, geomagnetic sensors, repeaters and other facilities, which greatly improves the operating efficiency of the system [5].

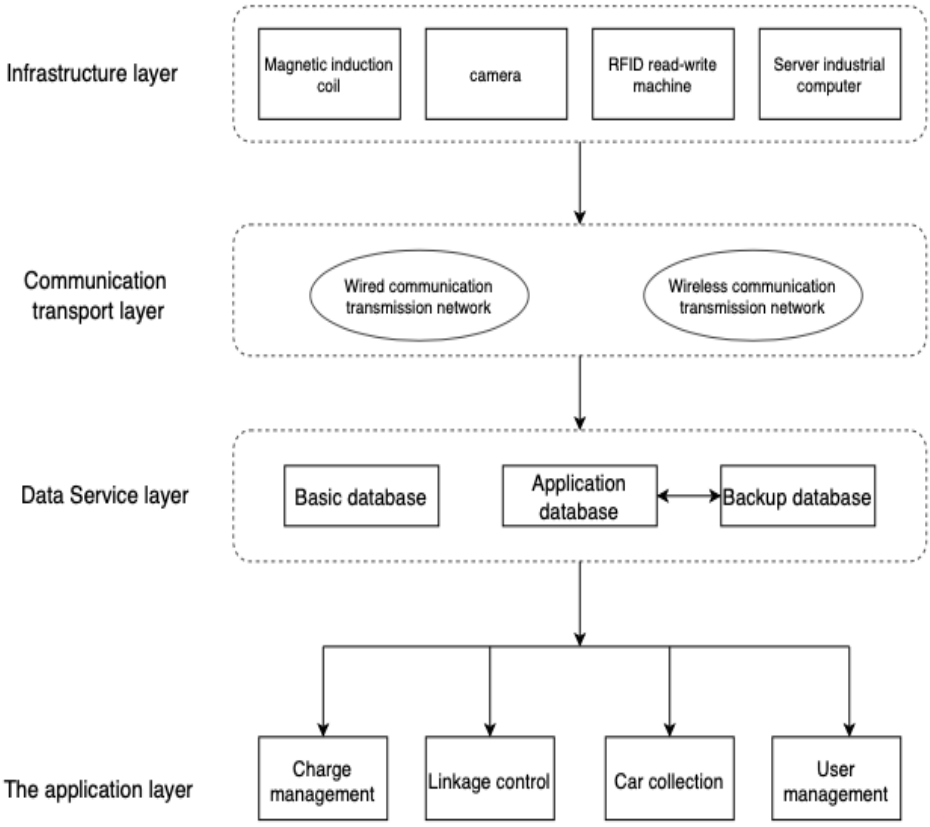

Fig. 1 Workflow framework of intelligent parking system

The diagram shows the system organization structure and implementation steps of intelligent parking. The core technology of smart parking mainly includes entrance and exit vehicle counting technology, vehicle identification technology, idle parking space recognition and display technology, and reverse car search technology. These technologies are mainly based on the infrastructure layer. The specific functions of each technology are as follows [6]:

Tab .1 Specific functions of each technology

Technologies	Effect
entrance and exit vehicle counting	This technology is the first step in the operation of smart parking. Corresponding equipment counts the number of vehicles entering and exiting the parking lot at the entrance and exit of the parking lot, and calculates the remaining number of parking spaces by subtracting the number of entering parking spaces plus the number of exiting vehicles from the total number of parking spaces in the parking lot, at the same time determining the time of vehicle entry and exit.
vehicle identification	Vehicle identification technology is the second most important technology in the construction of intelligent parking system after vehicle counting. The information recognized by the camera is wirelessly transmitted to the background data management terminal. The background data management terminal detects and compares the transmitted data with the standard data in the database, and combines the transmitted historical data to identify the vehicle.
idle parking space recognition and display	In order to quickly find free parking spaces, intelligent parking lots provide information to drivers by identification and display equipment. At present, the commonly used idle parking space recognition technology mainly includes three methods: license plate recognition, geomagnetic recognition, and ultrasonic recognition.
reverse car search	This technology divides the parking lot into appropriate areas, and the cameras installed at each entrance and exit will determine the specific information of the vehicles parked in each parking space based on the results of the license plate recognition of the incoming and outgoing vehicles, combined with the geomagnetic or ultrasonic parking space occupancy recognition in each area. It is convenient to carry out reverse car search.

3. Advantages of Intelligent Parking

3.1 Short queue time

According to estimates, the departure time of the traditional way is about 30s. Compared with the traditional way, a fully functional intelligent parking system saves time in both the process of finding a parking space and leaving the parking lot. The system can guide the vehicle to the nearest parking lot nearby or the least charged parking lot through detailed functions such as remaining parking space query and parking guidance. When the drivers want to leave, they can find the parking space with the help of the system, then quickly guide the vehicle to the exit, finally use mobile payment to pay for the release. On average, it only takes 2 to 3 seconds for each vehicle to leave the field, which greatly improves operating efficiency.

Take the smart parking application in Xiaoshan District, Hangzhou as an example. Xiaoshan District is the transportation hub of Zhejiang Province and one of the business centers of Hangzhou. In 2019, Hangzhou government launched the APP called Xiaoshan Smart City to implement the measures of "leave first, pay later". It integrates multiple functions by loading parking guidance public services, such as online guidance, big data analysis, non-inductive payment and so on. As of the end of September 2019, a total of 46 parking lots opened in Xiaoshan District, involving 13,468 parking spaces. Different from the traditional manual charging mode, the digital parking in Xiaoshan District supports diversified and multi-channel payment. The data shows that the intelligent parking system saves the total travel time by an average of 7.5%, increases the vehicle speed by an average of 7.6%, and reduced the total mileage by 0.6% [6].

3.2 Improvement of Economic Benefits

Transportation is an important factor for regional economic development. As most OD points for travel, the urban core business district has a strong agglomeration effect and attractiveness, which enables a variety of economic activities including the intelligent parking industry to be concentrated in one area. The distance between merchants and consumers is shortened, achieving the goals of reducing costs, maximizing benefits, and improving consumer satisfaction, which ultimately promotes the construction of economic structure.

Take a shopping mall located at the centre area of Guangzhou as an example. Before the system was put into use, the parking lot had many problems such as low parking space turnover, high management costs, and low service efficiency because there was lack of systematic parking management. The parking lot can accommodate up to 1,300 vehicles per day. After the intelligent parking system was put into use, the parking efficiency increased by 5 times from 20 times per minute to more than 100 times per minute. On weekends, the parking lot can accommodate more than 2,000 vehicles in a day. Because of the intelligent parking system, the workload of the parking lot administrator is reduced, the parking lot is managed in an orderly manner, and the operating cost of the entire parking lot is reduced at the same time. The sharp increase in mall traffic has led to a 20% increase in mall sales. In conclusion, intelligent parking system can drive the production and consumption, which is conducive to the overall development of the regional economy [7].

4. Existing problems and research countermeasures of intelligent parking:

4.1 Data Island

As an emerging model of the parking industry, intelligent parking has no clear regulations on the hardware specifications and software interfaces of parking space collection. There are currently more than one hundred companies in China that are engaged in the research and development of parking lot management systems and the production of parking equipment. However, the products produced by these companies are different, there are many difficulties in specific docking. In addition, the parking lot information networking standards have not yet been established between the various systems. The phenomenon of separate governance is common, and a large amount of data has not been integrated. Although there are multiple intelligent parking-related APPs in operation, the data displayed by each APP is different. Users cannot get accurate information about the number of remaining parking spaces, and even some parking lots are not displayed in some apps [8].

Therefore, we should use the integration and sharing of internal data resources to solve the problems of resource decentralization, system division, and management division in the construction of smart cities. At the technical level, the industry must implement the same specifications. In view of the lack of standards and specifications, it is necessary to establish a unified information construction standard to achieve cross-system technology integration, solve the problem of information islands, and promote resource sharing. At the same time, the government should strengthen supervision and play a more important role in the industry. In the process of putting intelligent parking system into use, relevant departments should promptly discover and collect such problems to make improvements, realize multi-system information sharing, so as to integrate resources to the maximum and avoid low-level duplication of construction.

4.2 Difficulty in implementation

The communication of applying intelligent parking is extremely difficult because it involves multiple stakeholders including owners, properties, and original equipment manufacturers. Except for roadside parking lots, the ownership of parking lots can be divided into three types: all government-invested parking lots, some government-invested parking lots and socially owned parking lots [9]. However, the property rights and operation of most parking lots belong to Different departments. Nowadays, there are few encouraging policies related to the application of intelligent parking, and there are no corresponding laws and regulations to force public parking lots to be connected to the data

collection system of government departments. The number of parking spaces controlled by the government is very limited. Constructing intelligent parking system only by the government cannot drive the industry. Some socially owned parking lots are not very enthusiastic about the system in terms of cost, revenue, and network security. Many cities are also facing financial pressures in the process of implementing smart parking. In addition to the investment in facilities predicted in the early stage, the business costs of negotiating with many socially owned parking lot owners cannot be accurately estimated. In general, it is difficult to accurately control the progress of the project.

Based on this, this study believes that market demand is an important driving force for the development of smart cities. The Paper *Difficult Construction of Public Parking Lots and Its Solutions -- A Case Study of Wuhan city* mentioned: Wisdom parking construction should realize the urban public parking lots of investment mode diversification, social public parking lots including commercial allotment have strong market autonomy in operation [10]. The construction of intelligent parking should give full play to the advantages of market allocation of resources. Social public parking lots with commercial facilities have strong market autonomy in operation. Enterprises can develop projects with broad application prospects based on actual needs through market-oriented competition. At the same time, we should pay attention to the preliminary planning, clarify who is responsible for the business scope and responsibilities before applying the intelligent parking system, and avoid self-built systems through division of labor and coordination of interests.

4.3 Limited space

The conflict between the increase in the number of urban vehicles and the shortage of parking spaces has exacerbated the problem of shortage of parking spaces, which is the root cause of today's urban parking problems. According to data released by the National Development and Reform Commission, the current ratio of cars to parking spaces in large cities in China is about 1:0.8, in small and medium-sized cities is about 1:0.5, but in developed countries is about 1:1.5. At present, the number of traditional parking spaces in China is about 120 million, while the demand for parking spaces exceeds 200 million [11]. The gap between the supply and demand of parking in the cities will further increase. Under the premise that most first-tier and new first-tier cities are saturated with land, it is particularly important for us to maximize the use of urban parking land.

The combined use of a three-dimensional parking lot with a smart parking system can effectively alleviate the shortage of parking spaces. Compared with traditional parking methods, three-dimensional parking lot has many outstanding advantages. First of all, the most obvious advantage is the high land utilization rate, the area occupied by the three-dimensional parking lot is only 5% to 30% of the traditional parking lot [12]. The use of double-layer mechanical garages can increase the utilization rate of the ground by 80% to 90%, when the number of layers increases, the land saving rate also increases, which greatly saves land resources [13]. Secondly, the cost is lower. It is undeniable that the construction of three-dimensional parking equipment requires a lot of construction costs and maintenance costs. The comprehensive cost is higher than that of a three-dimensional parking lot.

5. Conclusion

Based on the development and application of the intelligent parking system, this article summarizes the main advantages of the system and the shortcomings of the current system, and I try to put forward corresponding improvement suggestions. Intelligent parking system is a product of information development during the process of building smart city. Its characteristics of improving traffic efficiency, benefiting regional development, and reducing exhaust emissions have improved residents' travel experience and promoted a virtuous urban cycle. At the same time, it can also stimulate urban economic growth and promote the development of related industries. Regrettably, this article is not fully developed in the countermeasure recommendations. In practical applications, the factors that each parking lot needs to think about are obviously different. The proposed methods are somewhat general, so the application should be based on the actual situation and adapt to local conditions. With the development of the Internet of Things, more and more new technologies will inject energy into the

development of the industry in the future. Focusing on intelligent parking, we are contributing to the formation of a complete industrial ecological chain and the sustainable development of cities.

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