Research on Electric Vehicle Intelligent Parking Charging System

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Abstract. This article proposes an intelligent parking system in response to the current difficulties in charging electric vehicles in our country. The system integrates license plate recognition technology for vehicle identification and develops an intelligent system. It aims to prevent the occupation of charging station parking spaces by fuel-powered vehicles and the occurrence of the "short charging, long parking" phenomenon in electric vehicles while eliminating uncivilized parking behaviors. The system enhances the utilization efficiency of charging stations, thereby alleviating the challenges faced in charging electric vehicles. This paper provides an explanation and evaluation of the system through several sections, including technical introduction, application scenario selection, operational processes, practical significance, and feasibility analysis. Specifically, the operational processes propose corresponding mitigation measures for different scenarios. The conclusion presents prospects for this system, emphasizing its alignment with expected outcomes in terms of technology, economics, and feasibility. Furthermore, there is considerable potential for further development, contributing to the advancement of the electric vehicle industry in our country.

Keywords: Intelligent parking system, electric vehicle, charging.

1. Introduction

Nowadays, China has implemented policies and regulations to support the development of electric vehicles, including fiscal and tax support, subsidy policies, technical standards, and regulatory systems. The country has also promoted the release of the electric vehicle market through government guidance, independent innovation of enterprises, and consumer demand guidance, among other measures. The application of new technologies on electric vehicles will also help to form healthy competition with the traditional automotive industry and promote the transformation and upgrading of the entire automotive industry ecology. In 2017, China produced 794,000 electric vehicles, making it the world leader. The country has also implemented comprehensive laws and regulations, reflecting the trend towards a circular and low-carbon economy. The electric automobile industry is thriving. As of the end of 2019, electric vehicles accounted for only 5% of China's automobile market, with fuel vehicles making up the remaining 95% [1].

The majority of vehicles in China's automotive market are still fueled by traditional combustion engines, which poses significant challenges to the development of the country's electric vehicle industry. One of the major challenges is the shortage of charging stations. As of the end of 2022, data released by the China Electric Vehicle Charging Infrastructure Promotion Alliance revealed that the ratio of charging stations to vehicles in China was approximately 2.5:1. This falls far short of the targets set by the Ministry of Industry and Information Technology, which aims to achieve a ratio of 2:1 by 2025 and 1:1 by 2030. Furthermore, investigations indicate that due to limited parking spaces in urban areas, charging stations are often occupied by vehicles fueled with traditional combustion engines [2]. Service providers have not implemented adequate measures to address this issue, resulting in significantly low utilization rates of charging stations. This exacerbates the already challenging situation for electric vehicles, making the problem of charging difficulty even more severe.

In parking lots, the availability of charging stations is often hindered by conventional fuel vehicles occupying these spaces and the trend of electric vehicles engaging in extended parking while limiting their charging time. This study aims to address the issue of low charging station utilization and the

difficulty of charging electric vehicles caused by these occurrences. To tackle this problem, an intelligent parking system is proposed in this paper, encompassing a technical introduction, selection of application scenarios, operational processes, analysis of practical significance, and feasibility assessment. The objective is to validate the practical feasibility of the proposed system and enhance charging station utilization rates while mitigating challenges associated with electric vehicle charging.

This study aims to develop an intelligent parking system that utilizes mature license plate recognition technology to enhance charging station efficiency, reduce costs, alleviate the burden of electric vehicle charging, and contribute to the development of China's electric vehicle industry. It aligns with the country's carbon reduction strategy, providing insights for achieving further progress in green and sustainable development.

2. Instructions for the operation of the system

2.1. Introduction to Application Technology

Based on the above problems of ‘charging difficulty’ and ‘occupancy’ of electric vehicles and the current situation analysis, this paper presents an intelligent parking system based on license plate recognition technology.

License plate recognition technology uses computer image processing to extract information and determine the plate number. The device includes a camera, video acquisition interface, computer, and lighting device. The camera captures the video image, which is then processed and recognized by the computer to obtain the plate number. The auxiliary lighting device provides light in low light conditions. License plate recognition technology is widely used in China for highway, urban traffic, and parking lot management. In the development of intelligent transportation systems, the technology employs advanced video detection, image processing, pattern recognition, and artificial intelligence to reduce labor, save resources, and increase efficiency while creating commercial value. As the technology diversifies into integrated systems, it is becoming more mature and cost-effective in China [3]. Thus, this system will be developed and promoted using well-established technology. Figure 1 shows the extensive application of license plate recognition technology in toll management on highways and parking lots. This technology has reached a mature stage and successfully serves human society [4].

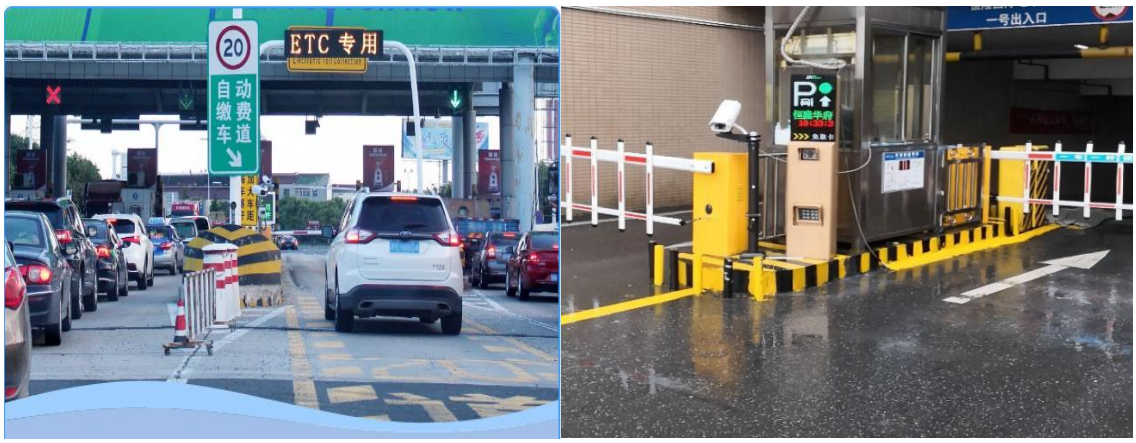


Figure 1. The popularization of license plate recognition technology [5]

2.2. Application scenario

On February 15, 2023, the Shanghai Municipal Transportation Commission, Municipal Development and Reform Commission, Municipal Road Transport Bureau, Municipal Public Security Bureau, and Municipal Fire Rescue Corps jointly issued the "Shanghai Public Parking Charging Facilities Construction Management Measures" notice, which means the construction of

new (reconstructed, expanded) public parking lots equipped with charging facilities should build the corresponding number of charging pile parking spaces according to different levels [6].

Most electric vehicle charging piles are placed in existing parking lots. But in fact, the vast majority of cars in China are fuel vehicles, in the parking lots with limited spaces, which will lead to fuel vehicles seizing charging pile parking spaces in parking lots, resulting in a shortage of charging pile parking spaces and difficulty in charging electric vehicles. In addition, some electric vehicle owners tend to occupy the charging spot even after the vehicle is fully charged. All of Those lead to the following two problems:

A. Fuel-powered vehicles dominate the market and often occupy charging positions intended for electric vehicles in parking lots, leading to charging difficulties for electric vehicles.

B. Due to a shortage of electric vehicle parking lots, more and more electric vehicles experience "short charge and long stop" where they park for a long time after charging.



Figure 2. The challenges being faced by China's electric vehicles [7]

At present, the phenomenon that traditional fuel vehicles occupy the space of charging stations in parking lots leads to the difficulty of charging electric vehicles, as shown in Figure 2. This issue is significant and noteworthy. The above problems have led to the low utilization rate of charging piles, the difficulty of charging, and the current situation of poor operating income. A series of vicious circles have also had a lot of impact on the development of the electric vehicles industry, and the industry has lacked strong measures to solve these problems. Therefore, the intelligent parking system is set up on each electric vehicle charging pile, by identifying whether it is an electric vehicle or whether the charging is completed, to improve the utilization rate of the charging pile, and ease the challenge of charging difficulties and long wait times for electric vehicles.

2.3. The process of system operation

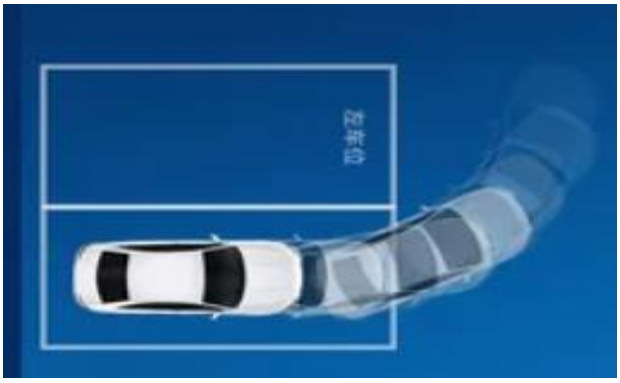


Figure 3. Vehicle access to parking space (area to be identified) [8]

Figure 3 shows the process of the car entering the area to be identified. For problem A, after a vehicle enters an energy-charging parking space, a camera detects whether it has entered and then performs intelligent license plate number identification. Chinese electric vehicle license plates are green and have 6 digits, while fuel vehicle license plates are blue and have 5 digits, the system confirms the vehicle's identity by comparing license plate information. If in the community or park parking lot, the identification information is uploaded to the cloud system, The system then determines whether the vehicle is an electric vehicle or a fuel vehicle and provides different feedback accordingly. For example, if it is an electric vehicle, the charging pile can be started normally. If it is a fuel vehicle, the charging pile's voice broadcast guides the owner to park in other spaces. This ensures that the charging pile parking space is only for electric vehicles.

For problem B, electric vehicles in the "short charge and long stop" scenario, if the vehicle remains in the parking space for over 2 hours after a full charge, the corresponding app will automatically lock the owner's contact information via the license plate for information reminder or WeChat public account notification [9]. Currently, when electric vehicles begin charging operations, they must scan mobile phone codes to bind and verify their mobile phone numbers. So this operation is convenient and easy to implement. Figure 4 shows the workflow of the intelligent parking system.

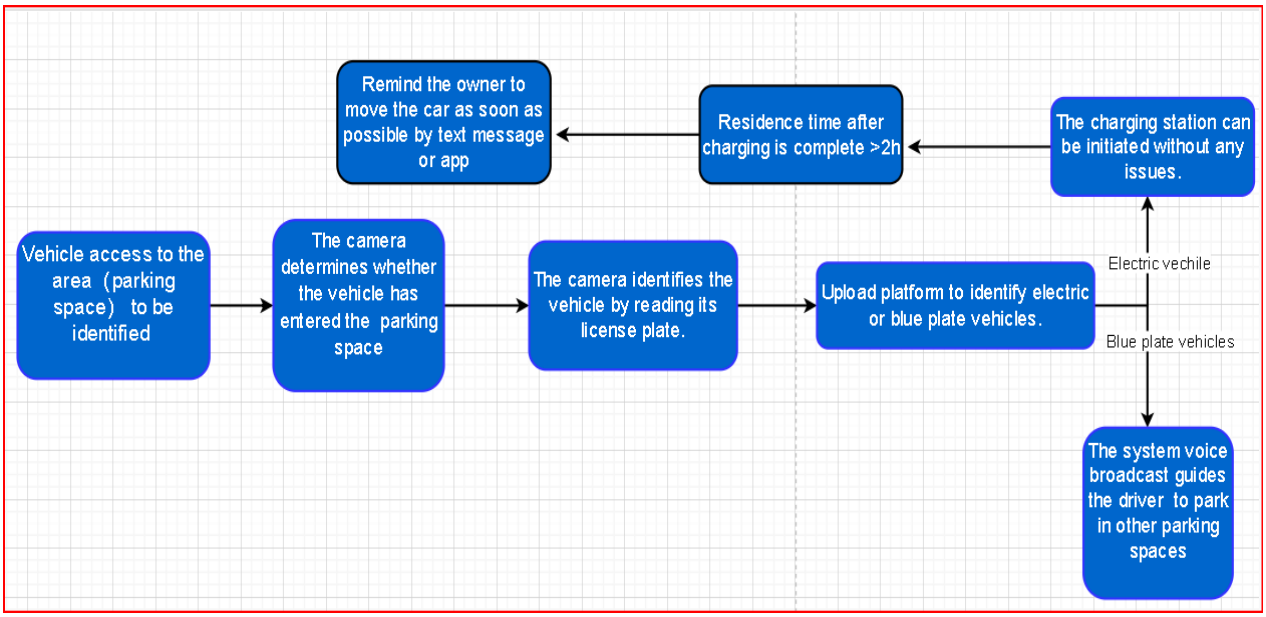


Figure 4. The detailed process of system operation (Picture credit: Original)

3. Analysis of Practical significance

Based on the above problems, the intelligent parking system proposes corresponding solutions to this, all of which are to identify and respond to the parked vehicles in the parking space through intelligent license plate recognition detection technology.

The intelligent parking system tackles the issue of electric vehicle charging difficulty by preventing fuel vehicles from occupying charging pile parking spaces. The system curbs this issue at its source, ensuring that there are sufficient charging pile parking spaces available for electric vehicles. The system identifies fuel vehicles entering a charging pile parking space and notifies the driver to find another parking spot through an alarm or voice broadcast. This approach minimizes parking space tension and avoids conflicts. It can also identify electric vehicles and start the charging pile for charging purposes. China's license plates for electric and fuel vehicles have clear differentiation, there are two distinctions: one based on color and one based on digits, allowing the system to distinguish their identities through various programs.

Some electric vehicle owners have short-term charging and long-term parking behavior. The system regularly scans the license plate of the parked vehicle. If the parking space is occupied for

more than two hours after the completion of charging, the owner will be reminded through the WeChat public account or SMS reminder to leave in time. If the reminder is ignored, the time will be billed and automatically deducted from the account balance. The implementation of this system greatly alleviates the problem of electric vehicle charging difficulty. It is unfair to owners with charging needs to occupy public charging parking spaces for long-term parking, which aggravates the tension of charging pile parking spaces and the dilemma of electric vehicle charging difficulties. In response to this phenomenon, the system reserves two hours of a busy time for the previous owner, which effectively alleviates the problem of occupancy based on humanization. Since most charging stations in China require users to link their mobile phone numbers for information before use, it is convenient to contact the owner. Additionally, fines and deductions for parking vehicles for extended periods are severe, which can help prevent the occurrence of such unwanted events to some extent.

4. Feasibility analysis and future study

4.1. Feasibility analysis

Since the early 1990s, relevant foreign researchers have been studying license plate recognition technology [10], and some notable works are as follows:

(1) R. Mullot developed a system that primarily utilizes the commonalities in text texture in vehicle images for positioning and recognition. This system has been applied to recognize license plates on both containers and ordinary vehicles.

(2) Yuntao Cui developed a license plate recognition system that employs Markov field techniques to extract and binarize license plate features.

(3) Tindail has created a license plate recognition system utilizing the principle of reflecting license plates. This system enables the recognition of all five license plate formats used in the UK.

(4) Young Sung Soh developed a real-time license plate recognition system that reportedly achieves a high accuracy rate of 99.2%.

At the same time, in China, many domestic researchers have also achieved remarkable results in license plate recognition. At the laboratory level, research institutions such as the Image Processing and Recognition Laboratory of Xi'an Jiaotong University, the Department of Computer Science and Engineering of Shanghai Jiaotong University, the State Key Laboratory of Artificial Intelligence of Tsinghua University, and the Department of Automation of Zhejiang University have conducted independent studies on license plate recognition and achieved significant results.

At the researcher level, the team led by Liu Zhiyong from the Institute of Automation at the Chinese Academy of Sciences published an article stating that they achieved a license plate positioning accuracy of 99.4% and a segmentation accuracy of 94.5% in a sample set of 3180 plates. Furthermore, Professor Hu Aiming from Beihang University and his colleagues developed a license plate recognition system using template matching technology, which was specifically applied to toll stations. This system has a recognition accuracy rate exceeding 97% [11]. These factors demonstrate that license plate recognition technology in China and even globally has reached a relatively mature stage. The current systems are capable of automatically identifying vehicles with high reliability and recognition rates. They boast a simple structure and user-friendly operation, enabling automated vehicle processing [12].

4.2. Future Study

During the actual license plate recognition process, various factors such as license plate discoloration, scratches, stains, and occlusions can introduce significant interference to the license plate recognition system. As shown in figure5, this can interfere with system identification. This interference often results in obstacles during the recognition process, impeding the system's ability to accurately identify and retrieve vehicle identity information. Additionally, noise pollution, low contrast, and color distortion can occur due to scene interference, displacement between the lens and the scene, and the influence of the transmission medium. These issues can negatively impact the

acquired image quality, making it difficult to determine the license plate position and carry out successful recognition. In some cases, they may even lead to system failures [13].



Figure 5. License plate discoloration, scratches, stains, and occlusions [14]

Future study directions will focus on license plate processing in special scenarios, aiming to achieve clear differentiation and handling of electric vehicles and conventional fuel vehicles under such conditions. This will enhance the accuracy and reliability of the system, aligning with the demands of real-world environments.

5. Conclusion

This article addresses the issue of charging station occupancy by conventional fuel vehicles and the problem of "short charging and long parking" by electric vehicles in parking lots. To alleviate these issues and improve the utilization rate of charging stations, an intelligent parking system is proposed. By distinguishing between electric vehicles and providing timely reminders for overstaying, the system aims to mitigate the aforementioned problems.

The longstanding issues of "conventional vehicles occupying charging spots" and "short-term charging and long-term parking" in China have been lacking effective measures. This problem has hindered the development of the electric vehicle industry in our country. Simultaneously, the low utilization rate of charging stations has resulted in unfavorable revenues for charging station operators. This system not only provides a partial solution to the difficulties faced by electric vehicle owners in charging their vehicles but also supports the development of the electric vehicle industry in China. Additionally, it assists charging station operators in generating income and increasing profits. In the future, the research focus of this project will prioritize precise license plate recognition in special scenarios, such as damaged or stained license plates. The system will be further developed for mass production, resulting in significantly reduced costs and contributing to the advancement of the electric vehicle industry in our country.

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