PILOT APPLICATION AND RESEARCH OF ELECTRIC BICYCLE INTELLIGENT MANAGEMENT SYSTEM BASED ON IOT AND WIRELESS CHARGING TECHNOLOGY IN THE CONSTRUCTION OF SMART CITIES IN CHINA

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This paper is based on the research project "Technical Guidelines for Electric Bicycle Intelligent Management System" initiated by the Wuhan Municipal Construction Bureau in 2022. Through the development of IOT electric bicycle management technology and medium-high power wireless charging, an integrated electric bicycle intelligent management platform was developed and piloted locally. This research has great application prospects in forecasting and statistical analysis of electric bicycle travel data, vehicle usage, charging safety, energy conservation and emissions reduction, effectively addressing the challenges of short-distance personal travel in the construction of smart cities.

Key Words : *electric bicycle intelligent management, electric bicycle management basing on IOT technology, wireless charging electic bicycle, smart tranportaion, short distance personal travel*

1. Overview

In the construction of smart cities in China, electric bicycles have become one of the most important means of transportation for people. However, due to the large number of electric bicycles and potential uncivil behaviors in their use, such as illegal parking, unauthorized entry into prohibited areas, and unsafe charging leading to fires, they present significant challenges for urban managers.

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2. Research on the Current Status of Electric Bicycle Application and Management in China

Electric bicycles are widely used in China, especially in urban areas. According to data from the National Bureau of Statistics, by the end of 2021, the number of electric bicycles in China had exceeded 320 million, accounting for more than half of the entire transportation market, making them a dominant force in urban transport. To regulate the electric bicycle market, both the State Council of China and local governments have introduced corresponding management policies.

On August 6, 2022, the State Council Safety Committee issued the "Key Work Tasks and Division of Labor Plan for Strengthening the Safety Supervision of the Entire Chain of Electric Bicycles" (hereinafter referred to as the "Plan"). [1]The plan outlined 12 key tasks from four aspects: enhancing safety quality at the production source, strengthening law enforcement in the distribution and sales phase, standardizing end-user safety management, and promoting safe control in the disassembly and recycling phase, clearly defining departmental responsibilities.

In October 2021, the People's Government of the Guangxi Zhuang Autonomous Region announced the "Management Measures for Electric Bicycles and Motorized Wheelchairs in the Guangxi Zhuang Autonomous Region", [2]which set specific requirements for the parking and charging management of electric bicycles and motorized wheelchairs.

In March 2022, Guangdong Province issued the "Methods for Implementing the Fire Protection Law of the People's Republic of China in Guangdong Province", [3]explicitly prohibiting the parking of electric bicycles and electric motorcycles, or charging them and their batteries in public lobbies, evacuation channels, safety exits, stairwells, or any indoor places that do not meet fire safety conditions. Bringing electric bicycles, electric motorcycles, and their batteries into elevator cars is also forbidden. Non-compliant entities face fines of up to 5,000 yuan, while individuals can be fined up to 1,000 yuan.

In March 2023, Fujian Province released the "Fire Regulations of Fujian Province (Revised Draft Amendment)". [4]It mandates that government bodies, associations, enterprises, institutions, and residential communities should establish centralized or relatively centralized parking and charging locations for electric bicycles and electric motorcycles according to fire technical standards. Additionally, the regulation emphasizes the need for the government to develop fire safety technical standards for these centralized parking and charging locations for electric bicycles and motorcycles.

In May 2022, the Wuhan City Government of Hubei Province implemented the new "Wuhan City Fire Management Regulations", [5]which clearly stipulated requirements for fire safety management of centralized electric bicycle charging stations and fire incident investigations. This topic is also one of the measures accompanying the execution of the new "Wuhan City Fire Management Regulations".

From the aforementioned information and policies, it's evident that the extensive use of electric bicycles by the Chinese public to address short-distance transportation needs is undeniable. Additionally, the vast majority of end-deliveries for China's booming courier and food delivery services rely on electric bicycles. The primary concerns of both the Chinese public and the government regarding electric bicycle management focus on several aspects: 1. Quality of electric bicycle products; 2. The pressure from the extensive traffic and parking of electric bicycles; 3. The safety of charging electric bicycles. Especially the latter, recent tragic fires caused by charging electric bicycles, widely reported by the media, have become a focal point of attention for both the government and the public.

To better address the aforementioned challenges of electric bicycles in the management of smart cities, this paper researches and demonstrates the standardized application of technologies, including IoT, wireless charging, and platform management, in the intelligent control of electric bicycles and their integration into smart city management.

3. Research on the Current Status of Electric Bicycle Application and Management in China

IoT technology can be extensively applied to the intelligent management of electric bicycles, especially suitable for scenarios like electric bike smartification, smart sharing of electric bikes, and intelligent battery swapping. It conveniently offers a one-stop IoT solution for intelligent electric scooters.

This paper utilizes a smart central control ECU as the sensing layer, collecting real-time location and status information from electric bikes, which is then transmitted to the cloud via the 4G Cat.1 network. The vehicle's location, trajectory, status, battery, malfunctions, alerts, and other data are sent to the operation and maintenance platform/APP. This allows for precise mileage tracking of the vehicles, effectively reducing accident rates and overall management costs. Combined with Bluetooth communication, voice broadcasting, and electronic fencing functionalities, it better guides users to park correctly, thus mitigating issues related to haphazard parking.

Meanwhile, relying on the big data analysis capabilities of the SaaS cloud platform, the distribution of

vehicles is clear at a glance. City managers can quickly gather statistics and perceive road congestion caused by electric bicycles, generate visual charts depicting electric bike usage frequency, and analyze short-distance travel habits and riding preferences of users in different areas, aiding in urban traffic operation decisions.

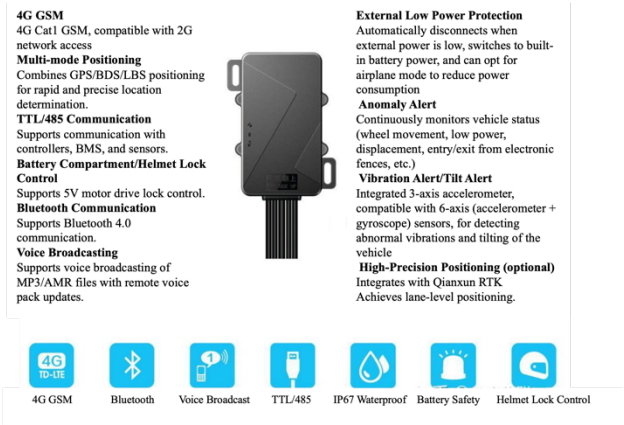


Fig. 1 IoT Central Control System Used in This Study

Furthermore, the application of IoT technology has made intelligent, shared e-bikes a viable solution for short urban commutes. In 2020, due to the impact of the pandemic, local governments relaxed regulations on electric bikes, leading to a surge in the deployment of shared electric bikes. It's estimated that around 7.5 million units were launched in 2020, with top-tier companies like Hellobike, Didi, and Meituan each contributing 2 million units, and second-tier companies like Liubike, Songguo, and Baimi each introducing 300,000 units. By 2024, the market size for outdoor positioning terminals for two-wheeled vehicles in China is projected to reach 12.3 billion yuan.

4. Research on the Standardized Application of Wireless Charging Technology in Electric Bicycle Intelligent Control Systems

This research employs the latest magnetic resonance wireless power supply technology, which offers power coverage between 100-1200W and has an external efficiency exceeding 90%. It has been widely applied in scenarios such as mobile robots, electric bicycles, warehouse logistics vehicles, golf carts, electric tools, and more.

The wireless charging module primarily consists of a transmitting end and a receiving end. The transmitting end includes the main transmitter and the transmitting coil, while the receiving end comprises the main receiver and the receiving coil. The receiving main unit is placed inside mobile devices like robots or electric bikes and is connected to the power source and main control, while the transmitting main unit is linked to the power grid. When charging is required, the mobile device moves to the charging position. Upon communication establishment between the transmitting and receiving main units, non-contact charging is achieved, even with a certain distance between the devices.

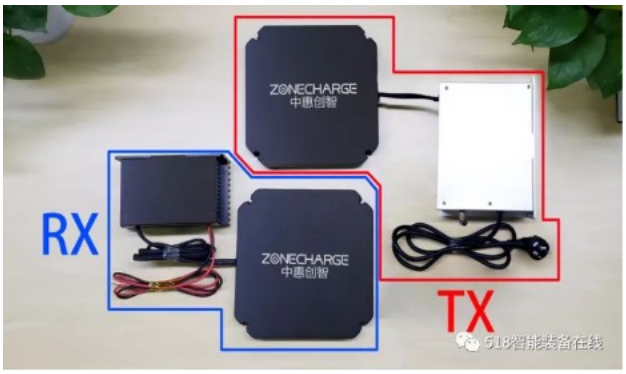


Fig. 2 Typical Wireless Charging Module with Reciever side (RX) and Transimiting side (TX). The system is capable of transimitting maximum 600W power withing 3-5cm range. The outer energy transimitting efficiency is 85-95%

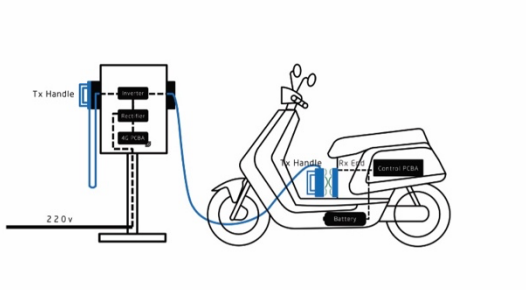


Fig.3 Construction Schemitic of Magnetic Attraction Wireless Charging System for Electric bicycle

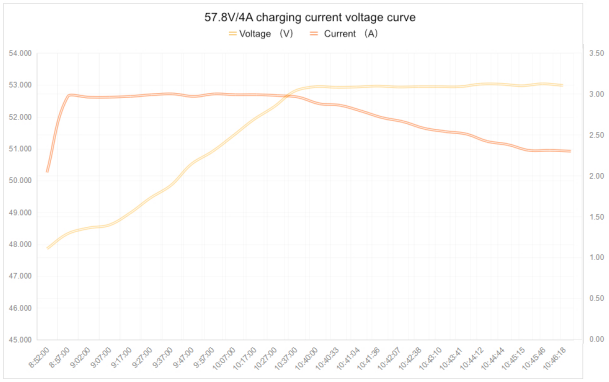


Fig.4 Typical Electric Bicycle Wireless Charging Voltage-Current Diagram (48V12A Battery Pack)

For the wireless power supply system developed for electric bicycles in this project, the following performance has been achieved:

(a) The maximum charging power is 320W, with a maximum charging current of 4A. It automatically adapts to charging lithium batteries and lead-acid batteries with voltages ranging from 24-72V.

(b) Energy transmission between the transmitter and receiver is contactless. Both the transmitting

and receiving ends achieve waterproof levels of IPX7 and IPX8 or higher, respectively.

(c) During the charging process, the transmitting coil and receiving coil maintain real-time 2.4G communication, with the live voltage of the battery load on the receiving end continuously transmitted to the transmitting end (as shown in Figure 3). The transmitting end can adjust the voltage, current, or switch in real-time based on the load received.

(d) Both the transmitting and receiving ends can be connected to the cloud using IoT technology.

(e) There are various charging pile options for electric bicycles, including magnetic absorption charging as shown in Figure 2, side pile methods, or ground pile methods.

(f) All electric bicycle charging piles are connected to the cloud, and they can instantly upload data such as location coordinates, charging information, and electric bicycle battery charging curves to the cloud. This data is then integrated into the big data management of smart cities.

In China, the public's concern about incidents of fires and casualties caused by electric bicycle charging is extremely high. Given the trend of strict control policies continually issued by the government, it's evident that now and in the near future, charging of electric bicycles in China will be designated in outdoor or specified public areas. Electric bicycle charging piles will become part of urban infrastructure as public utilities. Wireless power supply technology achieves non-contact and electrical insulation during charging, ensuring utmost safety in outdoor and public places. Moreover, its real-time monitoring of the charging process prevents battery overcharging and even monitors battery charging lifespan, eliminating the majority of fire hazards. Additionally, the combination of wireless charging piles and IoT technology enables large-scale data management of electric bicycles in urban management and promotes the proliferation of shared electric bikes.

5. Research on the Market Application of Intelligent Control Platforms for Electric Bicycles in Smart Property Management

Combining the IoT technology and wireless charging technology of electric bicycles discussed in Chapters 3 and 4, this paper constructs a demonstrative charging station in Wuhan and experimentally offers local residents the conversion of their existing electric bikes to wireless power supply. The daily operation of the charging station is shown in Figure 5. Considering the actual needs of users, the demo charging station uses both magnetic suction wireless charging piles and side charging piles. Existing electric bicycles were equipped with wireless charging receivers through simple modifications. All charging piles and electric bicycle receivers are integrated into the cloud platform developed in this paper for real-time monitoring. A charging payment application based on the WeChat Mini Program is provided for users.



Fig.5 Public Wireless Charging Station for Electric Bicycles



Fig. 6 User operation process for the E-Bike wireless Charging system:
a)Remove the magnetic suction disc from the charging pile.
b)Directly attach the magnetic suction disc to the receiver.
c)Use a mobile phone to scan a QR code on WeChat, enter the mini program, pay for the charging fee, and start charging.
d)After charging is complete, directly return the magnetic suction disc to the charging pile.

During the first phase of the demonstration pile operation, feedback from 50 users indicated positive evaluations of the reliability and safety of the wireless charging process. Preliminary validation was achieved for features such as charging safely in high outdoor temperatures, rain, convenience of use, and fire risk mitigation. The stability of the cloud platform and the mini program was initially verified. In

the next phase, there will be gradual promotion, and its data will serve as the practical basis for the Wuhan Municipal Construction Bureau to establish and issue technical guidelines for the intelligent control system of electric bicycles. Further research and exploration will focus on the best market application models that efficiently meet urban and property management needs and investment economics.

5. Conclusion

This research has successfully developed an intelligent control platform for electric bicycles based on IoT and wireless charging technologies, achieving its first-phase demonstration. The wireless charging station provides a safe and efficient charging solution for electric bicycles. The IoT cloud platform offers preliminary statistics and management of the charging, parking, and usage frequency of electric bicycles. In the next phase, researchers will use the intelligent control system of electric bicycles to regulate and manage prohibited riding and parking areas for enhanced safety, aiming to improve the economic and practical applications of electric bicycles in urban settings. The IoT platform can seamlessly integrate with related management platforms, connect with electric bicycle registration systems, and ensure the lifecycle management of electric bicycles, guaranteeing their safety. Through pilot projects, the study explores the best market application models that efficiently address urban and property management needs combined with investment economics. Given the increasing pressures of managing electric bicycles in urban and residential areas, the introduction of an intelligent control system for electric bicycles is imperative, bringing significant convenience and benefits to urban operations and property management.

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