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Research on the Application of Internet of Things Technology in Smart Cities

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Abstract: Internet of Things (IoT) technology has brought about significant new changes to residents' lives, prompting changes in management models across various industries and promoting the overall intelligence of urban construction. Especially in the context of continuous technological development, information sensor devices can be effectively utilized to connect multiple dimensions in urban construction, enhancing the intelligence level of cities in China. This paper mainly elaborates on the application significance of IoT technology in smart cities and proposes corresponding measures from aspects such as smart transportation systems, intelligent public utility management, urban safety and monitoring, environmental monitoring, and sustainability, providing references for relevant personnel.

Keywords: Smart city; Internet of Things; Intelligence introduction

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1. Introduction

The Internet of Things (IoT) technology is a combination of multiple information technologies. Applying it in the construction of smart cities can meet the development trends of the current era, actively leverage its efficient data analysis and processing capabilities, standardize urban information management processes, and reduce the cost of urban information management. Meanwhile, the application of IoT technology meets the requirements of modern city construction for environmental protection and energy conservation. It can be applied in various industries of the city to promote the continuous upgrading of the industrial structure. In the application of IoT technology, relevant departments should give full play to the advantages of new information technologies, such as wireless sensing and wireless communication in the field of smart transportation to improve the level of smart transportation construction. In the logistics sector, they should strengthen the integration and application of technology, actively improve the logistics information management system, and use radio frequency technology to strengthen logistics supervision and integrate logistics information, thereby significantly improving the operational efficiency of the logistics industry. The reconstruction of urban regional space brings about the extension of residents' living space and the evolution of industrial activities, which requires new technological support solutions and implementation paths.

Regional space reconstruction refers to the evolution of regional structure caused by the changes of various activities within and between regions, including the evolution of industrial space, land use space, urban

transportation space, employment space, residential space, social life space, and electronic information network space etc. The complex interaction of various spaces and relationships forms a scientific and intelligent regional ecosystem circle [1]. As the core carrier of the new generation of information technology, the Internet of Things (IoT) is driving the transformation of smart cities from "digital infrastructure" to "intelligent collaboration" with its full-chain capabilities of "perception-connection-computing-application". Its essence lies in achieving a deep mapping between the physical and digital spaces of cities through ubiquitous sensor networks, heterogeneous communication protocols, and intelligent data platforms, thereby addressing urban issues such as population expansion, resource strain, and low efficiency. This technological complexity is not only reflected in the integrated application of technologies such as wireless sensing, radio frequency identification, and embedded systems, but also in the establishment of a new governance paradigm for cities characterized by "interconnected everything, data interoperability, and efficiency multiplication".

2. The significance of IoT technology application in smart cities

The application of IoT technology in smart cities enables the comprehensive perception, real-time transmission, and intelligent decision-making of urban operation data. Through sensor networks deployed at traffic intersections and environmental monitoring stations, relevant departments can collect key indicators such as air quality index, traffic flow, and noise decibels in real time, and build a "digital twin" of the city. Meanwhile, based on machine learning models of massive historical data, it can predict congestion areas during peak hours. The application of IoT technology can improve the quality of life for residents. For example, remote monitoring devices enable patients in remote areas to receive tertiary hospital-level medical services. Rural schools can share high-quality urban courses through VR classrooms. In Yunnan's mountainous areas, the admission rate of key universities for children has doubled in three years. With adaptive learning systems, personalized teaching plans can be developed based on the analysis of students' behavior data, maximizing the utilization of educational resources.

Urban and regional planning should start from a long-term vision and a macro perspective, considering both the overall interests of the region and the interests of individual departments [2]. In the process of smart city construction planning, urban transportation construction is a key point and an important factor to ensure urban activities. In terms of the intelligent upgrade of urban governance, massive sensors can be relied on to collect dynamic data such as traffic flow, environmental quality, and energy consumption in real time. Combined with AI algorithms, a digital twin model of the city can be constructed to assist relevant departments in scientific prediction and resource scheduling. Smart grids can achieve peak-valley regulation through load prediction, reducing the risk of large-scale power outages. The application of IoT technology can also shape new social forms. For example, in the smart communities of Hangzhou Future Science and Technology City, functions such as facial recognition access control and intelligent express lockers are integrated. The owner's APP can view the security footage of children's activity areas, and the elderly fall detection system can automatically notify family members, thereby improving service quality.

The reshaping of smart cities by Internet of Things (IoT) technology essentially transforms cities from "mechanical aggregates" into "organic life forms" - through the coordinated operation of perception nerves (sensor networks), circulatory systems (data transmission), and brain centers (cloud computing platforms), achieving the optimal allocation of material flows, energy flows, and information flows. This transformation is not only reflected at the technical level but will also profoundly impact the spatial structure, social relations, and governance models of cities. In the future, with the maturation of 6G, terahertz communication, and flexible electronics, IoT will enter the "ubiquitous intelligence" stage: every wall of urban buildings may become a perception screen, and household waste can be precisely classified and resourcefully utilized through IoT tags. Even human implantable sensors can

be linked with urban medical systems to achieve health warnings. In this vision, IoT is no longer an external tool but an organic component of the urban fabric, supporting a “sustainable, resilient, and warm” future urban form. This is not only an inevitable evolution of technology but also a redefinition of urban civilization by humanity.

3. Application paths of IoT technology in smart cities

(1) Urban safety and monitoring

In the safety and monitoring of smart cities, edge node devices that support real-time analysis should be actively deployed. Local tasks such as facial recognition and abnormal behavior detection can be completed, and thermal imaging cameras and acoustic sensors can be integrated to form a three-dimensional protection system, enabling timely monitoring of criminal activities, fire emergencies, and traffic violations. In urban safety and surveillance, it is necessary to actively build a complete safety system. A fire evolution path reasoning model can be constructed based on knowledge graphs, and emergency communication and broadcasting can be realized. When the temperature in a certain business district suddenly rises, the locations of nearby fire hydrants and the nearest rescue teams can be automatically pushed to ensure the safety of urban residents. In the application of Internet of Things (IoT) technology, attention should be paid to the optimization of the perception layer, network layer, and platform layer. The parameter configuration standards for various sensor gateways should be unified, and slice bandwidth resources should be reasonably allocated. At the same time, a drag-and-drop visual editing toolbox can be provided to build a data security governance system for the system, break down cross-departmental collaboration barriers, and achieve intelligent urban safety management and monitoring.

(2) Intelligent public utility management

The application of IoT technology in smart services is mainly reflected in various aspects such as education and healthcare. Public service improvement can be achieved through sensors and data analysis to realize real-time monitoring of infrastructure. In smart water management, pressure and flow sensors can be installed at key nodes of the water supply network, combined with GIS software to build a three-dimensional model. Parameter detection instruments can be placed at water sources and end faucets to use artificial intelligence to analyze abnormal water quality and trace pollution paths, thereby ensuring people’s drinking water safety. With the continuous development of technology, in smart power business, intelligent terminals can be realized. Temperature and humidity sensors and gas concentration monitoring modules can be deployed in distribution rooms. At the end of transmission lines, demand-side response mechanisms can be used to guide users to use electricity during off-peak hours, reducing the peak-valley difference in the power grid. In the process of smart education construction, relevant departments can utilize Internet technology to build a smart education service platform, integrating educational resources from universities and famous teachers in the city, thereby promoting the balanced development of educational resources throughout the city. In smart healthcare development, IoT technology can be effectively leveraged to establish integrated medical service platforms. This facilitates the standardization and intelligent management of medical information databases, streamlines the oversight of medical personnel and equipment, helps ease doctor-patient tensions, and enhances overall hospital service efficiency. In the construction of smart cities, the role of IoT technology is not limited to the connection between sensors and devices, but also involves data collection, processing, and analysis [3].

(3) Smart transportation system

With the continuous development of current technology, the form of transportation has undergone changes. The application of IoT technology in smart transportation can achieve real-time traffic monitoring and

signal optimization through sensors and cameras, providing assistance for the improvement of urban traffic conditions. In recent years, with economic development, the population of cities has continued to expand. The application of IoT technology can provide reasonable solutions for shared bikes and shared cars. Users can effectively solve the problem of locking and unlocking shared vehicles through mobile apps. Moreover, based on intelligent sensors, geofencing technology can be applied to effectively solve the problem of chaotic parking of shared vehicles. With the continuous development of current technology, in the construction of transportation systems, electromagnetic sensors and lidar can be integrated to build a full-dimensional traffic situation perception network. Micro data centers can be deployed on street lamps and base station towers, and three-dimensional visualization models can be established to integrate map data, such as Baidu Maps, to form a virtual urban traffic sandbox that can be simulated and predicted. In specific application scenarios, the optimal carpooling combinations can be generated based on the analysis of the distance between passengers' starting and ending points and the calculation of path similarity. In smart logistics, UWB precise positioning can be used to achieve centimeter-level docking with loading and unloading platforms, thereby improving the public service capacity of transportation. Currently, IoT technology has achieved and extended information exchange and communication between any fields, and the gradual deepening of the concept of smart cities has pointed out the direction for urban development [4].

(4) Environmental monitoring and sustainability

Under the concept of sustainable development, people are increasingly focusing on environmental protection. In terms of environmental monitoring, the Internet of Things (IoT) technology is actively applied to monitor environmental parameters such as air quality, water quality, and temperature in real time in cities. This helps to build a comprehensive urban environmental management platform, monitor natural disasters, and enhance the city's emergency response capabilities. Additionally, a business information management platform can be established to uniformly manage sewage treatment, production, and other operations. The application of IoT technology can assist urban managers in formulating effective environmental resource management strategies. For instance, in urban sewage treatment, information sharing and resource integration can be utilized to collect data on water level, water volume, and water quality during the sewage treatment process and establish models to accurately analyze energy consumption in each stage of sewage treatment, thereby optimizing the sewage production plan and achieving refined management of sewage treatment. In terms of concentrated air pollution, particulate matter sensors and gas detectors for sulfur dioxide can be deployed around industrial parks and communities, combined with meteorological data to locate pollution sources and simulate their dispersion. Organic pollutant sensors can also be set up in landfill sites and hazardous material storage areas, and machine learning models can be trained using historical data to achieve closed-loop optimization from monitoring to governance. Relevant departments can use IoT technology to statistically analyze building energy consumption and traffic carbon emissions within the city, establish a carbon account system, and provide reliable data sources for the carbon trading market. Moreover, electronic fences can be set up at the boundaries of nature reserves to monitor illegal intrusions, and temperature and humidity sensors can be used in degraded forest areas to guide drip irrigation and reforestation, thereby improving the survival rate of afforestation. The application of IoT technology in smart cities can lead to more efficient, convenient, and sustainable development [5].

4. Conclusion

In summary, the introduction of IoT technology in smart city construction aligns with the trend of social development. Relevant urban departments should recognize the value of this technology and deeply explore its application scope, applying it in areas such as smart services, sewage treatment, and intelligent transportation. In the field of smart healthcare, IoT technology can be utilized to build a smart healthcare system, solving problems such as remote appointments and registrations, and optimizing resource allocation. In the field of smart transportation, a complete monitoring network can be established to monitor the conditions of various road sections in real time, and electromagnetic induction devices in vehicles can be used to help users quickly find available parking spaces, thereby effectively improving the quality of life for citizens.

Disclosure statement

The authors declare no conflict of interest.

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