Research on Key Technologies of Data Perception and Intelligent Scheduling for Smart Cities Empowered by Artificial Intelligence

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Abstract: With the acceleration of urbanization, the construction of smart cities has become the key to solve urban development problems. This paper focuses on the key technologies of data perception and intelligent scheduling of artificial intelligence (AI) empowering smart cities. This paper deeply analyzes the data sensing technologies such as multi-source data acquisition and preprocessing, as well as the intelligent scheduling technologies such as intelligent scheduling system architecture, task allocation strategy and intelligent optimization algorithm, and discusses the integration and cooperation mechanism of the two. Data perception provides accurate information support for intelligent scheduling, and intelligent scheduling feedback optimizes data perception strategy. By building a unified standard, reasonable resource allocation and supervision and evaluation mechanism, effective collaboration between the two can be achieved. The integration and coordination of these technologies is of great significance to improve the operation efficiency of smart cities and optimize resource allocation, and provide theoretical support and technical reference for the construction and development of smart cities.

1. Introduction

With the acceleration of urbanization, the scale of the city continues to expand and the population increases sharply. The traditional urban management model faces many challenges, such as traffic congestion, uneven distribution of resources and difficulties in environmental monitoring [1]. In this context, the concept of smart city came into being, aiming at improving the level of urban management and service by using modern information technology and realizing the sustainable development of the city [2]. As one of the most influential technologies today, AI provides strong technical support for the construction of smart cities. Through AI technologies such as machine learning and deep learning, smart cities can deeply analyze and mine massive data, thus realizing intelligent decision-making and management [3]. As the key link of smart city, data perception and intelligent scheduling have a direct impact on the operation efficiency and service quality of smart city.

Data perception is the basis for smart cities to obtain information. Through various sensors and data acquisition equipment, all kinds of data, such as traffic flow, environmental parameters and energy consumption, can be collected in real time and accurately [4]. These data provide a rich source of information for urban management, which is a prerequisite for intelligent decision-making. On the other hand, intelligent scheduling is based on data perception, according to certain algorithms and strategies, to rationally allocate and optimize urban resources, so as to meet various needs in the process of urban operation and improve resource utilization efficiency [5]. However, data perception and intelligent scheduling technology in smart cities still face some challenges. In terms of data perception, the diversity, mass and real-time requirements of data bring great pressure to data acquisition and preprocessing. In the aspect of intelligent dispatching, how to comprehensively consider various factors and formulate more optimized dispatching strategies to cope with the complex and changeable urban operating environment is still an urgent problem to be solved.

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Therefore, it is of great practical significance to study the key technologies of data perception and intelligent scheduling in AI-enabled smart cities. The purpose of this study is to analyze the relevant key technologies and explore the mechanism of technology integration and coordination, so as to provide theoretical support and technical reference for the construction and development of smart cities and promote the development of smart cities to a higher level.

2. Analysis of key technologies of data perception

In the smart city system, data perception plays the role of "antenna" and is the primary link to obtain the information of city operation status [6]. The quality of its key technologies directly determines the accuracy and effectiveness of subsequent intelligent decision-making and management.

The first is multi-source data acquisition technology. The data sources of smart cities are extensive and complex, including Internet of Things sensors all over the city. For example, traffic monitoring cameras and environmental monitoring sensors are used to capture the dynamic information of the physical world in real time; There are also unstructured and structured data from social media and government departments' databases [7]. Different types of sensors work according to their own principles. For example, geomagnetic sensors monitor traffic flow by sensing geomagnetic changes caused by vehicles, while meteorological sensors use various physical and chemical methods to measure meteorological parameters such as temperature and humidity. These sensors need to be properly laid out to ensure that the data is fully covered and accurate and reliable.

The preprocessing technology after data acquisition is also critical. There are problems such as noise, missing values and inconsistent data in the original collected data [8]. Data cleaning technology is used to remove noise and erroneous data, such as filtering algorithm to filter out random noise in sensor measurement; For missing values, methods such as mean filling and model prediction can be used to fill them. Data conversion technology unifies data with different formats and codes to meet the requirements of subsequent processing, such as standardizing data with different time formats and facilitating data analysis. In addition, data integration technology integrates data from multiple data sources, solves the problems of data duplication and conflict, and provides a high-quality data foundation for subsequent intelligent scheduling.

3. Research on the core technology of intelligent scheduling

3.1 Intelligent scheduling system architecture

As the "brain center" of smart city operation, intelligent scheduling is responsible for rational allocation and optimal scheduling of urban resources according to the information obtained by data perception, so as to realize the efficient operation of the city [9]. Intelligent scheduling system usually has a multi-level architecture. The bottom layer is the data access layer, which is responsible for collecting all kinds of data from the data perception system, such as traffic flow, energy consumption, facility status and other information. The middle layer is the data processing and analysis layer, which uses big data processing technology and AI algorithm to clean, mine and analyze massive data and extract valuable information. The top layer is the scheduling decision layer, which generates the optimal scheduling scheme based on the data analysis results and the preset scheduling objectives and constraints, and issues the execution instructions.

3.2 Task allocation strategy

Task allocation is the key link of intelligent scheduling, and it is necessary to comprehensively consider task characteristics and resource constraints [10]. Taking urban public transport dispatching as an example, factors such as passenger flow, station distribution and vehicle capacity in different periods all affect task allocation. A common strategy is task assignment based on priority. For example, in the morning and evening rush hours, there is a great demand for commuting, so the bus lines connecting the main residential areas and commercial areas are set as

high priority tasks, and vehicle resources are given priority. Table 1 shows the setting of bus line priority at different time periods. In this way, it can be ensured that under the limited resources, the key task needs are given priority and the overall service quality is improved.

Table 1 Priority Setting for Bus Tasks during Different Time Periods

Time Period	Main Travel Demand	Bus Route Type	Basis for Priority Setting	Priority Level
Morning Rush Hour	Commuting from residential areas to commercial areas	Routes connecting large residential areas with core commercial districts	High commuter volume, crucial for most people's work commutes	High
Morning Rush Hour	Commuting from residential areas to commercial areas	Routes passing through secondary areas	Serving commuting demands in some non-core areas	Medium
Morning Rush Hour	Commuting from residential areas to commercial areas	Routes serving remote areas	Relatively fewer travelers	Low
Off-Peak Hours	Scattered demands for daily travel and shopping, etc.	Routes connecting popular commercial districts with residential areas	Real-time monitoring of passenger flow to meet major daily travel needs	Medium
Off-Peak Hours	Scattered demands for daily travel and shopping, etc.	Other regular routes	Relatively small passenger flow	Low
Evening Rush Hour	Commuting from commercial areas to residential areas	Routes connecting core commercial districts with large residential areas	Concentrated demand for returning home from work	High
Evening Rush Hour	Commuting from commercial areas to residential areas	Routes passing through secondary areas	Serving returning demands in some non-core areas	Medium
Evening Rush Hour	Commuting from commercial areas to residential areas	Routes serving remote areas	Relatively fewer returning travelers	Low

3.3 Application of intelligent optimization algorithm in scheduling

Intelligent optimization algorithm provides a powerful tool for efficient scheduling. Taking genetic algorithm as an example, it simulates the process of biological evolution, and constantly optimizes the scheduling scheme through operations such as selection, crossover and mutation. In urban logistics distribution scheduling, genetic algorithm can take distribution path, vehicle allocation and so on as genetic codes, and distribution cost and time as fitness functions. The initial population represents different distribution schemes, and after several generations of evolution, a better scheme is gradually generated.

Another commonly used ant colony algorithm draws on the foraging behavior of ants. Ants will release pheromones in the process of finding food, and the path with high pheromone concentration is more likely to be chosen by other ants. In intelligent scheduling, such as traffic route planning, the path is regarded as the walking route of ants, and the pheromone concentration indicates the attraction of the path. With the continuous exploration of ants, the pheromone distribution on the path changes, and finally the optimal path is found. These intelligent optimization algorithms can quickly search for solutions close to the optimal solution in complex scheduling problems, improve scheduling efficiency and resource utilization, and help smart cities achieve refined management and efficient operation.

4. Technology integration and coordination mechanism

4.1 The necessity of integration of data perception and intelligent scheduling

In the construction of smart cities, data perception and intelligent scheduling do not exist in isolation, but are interrelated and complementary. The effective integration and coordination of the two is the key to realize the efficient operation of smart cities.

With the development of smart cities, the amount of data has exploded, and the data types have become more and more complex and diverse. If simple data perception cannot be effectively combined with intelligent scheduling, the collected data will be difficult to exert its maximum value. Without accurate data perception as a support, intelligent scheduling will become "passive water" and it is difficult to adapt to the needs of urban dynamic changes. For example, in the traffic management scene, if the data perception system can't get the road information accurately and in real time, the intelligent dispatching system can't reasonably plan the duration of traffic lights and allocate public transport, which leads to the aggravation of traffic congestion. Therefore, the integration of data perception and intelligent scheduling is an inevitable choice for smart cities to cope with complex and changeable operating environment.

4.2 Implementation of technology integration

The integration of data perception and intelligent scheduling technology is mainly achieved through data sharing and interaction. All kinds of urban operation data collected by data perception system are preprocessed and transmitted to intelligent dispatching system in real time. The intelligent scheduling system analyzes and processes these data and formulates scheduling strategies. At the same time, the feedback information of the intelligent scheduling system can guide the data sensing system to optimize the data acquisition strategy, such as adjusting the sensor layout and acquisition frequency. Taking urban energy management as an example, the data sensing system monitors the energy consumption data of each region in real time, and the intelligent dispatching system allocates and dispatches energy according to these data. If an abnormal energy consumption is found in a certain region, it can be fed back to the data sensing system to strengthen the energy consumption monitoring of specific equipment in this region. Table 2 shows the interaction process between them in the urban energy management scenario:

Table 2 Interaction between Data Perception and Intelligent Dispatching in Urban Energy Management

Interaction Phase	Behavior of Data Perception System	Behavior of Intelligent Dispatching System	Interaction Frequency	Trigger Conditions
Data Collection	Collect energy consumption data from industrial, commercial, and residential sectors in various regions	Receive energy consumption data	Real-time	Equipment operation
Analysis and Decision-Making	-	Combine supply analysis data to determine power supply strategies	Every 15 minutes	Energy consumption fluctuations exceed threshold values
Feedback and Optimization	Add measurement points or increase frequency in abnormal areas based on feedback	Feed back dispatching results and adjust strategies based on effectiveness	Instantaneous in case of abnormalities; Regularly every 1 hour	Dispatching deviations exceed the specified range

4.3 Construction of collaborative mechanism

In order to ensure the cooperative operation of data perception and intelligent scheduling, it is

necessary to construct a perfect cooperative mechanism. The first is to establish a unified data standard and interface specification to ensure the smooth interaction and sharing of data from different sources. Secondly, formulate a reasonable resource allocation mechanism, define the allocation principles of resources in data processing, storage and system operation and maintenance, and avoid resource competition and waste. Furthermore, a monitoring and evaluation mechanism is set up to monitor the collaborative effect of data perception and intelligent scheduling system in real time. By setting key indicators, such as scheduling accuracy and data transmission delay, the system is evaluated regularly to find and solve problems in the collaborative process in time. Only by building a comprehensive and effective collaborative mechanism can we give full play to the advantages of data perception and intelligent scheduling technology, promote the sustainable development of smart cities, and provide more convenient and efficient services for urban residents.

5. Conclusions

This paper focuses on the key technologies of data perception and intelligent scheduling in AI-enabled smart cities, and has achieved a series of results. In the aspect of data sensing technology, it is clear that multi-source data collection needs to rationally arrange all kinds of sensors to adapt to the complex data sources of smart cities. At the same time, data preprocessing technology is very important to improve data quality and provide a reliable data foundation for subsequent intelligent scheduling.

For intelligent scheduling, the multi-level design of its system architecture ensures the orderly progress from data access to scheduling decision. Task allocation strategy is based on priority, which can reasonably allocate resources according to different scenarios. For example, the priority setting of bus tasks can effectively meet the travel needs in different periods. Intelligent optimization algorithms, such as genetic algorithm and ant colony algorithm, provide efficient solutions for complex scheduling problems. The integration and collaboration of data perception and intelligent scheduling is the core of efficient operation of smart cities. Through data sharing and interaction, they form a virtuous circle, as shown in the interactive example of urban energy management. At the same time, a perfect coordination mechanism, including unified data standards, reasonable resource allocation and supervision and evaluation mechanism, has ensured the stability and effectiveness of coordination.

In the future, it is necessary to explore the integration with more emerging technologies such as blockchain to improve data security, expand the application of technology in more complex urban scenes, and create a better living environment for urban residents.

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