The study on the index system of the smart city based on knowledge map

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Abstract. Urbanization is the inevitable trend of urban development. In order to conducive to the supervision and guidance of smart city construction facts and the assessment and feedback of smart city operations, we propose a method to build the index system of the smart city based on the knowledge map. This method can effectively improve the query, visualization and reasoning ability of the index system, and provide the basis for using big data to build the index system automatically or semi-automatically, and finally give the knowledge map about the index system of the smart city.

1. Introduction

Urbanization is the inevitable trend of urban development. After industrialization, electrification and the digital development stage, the global urbanization process is obviously accelerated. Since the beginning of the 21st century, most cities in the world are facing more and more serious problems in the environment, climate, energy, economy, society and government governance. For example, the severe challenges of traffic congestion, environmental degradation, low development quality and unsustainable development greatly restrict the development of the city. As information technology develops, the smart city has become a scheme of urban sustainable development, a new concept and practice of global future urban development, and another leap of urban development [1-3]. There are many definitions and researches on the smart city. According to the definition of Li Deren, academician of the Chinese Academy of Engineering Academician and the Chinese Academy of Sciences, the smart city is a visual, measurable, perceptual, analysable and controllable smart urban management and operation mechanism based on the overall digitalization of the city, It analyzes the real-time information data support platform to obtain the theory and comprehensive decision of urban information management, including urban network infrastructure, sensors and computing resources. Human society, the physical world and the virtual world will interact with each other in order to achieve intelligent response. According to the view of academician Pan Yunhe, human beings...
will enter the era of CPS system, which consists of three spaces: physical space, human society and information space. Each space will be more closely linked with other spaces, forming a close closed-loop system. Among them, physical space and human society have the function of self-circulation, and information space also produces a self-circulation system under the action of human beings, this can be seen in Figure 1.

![Figure 1. CPS system](image)

A more important part of building a smart city is smart city assessment, which is conducive to the supervision and guidance of smart city construction facts and the assessment and feedback of smart city operation. The smart city watch list system is an important basis for smart city assessment. Through the establishment of the smart city indicator system, smart city assessment provides a "standard".

This paper proposes a research method of the smart city index system based on the knowledge map. The second part summarizes the research status include the smart city, the index system of smart city and knowledge map; the third part uses the knowledge map to build the process and method of smart city indicator system; the fourth part gives the index system of the smart city based on the national standard; finally, summarizes and prospects the work of this paper.

2. Related work

The indicator system of the smart city involves multiple levels and aspects of the smart city, which has many characteristics such as wide range, miscellaneous types and large quantity. A comprehensive grasp of all kinds of big data and indicator methods of smart city will help improve the government's governance ability and people's living standards. Knowledge map is widely used in the cognitive stage of artificial intelligence in the north. The characteristics of multi-source data fusion enable it to integrate information in various knowledge bases. The following is an introduction to the research results of the existing smart city and smart city indicator system.

2.1. The smart city

Urban data is the basic data of smart city construction, involving all the physical facilities of the city and the data that can be collected by human society. Urban data has the characteristics of big data, multi-dimensional space-time, multi-scale, multi-strength, and multi-dimensional heterogeneous. In order to better build the smart city, researchers of the existing smart city put forward a variety of technical system frameworks of the smart city. The current situation of smart city research based on the technical framework of "six horizontal and two vertical" of the 863 "smart city (phase I)" project of the Ministry of science and technology of China. The framework divides the smart city technical system into city perception layer and data according to the relationship since at the same time, it includes two security systems: evaluation system and security system, namely "two vertical". The
framework details the technology set and the interdependence of each layer, and provides detailed layout guidance for the whole development of smart city technology [4], As shown in Figure 2.

**Figure 2.** The framework of the smart city (phase I)

The existing smart city technology framework has its own advantages, and basically has a common feature: taking big data acquisition and management technology as the underlying support, taking data collection, storage, analysis and other technologies as the core elements of the framework, and providing diversified and personalized services or applications for users. Top-level design based on urban big data has become a consensus.
2.2. The index system of smart city
The index system of smart city is an important standard for scientific evaluation of the development level of smart city, assisting in the formulation of smart city layout and building policies, guiding and supervising the construction of smart city, and improving residents' happiness. The existing research on the evaluation index system of smart city focuses on three aspects: index selection at the micro level; index classification at the meso level; index system architecture at the macro level[5], this can be seen in Table 1.

Table 1. Research work on the index system of smart city

| Level           | Research work                     | Existing methods and shortcomings                                                                 |
|-----------------|-----------------------------------|-----------------------------------------------------------------------------------------------------|
| Micro level     | Index selection                   | Delphi method widely used in the selection of indicators through the experience of experts, which has great randomness and subjectivity in the selection of index |
| Middle level    | Index classification              | one is classified by time series, such as from construction, operation to experience; the other is classified by spatial distribution, such as intelligent transportation, intelligent medical |
| Macro level     | Architecture of index system      | One is to improve the early evaluation methods and theories of the urban informatization level, the other is to learn from other evaluation methods and theories in other areas of the city, such as the evaluation index system of urban regional competitiveness |

The work of constructing the index system of the smart city is divided into ten steps, including the definition of evaluation problems, the construction of evaluation framework, the construction of the indicator system, the selection of basic data mobile phones and samples, the processing of missing data, indicator measurement, data standardization, weight determination, indicator integration and result analysis.

2.3. Introduction to the knowledge map
As the latest achievement of the development of symbolism, a knowledge map is a significant cornerstone of artificial intelligence. The knowledge map is a knowledge system that includes structuring human knowledge, basic facts, general rules, and other related structured information. It can be used for intelligent tasks such as information retrieval, reasoning, and decision-making, and can give agents the ability of accurate query, deep understanding, and logical reasoning. It is widely used in knowledge-driven tasks such as search engines, question answering systems, intelligent dialogue systems, and personalized recommendations.

The knowledge map is a semantic knowledge site that summarizes knowledge. It uses symbols to describe some definitions in the physical world and their relationships. Its basic units are the triples of "entity-relation-entity" and the value pairs of entities and their associated attributes [6-7]. The entities are connected with each other through the relationship to construct the network knowledge system.

The construction of knowledge map includes three stages: information extraction, knowledge fusion, and knowledge processing. The overall structure of the knowledge map technology is shown in Figure 3[7]. The portion of the dotted line is the process of building and updating the knowledge map. The construction process of knowledge map (starting from the initial data) is to extract knowledge elements (entity) from academician data and store them in the data layer and pattern layer of knowledge base by some automated or semi-automated technical means, which is an iterative updating process.
A hypernymy ("is -a") relation is an important concept in the field of Natural Language Processing (NLP). This type of semantic relations is often used to describe the subordination relation between two semantic concepts, such as "(dog, animal)", "(rose, plant)" and "(sofa, furniture)"[8]. In this section, we will use the hypernymy relationship to build the index system of smart city.

3.1. Entity design
The existing index system of smart city is composed of three levels of indicators. The first level indicator is the upper level word of the second level indicator, and the second level indicator is the upper level word of the third level indicator.

Each indicator can be regarded as an entity, and each entity can be composed of several attributes to form an entity set. In addition to the entity attribute of the first level indicator, the second level indicator to which it belongs is also its attribute, thus forming a small set in a large set. The design of indicator entity is completed by using relation connection between entity and attribute. If there is an hypernymy relationship between entities, the upper indicator is an entity and the lower indicator is an attribute; if there is no the upper and lower relationship between entities, the relationship between the two entities is a sub relationship.

3.2. The construction of knowledge map
The index system generation block diagram based on the knowledge map proposed in this paper is shown in Figure 4. The information acquisition in this framework refers to obtaining the entity information of the index system from the existing smart city index system, and establishing the knowledge map of the index system according to entity extraction, relationship extraction, and attribute the extraction of the knowledge map. Then, the entity and relationship will be stored and applied to the query, visualization, and reasoning of the knowledge map.

Figure 3. The technical architecture of the knowledge graph
Figure 4. The framework of the knowledge map generation based on index systems

As shown in Figure 4, using the knowledge map to construct the index system of smart city, which can promote the query, visualize and automatically update according to knowledge reasoning. It provides a research basis for the automatic or semi-automatic construction of the index system based on the big data.

4. Experimental analysis

This section takes the national standard on the index system of smart city [9] as an example to build a knowledge map-based index system, as shown in Figure 5. Firstly, the index system is transformed into entity set, and then the relationship between entities and attributes is determined. Finally, using the framework of the knowledge map generation based on index systems to build the knowledge map.

Figure 5. The partial knowledge map of smart city
5. Conclusion and prospect
This paper designs the ontology and the knowledge map of the smart city index system, and puts forward the method of building and analysing smart city by using the knowledge map. Through three steps of information extraction, knowledge fusion, and knowledge processing, the knowledge map is constructed in a bottom-up way to eliminate redundant knowledge of the indicator system, accurately reflect the upper and lower relationship in the indicator system, and raise the update ability of the indicator system.
In the next step, we will mainly study the knowledge fusion of multi-indicator system, update the knowledge map of the indicator system through semi-automatic or automatic methods, and try to use more models to increase the accuracy of the indicator system of smart city.

Acknowledgments
This work was supported by the special fund of the China Association of Science and Technology, and by the special fund support of the Shenzhen Bureau of industry and information technology.

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