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Application of Deep Learning in Map Drawing

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Abstract

Map cartography includes two major tasks: map making and map application. The combination of map cartography and deep learning can improve the intelligent level of map cartography. This paper discusses the proposition of "deep learning+mapping". First, from the consistency of deep learning method and map space problem solving strategy, based on gradient descent, local correlation, feature reduction and nonlinear nature, the feasibility of combining the two methods is answered; Secondly, from the unique subject characteristics and technical environment of cartography, this paper analyzes the challenges faced by the combination of cartography and cartography, involving the nonstandard organization of map data, the professional requirements for sample establishment, the integration of geometric and geographical features, and the inherent spatial scale of maps; Thirdly, the breakthrough point and specific methods of integrating map making and map application into deep learning are discussed respectively.

Keywords： artificial intelligence, map visualization, spatial remote sensing, big data.

1. Introduction

As a visual representation of spatial phenomena, the map plays the role of analysis, expression and communication transmission in exploring the laws of bioscience characteristics, revealing the mechanism of geographical process and mining the spatial distribution pattern. Driven by new technologies such as network technology, big data analysis, artificial intelligence and multimedia visualization, the connotation and extension of map drawing have been greatly expanded. The scope of map drawing has expanded from the traditional real world to the virtual world, cyberspace and other pan-spaces, and the map audience is developing from serving human beings to facing intelligent machines at the same time, resulting in the concept of holographic high-precision navigation map. In the new technology of map drawing, a prominent trend is the combination of map and artificial intelligence, which shows that machine learning, deep learning and knowledge map play an increasingly important role in map cognition, map design and map analysis. With the support of intelligent technology, map spatial decision-making has higher cognitive ability of complex systems. Through the combination of map with deep learning and knowledge map in spatial decision-making, travel navigation and landscape design, the identification, judgment and prediction of spatial problems can better simulate human thinking. From the perspective of discipline system, the combination of cartography, which belongs to the secondary branch of surveying and mapping science and technology, and intelligent technology is an important component of the overall development of surveying and mapping technology from digitalization to internationalization to intelligence.

In the technical chain from earth observation data acquisition to spatial location information service, mapping is located at the back end, and the front-end positioning acquisition and image recognition are moving towards high-precision positioning, efficient processing and high automation with the support of artificial intelligence technology. The back-end mapping processing and information service should also be connected with artificial intelligence technology to realize the integration of artificial intelligence and surveying and mapping technology. Cartography is considered as a subject with highly intelligent characteristics. To this end, the development of cartography has been closely following the artificial intelligence (Al) technology, with a view to integrating A! When the new achievements in the field are introduced into the field of map making and cognitive analysis, the creative design ability of computer graphics system approaches to human brain behavior, which makes the map analysis system have similar intelligence level to that of human brain. Artificial intelligence is a new technical science to research and develop theories, methods, technologies and application systems for simulating, extending and expanding human intelligence. Since the concept of artificial intelligence was put forward at Dartmouth Conference in 1956, various intelligent expression and intelligent calculation models have been produced. First, "symbolism" based on rule-based reasoning, then "behaviorism" appeared, which imitated related intelligent life processes and physical processes. As a special application of AI, cartography develops in Al.

In different stages, they all responded positively to the application of A-related technical achievements, and showed the unique spatial intelligent technology of cartography.

2. Research methods and technical route

In 1990s, the field of cartography also carried out the research of expert system for map making and analysis, and discussed the research of map projection decision, transformation from spatial data to map symbols, map symbol design and so on. It has the functions of map color automatic design and symbol selection. However, the expert system of cartography has not substantially solved the problem of intelligent cartography, and the rules of cartography, knowledge extraction and the establishment of real expert knowledge are far from those of human brain. Only through the specification of cartography schema, oral investigation by experts and limited case analysis, a perfect library of cartography rules cannot be established. There is a lack of deep-seated informal rules description tools, and the inference engine based on mathematical logic is also unable to deduce rules.

(1) The idea of correspondence between deep learning method and map space problem solving

As a representative of the intelligent model of Connectionism, deep learning (DL) imitates the spirit of cerebral cortex.A machine learning method for the connection and signal transmission of meta networks. DL obtains learning samples through the training of case samples.

The inherent law of this data, its ultimate goal is to make the machine have the ability of learning and decision-making like human beings, and to identify features, types and structural information. From the application point of view, these models can be divided into DL models with linear structure, matrix array structure, tree structure and graph structure according to the data structure. For example, the circular network model RNN based on linear structure,

Model GCN. These models can realize the classification of cartographic data, the selection of visual symbols, the decision of map synthesis operators, the artistic style design of drawings and so on. In the map application analysis, the prediction of spatio-temporal information, the division of spatial pattern and the recognition of spatial patterns are realized.

In essence, DL model is a decision-making method for uncertain problems, which is no different from classical statistical learning (regression analysis, Markov chain, etc.) and traditional machine learning (support vector machine, random forest method, etc. The model can be understood as the problem solving of a highly abstract connecting space constructed by multi-layer neurons. A series of strategic ideas are applied to the fitting calculation of this mathematical space, which ensures the computational advantage of the model.

(2) Application of Deep Learning in Map Making Technology

Map-making includes two branches: map-making and map application. The former completes the conversion from number to figure, and the latter completes the analysis and application from figure to number. These two branch tasks can be combined with DL to improve their intelligence level. Because of the differences in the way and content of combination, they need to be discussed separately.

The design and production of map is a complex system engineering, which involves the integrated processing of various types of data sources, the analysis and extraction of spatial features, the map projection transformation, the scale transformation and the abstract generalization of features, the symbol design and visual expression. At present, DL has many models to realize features extraction, identity recognition, target classification, process prediction and other functions. These functions

Select the appropriate universal DL model, and complete the map data processing and graphic transformation through targeted improvement. The application of DL model needs to rely on various sample bases, and it is based on the training and learning of sample cases that it obtains the judgment and recognition ability similar to that of human brain. Therefore, it is also an important work to establish various sample bases accompanying the map drawing process. The technical flow of map drawing supported by DL is shown in Figure 1.

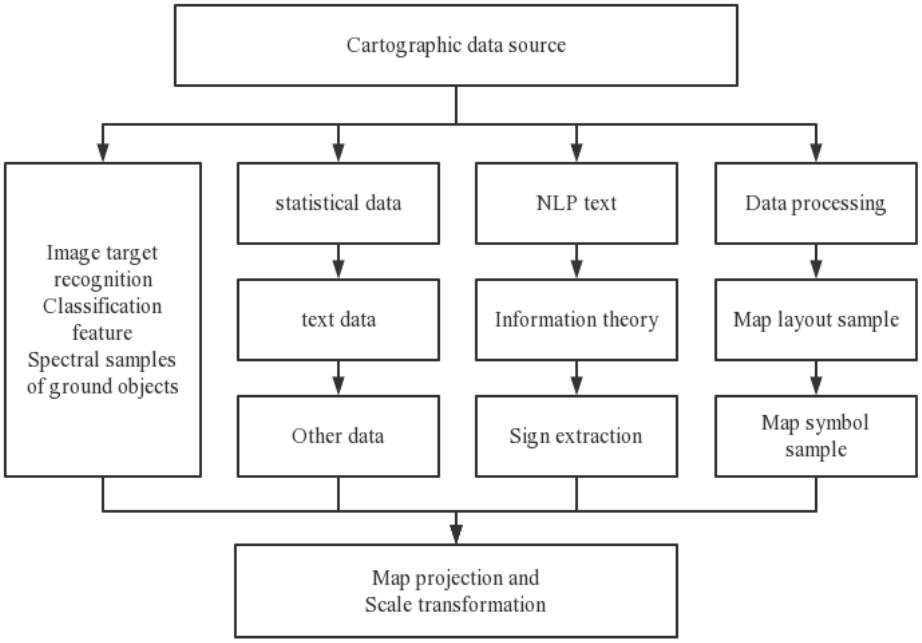

Fig.1 Map making process supported by DL model

(3) Application of Deep Learning in Map Analysis

Map application analysis is another task of map drawing technology, which involves a large number of decision-making analysis processes such as identification, judgment and reasoning, and is another combination point of DL application in cartography. The process of map analysis supported by DL model depends on the support of bioscience domain knowledge and map feature sample base. The flow of this analysis is shown in Figure 2.

According to the type differences of map analysis, appropriate learning models are selected from DL model base for pattern recognition, pattern recognition and pattern recognition respectively.

Process prediction, feature extraction, regression analysis and other different forms of analysis. The learning model in DL model base has a general decision-making analysis function. When analyzing the map field, the essence is to establish the mapping relationship between the abstract neuron space in the general model and the actual entity space in the map. It is necessary to establish the entities of neurons and map space in DL model.

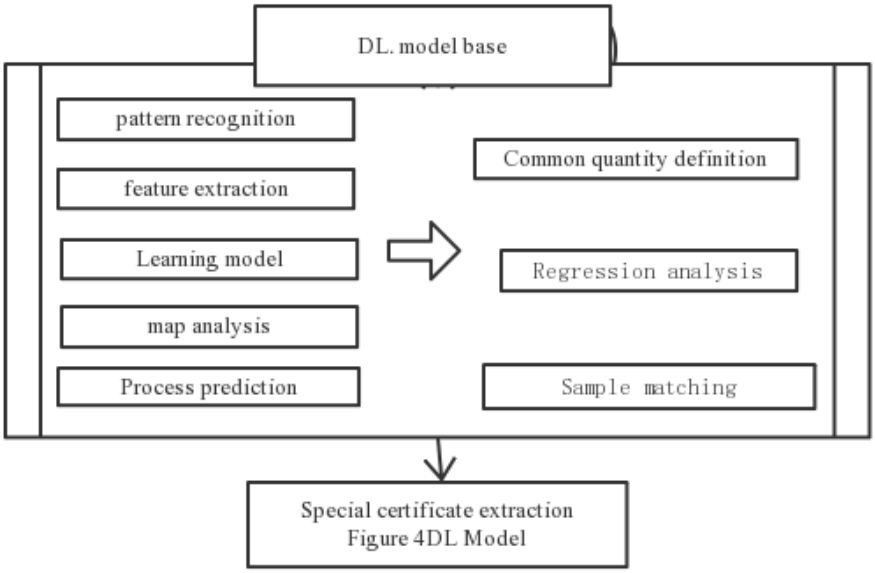

Fig.2 Map analysis process supported by DL model

Correspondence, and the description vector of neurons corresponds to the characteristics of geographical entities. Neurons in the DL model of map analysis can be geographical entities, target group structures, snapshots of spatio-temporal processes or spatial subdivision units. The organizational structures of these units can be abstracted into linear tables, matrices, tree structures and graph structures, and there are different data structures in the DL model base.

Learning model correspondence, data structure and task objectives are often the basis for choosing DL model. At the same time, the vector definition of these units requires geoscience expertise to establish the influencing factors, correlation and contextual conditions of their decision-making goals, and spatial cognitive science to establish cognitive gestalt parameters under the Gestat principle.

As the basis of learning and training, map sample database plays an important role in DL model of map analysis. Map sample types include spatial patterns, land use types and distribution patterns with different

spatial distribution characteristics, as well as geographical classification of landform types, wetland types, economic functional areas and urban functional areas. After training typical samples with a certain scale, DL model has the ability of self-decision, and can judge the partition, type and characteristics of newly input data by itself.

There are deep differences between map-based decision analysis and the combination of geoscience knowledge, which can be divided into shallow spatial analysis mainly based on graphic geometric characteristics and deep analysis of spatial semantic information combination with deep geoscience knowledge integration. The former mainly completes the decision analysis of geometric model, main features, spatial pattern, regional correlation, etc., while the latter belongs to the specialized analysis in the field of geosciences, involving the division of functional areas, the prediction of temporal and spatial process trends, and the extraction of geoscience laws, etc. This analysis process is also the embodiment of the data-intensive fourth scientific research paradigm generated by big data. DL model moves in data area

Next, the training based on samples reveals the spatial distribution knowledge and the temporal and spatial evolution law. The application of DL model in map analysis requires low data content, which can be completed on the basic geometric feature data of points, lines and planes.

(4) Challenges and Development Prospects of "Deep Learning+Mapping"

DL is a computational model that simulates human intelligent behavior. When it is applied in different fields, the model needs to consider the nature of the target problem in this field, the mechanism of intelligent decision-making, the structure and organization of input data, the preparation of samples and other conditions. At present, when DL is applied in several important fields, such as image understanding, natural language processing and chess, it faces different challenges, and "deep learning+mapping" also faces challenges. Influenced by the specific professional characteristics and application environment of map drawing technology, there is a unique problem of combining the two.

The data content of the map is composed of structured ground objects, and the types of geographical elements are rich and the structural relationship is complex. The data organization used for map storage lacks the standard pixel matrix structure like image organization. The expression of map vector data needs to adopt different data structures, including linear structure, tree structure, graph structure, etc., to describe the cluster target, layer structure target and network target of map vector data respectively. When establishing DL model for map analysis, we need to take into account a variety of data structures, such as RNN model based on linear structure.

3. Data source introduction

CNN model based on matrix structure, GCN model based on tree structure graph structure, etc. In the pixel organization matrix structure of image data, the neighborhood relationship and feature description of pixels are all determined and standardized, while the graph structure, which is widely used in map expression, is not fixed in the dimension and feature description of the neighborhood relationship of its nodes, and belongs to non-standardized data structure. The CNN model based on canonical structure and its improved derivative model have achieved good results in image recognition and understanding, but it may be difficult to play a role in the face of map data. The river network, road network, even-converted buildings, POl point access structure and so on in map data can all be transformed into map structures through certain forms.

In order to achieve this goal, only by combining the map with intelligent technology, making the map have the ability of intelligent analysis and understanding, and excavating the knowledge hidden behind the

map, can it be truly embodied. Cartography, which includes two major tasks, map making and map application, has always been combined with different technical achievements of artificial intelligence. After experiencing the cartographic expert system in the symbolic stage and the spatial optimization decision in the behaviorism stage, it is currently facing the problem of combining intelligent technology represented by deep learning under connectionism. On the one hand, there are many consistent strategies for deep learning and solving map space problems, which shows that the combination of the two is feasible; On the other hand, the combination faces a series of challenges. Compared with the remote sensing image processing of the adjacent disciplines of cartography, the data object, sample establishment, parameter definition and scale selection of map deep learning face certain problems. From the application point of view, the deep learning of maps is the application of universal DL model and the concretization of spatial intelligent thinking. How to improve the intelligent level of deep learning, more and more experts gradually abandon the knowledge of relying solely on data-shelving and turn to the strategy of domain knowledge and data-driven parallelism.

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