Using Chinese Natural Language Interfaces for Navigation in Mobile GIS

Jiangfan Feng[1], Nan Xu[2]

[1] College of Computer Science and Technology, Chongqing University of Post and Telecommunications, Chongqing 400065, China

[2] College of Computer Science and Technology, Chongqing University of Post and Telecommunications, Chongqing 400065, China

Abstract

The combination of "voice technology" and "Mobile GIS", has greatly improved the intelligent degree of mobile GIS. Recently, significant attention in the field of scientific research is turning to how to realize quick conversion between natural language and GIS commands. However, the current study mostly concentrates on rules of conversion between natural language sentences and GIS commands from the angle of artificial summary. From the perspective of intellectualization, this paper does a study of natural language understanding method of mobile voice GIS, which makes a conversion between natural language and GIS commands based on machine learning methods, reorganizes existing knowledge structure to acquire new knowledge for the purpose of identifying unrecognized sentence patterns. Our experimental results prove that the preliminary conversion mechanism between natural language and GIS commands could be formed on the basis of self-learning which based upon the current research results by utilizing BP algorithm based on artificial neural network.

Keywords: *Mobile GIS, Natural language understanding, Machine learning, Algorithm*

1. Introduction

With the development of Internet and the mobile communication technology, the mobile geographic information system, with mobile Internet as center, has become one of the most popular research directions of GIS applications. The intelligent degree of GIS applications can be improved by combining voice technology and mobile GIS [1]. For the reason that natural languages are complicated, colloquial, and diversified, there are still some obstacles in the process of mobile terminals handle the natural languages. Therefore, how to eliminate obstacles in natural language understanding and convert the natural languages to GIS commands smoothly has become the most popular research in the field of mobile GIS.

At present, there are several research methods as follows: (1) Map the natural languages to E-R models. (2) Map the natural languages to SQL sentences. (3) Map the natural languages to functions. Although these methods could realize the conversion natural languages to GIS commands, there is not an integrated mechanism of natural language understanding. It still in artificial summary stages with a certain limitation.

In the view of artificial intelligence, this paper utilizes the BP algorithm based upon artificial neural network, and reorganizes knowledge structures based on the current research results, to set up an integrated mechanism of conversion natural languages to GIS commands.

2. Research Status

2.1 The Conversion Technology of Natural language and GIS command

All the time, the natural language used in mobile GIS, reduce the complexity of operation, is the focus in the field of GIS target. Combination of speech technology and mobile GIS applications for mobile GIS, it provides users a good human-computer interaction and intelligent user-experience.

In recent years, the research of natural language understanding has made a series of achievements: The GIS query language based on Chinese is put forward after an explanation of the characteristics and merits of the Chinese language. (Zhou Yankun, Li Manchun, 2001) [2]. On the condition of restricted applied range, it proposed a thinking method that uses the keywords of natural language to structure a model library to mapping the query sentences (Zhang Lianpeng, 2002) [3]. And the basic spatial relation query form and spatial semantic in

query sentences in the light of the basic spatial relation i.e. measure relations, direction relations, and topology relations among geographical features (Ma Lin-bing, 2002) [4]. A computational model of ER-model-based restrictive-Chinese query language of relational database is put forward which simulates the language process mechanism of human (Yang Dong-qing et al, 2001) [5]. The semantic information extraction of the query conditions are studied based on the principle of information extraction. She proposed an intermediate language way of semantic query trees, designed a set of conversion algorithm to achieve the conversion of GIS query language in Chinese into SQL statements (Xu Ai-ping, 2007) [6]. A paper proposed an analytic method of GIS command based on restricted natural language, and they classification marked the restricted natural language, and designed corresponding GIS command functions to realize the geographic information service intelligently (Long Yi et al. 2009) [7].

Although it has made progress in the field of natural language understanding at present, but there still has the following questions:

(1) The current research mainly concentrates on conversion restricted natural languages to SQL sentences or E-R models, instead of establishment a complete natural languages understanding mechanism of application-oriented mobile GIS. The research achievements are still in design stage of simple prototype systems.

(2) Due to the fact that natural languages are complicated and artificial summary is insufficient, there are still some obstacles in conversion natural languages to GIS commands.

Based on machine learning methods, this paper utilize BP algorithm to self-learning current research results and to reorganize existing sentence structures, for the purpose of identifying unrecognized sentence patterns, then converting these sentences patterns to GIS commands.

2.2 Machine Learning in Natural Language Understanding

Machine learning is the core of artificial intelligence, whose main application areas contain expert system, pattern recognition, intelligent robots, automated reasoning, computer vision, and natural language understanding etc.

In the field of natural language understanding, the main source of Machine Learning is primitive linguistic data. We should preprocess the linguistic data through words segmentation and text markup firstly. Then machine learns the existing text samples, does some training and analysis, and applies to the unrecognized texts, for the purpose of learning the meaning of unrecognized texts and solving practical problems.

The machine learning methods applied in natural language understanding could mainly be divided in three categories:

(1) The Symbolic machine learning, such as the learning of decision trees etc.

(2) The Statistical machine learning, such as artificial neural network, Bayesian Learning, Genetic Algorithm, support vector machine etc.

(3) The learning based on the cases.

These methods could be used in the different aspects of natural language understanding, such as part-of-speech tagging, clause identification, speech recognition, word sense disambiguation, vocabulary acquisition, and grammar inference etc [8]. Among them, there is a very good performance in the artificial neural network method applied to study of the grammar inference. Consequently, combined the method of artificial neural network, this paper converts the natural languages to GIS commands.

In a word, Machine Learning is an important way and the key method of mobile GIS intelligence. The study of Machine Learning methods in the field of natural language understanding will promote the further development of natural language understanding and mobile GIS intelligence.

3. Overall Design of System

The most direct application of voice in mobile GIS is navigation in LBS. Hence this paper designs a system model combine the voice with the navigation in mobile GIS. As the figure:

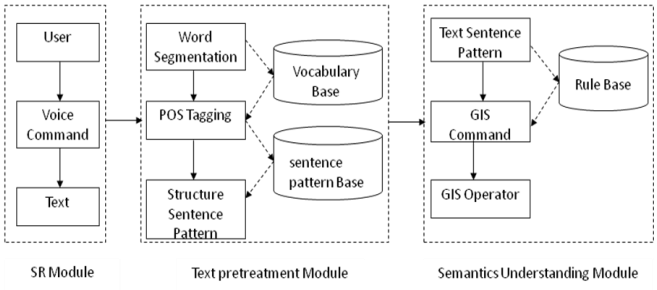

Fig.1 overall structure chart of system model

The system consists of three parts: the voice recognition module, the text preprocessing module and the semantic understanding module. Among them, the semantic understanding module is the core part of the system. Therefore transformation rules of natural languages to GIS commands is the research focus of this paper. The voice recognition module can identify user's voice commands by the voice recognition interface of an intelligent terminal and convert these commands to text languages. The text preprocessing module divides text sentences into small ones on the basis of the established lexicon, and constructs the input-pattern rules. The specific patterns include command operation, spatial query and spatial analysis. By this sentence pattern rules, we analyze segmented text languages so as to get the sentence patterns and do a standardizing disposal to the text languages. The semantic understanding module converses the treated sentences into corresponding GIS commands by the conversion rules to execute GIS operations, and achieve navigation for users.

4. Algorithm Steps

The artificial neural network could combine with a given learning sample to adjust the interconnection weights among neurons by faster speed and higher accuracy. And this method could make the system achieve stable state to content learning requirements. Moreover this algorithm also has some certain ability of self-study, promotion and summary. Combined with the BP algorithm of artificial neural network, this paper learns and trains the current syntactic structures, and builds an artificial neural network model of conversion natural languages to GIS commands.

The concrete steps as followed:

(1) To classified mark the vocabularies. As the table shows:

Table 1: Vocabulary classification and Numbers show

Example	label	number
Zoom out/in	Z	111
move	M	112
Open/save	O	120
gather	C	130
Look up/list	F	140
"From…to…"	SR、ST	151、152
"CQUPT"	I	210
"supermarket"	ES	220
"in/be apart from"	SV	310
"in the east/west"	SD	320
"adjacency"	SA	330

(2) To form digital sentence patterns, our experiment replaces the vocabulary in the table included in the natural language query sentence patterns into numbers and. For example, the sentence pattern of "from Chongqing University of Posts And Telecommunications to Jiefangbei" is "from... to ...". And according to the above-mentioned table, we mark the vocabularies and get the digital patterns as "151/210/152/210".

(3) To extract the keywords in the sentence patterns which can distinguish the sentence pattern, and make the keywords be the neurons of a three-layer BP neural network model. For instance, the key words distinguished the sentence pattern of "from Chongqing University of Posts And Telecommunications to Jiefangbei" are "from" and "to". Therefore, the neuron of this model is "151/152". By the same token, the other sentence patterns also can extract the neuron to set up the BP neural network model. Combine with these neurons, the input layer of the neural network model is formed.

(4)To mark the GIS commands. Such as "Draw the path from... to... " marks as 100, so do the other GIS commands. Combine with these marked commands, the output layer of the neural network model is formed. There is almost a one-to-one correlation between the input layer and the output layer.

(5) To Learn and train the input layer and the output layer by function $y = f(\sum_{i=1}^{m} w_i x_i)$, the weight coefficient of the network model is determined by function $\min \sum_{i=1}^{n} (d_{pi} - o_{pi})^2$.

(6) When the BP neural network model is stable, the conversion model of natural languages to GIS commands is formed preliminarily.

5. Experiment and analysis

(1) The experimental environment

The experiments of this paper is using client/server mode, the development environment as follows:

Server-side: MyEclipse8.5+Tomcat6.0

Client-side: Eclipse

(2) The experimental results

Based on learning and training the artificial neural network model set up by natural language sentence patterns, and then input the test sample data as:

$\begin{bmatrix} 140 & 342 & 0 & 0 \\ 140 & 341 & 0 & 0 \\ 140 & 330 & 0 & 0 \end{bmatrix}$, then get the output result: $\begin{bmatrix} 190 & 0 & 0 & 0 \\ 190 & 0 & 0 & 0 \\ 160 & 0 & 0 & 0 \end{bmatrix}$. To restore the data of the result, it will get three sentence patterns as: 140+342+E1+AU+E2, 140+E1+CJ+E2+341, 140+E1+340+E2, the corresponding GIS commands are: Judgment E1, E2 whether intersected and Judgment E1, E2 whether adjacent.

Therefore, the experimental results show that the method of this paper could achieve the purpose of identifying unrecognized sentence patterns by constructing artificial neural network model and study existing knowledge structures, and set up a conversion model of natural languages to GIS commands.

6 Conclusions

This paper utilizes the BP algorithm of artificial neural network to do research on natural language understanding in mobile GIS, and has got the artificial neural network model of conversion natural language to GIS commands preliminarily. But due to the limitation of sample data, the conversion accuracy of the network model needs to be improved. At the same time, the BP algorithm has the following disadvantages: (1) The weight value got from the BP algorithm is the local optimal value, not the global optimal value. (2) Model training continues for a long time. (3) It needs time and energy to determine the appropriate model, algorithm and parameter settings. Therefore, our next step work can utilize GA algorithm to optimize BP algorithm for an auxiliary, and improve the learning and training rate of network model.

Acknowledgments

The Project is supported by the National Nature Science Foundation of China (No.41101432), the Natural Science Foundation Project of Chongqing CSTC(No.2010BB2416)

References

[1] Zhang Xue-ying, and Lv Guo-nian, "Natural-language Spatial Relations and Their Applications in GIS", GEO-INFORMATION SCIENCE, Vol. 9, No. 6, 2007, pp. 77-81.
[2] Zhou Yan-kun, and Li Man-chun, "The Research of GIS Query Language Based on Chinese", BULLETIN OF SCIENCE AND TECHNOLOGY, Vol. 17, No. 1, 2001, pp. 35-40.
[3] Zhang Lian-peng, Liu Guo-lin, and JIANG Tao, "The Application of the Limited Natural Language Query on GIS", JOURNAL OF INSTITUTE OF SURVEYING AND MAPPING, Vol. 19, No.4, 2002, pp. 284-289.
[4] Ma Lin-bing, Gong Jian-ya. "Research on Spatial Database Query Oriented Natural Language", COMPUTER ENGINEERING AND APPLICATIONS, Vol. 39, No. 22, 2003, pp. 16-19.
[5] Cui Zong-jun, Tang Shi-wei, and Yang Dong-qing, "Studies on Er-model-based Restrictive-Chinese Query Language of Database", JOURNAL OF CHINESE INFORMATION PROCESSING, Vol. 15, No. 4, 2001, pp. 7-13.
[6] Xu Ai-ping, Xiong Hao, and Huang Yuan, "Semantic Information Extraction of the Query Conditions in GIS Chinese Query Sentences", COMPUTER ENGINEERING AND SCIENCE, Vol.29, No.8, 2007, pp. 99-101, 126.
[7] Ming Xiao-na, Long Yi, and Qian Chen-yang, "The Analytic Method of GIS Command Based on Constrained Natural Language", JOURNAL OF GEO-INFORMATION SCIENCE, Vol. 11, No. 2, 2009, pp. 183-188.
[8] Xu Rui, Wang Huilin, "Machine Learning Techniques Applied to Natural Language Processing", NEW TECHNOLOGY OF LIBRARY AND INFORMATION SERVICE,10.3969/j.issn.1003-3513.2008.z1.007.

Jiang-Fan Feng He received his B.S. degree from Southwest Agricultural University, and his Ph.D. degree from Nanjing Normal University, in 2002 and 2007. He works as associate professor of Chongqing University of Posts and Telecommunications. His main research area include spatial information integration and multimedia geographical information system.

Nan Xu She received the B.S in information management from ShiJiaZhuang Tiedao Univ. in 2009. She is currently working towards her M.S. in the Chongqing University of Posts and Telecommunications. Her current research interests include mobile GIS and multimedia geographical information system.