Construction of typhoon disaster knowledge graph based on graph database Neo4j

Pengcheng Liu[1,2], Yinliang Huang[3], Ping Wang[4], Qifan Zhao[1,2], Juan Nie[4], Yuyang Tang[5], Lei Sun[2], Hailei Wang[2], Xuelian Wu[2], Wenbo Li[2]

1. Institute of Physical Science and Information Technology, Anhui University, Anhui 230039, China
E-mail: 3131745993@qq.com, 593282826@qq.com
2 Institute of Technology Innovation, Hefei Institute of Physical Science, Chinese Academy of Sciences, Anhui 230088, China
E-mail: sunlei@hfcas.ac.cn, hailei@mail.ustc.edu.cn, xlwu@rntek.cas.cn, wbli@iim.ac.cn
3 Institute of Intelligent Machines, Chinese Academy of Sciences, Anhui 230031, China
E-mail: ylhuang@iim.ac.cn
4 Department of Airborne Remote Sensing, National Disaster Reduction Center of China, Beijing 100124, China
E-mail: wangping@ndrcc.org.cn, niejuan@ndrcc.org.cn

5. Bell Honors School, Nanjing University of Posts and Telecommunications, Nanjing 210023, China
E-mail: tangyuyang@126.com

Abstract: The typhoon knowledge graph can correlate various kinds of information in the typhoon data, conduct overall and related analysis, and finally provide effective assistance for typhoon prevention and post-disaster protection. The data of typhoon landing in China from 2000 to 2015 were selected to build a typhoon knowledge graph based on Neo4j graph database platform. The typhoon knowledge graph can be used to understand the occurrence of historical typhoons and obtain the distribution of typhoon data in time and space.

Key Words: Typhoon disaster, Knowledge Graph, Neo4j

1 INTRODUCTION

Typhoon is a severely destructive weather system. The number of typhoons that land in China is about 7 each year, and each time they cause loss of life and property [1]. In order to reduce damage caused by typhoon, it is necessary to analyze various typhoons information to understand the impact of typhoon disasters. However, with the advent of the dig data age, the amount of typhoon data is burgeoning. Moreover, the loose organization brings great challenges to the knowledge interconnection in the big data environment [2]. Knowledge graph [3] can organize knowledge in an orderly manner with its powerful semantic processing ability and open interconnection ability. Knowledge graph is able to integrate various related entities and concepts in the form of nodes and edges, and build entity-relationship networks in the form of graphs [2]. Knowledge graph can organize knowledge more orderly and organically, and realize intelligent acquisition and management of knowledge.

Neo4j is a graph database optimized for storing graph node, attributes, and edges [4]. It also is a database that supports massive data relational operations. Many researchers use Neo4j to build knowledge graphs: film knowledge graph [5], protein knowledge graph [6], Asian music knowledge graph [7] etc. In this paper, Neo4j is selected to construct the typhoon knowledge graph.

With the constructed typhoon knowledge graph in this paper, the number and intensity of typhoons that occurred in the history of a certain location, or the landing conditions of typhoon that occurred at the same time can be known. The constructed typhoon knowledge graph also can be used to summarize the general rules, and understand which locations are often affected by typhoon disasters or in which time periods.

2 BASIC KNOWLEDGE

2.1 Typhoon disaster

Typhoon is a low-pressure vortex that occurs on the tropical or subtropical ocean surface. It is a powerful and deep tropical weather system. Typhoons are common in summer and autumn, and their intensity is divided into multiple levels according to the central wind speed.

According to the "Grade of tropical cyclones" (GBT19201-2006) issued by China Meteorological Administration in 2006. Tropical cyclones are divided into six levels based on the maximum wind speed near the center. According to the "Basic Situation of National Disasters in China in 2018" [8] issued by the Ministry of Emergency Management and the Office of the National Disaster Reduction Committee: in 2018, a total of 10 typhoons made landfall in mainland China, and the number of typhoons in 2018 is 3 more than the average number in previous years. It is a rare situation throughout the history that three typhoons, such as "Abi", "Capricorn", and "Rumbia", landed in East China one month in succession and penetrated inland to affect North China, Northeast China and other places. The "Rumbia" Typhoon was the most severe typhoon in 2018, which caused severe rainstorms and floods in Shandong, Henan, Anhui, and Jiangsu provinces. The "Mangosteen"

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Typhoon was the strongest typhoon that landed in 2018, causing certain impacts on Guangdong, Guangxi, Hainan and other provinces. According to the document [8], a total of 32.606 million people were affected by the typhoon disasters, 80 people were killed and 3 were missing. And Typhoon caused directly economic losses of RMB 69.73 billion in 2018.

Table1. Level of Tropical cyclones

	Name	Level	Speed
1	Tropical depression	6~7	10.8~17.1m/s
2	Tropical storm	8~9	17.2~24.4m/s
3	Severe tropical storm	10~11	24.5~32.6m/s
4	Typhoon	12~13	32.7~41.4m/s
5	Severe typhoon	14~15	41.5~50.9m/s
6	Super typhoon	16+	51.0m/s+

From the above data, the damages caused by the typhoons are huge. However, with the continuous increase of typhoon data, it becomes difficult for researchers to analyze the data between different typhoons. Therefore, it is necessary to construct a typhoon knowledge graph. It has powerful semantic processing and opening interconnected capabilities.

2.2 Knowledge Graph

The knowledge graph is designed to describe the various entities or concepts that exist in the real world, and to reveal the relationships between entities [9]. The knowledge graph can formally describe the things that show the world and their relationships [7]. Knowledge Graph was first proposed by Google in 2012 and is a large knowledge base that provides intelligent search services [2]. From a semantic perspective, the knowledge graph describes entities and relationships in the objective [10]. The knowledge graph allows computers to better organize, manage, and understand various typhoon data. Furthermore, the computers can use the knowledge graph to accurately analyze, read and understand typhoon data. On the other hand, the knowledge graph also mines the knowledge hidden behind the typhoon data, and finally provides users with knowledge services.

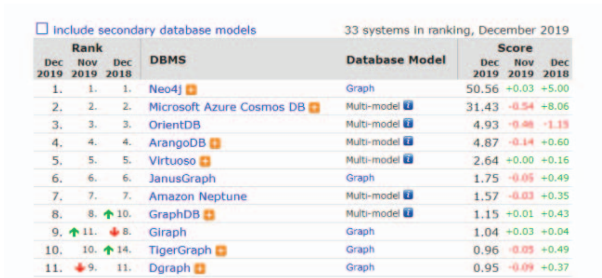
Knowledge Graph is a structured semantic knowledge which can be used to describe concepts and their relationships in the physical world in symbolic form [10]. The basic unit is the “entity relationship entity” triples, and the entity and its related attribute value pairs. The entities are connected to each other through relationships to form a networked knowledge structure.

In the knowledge graph, the organization of knowledge is based on a graph-based data model. There are two storage methods: RDF (Resource Description Framework) and graph database [11]. RDF [12] stores triples that do not contain attribute information, but graph database can store nodes and relationships with attributes. The data in RDF is easy to publish and share under the W3C standard. But graph data bases focus more on efficient graph queries and searches. Therefore, choosing a graph database as a storage method is more in line with the application requirements of typhoon knowledge [11].

2.3 Graph database—Neo4j

In the context of the era of big data, the relationship between the data that needs to be processed increases geometrically with the amount of data. It is difficult for traditional databases to handle relational operations [13]. Therefore, a database that supports massive complex data relational operations is needed. Relations dominate the graph database [13]. This means that typhoon data can be found directly through relationships to save query time.. Compared with the relational database, the typhoon knowledge graph database is more concise and more expressive.

According to the latest graph database ranking released by DB-Engines, Neo4j is still significantly, as in Figure 1.



☐ include secondary database models — 33 systems in ranking, December 2019

Rank Dec 2019	Rank Nov 2019	Rank Dec 2018	DBMS	Database Model	Score Dec 2019	Score Nov 2019	Score Dec 2018
1.	1.	1.	Neo4j	Graph	50.56	+0.03	+5.00
2.	2.	2.	Microsoft Azure Cosmos DB	Multi-model	31.43	-0.54	+8.06
3.	3.	3.	OrientDB	Multi-model	4.93	-0.48	-1.15
4.	4.	4.	ArangoDB	Multi-model	4.87	-0.14	+0.60
5.	5.	5.	Virtuoso	Multi-model	2.64	+0.00	+0.16
6.	6.	6.	JanusGraph	Graph	1.75	-0.05	+0.49
7.	7.	7.	Amazon Neptune	Multi-model	1.57	-0.03	+0.35
8.	8.	↑10.	GraphDB	Multi-model	1.15	+0.01	+0.43
9.	↑11.	↓8.	Giraph	Graph	1.04	+0.03	+0.04
10.	10.	↑14.	TigerGraph	Graph	0.96	-0.05	+0.49
11.	↓9.	11.	Dgraph	Graph	0.95	-0.09	+0.37

Fig 1. Ranking of Neo4j in Graph Database,

Neo4j is an open source NoSQL graph database implemented in Java. Its architecture is designed to optimize the rapid management, storage, and traversal of nodes and relationships [14]. In Neo4j, the relationship is the most important element in the database. It represents the interconnection between nodes. It used to point one node to another. This makes Neo4j a perfect representation of a typhoon knowledge graph. The information in the typhoon data is connected with relationships to form a typhoon knowledge graph. There are only two data types in Neo4j: nodes and edges [14]. The node can save the information of the typhoon entity. And the edge can connect the information in the typhoon data by entering the typhoon’s information into Neo4j as the node data. The typhoon knowledge graph is obtained by establishing relationships between multiple typhoon nodes.

3 CONSTRUCT TYPHOON KNOWLEDGE GRAPH

3.1 Data set

In this paper, the typhoon landing data from 1945 to 2015 were collected by Shanghai Zhui Feng Team’s website (http://www.stwc.icoc.cc), as in Figure 2.

There are different attributes (labels) data such as number, Chinese name, English name, landing location, landing time, peak intensity, etc, in the raw data set of the typhoons. Moreover, because of the typhoon attributes in raw data set are incomplete due to the long history, such as number 4505 typhoon. Parts of the typhoon attributes were selected, and the typhoons were classified according to the “Grade of tropical cyclones GBT 19201-2006” file.

CMA编号	中文名称	英文名称	登陆地点	登录时间	巅峰强度	登陆强度
4505	——	——	广东省江门市台山市赤溪镇	1945年7月7日	10级，25m/s，985hPa	8级，20m/s，994hPa
4510	——	——	广东省湛江市吴川市振文镇	1945年8月10日	13级，41m/s，960hPa	8级，20m/s，994hPa
4515	——	——	广东省惠州市惠阳区霞头镇	1945年8月25日	12级，35m/s，970hPa	12级，35m/s，970hPa
4516	——	——	台湾省花莲县新城乡	1945年9月2日	16级，53m/s，940hPa	14级，42m/s，955hPa
			福建省福州市马尾区琅岐镇	1945年9月3日		10级，25m/s，985hPa
4517	——	——	台湾省台东县东河乡	1945年9月10日	14级，46m/s，948hPa	12级，35m/s，970hPa
			福建省福州市福清市东瀚镇	1945年9月11日		10级，28m/s，982hPa
4519	——	——	海南省万宁市和乐镇	1945年9月21日	10级，25m/s，985hPa	10级，25m/s，985hPa
4603	——	——	浙江省台州市温岭市石塘镇	1946年6月23日	16级，56m/s，935hPa	12级，35m/s，970hPa
4606	——	Lngrid	香港特别行政区	1946年7月18日	17级，61m/s，920hPa	14级，43m/s，958hPa
			广东省珠海市香洲区南屏镇			

Fig 2. The raw data of the typhoon

When importing data in batches in Neo4j, it can only use CSV files to import data, so the collected typhoon attributes of the typhoon needs to be converted into CSV table data first. Then, the selected typhoon attributes were converted into CSV table data, as in Figure 3.

	A	B	C	D	E	F	G	H
1	4	启德	Kai-tak	台湾省花莲县丰滨乡	2000年7月9日	12级，35m/s，965hPa	11级，30m/s，980hPa	
2				浙江省台州市玉环县坎门镇	2000年7月10日			
3				上海市奉贤区海湾镇			10级，25m/s，985hPa	
4				辽宁省丹东市东港市长山镇	2000年7月11日		8级，18m/s，992hPa	
5	8	杰拉华	Jelawat	浙江省宁波市象山县爵溪镇	2000年8月10日	14级，45m/s，950hPa	12级，35m/s，975hPa	
6	10	碧利斯	Bilis	台湾省台东县成功镇	2000年8月22日	16级，55m/s，930hPa	16级，55m/s，930hPa	
7				福建省泉州市晋江市东石镇	2000年8月23日		12级，35m/s，965hPa	
8	13	玛莉亚	Maria	广东省汕尾市海丰县小漠镇	2000年9月1日	10级，28m/s，980hPa	10级，28m/s，980hPa	
9	16	悟空	Wukong	海南省陵水黎族自治县光坡镇	2000年9月9日	13级，40m/s，960hPa	13级，40m/s，960hPa	
10	102	飞燕	Chebi	福建省福州市福清市沙埔镇	2001年6月23日	13级，40m/s，960hPa	12级，35m/s，970hPa	
11	103	榴莲	Durian	广东省湛江市麻章区东简镇	2001年7月2日	12级，35m/s，970hPa	12级，35m/s，970hPa	
12				广西省钦州市钦南区犀牛脚镇			10级，28m/s，980hPa	
13	104	尤特	Utor	广东省汕尾市海丰县小漠镇	2001年7月6日	12级，35m/s，965hPa	11级，30m/s，970hPa	
14	105	潭美	Trami	台湾省台东县大武乡	2001年7月11日	8级，20m/s，995hPa	8级，20m/s，995hPa	
15	107	玉兔	Yutu	广东省茂名市电白县博贺镇	2001年7月26日	12级，33m/s，975hPa	12级，33m/s，975hPa	
16	108	桃芝	Toraji	台湾省花莲县丰滨乡	2001年7月30日	13级，40m/s，965hPa	13级，38m/s，965hPa	
17				福建省福州市连江县筱埕镇	2001年7月31日		11级，30m/s，985hPa	
18				山东省青岛市崂山区沿海地区	2001年8月1日		7级，15m/s，993hPa	
19	114	菲特	Fitow	海南省文昌市龙楼镇	2001年8月29日	8级，20m/s，985hPa	7级，15m/s，995hPa	
20				广西省防城港市港口区企沙镇	2001年8月31日		8级，18m/s，990hPa	
21				海南省澄迈县桥头镇	2001年9月3日		6级，12m/s，1001hPa	
22				广东省湛江市遂溪县草潭镇	2001年9月7日		5级，10m/s，1004hPa	
23				海南省三亚市林旺镇	2001年9月10日		5级，10m/s，1000hPa	

Fig 3. The CSV table data of the selected typhoon attributes.

As shown in Figure 3, there are null values in the CSV table. These null values appear when the data is converted to a CSV table because there is a one-to-many relationship in this typhoon data. Since importing null values into Neo4j will report an error, these null values need to be filled by Excel's own fill function.

Next, the magnitude of the data was modified to be easy to count, and the peak intensity was divided into wind speed, air pressure and wind level.

Finally, the data of the dataset used in this paper are, number, Chinese name, English name, landing location, landing time, wind level, wind speed, air pressure and typhoon type, as in Figure 4.

Number	ChineseNa	EnglishNa	Local	Time	Level	Speed	Pressure	Belongto
4	启德	Kai-tak	台湾省花莲县	2000年7月	12级	35m/s	965hPa	台风
4	启德	Kai-tak	浙江省台州市	2000年7月	12级	35m/s	965hPa	台风
4	启德	Kai-tak	上海市奉贤区	2000年7月	12级	35m/s	965hPa	台风
4	启德	Kai-tak	辽宁省丹东市	2000年7月	12级	35m/s	965hPa	台风
8	杰拉华	Jelawat	浙江省宁波市	2000年8月	14级	45m/s	950hPa	强台风
10	碧利斯	Bilis	台湾省台东县	2000年8月	16级	55m/s	930hPa	超强台风
10	碧利斯	Bilis	福建省泉州市	2000年8月	16级	55m/s	930hPa	超强台风
13	玛莉亚	Maria	广东省汕尾市	2000年9月	10级	28m/s	980hPa	强热带风暴
16	悟空	Wukong	海南省陵水黎	2000年9月	13级	40m/s	960hPa	台风
102	飞燕	Chebi	福建省福州市	2001年6月	13级	40m/s	960hPa	台风
103	榴莲	Durian	广东省湛江市	2001年7月	12级	35m/s	970hPa	台风
103	榴莲	Durian	广西省钦州市	2001年7月	12级	35m/s	970hPa	台风
104	尤特	Utor	广东省汕尾市	2001年7月	12级	35m/s	965hPa	台风
105	潭美	Trami	台湾省台东县	2001年7月	8级	20m/s	995hPa	热带风暴
107	玉兔	Yutu	广东省茂名市	2001年7月	12级	33m/s	975hPa	台风
108	桃芝	Toraji	台湾省花莲县	2001年7月	13级	40m/s	965hPa	台风
108	桃芝	Toraji	福建省福州市	2001年7月	13级	40m/s	965hPa	台风
108	桃芝	Toraji	山东省青岛市	2001年8月	13级	40m/s	965hPa	台风
114	菲特	Fitow	海南省文昌市	2001年8月	8级	20m/s	985hPa	热带风暴
114	菲特	Fitow	广西省防城港	2001年8月	8级	20m/s	985hPa	热带风暴
114	菲特	Fitow	海南省澄迈县	2001年9月	8级	20m/s	985hPa	热带风暴

Fig 4.A part of the processed data.

When saving those data, since the data set contains Chinese, it is important to change the encoding format of the CSV file to UTF-8 at first.

3.2 Construct a Knowledge Graph with Neo4j

After getting the CSV table data, the typhoon knowledge graph can be constructed by Neo4j.

There are five ways to import nodes in Neo4j:

1. Cypher CREATE statement, write a CREATE statement for each piece of data. (Slow when importing data in batches)
2. The Cypher LOAD CSV statement converts the data into CSV format and reads the data through LOAD CSV. (Data can be imported in batches, but the speed will decrease when faces with more than 10 million node data)
3. The official Java API-Batch Inserter. (Only available in Java)
4. Batch Import tool written by Michael Hunger, one of the authors of Neo4j. (Neo4j must be stopped before data can be import)
5. The official Neo4j-import tool. (occupies less resources than Batch Import, but can only generate a new database, and cannot insert data into an existing database)

As the data set s less than 10 million and LOAD CSV can be used directly in the visualization window of Neo4j, the LOAD CSV was selected as the method for importing typhoon data into Neo4j.

First the node data is imported with the help of LOAD CSV from typhoon CSV table to Neo4j column by column. The number, Chinese name and English name are imported as three different attributes of the same node. In this way, different attributes can be selected to display by the node according to requirements during visualization as in Figure 5.

Fig 5. Three attributes of typhoon.

Then the landing location, landing time, wind level, wind speed, air pressure and typhoon types are imported as nodes.

The last is to import relationship. In this article, the entity type can be considered as the relationship between entities. For example, the entity type of the date is time.

Therefore, the LOAD CSV was used to establish relationship between every two columns in typhoon CSV table. The typhoon number, Chinese name and English name were selected as the center node, and let the rest of nodes to establish a relationship with it. And the relationship is artificially set between the typhoon and time to "at". In the same way, the relationship with the area is set to "occur", with the wind speed is "wind speed is", with the air pressure is "air pressure is", and set "is" between the typhoon and wind level, as well as typhoon type, as in Figure 6.

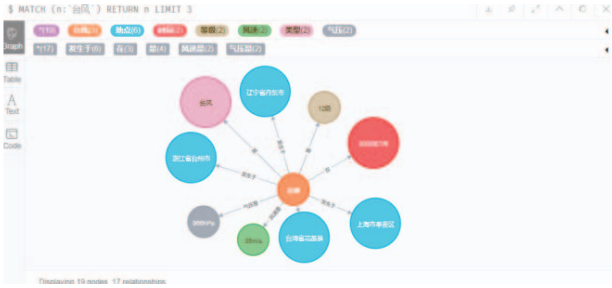


Fig 6.A typhoon and its relationships.

As shown in figure 6, Typhoon Kai-tak landed in four areas in July 2000: Taizhou City, Zhejiang Province; Dandong City, Liaoning Province; Fengxian District, Shanghai; and Hualian Country, Taiwan Province. Since the speed of Kai-tak is 35m/s, the air pressure is 965hPa, according to table 1, Kai-tak is a 12 level typhoon.

3 Display of typhoon knowledge graph

After importing all typhoon data, the typhoon knowledge graph was created. Then the typhoon data will be selectively viewed according to our requirement.

4.1 Typhoon at the same time

The information about typhoons occurring at the same time will be displayed in the Neo4j visualization window as in Figure 7.

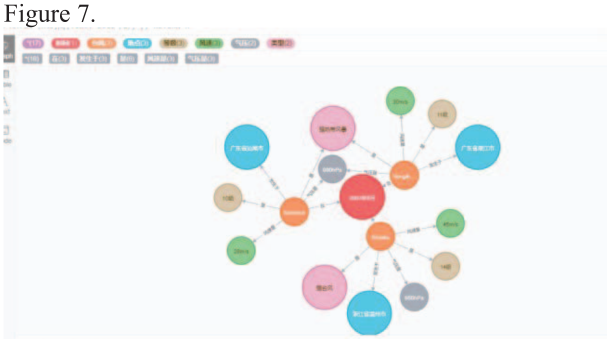


Fig 7. Situation of typhoons in August 2002.

In figure 7, there were three typhoons occurred in August 2002. The Typhoons of the Kammuri and the Vongfong occurred in Guangdong Province were severe tropical storms. The air pressure was both 980hPa, but the wind speed of the Vongfong Typhoon was a bit faster than the Kammuri Typhoon. In the same month, the Sinlaku Typhoon was a severe typhoon with a wind level of 14 and landed in Wenzhou City, Zhejiang Province.

4.2 Typhoon in the same location

The situation of typhoons landing in the same location will be viewed through Neo4j, so that the history of typhoon disasters in the area will be known clearly, as in Figure 8.

As shown in figure 8, six typhoons occurred in Shanwei City, Guangdong Province and two of them occurred in 2001. The strongest one of all six typhoons was the Typhoon Usagi in September 2013. It was a super typhoon with a wind level of 17, and wind speed of 60m/s. In addition, both the Typhoon Maria in September 2000 and the Typhoon Kammuri in August 2002 were severe tropical storms with similar data. The closest typhoon in the data set was the Typhoon Linfa in July 2015with 14 level.

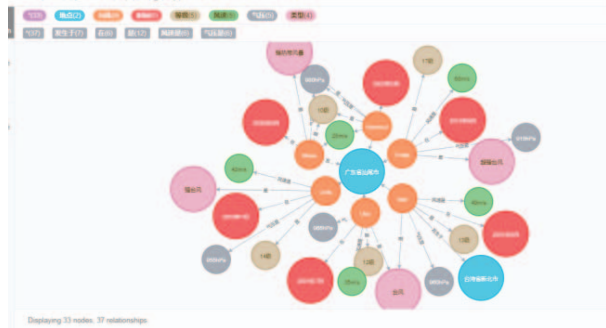


Fig 8. The Typhoons in Shanwei City, Guangdong Province.

4.3 Typhoon in the same wind level

In the same way, the landing conditions of typhoons with the highest wind speed levels in previous years can be obtained, as in Figure 9.

Fig 9. Situation of typhoons with wind level 17+.

In the typhoon data, there are five typhoons with a wind level of 17+. Since the Taiwan Province and the Fujian Province have suffered three typhoons with a wind of 17, it can be inferred that the Taiwan Province and the Fujian Province have a higher probability of suffering a super typhoon than other places. As a result, it is essential to pay more attention to the disaster prevention for Taiwan Province and Fujian Province.

The typhoon knowledge graph can not only analyze the data of a single typhoon, but also use the relationship between typhoons to conduct an overall analysis. It can help to sorting and analyzing historical typhoon data from damage brought by typhoon disasters, summarize certain rules from them, and carry out a series of preventive measures. With the assistance of typhoon knowledge graph, the damage brought by a typhoon will be reduced.

5 CONCLUSION

In this paper, the Neo4j was used to build a typhoon knowledge graph. With the assistance of typhoon knowledge graph, it is convenient to have a comprehensive understanding of typhoon disasters in recent years. Researchers will conduct a correlation analysis of typhoon from the perspective of time and space with typhoon knowledge graph. It is helpful to prevent typhoon disasters and timely rescue typhoon-affected areas.

But there are some issues that remain to be solved:

1. The data used in this paper is not comprehensive, and lack the data in recent years, but the data set will be updated in 2020 by website (http://www.stwc.icoc.cc). At that time, the data set will be enriched. So the new data can directly add to the database on the existing typhoon knowledge graph.
2. Due to the lack of some information in the data before 2000, so the current typhoon knowledge graph has a small amount of data. It is definitely not as good as a knowledge graph with a large amount of data in terms of some rules.
3. The function of Neo4j is undoubtedly very powerful, but due of the limitation that it can only be imported using CSV file, it takes a lot of time in data processing.

In summary, the typhoon knowledge graph can correlate the data that originally existed in the CSV table. And Neo4j's powerful information query function can satisfy queriers' high requirements. Knowledge graph not only help to search for desire information, but also obtain related-information through the relationship between entities. It greatly cut down the users' time to search for the information and improves work efficiency.

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