# Research and Application of Knowledge Graph in the Field of Emergency Information Management

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## ABSTRACT

*This research is being done with the intention of introducing a technology known as knowledge graphs in order to build a communication bridge between data and knowledge. Regarding the current state of affairs in the field of emergency management, which is defined by an excess of data but a paucity of knowledge, the purpose of this study is to address the situation that currently exists. The purpose of this study is to provide an explanation of the current state of development of the general knowledge representation method, the technology for knowledge representation in the emergency field, and the system for the building of knowledge maps. Furthermore, it proposes the technical system, key methodologies, and general process of emergency knowledge map development, beginning with the model layer and moving on to the data layer. Lastly, the article delves into the various application domains that emergency knowledge graphs could potentially be utilized in. It is predicted that the findings of this research will contribute to the realization of the formal expression of knowledge in the field of emergency management and will raise the level of intelligence involved in emergency decision-making in response to emergencies. This is something that will be accomplished via the contributions of the findings.*

***Keywords:*** *Emergencies, data layer, emergency knowledge, knowledge graph, level of intelligence*

## INTRODUCTION

Knowledge bases are necessary for both intelligent auxiliary decision-making and emergency response to emergencies. Within the present big data setting, the emergency field has a lot of data but not a lot of expertise; without condensed emergency knowledge, it is difficult for decision-makers to make accurate judgments on the real crisis. Therefore, to carry out rapid emergency response to emergencies, it is necessary to realize the intelligent transformation of "data-information-knowledge-wisdom" and build an emergency knowledge service system for multiple emergency subjects.

Emergency management for emergencies mainly includes key links such as prevention and preparation, monitoring and monitoring, prediction and early warning, rescue and disposal, and restoration and reconstruction. Including real-time risk information data of emergencies, massive, multi-source, and heterogeneous data information often emerges in various links of emergency response. Multi-source here refers to the diversification of data sources, such as remote sensing images, cameras, the Internet, mobile phone signaling, GPS tracking, etc.; data structure variations are referred to as heterogeneity. For example, structured data can be represented by text, audio, and video; unstructured data can be represented by images, voice, and text; and spatiotemporal data can be represented by geographic data and Internet of Things. Additionally, this data exhibits a geometric progression growth tendency and calls for quick decision-making and real-time processing. Driven by big data and artificial intelligence technologies, multi-source heterogeneous spatiotemporal data mining and technical support for the intelligence of emergency auxiliary decision-making require the application of techniques like machine learning, knowledge graphs, and cloud computing. Technologies like knowledge representation, knowledge fusion, and knowledge graphs have become crucial tools in the artificial intelligence field for machine cognitive computing. They are widely applied in applications such as natural language question answering, machine translation, semantic search, knowledge-based data mining, and decision-making.

This paper combines knowledge graph technology with knowledge engineering in the field of emergency management and suggests a way to create an emergency knowledge graph using heterogeneous data from several sources. This study presents the technical system and whole method of emergency knowledge graph development after first analyzing the research status of knowledge representation technology and domain knowledge graph; finally, discusses the application direction and prospects of emergency knowledge graph.

## METHODOLOGY

### Knowledge Representation

Simply put, "knowledge" is the collection of all concepts, facts, rules, etc. summed up by human beings through observing, learning, and thinking about various phenomena in the objective world. The development of knowledge representation techniques and technologies has made it possible to preserve and repurpose human experience and knowledge from the past. Knowledge representation, or modeling of the facts and relationships of domain knowledge, is the process of representing the body of existing knowledge as a model that a computer can store and process. There are numerous knowledge representation techniques available today, including those based on first-order predicate logic, production rules, frames, scripts, semantic networks, ontology-based representation, Bayesian network-based representation, and description logic. method of expression, etc.

### Representation of Emergency Knowledge

Facts in the emergency field are mostly reflected in emergency cases and emergency plans, concepts and rules, so the current research on emergency knowledge representation mainly focuses on emergency cases, scenarios, and plans. The development and evolution of the emergency itself and the response process constitute the event case, and for the knowledge representation of the case, many scholars have proposed various methods. A universal emergency case representation technique was presented by Zhang Yingju et al. and was based on the emergency idea tree, emergency ontology model, and event meta-model three-layer architecture. Zhang Xiankun et al. established a CBR-based emergency case ontology model on the basis of extending the ABC ontology model, defined specific concepts, entities and relationships, and gave a formal description of the case. Huang Chao and others took a different approach and proposed representation methods for structured information and unstructured information according to different sources of information. The whole case was finally represented as a semi-structured form containing quantitative data and extracted text. Referring to the relevant research on biological gene maps, A method for representing cases based on gene maps was proposed by Yu Feng et al., allowing for the systematic production of complicated emergency case structures. For the knowledge representation of emergency scenarios, Rong Juntao et al. used ontological ideas and methods to construct government crisis warning scenario and response scenario models. Wang Ning et al. extracted the common knowledge of emergency management in the field in the form of knowledge elements and established a situational representation and storage mode of emergency management cases. Chen Zuqin et al. split the emergency scenario into several scenario points, marked them to form a scenario chain, and extracted the response strategies corresponding to the scenarios from the cases to form an emergency response strategy library. In terms of the knowledge representation of the emergency plan, Zhao Ting expressed the emergency plan by using the frame representation method. Gu Yan also used the structuring technology based on frame notation to express the static plan and designed the structure and index of the plan library based on the relational model. Based on ontology, Jiang Baihua and others put forward the static and dynamic meta-model method of emergency plan, and described it in the form of multi-view. Zhang Ying et al. used the two-layer structure model of the upper ontology and the application layer to realize the digital representation of the earthquake plan and the formal description of knowledge.

## Domain Knowledge Graph

Knowledge graphs are now the most significant method of representing knowledge in the big data era. The knowledge graph, which is simply a semantic network with nodes representing things or concepts and edges representing the semantic relationship between them, is used to show the relationship between entities with attributes. At present, general knowledge graphs are more representative: YAGO, Dbpedia, Probase, etc.; in China, there are zhishi.me, CN-DBpe-Probase, Baidu's "Zhixin", and Sogou's "Zhicube", etc.

The creation of the domain knowledge map is still in its early stages as opposed to the general knowledge map, which currently has a reasonably developed technical infrastructure. Ruan Tong and others proposed a data-driven incremental knowledge map construction method, and demonstrated the application through three use cases of traditional Chinese medicine, marine and enterprise. Peng Qianhui proposed an automatic construction method for domain knowledge graphs, and created the WAKA-KG framework to help in domain knowledge graph creation. To address the issue of striking a balance between automation and manual participation, Yang Yuji and colleagues presented a "four-step method" for creating domain knowledge maps that includes building domain ontologies, crowdsourcing semi-automatic semantic annotation, external data completeness, and information extraction. Jiang Bingchuan and others studied the key technology and construction process of geographic knowledge graph. Perhaps,for the purpose of creating domain knowledge graphs, unified automated creation techniques are still lacking. In the last two years, the knowledge map of the security and pharmaceutical industries has been more visible to individuals due to technological advancements., such as the public security knowledge map of Minglue Data, and the traditional Chinese medicine knowledge map of Shanghai Shuguang Hospital.

Compared with the general knowledge map, which already has a relatively complete technical system, the construction of a domain knowledge map is still in the early stage. Ruan Tong and others proposed a data-driven incremental knowledge map construction method, and demonstrated the application through three use cases of traditional Chinese medicine, marine and enterprise. Peng Qianhui created the WAKA-KG framework to aid in the creation of domain knowledge graphs and suggested an automatic technique for creating them. A "four-step method" for creating domain knowledge maps that balances manual and automated participation was developed by Yang Yuji and colleagues. It involves creating a domain ontology, crowdsourcing semi-automatic semantic annotation, external data completeness, and information extraction. Jiang Bingchuan and others studied the key technology and construction process of geographic knowledge graph. Perhaps, it is for the purpose of creating domain knowledge graphs, unified automated creation techniques are still lacking. In the last two years, as technology has advanced, knowledge maps of the pharmaceutical and security sectors have come into public view. Examples of these maps are Shanghai Shuguang Hospital's traditional Chinese medicine knowledge map and Minglue Data's public security knowledge map.

The emergency knowledge map can be written as G={s, p, o}, which is a triple that forms a directed graph with nodes and edges. Edges show the relationships between concepts and concepts, concepts and entities, entities and entities, entities and attributes, and attributes and attribute values. Nodes indicate emergency-related concepts, related entities, and attribute values, as shown in Figure 1. The emergency knowledge map is divided into two logical levels: the model layer and the data layer. The schema layer is constructed upon the data layer and consists of ideas that primarily describe the relationships between concepts and the classes of things in the data layer. The data layer is mostly made up of a variety of factual knowledge, such as entities and attributes.

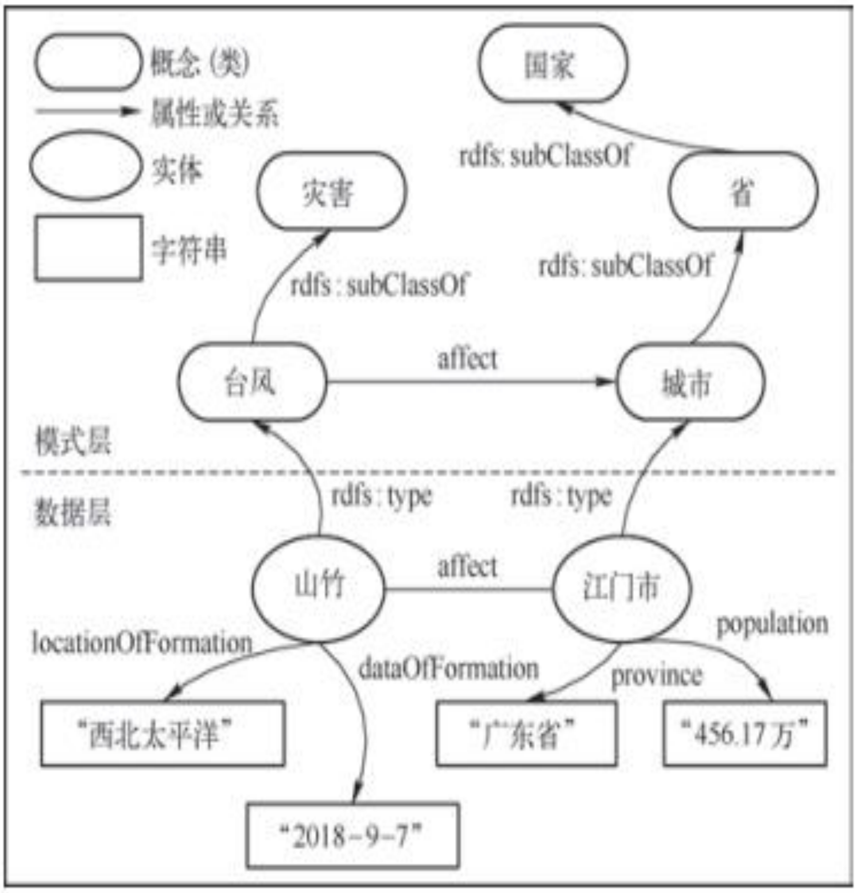


图1 知识图谱的定义示例

(rdfs：subClassOf 表示概念之间的语义关系；

rdfs：type 表示数据图中的实体与所属概念间的关系)

**Figure 1 Demonstration of Knowledge Graph**

When building knowledge graphs, a combination of top-down and bottom-up techniques is frequently employed, based on the hierarchical structure of domain knowledge. The top-down approach refers to pre-constructing the pattern layer of the domain knowledge map through the ontology editor, and The entities, properties, and relationships in the data source are extracted using a range of extraction techniques based on the pattern map in the bottom-up approach, and the results are then included into the knowledge graph.

**Ontology construction**

It can be seen from the above description that the construction of the pattern layer is the construction of the domain ontology. Ontology is a clear specification of conceptualization, that is, model information abstracted by modeling entities, including concepts, attributes and connections between the domain's notions. At present, ontology is crucial to the domains of semantic web,knowledge graph and artificial intelligence. The modeling metalanguage of ontology can describe the basic characteristics and evolution rules of things, which can be formally expressed as：

O={C，P，R}

Among them, O is the set of ontology primitives; C is the set of concepts, representing the core connotation of terms; P is the set of concept attributes, representing the related features of concepts; R is the set of relations between concepts, describing various types of relations between concepts. It can be seen that ontology uses a unified system to describe the concepts and terms of things, which can sort out domain knowledge, and then realize sharing and reuse.

In the field of emergency response, the primary task of ontology learning is to sort out concepts. According to the characteristics of emergency management, combined with the concept classification method proposed in the literature, the concepts are divided into two categories: general concepts and process concepts, see Table 1 for details. "General concepts" include time, physical environment, infrastructure, individuals, organizations, and social relations; "process concepts" include activities, interactions, events, and interventions.

**Knowledge Map Construction**

To put it narrowly, the knowledge map's creation involves populating the data layer. The majority of the data used in the field of emergency management are semi-structured, unstructured, and structured, and they exhibit incredibly complicated multi-source heterogeneity features. Therefore, starting from the source of knowledge, the knowledge map is mainly constructed through three steps: information extraction, integration, and reasoning. Figure 2 depicts the knowledge graph's building process.

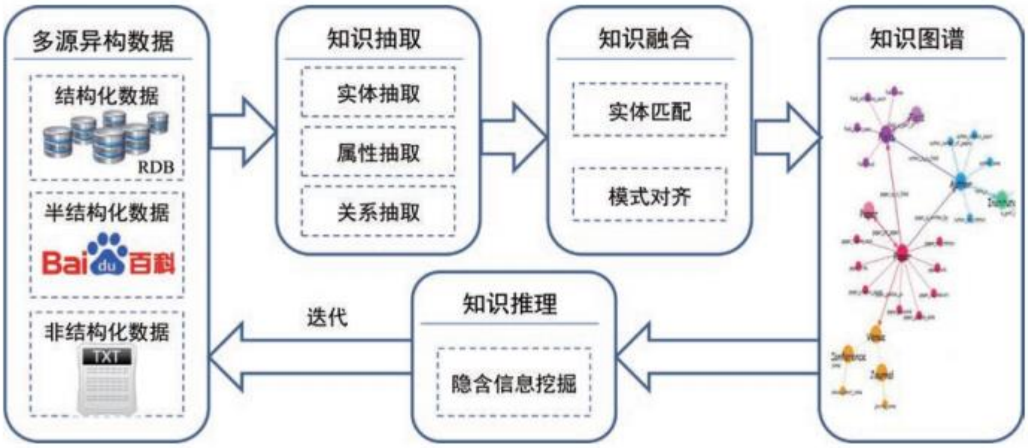


图 2　知识图谱构建过程

**Figure 2 Development of a Knowledge Graph**

**Information Extraction (Knowledge Extraction)**

The information extraction stage mainly obtains knowledge units from multi-source heterogeneous data, including emergency knowledge entities, entity attributes and entity relationships. Structured data has a fixed format and display structure, and is generally stored in a relational database, such as the hidden danger investigation records of a hazardous chemical production enterprise; in order to actualize the knowledge from the database, the extraction method consists of establishing the corresponding relationship between the idea in the database and the ontology in the knowledge graph. Automatically fetch entities, attributes and relationships. For semi-structured knowledge in various encyclopedia data, such as natural disaster information in Baidu Encyclopedia, the encapsulator-based method is generally used for extraction. Unstructured data is an unstructured plain text pattern, which is difficult to extract knowledge. Generally, the extraction method of supervised learning is used, that is, the unknown text is automatically marked through known entities. It should be noted that the most difficult problem in the process of entity extraction in the emergency domain is entity unification, that is, while pointing to the same thing, data from several sources are not consistent in some writing. For this problem, some basic rules are usually pre-defined to deal with.

**Integration (Knowledge Fusion)**

To create isolated graphs, the knowledge extraction stage's sole responsibility is to extract entities, attributes, and relationships from various data sources. In order to integrate these isolated maps, data integration, disambiguation, processing, verification, etc. are required to achieve the perfect fusion of knowledge. The knowledge fusion stage mainly performs entity matching and pattern alignment.

Entity matching mainly disambiguates entities with different identities but representing the same object in the real world, and identifies them as globally unique entities. The diversity of knowledge sources in the emergency field has led to problems such as the same name and multiple references. For example, the "disaster-causing factor" in Baidu Encyclopedia is the "disaster source" we refer to every day. At present, entity matching generally adopts the clustering method of unsupervised learning, and the key problem is the selection of similarity function. For semantic disambiguation, there is still a lack of semantic dictionaries in the emergency domain, and in most cases, the judgment of artificial domain experts is mainly used.

Schema alignment mainly refers to the fusion of entity attributes and attribute values. Entities from different data sources have different language expressions for their attributes, such as "age" and "age" are synonyms. Therefore, when integrating entity attributes, the features that can be considered include synonyms, near synonyms, and entity types at both ends of the attribute. At present, pattern alignment generally adopts a supervised learning method, mainly through manual annotation in advance.

**Reasoning (Knowledge Reasoning)**

The significance of reasoning is to mine implicit knowledge from knowledge graphs, that is, to use graph or logic-based methods to solve problems semantically without too much human participation. Knowledge reasoning includes two parts: the reasoning of entity relationship and the reasoning of entity attribute. The former is to infer and understand the potential relationship between entities, and the latter is to reason and update the attribute value of the entity.

The implementation of knowledge reasoning can utilize the extensible rule engine. For the relationship between entities, it can be realized by defining chain rules. For example, unsafe behavior of people is an important cause of safety production accidents. Non-compliance with operating procedures and poor technical quality are all unsafe behaviors of people. When production When the accident occurred, there were behaviors such as non-compliance with the operating procedures, and it can be inferred that non-compliance with the operating procedures was the direct cause of the accident. For entity attributes, it can be realized by defining calculation rules. For example, the typhoon's moving speed is included in the knowledge map, and the time when the typhoon reaches the land can be obtained through reasoning.

In addition, statistical reasoning is also the main method of knowledge reasoning, which uses machine learning technology to obtain new knowledge from graphs through statistical laws. At present, there are mainly methods such as description logic-based reasoning, probability graph-based reasoning, and representation learning-based reasoning.

## RESULT AND DISCUSSION

According to the object of knowledge map service, the application of emergency knowledge map can be divided into two levels, namely, people-oriented and intelligent system-oriented. Human-oriented applications are mainly to provide more convenient and accurate knowledge services for humans, such as intelligent retrieval, intelligent auxiliary decision-making analysis, etc.; intelligent system-oriented applications are mainly to enable machine systems to have human-like cognitive capabilities, such as intelligent question-answering platforms. The following briefly summarizes the commonly used application directions:

- ***Intelligent search***

In the past, the search results of search engines were displayed in the form of webpage links, but the search based on emergency knowledge graphs is usually presented in the form of knowledge cards, which is a formal expression of emergency knowledge. The knowledge map can associate elements such as disaster entities, weather conditions, and response measures to realize semantic search and query of emergency knowledge, and visualize them on the same page.

- ***Intelligent Decision Support***

Emergency response to emergencies requires more intelligent decision-making support from computers. Based on the knowledge map in the field of emergency response, the association analysis of the three elements of emergency, disaster bearing carrier and emergency management can be realized through machine learning algorithms such as classification and clustering, as well as complex network analysis technologies such as shortest path, link prediction and centrality analysis And mining, to achieve ad hoc decision support.

- ***Intelligent Communication***

As artificial intelligence technology has advanced, deep learning has been used to provide machine perceptual capabilities comparable to those of a person. Supported by a relevant knowledge base. Due to the structural characteristics of the emergency knowledge map, compared with traditional text data and relational databases, it has stronger semantic expression and understanding capabilities, and is the knowledge base for intelligent question answering in the field of emergency management.

- ***Intelligent Public Opinion Monitoring***

The advancement of Internet technology has provided more convenience for the development of social media, and people can express their opinions through Weibo and other platforms. Perhaps, for some emergencies, the opposite view will mislead the government and the public, and hinder the development of emergency rescue. Therefore, effectively filtering large-scale real-time data and monitoring the trend of public opinion is the key to emergency response. The monitoring system based on the knowledge map can semantically label the text information, my valuable information, reveal the relationship between information, and realize the public opinion analysis of mass media.

## CONCLUSION

This paper focuses on the discussion of knowledge representation methods and the development status of domain knowledge map construction technology and proposes a technical system and detailed construction process for emergency knowledge map construction that relies on a variety of heterogeneous data sources and elaborates on the emergency knowledge over the coming years. Possible directions of application of the map.

On the whole, the research work on the emergency knowledge graph is still in the exploratory stage, especially the combing of relevant knowledge in the field of emergency management and the abstraction of ontology in the field of emergency are not mature enough, and there is still a lot of work to be overcome.

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