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Research on Emergency Intelligence Process Based on Complex Networks

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Abstract: *Facing the challenges of the big data era, traditional emergency intelligence generation methods are no longer able to meet timeliness and quality requirements. This study proposes a new emergency intelligence process that draws on the core ideas of complex network theory. Comparative analysis shows that the core concepts of the emergency intelligence process and the complex network empirical analysis process are highly consistent. Based on this theoretical basis, an emergency intelligence process based on complex networks is constructed. This process makes the intelligence generation process more systematic and significantly enhance its explanatory power.*

Keywords: *emergency intelligence process; complex network; intelligence production*

1. Introduction

The emergency Intelligence system is a core element of emergency management execution. With the widespread application of technologies such as the Internet of Things, mobile Internet, intelligent electronic devices, and cloud computing, emergency intelligence has entered the era of big data [1], which is characterized by extensive information perception, collection and integration of massive heterogeneous data, and accurate production of intelligence products. Against this background, the complexity of intelligence generation processes, methods, and tool sets have increased significantly, and traditional intelligence production models are no longer able to adapt to the challenges of the big data era. Therefore, there is an urgent need to explore emergency intelligence system construction solutions that are compatible with the big data environment. This is not only of great significance to theoretical research, but also shows urgent demand and value in practical applications. By building a systematic emergency intelligence system, emergency management can be assisted to achieve accurate prediction, rapid response and effective decision-making. This not only ensures the smooth execution of emergency management, but also provides strong support for ensuring public safety and stability.

In the operation of the emergency intelligence system, the established intelligence process must be strictly followed, which covers a series of closely connected stages such as intelligence planning, collection, processing, analysis and application. However, in actual operation, the current emergency intelligence process fails to pay enough attention to the semantic architecture between the intelligence subject and its environment. This situation has led to a weakening of the correlation between the various links in the process and limited collaborative work efficiency, which has seriously affected the automation level and overall work efficiency of the emergency intelligence system. In view of this, this study adopts a complex network approach to describe the semantic structure of intelligence entities and scenarios, and designs an operation model for each stage of the intelligence process on this basis. This is intended to provide a solid theoretical foundation for building an emergency intelligence system that is closely connected, coordinated and unified.

2. Theoretical Foundation of Complex Networks

Complex networks is an important tool for studying the characteristics and functions of complex systems. They simplify individuals in the system into nodes, represent the interactions between individuals as lines between nodes, and describe complex systems as structured, ordered, and analyzable systems [2]. Complex networks can be used to analyze the intricate interpersonal communication networks in society, the predator-prey relationships between species in nature, and the semantic connections

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between words in an article. The core of complex network research is to explore the interaction patterns between individuals and how such interactions affect the characteristics and functions of the entire system. At the same time, the research methods of complex networks combine the optimization strategies of graph theory and social network analysis, as well as the methods of statistical physics in model construction, evolution mechanism exploration, structural regulation, and network simulation. In addition, complex network visualization technology provides researchers with an intuitive and vivid way to display the network. Using graphical methods, researchers can gain a clearer insight into the layout and structure of the network, more effectively mine the deep information in the data set, and deeply understand the analysis results. The empirical research process of complex networks includes [3]: First, clarify the subject and purpose of the research, that is, determine which entities in which field are selected as the research objects, and set specific research goals such as characteristic analysis and evolution model exploration. Then, collect empirical data related to the research object to provide data for subsequent model construction. In the process of building a complex network model, researchers need to use the model to map the research object and conduct quantitative analysis on it. Then, in the network analysis stage, select appropriate analysis indicators and methods based on the preset research objectives to conduct in-depth analysis of the network. Finally, the analysis results are presented in an intuitive way through visualization technology to help researchers better understand the internal structure and operation rules of the complex network. In this process, the complex network model defines the starting point of the research and runs through the entire process of analysis and results presentation.

3. Consistency between Emergency Intelligence Process and Complex Networks Research Process

This section adopts a comparative analysis method to deeply analyze the internal consistency of the empirical research steps of complex networks and the emergency intelligence processing process in each link. Through this comparison, it aims to provide a solid theoretical foundation for building an emergency intelligence process based on complex network theory.

3.1. Intelligence Planning

The ultimate goal of emergency intelligence products is not to simply collect data, but to deeply explore the truth of "target behavior trends" and "fact evolution paths", which requires users to determine intelligence needs in the intelligence planning stage. The representation method of intelligence needs is "intelligence needs = intelligence subject + intelligence effectiveness". "Intelligence subject" is not only individuals and entities related to individuals, but also includes special entities such as events. From a micro perspective, the intelligence subject can be a micro individual or object, or a macro group or event. "Intelligence effectiveness" refers to the form of knowledge that is closely related to the subject and is hoped to be obtained from intelligence, such as detailed information query, in-depth data analysis, timely early warning prompts, and accurate speculation on future trends. Combined with the previous discussion, it can be seen that emergency intelligence planning and the "selection of research objects and targets" stage of complex networks research both take entities and their attributes and behavioral laws as research targets. Therefore, the two stages are consistent in connotation.

3.2. Intelligence Collection

Intelligence collection needs to provide a data basis for subsequent analysis. In this link, the scope of data to be collected is extremely wide, covering not only digital information captured by modern information technologies such as the Internet of Things, the Internet, and sensors, but also first-hand information obtained by traditional field research and interviews. Compared with data acquisition in complex networks research, intelligence collection and complex networks data collection show internal consistency in target positioning and operation mode. Both the collection of emergency intelligence and the acquisition of complex network data try to reflect the status and behavioral characteristics of the research object. At the same time, they ensure the comprehensiveness and accuracy of information by combining online and offline data acquisition strategies. In summary, emergency intelligence collection and complex networks data collection both provide a data basis for subsequent analysis, and the two are essentially the same.

3.3. Intelligence Processing

In intelligence processing, raw intelligence materials are transformed into standardized and ordered

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information. Emergency intelligence data, as a detailed record of the status and behavior of intelligence subjects and their related entities in a specific time and space context, contains rich knowledge and information. This knowledge is reflected in the characteristics of multiple entities in the real world that are closely related to the intelligence subject and the intricate connections between them. This data structure is consistent with the construction logic of the knowledge graph [4]. As a powerful information organization model, the knowledge graph can accurately extract entities, attributes and their relationships through preliminary data processing and integrate them into a unified framework. This not only fully and systematically expresses the core information in the intelligence data, but also strengthens the presentation of complex relationships between entities. The information organization method of the network structure, combined with the advanced reasoning mechanism, enables the knowledge graph to achieve high efficiency and high accuracy when querying. Therefore, the knowledge graph is suitable as a content organization model in the emergency intelligence processing. Under this condition, emergency intelligence processing becomes a process of complex network construction, which is the same as data processing and network construction in complex networks research.

3.4. Intelligence Analysis

Intelligence analysis, as the core link of the emergency intelligence process, has the function of producing high-quality intelligence products through in-depth analysis and mining of data. This process is a dynamic application system of comprehensive analysis methods, which requires intelligence analysts to build effective logical links and implement analysis methods in an orderly manner so that the analysis process reflects the characteristics of internal connections. In intelligence processing supported by knowledge graphs, intelligence objects and their related objects appear in the form of network entity nodes in the graph. The analysis problem of intelligence objects can be regarded as a node-oriented network analysis problem. For such problems, we can adopt network analysis techniques derived from graph theory, social network analysis and statistical physics to build a basic framework for problem solving. It is worth noting that the emergency intelligence analysis method under the network perspective belongs to the network analysis method. For example, big data analysis techniques are a collection of statistical, clustering and other strategies for network nodes. In addition, in the intelligence analysis process, qualitative analysis and super-logic analysis can also be used to broaden the analysis ideas and correct the analysis process. When we convert intelligence needs into network analysis problems, we are essentially analyzing intelligence needs with a complex network model. This analysis introduces orderliness to the selection and application of intelligence analysis methods, enabling analysts to ensure the high-quality output of intelligence products according to standardized procedures, thereby greatly reducing reliance on personal talent and experience. Therefore, the intelligence analysis stage is essentially consistent with the network analysis stage of complex networks research.

3.5. Intelligence Application

Intelligence application is to transform intelligence products into practical action plans. In this process, users of emergency intelligence rely on the intelligence products to make decisions for subsequent action plans. The more comprehensive and detailed the information in the hands of intelligence users, the higher the accuracy of their decision-making. Intelligence products not only need to provide analysis results corresponding to intelligence needs, but also need to present this information efficiently and intuitively. Through systematic organization and optimized display structure, users can easily browse and retrieve, thereby enhancing their information processing capabilities. Emergency intelligence products based on complex networks organize knowledge content in the form of graphs, using complex networks as a medium to intuitively display the complex relationships and evolution paths between elements in intelligence analysis [5]. It is worth noting that the application of emergency intelligence and the display of complex network analysis results are essentially the same. They both focus on network visualization, with the aim of enhancing the clarity of intelligence products or analysis conclusions, thereby promoting the user's cognitive process. Therefore, the two are consistent in connotation.

In summary, the emergency intelligence process and the complex network empirical analysis process are essentially consistent in all aspects. Therefore, the complex network can be used as a tool to link the various aspects of the emergency intelligence process. Based on the network analysis paradigm, a coordinated and unified emergency intelligence process can be designed.

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4. Design of Emergency Intelligence Process

4.1. Intelligence Planning Operation Mode

The intelligence planning process includes two important steps: setting intelligence requirements and analyzing requirements. It can be based on the formula "intelligence needs = intelligence subject + intelligence effectiveness". This formula shows that in the planning process, we need to clearly define the intelligence subject and clarify the role that intelligence should play. In the face of emergencies, it is difficult to define the intelligence subject. Since such events often involve variable object types, entities of different sizes, and complex and dynamic behavior patterns, an effective method is needed to accurately grasp the outline of the intelligence subject. To address this problem, we can adopt the classification and statistics of historical intelligence cases and combine them with the network graph model to describe the intelligence scenario. Through this model, on the basis of determining the boundaries of the intelligence scenario, the explicit and implicit entities and their mutual connections are identified and incorporated. In this way, intelligence users can understand the scenario with the support of human-assisted analysis and filter out entities that are suitable as intelligence subjects. In terms of clarifying the role of intelligence, it is necessary to classify intelligence roles based on a systematic analysis of intelligence cases. These roles can include core categories such as information retrieval, information aggregation, early warning and trend prediction. Intelligence users can accurately express their intelligence needs based on these classification systems and their own intelligence subjects. Of course, more sophisticated strategies are needed to handle complex intelligence needs. Such needs are often complex, consisting of multiple sub-needs, and the combination pattern is not clear. In this regard, examples involving complex needs can be collected to extract the logical paths that intelligence experts use to deconstruct such needs. These logical paths can be converted into specific demand analysis operation processes and accumulated as case databases for complex case analysis.

4.2. Intelligence Collection Operation Mode

Intelligence collection departments need to connect with various data resources and integrate different forms of data, including structured, semi-structured and unstructured data, to accumulate intelligence materials. Data sources can be divided into two types: network data and non-network data according to the generation path. Network data includes Internet information, social media records, communication logs and video surveillance content, etc., which come from the Internet, sensor networks and smart devices. In contrast, non-network data is mainly collected through manual input. It is particularly important to note that non-digital intelligence materials should be converted into electronic form in a timely manner for archiving and preservation. Intelligence departments need to be good at using various data resources and actively promote data sharing and data openness to improve the efficiency and quality of intelligence collection and provide more comprehensive and accurate information support for decision-making.

4.3. Intelligence Processing Operation Mode

The intelligence processing stage is to transform the heterogeneous information collected from multi-source data into an orderly knowledge system for the purpose of intelligence production. In this paper, we use knowledge graph technology to store massive data in the database for subsequent analysis and application. First, based on the professional knowledge and practical experience in the emergency field, the basic framework of the knowledge graph is established as a guide for the entire processing process. Then, knowledge extraction is performed on the data, including detailed operations such as entity recognition, relationship definition, and attribute extraction. For unstructured and semi-structured data, rule-oriented, supervised learning, and semi-supervised learning methods are used to deeply mine the entities, relationships, and attributes in the data. Finally, knowledge integration is carried out to fuse the entities, relationships, and attributes of the same concept captured from different data sources, organize the knowledge graph according to the framework, and store it in the database, realizing the systematic organization and preservation of intelligence materials.

4.4. Intelligence Analysis Operation Mode

The intelligence analysis process includes three core stages: problem conversion, algorithm and data selection, and intelligence generation. In the problem conversion stage, the first step is to identify and analyze the work requirements, and then pass the analyzed intelligence demand information to the

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problem conversion module. This module converts the intelligence requirements into complex network analysis problems based on the network analysis idea. This conversion is similar to the solving strategy of mathematical problem, which abstracts the essence of the problem into specific knowledge points and guides the systematic application of subsequent mathematical tools. The conversion can be implemented by applying a mapping table. The mapping table is designed by an expert team and can connect intelligence needs with network problems. In the algorithm and data selection stage, based on the results of network problem conversion, network analysis methods, evaluation indicators and data source options are recommended to assist analysts in making appropriate choices. The intelligence generation stage is to extract necessary resources from the knowledge graph database and technical tool library based on the selected analysis methods for intelligence product production. At the same time, analysts can use other intelligence analysis techniques to deepen the preliminary results and enhance the value density of intelligence products. These three stages are intertwined to form a complete intelligence analysis process. Problem conversion provides the basis and direction for subsequent work, algorithm and data selection supports specific analysis, and the intelligence generation stage generates the output of intelligence products.

4.5. Intelligence Application Operation Mode

Two functions need to be completed in intelligence application stage: first, use visualization technology to display the intelligence product to help users gain a deeper understanding of the intelligence content, so as to enhance the user's understanding of the intelligence product and assist in decision-making; second, extract multi-dimensional features to depict the intelligence scenario, apply the context matching algorithm to retrieve cases and decision-making strategies for users. In the visualization display stage, through the intelligent display of various analysis elements, users are guided to understand the logic of analysis and generation of intelligence products. Specifically, at the micro level, the key attribute characteristics of the entity and the association path between entities should be highlighted; at the macro level, the dynamic development trend of the entity group should be displayed. This display method targeting different levels helps users better grasp the overall intelligence picture and make more efficient decisions. In terms of decision-making function, users retrieve cases and decision plans similar to the multi-dimensional feature intelligence scenario, and then customize the command plan based on these recommended strategies to make the plan fit the actual situation. In the process of intelligence application, new intelligence needs will be generated and fed back to the intelligence planning stage.

5. Conclusion

In a big data environment, emergency intelligence generation is more difficult, which poses a great challenge to the timeliness and quality of intelligence analysis. In order to effectively solve these problems, it is urgent to build a highly correlated intelligence process to achieve standardized intelligence production. Based on the similarities between the emergency intelligence process and the empirical research methods of complex networks, this paper proposes to establish an emergency intelligence process model and its operation mechanism based on complex networks. This mechanism uses complex network theory to describe the relationship between intelligence elements and the environment, transforms intelligence generation into a complex network analysis problem, and thus guides the systematic application of intelligence analysis technology. At the same time, we advocate the use of complex networks as a means of organizing and displaying intelligence content to enhance the orderliness, systematicness and explanatory power of intelligence production. Future research directions will focus on automated intelligence demand analysis strategies and problem conversion methods to further improve the efficiency and level of intelligence processing.

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