Application and Innovation of Big Data Visualization Analysis in Supporting Think Tank Research: Postprint

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Abstract

[Purpose/Significance] Think tank research in the big data environment aims to effectively collect, process, and analyze massive information, excavate the logical patterns embedded therein, and visualize large volumes of unstructured data, which constitutes a focal point in contemporary think tank research. [Method/Process] This paper examines the current research status of think tanks and big data visualization both domestically and internationally, systematizes relevant theories on employing big data visualization for think tank research, and analyzes the application and innovation of big data visualization methodologies in think tank research. [Results/Conclusion] The findings indicate that research methodologies for think tanks in China remain relatively monolithic, while think tank research approaches utilizing big data visualization are developing rapidly, encompassing technologies such as massive data processing, visualization algorithms, graphical visualization, human-computer interaction, and distributed processing that support big data visualization analysis for think tanks. The application of big data visualization analysis in think tank research facilitates intuitive presentation of think tank data and information, dynamic graphical visualization for comparative analysis, user interaction support for visualization analysis, aggregation and sharing of think tank data resources, and enhances the role and influence of think tanks.

Full Text

Application and Innovation of Big Data Visualization Analysis in Supporting Think Tank Research

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Abstract

[**Purpose/significance**] Think tank research in the big data environment aims to effectively collect, process, and analyze massive information, excavate the logical rules contained within it, and visualize large amounts of irregular data—making this a hot topic in contemporary think tank research. [**Method/process**] This article analyzes the current research status of think tanks and big data visualization both domestically and internationally, systematically organizing relevant theories on big data visualization methods for think tank research. It examines the application and innovation of big data visualization methods in supporting think tank research, and employs CiteSpace software to analyze the current state of think tank research in China. [**Result/conclusion**] The results show that current think tank research methods in China remain relatively simple, while big data visualization research involves multiple disciplines and industry applications. Big data visualization methods for think tank research are developing rapidly, encompassing technologies such as massive data processing, visualization algorithms, graphic visualization, human-computer interaction, and distributed processing that support big data visualization analysis in think tank research. The application of big data visualization analysis in think tank research can help achieve efficient data processing, scientific and accurate decision-making, visualization of complex graphics, simplification of complex problems, enhanced user interaction, resource aggregation and sharing, and improved think tank effectiveness and influence.

Keywords: think tank, big data, visualization, visualization analysis, research methods

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Think tank research is fundamentally built upon scientific data analysis to forecast future research trends and directions, thereby establishing competitiveness and influence. As the issues facing think tank research become increasingly complex, achieving specialization and refinement to meet the challenges of new-type think tanks will be key to determining the future success of think tank institutions [1]. As early as January 2015, the "Opinions on Strengthening the Construction of New-Type Think Tanks with Chinese Characteristics" issued by the General Office of the CPC Central Committee and the State Council emphasized the importance of policy consultation, calling for innovation-driven efforts to build a new-type think tank system with Chinese characteristics, thereby vigorously promoting future research on characteristic new-type think tanks [2]. With the rapid development of the internet, the collection, storage, and analysis of big data have brought new impetus and challenges to China' s think tank research. Particularly, the application of big data visualization methods—from the perspectives of policy operation, government management, and decision-making—helps decision-makers and the public understand key issues and obtain effective information based on massive data processing and analysis, representing a fundamental trend in future think tank research.

1.1 Current State of Think Tank Research

Think tank research has entered a stage of rapid development. In terms of institutional numbers, the "2015 Global Go To Think Tank Index Report" released by the University of Pennsylvania on February 9, 2016, indicated that there were 6,846 think tank institutions worldwide, with the United States ranking first globally with 1,835 think tanks, and China ranking second with 435 think tanks [3].

Scholars both domestically and abroad have conducted in-depth research on think tanks. Jacques Peter employed scientometric methods to statistically measure think tank data and analyze the operational mechanisms of traditional American think tanks [4]. Domestic scholar Lü Hong conducted bibliometric analysis and information mining based on WOS to summarize current international think tank research hotspots: (1) the development and operational status of think tank groups and their social influence; (2) the role positioning and decision-making functions of think tanks; (3) classification, fields, and functional studies of think tanks; and (4) case studies of think tanks [5].

Research on literature quantity can characterize changes in research fields to a certain extent. Therefore, we conducted domestic and international literature searches to compare publication volumes and understand trends in think tank research. For domestic literature, we selected the CSSCI journal database from CNKI, using "think tank" as the exact title search term, excluding conference notices and reports, with a time span from 2000 to 2016, yielding 721 articles. For international literature, we selected the WOS Core Collection database, using "Think tanks" as the topic and "Article" as the document type, with the same time span from 2000 to 2016, yielding 384 articles. The search was conducted on July 19, 2017. The results of publication volume are shown in [Figure 1: see original paper].

Figure 1 The quantitative comparison of published articles in think tank research at home and abroad

Figure 1 shows that before 2011, international literature on think tank research exceeded domestic literature in quantity, indicating that foreign scholars started think tank research earlier and accumulated a certain volume of literature, with a steady growth trend over the past 16 years. Domestic think tank research started relatively late, beginning gradually at the turn of the century, but the number of relevant papers has increased since 2011.

1.2 Current State of Big Data Visualization Research

Big data visualization analysis is currently one of the important methods for big data analysis. Large-scale data is processed and analyzed, then displayed intuitively using graphics and images. This data typically comes from databases, HTML, XML files, source code, etc. Through storage and analysis, it enables statistical analysis, knowledge representation, user interaction, visual presenta-

tion, human cognition, perception, and exploratory decision-making [6-11]. Big data visualization technology fully utilizes data analysis, combining the advantages of machines and humans to analyze and solve problems, achieving visual perception [12].

Big data visualization methods originated from initial scientific visualization [13] and information visualization generated with information growth [14], collectively known as data visualization. Nightingale once used traditional data visualization methods to collect and analyze medical and public health information, with pie charts being the most frequently used [15]. With the development of internet technology and increasing information volume, big data visualization is no longer confined to traditional graphic visualization. Based on massive data, it gradually demonstrates interactive functions in content-rich graphics. Interactive data visualization facilitates the selection and representation of complex data, helping users interact with systems [16-17]. Due to different industry applications and data types, big data visualization analysis methods also vary, with applications spanning politics, economics, finance, healthcare, and other industries, processing data types including structured data, text, networks, images, and more [18].

1.3 Problem Statement

Through comparative analysis of domestic and international think tank research literature and review of current research status, we find that foreign think tank research started earlier, while China' s think tank research, despite having some achievements, still employs relatively simple methods and has not yet formed a mature research system. The arrival of the big data era poses new challenges for China' s think tank research: How can we conduct big data-driven think tank research? Current big data visualization methods can intuitively display information for massive data, with applications involving multiple data types and industry decision-making analysis, encompassing multidisciplinary cross-research. Therefore, how can we apply big data visualization analysis to support the application and innovation of think tank research?

This article elaborates on think tank research methods and theories, systematically organizes big data visualization methods and theories for think tank research, analyzes the application and innovation of think tank research methods from the perspective of big data visualization, employs CiteSpace software to conduct visualization analysis of some think tank research literature from CNKI, and provides prospects for future results.

2. Development Dynamics of Think Tank Research Methods

American scholar Paul Dickson first analyzed think tanks in his 1971 publication "Think Tanks" and examined their functions. Subsequently, an increasing number of people recognized the importance of think tanks, and scholars both domestically and abroad began researching them, covering government policies,

economics, education, and many other aspects. Think tank research methods have continuously evolved alongside this growing body of research.

2.1 Traditional Statistical Methods

Initially, foreign scholars conducted think tank research primarily based on theoretical research, using qualitative and quantitative analysis methods. Abelson employed quantitative analysis methods to measure the influence of think tanks on society, politics, and economics [19]. Meanwhile, methods such as questionnaires, expert interviews, and visits were gradually applied to think tank research. Rich was the first to apply regression analysis from statistics to think tank research, conducting empirical studies on the role of think tanks in U.S. healthcare reform and government policy formulation [20]. To analyze the state of think tank research domestically and internationally, Zhao Rongying et al. used bibliometric methods to analyze the cumulative volume of think tank research literature and grasp current research trends [21]. From theoretical research to statistical analysis, traditional measurement methods have played an important role in think tank research, laying the foundation for emerging think tank research methods in the big data era.

2.2 Think Tank Research Methods in the Big Data Environment

Only by completing the entire process from Data to Information to Intelligence to Solution can research truly provide scientific decision-making and consulting recommendations that effectively serve decision-making [22].

In the big data environment, data-driven thinking has gradually spread in think tank research, with big data visualization analysis methods being flexibly applied to achieve massive data analysis and intuitive graphic display. For example, constructing network maps of cooperation among countries and regions in international think tank research can intuitively display cooperation patterns, and co-occurrence network graphs of high-frequency keywords can be drawn [5]. Combining visualization with literature analysis enables comparative analysis of domestic and international think tank research, grasping current trends and hotspots [23].

Network maps can intuitively display hotspots and trends in think tank research, providing a basis for decision-making by governments and educational institutions. Current tools for visualizing think tank research include Pajek (cooperation network mapping software), CiteSpace, VOSviewer, etc. The importance of think tank research to politics, economics, and education is gradually increasing, and big data visualization research methods are also more convenient and intuitive, better enabling decision-makers to grasp hotspots and trends in think tank research.

2.3 Big Data Visualization Methods for Think Tank Research

Big data visualization technology is currently an important means for data representation, data processing, and decision analysis in think tank research. Current big data visualization methods for think tank research mainly include: massive unstructured data processing technology for think tanks, big data visualization algorithm technology for think tank research, complex information graphic visualization technology for think tanks, human-computer interaction technology supporting visual analysis for think tank research, and distributed processing technology in visualized think tank research.

Massive unstructured data processing technology is an important foundation for analyzing think tank information and data, primarily focusing on quantitative analysis of massive unstructured data. Current big data analysis platforms can achieve mining and analysis of massive unstructured data collected in real time [24]. Meanwhile, the rapid development of cloud storage technology can improve the storage and retrieval of massive data, enhancing data processing efficiency. Big data visualization algorithms for think tank research are based on improved and optimized classical algorithms, such as classification, decision trees, Naive Bayes, Apriori algorithms, neural networks, genetic algorithms, etc. These primarily involve improvements in computer processing technology and graphic analysis technology based on classical algorithms, promoting big data visualization research in think tanks. For example, currently used machine learning algorithms can predict development trends of uncertain events based on massive data through deep learning, with rich graphic expression and good user interaction performance [25].

The rapid development of internet and information technology has caused information to grow exponentially, and think tank information has also grown rapidly, posing challenges for information collection, storage, and analysis. Professor Pan Jiaofeng, combining his think tank research and practical experience, proposed the DIIS think tank research method. Complex information graphic visualization technology for think tanks presents different visualization results based on different data types, involving data including text data, network data, spatiotemporal data, multidimensional data, etc., with real-time interactive functions [26-27]. Currently, virtual reality technology, visualization simulation technology, and others have been applied in think tank complex information visualization, with more comprehensive content and richer interaction forms, promoting the rapid development of big data visualization in think tank research. In the big data environment, human-computer interaction technology supporting visual analysis for think tanks has gradually become an important method in big data visualization for think tank research [28].

With the rapid increase in information volume processed in think tank research and the need for resource sharing, distributed processing technology in visualized think tank research has gradually been applied. Distributed computing such as cloud computing technology, with its deep learning capabilities, can

perform image recognition, speech recognition, data analysis, etc. [29-30]. It also features rapid resource access and multi-user sharing, with wide distribution, large user base, and strong network system performance, widely applied in current big data visualization for think tank research, helping to concretize and multidimensionalize shared data visualization analysis results.

3. Analysis of Think Tank Application Research from the Perspective of Big Data Visualization

Currently, countries worldwide increasingly emphasize think tank construction, viewing think tank research results as important bases for political and economic decision-making. With the arrival of the big data era and the surge in information volume, how to effectively conduct massive data collection and perform effective, dynamic, and intuitive analysis has become a challenge for think tank research. Big data visualization methods for think tank research are currently relatively emerging approaches. Social network analysis, knowledge mapping, and co-occurrence network analysis are commonly used visualization methods in think tank research, not only strongly promoting think tank research but also facilitating efficient and accurate data collection, processing, analysis, and prediction. Therefore, this article analyzes the application research and innovation of think tanks from the perspective of big data visualization, and uses CiteSpace software to conduct visualization analysis and exploration of some think tank research journal articles from CNKI. The discussion covers seven aspects: rapid and efficient processing of think tank data, scientific and accurate decision-making in think tank research methods, application of complex graphic visualization in think tank reports, simplification of complex problems in think tank research results, user interaction supporting visual analysis in the think tank research process, methodological innovation in think tank data resource aggregation and sharing, and how big data visualization enhances think tank effectiveness and influence.

3.1 Rapid and Efficient Processing of Think Tank Data

Big data visualization methods for think tank research offer faster speed and higher efficiency in the data processing stage compared to traditional methods. The collected think tank data includes traditional structured data and massive unstructured data, which is more comprehensive and specific than traditional statistical data.

The article' s data comes from the CSSCI database in CNKI, with a cutoff date of July 19, 2017, precisely retrieving 795 journal articles with "think tank" in the title from 2000 to 2017. By importing the data into CiteSpace for data conversion and processing, it quickly becomes standard format data for visualization processing. Selecting the "keyword" option, setting the selection criteria parameter to top50, Threshold interpolation to (2, 1, 10; 2, 1, 10; 2, 1, 10), and choosing Pruning sliced networks and Minimum spanning tree methods for keyword field identification and visualization analysis, we rapidly obtained

analysis results. The spatial state of literature data visualization analysis is represented in data form as shown in .

Table 1 The data representation of the spatial state of the literature data visualization analysis

Except for 10 citations in 2001, all other data from 2000 to 2006 are 0, so the table only lists data from 2007 to 2017. Table 1 clearly shows that the number of citations related to think tank research literature has been increasing from 2008 to 2017, with the highest number of citations being 736 in 2016, indicating that domestic think tank research has been gaining momentum since 2007. The 逐年递增 of clustering nodes and intra-year connection numbers also indirectly demonstrates that the number of articles on think tank research in the CSSCI database has gradually increased, reflecting the strengthening research trend. Based on traditional think tank research methods, big data visualization methods can quickly process and analyze large amounts of think tank data and obtain objective and detailed data analysis results in a timely manner, providing certain support for efficient think tank research.

3.3 Application of Complex Graphic Visualization in Think Tank Reports

The application of big data visualization methods in think tank research compensates for the shortcomings of traditional methods in graphic visualization. Using computer technology to effectively process large-scale clusters of information, it displays correlations between data in the form of multidimensional visual graphics. Particularly, the application of complex graphic visualization in think tank research reports enables users to intuitively see relationships between data and the overall network formed by data connections. Currently, virtual reality technology, visualization simulation technology, and others are developing rapidly and gradually appearing in think tank reports, with more comprehensive content and richer interaction forms.

The World Resources Institute (WRI) uses big data visualization technology in its self-built database to help users quickly query visualization graphics such as research field distribution maps, research hotspot maps, and spatiotemporal maps, helping users intuitively and accurately observe regional distribution, hotspots, and trends of research fields when querying relevant reports. CNKI also uses big data visualization methods for literature visualization analysis in its database and related reports, displaying report content through complex graphics to help users understand citation networks, related authors, similar literature, and other visualization graphics, intuitively showing research hotspots, relevant researchers, and extended literature. Currently, scientific knowledge mapping is a commonly used visualization analysis method in domestic and international think tank research reports. Important nodes and relationships between nodes can be displayed intuitively through graphics, helping to grasp think tank research trends. By displaying collected literature information in

the form of co-occurrence networks using CiteSpace , users can intuitively see keywords throughout the entire network system and judge hotspots and trends in think tank research through the displayed node sizes. The visualization result is shown in [Figure 2: see original paper].

Figure 2 The co-occurrence network graph of keywords

In Figure 2, node size represents the frequency of keywords related to think tank research, and connections between nodes represent correlation degrees. The keywords with the highest frequency in think tank research literature since 2000 include "think tank," "university think tank," "Chinese characteristics," "think tank construction," "new-type think tank," "decision consultation," and "research results."Judging from node sizes, these keywords are all current hotspots in think tank research. The output graphics also include relevant specific graphic data, including specific keywords, frequency, centrality, and year, as shown in .

Table 2 The frequency and centrality of keywords

Table 2 shows keywords sorted in descending order of frequency to judge domestic think tank research hotspots in recent years. The keyword "think tank" has a frequency of 200 and centrality of 0.37. Combined with color changes of focal points in the graph, we find that literature containing this keyword has the longest time span. Except for "decision consultation" with centrality of 0.35, the frequency and centrality of other keywords gradually decrease, with shorter time spans. This intuitively demonstrates that domestic think tank research has gradually increased since 2007 and has derived multiple research branch directions. Complex graphic visualization intuitively displays the content, distribution, correlation, and node characteristics of relevant literature keywords. The color changes of annual rings from the focal center to the circumference can be used to judge hotspots and trends in think tank research over the years. Although complex graphic visualization requires support from large amounts of data, its intuitive display of graphic information in think tank research reports helps the public and researchers concretely understand abstract problems and improve research efficiency.

3.2 Scientific and Accurate Decision-Making in Think Tank Research Methods

Big data visualization methods for think tank research are based on scientific research methods. Relying on computer technology and big data visualization algorithms, they achieve efficient and scientific analysis of massive think tank data on the basis of statistical analysis, ensuring scientific and accurate decision-making. Based on keyword co-occurrence network analysis of think tank research literature, we conducted cluster algorithm analysis on the results and displayed the visualization, as shown in [Figure 3: see original paper].

Figure 3 The cluster network graph of keywords

Figure 3 shows that through cluster algorithm analysis, keyword categories are

displayed in different colors in the visualization graph. We can intuitively see that among the retrieved articles related to think tank research, high-frequency keywords can be roughly divided into three categories: think tank, think tank construction and university think tank, and Chinese characteristics and decision consultation. In other words, different colored node areas represent different emphases in think tank research. Therefore, on the basis of judging think tank research hotspots, the visualization results obtained through cluster algorithm analysis can reveal the main branch directions and emphases of think tank research. Scientific calculation methods help think tank researchers conduct scientific analysis quickly, efficiently, and accurately. On January 19, 2015, the Big Data Engineering Technology Research Center of the School of Electronic Information and Electrical Engineering at Shanghai Jiao Tong University was established, with one of its goals being to build a top-level think tank for the big data industry under the big data environment, strengthening think tank construction while promoting the rapid development of the big data industry and enhancing the social influence of think tanks. Researchers at Shanghai Jiao Tong University analyze data from high-dimensional space based on big data analysis algorithms, discovering the most essential information according to the inherent patterns of data and the structure and relationships between data [31]. Therefore, strict setting of data processing procedures and optimization of big data visualization algorithms help scientifically improve think tank research processes, visualize analysis results, display main viewpoints, and improve the scientificity and accuracy of decision-making.

3.4 Simplification of Complex Problems in Think Tank Research Results

Think tank research based on big data visualization can effectively display research results, using graphic forms to intuitively present numerous professional results, greatly simplifying problems and facilitating accurate understanding and macro-analysis by more users, thereby jointly participating in policy formulation and think tank research. Major international think tanks publish annual research reports related to think tank research, and big data visualization methods are used in these reports to visualize research results, simplifying complex problems for public reading. The Royal Institute of International Affairs uses knowledge mapping in its published research reports to intuitively, simply, and efficiently display research results. In recent years, the development and application of big data visualization software have provided convenience for domestic and international think tank research. Large amounts of complex data can be calculated through software to generate graphics that intuitively display calculation results, simplifying analysis processes and improving decision-making efficiency.

Traditional analysis methods can abstract and simplify data but struggle to accurately represent relationships and structures between think tank data, and their descriptions of think tank results are also professional and not easily un-

derstood. Big data visualization methods, however, enable users to efficiently obtain knowledge resources from intuitively displayed graphic information, using multidimensional graphics to display think tank research results, such as hierarchical and network structure visualization, spatiotemporal visualization, and other specific graphic information, helping to simplify complex problems and understand analysis efficiently.

Thus, big data visualization methods for think tank research can present complex problems in think tank research results in a simple and understandable way, making it easier for the public to accept think tank research results, thereby increasing public participation in government policy formulation processes and public judgment and recognition of think tank research results. Taking temporal visualization analysis as an example, it is also commonly used in think tank research to judge research trends in various years. This visualization result is shown in [Figure 4: see original paper].

Figure 4 The visualization analysis of time series of keywords

Figure 4 clearly shows that starting from 2000, hotspots in think tank research gradually shifted from decision consultation and new-type think tanks to think tank construction, and after 2010, gradually transitioned from university think tanks to new-type think tanks with Chinese characteristics. This indicates that under the development of China' s think tank research in recent years, multiple new research branches have emerged with good development momentum. Unlike the cumbersome and complex traditional bibliometric statistics, temporal visualization methods display complex problems intuitively by setting certain time intervals, completely showing the temporal changes of abstract data and even specific details, including focal sizes and correlation relationships, enriching information meaning, simplifying analysis processes, intuitively displaying current development trends of China' s think tank research, making results more acceptable to the public—representing one of the application innovations of big data visualization methods in think tank research.

3.5 User Interaction Supporting Visual Analysis in the Think Tank Research Process

Think tank research trends and hotspots can be displayed through big data visualization, but to make it easier for users to understand and analyze, user interaction functions have been applied to big data visualization in think tank research, allowing certain processing and manipulation of data or graphic results to analyze and understand data. Nowadays, massive unstructured data makes traditional visualization analysis methods have certain limitations in helping users understand data, while user interaction functions supporting visual analysis in think tank research can improve this situation. Scientific knowledge mapping software provides good user interaction functions in visual analysis of think tank research, representing one of the big data visualization methods for think tank research. By conducting visualization analysis of literature authors

in think tank research using CiteSpace software, we generated a co-occurrence network of literature authors and captured the dynamic operation process of the network graph. According to needs, we can change node size in real time to highlight focal points, as shown in [Figure 5: see original paper].

Figure 5 The co-occurrence network graph of literature authors

The literature author co-occurrence network is dynamically displayed through an interactive interface. Figure 5(a) shows the initial operation period of the network graph, where connection lines between nodes are relatively chaotic and focal points are not obvious. Figure 5(b) shows the later operation period, where connection lines between nodes gradually become clear, and through adjustment of text size and node size, the distribution of main authors is displayed, highlighting network focal points. The visualized interactive interface helps improve the flexibility and efficiency of think tank research, and information relationship graphs can transmit data information to users through interactive functions.

At the second New Economy Think Tank Conference held on January 7, 2017, Justine Cassel, Associate Dean of the School of Computer Science at Carnegie Mellon University, believed that the next generation of human-computer interaction interfaces needs to have two attributes: natural interaction through conversation and body language; and adoption of social models rather than task models [32]. Intuitive and natural human-computer interaction will help improve future think tank platforms and technological innovation. RAND Corporation has data from multiple U.S. administrative agencies and industries, and good interaction between information demanders, suppliers, and multiple databases helps enhance the flexibility of subsequent analysis. Big data visualization interaction functions make the analysis process of think tank research more flexible, intuitive, and convenient, while also ensuring the accuracy and acceptability of results.

3.6 Methodological Innovation in Think Tank Data Resource Aggregation and Sharing

The aggregation and sharing of think tank data resources is an inevitable trend for future think tank development. Think tank research typically involves accessing numerous knowledge-based databases, and obtaining and processing large amounts of information from databases presents certain difficulties. Due to relative independence of data between institutions, resource sharing is limited. Moreover, public users cannot intuitively judge the research status of think tank research institutions, connections between institutions, and database resources using traditional query and statistical methods. With the application and popularization of internet and multimedia technology, think tank research institutions have used internet platforms for data collection, analysis, visualization results display, and think tank data resource sharing, achieving mutual exchange between institutions and joint participation in learning and research by the general public.

Currently, many think tanks use distributed processing technology to establish knowledge-based databases, integrate relevant data resources, build open data resource platforms, use big data visualization analysis methods to intuitively display data resource distribution, enable public participation in analysis and judgment, efficiently obtain think tank data resources, and achieve think tank data resource sharing. Many internationally renowned think tanks have established powerful databases to preserve important literature and research reports, while providing network resource sharing platforms to strengthen knowledge learning and sharing. The Royal Institute of International Affairs has established a dedicated digital resources department to support resource sharing based on perfecting its database construction. The Carnegie Endowment for International Peace also provides think tank knowledge resource sharing services for its registered members. The Data Center of Chinese Social Sciences Network of the Chinese Academy of Social Sciences integrates and aggregates academic journals and social survey data in the field of social sciences on an open platform to achieve resource sharing. Meanwhile, the establishment of cloud platforms and the development and application of related supporting systems have greatly improved the storage and utilization efficiency of think tanks, made information communication between databases more convenient, enabled users to access databases easily, reduced information acquisition costs, effectively realized resource sharing, and met user needs.

With the support of big data visualization software, users can conveniently identify think tank research-related institutions, thereby understanding the research status of China' s think tank research institutions and connections between institutions, indirectly judging cooperation and resource sharing between institutions. As shown in [Figure 6: see original paper], within the selected literature scope, research institutions that have conducted more think tank research mainly include University of Chinese Academy of Sciences, Documentation and Information Center of Chinese Academy of Sciences, School of Information Management at Nanjing University, School of Information Management at Wuhan University, Center for Studies of Information Resources at Wuhan University, School of Public Policy and Management at Tsinghua University, and Department of Information Management at Peking University. Different node colors indicate different node categories, and a few nodes have connection lines representing correlation relationships. In the visualization results of think tank research institutions, China has a considerable number of think tank research institutions, but connections between institutions are weak, and there is certain independence between institutions. Therefore, for in-depth research and construction of China' s think tanks, institutions should strengthen cooperation, share resources, and avoid island effects. Users should not only be able to conveniently identify and access mainstream research institutions and databases but also better share think tank data and visualization analysis results based on big data cloud service functions, achieving seamless communication of resources and more efficient and accurate resource sharing.

Figure 6 The co-occurrence network of institutes that published articles in

think tank research

3.7 Big Data Visualization Enhances Think Tank Effectiveness and Influence

Dr. James McGann, Director of the Think Tanks and Civil Societies Program at the University of Pennsylvania, once stated that big data can be used not only to collect massive data but more importantly to conduct professional analysis of massive data. Through data analysis results, social problems such as health and transportation can be discovered, providing decision-making bases for future problem-solving by governments and researchers. Good utilization of big data technology can boost the effectiveness and influence of think tanks.

The application and innovation of big data visualization analysis methods in think tank research enable think tank researchers to fully combine the internet, computer technology, database technology, etc., to conduct in-depth think tank research, use big data visualization analysis methods to analyze problems, and help decision-makers and the public understand problems and obtain knowledge resources, boosting scientific decision-making by governments in solving social problems. In recent years, big data visualization has gradually derived a large number of emerging technologies, which have good promoting effects on future think tank research. However, at the social level, big data visualization analysis technology needs user-friendly interactive systems for the public, not only enabling think tank workers to quickly master big data visualization analysis technology to meet the needs of think tank researchers but also enabling more of the public to understand problems, participate in government decision-making, promote public cognition and learning of think tank research results, achieve think tank data resource sharing, and effectively enhance the social influence of think tanks.

4. Conclusion

This article elaborates on the current research status of think tank research and big data visualization, systematically organizes relevant theories on big data visualization methods for think tank research, and analyzes the application and innovation of think tank research supported by big data visualization analysis. The results show that:

(1) Think tank construction is gradually receiving widespread attention from governments worldwide, with more and more scholars conducting related research on think tanks, making think tank research a hot topic in academia. However, China' s think tank research methods are still relatively simple and have not yet formed a complete research system. In the big data era, the collection, processing, and analysis of massive information have become difficult. Based on traditional visualization methods, big data visualization analysis methods can efficiently process massive data and intuitively display data analysis results in graphics and

space, with certain result acceptability. It is necessary to apply big data visualization methods to think tank research.

(2) Think tank research methods have mainly evolved from traditional measurement analysis methods, but facing massive think tank information, big data visualization methods for think tank research have developed rapidly. Currently, big data visualization methods for think tank research mainly include massive unstructured data processing technology for think tanks, big data visualization algorithm technology for think tank research, complex information graphic visualization technology for think tanks, human-computer interaction technology supporting visual analysis for think tank research, and distributed processing technology in visualized think tank research.

(3) Big data visualization technology is gradually being applied in think tank research, providing strong support for methodological and technological innovation in think tank research. Massive think tank data can be quickly and accurately obtained through computer software platforms and efficiently preprocessed. Scientific data collection, processing, and analysis methods make think tank research methods more scientific and accurate in decision-making. Using multidimensional graphic interfaces to display complex data structures through visualization forms simplifies complex problems. Meanwhile, good interaction technology enables users to manipulate, analyze, and understand data more accurately. Big data cloud sharing technology based on big data can help more users access knowledge-based databases, collect data in real time, and analyze results, effectively achieving resource sharing.

(4) Think tank research methods supported by big data visualization currently have certain applications and represent significant improvements to traditional research methods, providing strong support for the application and innovation of think tank research. This is not only an initial exploration of current think tank research methods but also a future development trend for this research.

References

[1] Xu Xin, Wu Shanyan. Research on the Construction of Think Tank Knowledge Base[J]. Information Studies: Theory & Application, 2014, 3: 68-72.
[2] General Office of the CPC Central Committee, State Council. Opinions on Strengthening the Construction of New-Type Think Tanks with Chinese Characteristics[EB/OL]. [2017-06-10]. http://www.gov.cn/xinwen/2015-01/20/content_2807126.htm.
[3] Mcgann J G. 2015 Global Go To Think Tank Index Report[EB/OL]. [2017-05-18]. http://repository.upenn.edu/cgi/viewcontent.cgi?article=1009&context=think_tanks.
[4] Peter J. Jacques, Riley E. Dunlap, Mark Freeman. The Organization of

Denial: Conservative Think Tanks and Environmental Scepticism[J]. Environmental Politics, 2008, 17(3): 349-385.
[5] Lü Hong. Analysis of International Think Tank Research Trends and Hot Topics[J]. Higher Education Development and Evaluation, 2016, (05): 42-49, 83, 121.
[6] Gershon N D, Eick S G. Information Visualization[J]. IEEE Computer Graphics and Applications, 1997, 17(4): 29-31.
[7] Peck R, Olsen C, Devore J. Introduction to Statistics and Data Analysis (3 edition)[M]. Australia, Belmont, CA, 2008.
[8] Lifschitz V, Harmelen F V, Porter B. Handbook of Knowledge Representation[M]. Elsevier, 2008, 2(4): 374–391.
[9] Frey S, Sadlo F, Ma K L, et al. Supporting Communication and Coordination in Collaborative Sensemaking[J]. IEEE Transactions on Visualization and Computer Graphics. 2014, 20 (12): 1633-1642.
[10] Leung Y K, Apperley M D. A Review and Taxonomy of Distortion-oriented Presentation Techniques[J]. Transactions on Computer-Human Interaction. 1994, 1(2): 126-160.
[11] Drigas A, Koukianakis L, Papagerasimou Y. Towards an ICT-based Psychology: W-psychology[J]. Computers & Human Behavior. 2011, 27: 1416–1423.
[12] Boukhelifa N, Rodgers P J. A Model and Software System for Coordinated and Multiple Views in Exploratory Visualization[J]. Information Visualization, 2003, 2(4): 258–269.
[13] Yu Hongfeng. Large-Scale Scientific Visualization[J]. Communications of the China Computer Federation, 2012, 8(9): 29-36.
[14] Chen Ming. Big Data Visualization Analysis[J]. Computer Education, 2015, (05): 94-97.
[15] Agrawal R, Srikant R. Fast Algorithms for Mining Association Rules in Large Databases[C]. Proceedings of the 20th International Conference on Very Large Data Bases, VLDB' 94, Santiago, Chile, 1994.
[16] Dilla W, Janvrin D J, Raschke R. Interactive Data Visualization: New Directions for Accounting Information Systems Research[J]. Journal of Information Systems American Accounting Association. 2010, 24(2): 1-37.
[17] Roger S. Software Engineering: A Practitioner' s Approach[M]. New York: McGraw Hill. 2010.
[18] Card S K, Mackinlay J D, Shneiderman B. Readings in information visualization: using vision to think[M]. Readings in information visualization: Morgan Kaufmann Publishers, 1999: 1-34.
[19] Abelson D E. American Think-Tank and Their Role in US Foreign Policy[M]. New York: ST. Martin' s Press, 1996.
[20] Rich A. Think Tanks, Public Policy, and the Politics of Expertise[M]. New York: Cambridge University Press, 2004.
[21] Zhao Rongying, Wei Xuqiu. Dynamic Analysis of Domestic and International Think Tank Research Based on Literature Data[J]. Think Tank: Theory & Practice, 2016, (03): 6-14.
[22] Lü Qing. From Think Tank Research Theory to Science and Technology

Think Tank Construction: An Interview with Pan Jiaofeng, Dean of Institutes of Science and Development, Chinese Academy of Sciences[J]. Think Tank: Theory & Practice, 2016, (06): 2-5.
[23] Wu Huijuan, Qin Wen, Han Lincong, Sun Hongfei. Comparative Analysis of Knowledge Mapping of Domestic and International Think Tank Research Trends[J]. Modern Information, 2016, (11): 170-177.
[24] Chen Chen. Research on Library Unstructured Big Data Analysis and Decision System Based on Hadoop[J]. Information Science, 2017, (01): 24-28.
[25] He Qing, Li Ning, Luo Wenjuan, Shi Zhongzhi. Overview of Machine Learning Algorithms under Big Data[J]. Pattern Recognition and Artificial Intelligence, 2014, (04): 327-336.
[26] Viégas F B, Wattenberg M, Feinberg J. Participatory Visualization with Wordle[J]. IEEE Transactions on Visualization & Computer Graphics, 2009, 15(6): 1137-1144.
[27] Zhao J, Chevalier F, Collins C, et al. Facilitating Discourse Analysis with Interactive Visualization[J]. IEEE Transactions on Visualization & Computer Graphics, 2012, 18(12): 2639-48.
[28] Oviatt S, Cohen P, Wu L, et al. Designing the User Interface for Multimodal Speech and Pen-Based Gesture Applications: State-Of-The-Art Systems and Future Research Directions[J]. Human-computer Interaction, 2000, 15 (4): 263-322.
[29] Chan T H, Jia K, Gao S, Liu J, et al. PCANet: A Simple Deep Learning Baseline for Image Classification[J]. IEEE Transactions on Image Processing, 2014, 24 (12): 5017–5032.
[30] Hinton G, Deng L, Yu D, et al. Deep Neural Networks for Acoustic Modeling in Speech Recognition: The Shared Views of Four Research Groups[J]. IEEE Signal Process Magazine. 2012, 29 (6): 82–97.
[31] China News Service. Shanghai Jiao Tong University Builds Top Industry Think Tank to Promote Big Data Industry Development[EB/OL]. [2017-05-19]. http://www.chinanews.com/edu/2015/01-19/6983566.shtml.
[32] CRI Online. Second New Economy Think Tank Conference Held, Human-Computer Interaction and Platform Economy Become Hot Topics[EB/OL]. [2017-06-07]. http://news.cri.cn/20170107/95f2415b-7777-78e8-ff4b-4f9e9435b60e.html.

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