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Bibliometric Analysis and Visualization of Complex Network Research: A Five-Year Study Using Web of Science Data

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Abstract:

In this study, bibliometric techniques were employed, utilizing the Web of Science database to gather literature on the topic of complex networks from the past five years. Through the application of VOSviewer for visualization, the research landscape of the complex network field was systematically reviewed. This included an analysis of author collaboration networks, the temporal distribution of publications, and the identification of research hot spots within the domain. The findings aim to serve as a valuable reference for emerging scholars in this area of study.

Keywords:

Complex network; bibliometrics; visualization.

1. Introduction

The research of complex networks began in the late 1990s, and in June 1998, Watts and other (Watts DJ)[1] presented a small world network model of WS in the Collective dynamics of 'small-world' networks . Then, in October 1999, BarabSi and Albert[2] published Emergence of scaling in random networks in Science, and proposed a BA scale free model. The WS small world model and BA scale-free model have played a pioneering role in the field of complex networks. After that, the research of complex networks has entered a rapid development stage, and a large number of published complex network papers are involved in a number of fields, such as electronic, communication, biological transportation and other research fields[3]. At present, it has become one of the hottest research fields in the academic field. Although the scholars have not reduced the research heat of the complex network field, it is difficult to grasp the research situation in many directions and put into the research quickly. Therefore, in the face of these problems, this paper uses the method of bibliometrics to explore the cooperative network, the distribution of periodicals and the research hot spots in the field of complex network with visual atlas, and break through the traditional method of analysis.

2. Data sources and research methods

The paper uses web of scienceTM core collection as data source to retrieve papers in complex network domain. The article uses topic to search with Search formula: topic = "complex network" or "complex networks", time span:2013-2017 , the search time is 12-Oct-2017, document types select “article” , countries/territories select “PEOPLES R CHINA”. In this paper, a total of 3651 papers were retrieved. The extracted fields include title, author(s) / editor(s), abstract, keywords, source, addresses and so on.

The retrieved bibliographic data is saved in a fixed format to a specific folder and processed by Bibexcel[4]. Bibexcel is designed to help users analyze bibliographic data or any formatted data that is formatted in a similar manner. Because of the possibility of the author's name, and the different forms of the author's name, this paper makes a distinction between the author of the author's work unit by hand and the same author's name in the form of writing. Use Bibexcel to process data into corresponding format, and then import visual analysis software VOSviewer[5]. VOSviewer is a visual

analysis software developed by Dr. Van Eck and Waltman of Leiden University in Holland. It is an open access (OA) application that is used to build and display bibliometric knowledge maps. Compared with other visual analysis tools, VOSviewer pays more attention to graphical display. In the Label view, the importance of the project in the overall co-occurrence network is proportional to the size of the node displayed. Another important feature is mapping capacity for large scale data (more than 10000 records), which uses a special algorithm to determine the display effect of the label, thus avoiding the drawbacks of the overlapping of the labels[5].

This paper uses the method of bibliometrics to analyze the research status of the complex network field. With the help of the external characteristics of the literature, the present situation and future development trend of complex network research are described by using the method of mathematics and statistics. In order to reflect the current situation of research in the field more clearly and objectively, this paper applies the visualization method to draw the map of scientific knowledge.

3. Analysis of the characteristics of literature

3.1 Author collaboration network

After cleaning the original data into Bibexcel, extracting the author's information and carrying out statistics, 8385 authors have been obtained, of which there are only 6217 authors in 1 papers, accounting for about 74.14% of the total, and the author with the largest number of papers is Cao, Jinde. According to Price's law[7], the core author's method of determining the core author's contribution is the following:

$$M = 0.749\sqrt{N_{\max}} \tag{1}$$

Among them, M is the number of papers, and the number of authors who are the most prolific authors in the years of statistics. We stipulate that the number of papers published in M above is the core author.

According to statistics, the author who sends the most volume is Cao, Jinde, the number of posts is 58, so the value is 58, and the core author contribution M is 5.7. According to the principle of rounding, we chose the core author of 6 articles (including 6 articles). Using Bibexcel software to process the author's data and transform it into appropriate VOSviewer software, the following network diagram 1 is formed:

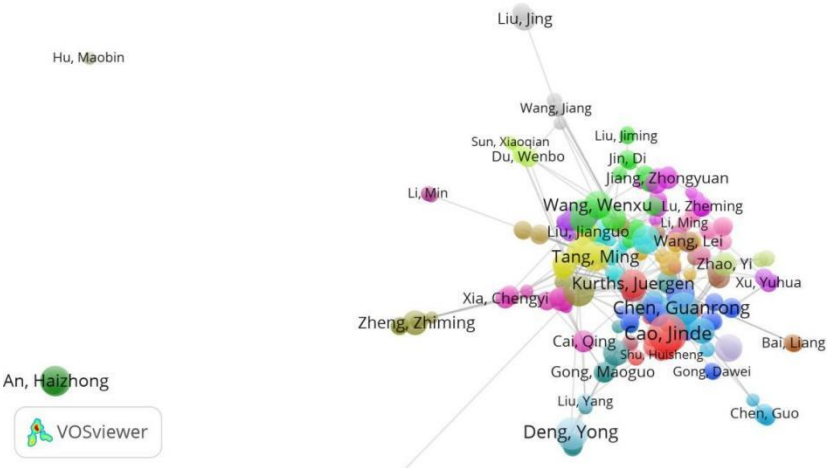

Figure 1. Collaboration network diagram of core author in complex network domain.

As you can see from Figure 1, Cao, Jinde, Deng, Yong, Kurths, Juergen, Wang, Zhen, Small, Michael and Chen, Guanron and so on are much more, for the high-yield author. Secondly, there are few isolated points in the map. Most of the core authors have close relations with each other, and there are more cooperation, which is easy to form an academic group and is conducive to the development of the subject field.

3.2 Analysis of the periodicals of the text

The literature data were imported into Bibexcel, and the literature was extracted and statistically analyzed. 606 journals were obtained. Among them, 330 journals published only 1 papers in their statistical years. This article selects the top 30 journals in the number of published papers. The specific data are shown in Table 1:

Table 1. Publication of the top 30 journals in the field of complex networks

Publication Name	quantity	Publication Name	quantity
PHYSICA A-STATISTICAL MECHANICS AND ITS APPLICATIONS	524	INTERNATIONAL JOURNAL OF MODERN PHYSICS B	41
SCIENTIFIC REPORTS	187	JOURNAL OF THE FRANKLIN INSTITUTE-ENGINEERING AND APPLIED MATHEMATICS	41
PLOS ONE	143	APPLIED MATHEMATICS AND COMPUTATION	41
NEUROCOMPUTING	109	DISCRETE DYNAMICS IN NATURE AND SOCIETY	40
PHYSICAL REVIEW E	107	JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT	35
INTERNATIONAL JOURNAL OF MODERN PHYSICS C	106	PHYSICS LETTERS A	31
ACTA PHYSICA SINICA	92	EUROPEAN PHYSICAL JOURNAL B	31
NONLINEAR DYNAMICS	84	IET CONTROL THEORY AND APPLICATIONS	28
MATHEMATICAL PROBLEMS IN ENGINEERING	82	INFORMATION SCIENCES	27
CHAOS	72	CHINESE PHYSICS LETTERS	27
CHINESE PHYSICS B	71	IEEE TRANSACTIONS ON NEURAL NETWORKS AND LEARNING SYSTEMS	26
EPL	70	ABSTRACT AND APPLIED ANALYSIS	23
CHAOS SOLITONS & FRACTALS	48	IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS I-REGULAR PAPERS	22
COMMUNICATIONS IN NONLINEAR SCIENCE AND NUMERICAL SIMULATION	46	COMPLEXITY	22
MODERN PHYSICS LETTERS B	44	NEW JOURNAL OF PHYSICS	20

It can be seen from table 1 that the amount of PHYSICA A-STATISTICAL MECHANICS AND ITS APPLICATIONS is the largest in the statistical years, and the number of SCIENTIFIC REPORTS, PLOS ONE, NEUROCOMPUTING, PHYSICAL, and PHYSICAL is more than 100. For the scholars who have just entered the complex network field, we can go directly to the journals listed in the table 1 to find the relevant literature reading, so that the new direction of the field research can be better grasped.

3.3 Research hot spot analysis

In order to better display the research hotspots in the field of complex networks in recent years, we import data into Bibexcel and extract key words for statistics and processing. In this paper, we select the keywords that appear more than 15 times (including 15), and use VOSviewer software to draw the network map for visualization, as shown in Figure 2.

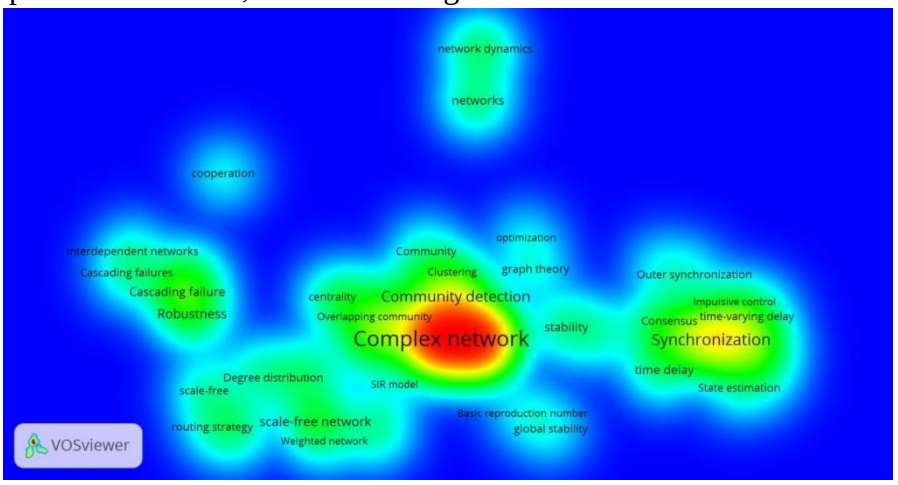

Figure 2. Keyword hot density graph in complex network domain

Figure 2 is a density visualization chart. The difference in color represents the frequency of the key words appearing in the paper. The higher the frequency is, the more popular the key words are, the color of the key words in yellow, green and light blue is decreasing in turn. As you can see from the diagram, the hottest key words are complex network, the next is synchronization, community detection, scale-free network, and Cascading failure. From this we can see that in recent years, the perspective of scholars is more inclined to these directions.

4. Conclusion

This paper examines five years of data from the Web of Science database, focusing on the field of complex networks through a bibliometric lens. Utilizing visualization software, it assesses the current research landscape by analyzing author collaboration networks, journal distributions, and research hot spots. The results reveal a year-by-year increase in complex network research, drawing significant attention from scholars across various disciplines. Analysis of author collaboration networks indicates strong and strengthening cooperative relationships among researchers. The journal "PHYSICA A-STATISTICAL MECHANICS AND ITS APPLICATIONS" has published numerous influential papers in this field, significantly contributing to its development. Synchronization and community detection emerge as prominent research hot spots. While this study provides a valuable reference for researchers in the field, it acknowledges the need for further exploration incorporating additional data sources for a more comprehensive understanding.

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