

Academic Community Network Analysis of Artificial Neural Network

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Abstract. Artificial neural network is one of the hottest research areas in recent years. Inspired by the system of human brains, Artificial neural network is widely used in expert systems, machine learning and other fields. In recent years, the artificial neural networks related literature shows explosive growth. Through social network research on the artificial neural networks can help us to understand and predict trends and changes in the field of neural network. In this paper, a social network of co-writing is built based on for last 15 years SCI articles, which themed "artificial neural network". The information from the full record of these papers is abstracted and the discussion on it is shown in two aspects: time period and impact factor. By the analysis and comparison on the nature of the complex network, it can be found that artificial neural networks draw more and more attention, research cooperation in this field is more common, and in the group of authoritative experts this feature is particularly evident. Meanwhile, it is obvious that social network of artificial neural network is a typical scale-free network.

1. Introduction

Artificial neural network (Ann) is a mathematical model simulating the information transmission principle of nervous system in nature. Analogous to biological terminology, we call each node in the network function of function output a neuron, which is called an excitation function. For artificial neural networks, the output results of the network are determined by the network structure, excitation function and edge weights. Artificial neural network simulates human brain has the self learning, associative storage and efficient search for the optimal solution, and other functions, can realize the approximate any nonlinear relationship now, due to the equilibrium distribution of processing nodes, make it have good fault tolerance, ease of distributed processing. It originated in the last century 40 s, 80 s with attention to breakthrough of biological theory and technology and the rapid development, and development in multiple branch area, including the adaptive resonance theory, Hopfield network model, multi-layer network BP algorithm and the self-organizing feature map theory [1].

For now, the study of the theory of the artificial neural network are mainly concentrated in two aspects, one is from the perspective of cognitive science to study the formation mechanism of the



human brain and thought pattern, from the perspective of mathematical model to build more perfect. Artificial neural network has been widely used in pattern recognition and expert system, robot, and other fields, and in the future we can expect it will play a major role in the economy, such as efficiency, market forecasting, etc.

The social network of scientific research refers to the network formed by experts and scholars in specific fields and connected by scientific research and cooperation. Among them, scientific research cooperation includes co-citation, co-authors, common keywords and cooperative members [2]. Through the analysis of the social network of scientific research, we can understand the social network characteristics and infer the status and role of specific members in this field, and analyze the characteristics of academic relations in this field.

This article through to all 24616 articles in recent 15 years with artificial neural network as the theme of the SCI retrieval paper, from the angles of different times and different influence factors to analyze the whole record, by investigating the scientific research and social network complexity qualitative change to analysis and forecast of artificial neural network in the field of scientific research and development status and trends.

2. Related Work

In recent years, due to the rapid development of information technology, the trend of sharing and cooperation from all walks of life and running mode, thus a variety of social network formed, and the relative research of complex network is promoted by experts and scholars from worldwide outstanding complex network laboratory. For example, the university of California, Los Angeles (UCLA) Complex Network Research, Complex Network Research center (CCNR), etc.; At home, the well-known institutions in this field include Shanghai jiaotong university, Beijing normal university, Chinese academy of sciences and so on. Over the past decade, the number of papers focused on "social networking" has tripled, while other areas of research, including chemistry and physics, have grown in relation to social networks. The following figures show the growth trend of SCI retrieval papers and small world SCI retrieval papers on scale-free networks.

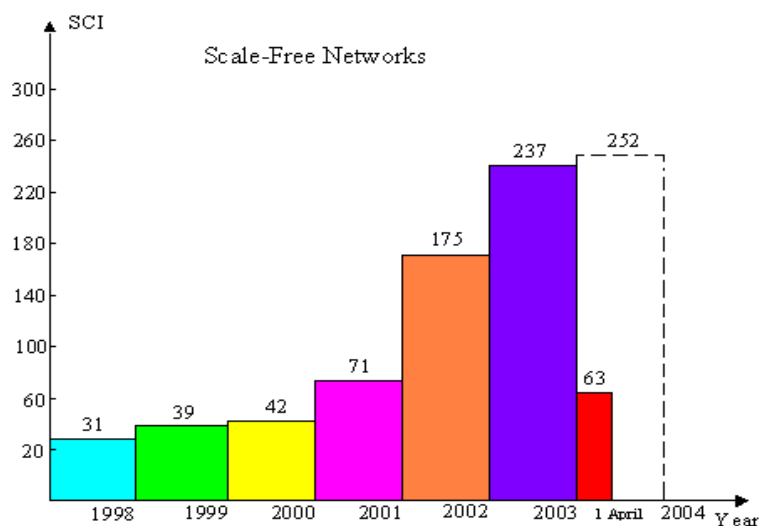


Figure 1: Scale-Free Networks.

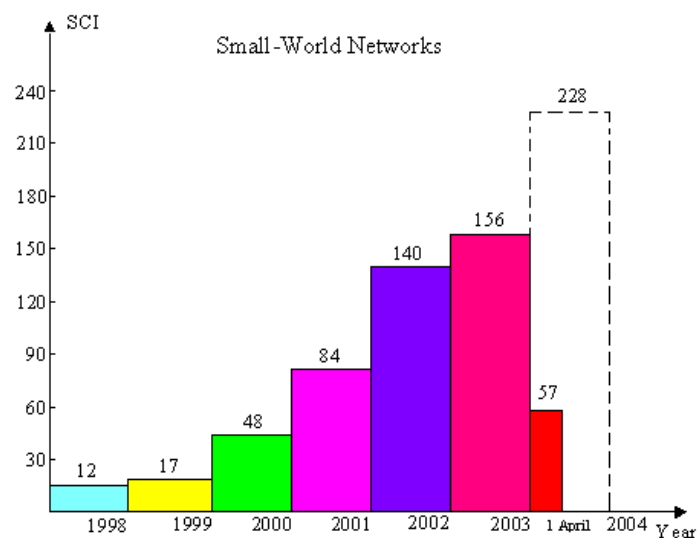


Figure 2: Small-World Networks.

As for the social network of scientific research cooperation, there are also a large number of experts and scholars who have conducted a lot of researches from different perspectives and academic fields. For example, Morris uses the research method of common keywords to extract keywords from the medical information, and divides medicine into several sub-branches. Renchu Guan extracted several independent groups and core members from the academic conference on biological information through the analysis method of cooperative members; Newman to analyze the three large public literature database, extract the database of the network features, found 1999 years, Medline, Spires, and NCSTRL nodes is respectively 1520251, 11994, 56627 nodes, the network diameter 24, 31, 19, respectively, the average path length 416, 31, 4 respectively [3]; Wang fusheng has built a network model that can describe the evolution process of coauthored scientific research network well [4]. Li Kaixuan for six years, published on the intelligence science made a statistical analysis, involving a total of 2400 papers, 2629, the largest of which there are 221 authors a connected network, average path length is 81545, network diameter of 19 [5].

3. Analysis Method Of Complex Network Characteristics

Complex system is one of the most popular topics in the 21st century. It covers a wide range of intersecting areas and is of great use value. The complex system presents an elusive order on the surface of random and irregular representation, which is characterized by self-organization, self-similarity, evolution and self-adaptability [6]. Although the cognition and utilization of complex systems are still in the embryonic stage, we can meet this is a leading course of development.

Complex network is a subject under complex system. In fact, we live in a complex network every day. The power grid, communication network, biological network and social network are all complex networks. The qualitative and quantitative study of complex networks is a challenging task, we hope to be able to look each other in the same network to find its universality, and be able to find a kind of a universal rule. The current results mainly include "small world" network, scale-free network and so on.

Each node in a social network represents a role (actor), each of which represents a linkage or flow between nodes. The relationship between the roles can be varied, such as relatives, acquaintance, business cooperation, evaluation relationship, etc [7]. So we know that our focus is not on individuals and their attributes, but on the framework and relationships of the entire network. The benefit of abstracting a social network into this form is that we can analyze social behavior as a product of a network of relationships. The research on social network is divided into two categories, one is to pay attention to the connection with the node and to obtain the individual's nature; the second is to focus on the whole network to analyze the causes of network behavior. In the latter, the natural attributes of

nodes can be used as variables of social network, such as age, gender, occupation, etc. We can also view the individual's behavior as the product of the interaction of the whole network.

This paper studies the scientific social network. As a specific kind of complex network, through the analysis of the characteristics of the complex network, we can understand the social network structure, which explains the network group behavior, inference, comparison. The academic research in the field of development and change, at the same time can help us understand the complexity of network structure on the complexity of network behavior. As a social network, our analysis of its complex network nature focuses on the structure of the whole network and the role of certain individual nodes in the whole network.

In this article, we build a social network of scientific research based on collaboration. In the field of artificial neural networks, there is a relationship between two or more roles if two or more roles are co-authored. This paper extracts the information we need from the SCI retrieval library and establishes a relational model. When there are multiple collaborations between two people, we calculate them on a single basis.

3.1. Analysis of Complex Network Characteristics

Generally, the analysis of complex network properties can be divided into four levels: network structure, network node, edge and dynamic characteristics.

The research of network structure is mainly the structure of the whole network, including the average degree, network diameter, figure density and so on. Degree is the number of edges connected to a node. The greater the degree of a node, the more important the node is. The degree of distribution $p(k)$ represents the probability distribution of nodes with k degrees in a complex network. According to the degree distribution, complex networks can be divided into several types. In the rule network, the degree of each node is the same, and its distribution law conforms to the delta distribution. The random network is also called the uniform network, and its degree distribution obeys binomial distribution, which means that there is no node far larger than the average degree. In real life, there is a network of American expressways. When the degree distribution obeys the exponential distribution, $P_k = k^{-\lambda}$, the network shows that most of the nodes are very low, and the number of nodes is very high. Such network is called scale-free network, which will be introduced later.

The network node wind is more concerned with the location of individual nodes in the network, such as the average clustering coefficient. The clustering coefficient reflects the aggregation degree of the whole network, mean clustering, $\bar{C} = \sum_k p(k)C(k)$, $p(k)$ is the degree distribution of nodes, $C(k) = \frac{m_m(k)}{k(k-1)/2}$, $m_m(k)$ is the average number of connections between nodes of nodes with degrees k .

For the edges in the network, the main concern is the average path length. The shortest path refers to the shortest path length between two nodes, and the average path length is the average shortest path length between each node in the network. The network with a small average path between nodes is a "small world network".

Here, we particularly want to present two complex networks that are particularly important and common in life: scale-free networks and small world networks. These two concepts come from two seminal articles: Collective dynamic of small-world networks (Watts and Strogatz, Nature, 1998), Emergence of scaling in random networks (Barabasi and Albert, Science, 1999) [8]. The idea of the small world network is to use a subnet composed of high concentration of node, along with randomly generates random connection structure model of the path, to verify that the famous theory of "six degrees of separation". Once on the Internet to open a "six emails to travel around the world" relay, asked volunteers to register the site, and on the website for your own email may implement the task of relatives and friends. The ultimate goal of the email is 18 people across the country. In the end, there were 384 emails, which were completed in 5-7 steps, and the "six-degree isolation theory" was verified.

The idea of the scale-free network comes from the time when people took for granted that a network made up of Internet connections should belong to a random network obeying binomial

distribution. When calculating the number of web pages with k connections, it is found that the number is subject to the power exponential distribution, rather than the poisson distribution previously assumed. This finding is of practical significance. Proven through the Internet as a scale-free network, we can conclude that the status of each webpage or website in the Internet and authority are extremely unequal, and based on this channel message transmission is not equal. In other networks, there are a lot of networks that are scale-free, such as American airlines and language networks. It is not hard to imagine that, for strategic reasons and economic considerations, the air network must be more dense in prosperous developed areas. And the vocabulary we use in our lives is a very small part of the total vocabulary.

3.2. Basic Model of Complex Network

The basic model of complex network is divided into flow model and structure model. [9]

In the flow model, we treat each node and the connection (side) between nodes as pipes, and the data flow flows through the network. In this model, the larger the node, the more information flows through it. At the same time, the larger the node, the more likely it is to be searched. As can be seen from the previous narration, artificial neural network is a typical flow model.

In the structural model, the node is the skeleton, and the social relation is carried on the node.

In this model, a network consists of several roles. We can infer the role of a node with significant characteristics in the network by analyzing the network structure. The social network discussed in this paper is the structural model. Coauthored is the skeleton, and the social network is co-authored by experts and scholars in the field. In such a social network, we hope to predict the cause of network behavior by analyzing the characteristics of network structure, and predict the trend of the network. In other words, we hope to analyze the characteristics, changes and development trends of artificial neural network research society through the topology characteristics of the network. At the same time, the status and influence of experts and scholars represented by this node can be judged by some nodes with obvious characteristics.

4. Data Processing And Analysis

Artificial neural network first appeared in the 1940s, but it has developed rapidly from theory to application in the last decade. In the scientific research social network, the academic ability of brick scholars is evaluated by the number of articles published in different authoritative publications. Therefore, the comparative analysis of the nature of the social network is conducted from different time periods and different influencing factors (IF).

First, download the source data from the SCI retrieval library. The search time range is 2000.1.1-2014.12.31, the search literature topic is artificial neural network. Download the full records of qualified documents to the local format as a text file. Among them, the valuable records of this article are as follows:

- AF: The author's full name
- DT: Type
- DE: Keywords
- C1: The author's addresses
- PY: Publication year
- SN: Serial number

We will select the information needed to construct a complex network from the above items. A fully documented AF term links two or more authors with a co-authored relationship, and all of the full records make up a complex network of scientific research through intricate connections. In this complex network, a node is uniquely identified by the author's full name and address.

4.1. Changes of Complex Network Properties At Different Time Periods

In this paper, the total SCI records in the time period of 2000.1.1-2014.12.31 are divided into three sections for a period of five years. We hope that by comparison, we can see the changes of the research social network of artificial neural network. Fig.3 – Fig.6 is the complex network graph, degree distribution, number distribution and clustering coefficient distribution of the paper that was published in 2000-2004, 2005-2009, 2010-2014. Table 1 compares the nature of these three social networks.

Comparing the three periods of data, we can see clearly that the author of a recent time period is more than double the previous number of number and the latter for the former more than twice as many a time period. This data shows that because of the rapid development of artificial neural network in recent years, there are more and more researchers involved in related research. In the average column we see that as the years go up, the average gets bigger and bigger. The average represents the number of scholars who have worked with each author on average. From this we can deduce that, with the increase of the year, the cooperation in the academic field has become more and more frequent. For network diameter, average path length column in the 2010-2014, 2005-2009, 2009-2005 network diameter of 12,20,12 respectively, 1.47, 5.86, 3.826, we can infer that, in the two periods, the nature of the network not to have the fundamental change, only the former than the latter is much larger network size; In the first two periods, the nature of the network changed fundamentally. It can be inferred that a lot of frequent scientific cooperation is the root cause of this change in nature.

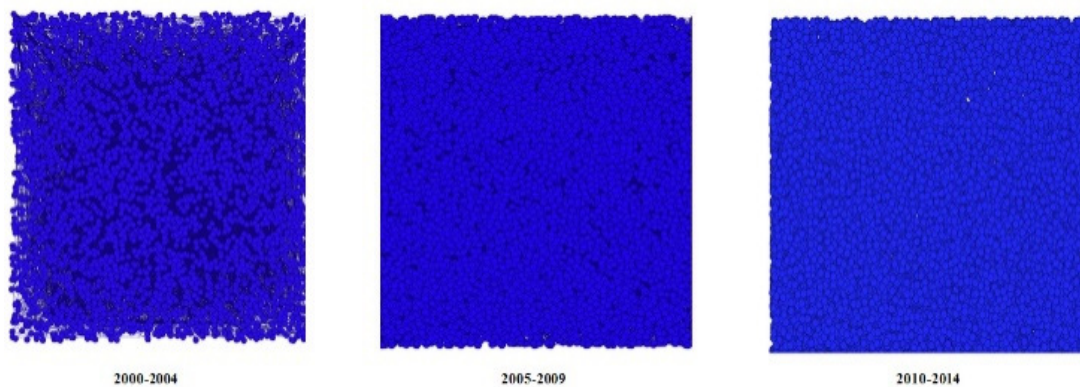


Figure 3: Complex network.

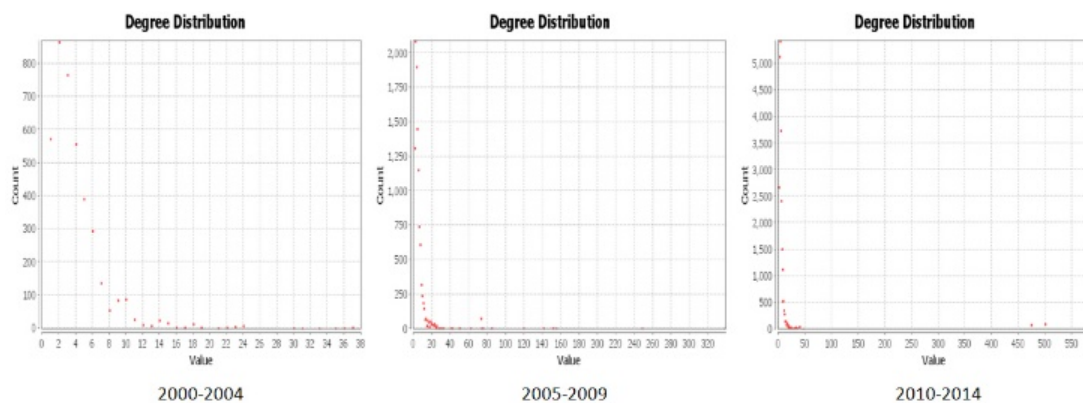


Figure 4: Degree distribution.

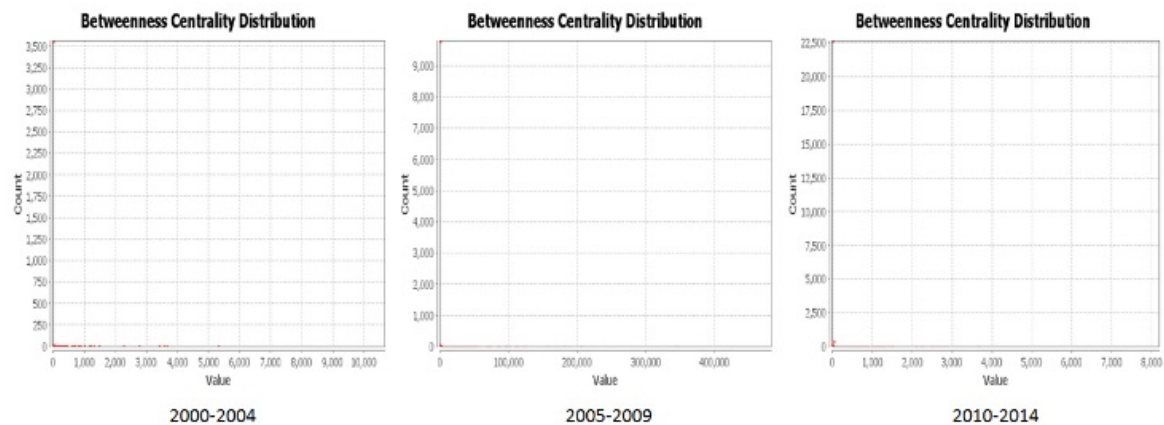


Figure 5: Network betweenness.

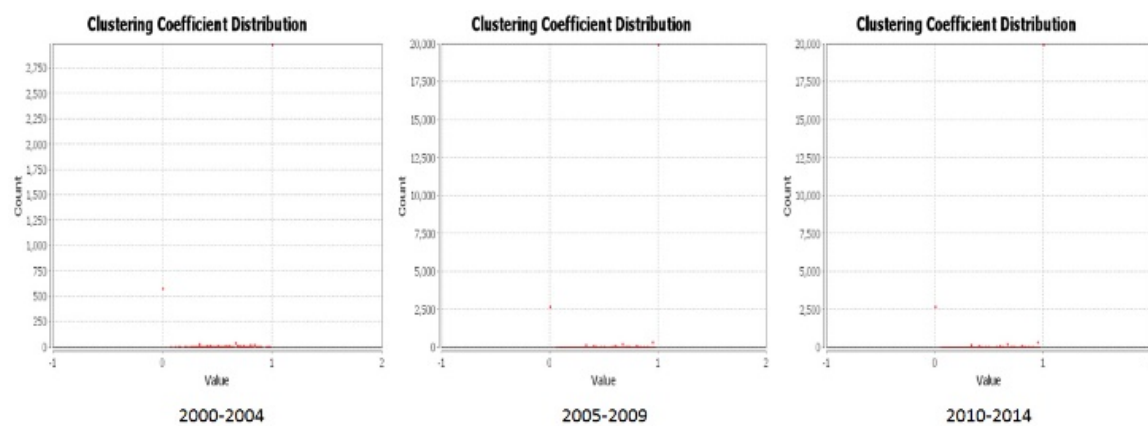


Figure 6: Clustering coefficient distribution.

Table 1: Comparison of complex network properties

Year	Number of nodes	Number of edges	Average degree	Network diameter	Average clustering coefficient	Average path length
2000-2004	3949	7972	3.983	12	0.952	3.268
2005-2009	10813	28505	5.273	20	0.954	5.86
2010-2014	25308	213382	11.071	12	0.955	1.47

It can be seen from the clustering coefficient distribution that there is no significant change in the network concentration of these three periods.

It can be seen from the distribution of three time periods that the distribution rate of its composition obeys exponential distribution. Therefore, during these three periods, all three networks belong to the scale-free network. The most striking feature of scale-free networks is that very few nodes have edges that exceed the average degree. In the social network of scientific research, which can prove that, only a few people have a more than average amount of cooperation with others, and these people is in the

field of academic activists, with a lot of experience of cooperation with others, in the research of social network play the role of mainstay.

4.2. *The Changes of Complex Network Properties Of Different Influencing Factors*

The influence factor (IF) reflects the average value of the number of citations published by a scientific publishing institution, and the higher the value of the factor is, the greater the authority of the publishing body shows. Conversely, the higher the academic prestige, the greater the likelihood that his article will be published in journals with high impact factors. So we naturally take into account that there is no difference between a more authoritative social network and a more general social network. In this paragraph, we study the characteristics of the social network of scientific research with the influence factors of periodicals as variables. Among them, the complex network is divided into two categories: the influencing factor is greater than 3 and less than or equal to 3, and the data adopts the SCI full record of the last three years in 2012-2014. Fig.7 - Fig.10 respectively during 2012 to 2014 published in impact factor is greater than 3 and less than or equal to 3 papers of the scientific research and social network diagram, degree distribution, betweenness and clustering coefficient distribution. Table 2 compares the nature of these two social networks.

Table 2 shows the properties of two types of complex networks that affect factors greater than three and influence factors less than or equal to 3 in the three years of 2012-2014. It is easy to see that although the number of authors in the network with the influence factor greater than 3 is much smaller than the network with a factor of less than 3, the number of edges of the former is far greater than that of the latter. Similarly, the average degree of the former is much larger than the latter, while the network diameter and average path length are less than the latter.

The contrast distribution map shows that the network degree distribution with the influence factor greater than 3 is more uniform than that of the network with the influence factor less than 3.

The larger the influence factor, the greater the authority of the publisher; similarly, the academic level of scholars who publish articles in this publication is correspondingly higher. Through the characteristic data of it, we can be seen that in composed of scholars of high academic level of scientific research and social network of the members of the node degree of close degree, the research collaboration with each other frequently than academic level is not so high scientific research and social networks. We can imagine, with the top researchers in the field of BBS to the authority of the same international conference of risk is very big, and its research cutting-edge projects of research institutes are also very possibility exists, then for two or more high academic level of the possibility of scholars understanding and cooperation.

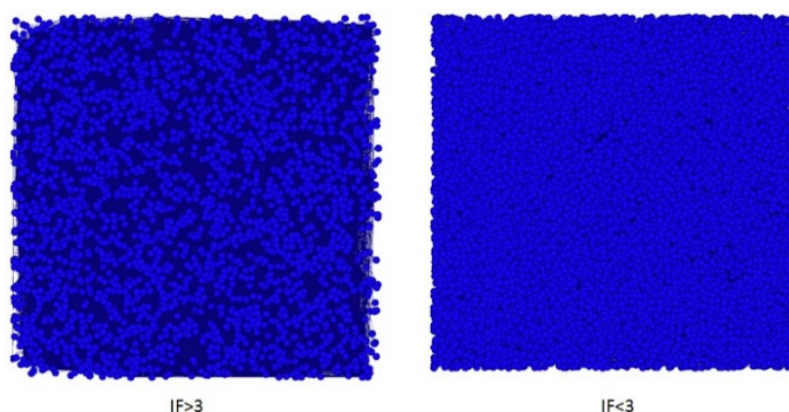


Figure 7: IF social network.

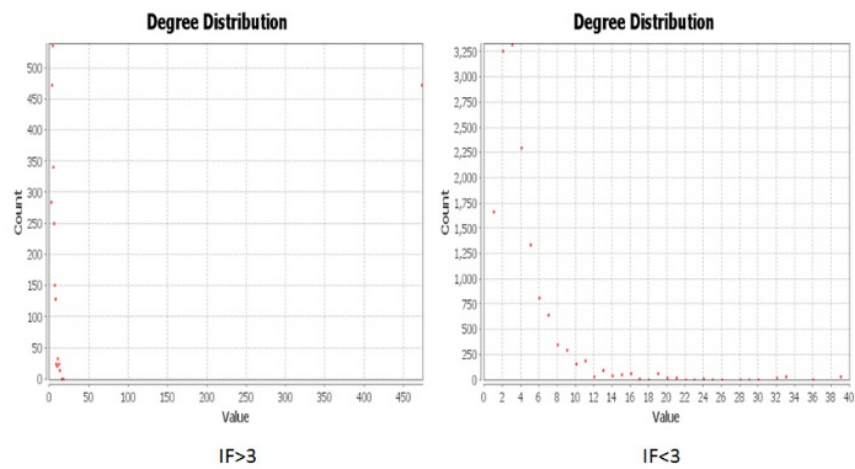


Figure 8: IF degree distribution.

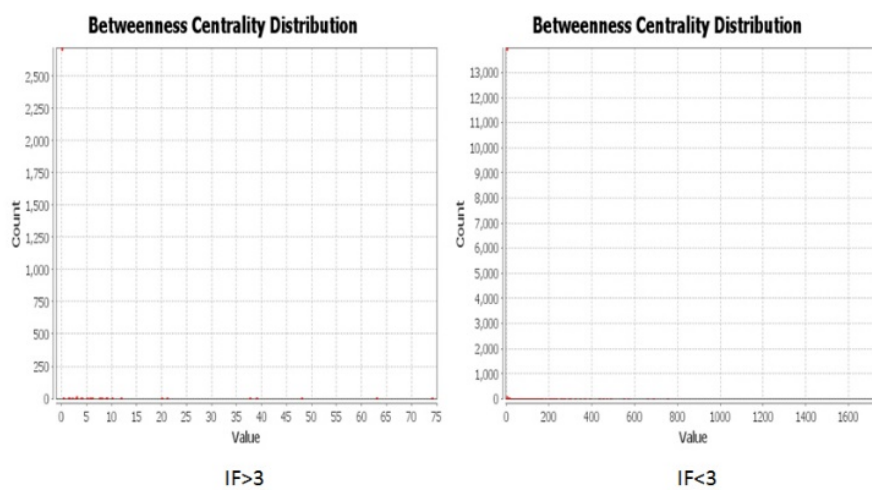


Figure 9: IF number distribution.

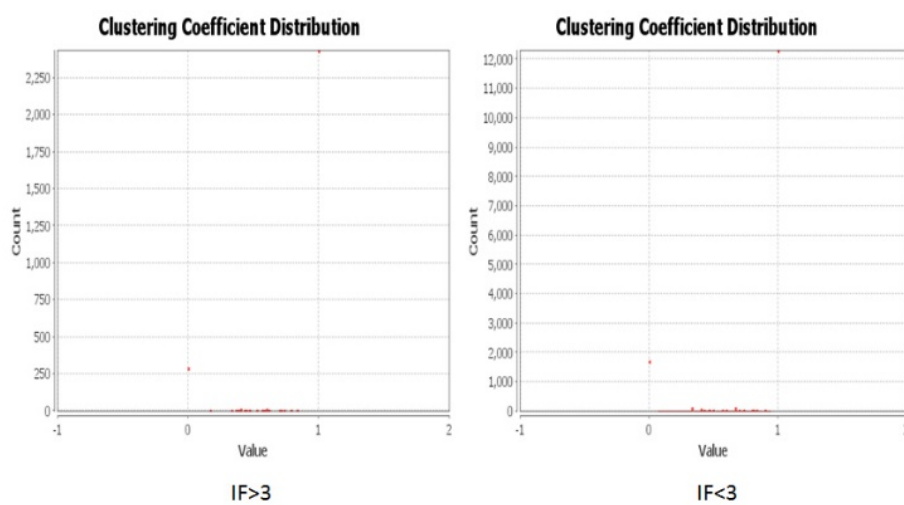


Figure 10: IF clustering coefficient distribution.

Table 2: Comparison of Complex Network Properties of Different Influencing Factors

	Number of nodes	Number of edges	Average degree	Network diameter	Average clustering coefficient	Average path length
IF>3	2770	116375	84.019	3	0.991	1.004
IF≤3	14991	32310	4.279	8	0.965	1.557

5. Conclusions

With the in-depth development of artificial neural network theory, the research on the relation between the field of science and society is improved. The research about the changes of the development process and trend prediction becomes very meaningful. This article uses the method of social network of artificial neural network in the field of literature data excavation and research, and through the analysis of the complex network of the network properties observed in the field of scientific research cooperation relationship between the change and trend of development. The relationship between scientific research and social network is constructed via the co-author of way, based on the literature with the theme of artificial neural network, published in the SCI retrieval database within nearly 15 years. Two aspects, time and influence factors of comparative investigation, are taken account of. This research found that artificial neural network research in the field of heat on the rise, and academic cooperation is more and more frequently used; In the more prestigious groups, the more widely used the coauthored research collaboration. At the same time, we can see that the research of artificial neural network society is a typical scale-free network, which most people have only a handful of scholars of cooperation, and a few people have far higher than the average number of scholars of cooperation. Looking at the growth trend of three periods, we can imagine that in the next few years, the number of papers and the number of scholars in the field of artificial neural network will continue to grow. Co-authored research collaborations will be more widely used.

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