Analysis of the Discipline System Model of Scientific Information Technology Based on Big Data Mining Algorithms

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Abstract:

In order to improve the construction effect of the subject system of the history of science and technology with Chinese characteristics, this paper combines the big data technology to build the subject system of the history of science and technology with Chinese characteristics. This paper proposes a maximum point finding probability algorithm for massive point set data, and proves the reliability of the algorithm. Moreover, this paper introduces matrix distance and objectively weights the comprehensive evaluation results of different years. In addition, this paper conducts simulation experiment research with algorithm, and verifies the effect of the subject system model of the history of science and technology with Chinese characteristics based on big data technology. The research results show that the subject system model of the history of science and technology with Chinese characteristics based on big data technology proposed in this paper can play an important role in the construction of the subject system of the history of science and technology with Chinese characteristics.

Keywords: big data; history of science and technology; discipline; system construction; information science

1 INTRODUCTION

In the past, in order to understand the overall situation of the development of a subject area, the method that researchers usually use is the statistical method, which consumes a considerable amount of manpower to collect almost all the literature in this field, and the workload is very large [1]. Moreover, it is not only labor-intensive, but also human intervention and subjective judgments to screen out some of the research-related content from the huge data collected. With the development of time, the research literature will continue to accumulate, and it will be very difficult to use the literature to study the development of the discipline. Therefore, the use of new methods to explore the development process and future development trend of science history research has received widespread attention from domestic and foreign researchers in the history of science [2]. Academic journals are the main position to promote academic development, and the prosperity of academics is the social responsibility of the existence of academic journals, and it is also its essential meaning. The science and technology history documents are the objective carriers of recording science and technology. In addition, quantitative research is carried out on the literature to reveal the laws of the scientific process [3].

The use of metrology methods to research academic journals, to analyze research institutions, authors, and keyword hotspots in a certain field has positive significance for objective evaluation of the research field. New research tools and methods are also being used by scholars in the research on the history of science and technology, which injects new blood and new ideas into the research on the history of science and technology, and also opens up new directions for the research on the history of science, which is very important for promoting science and technology. The close integration of historical research and sociology makes the history of science and technology more advanced with the times [4]. Literature [5] conducts an in-depth analysis of scientific research achievements in the history of science and technology, uses the research method of knowledge map to visually and intuitively observe and evaluate the development of the discipline, sorts out the context of the development of the history of science and technology discipline and the problems existing in the development, and puts forward suggestions , to study the potential opportunities for the development of the history of science and technology, so that its development can cope with the challenges of reality calmly, and bring opportunities for the construction and development of our history of science and technology. The institutionalization of the discipline of the history of science and technology requires a holistic development vision and macro development strategy, and exerts its own interdisciplinary advantages.

The history of science and technology arises with the development of science and technology. It is a comprehensive discipline with both arts and sciences that runs through ancient and modern China and foreign countries[6]. The study of the history of science and technology can deeply examine science, and the rapid development of science and technology has increasingly become one of the important factors affecting the development of human society. Under the background of this era, the important mission of the subject of the history of science and technology is particularly important. Through the understanding and analysis of the process of the history of science and technology, the knowledge structure of the history of science and technology can be established to adapt to the times [7]. The history of science and technology is a discipline that describes and explains the production, development and systematization process of science and technology, and studies its historical interaction with various social fields such as politics, military, economy, industry, culture, and philosophy [8]. Science and technology countries, such as the United States, the United Kingdom, France, Germany, Russia, Italy, Spain and other countries have specialized research institutions on the history of science and technology, and world-renowned universities, such as Harvard University, Cambridge University, Princeton University, Yale University, etc. The history of technology is a professional discipline, which shows that the history of science and technology has been highly valued in Western countries. The history of science and technology is divided according to the research scope of the discipline, mainly involving four types of science, engineering, agriculture, and medicine [9].

The main fields of research on the history of science and technology, specifically, can be roughly divided into: the history of astronomy, the history of physics, the history of mathematics, the history of medicine, the history of chemistry, the history of biology, and the history of geography. From the perspective of disciplinary theory, "the object of research on the history of science and technology is the development of science and technology, and their interaction with society. Like political history, economic history, and art history, the history of science is essentially historical and scientific in nature. discipline" [10]. The history of mathematics (Mathematical history) belongs to the intersection of mathematics and history. The study of mathematics history should follow the laws of history and mathematics at the same time. the regular pattern. The methods of mathematics history research usually include mathematical analysis, comparative research and other methods [11]. History of astronomy belongs to astronomy, but it is also a part of the history of natural science. Now the history of astronomy has already become a mature subject, and there are various research classification methods such as sub-discipline, region, and chronology. The History of Physics is the occurrence and development of physics in the historical process [12].

In the history of scientific development, physics and neighboring astronomy, chemistry and mineralogy are closely related, and physics and mathematics are more closely related. The concepts, theories and methods of physics also help the establishment and development of other disciplines, such as meteorology, earth science, biology and so on. The relationship between physics and philosophy is also very special [13]. Medical history (Medical history) is an interdisciplinary subject. Medical history education integrating medical disciplines and humanities helps to strengthen the scientific literacy of medical students. In modern society, medical education is particularly important. The relationship between science and culture to reveal the law of medical development [14]. Agricultural History is an interdisciplinary subject that studies the historical evolution and regularity of agricultural production, agricultural economy and rural society. As a discipline, agricultural history research is most closely related to people's livelihood, and agriculture occupies a dominant position in the social economy. The analysis of ancient economy and society must start with the study of agriculture[15]. Chemical History (Chemical History) is the history of chemistry formed in the historical development of -I'7. Ancient chemistry is practical chemistry and the accumulation of various chemical process knowledge. Its production and development are related to the most basic life and production of human beings. Today, as a basic subject, chemistry is playing an increasingly important role in all aspects of science and technology and social life. The history of geography is a science that studies the generation and development of geographical knowledge, the formation, development process and laws of the geographical discipline system. The history of geography is the process of human exploration and study of the geographical environment, in order to explore the law of the emergence and development of geography. According to time, the history of geography can be divided into three stages, namely ancient, modern and modern [16].

By analyzing the different research objects, research perspectives and research methods adopted by the researchers in the history of science, we can distinguish the different research dimensions of the history of science and describe the dimensional space of the research of the history of science. By analyzing the structure of this dimensional space, the author understands the overall development of the research on the history of science, and mainly reflects the main characteristics of the researcher of the history of science. The author also puts forward his own unique views on the development of domestic science history research [17].

This paper combines big data technology to build a subject system of the history of science and technology with Chinese characteristics to promote the summary and retrieval of sustainable research results.

2 INFORMATION RETRIEVAL TECHNOLOGY IN THE HISTORY OF SCIENCE AND TECHNOLOGY

2.1 External storage algorithm for maximum point search

Quite a few algorithms already exist to find maxima in a set. These algorithms have their own advantages and disadvantages when the input data can be loaded into the memory, but only a few algorithms can be transplanted to the massive data point set, and the efficiency of the algorithm is not very ideal. Aiming at this problem, this paper designs a maximum point search algorithm for massive point set data.

It assumes that the number of R-dimensional data point sets is N, and the point set distribution satisfies the independent and identical distribution (L.I.D). Taking two-dimensional data as an example, the distribution area is a rectangular area (for example, x∈[0,1], y∈[0,1], other rectangular areas can be transformed into the corresponding area by appropriate movement of the coordinate system), the expected value of the maximum point number is logN, and the expected value of the maximum point number for multidimensional data is $\frac{\log^{R-1} N}{(R-1)!}$.

We abbreviate the algorithm as EMMFPA. First, a space is set in the memory to store the global maximum point, and the size of the space is enough to store $\left[k[\frac{\log^{R-1} N}{(R-1)!}] \right]$ points (the total number of point is set to N points, k>1). Each time a page that can store G points is loaded, and the size of the page can be calculated according to the size of the memory space.

Theorem 1:

$$\Pr\left(M_N - H_N \geq \varepsilon\right) \leq e^{-\varepsilon^2/(2H_N+\varepsilon)} \quad (1)$$

Among them, M_N is the number of maximum points in the point set of N points, $H_N = \sum_{j\leq N} 1/j$ is the N-order harmonic series, ε>0.

Lemma 1

$$\Pr\left(M_N \geq k\log N\right) < Exp(-\frac{\left((k-1)\log N - \gamma\right)^2}{(k+1)\log N + \gamma}) \quad (2)$$

Among them, y=0.57721... is Euler's constant.

Certificate: $H_i - \log i$ is decreasing, and the lower bound is γ (i is the set of positive integers), so $H_N > \log N + \gamma$. If $\varepsilon = k\log N - H_N$ exists in Theorem 1, then there is:

$$\begin{aligned}\Pr\left(M_N \geq k\log N\right) &\leq Exp\left(-\frac{\left(k\log N - H_N\right)^2}{2H_N + k\log N - H_N}\right)\\ &= Exp\left(-\frac{\left(k\log N - H_N\right)^2}{k\log N + H_N}\right) \\ &< Exp\left(-\frac{\left(\left(k-1\right)\log N - \gamma\right)^2}{\left(k+1\right)\log N + \gamma}\right)\end{aligned} \quad (3)$$

The certificate is complete.

Lemma 2:

$$\Pr\left(M_N \geq k\log N\right) < Exp\left(-\frac{\left(k\log N - \log\left(pG\right) - \gamma\right)^2}{k\log N + \log\left(pG\right) + \gamma}\right) \quad (4)$$

$\Pr\left(M_{pR} \geq k\log N\right)$ is the probability that the number of maximal points appearing in page p exceeds the global preset maximal point set space.

Certificate: From Lemma 2, we know $\Pr\left[M_{pR} \geq k\log\left(pG\right)\right] < Exp\left(-\frac{\left(\left(k_1-1\right)\log\left(pG\right)-\gamma\right)^2}{\left(k_1+1\right)\log\left(pG\right)+\gamma}\right)$, where k_1 is any positive integer. If $k_1 = k\log N / \log\left(pG\right)$, then there is:

$$\begin{aligned}\Pr\left(M_{pG} \geq k_1 \log pG\right) &= \Pr\left(M_{pG} \geq k\log N\right)\\ &< Exp\left(-\frac{\left(\left(\frac{k\log N}{\log\left(pG\right)} - 1\right)\log\left(pG\right) - \gamma\right)^2}{\left(\frac{k\log N}{\log\left(pG\right)} + 1\right)\log\left(pG\right) + \gamma}\right) \\ &= Exp\left(-\frac{\left(k\log N - \log\left(pG\right) - \gamma\right)^2}{k\log N + \log\left(pG\right) + \gamma}\right)\end{aligned} \quad (5)$$

The certificate is complete.

From Lemma 3, we can get:

Theorem 2:Pr(Overflow)<

$$\begin{cases} 1 - \prod_{p=1}^{[N/G]}\left(1 - Exp\left(-\frac{\left(k\log N - \log\left(pG\right) - \gamma\right)^2}{k\log N + \log\left(pG\right) + \gamma}\right)\right) & N\%G=0 \\ 1 - \left(1 - Exp\left(-\frac{\left(k\log N - \log\left(pG\right) - \gamma\right)^2}{k\log N + \log\left(pG\right) + \gamma}\right)\right)\prod_{p=1}^{[N/G]}\left(1 - Exp\left(-\frac{\left(k\log N - \log\left(pG\right) - \gamma\right)^2}{k\log N + \log\left(pG\right) + \gamma}\right)\right) & N\%G \neq 0 \end{cases}$$

(6)

Pr(Overflow) is the probability that the space overflow of the global maximum point set occurs in the program running.

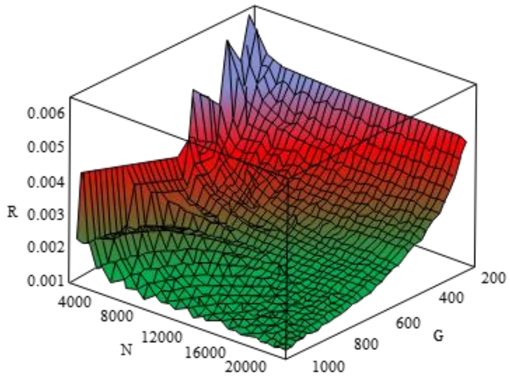


Figure 1 The relationship between the number N of points in the point set, the number G of points per page and Pr (0verflom) determined by Theorem 2

Figure 1 is a graph of the relationship between the number of points in the point set N, the number of points per page R and Pr (Overflow) determined by Theorem 2. Among them, r=0.577, k=3, that is, the global maximum point space is 3logN. Since the probability of overflow is very low when k>3, it is not obvious to the number of observation points N, the number of memory points G loaded into each page and the probability of overflow Pr(Overflow). Therefore, we choose k=3.

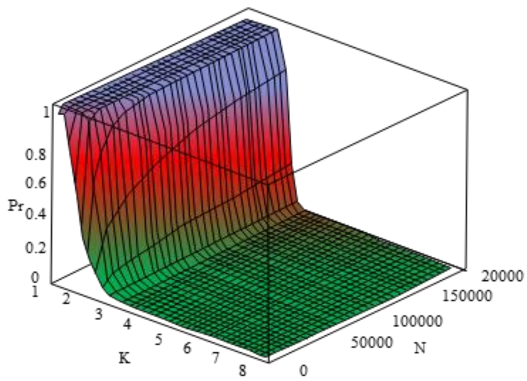


Figure 2 The relationship image of the number of points N, parameter k and Pr (0verf1ow) in the point set determined by Theorem 2

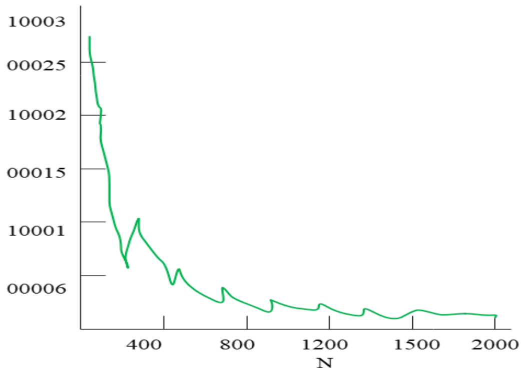


Figure 3 The relationship between the number of points N and Pr (Overflom) in the point set determined by Theorem 2 when k=4

Figure 2 is a graph of the relationship between the number N of points in the point concentration, the parameter k, and Pr (Overflow) determined by Theorem 2. Among them, y=0.577, G=200. Figure 3 is a graph of the relationship between the number of points in the point set N and Pr(Overflow) determined by Theorem 1.4 when k=4, where G=200. As can be seen from Figure 2 and Figure 3, when k ≥ 4, as long as there are a certain number of total points in the point set, the probability of overflow is extremely small. The curve in Figure 3.3 jumps at an integer multiple of R, because when a new page starts to be loaded, the overflow probability reflected in the formula increases. In actual use, k≥4 can be set, which can fully guarantee the normal operation of the algorithm. The algorithm only calls the data once, so its I/O complexity is 0 (N/G), which is an algorithm with linear I/O times.

2.2 Algorithm test and analysis of two-dimensional data

In the simulation experiment to verify the two-dimensional EMMFPA algorithm, the memory is set to 512MB. During the experiment, the coordinate value of each point is a 32-bit double-precision floating-point number on [0,1], which is randomly generated by the system in advance. Moreover, it can be considered that each point and its additional information occupy a space of 1MB. The page size is R==200. We randomly generated 100 sets of data, each set of data is generated page by page, the number of pages is from 1 to 1000, and the final total amount of each set of data is about 200GB. The experimental data is shown in Figure 4.

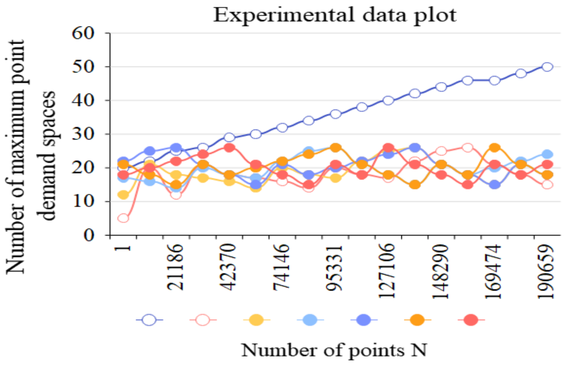


Figure 4 Data graph of the 2D experiment

It can be seen from the figure that there may be obvious fluctuations in a single experiment, but the experiments are far less than the preset global maximum point memory space.

2.3 Certificate of algorithmic reliability for high-dimensional data

Since the number of maxima increases sharply with the increase of dimension, and for IID data, the expected value of the number of maxima is $\frac{\log^{R-1} N}{(R-1)!}$. The EMMFPA algorithm first creates a space in the memory to store the global maximum point, and the size of the space is enough to store $\left\lceil k[\frac{\log^{R-1} N}{(R-1)!}] \right\rceil$ points. When the maximum point found at any time during the running of the program is larger than the global space size we set, our algorithm fails. Therefore, our certificate is mainly an analysis of the maximum number of points. Through the certificate, we can conclude that as long as a suitable value of k is set, the probability of the algorithm failure can be less than a very small number, and the algorithm is also practically feasible. The certificate is as follows:

Theorem 3:

$$\Pr\left(X \geq (1+\delta)\mu\right) \leq \left(\frac{e^{\delta}}{(1+\delta)^{(1+\delta)}}\right)^{\mu} \quad (7)$$

Theorem 3 is a standard Chernoff-type bound. Among them, X is a binomial distributed random variable with expected value μ, δ>0. $X = M_N$ is the maximum number of points in the point set S of N points on the R-dimensional space. Then, the expected value of M_N is $\mu = E(M_N) \approx \frac{\log^{R-1} N}{(R-1)!}$, and when δ=k-1(k>1), we get:

Lemma 4:

$$\Pr\left[M_N \ge kE\left(M_N\right)\right] \le \left(e^{k-1}/k^k\right)^{E(M_N)} \quad (8)$$

Lemma 5:

$$\Pr\left[M_{pG} \ge kE\left(M_N\right)\right] \le \left\{\frac{e^{kE(M_N)/E(M_{pG})-1}}{\left[kE\left(M_N\right)/E\left(M_{pG}\right)\right]^{\left[kE(M_N)/E(M_{pG})\right]}}\right\}^{E(M_{pG})} \quad (9)$$

Certificate: From Lemma 4, we get

$$\Pr\left[M_{pG} \ge k_1 E\left(M_{pG}\right)\right] \le \left(e^{k_1-1}/k_1^{k_1}\right)^{E(M_{pG})} \quad (10)$$

If $k_1 = kE\left(M_N\right)/E\left(M_{pG}\right)$, then there is:

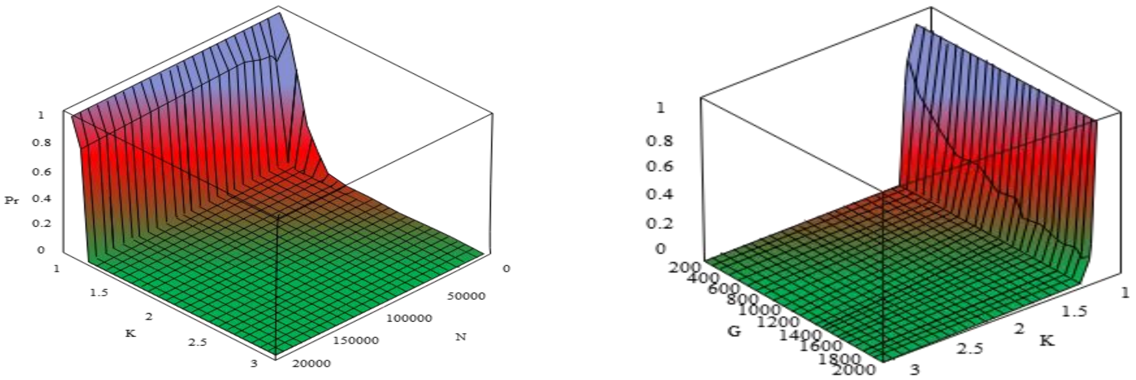
$$\Pr\left[M_{pG} \ge k_1 E\left(M_{pG}\right)\right] = \Pr\left[M_{pG} \ge kE\left(M_N\right)\right] \le \left\{\frac{e^{kE(M_N)/E(M_{pG})-1}}{\left[kE\left(M_N\right)/E\left(M_{pG}\right)\right]^{\left[kE(M_N)/E(M_{pG})\right]}}\right\}^{E(M_{pG})} \quad (11)$$

From Lemma 5, we can get:

Theorem 6: Pr(Overflow)

$$\begin{cases} 1-\prod_{p=1}^{[N/G]}\left\{1-\Pr\left[M_{pG} \ge kE\left(M_N\right)\right]\right\} & N\%G=0 \\ 1-\left\{1-\Pr\left[M_N \ge kE\left(M_N\right)\right]\right\}\prod_{p=1}^{[N/G]}\left\{1-\Pr\left[M_{pG} \ge kE\left(M_N\right)\right]\right\} & N\%G \ne 0 \end{cases} \quad (12)$$

Pr(Overflow) represents the probability of algorithm failure.



(a) Function graph of overflow probability and k,N in Theorem 6

(b) Function graph of overflow probability and k,G in Theorem 6

Figure 5 Function image simulation

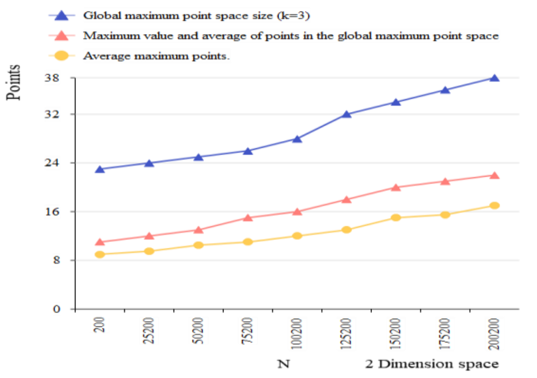
Figure 5(a) is the function graph of overflow probability and k,N in Theorem 6. N represents the number of points in the data set S, the number of call-in points per page of the program is C=200, the dimension R=5, and the value range of k is (1, 3).

Figure 5(b) is the function graph of overflow probability and k, G in Theorem 6. N=20000 represents the number of points in the data set S, the number of call-in points per page of the program G is in the range of [200, 2000], the dimension R=5, and the value of k is in the range of (1, 3).

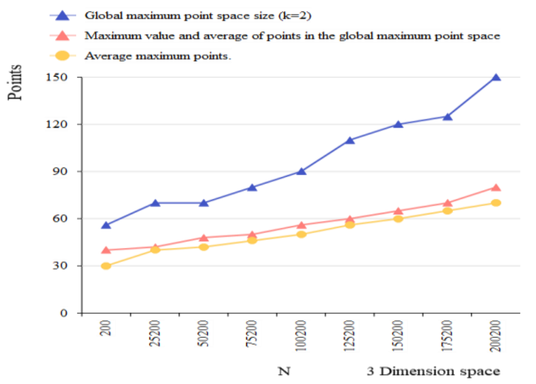
As can be seen from Figure 5(b), when the value of k is small, the overflow probability is very large, and when k takes a suitable value, the overflow probability will be very small. It can be seen from Figure 5(b) that when the value of k is too small, the overflow probability will increase with the decrease of the number of call-in points G per page. However, when k takes an appropriate value, G has little effect on the program overflow probability.

When simulating the high-dimensional EMMFPA algorithm, the value of each dimension data point is a double-precision floating-point number between (0, 1), which is randomly generated by the system. The number of call-in points per page is G-=200, and the global maximum point space is set to be able to store $\left\lceil k[\frac{\log^{R-1} N}{(R-1)!}] \right\rceil$ data points, k∈[2,3]. 100 groups of data are randomly generated, and the number of points in each group of data increases from 200 to 200,200.

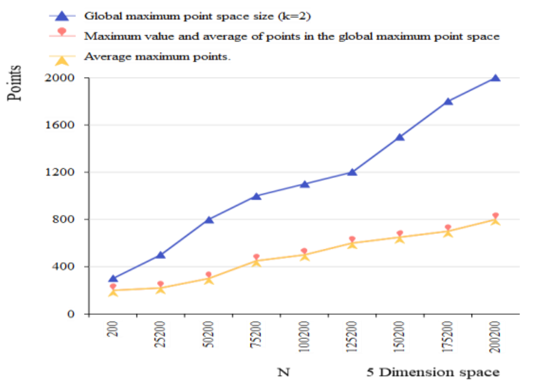
The test results are shown in Figure 6. In order not to lose generality, only 2, 3, 5, and 8-dimensional data are listed here. The experimental results are completely in line with our speculation.



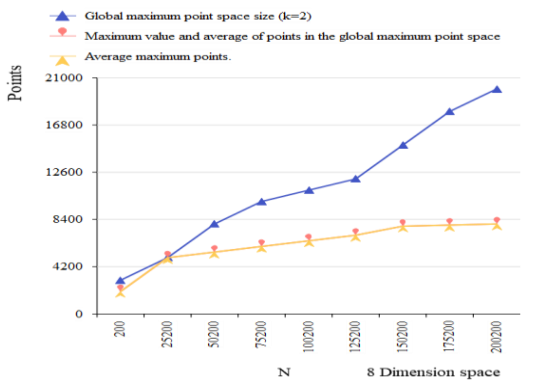
(a) The result diagram of the two-dimensional data space experiment



(b) The result diagram of the 3D data space experiment



(c) The result diagram of the five-dimensional data space experiment



(d) The result diagram of the eight-dimensional data space experiment

Figure 6 Test result diagram

2.4 Application of maximal point search algorithm in database

With the continuous development of database technology and the wide application of database management systems, the amount of data stored in the database has increased dramatically. At this time, how to find out the most interesting information from the massive data and serve people to make effective decisions has become an important research topic. Skyline query problem is a variant of maximal point problem or Pareto optimality, and the research results of Skyline query greatly enrich the research of maximal point problem. Skyline refers to selecting a subset from a given set of objects S in an N-dimensional space. Moreover, none of the points in this subset can be controlled (dominated) by any other point in S, and the point that satisfies this condition is called SP (Skyline Point). The control relationship here refers to multiple objects (object set S) in a given N-dimensional space. If there are such two objects $P=\left(p_1, p_2, \cdots, p_N\right)$ and $Q=\left(q_1, q_2, \cdots, q_N\right)$, the property value of object P in all dimensions is not worse than that of object Q, and the property value of object P is better than that of object Q in at least one dimension, then P controls Q (Figure 7).

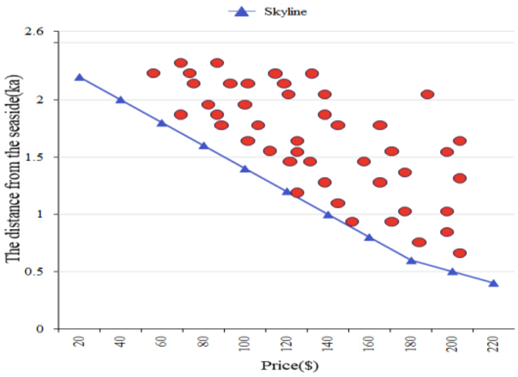


Figure 7 Example of Skyline query questions

A virtual SP point is added. The coordinate value of each dimension of this virtual SP point is $1-(\frac{\ln N}{N})^{\frac{1}{R}}$, this position is found to have a better dominant effect through experiments, and it will be easier to be dominated by other points.

If the last virtual SP point is not dominated, the algorithm fails. But this paper can prove that the probability that the virtual SP point is not dominated is 1/N. The certificate is as follows:

The probability that the virtual point is not dominated is that the area D is empty. The probability that region D is empty is $\left\{1-\left[(\frac{\ln N}{N})^{\frac{1}{R}}\right]^R\right\}^N$. Because $\left\{1-\left[(\frac{\ln N}{N})^{\frac{1}{R}}\right]^R\right\}^N=\left[1+(\frac{-\ln N}{N})\right]^N \le e^{-\ln N}=1/N$, for all X, $\left(1+\frac{X}{N}\right)^N \le e^X$. The certificate is complete.

Of course, it is also possible not to set virtual SP points, but through experiments, it is found that setting virtual points can improve the efficiency of the algorithm and greatly reduce the space of global SP points.

3 SUBJECT SYSTEM OF HISTORY OF SCIENCE AND TECHNOLOGY WITH CHINESE CHARACTERISTICS BASED ON BIG DATA TECHNOLOGY

This paper introduces the matrix distance to objectively weight the comprehensive evaluation results of different years, and reflects the idea that the smaller the deviation of the evaluation index from the ideal state, the greater the weighting of the comprehensive evaluation results.

The principle of scientific and technological evaluation based on matrix distance time series weighting is shown in Figure 8.

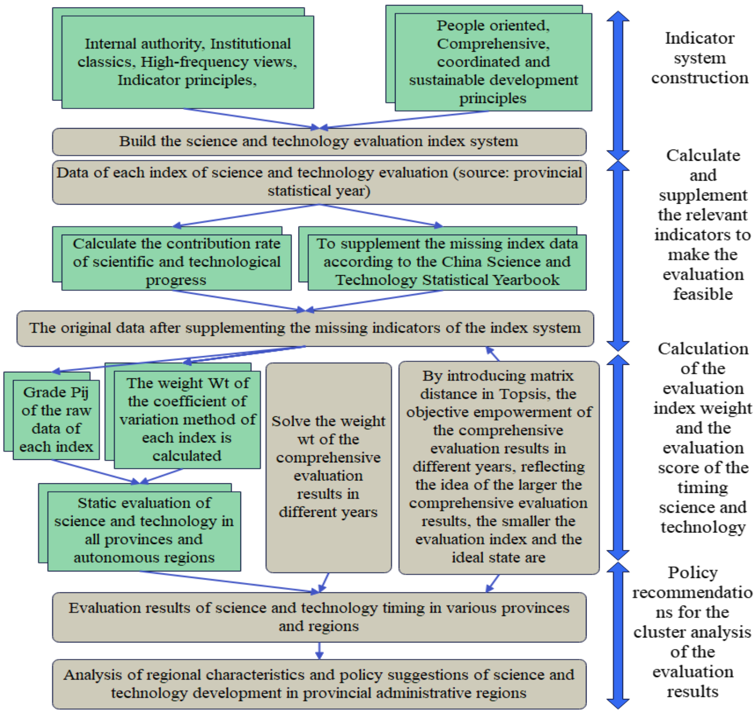


Figure 8 Principles of science and technology evaluation

All countries in the world regard the development of science and technology as an important national strategy, and the input and output of science and technology are two important aspects of scientific and technological activities, and are the most direct reflection of scientific and technological strength. Moreover, the typical views of international authoritative institutions also focus on such indicators. Therefore, there is no doubt that two standard layers of scientific and technological input and scientific and technological output should be constructed.

The scientific development connotation of "comprehensive, coordinated and sustainable development" requires that the development of science and technology be coordinated with economic growth and social progress. It requires that the achievements of scientific and technological development can comprehensively benefit all aspects and levels of social life, so as to ensure the sustainable development of science and technology.

This paper combines the second part of the algorithm and Figure 8 to carry out simulation experiments, and to verify the effect of the subject system model of the history of science and technology with Chinese characteristics based on big data technology. Moreover, this paper counts the effect of this model on scientific and technical knowledge clustering, and obtains the results shown in Figure 9.

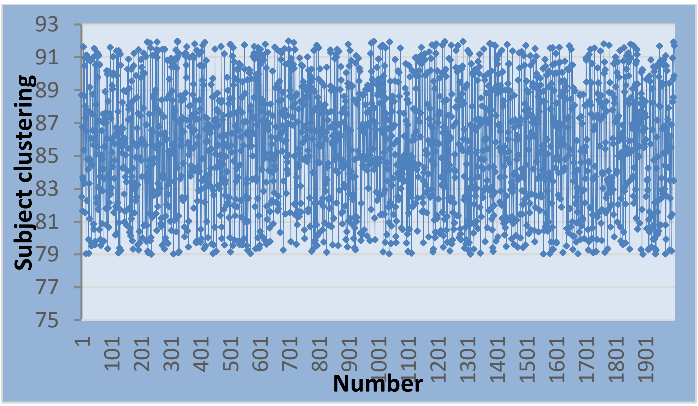


Figure 9 Clustering effect of the subject system model of the history of science and technology with Chinese characteristics based on big data technology

Through the above research, we can see that the subject system model of the history of science and technology with Chinese characteristics based on big data technology proposed in this paper can play an important role in the construction of the subject system of the history of science and technology with Chinese characteristics.

4 CONCLUSION

As the application of science and technology in today's society is more and more extensive, researchers' interest in how to grasp the law of its development continues to increase, and the subject of history of science and technology has received more and more attention in related fields at home and abroad. The future development trend of my country's history of science and technology is to move towards a more comprehensive perspective, which is more and more important in meeting the needs of the country and the needs of society. However, in terms of academic ideas and methods, the innovative awareness of using new methods to explore research fields needs to be strengthened. Moreover, it is necessary to pay attention to the application of visualization technology, and to strengthen the research and innovation of scientific thinking, scientific methods and scientific tools. Combining the new technology research methods with the development of the history of science and technology can reveal the research trend of the history of science and technology more deeply and objectively. This paper combines the big data technology to construct the discipline system of the history of science and technology with Chinese characteristics. The research shows that the subject system model of the history of science and technology with Chinese characteristics based on big data technology proposed in this paper can play an important role in the construction of the subject system of the history of science and technology with Chinese characteristics.

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