

Visualization analysis of research frontier and development trend in the branches of library information and archival science

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Abstract

Based on 12,206 articles during 15 years in 21 international representative journals in the field of library information and archival science, the paper analyzed and processed citations and keywords data by CiteSpace II, and generated hybrid network diagram consisting of co-citation literature network and co-occurrence descriptor network. By knowledge map, we presented mainstream research fields, main academic characters and their important cited literatures in all the branches of library information and archival science, and revealed the evolution process, research hotspots and development trends of all the branches.

Introduction

Library science, information science, archives science have close relations. Internationally, library information and archival science is generally regarded as a first-level subject under the management science category. Many scholars have studied the development of the three branch disciplines. Sha and Niu(2005), using content analysis method, analyzed the themes of 2175 academic papers in 5 information science international core journals 1994-2005, and surveyed subject distribution and structure change of information science papers to explore information science research progress and current academic frontiers. Yang(2007), according to the situation of information science project approval in 2000-2004 at home and abroad, drew the frontier fields of information science research by statistical hypothesis testing. Ye(2008) adopted the method of objective recognition and subjective choice to analyze frontier research fields of library and information science since 1990. Liao(2009) studied foreign information science research frontiers during 1991-2007 based on TDA (Derent analyst), a tool developed by Thomson Corp. Zheng(2010) studied library science research frontiers in 13 library science journals from the perspective of research subject distribution. Anegon et al.(1998) used the methods of clustering analysis, multi-dimensional scale analysis, principal component analysis to display research frontiers of library and information science in Spanish library by knowledge maps. Astrom(2007) selected 21 library and information science journals 1990-2004 to study the change of research frontiers during 15 years by co-citation analysis method. Persson(2010) weighted direct citations with shared references and co-citations in an attempt to decompose a citation network of articles on the subject of library and information science.

The scholars, from different angles, using different methods, studied library and information science research frontiers. Some of them are from the angle of the knowledge map visualization, but most of them are still at the first generation of information visualization level. Based on the theory and method of citation analysis and co-citation analysis constructed by Garfield, Price and Small, et al., in fact, knowledge visualization has been pushed to the second-generation information visualization technology with multivariate, time-sharing, dynamic complex network analysis from the first-generation single, static visualization technology realized by multiple dimension reduction, simplified algorithm. Currently, Drexel University scholar Chen C. has made great contributions to the field of second-generation information visualization technology. He developed scientific literature analysis and knowledge map visualization software-CiteSpace that can show evolution trends and frontier fields of scientific development by analyzing and processing scientific literature bibliography

data(especially citations and keywords)(Chen 2007). Since 1998, Chen has published some academic papers about knowledge visualization in international authoritative journals-《Journal of the American Society for Information Science and Technology》, etc (Chen 2002, 2003). By applying co-citation and co-descriptor analysis in CiteSpace software, he studied discipline frontiers and development trends of "terrorism" research from 1990 to 2003, and also explored the research progress and evolution process of "species extinction" field from 1981 to 2003(Chen 2006).

The related researches, refer to the currently research situation, were based on a branch discipline or regarded library and information science as a whole. To deal with research limitations, we believe it is necessary to discuss comprehensively research fields, main academic characters and their literatures, research frontiers, development trends in all the branch disciplines of library information and archival science including archives science. This study can not only guarantee a systematic study, but also undertake comparative analysis of the branch disciplines to explore the connection and difference among the three disciplines, as is of positive significance for the development of library information and archival science.

Methods

By applying CiteSpace on the base of journals of library information and archival science, we draw knowledge maps of all the branch disciplines of Library Information and Archival science through the co-citation literatures network and co-occurrence descriptors network.

Journal selection and data source

According to Journal Impact Factor of JCR (Journal Citation Reports)and some other factors, we selected 21 Journals that can represent the branch disciplines from 66 professional Journals in the information science and library science subject field of SSCI(Social Science Citation Index)2009. The basic screening principle is as follows:

- ①eliminate journals attached to computer science;
- ②eliminate other professional journals, such as medical information, legal information, government information, etc.;
- ③eliminate multi-discipline, such as interdisciplinary journals of library science and information science, information science and computer science, library science and computer science, etc.

By doing those screening steps above, we got 21 journals representing the branch disciplines of library information and archival science, including information science:7 ; library science:12 ; archives science:2, as are shown in Table 1.

We retrieved and downloaded paper data of the 21 journals in 15 years backwards (1996-2010) from web of science, with the literature type as article. Altogether we got 12,206 bar, including titles, keywords, abstracts, references.

Table 1 main representative journals in library information and archival science

ID	Category	Journal	J. Impact Factor	T. Articles
1	Information science	ANNU REV INFORM SCI	2.929	19
2	Information science	J AM SOC INF SCI TEC	2.3	1371
3	Information science	INFORM MANAGE-AMSTER	2.282	796
4	Information science	SCIENTOMETRICS	2.167	1393
5	Information science	J INF TECHNOL	2.049	291
6	Information science	INFORM PROCESS MANAG	1.783	865
7	Information science	J INF SCI	1.706	614
8	Library science	J DOC	1.405	449

9	Library science	J ACAD LIBR	1	801
10	Library science	PORTAL-LIBR ACAD	0.896	260
11	Library science	LIBR QUART	0.857	219
12	Library science	COLL RES LIBR	0.855	483
13	Library science	ELECTRON LIBR	0.544	639
14	Library science	LIBR RESOUR TECH SER	0.444	254
15	Library science	LIBR COLLECT ACQUIS	0.429	275
16	Library science	INTERLEND DOC SUPPLY	0.403	305
17	Library science	LIBR TRENDS	0.393	613
18	Library science	LIBR J	0.343	1739
19	library science	LIBR HI TECH	0.272	347
20	Archives science	RESTAURATOR	0.4	238
21	Archives science	J SOC ARCH	0.3	235

Research tools and methods

CiteSpace is knowledge visualization software developed by Dr Chen C. It is written by Java based on co-citation analysis. The software can use pathfinder algorithm or minimum spanning tree algorithm to analyze and process the scientific literature co-citation network path. The software also offers burst detection algorithm, which detects words of high frequency variation from a lot of conventional words mainly through investigating the time distribution of frequency, and analyzes discipline research frontiers and development trends according to the change of term frequency, rather than high or low of term frequency. In the citation network map generated by the software, citation rings of different sizes and different colors represent cited times and cited year of citation nodes, and links of different colors indicate co-citation year between different citation nodes. Data contents include titles, keywords, abstracts, references, etc.

Through running CiteSpace, we can draw knowledge visualization maps of major branch disciplines of library information and archival science. Firstly input recorded data of representative journals into CiteSpace software. Then, set “option”, regulate “threshold”, choose “pathfinder algorithm”, select the network nodes as “reference” and “term”. Term item contains “noun phrases” and “burst term” (with the meaning of sudden growth of term frequency). Select the source as “title” and “descriptor”. The noun phrases can express the mainstream research fields of library information and archival science, and burst terms can show the research frontiers and development trends of library information and archival science. Finally, running the software, we can generate hybrid network diagram consisting of co-citation literatures network and co-occurrence descriptors network. The network can show the important cited literatures for the main branch disciplines of library information and archival science, the important research fields would be expressed by noun phrases, and development trends should be expressed by burst terms.

Based on respective 15 years citation data of representative journals for the three branch disciplines of library information and archival science, we draw knowledge maps of the branch disciplines to show their mainstream research fields during the 15 years and research frontiers and development situations into 21 century. Because these knowledge maps are based on citation analysis, they can clearly show key node literatures of forming these mainstream research fields and knowledge foundation of forming research frontiers.

process: Information seeking from the user's perspective". This paper pointed out the traditional information retrieval was carried out from the angle of system, and constructed the thought of information retrieval based on the perspective of user. The article became a classic literature of information retrieval, which was cited for 825 times in Google scholar. Taylor(1968)-"Question-negotiation an information-seeking in libraries" is also a key node literature which been cited for 665 times. The paper is a study of two types of the process of question- negotiation in libraries and information centers. Through taped interviews with special librarians and information specialists, five levels of information were isolated. There are consciously sought and received by the librarian in the negotiation process: (1) subject definition; (2) objective and motivation; (3) personal characteristics of the inquirer; (4) relationship of inquiry description to file organization; (5) anticipated or acceptable answers. The second type of negotiation, self-help, is the inquirer solely negotiates with the total information system.

Table2 key node literatures of library science research

Centricity	Author	Year	Source
0.07	BELKIN NJ	1982	J DOC
0.06	BERTOT JC	2001	STAT PERFORMANCE MEA
0.06	KUHLTHAU CC	1991	J AM SOC INFORM SCI
0.05	BROWN CM	1999	J AM SOC INFORM SCI
0.04	TENOPIR C	2000	ELECT J REALITIES SC
0.04	ELLIS D	1989	J DOC
0.04	TAYLOR RS	1968	COLL RES LIBR

Library science research frontier and development trend



Fig.2 library science research frontier and development trend

Setting term item as “burst term”, running the software, we get the knowledge visualization map of library science research frontiers(Fig.2).

From the map we can see keywords of rapid growth of frequency and their chronological distributions. Early burst terms were document delivery ; analysis-ii ; service quality ; digital libraries ; special collections. It means that these research topics were once paid attention and got great breakthrough.

“health information ; web-2 ; institutional repositories ; information behavior ; world war, etc” have suddenly appeared recent years, which meant that “health information ; web-

2 ; institutional repositories ; information behavior ; world war” are recent research frontiers, and are likely to become the future development trends of library science research. World war was researched the most in the journal of «library trends» . The research topic of world war is about the change of the library service, policy, and culture during the two world wars and after the world wars. Observing the gradient process of these research frontier terms, we found that the future research of library science would be more thorough, and start to pay attention to intensive fields such as health information, world war, information behavior, etc. Moreover, under the internationalization and network environment of social development, web2.0 services and institutional repositories were also pushed the research frontier fields of library science research.

Information science visualized analysis

7 information science journals listed in Table1 represent higher academic level of information science, among which JASIST- «Journal of the American Society for Information Science and Technology» is an authoritative periodical sponsored by the American Scientific and Technological Information Research Institute. The 7 journals except «Information Processing&Management» are not only indexed by SSCI, but also indexed by SCI. Importing total 5349 bar data of the 7 journals into CiteSpace software, we can get library science visualization maps.

Information science mainstream research field

Setting term item as “noun phrase”, running the software, we get knowledge visualization map of information science mainstream research fields(Fig.3).

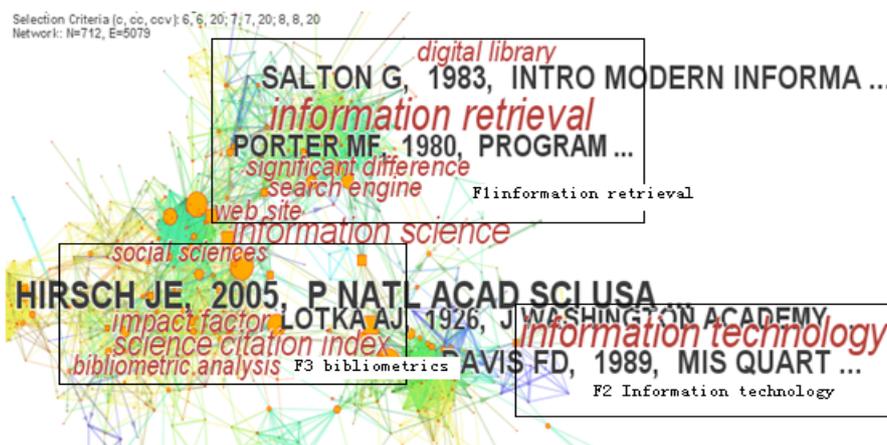


Fig.3 information science mainstream research field

According to the knowledge map, information science locates at central positions. The information science research can be divided into three mainstream research fields:

(1) F1 Information retrieval。 Representative high-frequency terms : Information retrieval; search engine; significant difference; web site; digital library. some representative figures and academic literatures of higher influence in the field: Salton(1983);Porter(1980).

(2) F2 Information technology。 some representative figures and academic literatures of higher influence in the field: Davis(1989).

(3) F3 Bibliometrics。 Representative high-frequency terms : science citation index; impact factor; bibliometric analysis; social sciences. some representative figures and

academic literatures of higher influence in the field: Hirsch(2005) ; Lotka(1926). Figure 3 shows the article of Hirsch(2005) about H index was cited for the most.

Table 3 lists some key literatures of information science. the book- «multimedia data analysis» that written by Hair et al.(1998) is the most important node literature,. It can be rated as the number one, which was cited as high as 19,757 times during just 12 years in Google scholar. Small(1999)-“Visualizing science by citation mapping” is also a key node literature which have been cited 248, 155 times in Google scholar and SCIE respectively. The paper attempts to construct maps of science using citation data are reviewed, focusing on the use of co-citation clusters. Newwork is reported on a dataset of about 36,000 documents using simplified methods for ordination, and nesting maps hierarchically. “The frequency distribution of scientific productivity” published by Lotka(1926) in 1926 examined the frequency distribution of scientific productivity of chemists and physicists. After analyzing the number of publications of chemists listed in Chemical Abstracts 1907–1916 and the contributions of physicists listed in Auerbach's Geschi-chtstafelnder Physik, he observed that the number of persons making n contributions is about 1/n² of those making one and the proportion of all contributors that make a single contribution is about 60%. By being cited for 1089 times, the paper of Lotka became a foundational literature in the field of bibliometrics.

Table3 key node literatures of library science research

Centricity	Author	Year	Source
0.17	HAIR JF	1998	MULTIVARIATE DATA AN
0.16	SMALL H	1999	J AM SOC INFORM SCI
0.14	LAWRENCE S	1999	NATURE
0.13	LOTKA AJ	1926	J WASHINGTON ACADEMY
0.09	BRIN S	1998	COMPUT NETWORKS ISDN
0.08	HARTER SP	1992	J AM SOC INFORM SCI
0.08	SPINK A	1998	INFORM PROCESS MANAG

Information science research frontier and development trend

Setting term item as “burst term”, running the software, we get the knowledge visualization map of information science research frontiers(Fig.4).



Fig.4 information sciece research frontier and development trend

Each triangle in the figure represents a term sprang up suddenly. Gradient process of Color means the gradual change of burst terms by time. The font size of triangle labels means mutation degree of burst terms. The map shows, in the mid 1990s, “information systems” and “information system” became burst terms with the highest mutation degree, as means that the

research for information system constituted the most important research content of information science. Similar burst terms were “expert systems”, “system success”. All of these accounts for the research for management information system were contemporary research frontier filed. It was consistent with technology tradition of information science and it was also that information science research was oriented towards the background of the large-use of management information system for the enterprise. “Citation analysis, image retrieval, use satisfaction” were also the important aspects of contemporary information science research. When it came to the late 1990s, “electronic commerce, neural networks” sprang up suddenly, as meant electronic commerce and neural networks entered suddenly into the research vision of information science scholars. It had a great relationship with the rise of the enterprise electronic commerce. Stepping into the 21st century, “knowledge management” began to emerge, and became the research frontier of information science. On one hand, it explained that enterprise knowledge management had rose; On the other hand, it also explained that information science research had upgraded management for information to management for knowledge, and the change happened around the year 2000. Professor Yan Y. argued that knowledge was that human beings through information understand and master the nature, the human society, the thinking ways and the motion laws, and systematic information collection through recombination of people's brains (Lou 2005).

In the early 21st century, the society was under the impact of the network. It was just during the first few years of the early 21st century that Internet entered numerous families, and “web sites” became the research frontiers of information science in 2003.

Recently, “retrieval systems, information retrieval systems, open access, social capital, journal impact factor” have grown at a high speed. It means that the research for management information system in information science has stepped into the stage of information retrieval system. Open access, social capital in knowledge management and journal impact factor will probably become research hotspots of information science research in the future. “mpeg-7” is the burst term in 2010. Called Multimedia Content Description Interface, mpeg-7 which is an new group of mpeg(Moving Pictures Experts Group), is put forward to solve the conflict between increasing images, sounds information management and quick search in October, 1998, and will be completed and published in 2010(<http://ce.sysu.edu.cn/hope/Education/ShowArticle.asp>). Mpeg-7 will also very probably become a research hotspot of information science research in the coming several years.

Analyzing recent burst terms, we find that the several terms are highly consistent with the 3 mainstream research fields put forward before, which can essentially represent the development trends of the 3 mainstream research fields.

(1) “Retrieval systems, information retrieval systems, open access” may become the future development trends of F1——information retrieval. Open Access means that the users, through public Internet, can freely read, download, copy, circulate, print and retrieval full-text papers, or create papers’ full-text link, index papers, incorporate papers as material into software, or use papers with any legitimate purpose, and without any limitation of economic and legal and technical aspects, unless the network itself causes the obstacles of data acquisition (Bernius 2010).

(2) “Mpeg-7” may represent the future development of F2——information technology. Actually, mpeg-7 can also be delimited research category of F1——information retrieval. Because mpeg-7 is a standard built to deal with information retrieval difficulties based on audio-visual content in the mass information along with the arrival of the era of information explosion. And “retrieval systems, information retrieval systems” can also be delimited research category of F2——information technology. We believe there are overlapping parts between the two fields

(3) Journal impact factor can represent the future development of F3——bibliometrics. Along with the popular of quantitative research and evaluation work, measuring indicators and evaluation indicators, such as journal impact factor, characteristic impact factor, H index, etc. will receive extensive attentions from information science research in the future, and will probably become research hotspots of information science research in the coming several years.

Archives Science visualized analysis

Importing total 473 bar data of the 2 journals in archives science in table 1 into CiteSpace software, we can get archives science visualization maps

Archives Science mainstream research field

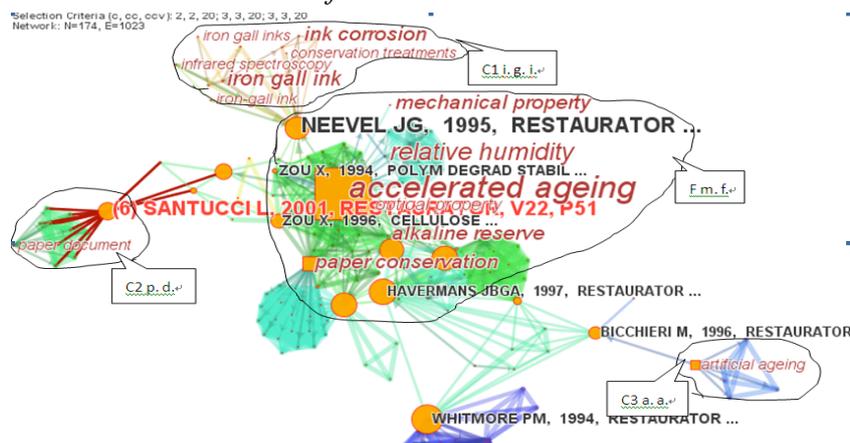


Fig.5 archives Science mainstream research field

The archives science research can be delimited 1 mainstream field(F) and 3 nonmainstream field(CI ; C2 ; C3). Articles connecting two clustering paths are called key points. CiteSpace II can detect the key literature in the mainstream research fields and the key literature triggering non-mainstream research enthusiasm (Chen 2004).

(1) F is the core research field in archives science research. “accelerated ageing; alkaline reserve; paper conservation; conservation treatment; mechanical property; relative humidity” involving documents and archives protection constitute the mainstream field of archives science research. The map show that the two most important scholars are Neevel(1995) and Zou(1994, 1996). Neevel(1995)-“Phytate: a potential conservation agent for the treatment of ink corrosion caused by iron gall inks”, ZOU X(1994,1996)-“Prediction of paper permanence by accelerated aging I. Kinetic analysis of the aging process” and “Accelerated aging of papers of pure cellulose: mechanism of cellulose degradation and paper embrittlement” are 3 key node literatures; which were cited respectively for 64; 63; 42.

(2) C1 is the study of “iron gall ink”. Iron gall ink is a kind of excellent writing materials water-resistant, dark lubricious and non-fading color, (<http://baike.baidu.com/view/1935453>). The key literature triggering the research field is Neevel (1995)-“Phytate: a potential conservation agent for the treatment of ink corrosion caused by iron gall inks” describing the ideal performance of iron gall ink for boycotting ink recession and aging. C2 is the study of “paper document”. The key literature triggering the research field is santucci(2010)-“Cellulose viscometric oxidometry”, in which the author suggested that the depolymerization of oxidized cellulose (e.g. paper) caused by alkalinity can be exploited to evaluate its degree of oxidation: a rough estimate can be obtained with just one sample measured before and after heating in the alkaline solvent for viscosity itself; a more accurate evaluation requires reduction of the sample prior to the viscometric measurement. C3 is the study of article

ageing. The key literature triggering the research field is Bicchieri(1996)-“The Degradation of Cellulose with Ferric and Cupric Ions in a Low-acid Medium”. There are two aims of the paper: first one is to quantify the degradative effects that induced by iron and copper ions in a low-acid medium and to verify whether experimental data are in agreement with one of the mechanisms proposed in the literature; the second one is to determine whether the use of a reducing material can obstacle the oxidation catalyzed by metals.

Archives science research frontier and development trend

Setting term item as “burst term”, running the software, we get the knowledge visualization map of information science research frontiers(Fig.6).



Fig.6 archives science research frontier and development trend

The literatures that purple circles represent are important knowledge foundations for archival science development. At the turn of the century, “relative humidity; surface oxidation; alkaline reserve” grew rapidly with the meaning of increasing research and having a breakthrough in these research areas. In recent years, increasing growth of “calcium phytate ; calcium hydrogen carbonate ; phytate treatment” explains the study of phytate has become the latest research frontiers of archives science research. Phytate is a kind of organic compounds extracted from plants. It has strong antioxidation and anticorrosion function that has been widely used in food, medicine, paint coating, daily chemical, metal processing, textile industry, plastic industry and high polymer industry, etc(<http://baike.baidu.com/view/140757>). We believe that phytate is likely to be used for protection of documents, and can become a new research hotspot. The evolution of “record keeping” to “records management” also explains archives science research has evolved into management of archival records from preservation of archival records, as can be accounted for the coming of “Information Explosion” etc. “Iron gall ink” is burst term in latest 2 years with the highest mutation degree in the map, as means that the research of iron gall ink in archives science has got a great breakthrough recently. Combining archives science mainstream research field showed in figure 5, we can know that the study of iron gall ink is just at the edge of archives science research, but according to the mutation degree of “iron gall ink” in the map, and the age of mutation, the author analyzes the study of iron gall ink is likely to enter into the core mainstream field of the archives science research.

Conclusion

Based on international representative journals in the field of library information and archival science, the paper the presented main academic characters and their important cited literatures, mainstream research fields and frontier development trends in all the ranches of

library information and archival science by knowledge map, and analyzed deeply knowledge foundations that the development of the branch disciplines relied upon.

(1) Library science has four mainstream research fields: digital library; library service; special library; information retrieval. The future of library science research will lead to thorough, intensive fields, such as health information, information behavior, impact of world war on library. Web 2.0 service and institutional repository, which are performed based on network environments represent research trends of library science in the coming few years.

(2) Information science can be delimited 3 mainstream research fields: bibliometrics; Information technology; Information retrieval. Information retrieval system and open access will be the future direction of Information retrieval. Multimedia technology with mpeg-7 as a representative represents the future direction of information technology. The future direction of bibliometrics may be more focused on measuring indicators and evaluation indicators, such as journal impact factor, H index, characteristic impact factor.

(3) Archives science can be delimited 1 mainstream and 3 nonmainstream research fields. Phytate and iron gall ink, such compounds which bound up with paper protection may enter into the mainstream research field of archives science, and represent the future trends of archives science research.

From transversal comparison of all the branch disciplines, a sharing mainstream research field of library science and information science is information retrieval. Therefore, information retrieval is of great significance not only for library science development but also for information science development.

In addition, we found that the evolution process of information science was bound up with enterprise activities. Management information system, e-commerce, knowledge management, web site that caused great changes for enterprise ever became the research frontiers of information science. The relationship between enterprise and information science may still exist in the future. According to the research frontier terms of library and information science, the future trends of library and information science would certainly not depart from network environment, and would proceed around network.

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