Thematic Maps of 19 iSchools

Chaomei Chen
College of Information Science and Technology, Drexel University
3141 Chestnut Street, Philadelphia PA 19104-2875, USA
email: chaomei.chen@cis.drexel.edu

Abstract

The identity of iSchools has drawn widespread attention in the iSchool movement. What is special about an iSchool? What do people do in an interdisciplinary iSchool? How does one iSchool differ from another? How do iSchools fit together as a community? There are many ways to address these questions at different levels. For example, one may choose to interview all the iSchool deans, all the iSchool faculty members, and/or all the iSchool graduates; and one may choose to study the mission statement and strategic plan of each individual iSchool. In this paper, we introduce a macroscopic-and-microscopic analysis of the nature of the iSchool community in terms of scholarly communication patterns and emerging as well as established specialties associated with individual iSchools. Two different types of thematic maps are illustrated: author-concept maps depicting what iSchool authors publish and citation maps of what iSchool authors regarded as important. Author-concept maps of six intellectually diverse iSchools and one overall thematic map of 19 iSchools are presented.

Introduction

The iSchool movement refers to the formation of information schools with the aim to embrace information, people, and technology in a cohesive educational and scholarly framework. As of January 2008, the iSchool community has 19 iSchools (See Table 1). Many of them have roots in library and information science schools. A common character of these iSchools is that they are interdisciplinary, including information science, computer science, and other disciplines. The first three iConferences, participated by iSchool faculty members and students, took place at Pennsylvania State University in 2005, at University of Michigan in 2006, and at the University of California at Los Angeles in 2008.

Table 1. List of 19 iSchools. Source of Membership: http://www.ischools.org/oc/schools.html.

Institution	iSchool	# Faculty as of 5/22/2008	# Papers (2000-2007) (Web of Science)
Drexel University	College of Information Science and Technology	35	189
Florida State University	College of Information	30	144
Georgia Institute of Technology	College of Computing	85	619
Indiana University	School of Informatics	76	307
Indiana University	School of Library and Information Science	27	153
Pennsylvania State University	College of Information Sciences and Technology	53	200
Rutgers, the State University of New Jersey	School of Communication, Information, and Library Studies	45	128
Syracuse University	School of Information Studies	41	251
University of California, Berkeley	School of Information	18	72
University of California, Irvine	School of Information and Computer Sciences	67	193
University of California, Los Angeles	Graduate School of Education and Information Studies	110	215
University of Illinois	Graduate School of Library and Information Science	27	111
University of Maryland	College of Information Studies	29	96
University of Michigan	School of Information	47	137
University of North Carolina	School of Information and Library Science	31	100
University of Pittsburgh	School of Information Sciences	38	149
University of Texas, Austin	School of Information	23	65
University of Toronto	Faculty of Information Studies	19	148
University of Washington	Information School	28	132

The identity of iSchools has drawn much attention (Bruce, Richardson, & Eisenberg, 2006). Some of the commonly identified attributes of an iSchool include: 1) the focus of the school should be on information; 2) information should be clearly at the center of the schools' academic, research, and service programs; 3) the school should focus on the interaction of people with information and technology; 4) the faculty of an information school should come from various disciplines and have broad based, inclusive, multidisciplinary mindsets. A commonly used model of the iSchool movement is the notion of a scientific community as a framework that accommodates a variety of sub-fields.

Searching for identify is important for an interdisciplinary scientific community. It is important to identify what we do, what we value, and where the challenges and opportunities are. There are many ways to approach to these questions. In this paper, we demonstrate an exploratory study of thematic structures of the iSchools based on faculty members' publications. Analyzing these maps offers a holistic and macroscopic approach to the study and track the diverse and dynamic structure of the invisible college formed by the iSchool community. We hope that this study will attract more attention to the study of complex macroscopic phenomena, such as the iSchool movement at inter-institutional levels. The next section will summarize relevant work, followed by a description of the analytical approach.

Related Work

The iSchools' search for identify has been compared to the search for identify in the 1970s for information science (A. Debons, 1974; Anthony Debons & Harmon, 2006). The identity search for information science, which is a key component in all the iSchools, was regarded as a process to establish a new field and find an existing host for the new field. In contrast, the identity search for iSchools is being seen as a process to establish a new host that can accommodate multiple existing disciplines.

The identity search for information science emphasized the idea of mapping entire sets of concepts and visualizing the concepts and their interrelations in a holistic manner (A. Debons, 1974). It is believed that the mapping metaphor can help one to find their way in multidisciplinary fields. In a recently published a series of four papers, Zins reported his extensive critical Delphi study of the fundamental concepts of information science (Zins, 2007b), including a knowledge map of information science (Zins, 2007c) and classification schemes of information science (Zins, 2007a). Zins' Delphi study provides invaluable information for understanding the fundamental issues of information science. The field of information science has been the subject matter of a number of bibliometric studies, e.g. (White & McCain, 1998).

In a typical citation analysis, the identify of the subject domain is assumed in that researchers often identify a list of journals or a list of authors in order to retrieve the citation data to be analyzed. Since the iSchools' identity search is different, i.e. one does not have an existing list of journals to begin with, we will take a different approach. Instead of retrieving bibliographic data with respect to a specific discipline, we will retrieve the data based on the iSchools' affiliations. In other words, the data we will analyze consist of the publications of iSchool authors. This is a descriptive rather than a predictive study of the iSchool community. The readers should note that we do not address the future options of the iSchools in this paper. iSchool identify is elusive and the first casualty of premature identify can be the elimination of future options that are not now foreseen (King, 2006).

The coverage of the data is limited in itself. See more details in the next section. The data are incomplete, and in fact, no data can be absolutely complete. On the other hand, we will demonstrate that with the widely available data one can generate thematic maps with low-cost methods and obtain potentially invaluable information concerning the holistic questions concerning who we are and what we do in the iSchool community as a whole.

Methods

We use the bibliographic data of iSchool authors' publications retrieved from the Web of Science. For example, to retrieve the data for the College of Information Science and Technology, Drexel University, we use the name of the college as part of the search query. In this study, we retrieved the last 10 years of data between 1998 and 2007. Some iSchools do not have data until later years. A total of 3,969 records with the article-only document type were used in the analysis.

The data set was analyzed and visualized with CiteSpace (C. Chen, 2006). CiteSpace is a freely available Java application[1] for visualizing and analyzing scientific literature (C. Chen, 2004). It takes the

[1] http://cluster.cis.drexel.edu/~cchen/citespace

data set retrieved from the Web of Science and produces various network visualizations. It also allows the user to interactively explore a data set. CiteSpace extracts noun phrases from the title and/or abstract fields. One can generate hybrid networks that contain two different types of nodes, for example, citing authors and noun phrases, cited papers and noun phrases, and institutions and noun phrases. In CiteSpace, users can choose an extraction window for noun phrase extraction in terms of the minimum and maximum numbers of words in a legitimate phrase. The default choice of the minimum is two, and the maximum is 4. For example, *web search engines* and *information visualization techniques* are valid noun phrases. The concept of burst refers to a sharp increase of the frequency of a variable (Kleinberg, 2002), such as word frequency, citation counts, or publication counts.

To accommodate the diversity across the 19 iSchools, our analysis highlights a few individual iSchools as well as the entire iSchool caucus. First, we generated an overall associative map of the 19 iSchools based on factor analysis of word distributions in corresponding faculty members' publications. Then we chose six iSchools so that they would be representative with respect to the diversity. Each of the six iSchools was analyzed to reveal the major research areas based on iSchool faculty members' publications over the last 8 years between 2000 and 2007.

Author-concept maps consist of authors in a chosen iSchool who published in journals and conference proceedings indexed by the Science Citation Index and the Social Science Citation Index, for example, the proceedings of the *American Society for Information Science and Technology*, and proceedings in *Lecture Notes in Computer Science* and other series. If an author's publications involve co-authors outside his/her iSchool, these co-authors will be also included. Coauthorship between two authors is visualized as a line connecting their corresponding nodes in the map. The map also includes noun phrases extracted from the title and abstract fields of an underlying bibliographic record. For example, if a faculty member of the iSchool published a paper and its title or abstract contains the phrase *complex networks*, the map will depict this relation through a line connecting the author node and the noun phrase node. Without losing general validity, we did not use stemming algorithms. The relations between phrases are defined by their co-occurrences within the data set. We refer to these noun phrases as concept nodes in this paper, although they can be further aggregated or clustered.

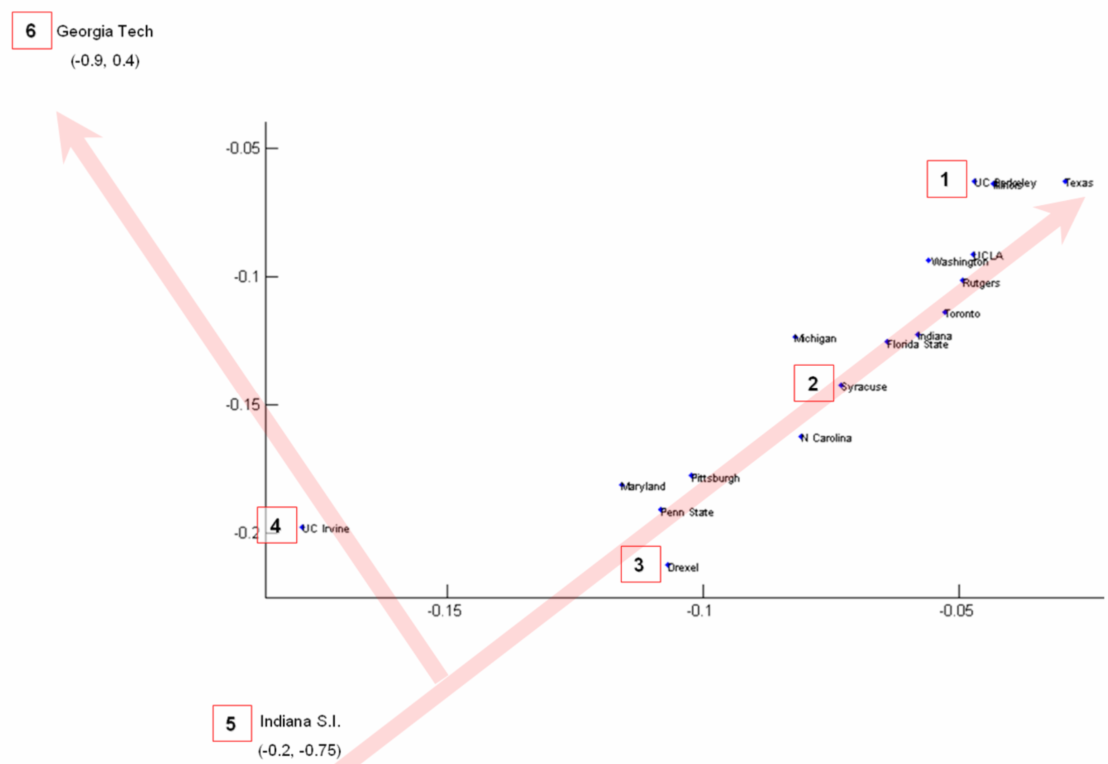

Figure 1. Interrelationships among 19 iSchools based on a factor analysis of word distributions across iSchools.

Results

The results are presented in three categories: 1) author-concept maps of six individual iSchools, 2) geospatial maps of institutional and international collaborations, and 3) thematic maps of the 19 iSchools as perceived by the iSchool community.

Associative Map

The interrelationships among the 19 iSchools are depicted in Figure 1 based on a 2-dimensional factor analysis of a 454-term by 19-institution matrix. As shown in Figure 1, the collective latent semantic space is diverse. On the one hand, two iSchools stand out as 'outliers' in the 2-dimesional projection, Georgia Tech and Indiana University (School of Informatics). A closer look at the remaining 17 iSchools revealed further details of the structure. For example, University of California, Irvine, emerged as another 'outlier' at a smaller scale. On the other hand, iSchools such as Syracuse were located in the middle of several others. In order to convey the diversity at the level of individual institutions, we selected six of them for further analysis. The two dimensions along the directions marked in Figure 1 suggests an alternative interpretation of the interrelationships. For example, one may hypothesize that the closer an iSchool to Georgia Tech, the more likely it has a strong focus on algorithms. The majority of iSchools seem to fall on the Indiana-Texas axis, suggesting that the iSchools may indeed have something fundamentally in common. In this study, we will take a network analysis approach and focus on the analysis of largest connected components of author-concept networks from a sample of six iSchools marked in Figure 1.

Six Individual iSchools

We selected six iSchools to illustrate the nature of the diversity in detail. The six chosen iSchools are University of California at Berkeley (UC Berkeley), Syracuse, Drexel, University of California at Irvine (UC Irvine), Indiana University's School of Informatics (Indiana S.I.), and Georgia Tech. All the author-concept networks of individual iSchools were generated and visualized using CiteSpace with the same threshold setting of 2, 1, 20; 2, 1, 20; 2, 1, 20. The first number 2 in the threshold setting means that an author must have two or more publications, or, a concept term must appear twice or more, in at least one year during the 8-year time span of 2000-2007. The second and third numbers in the threshold values set the filtering criteria for the strength of connectivity, e.g. 20 for including links that are stronger than 20% of the strongest connection in the dataset.

UC Berkeley

An author-concept map is shown in Figure 2 for the iSchool at UC Berkeley. The largest connected component of the network is prominent in the center of the map, including authors such as *Larson*, *Buckland*, *Gey*, *Cooper* and others. Topics published by these authors include *usage pattern* (top of the map), *multilingual retrieval* (middle), *machine translation*, *logistic regression*, *multiple probabilistic searches*, and *digital library* (lower half of the map). Three authors had a relatively higher rate of publication, namely, *Chen* and *Cooper* in the early 2000's, and *Habib* more recently. The map suggests that core research areas of the iSchool include usage pattern analysis, information retrieval, especially multilingual retrieval and translation, and digital libraries.

Syracuse University

Figure 2 shows the two largest connected components of a 110-node and 313-link author-concept network of Syracuse University's iSchool. The left component in the map, containing 23 nodes, highlights authors such as *Nicholson*, *Zhang*, and *Liddy*. Both Nicholson and Zhang were associated with a burst of publications, as indicated by the red rings. There were associated with terms such as *natural language processing*, *digital reference services*, *data mining*, *data warehousing*, and *management information systems*.

The right component in the map, containing 64 ndoes, includes prominent authors such as *Zubieta*, *Ruhlandt-Senge*, and *Englich*. Englich's name is associated with a burst of publication. These authors were associated terms such as *crystal data, x-ray crystallography* and *structural characterization*. The two components represent quite different topics.

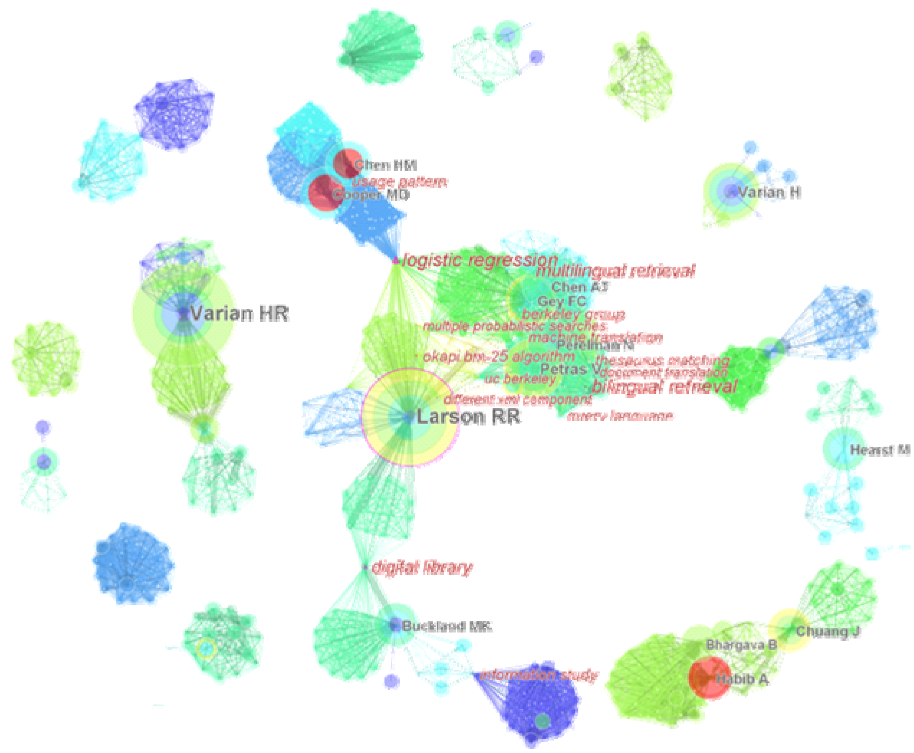

Figure 2. An author-concept map of UC Berkeley (2000-2007). The entire network: Nodes=659, Links=7,741. The component size: 322 (48.86%).

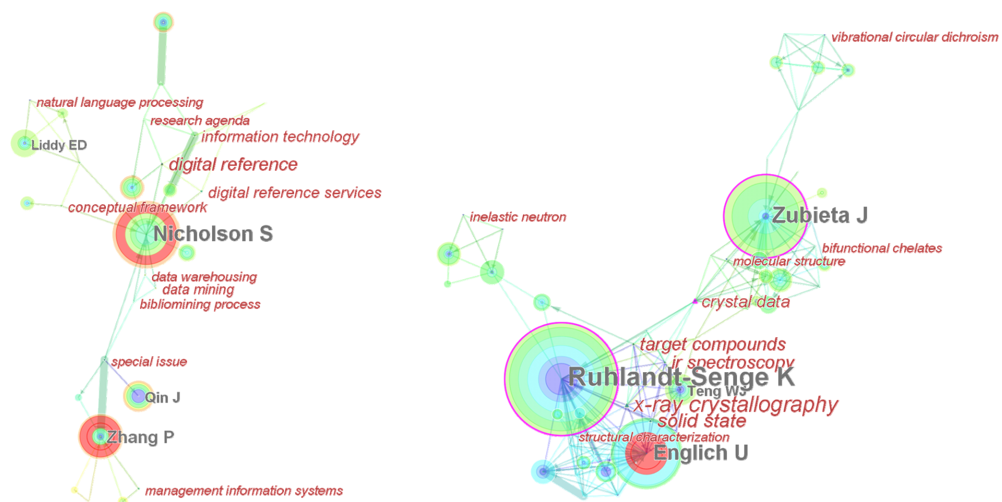

Figure 3. Two largest connected components of an author-concept map of the iSchool at Syracuse University (2000-2007). The entire network: Nodes=110, Links=313. The component sizes: 23 (left), 64 (right).

Drexel University

Figure 4 shows the largest component of Drexel's iSchool. The component contains of 147 nodes, which is 94.23% of nodes in the entire network. To the lower left, *White* and *McCain* are surrounded by terms such as *multidimensional scaling*, *author cocitation analysis*, *information science*, and *scholarly communication*; *Chen* is connected to *knowledge domain,* and *digital library*. Towards the center, *Hu* is linked with biomedical literature and precision-focused biomedical literature search (not shown). Further to the right, *Song* is connected to terms such as data mining, data analysis, and user request. *Agosto* near to the lower right is linked to terms such as theoretical model, empirical model, and urban teenagers (not shown). The left half of the large component primarily corresponds to citation-related research, whereas the right half corresponds to data mining and its applications to biomedical literature.

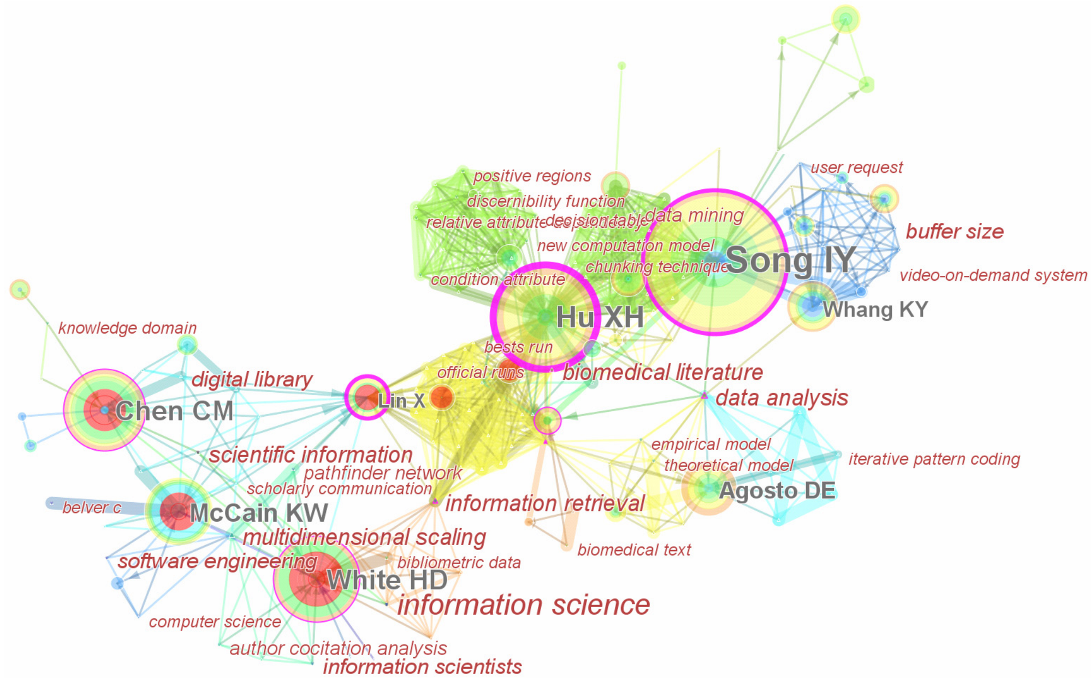

Figure 4. The largest connected component of an author-concept map of Drexel University's iSchool (2000-2007) . The entire network: Nodes=156, Links=1,017. The component size: 147 (94.23%).

UC Irvine

The 4th individual iSchool is UC Irvine's one. Its author-concept map contains 123 nodes and 497 links (Figure 5). Unlike earlier examples in this paper, the image corresponds to the period of 2003-2007 instead of 2000-2007 due to the lack of data. The most prominent author is *Baldi* at the center of the network. The network includes topic terms such as *graphical model*, *recursive neural network*, *support vector machines*, *system biology*, and *small molecules*. Most of these terms indicate research in data mining, machine learning, and bioinformatics.

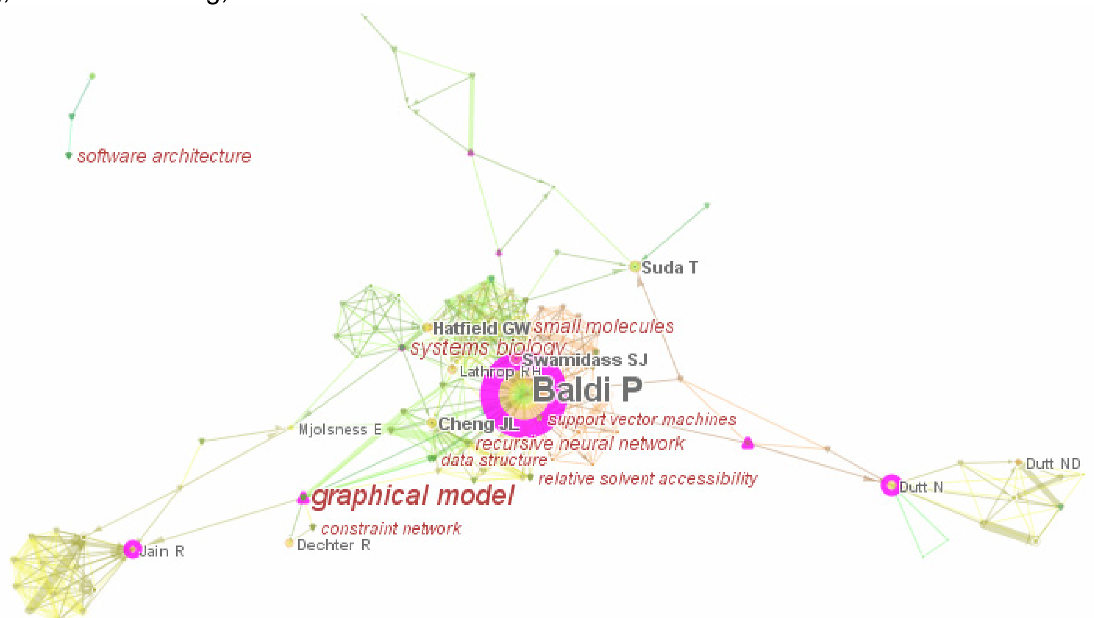

Figure 5. UC Irvine's author-concept map, containing 123 nodes and 497 links (The time span is 2003-2007).

Indiana University

The School of Informatics at Indiana University formed a network of 322 nodes and 2,489 links. Figure 6 depicts the largest connected component of their author-concept map. Prominent author nodes in the network component include names such as Baik, Vespignani, and Kim. Author Fernandez is one with a burst of publications. Concept terms in the component include complex networks, disordered proteins, protein disorder, and intrinsic disorder. It appears, at the glance, that bioinformatics research from network analysis and modeling perspectives formed the core of the collective work in this iSchool. Overall, the majority of these activities of publication took place over the past 3 or 4 years. For example, Baik's tree ring depicts four layers of tree rings, corresponding to the number of publications per year over the last 4 years.

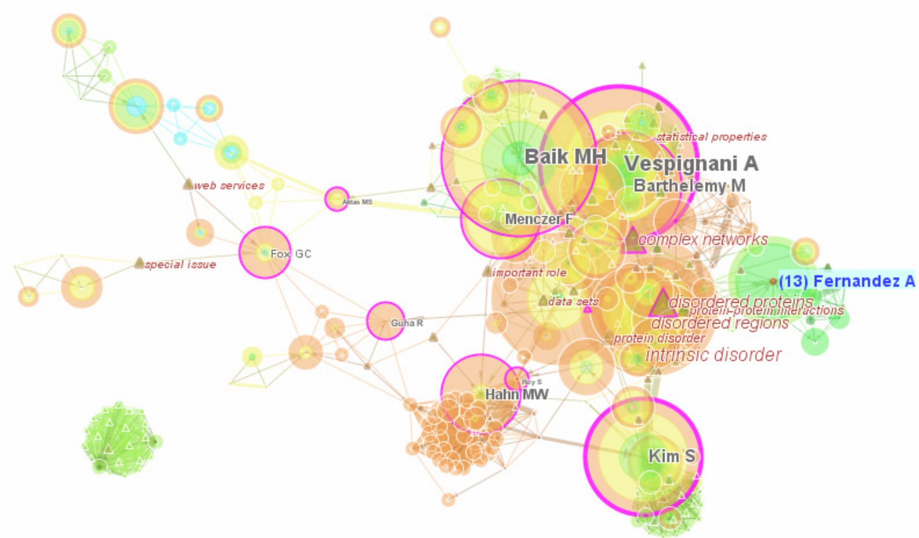

Figure 6. The largest connected component of an author-concept map of the School of Informatics, Indiana University (2000-2007). The entire network: Nodes=322, Links=2,489. The component size: 292 (90.68%).

Georgia Tech

Georgia Tech's iSchool is an apparent outlier in the factor analysis map. Figure 7 shows the largest connected component of its author-concept map of 502 nodes and 2,435 links. The largest component contains 465 nodes or 92.63% of the entire set of nodes. Author names associated with the most productive Georgia Tech authors include *Liu* (left in Figure 7), *Rossignac* (right), *Abowd* (lower left), and *Harold* (right). In particular, *Liu*, *Harold*, *Vigoda*, *Paride*, and *Smaragdakis* are associated with a burst of publications. The map highlights terms such as *algorithms*, *design*, *performance*, *peer-to-peer network*, *markov chain*, *approximation algorithms*, and *software test*, indicating a strong trait of computer science and software engineering.

Between iSchools and Beyond

Figure 8 is an institutional collaboration network. All publications from an iSchool are aggregated under the name of its university. A line directly connecting two institutions in the map means that their faculty members jointly published papers in the last 10 years (1998-2007). Indiana University includes two iSchools. They are merged as one in this visualization. Three institutions have experienced abrupt increases of publications, shown as red rings, namely Indiana University in 2006 and 2007, University of Toronto in 2000-2004, and University of Texas in 2006-2007.

Figure 9 shows a geographic map with a collaboration overlay in Google Earth. If two institutions published a paper together, their locations will be connected on the map. The color of the connection depicts the year of the joint publication. According to the map, iSchools tend to have frequent collaboration with European and Japanese researchers. In general, the scope of international collaboration has been expanding over time.

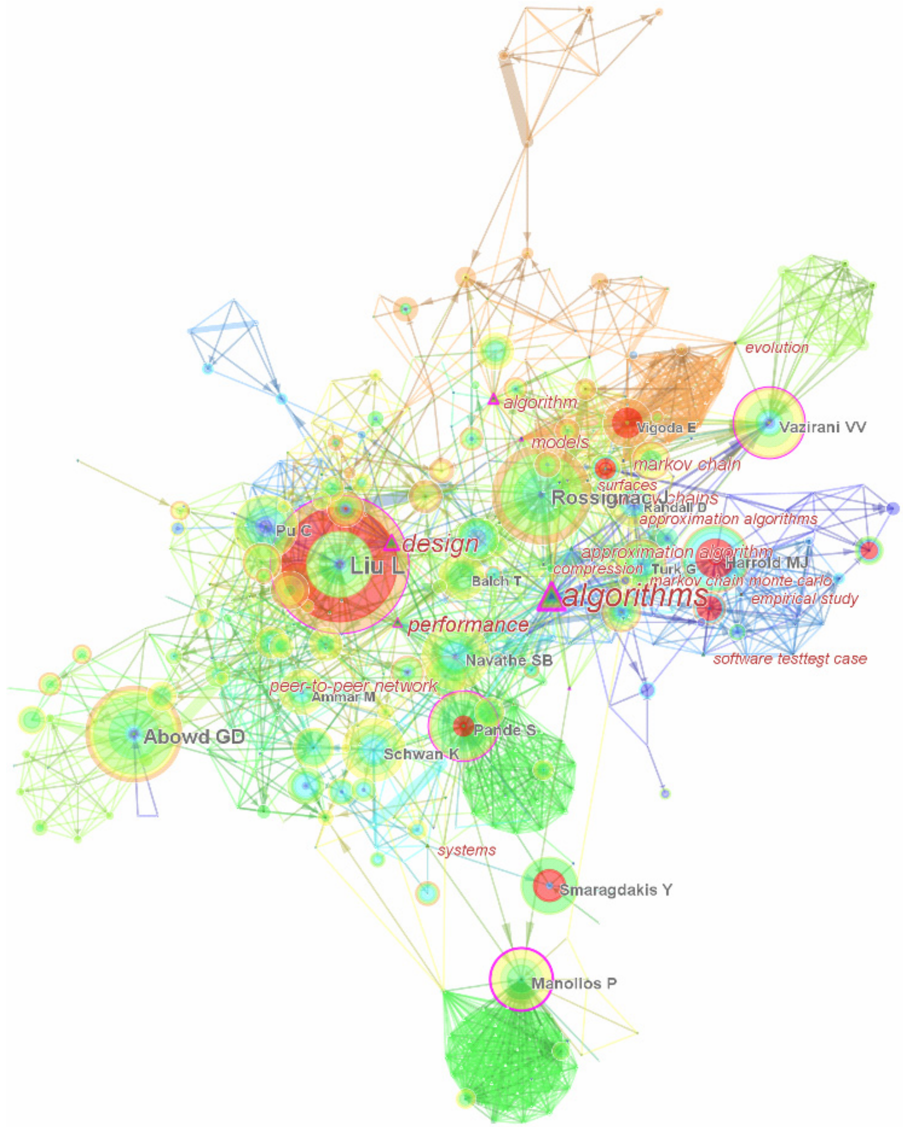

Figure 7. The largest connected component of an author-concept map of Georgia Tech's iSchool (2000-2007). The entire network: Nodes=502, Links=2,435. The largest component contains 465 nodes (92.63%).

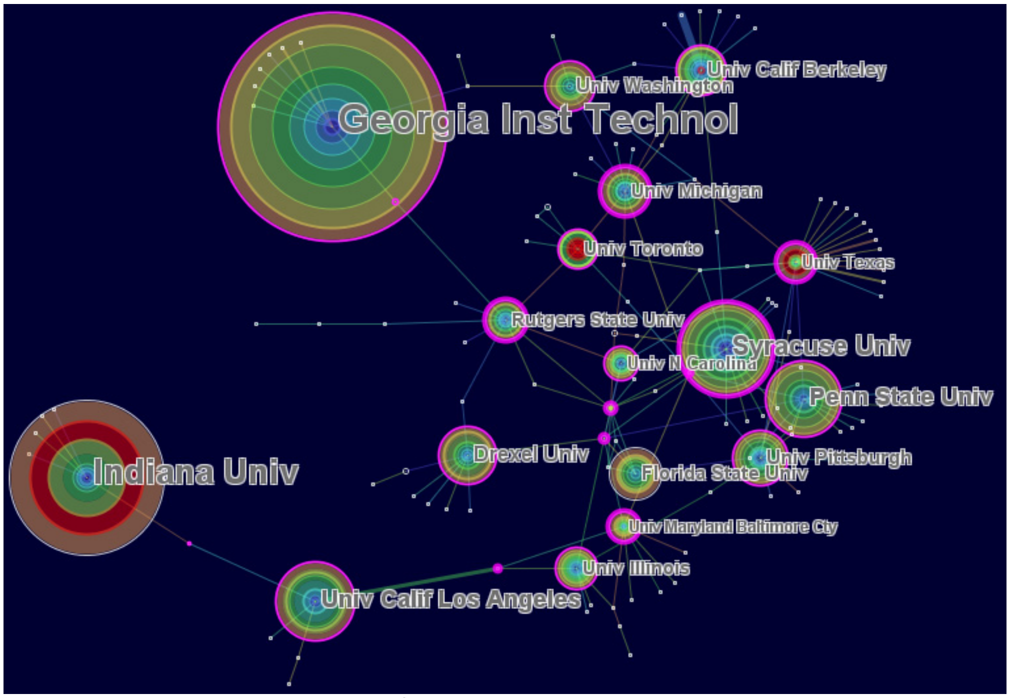

Figure 8. A hybrid map of institutional collaboration and topical terms.

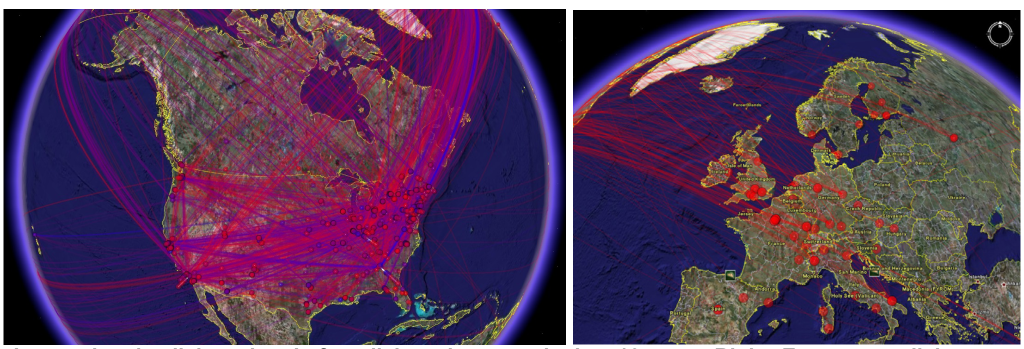
Figure 9. International collaboration. Left: collaboration over the last 10 years. Right: European collaborators in 2007.

A Thematic Map of 19 iSchools

The author-concept maps address the question of who is doing what. The thematic map discussed below addresses the question of what the sources of inspiration are in terms of what they cite in their publications.

Figure 10 is an aggregated impact image painted by citation trails made by researchers from the 19 iSchools. The map shows the largest connected component in a document co-citation network of 836 cited references and 7,604 co-citation links. The largest component, consisting of 692 cited papers (82.78% of the nodes in the entire network), reflects the core of a collective intellectual base of the 19 iSchools. These major areas include *citation analysis*, *situated learning*, *search and information seeking*, *complex network analysis*, *statistical inference*, *protein interaction and bioinformatics*. Highly cited works are labeled in the map. Red rings indicate hot spots receiving rapid increases of citations – citation burst. The visualized network shows that *complex network analysis* is a recently emerged area of research to the iSchool community. Another area of attraction is *bioinformatics*, which is a recently emerged area with a substantial number of hot-spot papers. In contrast, a prominent hotspot in *citation analysis* is a 1998 JASIST article by White and McCain on author co-citation analysis. The majority of citation activities in this area were made in the earlier years. The central and long-lasting area in the largest connected component is to do with information seeking and relatively more recent studies of search on the web. The area of situated learning is closely related to the broad area of information seeking.

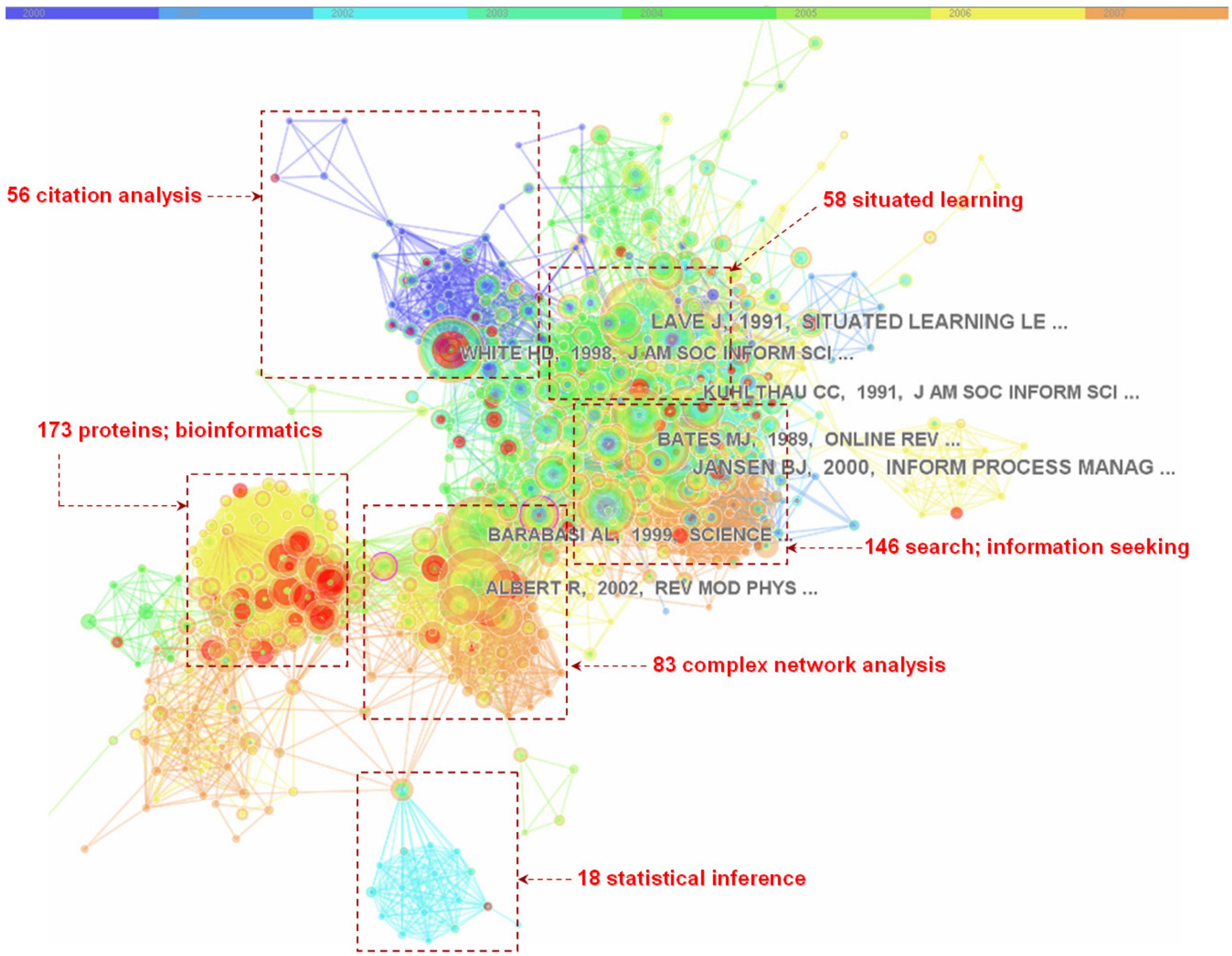

Figure 10. The largest connected component of 692 cited papers in a thematic map of co-cited references by authors from the 19 iSchools (2000-2007). The original network contains 836 cited references and 7,604 co-citation links (CiteSpace threshold setting: 3,2,25; 3,2,25;, 3,2,25).

Table 2 lists the seven highly cited references labeled in Figure 10. To put their citations in a broader context, the table includes citation counts according to Google Scholar, as of January 21, 2008. Among the these references, the earliest one is the 1989 paper on berry picking by Bates and the most recent one is the 2002 paper by Albert and Barabasi on complex networks, cited close to 7,000 times on the Web. The 1991 book on situated learning by Lave, an anthropologist, and Wenger, a computer scientist, has received 9,281 citations on the Web. The majority of these highly cited references are related to information seeking behavior, ranging from Bates' 1989 paper on online search to the 2000 paper by Jansen et al. on web-based search. The 1998 paper by White and McCain is an author co-citation analysis of information science.

Table 2. Works highly cited by the iSchools. *Citation counts by Google Scholar.

Year	Cited*	Author	Title	Source	Vol.	Page
1989	438	BATES MJ	The design of browsing and berrypicking techniques for the online search interface	Online Review	13	407
1991	359	KUHLTHAU CC	Inside the search process: Information seeking from the user's perspective	Journal of the American Society for Information Science	42	361
1991	9281	LAVE J & WENGER E	Situated learning: Legitimate peripheral participation	University of Cambridge Press		
1998	256	WHITE HD & MCCAIN KW	Visualizing a discipline: An author co-citation analysis of information science, 1972-1995	Journal of the American Society for Information Science	49	327

1999	3031	BARABASI AL & ALBERT R	Emergence of scaling in random networks	Science	286	509
2000	485	JANSEN BJ et al.	Real life, real users, and real needs: a study and analysis of user queries on the web	Information Processing & Management	36	207
2002	3983	ALBERT R & BARABASI AL	Statistical mechanics of complex networks	Reviews of Modern Physics	74	47-97

Table 3 shows a list of burst concept phrases in the all-in-one dataset of the 19 iSchools. The burst of a term indicates that an underlying topic has drawn a substantial amount of attention.

Table 3. The burst of research topics.

Concept Phrases	Burst Rate	2000	2001	2002	2003	2004	2005	2006	2007
regression-testing	3.38								
knowledge-management	4.95								
peer-to-peer-network	3.47								
routing-protocol	3.36								
web-search-engine	3.20								
biomedical-literature	3.26								
protein-structure	3.38								
complex-network	3.27								
graphical-model	3.73								
intrinsic-disorder	4.42								

Discussions

Author-concept maps provide a glimpse of who-has-been-doing-what in the invisible college of the 19 iSchools as well as individual ones. The thematic map of iSchool authors' collective citing patterns paints a big picture of the community's intellectual memory. Taken together, one can examine the iSchool movement from holistic perspectives as well as detailed, Delphi-like surveys with iSchool faculty members.

The interdisciplinary trait of iSchools is evident in the author-concept maps and the all-in-one co-citation map. In addition to research focuses of traditional library and information science, we found a recurring pattern across several iSchools in this study – an interdisciplinary integration of information science and technology. For example, the analysis reveals the popularity of bioinformatics in several iSchools. On the other hand, individual iSchools have their own areas of specialties such as multilingual retrieval and citation analysis. These maps provide a cost-effective method for us to identify and address underlying issues concerning the iSchool movement from a macroscopic perspective.

We hope to provide a methodology that can be easily used by the members of the iSchool community so that one can repeatedly apply the method to new data, from different perspectives, with different questions in mind. From a methodological point of view, we introduce this method to supplement heavy-duty qualitative methods such as Delphi surveys. More importantly, our method has the potential of being applied to address questions such as what is the image of the iSchools in the eyes of non-iSchools, or in the eyes of physicists and medical researchers.

The exercise can be extended to the iSchools we have not analyzed, to non-iSchools, or other institutional groupings. Given the intellectual diversity of the 19 iSchools, the consistency and domain-independence of the method, this analytic approach is applicable to a much wider variety of invisible colleges defined by discipline, by institution, by faculty, or other dimensions. On the other hand, cautions should be exercised due to limitations associated with factors such as the use of potentially incomplete data. For example, iSchool authors' most representative work may be published elsewhere rather than in journals and conferences indexed in the Science Citation Index or Social Science Citation Index. Other sources of data such as Google Scholar may provide alternative pictures. Furthermore, other sources of data may provide valuable insights that are difficult to derive from bibliographic data. For example, faculty members' research interests are often clearly identified on their websites, but such information may not be readily available from their bibliographic records.

Identity issue aside, one can envisage faculty members from different iSchools using such maps to find future collaborators, and students using such maps to find advisors. One may also envisage the revelation of structural holes and missing links as the opportunities for creative thinking and discoveries in the future.

Conclusions

Using the widely available publication data, we have demonstrated how one can analyze an invisible college as diverse as the iSchool community. This approach is introduced as a supplement method for heavy-duty qualitative methods. On the other hand, this analysis focuses on iSchools' scholarship and omits other aspects such as education. The use of the particular data means that these maps reflect an aggregated view of iSchool authors. Views from authors outside iSchools are not presented unless they collaborate with iSchool authors. We recommend readers to maintain an open mind for the future of iSchools and take these maps and the method as one way to analyze and track the evolution of the iSchool movement and, perhaps more importantly, identify opportunities ahead for iSchools.

Acknowledgements

The bibliographic records used in this study were retrieved by Stephen Inglese and James Zhang.

References

Bruce, H., Richardson, D. J., & Eisenberg, M. (2006). The I-Conference: Gathering of the Clans of Information. *Bulletin of the ASIST, April/May, 2006*.
Chen, C. (2004). Searching for intellectual turning points: Progressive Knowledge Domain Visualization. *Proc. Natl. Acad. Sci. USA, 101*(suppl), 5303-5310.
Chen, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of the American Society for Information Science and Technology, 57*(3), 359-377.
Debons, A. (1974). *Information science: Search for identity.* Paper presented at the Proceedings of the 1972 NATO Advanced Study Institute in Information Science, Seven Springs, Champion, Pennsylvania.
Debons, A., & Harmon, G. (2006). The I-Conference in Retrospect. *Bulletin of the ASIST, April/May, 2006*.
King, J. L. (2006). Identify in the i-School movement. *Bulletin of the ASIST, April/May 2006*.
Kleinberg, J. (2002, July 23-26, 2002). *Bursty and hierarchical structure in streams.* Paper presented at the Proceedings of the 8th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, Edmonton, Alberta, Canada.
White, H. D., & McCain, K. W. (1998). Visualizing a discipline: An author co-citation analysis of information science, 1972-1995. *Journal of the American Society for Information Science, 49*(4), 327-356.
Zins, C. (2007a). Classification schemes of Information Science: Twenty-eight scholars map the field. *Journal of the American Society for Information Science and Technology, 58*(5), 645-672.
Zins, C. (2007b). Conceptions of information science: Research Articles. *Journal of the American Society for Information Science and Technology, 58*(3), 335-350.
Zins, C. (2007c). Knowledge map of information science: Research Articles. *Journal of the American Society for Information Science and Technology, 58*(4), 526-535.