

Social Navigation, Recommender Systems, and Libraries

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I. General Principles of Social Navigation¹

The idea of social navigation (SN) in virtual spaces is closely modelled on navigation and orientation in non-virtual spaces. It is an idea borrowed from architecture, urban design, and in general sociology, all disciplines that have long established that people tend to follow other people's trails in space. SN lets users help each other and generally serve as a navigational aid. A typical example of SN is following in someone else's trail; i.e., following direct or indirect advice from someone else. The advice provider can be a real human being that is synchronously present (in the context of the academia, think about dissertation advisors), a trace of another human being's actions (e.g., borrowing a book from the library on the basis of it looking well-read) or an artificial entity altogether, as long as the navigator sees it as another inhabitant of the (virtual) space (e.g., MUD robots). Common virtual examples include recommended URLs, FAQs, recommender systems, computer-supported cooperative work (CSCW) systems, which provide an awareness of co-workers' activities, visitor counts on webpages, online guides, collaborative virtual environments (CVEs), etc.

SN can either be deliberately designed to be part of a system, as in most of the examples above, or it can emerge spontaneously, sometimes in unpredictable forms or places.²

SN provides a sense of security and safety. ("If other people have gone there, it is safe for me to do so, too.") As a concept in the area of human-computer interaction (HCI), it was introduced by Dourish and Chalmert in 1994. They defined it as navigation towards a cluster of people or navigation because other people have looked at something.³ At first SN was exemplified by recommender systems like Amazon.com, but later Dieberger expanded the definition to include recommendations of websites and bookmarks.⁴

As all other approaches in HCI, SN can be seen from several different perspectives and traced in several different domains, including the "real" world of human activities, and the various virtual worlds of information spaces. It is concerned with the creation of social settings and "places" in information space and the human behavior in them, i.e., the sociability of information creation, and with people as both consumers and creators of information. People are seen not as single users but as

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members of many different types of information spaces both real and virtual, which are lively spaces, inhabited by other people, i.e. they are “places.”

Consequently, perhaps the best metaphor to express what SN is all about is the idea of footprints in the snow or a pathway through the grass in the park. In other words, the main purpose of social navigation is to facilitate way-finding be it through prescribed or subsequently afforded means.

In a sense, SN is a reaction towards the more traditional HCI approaches which view the information and the user of the information as inhabiting two distinct worlds or spaces. SN positions people inside, not outside of the information space, where they will try to bridge the gulf between themselves and the information space. SN shares many of the assumptions of traditional HCI but also introduces more socially based ways of thinking, and, especially, the realization that computers are used for more than just work. It borrows from and frequently critiques aspects of CSCW, IUI (intelligent user interfaces), IR (information retrieval) theories and CVEs. In this sense, SN is the result of certain disenchantment with both classic HCI and even CSCW, following the realization that the cognitive approach is limited in its potential to understand and explain the changes in technology and the uses people put it to.

It should be kept in mind that SN is also connected to social informatics (SI), i.e., the study of the social consequences of technology. However, even though both SI and SN ask the question of why some information-communication technologies (ICTs) work in practice and others don't and locate the answer in a social dimension of some sort, with SI it is in organizational practice, while with SN, it is mostly within the realm of human sociability. In other words, even though the SN approach is potentially relevant to community action, it does not explicitly concern itself with social change and activism the same way that SI does.

The SN approach takes SI one step further; instead of looking at the social consequences of ICTs, it attempts to situate the social within the virtual. It plays on the idea that people can be seen as existing in an information space, or even multiple information spaces, and that within these information spaces, they leave traces that are of interest to other inhabitants of the same space. Ultimately, SN as a design philosophy is the result of the realization that using computers needs to become a more enjoyable, social activity.⁵

II. Short History and Typology of SN

Some of the signposts in the history of SN as a design approach and a conceptual framework include the PERSONA collaborative project between the Swedish Institute of Computer Science (SICS) and Napier University, Edinburgh, the 1998 workshop in Sweden on Personal and Social Navigation of Information Spaces and its published proceedings,⁶ a panel on SN at the CHI conference in 1999, organized by Alan Wexelblat, another workshop on SN held in conjunction with the CHI 2000 conference, the joint Delos-NSF workshop on personalization and recommender systems in digital libraries held at Dublin City University in 2001, and the publication of a second expanded edition of *Social Navigation of Information Space* in 2003.⁷

SN can be direct, where the communication between the advice provider and the user is mutual and two-way. In some way, one can see other people moving around, can consult or instruct specialist agents, can get advice and help from other people. SN can also be indirect, where the communication is non-mutual and in one direction only. The goal is to provide information on what other people have done, pointing to “suitable” choices based on preferences.

III. Recommender Systems (RSs)

Recommender systems are one of the most well-known instances of social navigation. As Resnik and Varian described them in 1997, they assist and augment the natural social process.⁸ They are prevalent in the e-commerce and entertainment sectors, and comparatively less used in libraries. The most well developed example of a RS on a library OPAC that we are aware of is the one used at the University of Karlsruhe, developed in 2002. It is based on log file analysis, not on ratings, and has been fully operational in the public interface of the catalog. As Geyer-Schultz et al. explain, there a number of obstacles to RSs on library OPACs, including librarians' concerns with privacy, the additional investments in IT-equipment required, as well as the sheer volume of the system compared to some traditional commercial environments.⁹

Most RSs are based on collaborative filtering (CF),¹⁰ which operates on the assumption that users who agreed with each other in the past are likely to agree with each other in the future. CF can be several types. In pull-active CF users pull the information they want by formulating queries based on the characteristics of the items or the previous users' reactions to the items. An early example is the Tapestry system at Xerox PARC. Pull-

active CF systems are applicable for smaller communities. CF systems can also be push-active when users push items to other users based on their understanding of the users' needs (e.g., Lotus Notes). These are suitable for small communities. A third type of CF is the automated one where systems automatically analyze the relationships between users and form recommendations based on correlations among different users' behaviors (e.g., GroupLens, Amazon.com, Netflix). These require little or no user effort—it is the CF system that puts in the effort in contrast to push or pull CF systems.

The key advantage of all three CF mechanisms is that they do not consider the content at all; each item and user is treated individually, but upfront human effort is great—someone needs to make a recommendation. CF can also be based on implicit interest measures—based on implicit observations of behaviors that the user would have exhibited independent of the recommender system. Implicit ratings are used, for instance, partially in Google's link mining. Implicit data is often noisy (users may purchase a product they personally dislike as a gift), but potentially more available and more honest.

CF can be based on situational recommendations: a combination of the user's long-standing interests and a specific short-term interest. CF can be used for recommending for groups, where the group is merged into a single user, or merging the recommendations of the individual members. CF can be based on manual override, where the user selects which other users are used to produce recommendations for him or her; or how the opinions are combined precisely (e.g., Launch.com, Epinions.com). CF can also provide confidence measures and explanations, but in general these tend to inhibit the number of users willing to provide recommendations.

It is important to keep in mind that, as much as RSs try to mimic the way people make choices in the real world, there are important differences. In general social navigation systems allow the user to see him/herself and his/her impact on the system, while recommender systems don't; they also show the path less traveled, RSs don't.¹¹

Even though RSs seem currently strategically important primarily for e-commerce, it has been argued that for scientific libraries, they can not only prevent the information overload, but also take up some of the traditional functions of academia, namely literature recommendations by advisors and peers.¹² However, the privacy issues do present a problem and perhaps

explain why RSs in the research environment tend to be discussed in conjunction with comparatively closed, self-selected user groups (e.g., researchers in a specific subject area) than on open OPACs.¹³ The University of Karlsruhe RS, for instance, which includes 15 million documents, is based on transaction log data, where the library is compared to an information market in which selecting an object is considered as a purchase of this object. For privacy reasons, no lending data are used.¹⁴

The methods employed in RSs vary tremendously—from ranking of products and services, writing annotations and reviews, to content analysis of the item itself to make suggestions.¹⁵ Among the various algorithms proposed for RSs, most view the recommendation process as a prediction problem, but some authors suggest that treating it using Markov decision processes is a more appropriate model.¹⁶ It is important to heed Wei et al.'s advice, however, that no one technique is best for all users in all situations and that RSs should incorporate a wide variety of such techniques.¹⁷

IV. Social Navigation and Libraries: Affordances and Issues

A number of issues surround the idea of applying the principles of SN to libraries. For instance, does "voting" work for movies, restaurants, etc. taste-related products better than for scientific journals, if it works for scientific domains at all? If RSs, an instance of SN, are developed to address the abundance of choice we face in taste domains (films, music, restaurants), are they applicable to research domains? Further, if SN as a design principle is supposed to be a delightful experience that breaks away from the pure efficiency of usability testing concepts, which focus on efficiency in terms of time spent and number of errors,¹⁸ does research in academic environments yield itself to such concerns?

SN follows in the footsteps of one of the major assumptions of social informatics, i.e., that an IT application does not have the same meanings for all who use it and does not have similar consequences for all. In other words, people's interpretations of IT are influenced by prior beliefs, current incentives, and perceived demands. This view of IT is difficult to conceive of in the environment of libraries or even academia at large because it presupposes fluidity, it challenges the notion of expertise, and more specifically the locus of the expertise (be it the professor or the librarian who has created a classification of the world that is hierarchical and very slow to change.) Creating an environment that affords user-contributed data (recommendations, folksonomies, etc.)

has two major problems—one philosophical, and the other technical (forcing unstructured data to play well with very structured legacy data.)

SN in general transcends the very traditional view of HCI in which there is a human interacting with a computer system independently of a common information space, and in libraries this presents a problem. It requires a shift of perspective on what information is—it is not an objective set of data; but an interpretation, a socially interwoven subjective view of the world.

The biggest problem with RSs applied to libraries is that of privacy. Research has shown that even though familiarity with the recommender does not impact the perceived usefulness of the recommendation, profile similarity and rating overlap have a significant impact on perceived usefulness.¹⁹

Another problem is the fact that there may be research spaces that are not “social” in nature and hence SN will not work as an approach. It is also possible that there are cultural differences in SN that may be difficult to replicate in virtual worlds.

Before we proceed with a description of our attempt to implement a RS on the legacy OPAC at CUL, a few final qualifications. First, in the process of helping people make choices, RSs probably affect users’ opinions of the items by influencing their own ratings towards a displayed (predicted) rating, or through the scale used to rate.²⁰ Other issues that surround RSs in the library include the problem of evaluating recommendations (should recommendations from faculty in a subject area weigh more than those of faculty in other subject areas, or those of graduate students or students in general), what is the cost structure of building a RS in a library, both for the system and the patrons (e.g., is it very costly for the user to miss a good item or sample a bad one), and finally, is the dataset large enough to provide meaningful recommendations?²¹

IV. CUL’s Data Mining Project for a Recommender System

CUL took its first steps in developing a catalog recommender system in the fall of 2005. There had been a desire from staff throughout the system to utilize SN in some form to enhance the information discovery process in our catalog. In response to a call for projects for a Master of Engineering program in Operations Research and Industrial Engineering, CUL staff proposed to use data mining of library circulation transactions to develop a RS. A team of three students took on the project and immediately began working with several CUL

staff to gain an understanding of the library’s data and scope the system. The whole group defined the guiding principles and limitations we would be working with and decided what data points the system would use to match categories of users to categories of books. The students went to work producing software and two databases using historical and current circulation data for the monographic books used by our graduate student population.

Guiding Principles and Limitations

This project gave us an opportunity to define how we wanted the system to combine some of the long-standing traditions libraries have maintained with some new ideas of information organization. Among the guiding principles and limitations we defined for the project:

Our materials, our patrons

We felt that it was important to focus the scope of this system on the materials currently held at CUL and the patron base we serve directly. Some existing systems, notably Amazon.com and Library Thing, connect a wide range of users with materials that they might be interested in from throughout the world. We wanted to direct our users to relevant materials that were readily available from our collections.

Patron privacy

From the beginning of the project, we wanted any system we developed to maintain our standards of patron privacy. Our LMS removes the patron identity connected to a circulation transaction when the material is discharged, retaining only the status of the patron (faculty, graduate, etc...). A symptom of removing the patron identification from our historical circulation data is that we could only use this data to count uses of a book. When dealing with our current circulation data, it was important for us to ensure that we weren’t perpetuating this patron to book use connection significantly in our efforts to provide meaningful associations for our RS. To accomplish this, we established a daily data feed containing the patron to book connections, the software would process this data, make the relevant connections, and then we would delete the original file.

Data Points and “Tags”

Rather than developing a system where users could enter their own terms to tag themselves and their books, our system was being populated completely with data that existed in our LMS or could readily be obtained

and connected. After closely examining the data we had available to us, we determined the best data match point for linking the use of books together and the most relevant data to use as categories or “tags” for our patrons and books.

BIB_ID

CUL's LMS database uses a BIB_ID to indicate a unique instance of a bibliographic record. Each BIB_ID has one or more MFHD_IDs and ITEM_IDs linked to it to indicate individual holdings at branch libraries and individual physical items respectively. Although it is the ITEM_ID that actually gets checked-out to a patron, we concluded that the BIB_ID is the more relevant match for trying to indicate when *people who used this book also used that book*.

User tags

The data we had ready access to for our patrons varied greatly depending on their status within the University. Table 1 indicates the descriptive data we could access for our major patron groups.

The field of study for the graduate students seemed to be the most detailed descriptive data. CU currently offers 121 graduate fields of study, often several in each department. We also considered our potential audience for this system and thought that new or aspiring graduate students could be interested in seeing what other graduates in their chosen fields read. For these reasons, we decided to focus our efforts on books used by the graduate student population.

Book tags

CUL uses LC classification and subject headings, but our team felt that it was important to incorporate a different form of classification that might be more im-

mediately relevant in the recommender system environment. The Hierarchical Interface to Library of Congress Classification (HILCC) developed at Columbia University²² maps LC call numbers into a set of thirteen top level categories with one to three lower levels of categories for narrower focus. We thought that HILCC categories might be a more user friendly way to navigate through subject categories.

Results

Taking the information and data in hand, the student team developed programs in SAS and MS Access and produced two databases as project deliverables.²³

Ranking Database

Most frequently used books in HILCC categories. Using the last five years of historical circulation data, this database simply counts the number of times a particular book has been checked-out. This ranking of books could potentially be used as a starting point for research. A user could find the books that are most frequently used within a given HILCC category. Keeping our focus on use by graduate students, we found that over 365,000 different books circulated to graduate students, but of these, 90 percent circulated fewer than three times.

Though this data could be used to create lists of the most frequently used books, the students and CUL staff concluded that once a user delved down to a narrow HILCC category, such as History & Archaeology→Regions & Countries→Americas (General), only the top few books (9 in this category) circulated more than three times. It is questionable whether this system had enough data to be relevant at these narrow HILCC categories.

Relationship Database

People who used this book also used these books. The students created software to process daily snapshots of circulation transactions. These snapshots included any book that had been checked-out to a patron during the day that was still checked out when the data feed was run. The software would match BIB_IDs of books that were checked out to the same patron, and then remove the specific patron identifying data. The output of this program is a database of four tables: book to book, HILCC to HILCC, field of study to HILCC, and field of study to book. These tables interact to allow the database user to see various relationships between books, fields of study, HILCC category. Each day's data is added to the existing tables to build more connections over time.

Table 1: Patron descriptive data

Patron Group	Descriptive Data
Undergraduate	College or school of enrollment— <i>Arts & Sciences, Engineering, ...</i>
Graduate	Field of study— <i>Aerospace Engineering, Operations Research...</i> OR Professional college of enrollment— <i>Law, Management, ...</i>
Staff	Department— <i>Administration, Chemical Engineering, ...</i>
Faculty	Department— <i>Natural Resources, English, Chemical Engineering, ...</i>

Some RS suggestions that could be made include:

- People who use this book also use...
- Graduate students in Aerospace Engineering most often use books from the following three HILCC categories...
- You may find useful books from the following HILCC categories...

The final results of this project were presented after only 64 days of data were collected, so the total number of connections between books was rather small. By the conclusion of the project, we realized that there were better ways to gather the daily data in order to get more book-to-book connections while maintaining patron privacy.

Conclusions

Although this project did not result in a usable RS for the CUL catalog, we gained a much greater understanding of how our data might be used in any future RS development. Through expanding the scope, revising our data collection, providing user interactivity, and locating more relevant data, we can build a significantly more relevant and useable RS. Some specific efforts we can undertake include:

- Access more descriptive data about our patrons, particularly our undergraduates, to expand our scope to more of our constituents.
- Collect our data in a more effective way to find more connections between people and books.
- Approach peer institutions to increase the amount of relevant data. This would also increase the potential user base for the RS.
- Include the ability for users to add their own descriptive tags and ratings. This would increase the total amount of usable data while adding some sense of ownership for the users.

SN is, and will continue to be, important to libraries. Through understanding our data, our user base, and our materials, we can help to develop useful RS to improve the information discovery process for our patrons.

Notes

1. Perhaps the best introduction to SN as a design approach or a philosophy of design, if you will, to date is to be found in Kristina Höök, David Benyon and Alan J. Munro, eds., *Designing Information Spaces: The Social Navigation Approach* (London: Springer, 2003). See also "Social Navigation," <http://www.sics.se/humle/socialcomputing/kallas/socialNavigation.html>. Höök also provides an overview of existing SN systems at Kristina Höök, "Social Navigation

System Links," http://www.sics.se/~kia/socnav_links.html.

2. See Jenny Robins, "Affording a Place: The Role of Persistent Structures in Social Navigation," *Information Research* 7, no.3 (April 2002), <http://informationr.net/ir/7-3/paper131.html> for some examples of spontaneous unplanned behaviors (e.g., when students "grade" professors for the benefit of other prospective students), or anarchistic behaviors when the participants take control over the persistent structures in the system.

3. The idea was presented in a short paper by Paul Dourish and Michael Chalmers, "Running out of Space: Models of Information Navigation" at the HCI conference in Glasgow, Scotland in 1994. For a later version, see Paul Dourish, "Where the Footprints Lead: Tracking Down Other Roles for Social Navigation," in *Designing Information Spaces*, ed. Kristina Höök et al. (London: Springer, 2003), 273–92.

4. Andreas Dieberger, "Social Connotations of Space in the Design for Virtual Communities and Social Navigation," in *Social Navigation of Information Space*, ed. Alan J. Munro et al. (London: Springer, 1999), 35–54.

5. There is a sound scientific basis for such a "playful" understanding of the way people and information communication technologies interact. Some of the theories that support such an understanding of people and computers include distributed cognition (Hollan James, Edwin Hutchins, and David Kirsch, "Distributed Cognition: Toward a New Foundation for Human-Computer Interaction Research," *ACM Transactions on Computer-Human Interaction* 7, no. 2 (2000): 174–96); social computing (Paul Dourish, *Where the Action Is: The Foundations of Embodied Interaction* (Cambridge, Mass.: MIT Press, 2001.)); experiential cognition (George Lakoff and Mark Johnson, *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought* (New York: HarperCollins, 1999.)) The SN approach also complements other novel design approaches, such as holistic design (Kenneth Maxwell, "The Maturation of HCI: Moving Beyond Usability Toward Holistic Interaction," in *Human-Computer Interaction in the New Millennium*, ed. John M. Carroll, (New York: ACM Press, 2002); or scenario-based design (John M. Carroll, *Making Use: Scenario-Based Design of Human Computer Interactions*, (Cambridge, Mass.: MIT Press, 2000.)).

6. Alan J. Munro, Kristina Höök, and David Benyon, eds., *Social Navigation of Information Space* (London: Springer, 1999).

7. Kristina Höök, David Benyon and Alan J. Munro, eds., *Designing Information Spaces: The Social Navigation Approach* (London: Springer, 2003).

8. Paul Resnik and Hal R. Varian, "Recommender Systems," <http://www.acm.org/pubs/cacm/MAR97/resnick.html>. This is still one of the best introductions to the general issues surrounding recommender systems.

9. See Andreas Geyer-Schultz, Andreas Neumann, and Anke Thede, "Others Also Use: A Robust Recommender System for Scientific Libraries," in *ESDL*, ed T. Koch and L.T.Sølvberg, (Berlin: Springer-Verlag, 2003), 113–25.

10. The overview of CF is based on Joseph A. Konstan and John Riedl, "Collaborative Filtering: Supporting Social Navigation in Large, Crowded Infospaces," in *Designing Information Spaces: The Social Navigation Approach*, ed. Kristina Höök, David Benyon and Alan J. Munro (London,: Springer, 2003), 43–82.

11. For examples of CF systems see Kristina Höök, "Social Navigation System Links" http://www.sics.se/~kia/socnav_links.html She lists the following collaborative filtering systems: Amazon.com, launch.com, movielens.org, movie-critic.com, Phoaks, landsend.com, fancentral.org.

12. See Andreas Geyer-Schultz et al., "Behavior-Based Recommender Systems as Value-Added Services for Scientific Libraries," <http://www.ipd.uni-karlsruhe.de/~mart/presentations/nf02.pdf>.

13. See, for instance, Stuart Middleton, Nigel R. Shadbolt, and David C. De Roure, "Ontological User Profiling in Recommender Systems," *ACM Transactions on Information Systems* 22 no.1 (January 2004): 54–88, which examines the problem of recommending online academic research papers in two experimental systems, Quickstep and Foxtrot. They create user profiles from unobtrusively monitored behavior and relevance feedback, but try to represent the profiles in terms of a research-paper topic ontology rather than users' profiles.

14. See Andreas Geyer-Schultz, Andreas Neumann, and Anke Thede, "An Architecture for Behavior-based Library Recommender Systems," *Information Technology and Libraries* 22, no.4 (Dec. 2003): 165–74. On various algorithms for CF, see Joseph A. Konstan and John Riedl.

15. Raymond Mooney and Loriene Roy, "Content-Based Book Recommending Using Learning for Text Categorization," *Proceedings of DL-00, 5th ACM Conference on Digital Libraries, San Antonio, TX 1999*: 195–204.

16. See Guy Shani, David Heckerman, and Ronen I. Brafman, "An MDP-Based Recommender System," *Journal of Machine Learning Research* 6 (2005): 1265–95.

17. See Yan Zheng Wei, Luc Moreau, and Nicholas R. Jennings, "A Market-Based Approach to Recommender Systems," *ACM Transactions on Information Systems* 23 no.3 (July 2005): 227–66. In fact, they propose a market place in which the various recommendations methods compete.

18. See Mattias Forsberg, Kristina Höök, and Martin Svensson, "Design Principles for Social Navigation Tools," <http://www.sic.se/humle/projects/persona/web/> for six principles of SN design: integration, trust, presence, privacy, ap-

propriateness, and personalization.

19. See Philip Bonhard et al., "Accounting for Taste: Using Profile Similarity to Improve Recommender Systems," *CHI 2006 Proceedings*: 1057–66. They argue that the usefulness of recommender systems can be improved by including more information about the recommender and examine specifically the influence familiarity with the recommender, profile similarity between decision maker and recommender, and ratings overlap with a particular recommender have on the choices of decision makers.

20. Dan Cosley et al., "Is Seeing Believing? How Recommender Interfaces Affect Users' Opinions," *CHI* 5, no.1 (2003): 585–92. They found that users tend to rate towards the predictions the system shows, whether the prediction is accurate or not and that interface design influences the use of recommendations, which questions the widely held belief that large rating systems are self-correcting.

21. These are issues raised by Resnick and Varian in the context of recommender systems in general. They also mention the following concerns: matching people by tastes automatically is far more valuable in a large set of people who may not know each other; personalized aggregation of recommendations is more valuable when people's tastes differ than when there are a few experts; recommender systems need to discourage "free riders" and the manipulated recommendations resulting from the "vote early and often phenomenon," as well as the issue of privacy.

22. Columbia University Library originally developed HILCC for use with electronic resources and is described in S. P. Davis, "HILCC, A Hierarchical Interface to Library of Congress Classification," *Journal of Internet Cataloging* 5, no. 4 (2002):19–49. More information can be found at "Columbia HILCC: A Hierarchical Interface to LC Classification," <http://www.columbia.edu/cu/libraries/inside/projects/metadata/hilcc/>.

23. See Jared Bisogni, Dong-il Steven Ryu, and Yoojin Shin, Library Data Mining Project (Ithaca, N.Y.: School of Operations Research and Industrial Engineering, College of Engineering, Cornell University, 2006).

Bibliography

Bisogni, Jared, Dong-il Steven Ryu and Yoojin Shin. Library Data Mining Project. Ithaca, N.Y.: School of Operations Research and Industrial Engineering, College of Engineering, Cornell University, 2006.

Bonhard, Philip, Clare Harris, John McCarthy, and M. Angela Sasse. "Accounting for Taste: Using Profile Similarity to Improve Recommender Systems." *CHI 2006 Proceedings*: 1057–66.

Carroll, John M. *Making Use: Scenario-Based Design of Hu-*

- man Computer Interactions. Cambridge, Mass.: MIT Press, 2000.
- "Columbia HILCC: A Hierarchical Interface to LC Classification." <http://www.columbia.edu/cu/libraries/inside/projects/metadata/hilcc/> (accessed January 3, 2007).
- Cosley, Dan, Shyong K. Lam, Istvan Albert, Joseph A. Konstan, and John Riedl. "Is Seeing Believing? How Recommender Interfaces Affect Users' Opinions." *CHI* 5 no.1 (2003): 585–92.
- Davis, S.P. "HILCC, A Hierarchical Interface to Library of Congress Classification." *Journal of Internet Cataloging* 5, no. 4 (2002): 19–49.
- Dieberger, Andreas. "Social Connotations of Space in the Design for Virtual Communities and Social Navigation." In *Social Navigation of Information Space*, edited by Alan J. Munro, Kristina Höök, and David Benyon, 35–54. London: Springer, 1999.
- Dourish, Paul. *Where the Action Is: The Foundations of Embodied Interaction*. Cambridge, Mass.: MIT Press, 2001.
- . "Where the Footprints Lead: Tracking Down Other Roles for Social Navigation." In *Designing Information Spaces: The Social Navigation Approach*, edited by Kristina Höök, David Benyon, and Alan J. Munro, 273–92. London: Springer, 2003.
- Forsberg, Mattias, Kristina Höök, and Martin Svensson. "Design Principles for Social Navigation Tools." <http://www.sics.se/humle/projects/persona/web/> (accessed November 24, 2006).
- Geyer-Schultz, Andreas, Andreas Neumann, and Anke Thede. "Others Also Use: A Robust Recommender System for Scientific Libraries." in *ESDL*, edited by T. Koch and L.T. Sølvsberg, 113–25. Berlin: Springer-Verlag, 2003.
- . "An Architecture for Behavior-based Library Recommender Systems." *Information Technology and Libraries* 22, no. 4 (Dec. 2003): 165–74.
- Geyer-Schultz, Andreas, Michael Hahsler, Andreas Neumann, and Anke Thede. "Behavior-Based Recommender Systems as Value-Added Services for Scientific Libraries." C. Warren Neel Conference on Statistical Data Mining & Knowledge Discovery. Knoxville, TN 23 June, 2002. <http://www.ipd.uni-karlsruhe.de/~mart/presentations/nf02.pdf> (accessed December 29, 2006).
- Hollan, James, Edwin Hutchins, and David Kirsch. "Distributed Cognition: Toward a New Foundation for Human-Computer Interaction Research." *ACM Transactions on Computer-Human Interaction* 7, no. 2 (2000): 174–96.
- Höök, Kristina. "Social Navigation System Links." http://www.sics.se/~kia/socnav_links.html (accessed December 17 and 21, 2006).
- Höök, Kristina, Benyon, David, and Alan J. Munro, eds. *Designing Information Spaces: The Social Navigation Approach*. London: Springer, 2003.
- Konstan, Joseph A. and John Riedl. "Collaborative Filtering: Supporting Social Navigation in Large, Crowded Infospaces." In *Designing Information Spaces: The Social Navigation Approach*, edited by Kristina Höök, David Benyon and Alan J. Munro, 43–82. London,; Springer, 2003.
- Lakoff, George and Mark Johnson. *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*. New York: HarperCollins, 1999.
- Maxwell, Kenneth. "The Maturation of HCI: Moving Beyond Usability Toward Holistic Interaction." In *Human-Computer Interaction in the New Millennium*, edited by John M. Carroll. New York: ACM Press, 2002.
- Middleton, Stuart, Nigel R. Shadbolt, and David C. De Roure. "Ontological User Profiling in Recommender Systems." *ACM Transactions on Information Systems* 22 no.1 (January 2004): 54–88.
- Munro, Alan J., Kristina Höök, and David Benyon, eds. *Social Navigation of Information Space*. London: Springer, 1999.
- Mooney, Raymond and Loriene Roy. "Content-Based Book Recommending Using Learning for Text Categorization." *Proceedings of DL-00, 5th ACM Conference on Digital Libraries, San Antonio, TX 1999*: 195–204.
- Resnik, Paul, and Hal R. Varian. "Recommender Systems" <http://www.acm.org/pubs/cacm/MAR97/resnick.html> (accessed December 15, 2006).
- Robins, Jenny. "Affording a Place: The Role of Persistent Structures in Social Navigation." *Information Research* 7, no. 3 (April 2002), <http://informationr.net/ir/7-3/paper131.html> (accessed 30 November, 2006).
- Shani, Guy, David Heckerman, and Ronen I. Brafman. "An MDP-Based Recommender System." *Journal of Machine Learning Research* 6 (2005): 1265–95.
- "Social Navigation" <http://www.sics.se/humle/socialcomputing/kalas/socialNavigation.html> (accessed December 21, 2006).
- Wei, Yan Zheng, Luc Moreau, and Nicholas R. Jennings. "A Market-Based Approach to Recommender Systems." *ACM Transactions on Information Systems* 23 no. 3 (July 2005): 227–66.