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A literature review and classification of recommender systems research

Deuk Hee Park, Hyea Kyeong Kim, Il Young Choi, Jae Kyeong Kim *

Department of Management, School of Management, KyungHee University, 1 Hoeki-Dong, Dongdaemoon-Gu, Seoul 130-701, Republic of Korea

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ABSTRACT

Recommender systems have become an important research field since the emergence of the first paper on collaborative filtering in the mid-1990s. Although academic research on recommender systems has increased significantly over the past 10 years, there are deficiencies in the comprehensive literature review and classification of that research. For that reason, we reviewed 210 articles on recommender systems from 46 journals published between 2001 and 2010, and then classified those by the year of publication, the journals in which they appeared, their application fields, and their data mining techniques. The 210 articles are categorized into eight application fields (books, documents, images, movie, music, shopping, TV programs, and others) and eight data mining techniques (association rule, clustering, decision tree, k-nearest neighbor, link analysis, neural network, regression, and other heuristic methods). Our research provides information about trends in recommender systems research by examining the publication years of the articles, and provides practitioners and researchers with insight and future direction on recommender systems. We hope that this paper helps anyone who is interested in recommender systems research with insight for future research direction.

1. Introduction

Recommender systems have become an important research area since the emergence of the first research paper on collaborative filtering in the mid-1990s (Resnick, Iakovou, Sushak, Bergstrom, & Riedl, 1994; Shardanand & Maes, 1995). In general, recommender systems directly help users to find content, products, or services (such as books, digital products, movies, music, TV programs, and web sites) by aggregating and analyzing suggestions from other users, which mean reviews from various authorities, and users (Frias-Martinez, Chen, & Liu, 2009; Frias-Martinez, Magoulas, Chen, & Macredie, 2006; Kim, Ji, Ha, & Jo, 2010). These systems use analytic technology to compute the probability that a user will purchase one of the products at each place, so that users will receive recommendations for the right products to purchase.

Recommender systems are generally classified into collaborative filtering (CF) and content-based filtering (CB). In general, CF uses an information filtering technique based on the user's previous evaluation of items or history of previous purchases. However, this technique has been known to reveal two major issues: sparsity problem and the scalability problem (Claypool et al., 1999; Sarwar, Karypis, Konstan, & Riedl, 2000a, 2000b). In contrast, CB analyzes a set of documents rated by an individual user and uses the contents of the documents, as well as the provided ratings, to infer a user profile that can be used to recommend additional items of interest (Basu, Hirsh, & Cohen, 1998). However, the syntactic nature of CB, which detects similarities between items that share the same attribute or characteristic, causes overspecialized recommendations that only include items very similar to those of which the user is already aware (Lopez-Nores, Garca-Duque, Frenandez-Vilas, & Bermejo-Munoz, 2008).

Over the last decade, most of researchers have studied new approaches of recommender systems in order to solve these problems of CF and CB, and to implement them into real world situations. Specifically, applying data mining techniques to recommender systems has been effective in providing personalized information to the user by analyzing his or her preferences.

However, more research is needed to be applicable in real world situations because research fields on recommender systems are still broader and less mature than in other research areas. Therefore, the existing articles on recommender systems must be reviewed with an eye toward the next generation of recommender systems, which will improve recommendation methods to offer more useful and appropriate information to users.

In this research, we reviewed and classified articles on recommender systems that were published in academic journals between 2001 and 2010, in order to gain insight on recommender systems. This research is organized as follows:

(1) The research methodology used in this study is reported.
(2) Criteria for classification of research papers on recommender systems are presented.

* Corresponding author. Tel.: +82 2 961 0508.
E-mail address: jaek@khu.ac.kr (J.K. Kim).

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(3) Research papers on recommender systems are analyzed and the results of their classifications are presented.
(4) Conclusions are presented, and the limitations and implications of this study are discussed.

We hope that this research will accentuate the importance of recommender systems and provide researchers and practitioners with insight on recommender systems research.

2. Research methodology

The purpose of this study is to understand the trend of recommender systems research by examining the published articles, and to afford practitioners and academics with insight and future direction on recommender systems.

Hence, we will verify the distribution of research papers on recommender systems by their year of publication, and classify the research papers by the data mining techniques used for recommendation and by the application fields used. However, considering the nature of research on recommender systems, it would be difficult to confine each paper to a specific discipline. Additional proof of this difficulty can be seen from the fact that research papers on recommender systems are scattered across diverse journals such as marketing, information technology, information science, computer science, and management. As a result, it is necessary to compile the increasing number of research papers on recommender systems systematically. The following electronic journal databases were searched to provide a comprehensive bibliography of research papers on recommender systems:

- ABI/INFORM Database;
- ACM Portal;
- EBSCO Academic Search Premier;
- EBSCO Business Source Premier;
- IEEE/IEE Library;
- Science Direct.

The search process of research papers on recommender systems was performed on the top 125 MIS journals. The search was performed based on five descriptors: "Recommender system", "Recommendation system", "Personalization system", "Collaborative filtering", and "Contents filtering". Two authors reviewed the full text of each research paper, and papers that were not truly related to recommender systems were deleted if the two authors agreed to do so. If the authors' opinions were different, another author reviewed the paper and decided whether to delete it or not. The following research papers, set forth in the description below, were excluded because they were unfit for our research:

- Conference papers, master's and doctoral dissertations, textbooks, unpublished working papers, non-English papers, and news articles were eliminated, Unlike these publications, papers published by academic journals are thought to be reliable and worthy of comment, because they are published after peer review.
- Because research on recommender systems is relatively current, we have only searched research articles published between 2001 and the end of 2010. This 10-year period is considered to be representative of recommender systems research.
- Only research papers that described how recommender systems can be applied were chosen.

We selected 210 research papers on recommender systems from 46 journals. Each research papers was prudently reviewed and classified into one of the eight categories in the application fields and data mining techniques. Although the investigation was not exhaustive, it provides as a comprehensive basis for understanding recommender system research.

3. Classification method

Our classification framework consists of recommendation fields and data mining techniques. In this research, we classify the research papers that were reviewed into eight categories of application fields and eight categories of data mining techniques. The overall graphical classification framework for recommender systems research papers is presented in Fig. 1.

3.1. Classification framework for application fields

Many recommender systems have been used to provide users with information to help them decide which products to purchase (Schafer, Joseph, & Riedl, 2001). However, it is not easy to find papers that classify research papers systematically, even though recommender systems have been applied to diverse business areas. Accordingly, it is meaningful to investigate application fields. Our research adopts the basic classification scheme of Schafer et al., 2001, who have classified recommendation applications by real world, such as books, movies, music, shopping and others. We classify research papers by application fields such as books, documents, images, movies, music, shopping, TV programs and others. Through in-depth reviews of research papers, classifying shopping fields involves online, offline, and mobile shopping product, classifying document fields involves papers, blogs and web pages. Also, other fields involve a minority of recommendation fields such as hotel, travel, and food.

3.2. Classification framework for data mining techniques

In general, data mining techniques are defined as extracting or mining knowledge from data. These techniques are used for the exploration and analysis of large quantities of data in order to discover meaningful patterns and rules (Berry & Linoff, 2004). They can be used to lead decision making and to predict the effect of decisions. Significantly, many researchers have used data mining techniques to improve the performance of recommender systems. Consequently, it is meaningful to classify the research papers according to data mining techniques. We widely classified data mining techniques into the following eight categories: association rule, clustering, decision tree, k-nearest neighbor, link analysis, neural network, regression, and other heuristic methods.

(1) *Association rule:* Association rule mining refers to the discovery of all association rules that are above user-specified minimum support and minimum confidence levels. Given a set of transactions in which each transaction contains a set of items, an association rule applies the form $X \Rightarrow Y$, where X and Y are two sets of items (Cho, Kim, & Kim, 2002).
(2) *Clustering:* The clustering method identifies a finite set of categories or clusters to describe data. Among the clustering methods, the most popular are *K*-means and self-organizing map (SOM). *K*-means takes the input parameter, *K*, and partitions a set of n objects into *K* clusters (Berry & Linoff, 2004). SOM is a method for an unsupervised learning, based on an artificial neurons clustering technique (Lihua, Lu, Jing, & Zongyong, 2005).
(3) *Decision tree:* Most popular classification methods are decision tree induction. Decision tree induction techniques build decision trees to label or categorize cases into a set of known

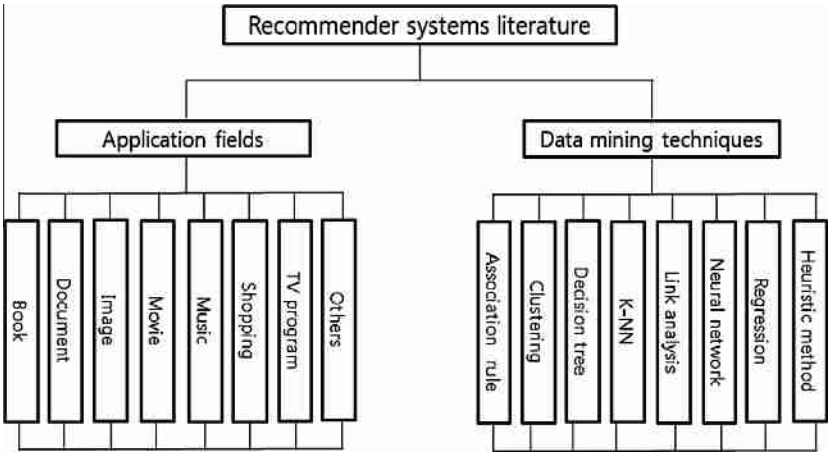

Fig. 1. Classification framework.

classes. The top node in a tree is called as a root node. A decision tree is a tree in which each internal (non-leaf) node represents a test on an attribute, each branch represents an outcome of the test, and each terminal (leaf) node represents a class prediction (Kim, Cho, Kim, Kim, & Suh, 2002).

(4) *k-Nearest* neighbor: The k-NN (k-nearest neighbor) model, a typical traditional CF-based recommender system, makes recommendations according to the following three phases. (1) Recommender systems construct a user profile using the user's preference ratings, which are obtained either directly from explicit ratings of items or indirectly from purchase or usage information. (2) Recommender systems apply statistical or machine learning techniques to discover k users, known as neighbors or recommenders, who in the past have shown similar behaviors. A neighborhood is formed based on the degree of similarity between a mark user and other users. (3) Once a neighborhood is formed for a target user, recommender systems make a top-n item set that the target user is most likely to purchase by analyzing the items in which neighbors have exhibited interest (Kim, Kim, & Ryu, 2009).

(5) *Neural network:* A neural network is a parallel distributed information processing system that is able to learn and self-organize. This system consists of a large number of uncomplicated processing entities which are interconnected to form a network that conducts complex computational tasks (Ibnkahla, 2000). A neural network builds a class of very pliable model that can be used for a diversity of different applications, such as prediction, non-linear regression, or classification (Anders & Korn, 1999).

(6) *Link analysis:* Link analysis discovers relations between domains in large databases. One type of link analysis, social network analysis is a sociological approach for analyzing patterns relationships and interactions between social actors in order to find a fundamental social structure. Also, link analysis has presented great potential in improving the accuracy of web searches. Link analysis consists of PageRank and HITS algorithms. Most link analysis algorithms handle a web page as a single node in the web graph (Cai, He, Wen, & Ma, 2004).

(7) *Regression:* Regression analysis is a powerful process for analyzing associative relationships between dependent variables and one or more independent variables. It has been used for curve fitting, prediction, and testing systematic hypotheses about relationships between variables (Malhotra, 2007).

(8) *Other heuristic methods:* Heuristic methods have been developed by adding new method to existing methods. Heuristic methods include mixture models and the, ontology method.

3.3. Classification process

Each of the selected research papers was reviewed and classified according to the proposed classification framework by two of the four authors of this paper (first team). The other two authors (second team) made a final verification of the classification results. The classification process is composed of the following four steps:

(1) Electronic database search.
(2) Initial classification by one of the two researchers in the first team.
(3) Independent verification of classification results by the other researcher in the first team.
(4) Final verification of classification results discussed by the second team.

The selected criteria and evaluation framework is represented in Fig. 2. The research papers were analyzed by year of publication, by journals in which the research papers were published, and by application fields and data mining techniques.

4. Classification of research papers

We selected a total of 210 research papers from 46 journals and classified them according to the classification framework. The results of our analysis will supply guidelines for future research on recommender systems. The details are described below.

4.1. Distribution by year of publication

The distribution of research papers by year of publication between 2001 and 2010 is shown in Fig. 3. It is apparent that publications related to recommender systems steadily increased between 2000 and 2004, and rapidly increased between 2007 and 2010. The decrease of research papers between 2005 and 2006 is thought to be because recommender systems research apparently extended a new application field between 2005 and 2006. Whereas a majority of recommender systems research between 2005 and 2006 were limited to movie and shopping fields,

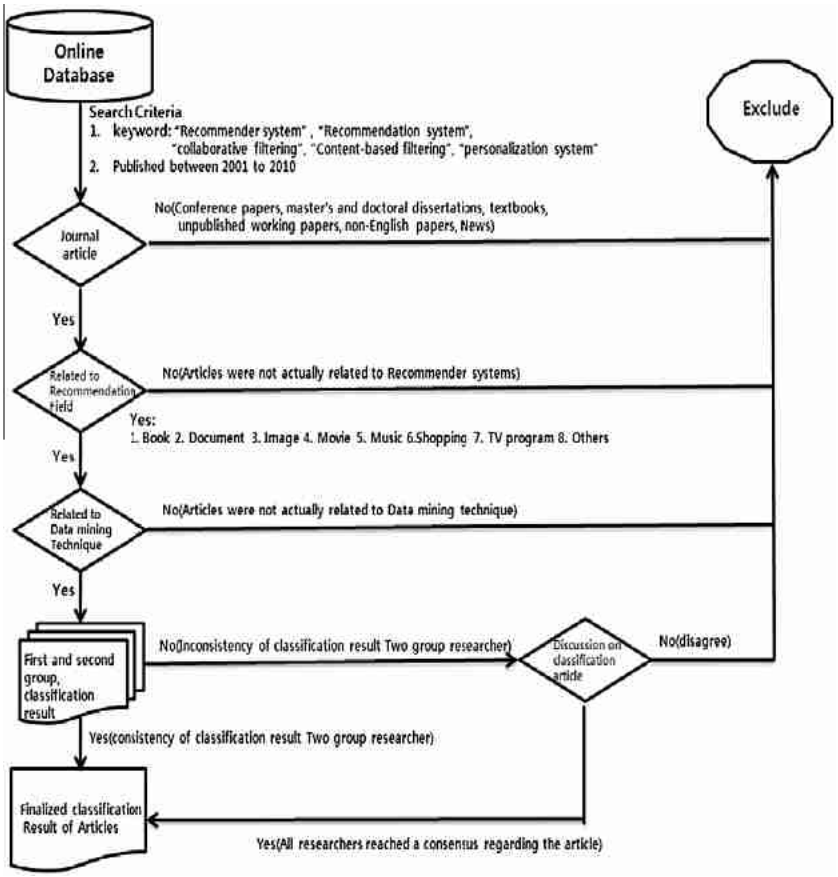

Fig. 2. Selection criteria and evaluation framework.

this research began to extend to other fields such as books, documents, music and other fields in 2007.

4.2. Distribution by journal

Research papers are selected from a total of 46 different journals. Distribution of research papers by journal is presented in Table 1. Expert Systems with Applications published more than 33% (70 out of 210 research papers, or 33.33%) of the total number of research papers. IEEE Intelligent System (21 out of 210 research papers, or 10.00%), along with, Decision Support Systems and ACM Transactions on Information Systems (12 out of 210 research papers, or 5.71%), published the second and third largest percentage of recommender systems-related research papers among the journals. The most research papers were published in Expert Systems with Applications, because this journal focuses on knowledge of the application of expert and intelligent system by industry, governments and universities worldwide (Ngai, Xiu, & Chau, 2009).

4.3. Distribution by application fields and data mining techniques

Distribution of research papers by application fields is represented in Fig. 4. The majority of the research papers were related to movie (53 out of 210 research papers, or 25.2%) and shopping (42 out of 210 research papers, or 20.0%). Because recommender systems in movie and shopping fields have a larger number of practical applications than other fields, it is inferred that although many research papers were published, few of them were related to image fields (7 out of 210 research papers, or 3.3%), and music, and TV program fields (9 out of 210 research papers, or 4.2% respectively). In particular, because the data of MovieLens (www.movielens.org/) are freely accessed, many recommendation methodologies have been proposed and evaluated with MovieLens data, which explains why there is more the recommender systems researches in movie fields than in other fields.

Distribution of research papers by application fields and journal is represented in Table 2. Among the application fields and journals, Expert Systems with Applications included most of the application fields. However, research papers about recommending music and TV programs were usually published in more specific journals. Because music and TV program related papers are usually published at the specific journals.

Distribution of research papers by data mining techniques is shown in Fig. 5, and distribution of the 210 research papers classified by the suggested classification framework is shown in Table 3. Among data mining techniques, the heuristic and k-NN (k-nearest

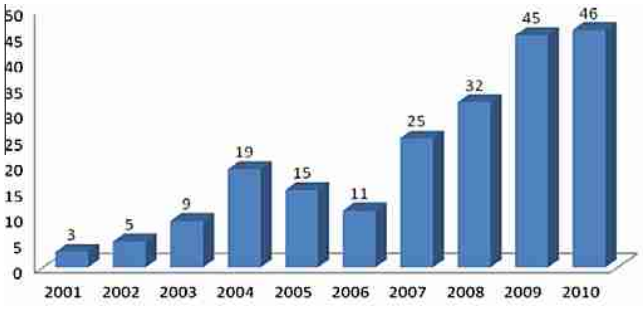

Fig. 3. Distribution of research papers by year of publication.

Table 1
Distribution of research papers by journal in which the research papers were published.

Journal title	Amount	Percentage (%)
Expert Systems with Applications	70	33.33
IEEE Intelligent Systems	21	10.00
ACM Transactions on Information Systems	12	5.71
Decision Support Systems	12	5.71
Knowledge-Based Systems	11	5.24
IEEE Internet Computing	9	4.29
IEEE Transactions on Consumer Electronics	9	4.29
International Journal of Electronic Commerce	7	3.33
Electronic Commerce Research & Applications	6	2.86
IEEE Transactions on Knowledge and Data Engineering	6	2.86
IEEE Transactions on Audio, Speech, and Language Processing	3	1.43
International Journal of Human Computer Studies	3	1.43
Journal of Systems & Software	3	1.43
Behavior & Information Technology	2	0.95
Computers in Human Behavior	2	0.95
Information Processing & Management	2	0.95
IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans	2	0.95
Management Science	2	0.95
ACM Transactions on Computer–Human Interaction	1	0.48
ACM Transactions on Knowledge Discovery from Data	1	0.48
AI Magazine	1	0.48
Communications of the ACM	1	0.48
Computer	1	0.48
Computer Supported Cooperative Work	1	0.48
Computers & Operations Research	1	0.48
Electron Markets	1	0.48
IEEE Circuits and Systems for Video Technology	1	0.48
IEEE Pervasive Computing	1	0.48
IEEE Security & Privacy	1	0.48
IEEE Software	1	0.48
IEEE Spectrum	1	0.48
IEEE Transactions on Fuzzy Systems	1	0.48
IEEE Transactions on Information Forensics and Security	1	0.48
IEEE Transactions on Multimedia	1	0.48
IEEE Transactions on Pattern Analysis and Machine Intelligence	1	0.48
IEEE Transactions on Services Computing	1	0.48
IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews	1	0.48
Information & Management	1	0.48
Information Systems	1	0.48
International Journal of Information Management	1	0.48
International Journal of Technology Management	1	0.48
IT Professional	1	0.48
Journal of Computer Information Systems	1	0.48
Journal of Software Maintenance	1	0.48
Journal of Management Information Systems	1	0.48
Journal of Information Science	1	0.48
Total	210	100.00

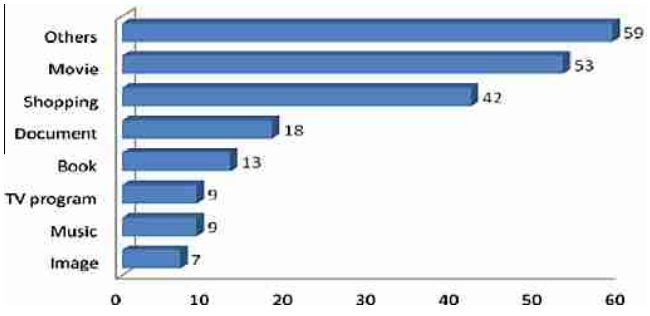

Fig. 4. Distribution of research papers by application fields.

neighbor) models have been used the most often in application fields. Because, the heuristic model is not one method but instead involves adding on new methods to existing diverse methods, it is used to expand advanced research. Also, the CF system is one of the most successful methodologies in recommender systems, and k-NN is a popular type of CF, so k-NN has been applied in most of the application fields.

4.4. Distribution of research papers by publication years and application fields

Distribution of research papers by publication years and application fields is shown in Fig. 6, which shows decreases in most of the application fields during 2006. Until 2006, most recommender systems research was focused on movies and shopping fields. However, the focus of recommender systems research has extended not only to movie and shopping fields, but also to books, documents, music, and other fields beginning in 2007.

4.5. Distribution of research papers by publication years and data mining techniques

Distribution of research papers by publication years and data mining techniques is shown in Fig. 7. Among the data mining techniques, most of the techniques are decreased in 2006, except that the heuristic method increased steadily and reached a peak in 2010. Because the heuristic method is not only one method, but rather involves diverse methods that are not included in other server data mining techniques, its usage has increased annually.

Table 2
Distribution of research papers by recommendation field and journals.

Field	Journal	Amount	
Book	ACM Transactions on Information Systems	2	
	Decision Support Systems	2	
	Electronic Commerce Research & Applications	2	
	IEEE Internet Computing	2	
	Computers in Human Behavior	1	
	Expert Systems with Applications	1	
	International Journal of Information Management	1	
	Knowledge-Based Systems	1	
	Management Science	1	
			13
Document	Expert Systems with Applications	5	
	IEEE Intelligent Systems	3	
	ACM Transactions on Information Systems	2	
	Decision Support Systems	2	
	IEEE Internet Computing	1	
	IEEE Transactions on Information Forensics and Security	1	
	Journal of Computer Information Systems	1	
	Journal of Systems & Software	1	
	Knowledge-Based Systems	1	
	International Journal of Human Computer Studies	1	
			18
Image	Expert Systems with Applications	4	
	Journal of Information Science	1	
	IEEE Intelligent Systems	1	
	IEEE Transactions on Multimedia,	1	
			7
Movie	Expert Systems with Applications	21	
	ACM Transactions on Information Systems	6	
	Knowledge-Based Systems	5	
	International Journal of Electronic Commerce	4	
	IEEE Intelligent Systems	3	
	Electronic Commerce Research & Applications	2	
	IEEE Internet Computing	2	
	IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans	2	
	ACM Transactions on Knowledge Discovery from Data	1	
	Behavior & Information Technology	1	
	Communications of the ACM	1	
	Computer	1	
	Decision Support Systems	1	
	IEEE Circuits and Systems for Video Technology	1	
	IEEE Transactions on Knowledge and Data Engineering	1	
	Information Processing & Management	1	
			53
Music	IEEE Transactions on Audio, Speech, and Language Processing	3	
	Expert Systems with Applications	2	
	ACM Transactions on Information Systems	1	
	IEEE Intelligent Systems	1	
	IEEE Transactions on Consumer Electronics	1	
	Information Processing & Management	1	
			9
Others	Expert Systems with Applications	22	
	IEEE Intelligent Systems	8	
	IEEE Transactions on Knowledge and Data Engineering	5	
	Decision Support Systems	4	
	IEEE Internet Computing	3	
	IEEE Transactions on Consumer Electronics	3	
	International Journal of Electronic Commerce	2	
	Computer Supported Cooperative Work	1	
	Electron Markets	1	
	IEEE Pervasive Computing	1	
	IEEE Security & Privacy	1	
	IEEE Software	1	
	IEEE Spectrum	1	
	IEEE Transactions on Fuzzy Systems	1	
	IEEE Transactions on Pattern Analysis and Machine Intelligence	1	
	IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews	1	
	IT Professional	1	
	Knowledge-Based Systems	1	
	Management Science	1	
			59
Shopping	Expert Systems with Applications	14	
	IEEE Intelligent Systems	5	

Table 2 (*continued*)

Field	Journal	Amount	
	Decision Support Systems	3	
	Electronic Commerce Research & Applications	2	
	International Journal of Human Computer Studies	2	
	Knowledge-Based Systems	2	
	ACM Transaction on Computer–Human Interaction	1	
	ACM Transactions on Information Systems	1	
	AI Magazine	1	
	Behavior & Information Technology	1	
	Computers & Operations Research	1	
	IEEE Transactions on Consumer Electronics	1	
	IEEE Transactions on Services Computing	1	
	Information & Management	1	
	Information Systems	1	
	International Journal of Electronic Commerce	1	
	International Journal of Technology Management	1	
	Journal of Software Maintenance	1	
	Journal of Systems & Software	1	
	Journal of Management Information Systems	1	
			42
TV program	IEEE Transactions on Consumer Electronics	4	
	Computers in Human Behavior	1	
	Expert Systems with Applications	1	
	IEEE Internet Computing	1	
	Journal of Systems & Software	1	
	Knowledge-Based Systems	1	
			9
Total			210

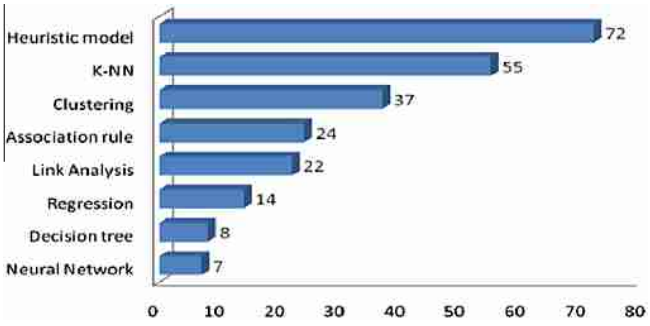

Fig. 5. Distribution of research papers by data mining techniques.

Based on their previous rates of change, more heuristic methods are expected to be used significantly in the future.

5. Conclusion, research implication and future work

Recommender systems have attracted the attention of academics and practitioners. In this research, we have identified 210 research papers on recommender systems, which were published between 2001 and 2010, to understand the trend of recommender systems-related research and to provide practitioners and researchers with insight and future direction on recommender systems. The results represented in this paper have several significant implications:

- Based on previous publication rates, interest in recommender systems related research will grow significantly in the future.
- Fifty-three research papers were related to movie recommendations, whereas image recommendations were identified in only seven research papers. Image field, and Music, and TV program recommendations were identified in nine research papers respectively. Therefore, more research is required to for image, music and TV program recommendations. This result was due to the easy use of the MovieLens data set. Therefore, it looks to be necessary to prepare data sets in other fields.
- Among the 210 research papers, 55 research papers used k-NN and 72 research papers have used heuristic models in the recommender system domain. k-NN creates applied user profile using the user's preference ratings obtained either directly from the user's explicit ratings of items or indirectly from the user's purchase or usage information. Therefore, it is not surprising that the k-NN method has been used in an extensive range of recommender systems domains. Also, because the heuristic model is not a single method, but one that consist of existing diverse methods, its use will be increased.
- Research papers using clustering and association rule techniques rank behind k-NN. From this, we know that both clustering and association rule techniques have been widely used in real business application than other techniques.
- Recently, social network analysis has been used in various applications. However studies on recommender systems using social network analysis are still deficient. Henceforth, we expect that new recommendation approaches using social network analysis will be developed. Therefore, developing the recommendation system research using social network analysis will be an interesting area further research.
- The number of heuristic methods is increasing every year. This result has been caused by the many researchers developing new methodologies and mixed technique model.
- Our research is significant because the majority of recommender systems research has been published in 125 MIS journals, such as ACM, IEEE publications. However, recommender systems research has shifted from the MIS field to various business fields, so we expect to see more recommender systems research published in management and business journals.

Our classification model will provide the practitioner and academic with guideline for future research on recommender systems. However our research has the following limitations: First,

Table 3
Distribution of research papers by application fields and journals.

Recommendation field	Data mining techniques	Reference
Book	Heuristic model	Riedl (2001)
	Clustering	Linden, Smith, and York (2003)
	k-NN	McSherry (2004)
	Link analysis	Huang, Chen, and Zeng (2004)
	Link analysis	Huang, Zeng, and Chen (2007a, 2007b)
	Link analysis	Ziegler and Golbec (2007)
	Regression	Hernández del Olmo and Gaudioso (2008)
	Clustering	Rosaci, Sarné, and Garruzzo (2009)
	k-NN, heuristic model	Kim, Kim, Oh, and Ryu (2010)
	Association rule, k-NN	Kim et al. (2010)
	Heuristic model, link analysis	Hwang, Wei, and Liao (2010)
	Heuristic model	Crespo et al. (2010)
Document	k-NN, neural network, regression	Lee, Hui, and Fong (2002)
	Association rule, clustering	Wang and Shao (2004)
	Heuristic model	Middleton, Shadbolt, and De Roure (2004)
	Clustering, neural network	Lihua et al. (2005)
	Heuristic model	Melamed, Shapira, and Elovici (2007)
	Link analysis	Liang, Yang, Chen, and Ku (2008)
	Heuristic model	Weng and Chang (2008)
	Clustering	Wei, Yang, and Hsiao (2008)
	k-NN, regression	Tang and McCalla (2009)
	Clustering	Lai and Liu (2009)
	Association rule, clustering, Link analysis	Göksedef and Gündüz-Öğüdücü (2010)
	Heuristic model	Champin, Briggs, Coyle and Smyth (2010)
	Heuristic model	Moens, De Beer, Boiy, and Gomez (2010)
	Clustering, heuristic model	Jalali, Mustapha, Sulaiman, and Mamat (2010)
	Link analysis	Dell'Amico and Capra (2010)
Image	Heuristic model	Kwon (2003)
	Heuristic model	Kim, Lee, Cho, and Kim (2004)
	Heuristic model	Boutemedjet and Ziou (2008)
	k-NN	Lee, Park, and Park (2008)
	k-NN, link analysis	Kim, Kim, and Cho (2008)
	k-NN	Lee, Park, and Park (2009)
	Heuristic model, k-NN	Nan Zheng, Li, Liao, and Zhang (2010)
Movie	k-NN	Naren, Benjamin, Batul, Ananth, and George (2001)
	Association rule	Herlocker and Konstan (2001)
	Association rule, decision tree, k-NN	Cheung, Kwok, Law, and Tsui (2003)
	Clustering, k-NN	Roh, Oh, and Han (2003)
	Clustering	Cheung, Tsui, and Liu (2004)
	k-NN	Han, Xie, Yang, and Shen (2004)
	Clustering, k-NN	Weng and Liu (2004)
	k-NN	Zeng, Xing, Zhou, and Zheng (2004)
	k-NN	Herlocker, Konstan, Terveen, and Riedl (2004)
	Link analysis	Miller, Konstan, and Riedl (2004)
	Clustering, k-NN	Min and Han (2005)
	k-NN	Li, Lu, and Xuefeng (2005)
	Clustering	Kim and Yum (2005)
	Regression	Lee, Jun, Lee, and Kim (2005)
	Heuristic model	Adomavicius, Sankaranarayanan, Sen, and Tuzhilin (2005)
	Heuristic model	Salter and Antonopoulos (2006)
	Association rule, k-NN	Du Boucher-Ryan and Bridge (2006)
	Heuristic model	Prangl, Szkaliczki, and Hellwagner (2007)
	k-NN	Hurley, O'Mahony and Silvestre (2007)
	Heuristic model	Im and Hars (2007)
	Clustering, k-NN	Symeonidis, Nanopoulos, and Manolopoulos (2008)
	k-NN	Symeonidis, Nanopoulos, Papadopoulos, and Manolopoulos (2008)
	k-NN	Chen, Cheng, and Chuang (2008)
	Association rule	Leung, Chan, and Chung (2008)
	Heuristic model	Russell and Yoon (2008)
	k-NN	Lee and Olafsson (2009)
	k-NN	Jeong, Lee, and Cho (2009a)
	k-NN	Jeong, Lee, and Cho (2009b)
	Clustering, k-NN	Merve and Arslan (2009)
	k-NN	Koren, Bell, and Volinsky (2009)
	k-NN	Chen, Wang, and Zhang (2009)
	Clustering	Kwon, Cho, and Park (2009)
	Heuristic model	Cho, Kwon, and Park (2009)
	Heuristic model	Yang and Li (2009)
	k-NN	Bobadilla, Serradilla, and Hernando (2009)
	Heuristic model	Julià, Sappa, Lumbreras, Serrat, and López (2009)
	Heuristic model	Koren (2010a)
	Heuristic model	Winoto and Tang (2010)
	Heuristic model	Ahn, Kang, and Lee (2010)

Table 3 (*continued*)

Recommendation field	Data mining techniques	Reference
	Heuristic model, link analysis, regression	Hwang (2010)
	k-NN	Bobadilla, Serradilla, and Bernal (2010)
	Regression	Ozok, Fan, and Norcio (2010)
	Heuristic model, k-NN	Koren (2010b)
Music	k-NN	Ganesan, Garcia-Molina, and Widom (2003)
	Clustering, regression	Zhu, Shi, Kim, and Eom (2006)
	Clustering	Li, Myaeng, and Kim (2007)
	Association rule, k-NN	Yoshii, Goto, Komatani, Ogata, and Okuno (2008)
	Link analysis	Shao, Ogihara, Wang, and Li (2009)
	Clustering, heuristic model	Su, Yeh, Yu, and Tseng (2010)
	Heuristic model	Nanopoulos, Rafailidis, Symeonidis, and Manolopoulos (2010)
	Clustering, neural network	Liu, Hsieh, and Tsai (2010)
Others	Heuristic model	Taab, Werther, Ricci, Zipf, and Gretzel (2002)
	Neural network	Yuan and Tsao (2003)
	Clustering	Chau, Zeng, Chen, Huang, and Hendriawan (2003)
	Heuristic model	Yang, Knoblock, and Wu (2004)
	Heuristic model	Adomavicius and Tuzhilin (2005)
	Heuristic model	Wei, Moreau, and Jennings (2005a)
	Clustering	Ha (2006)
	Heuristic model	McGinty and Smyth (2006)
	Heuristic model	Park, Kang, and Kim (2006)
	Regression	Gretzel and Fesenmaier (2006)
	Heuristic model	Alexander, Gerhard, and Lars (2007)
	Link analysis	Reichling, Veith, and Wulf (2007)
	Association rule	Adda, Valtchev, Missaoui, and Djeraba (2007)
	Clustering, neural network	Martín-Guerrero, Lisboa, Soria-Olivas, Palomares, and Balaguer (2007)
	k-NN, regression	Lee, Ahn, and Han (2007)
	Clustering	Lee and Park (2007)
	Heuristic model	Adomavicius and Kwon (2007)
	Heuristic model	Ricci and Nguyen (2007)
	Link analysis	Zeng, Wang, Zheng, Yuan, and Chen (2008)
	Heuristic model	Lin (2008)
	Heuristic model	Liang (2008)
	Heuristic model	Hernández del Olmo and Gaudioso (2008)
	Link analysis	Malinowski, Weitzel, and Keim (2008)
	Clustering	Linden (2008)
	Regression	Moon and Russell (2008)
	Association rule, k-NN	Hsu (2008)
	Link analysis	Wang and Chiu (2008)
	Decision tree , k-NN	Hernández del Olmo, Gaudioso, and Martin (2009)
	Heuristic model	Hsu (2009)
	Heuristic model	Schiaffino and Amandi (2009)
	Heuristic model	Porcel, López-Herrera, and Herrera-Viedma (2009a)
	Heuristic model	Zhen, Huang, and Jiang (2009a)
	Decision tree	Wang, Chiang, Hsu, Lin, and Lin (2009)
	Association rule	Yang and Wang (2009)
	Heuristic model	Porcel, Moreno, and Herrera-Viedma (2009b)
	Link analysis	Arazy, Kumar, and Shapira (2009)
	Heuristic model	Zhen, Huang, and Jiang (2009b)
	Heuristic model	Kim, Jeong, and Baik (2009)
	Heuristic model, neural network	Han and Chen (2009)
	Heuristic model	Lesk (2009)
	Association rule, Clustering, regression	Kwon and Kim (2009)
	Association rule, k-NN	Schiaffino and Amandi (2009)
	Link analysis	Li and Kao (2009)
	Link analysis	Kuo, Chen, and Liang (2009)
	Heuristic model	Symeonidis, Nanopoulos, and Manolopoulos (2010)
	Heuristic model	Pillonetto, Dinuzzo, and De Nicolao (2010)
	Heuristic model	Zhen, Huang, and Jiang (2010)
	Heuristic model	Jalali et al. (2010)
	Heuristic model	Porcel and Herrera-Viedma (2010)
	Heuristic model	Zhan et al. (2010)
	Heuristic model, k-NN	Munoz-Organero, Ramíez-González, Muñoz-Merino, and Kloos (2010)
	Heuristic model, k-NN	Blanco-Fernandez, Lopez-Nores, Pazos-Arias, Gil-Solla, and Ramos-Cabrer (2010)
	Heuristic model	Yager, Reformat, and Gumrah (2010)
	Heuristic model	Bergamaschi, Guerra, and Leiba (2010)
	Heuristic model	Backhaus et al. (2010)
	Link analysis, regression	Kato, Kashima, Sugiyama, and Asai (2010)
Shopping	Association rule, decision tree	Kim et al. (2002)
	Association rule, decision tree	Cho, Kim & Kim (2002)
	Association rule, clustering	Ha (2002)
	k-NN	Vezina and Militaru (2004)
	Regression	Ant Ozok, Quyin, and Norcio (2004)
	Association rule, k-NN	Wang, Chuang, Hsu, and Keh (2004)

(*continued on next page*)

Table 3 (*continued*)

Recommendation field	Data mining techniques	Reference
	k-NN	Cho and Kim (2004)
	Association rule, k-NN	Liu and Shih (2005a)
	Association rule, k-NN	Liu and Shih (2005b)
	Association rule, clustering	Cho, Cho & Kim (2005)
	k-NN, regression	Kim, Yum, Song, and Kim (2005)
	Decision tree	Yu, Ou, Zhang, and Zhang (2005)
	Heuristic model	Wei, Moreau, and Jennings (2005b)
	Clustering	Choi, Kang, and Jeon (2006)
	Heuristic model	Garfinkel, Gopal, Tripathi, and Yin (2006)
	k-NN	Zanker, Jannach, Gordea, and Jessenitschnig (2007)
	Association rule	Zhang and Jiao (2007)
	Association rule	Pu and Chen (2007)
	Clustering, link analysis	Wang, Dai, and Yuan (2008b)
	Clustering	Kim and Ahn (2008)
	Association rule, k-NN	Wang and Wu (2009)
	k-NN	Albadvi and Shahbazi (2009)
	Heuristic model	Pu and Chen (2009)
	k-NN	Kim et al. (2009)
	Association rule, k-NN	Robillard and Dagenais (2009)
	Heuristic model	Moosavi, Nematbakhsh, and Farsani (2009)
	Heuristic model	Martin-Vicente, Gil-Solla, Ramos-Cabrer, Blanco-Fernandez, and Lopez-Nores (2010)
	Heuristic model	Ochi, Rao, Takayama and Nass (2010)
	Heuristic model	Funk, Rozinat, Karapanos, Alves de Medeiros, and Koca (2010)
	Link analysis	Yuan, Guan, Lee, Lee, and Hur (2010)
	Heuristic model	Taha and Elmasri (2010)
	Heuristic model, k-NN	Wang and Wu (2010)
	Heuristic model	Pathak, Garfinkel, Gopal, Venkatesan, and Yin (2010)
	Association rule, heuristic model	Chen and Pu (2010)
TV program	Decision tree	Lee and Yang (2003)
	Heuristic model, link analysis	Blanco-Fernandez, Pazos-arias, Gil-Solla, Ramos-Cabrer, and Lopez-Nores (2008)
	Heuristic model, k-NN	Martinez et al. (2010)
	Heuristic model, k-NN	Martin-Vicente et al. (2010)
	Clustering, heuristic model	Cantador and Castells (2010)

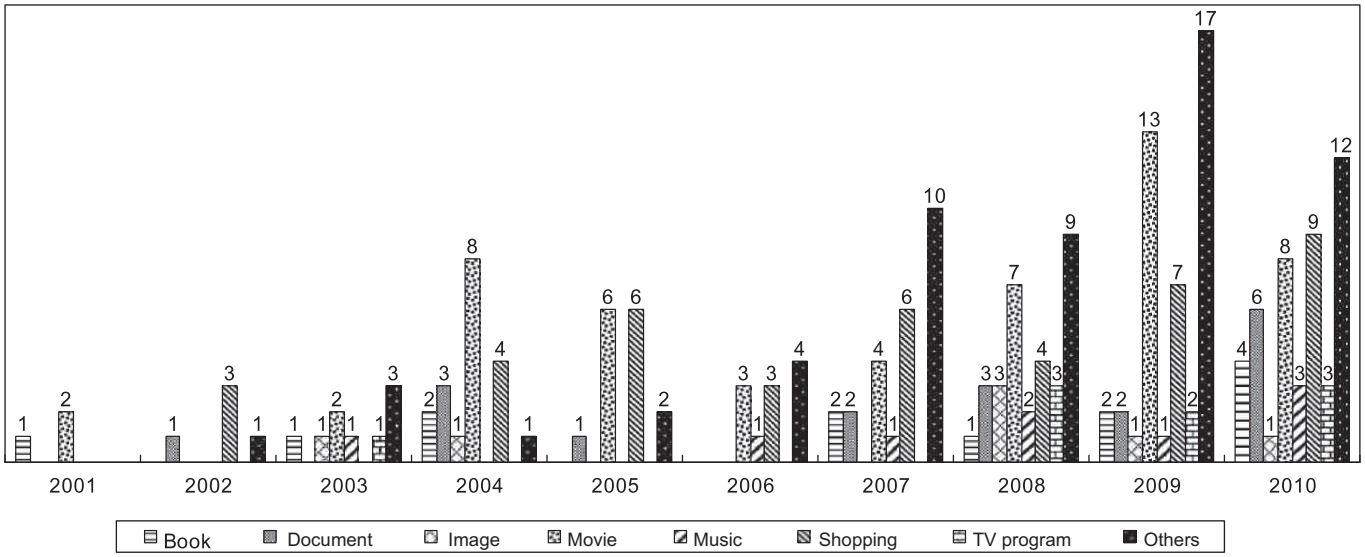

Fig. 6. Distribution of research papers by publication year and application fields.

due to the limitations of time and manpower, we only surveyed research papers published between 2001 and 2010, and our searches were based on the top 125 MIS. Therefore, if the research had been extended to cover other journals such as those focused on computer science and, marketing, the results might have been different. Second, our findings are based on articles that were selected solely from academic journals. If articles from conferences had been included, the results would have been more diverse. Third, our study was conducted based on a search of the following keywords: "Recommender system", "Recommendation system", "Personalization system", "Collaborative filtering", and "Contents filtering". Besides these five keywords, we did not search additional keywords, such as "Hybrid Filtering". Research papers that referred to recommender systems, but did not include any of the five key-words, could not be extracted. We think that recommender systems research also has been published in other lan-

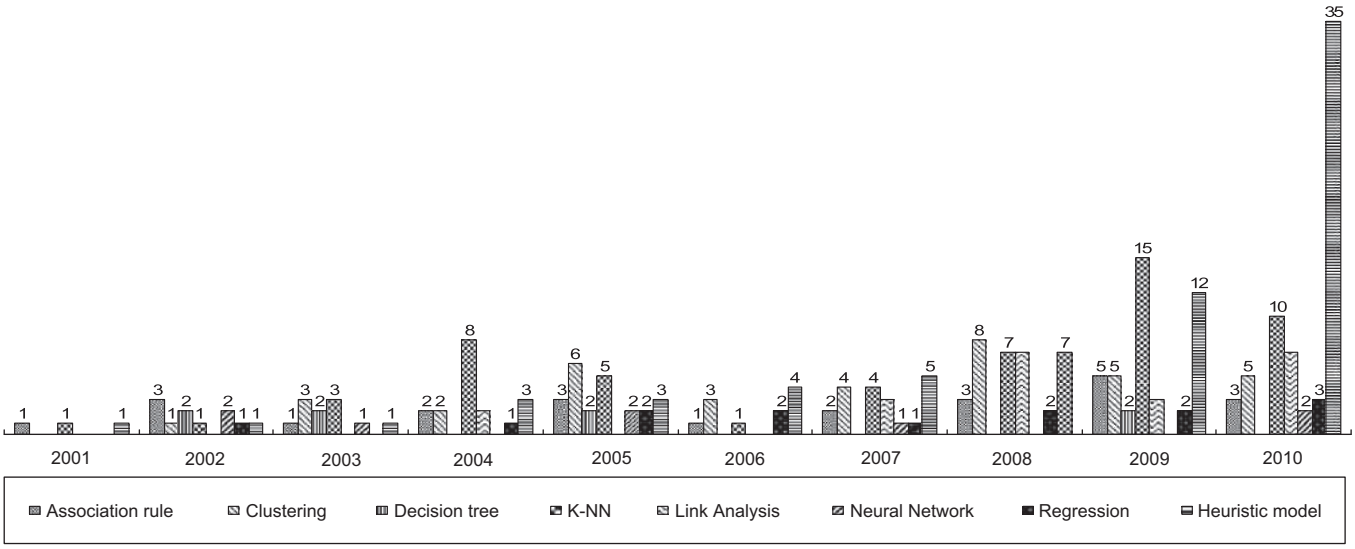

Fig. 7. Distribution of research papers by publication year and data mining technique.

guages. Finally, we classified data mining techniques, but not data mining model.

Accordingly, we will continue to classify articles on an ongoing basis. Moreover, it is also necessary to include conference papers and non-English papers in order to extend our classification model.

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Reference

Adda, M., Valtchev, P., Missaoui, R., & Djeraba, C. (2007). Toward recommendation based on ontology-powered web-usage mining. *IEEE Internet Computing, 11*, 45–52.

Adomavicius, G., & Kwon, Y. O. (2007). New recommendation techniques for multicriteria rating systems. *IEEE Intelligent Systems, 22*, 48–55.

Adomavicius, G., Sankaranarayanan, R., Sen, S., & Tuzhilin, A. (2005). Incorporating contextual information in recommender systems using a multidimensional approach. *ACM Transactions on Information Systems, 23*, 103–145.

Adomavicius, G., & Tuzhilin, A. (2005). Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions. *IEEE Transactions on Knowledge and Data Engineering, 6*, 734–749.

Ahn, H. J., Kang, H. J., & Lee, J. P. (2010). Selecting a small number of products for effective user profiling in collaborative filtering. *Expert Systems with Applications, 37*, 3055–3062.

Albadvi, A., & Shahbazi, M. (2009). A hybrid recommendation technique based on product category attributes. *Expert Systems with Applications, 36*, 11480–11488.

Alexander, F., Gerhard, F., & Lars, S. T. (2007). Guest editors' introduction: Recommender systems. *IEEE Intelligent Systems, 22*, 18–21.

Anders, U., & Korn, O. (1999). Model Selection in Neural Networks. *Neural Networks, 12*, 309–323.

Ant Ozok, A., Quyin Fan & Norcio, Anthony F. (2004). Design guidelines for effective recommender system interfaces based on a usability criteria conceptual model: results from a college student population. *Behaviour & Information Technology*.

Arazy, O., Kumar, N., & Shapira, B. (2009). Improving social recommender Systems. *IT Professional, 11*, 38–44.

Backhaus, K., Frohs, M., Weddeling, M., Steiner, M., Becker, J., & Beverungen, D. (2010). Enabling individualized recommendations and dynamic pricing of value-added services through willingness-to-pay data. *Electron Markets, 20*, 131–146.

Basu, C., Hirsh, H., & Cohen, W. (1998). Recommendation as classification : Using social and content-based information in recommendation, *In Proceedings of the 15th National Conference on, Artificial Intelligence*, 714–720.

Bergamaschi, S., Guerra, F., & Leiba, B. (2010). Guest editors' introduction: Information overload. *IEEE Internet Computing, 14*, 10–13.

Berry, M. J. A., & Linoff, J. S. (2004). *Data Mining Techniques for Marketing. Sales and Customer Relationship Management* (2nd ed.,). Wiley.

Blanco-Fernandez, Y., Pazos-arias, J. J., Gil-Solla, A., Ramos-Cabrer, M., & Lopez-Nores, M. (2008). Providing entertainment by content-based filtering and semantic reasoning in intelligent recommender systems. *IEEE Transactions on Consumer Electronics, 54*, 727–735.

Blanco-Fernandez, Y., Lopez-Nores, M., Pazos-Arias, J. J., Gil-Solla, A., & Ramos-Cabrer, M. (2010). Exploiting digital TV users' preferences in a tourism recommender system based on semantic reasoning. *IEEE Transactions on Consumer Electronics, 56*, 904–912.

Bobadilla, J., Serradilla, F., & Hernando, A. (2009). Collaborative filtering adapted to recommender systems of e-learning. *Knowledge-Based Systems, 22*, 261–265.

Bobadilla, J., Serradilla, F., & Bernal, J. (2010). A new collaborative filtering metric that improves the behavior of recommender systems. *Knowledge-Based Systems, 23*, 520–528.

Boutemedjet, S., & Ziou, D. (2008). A Graphical model for context-aware visual content recommendation. *IEEE Transactions on Multimedia, 10*, 52–62.

Cai, D., He, X., Wen, J.R., & Ma, W.Y. (2004). Block-level link analysis, *Proceedings of the 27th annual international ACM SIGIR conference on Research and development in, information retrieval*, 440–447.

Champin, P. A., Briggs, P., Coyle, M., & Smyth, B. (2010). Coping with noisy search experiences. *Knowledge-Based Systems, 23*, 287–294.

Cantador, I., & Castells, P. (2010). Extracting multilayered communities of interest from semantic user profiles: Application to group modeling and hybrid recommendations. *Computers in Human Behavior, 27*, 1321–1336.

Chau, M., Zeng, D., Chen, H., Huang, M., & Hendriawan, D. (2003). Design and evaluation of a multi-agent collaborative Web mining system. *Decision Support Systems, 25*, 167–183.

Chen, G., Wang, F., & Zhang, C. (2009). Collaborative filtering using orthogonal nonnegative matrix tri-factorization. *Information Processing & Management, 45*, 368–379.

Chen, L., & Pu, P. (2010). Experiments on the preference-based organization interface in recommender systems. *ACM Transaction on Computer-Human Interaction, 17*, 1–33.

Chen, Y. L., Cheng, L. C., & Chuang, C. N. (2008). A group recommendation system with consideration of interactions among group members. *Expert Systems with Applications, 34*, 2082–2090.

Cheung, K. W., Kwok, J. T., Law, M. H., & Tsui, K. C. (2003). Mining customer product ratings for personalized marketing. *Decision Support Systems, 35*, 231–243.

Cheung, K. W., Tsui, K. C., & Liu, J. (2004). Extended latent class models for collaborative recommendation. *IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans, 34*, 143–148.

Cho, J. H., Kwon, K. S., & Park, Y. T. (2009). Q-rater: A collaborative reputation system based on source credibility theory. *Expert Systems with Applications, 36*, 3751–3760.

Cho, Y. B., Cho, Y. H., & Kim, S. H. (2005). Mining changes in customer buying behavior for collaborative recommendations. *Expert Systems with Applications, 28*, 359–369.

Cho, Y. H., Kim, J. K., & Kim, S. H. (2002). A personalized recommender system based on web usage mining and decision tree induction. *Expert Systems with Applications, 23*, 329–342.

Cho, Y. H., & Kim, J. K. (2004). Application of web usage mining and product taxonomy to collaborative recommendations in e-commerce. *Expert Systems with Applications, 26*, 233–246.

Choi, S. H., Kang, S. M., & Jeon, Y. J. (2006). Personalized recommendation system based on product specification values. *Expert Systems with Applications, 31*, 607–616.

Claypool, M., Gokhale, A., Miranda, T., Murnikov, P., Netes, D., & Sartin, M. (1999). Combining content-based and collaborative filters in an online newspaper, *Proceedings of the ACM SIGIR'99 Workshop on Recommender Systems*.

Crespo, R. G., Martínez, O. S., Lovelle, J. M. C., García-Bustelo, B. C. P., Gayo, J. E. L., & de Pablos, P. O. (2010). Recommendation system based on user interaction data applied to intelligent electronic books. *Computers in Human Behavior, 27*, 1445–1449.

Dell'Amico, M., & Capra, L. (2010). Dependable filtering: Philosophy and realizations. *ACM Transactions on Information Systems, 29*, 1–37.

Du Boucher-Ryan, P., & Bridge, D. (2006). Collaborative recommending using formal concept analysis. *Knowledge-Based Systems, 19*, 309–315.

Frias-Martinez, E., Chen, S. Y., & Liu, X. (2009). Evaluation of a personalized digital library based on cognitive styles: Adaptivity vs. adaptability. *International Journal of Information Management, 29*, 48–56.

Frias-Martinez, E., Magoulas, G., Chen, S. Y., & Macredie, R. (2006). Automated user modeling for personalized digital libraries. *International Journal of Information Management, 26*, 234–248.

Funk, M., Rozinat, A., Karapanos, E., Alves de Medeiros, A. K., & Koca, A. (2010). In situ evaluation of recommender systems: Framework and instrumentation. *International Journal of Human – Computer Studies, 68*, 525–547.

Ganesan, P., Garcia-Molina, H., & Widom, J. (2003). Exploiting hierarchical domain structure to compute similarity. *ACM Transactions on Information Systems, 21*, 64–93.

Garfinkel, R., Gopal, R., Tripathi, A., & Yin, F. (2006). Design of a shopbot and recommender system for bundle purchases. *Decision Support Systems, 42*, 1974–1986.

Göksedef, M., & Gündüz-Öğüdücü, S. (2010). Combination of web page recommender systems. *Expert Systems with Applications, 37*, 2911–2922.

Gretzel, U., & Fesenmaier, D. R. (2006). Persuasion in recommender systems. *International Journal of Electronic Commerce, 11*, 81–100.

Ha, S. H. (2002). Helping online customers decide through web personalization. *IEEE Intelligent Systems, 17*, 34–43.

Ha, S. H. (2006). Digital content recommender on the Internet. *IEEE Intelligent Systems, 2*, 70–77.

Han, L., & Chen, G. (2009). HQE: A hybrid method for query expansion. *Expert Systems with Applications, 36*, 7985–7991.

Han, P., Xie, B., Yang, F., & Shen, R. (2004). A scalable P2P recommender system based on distributed collaborative filtering. *Expert Systems with Applications, 27*, 203–210.

Herlocker, J. L., & Konstan, J. A. (2001). Content-independent task-focused recommendation. *IEEE Internet Computing, 5*, 40–47.

Herlocker, J. L., Konstan, J. A., Terveen, L. G., & Riedl, J. (2004). Evaluating collaborative filtering recommender systems. *ACM Transactions on Information Systems, 22*, 5–53.

Hernández del Olmo, F., & Gaudioso, E. (2008). Evaluation of recommender systems: A new approach. *Expert Systems with Applications, 35*, 790–804.

Hernández del Olmo, F., Gaudioso, E., & Martin, E. H. (2009). The task of guiding in adaptive recommender systems. *Expert Systems with Applications, 36*, 1972–1977.

Hsu, I. C. (2009). SXRS: An XLink-based recommender system using semantic web technologies. *Expert Systems with Applications, 36*, 3795–3804.

Hsu, M. H. (2008). A personalized English learning recommender system for ESL students. *Expert Systems with Applications, 34*, 683–688.

Huang, Z., Chen, H., & Zeng, D. (2004). Applying associative retrieval techniques to alleviate the sparsity problem in collaborative filtering. *ACM Transactions on Information Systems, 22*, 116–142.

Huang, Z., Zeng, D., & Chen, H. (2007a). A comparison of collaborative-filtering recommendation algorithms for e-commerce. *IEEE Intelligent Systems, 22*, 68–78.

Huang, Z., Zeng, D. D., & Chen, H. (2007b). Analyzing consumer-product graphs: Empirical findings and applications in recommender systems. *Management Science, 53*, 1146–1164.

Hurley, N. J., O'Mahony, M. P., & Silvestre, G. C. M. (2007). Attacking recommender systems: a cost-benefit analysis. *IEEE Intelligent Systems, 22*, 64–68.

Hwang, S. H., Wei, C. P., & Liao, Y. F. (2010). Coauthorship networks and academic literature recommendation. *Electronic Commerce Research and Applications, 9*, 323–334.

Hwang, S. L. (2010). Designing utility-based recommender systems for e-commerce: Evaluation of preference-elicitation methods. *Electronic Commerce Research and Applications*.

Ibnkahla, M. (2000). Applications of neural networks to digital communications-a survey. *Expert Systems with Applications, 80*, 1185–1215.

Im, I., & Hars, A. (2007). Does a one-size recommendation system fit all? the effectiveness of collaborative filtering based recommendation systems across different domains and search modes. *ACM Transactions on Information Systems, 26*, 1–30.

Jalali, M., Mustapha, N., Sulaiman, M., & Mamat, A. (2010). Corrigendum to "WebPUM: A web-based recommendation system to predict user future movements. *Expert Systems with Applications, 37*, 6201–6212.

Jeong, B., Lee, J. W., & Cho, H. B. (2009a). User credit-based collaborative filtering. *Expert Systems with Applications, 36*, 7309–7312.

Jeong, B., Lee, J. W., & Cho, H. B. (2009b). An iterative semi-explicit rating method for building collaborative recommender systems. *Expert Systems with Applications, 36*, 6181–6186.

Julià, C., Sappa, A. D., Lumbreras, F., Serrat, J., & López, A. (2009). Predicting missing ratings in recommender systems: Adapted factorization approach. *International Journal of Electronic Commerce, 14*, 89–108.

Kato, T., Kashima, H., Sugiyama, M., & Asai, K. (2010). Conic programming for multitask learning. *IEEE Transactions on Knowledge and Data Engineering*.

Kim, C. Y., Lee, J. K., Cho, Y. H., & Kim, D. H. (2004). VISCORS: a visual-content recommender for the mobile web. *IEEE Intelligent Systems, 19*, 32–39.

Kim, D. H., & Yum, B. J. (2005). Collaborative filtering based on iterative principal component analysis. *Expert Systems with Applications, 28*, 823–830.

Kim, H. K., Kim, J. K., & Ryu, Y. U. (2009). Personalized recommendation over a customer network for ubiquitous shopping. *IEEE Transactions on Services Computing, 2*, 140–151.

Kim, H. N., Ji, A. T., Ha, I., & Jo, J. S. (2010). Collaborative filtering based on collaborative tagging for enhancing the quality of recommendation. *Electronic Commerce Research and Applications, 9*, 73–83.

Kim, J. H., Jeong, D. W., & Baik, D. K. (2009). Ontology-based semantic recommendation system in home network environment. *IEEE Transactions on Consumer Electronics, 55*, 1178–1184.

Kim, J. K., Cho, Y. H., Kim, W. J., Kim, J. R., & Suh, J. H. (2002). A personalized recommendation procedure for internet shopping support. *Electronic Commerce Research and Applications, 1*, 301–313.

Kim, J. K., Kim, H. K., & Cho, Y. H. (2008). A user-oriented contents recommendation system in peer-to-peer architecture. *Expert Systems with Applications, 34*, 300–312.

Kim, J. K., Kim, H. K., Oh, H. Y., & Ryu, Y. U. (2010). A group recommendation system for online communities. *International Journal of Information Management, 30*, 212–219.

Kim, K. J., & Ahn, H. C. (2008). A recommender system using GA K-means clustering in an online shopping market. *Expert Systems with Applications, 34*, 1200–1209.

Kim, Y. S., Yum, B. J., Song, J. H., & Kim, S. M. (2005). Development of a recommender system based on navigational and behavioral patterns of customers in e-commerce sites. *Expert Systems with Applications, 28*, 381–393.

Koren, Y. (2010a). Collaborative filtering with temporal dynamics. *Communications of the ACM, 53*.

Koren, Y. (2010b). Factor in the neighbors: Scalable and accurate collaborative filtering. *ACM Transactions on Knowledge Discovery from Data, 4*, 1–24.

Koren, Y., Bell, R., & Volinsky, C. (2009). Matrix factorization techniques for recommender systems. *Computer, 42*, 30–37.

Kuo, M. H., Chen, L. C., & Liang, C. W. (2009). Building and evaluating a location-based service recommendation system with a preference adjustment mechanism. *Expert Systems with Applications, 36*, 3543–3554.

Kwon, K. S., Cho, J. H., & Park, Y. T. (2009). Multidimensional credibility model for neighbor selection in collaborative recommendation. *Expert Systems with Applications, 36*, 7114–7122.

Kwon, O. B. (2003). "I know what you need to buy": context-aware multimedia-based recommendation system. *Expert Systems with Applications, 25*, 387–400.

Kwon, O. B., & Kim, J. H. (2009). Concept lattices for visualizing and generating user profiles for context-aware service recommendations. *Expert Systems with Applications, 36*, 1893–1902.

Lai, C. H., & Liu, D. R. (2009). Integrating knowledge flow mining and collaborative filtering to support document recommendation. *Journal of Systems and Software, 82*, 2023–2037.

Lee, H. J., & Park, S. J. (2007). MONERS: A news recommender for the mobile web. *Expert Systems with Applications, 32*, 143–150.

Lee, H. Y., Ahn, H. C., & Han, I. G. (2007). VCR: Virtual community recommender using the technology acceptance model and the user's needs type. *Expert Systems with Applications, 33*, 984–995.

Lee, J. S., Jun, C. H., Lee, J. W., & Kim, S. Y. (2005). Classification-based collaborative filtering using market basket data. *Expert Systems with Applications, 29*, 700–704.

Lee, J. S., & Olafsson, S. (2009). Two-way cooperative prediction for collaborative filtering recommendations. *Expert Systems with Applications, 36*, 5353–5361.

Lee, P. Y., Hui, S. C., & Fong, A. C. M. (2002). Neural networks for web content filtering. *IEEE Intelligent Systems, 17*, 48–57.

Lee, T. Q., Park, Y., & Park, Y. T. (2008). A time-based approach to effective recommender systems using implicit feedback. *Expert Systems with Applications, 34*, 3055–3062.

Lee, T. Q., Park, Y., & Park, Y. T. (2009). An empirical study on effectiveness of temporal information as implicit ratings. *Expert Systems with Applications, 36*, 1315–1321.

Lee, W. P., & Yang, T. H. (2003). Personalizing information appliances: a multi-agent framework for TV program recommendations. *Expert Systems with Applications, 25*, 331–341.

Lesk, M. (2009). Reading over your shoulder. *IEEE Security & Privacy, 7*, 78–81.

Leung, C. W., Chan, S. C., & Chung, F. (2008). An empirical study of a cross-level association rule mining approach to cold-start recommendations. *Knowledge-Based Systems, 21*, 515–529.

Li, Q., Myaeng, S. H., & Kim, B. M. (2007). A probabilistic music recommender considering user opinions and audio features. *Information Processing & Management, 43*, 473–487.

Li, Y., Lu, L., & Xuefeng, L. (2005). A hybrid collaborative filtering method for multiple-interests and multiple-content recommendation in E-Commerce. *Expert Systems with Applications, 28*, 67–77.

Li, Y. M., & Kao, C. P. (2009). TREPPS: A Trust-based recommender system for peer production services. *Expert Systems with Applications, 36*, 3263–3277.

Liang, T. P. (2008). Recommendation systems for decision support: An editorial introduction. *Decision Support Systems, 45*, 385–386.

Liang, T. P., Yang, Y. F., Chen, D. N., & Ku, Y. C. (2008). A semantic-expansion approach to personalized knowledge recommendation. *Decision Support Systems, 45*, 401–412.

Lihua, W., Lu, L., Jing, L., & Zongyong, L. (2005). Modeling user multiple interests by an improved GCS approach. *Expert Systems with Applications, 29*, 757–767.

Lin, K. J. (2008). E-commerce technology: back to a prominent future. *IEEE Internet Computing, 12*, 60–65.

Linden, G. (2008). People who read this article also read.... *IEEE Spectrum, 5*.

Linden, G., Smith, B., & York, J. (2003). Amazon.com recommendations: Item-to-item collaborative filtering. *IEEE Internet Computing, 7*, 76–80.

Liu, N. H., Hsieh, S. J., & Tsai, C. F. (2010). An intelligent music playlist generator based on the time parameter with artificial neural networks. *Expert Systems with Applications, 37*, 2815–2825.

Liu, D. R., & Shih, Y. Y. (2005a). Integrating AHP and data mining for product recommendation based on customer lifetime value. *Information & Management, 42*, 387–400.

Liu, D. R., & Shih, Y. Y. (2005b). Hybrid approaches to product recommendation based on customer lifetime value and purchase preferences. *Journal of Systems & Software, 77*, 181–191.

Lopez-Nores, M., Garca-Duque, J., Frenandez-Vilas, R. P., & Bermejo-Munoz, J. (2008). A flexible semantic inference methodology to reason about user preference in knowledge-based recommender systems. *Knowledge-Based systems, 21*, 305–320.

Malhotra, N. K. (2007). *Marketing research: An applied orientation* (5th ed.). Pearson Education Inc.

Malinowski, J., Weitzel, T., & Keim, T. (2008). Decision support for team staffing: An automated relational recommendation approach. *Decision Support Systems, 45*, 429–447.

Martinez, A. B. B., Lopez, M. R., Montenegro, E. C., Fonte, F. A. M., Burguillo, J. C., & Peleterio, A. (2010). Exploiting social tagging in a Web 2.0 recommender system. *IEEE Internet Computing, 14*, 23–30.

Martín-Guerrero, J. D., Lisboa, P. J. G., Soria-Olivas, E., Palomares, A., & Balaguer, E. (2007). An approach based on the Adaptive Resonance Theory for analysing the viability of recommender systems in a citizen Web portal. *Expert Systems with Applications, 33*, 743–753.

Martin-Vicente, M. I., Gil-Solla, A., Ramos-Cabrer, M., Blanco-Fernandez, Y., & Lopez-Nores, M. (2010). A semantic approach to avoiding fake neighborhoods in collaborative recommendation of coupons through digital TV. *IEEE Transactions on Consumer Electronics, 56*, 54–62.

McSherry, D. (2004). Balancing user satisfaction and cognitive load in coverage-optimised retrieval. *Knowledge-Based Systems, 17*, 113–119.

McGinty, L., & Smyth, B. (2006). Adaptive selection: An analysis of critiquing and preference-based feedback in conversational recommender systems. *International Journal of Electronic Commerce, 11*, 35–57.

Melamed, D., Shapira, B., & Elovici, Y. (2007). MarCol: A market-based recommender system. *IEEE Intelligent Systems, 22*, 74–78.

Merve, Acilar. A., & Arslan, A. (2009). A collaborative filtering method based on artificial immune network. *Expert Systems with Applications, 36*, 8324–8332.

Middleton, S. E., Shadbolt, N. R., & De Roure, D. C. (2004). Ontological user profiling in recommender systems. *ACM Transactions on Information Systems, 22*, 54–88.

Miller, B. N., Konstan, J. A., & Riedl, J. (2004). PocketLens: Toward a personal recommender system. *ACM Transactions on Information Systems, 22*, 437–476.

Min, S. H., & Han, I. G. (2005). Detection of the customer time-variant pattern for improving recommender systems. *Expert Systems with Applications, 28*, 189–199.

Moens, M. F., De Beer, J., Boiy, E., & Gomez, J. C. (2010). Identifying and resolving hidden Text salting. *IEEE Transactions on Information Forensics and Security, 5*, 837–847.

Moon, S. K., & Russell, G. J. (2008). Predicting product purchase from inferred customer similarity: An autologistic model approach. *Management Science, 54*, 71–82.

Moosavi, S., Nematbakhsh, M., & Farsani, H. K. (2009). A semantic complement to enhance electronic market. *Expert Systems with Applications, 36*, 5768–5774.

Munoz-Organero, M., Ramíez-González, G. A., Muñoz-Merino, P. J., & Kloos, C. D. (2010). A collaborative recommender system based on space-time similarities. *IEEE Pervasive Computing, 9*, 81–87.

Nanopoulos, A., Rafailidis, D., Symeonidis, P., & Manolopoulos, Y. (2010). MusicBox: personalized music recommendation based on cubic Analysis of social tags. *IEEE Transactions on Audio, Speech, and Language Processing, 18*, 407–412.

Naren, R., Benjamin, J. K., Batul, J. M., Ananth, Y. G., & George, K. (2001). Privacy risks in recommender systems. *IEEE Internet Computing, 5*, 54–62.

Ngai, E. W. T., Xiu, L., & Chau, D. C. K. (2009). Application of data mining techniques in customer relationship management: A literature review and classification. *Expert Systems with Applications, 36*, 2592–2602.

Ochi, P., Rao, S., Takayama, L., & Nass, C. (2010). Predictors of user perceptions of web recommender systems: How the basis for generating experience and search product recommendations affect user response. *International Journal of Human – Computer Studies, 68*, 472–482.

Ozok, A. A., Fan, Q., & Norcio, A. F. (2010). Design guidelines for effective recommender system interfaces based on a usability criteria conceptual model: results from a college. *Behaviour & Information Technology, 29*, 57–83.

Park, S. J., Kang, S. G., & Kim, Y. K. (2006). A channel recommendation system in mobile environment. *IEEE Transactions on Consumer Electronics, 52*, 33–39.

Pathak, B., Garfinkel, R., Gopal, R. D., Venkatesan, R., & Yin, F. (2010). Empirical analysis of the impact of recommender systems on sales. *Journal of Management Information Systems, 27*, 159–188.

Pillonetto, G., Dinuzzo, F., & De Nicolao, G. (2010). Bayesian online multitask learning of gaussian processes. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 32*, 193–205.

Porcel, C., & Herrera-Viedma, E. (2010). Dealing with incomplete information in a fuzzy linguistic recommender system to disseminate information in university digital libraries. *Knowledge-Based Systems, 23*, 32–39.

Porcel, C., López-Herrera, A. G., & Herrera-Viedma, E. (2009a). A recommender system for research resources based on fuzzy linguistic modeling. *Expert Systems with Applications, 36*, 5173–5183.

Porcel, C., Moreno, J. M., & Herrera-Viedma, E. (2009b). A multi-disciplinar recommender system to advice research resources in university digital libraries. *Expert Systems with Applications, 36*, 12520–12528.

Prangl, M., Szkaliczki, T., & Hellwagner, H. (2007). A framework for utility-based multimedia adaptation. *IEEE Circuits and Systems for Video Technology, 17*, 719–728.

Pu, P., & Chen, L. (2007). Trust-inspiring explanation interfaces for recommender systems. *Knowledge-Based Systems, 20*, 542–556.

Pu, P., & Chen, L. (2009). User-involved preference elicitation for product search and recommender systems. *AI Magazine, 29*, 93–104.

Reichling, T., Veith, M., & Wulf, V. (2007). Expert recommender: Designing for a network organization. *Computer Supported Cooperative Work, 16*, 431–465.

Resnick, P., Iakovou, N., Sushak, M., Bergstrom, P., & Riedl, J. (1994). GroupLens: An open architecture for collaborative filtering of netnews. *Computer Supported Cooperative Work Conf.*

Ricci, F., & Nguyen, Q. N. (2007). Acquiring and revising preferences in a critique-based mobile recommender system. *IEEE Intelligent Systems, 22*, 22–29.

Riedl, J. (2001). Personalization and privacy. *IEEE Internet Computing, 5*, 29–31.

Robillard, M. P., & Dagenais, B. (2009). Recommending change clusters to support software investigation: an empirical study. *Journal of software maintenance, 22*, 143–164.

Roh, T. H., Oh, K. J., & Han, I. G. (2003). The collaborative filtering recommendation based on SOM cluster-indexing CBR. *Expert Systems with Applications, 25*, 413–423.

Rosaci, D., Sarné, G. M. L., & Garruzzo, S. (2009). MUADDIB: A distributed recommender system supporting device adaptivity. *ACM Transactions on Information Systems, 27*, 1–41.

Russell, S., & Yoon, V. (2008). Applications of wavelet data reduction in a recommender system. *Expert Systems with Applications, 34*, 2316–2325.

Schafer, J. B., Joseph, A., & Riedl, J. (2001). E-commerce recommendation applications. *Data Mining and Knowledge Discovery, 5*, 115–153.

Schiaffino, S., & Amandi, A. (2009). Building an expert travel agent as a software agent. *Expert Systems with Applications, 36*, 1291–1299.

Salter, J., & Antonopoulos, N. (2006). Cinema screen recommender agent: combining collaborative and content-based filtering. *IEEE Intelligent Systems, 21*, 35–41.

Sarwar, B., Karypis, G., Konstan, J. A., & Riedl, J. (2000a). Application of dimensionality reduction in recommender system- a case study. *Proceedings of the ACM WebKDD-2000 Workshop*.

Sarwar, B., Karypis, G., Konstan, J. A., & Riedl, J. (2000b). Analysis of recommendation algorithms for e-commerce. *Proceedings of the ACM E-Commerce*, 158–167.

Shao, B., Ogihara, M., Wang, D., & Li, T. (2009). Music recommendation based on acoustic features and user access patterns. *IEEE Transactions on Audio, Speech, and Language Processing, 17*, 1602–1611.

Shardanand, U., & Maes, P. (1995). Social information filtering: Algorithms for automating 'Word of Mouth'. *Human Factors in Computing Systems Conf.*

Su, J. H., Yeh, H. H., Yu, P. S., & Tseng, V. S. (2010). Music recommendation using content and context information mining. *IEEE Intelligent Systems, 25*, 16–26.

Symeonidis, P., Nanopoulos, A., & Manolopoulos, Y. (2008). Providing justifications in recommender systems. *IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans, 38*, 1262–1272.

Symeonidis, P., Nanopoulos, A., & Manolopoulos, Y. (2010). A unified framework for providing recommendations in social tagging systems based on ternary semantic analysis. *IEEE Transactions on Knowledge and Data Engineering, 22*, 179–192.

Symeonidis, P., Nanopoulos, A., Papadopoulos, A. N., & Manolopoulos, Y. (2008). Collaborative recommender systems: Combining effectiveness and efficiency. *Expert Systems with Applications, 34*, 2995–3013.

Taab, S., Werther, H., Ricci, F., Zipf, A., & Gretzel, U. (2002). Intelligent systems for tourism. *IEEE Intelligent Systems, 6*, 53–66.

Taha, K., & Elmasri, R. (2010). SPGProfile: Speak group profile. *Information Systems, 35*, 774–790.

Tang, T. Y., & McCalla, G. (2009). A multidimensional paper recommender: Experiments and evaluations. *IEEE Internet Computing, 13*, 34–41.

Wang, H. F., & Wu, C. T. (2009). A mathematical model for product selection strategies in a recommender system. *Expert Systems with Applications, 36*, 7299–7308.

Wang, H. F., & Wu, C. T. (2010). A strategy-oriented operation module for recommender systems in E-commerce. *Computers & Operations Research, 39*, 1837–1849.

Wang, F. H., & Shao, H. M. (2004). Effective personalized recommendation based on time-framed navigation clustering and association mining. *Expert Systems with Applications, 27*, 365–377.
Wang, J. C., & Chiu, C. C. (2008). Recommending trusted online auction sellers using social network analysis. *Expert Systems with Applications, 34*, 1666–1679.
Wang, Y., Dai, W., & Yuan, Y. (2008). Website browsing aid: A navigation graph-based recommendation system. *Decision Support Systems, 45*, 387–400.
Wang, Y. F., Chuang, Y. L., Hsu, M. H., & Keh, H. C. (2004). A personalized recommender system for the cosmetic business. *Expert Systems with Applications, 26*, 427–434.
Wang, Y. F., Chiang, D. A., Hsu, M. H., Lin, C. J., & Lin, I. L. (2009). A recommender system to avoid customer churn: A case study. *Expert Systems with Applications, 36*, 8071–8075.
Wei, C. P., Yang, C. S., & Hsiao, H. W. (2008). A collaborative filtering-based approach to personalized document clustering. *Decision Support Systems, 45*, 413–428.
Wei, Y. Z., Moreau, L., & Jennings, N. R. (2005a). A market-based approach to recommender systems. *ACM Transactions on Information Systems, 23*, 227–266.
Wei, Y. Z., Moreau, L., & Jennings, N. R. (2005b). Learning users' interests by quality classification in market-based recommender systems. *IEEE Transactions on Knowledge and Data Engineering, 17*, 1678–1688.
Weng, S. S., & Chang, H. L. (2008). Using ontology network analysis for research document recommendation. *Expert Systems with Applications, 34*, 1857–1869.
Weng, S. S., & Liu, M. J. (2004). Feature-based recommendations for one-to-one marketing. *Expert Systems with Applications, 26*, 493–508.
Winoto, P., & Tang, T. Y. (2010). The role of user mood in movie recommendations. *Expert Systems with Applications, 37*, 6086–6092.
Vezina, R., & Militaru, D. (2004). Collaborative filtering: theoretical positions and a research agenda in marketing. *International Journal of Technology Management, 28*, 31–45.
Yager, R. R., Reformat, M. Z., & Gumrah, G. (2010). WebPET: An online tool for lexicographic decision making. *IEEE intelligent systems, 25*, 76–83.
Yang, H. L., & Wang, C. S. (2009). Recommender system for software project planning one application of revised CBR algorithm. *Expert Systems with Applications, 36*, 8938–8945.
Yang, J. M., & Li, K. F. (2009). Recommendation based on rational inferences in collaborative filtering. *Knowledge-Based Systems, 22*, 105–114.
Yang, Q., Knoblock, C. A., & Wu, X. (2004). Guest editors' introduction: mining actionable knowledge on the web. *IEEE Intelligent Systems, 19*, 30–31.
Yoshii, K., Goto, M., Komatani, K., Ogata, T., & Okuno, H. G. (2008). An efficient hybrid music recommender system using an incrementally trainable probabilistic generative model. *IEEE Transactions on Audio, Speech, and Language Processing, 16*, 435–447.
Yu, J. X., Ou, Y., Zhang, C., & Zhang, S. (2005). Identifying interesting visitors through Web log classification. *IEEE Intelligent Systems, 20*, 55–59.
Yuan, S. T., & Tsao, Y. W. (2003). A recommendation mechanism for contextualized mobile advertising. *Expert Systems with Applications, 29*, 399–414.
Yuan, W., Guan, D., Lee, Y. K., Lee, S. Y., & Hur, S. J. (2010). Improved trust-aware recommender system using small-worldness of trust networks. *Knowledge-Based Systems, 23*, 232–238.
Zanker, M., Jannach, D., Gordea, S., & Jessenitschnig, M. (2007). Comparing recommendation strategies in a commercial context. *IEEE Intelligent Systems, 22*, 69–73.
Zeng, C., Xing, C. X., Zhou, L. Z., & Zheng, X. H. (2004). Similarity measure and instance selection for collaborative filtering. *International Journal of Electronic Commerce, 8*, 115–129.
Zeng, D., Wang, F. U., Zheng, X., Yuan, Y., & Chen, J. (2008). Intelligent-commerce research in china. *IEEE Intelligent Systems, 23*, 14–18.
Zhan, J., Hsieh, C. L., Wang, I. C., Hsu, T. S., Liau, C. J., & Wang, D. W. (2010). Privacy-preserving collaborative recommender systems. *IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews, 40*, 472–476.
Zhang, Y., & Jiao, J. (2007). An associative classification-based recommendation system for personalization in B2C e-commerce applications. *Expert Systems with Applications, 33*, 357–367.
Zhen, L., Huang, G. Q., & Jiang, Z. (2009a). Collaborative filtering based on workflow space. *Expert Systems with Applications, 36*, 7873–7881.
Zhen, L., Huang, G. Q., & Jiang, Z. (2009b). Recommender system based on workflow. *Decision Support Systems, 48*, 237–245.
Zhen, L., Huang, G. Q., & Jiang, Z. (2010). An inner-enterprise knowledge recommender system. *Expert Systems with Applications, 37*, 1703–1712.
Zheng, N., Li, Q., Liao, S., & Zhang, L. (2010). Which photo groups should I choose? A comparative study of recommendation algorithms in Flickr. *Journal of Information Science, 36*, 733–750.
Zhu, X., Shi, Y. Y., Kim, H. G., & Eom, K. W. (2006). An integrated music recommendation system. *IEEE Transactions on Consumer Electronics, 52*, 917–925.
Ziegler, C. N., & Golbec, J. (2007). Investigating interactions of trust and interest similarity. *Decision Support Systems, 43*, 460–475.