An Analysis of Research on Information Reuse and Integration

Min-Yuh Day [1, 2], Chorng-Shyong Ong [1], and Wen-Lian Hsu [2,*], *Fellow, IEEE*
[1] *Department of Information Management , National Taiwan University, Taiwan*
[2] *Institute of Information Science, Academia Sinica, Taiwan*
{myday, hsu}@iis.sinica.edu.tw; ongcs@im.ntu.edu.tw

Abstract

Information Reuse and Integration (IRI) plays a pivotal role in the capture, representation, maintenance, integration, validation, and extrapolation of information. Both information and knowledge are applied to enhance decision-making in various application domains. The objective of this paper is to provide a summary and analysis of research devoted to advancing the field of information reuse and integration. To this end, we identify the most popular research topics, together with the most productive researchers and institutions associated with the majority of research publications of the International Conference on Information Reuse and Integration during the past six years (2003-2008). Based on those publications, we have identified the most popular research topics, as well as the top researchers and institutions in the field of Information Reuse and Integration.

Keywords: Content Analysis; Information Reuse and Integration; IRI Topics; Meta Analysis

1. Introduction

The study of Information Reuse and Integration (IRI) is a relatively new research area; thus, an analysis of the latest literature would be useful to show what researchers are doing and what can be done to improve our approach [7]. This paper analyzes articles published by the IEEE International Conference on Information Reuse and Integration between 2003 and 2008. Specifically, we consider topics, authors, and institutions.

IRI research can be broadly categorized into application development, IRI theory building, and the study of reference disciplines. Since IRI applications are the outcomes of IRI research activities, it is important to periodically survey IRI applications to monitor progress in the field as a basis for setting the direction of future research. Through this survey, our intention is to inform both academicians and practitioners about the areas in which IRI applications are reported, as well as to provide insight into major historical trends, the implications of this study, and future directions for new theoretical developments [8]. We also provide a comprehensive reference list of literature on IRI.

The International Conference on Information Reuse and Integration (IRI) is currently sponsored by the IEEE Systems, Man, & Cybernetics Society. The first Information Reuse and Integration (IRI) conference was held in 1999. IEEE IRI 2003, 2004, 2005, 2007, 2008 were held in Las Vegas, and IRI 2006 was held in Waikoloa, Hawaii, USA. Since it started in 2003, IEEE-IRI has become a major, highly respected international conference. The proceedings of the IEEE IRI are indexed and included in IEEE Xplore, DBLP, Scopus, and EI.

We selected IRI conferences over other sources, such as computer science (CS) journals and other CS conferences for a number of reasons. First, we consider IEEE IRI to be the most prestigious international conference in the field of IRI. For example, IRI consistently receives more than 200 submissions from researchers all over the world (IRI 2007), and it has become the primary forum for IRI researchers to interact, communicate, and demonstrate their research. Second, as a conference, IRI has a faster turnaround time than journals, i.e., its review process is much shorter than that of CS journals [24]. As a result, papers published in IRI can report new ideas and thoughts, the latest research directions, and up-to-date research results in a timely manner.

Our objective is to provide a summary and analysis of research that advances the field of information reuse and integration. To this end, we identify the most popular research topics, together with the most productive researchers and institutions associated with the majority of research publications of the International Conference on Information Reuse and Integration during the past six years (2003-2008). Based on a detailed analysis of those publications, we have identified the most popular research topics, as well as the top researchers and institutions in the field of Information Reuse and Integration. In the following, we discuss our findings and the implications of the study.

The remainder of this paper is organized as follows. In Section 2, we present a brief introduction of the background of this research. Section 3 describes the research methods and data used in this study. In Section 4, we provide the

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results of our analysis and discuss their implications. Finally, in Section 5, we summarize our conclusions and consider future research avenues.

2. Research Background

We review prior related work on literature-based discipline assessment [3, 4, 20, 21, 24, 25]. Two major approaches are used to assess a scientific discipline based on the literature data: classification and citation analysis.

The classification approach categorizes the literature along different dimensions, such as topics and research methods [13, 19-21]. For example, Glass et al. [13] presented an analysis of research in the computing disciplines. They break the computing field down into the three most common academic subdivisions: computer science (CS), software engineering (SE), and information systems (IS). Vessey et al. [21] proposed a unified classification system for research in the computing disciplines that also consists of three computing disciplines, namely CS, SE, and IS. In addition, they introduced a multi-faced system based on five research-focused characteristics: topic, approach, method, unit of analysis, and reference discipline. Similarly, in the software engineering (SE) field, Glass [11] have provided an annual series of assessments of systems and software engineering scholars and institutions since 1994 [11-14]. Claver et al. [7] analyzed the articles published in the MIS Quarterly and Information & Management journals between 1981 and 1997 based on the most frequent topics, research methods, and top authors. Palvia et al. [17] identified the most productive authors and universities associated with the majority of research publications in Information & Management between 1992 and 2005. Arnott and Pervan [2] presented eight key issues for the decision support systems discipline by performing content analysis of 1093 DSS articles published in 14 major journals from 1990 to 2004.

The citation analysis approach is a bibliometric perspective that generates and analyzes networks of related papers (or authors) based on literature citation information [4, 10, 22, 23]. This approach, which has been used in several studies to measure the quality of journals and conferences [4, 10], is often used to study the research specialties and the intellectual structure of a wide range of scientific disciplines such as economics [16], computer science [5], and information science [22]. It has also been used to evaluate the productivity and reputation of individual researchers, academic programs and institutions, and journals [15]. For example, Chan et al. [4] adopted a citation analysis approach to identify information systems citation patterns based on a three-year (2000-2002) set of International Conference on Information Systems (ICIS) articles. They provide the citation ranking of journals and conferences in the IS research area. In contrast to US-based conferences like ICIS, Whitley and Galliers [23] presented an alternative perspective on citation data from the first 10 years of the European Conference on Information Systems (ECIS).

Literature-based discipline assessment can be conducted by an automatic approach [18] or as a manual process [24]. Ren and Taylor [18] provided an automatic and versatile framework to support publications ranking for research institutions and scholars, but it is not suitable for the classification approach, i.e., topic classification. Hence, most literature-based discipline assessments have been conducted via a manual process.

Numerous works have examined the topics addressed in IS research [1, 6, 7, 9, 19] as well as the sub-fields of IS research, for example, human computer interaction [25] and decision support systems [2, 8]. However, to the best of our knowledge, the topics addressed in IRI research have received little attention. To fill this gap in the literature, we consider the following research questions:

RQ1: What are the most popular research topics in IRI?

RQ2: Who are the most productive researchers in the IRI research community?

RQ3: Which institutions are the most productive in IRI?

3. Method

Researchers have used two major approaches to assess the state of the IS field empirically [20, 24]. The first approach is based on classification studies that code categories of interest, typically topics and research methods, either manually or by using keywords [1, 6, 9]. The second approach is based on citation studies, which examine references to cited articles. It has been used almost exclusively to assess the degree of reliance of IS on other disciplinary areas [4]. Because we wished to conduct a comprehensive study of the diversity of IRI research, we adopted the classification approach in this study. To answer the above research questions, we analyzed research papers published by IRI conferences over the past six years (2003-2008).

Our analysis of IRI literature was based on the study of the IEEE International Conference on Information Reuse and Integration (IEEE IRI). The main reason for this decision was that IEEE IRI is a well established conference that focuses on research in the IRI area.

To compile an IRI literature list, we used two well-known online data sources: IEEE Xplore and DBLP. The data sources supply the following information about each article: title, authors, title of conference, year of publication, number of pages, keywords and Abstract. IEEE INSPEC

provides affiliation information about the first author. We consider that this information is sufficient for our study, at least for the classification of articles belonging to one subject or topic and for identifying the authors.

We developed a simple web focused crawler program to download literature information for all IRI papers published between 2003 and 2008 from IEEE Xplore and DBLP. We only included research papers; keynotes and panel discussions were excluded.

After downloading all the data, we integrated the literature information in a spreadsheet. During data processing, we found some inconsistencies in the data provided by IEEE Xplore and DBLP. First, some authors' names were inconsistent; for example, the name "Stuart Harvey Rubin" (cited 14 times) was sometimes written as "Stuart H. Rubin"(6 times). Second, the first author's affiliations were inconsistent, for example, "Central Michigan University, Mount Pleasant, USA" was sometimes written as "Central Michigan University, Mt Pleasant, MI". We manually checked and rectified this problem. After preprocessing the data, we obtained a list of 601 papers authored by 1301 authors in 40 countries. Table 1 shows the locations and the number of papers of the IRI conferences.

Table 1. Location and number of papers of the IRI conferences

Year	Location	Number of Papers
2003	Las Vegas, Nevada, USA	86
2004	Las Vegas, Nevada, USA	104
2005	Las Vegas, Nevada, USA	100
2006	Waikoloa, Hawaii, USA	107
2007	Las Vegas, Nevada, USA	120
2008	Las Vegas, Nevada, USA	84
TOTAL		601

4. Data Analysis and Discussion

The analysis is based on the data derived from the papers published by the International Conference on Information Reuse and Integration during the past six years (2003-2008). The purpose of this analysis is to answer the research questions mentioned earlier.

It should be noted that the published IRI literature is not representative of IRI applications in practice, as many IRI applications go unreported. Therefore, we should not interpret the results of this survey as if they reflect real world practice [8].

4.1. Topics

An analysis of the topics most frequently addressed in the 2003-2008 period is presented in Table 2. The table shows the number of articles dedicated to each topic and the percentage of the total number of articles considered. Prior research [17] indicated that the total count of all topic frequencies is higher than the total number of articles for this period, simply because an article often dealt with multiple topics. Although there are 69 distinct topics for the

Table 2. The most popular research topics in IRI (2003-2008)

Rank	Topics	IRI2003	IRI2004	IRI2005	IRI2006	IRI2007	IRI2008	Frequency	%
1	Data Mining and Knowledge Discovery	4	19	8	4	12	6	53	8.82%
2	Component-Based Design and Reuse	5	8	4	8	9	3	37	6.16%
3	Reuse in Software Engineering		7	10	4	4	3	28	4.66%
4	Fuzzy Neural Systems and Soft Computing		7	6	4	8		25	4.16%
5	Knowledge Acquisition and Management		8	8	4	4		24	3.99%
6	Agent Based Information Systems	8	3	3		5	3	22	3.66%
7	Information Assurance		6	7	8			21	3.49%
8	Heuristic Optimization and Search				8	8	3	19	3.16%
9	Multimedia Reuse and Integration	1	4	3	4	4	3	19	3.16%
10	AI & Decision Support Systems	4	3	7		4		18	3.00%
11	Biomedical & Healthcare Systems				7	4	6	17	2.83%
12	Large Scale Data Integration		3	4	4		6	17	2.83%
13	Natural Language Understanding		3	4	4	3	3	17	2.83%
14	Software Stability	7		3		6		16	2.66%
15	Manufacturing Systems & Business Process Engineering	4				3	6	13	2.16%
16	Software Development, Frameworks and Tools for Reuse		6	6				12	2.00%
17	Database Systems and Integration	5					6	11	1.83%
18	HW & SW Engineering for Reuse		3	7				10	1.66%
19	Knowledge Management and E-Government		3		4	3		10	1.66%
20	Knowledge Management and Ontological Engineering			3		4	3	10	1.66%

Table 3. The most popular controlled index terms in IRI (2003-2007)

Rank	Controlled Index Term	Frequency	%
1	software reusability	85	3.95%
2	object-oriented programming	69	3.20%
3	Internet	61	2.83%
4	data mining	58	2.69%
5	formal specification	35	1.63%
6	software architecture	34	1.58%
7	knowledge management	28	1.30%
8	learning (artificial intelligence)	28	1.30%
9	XML	25	1.16%
10	information retrieval	24	1.11%
11	knowledge based systems	23	1.07%
12	ontologies (artificial intelligence)	21	0.98%
13	decision making	19	0.88%
14	genetic algorithms	18	0.84%
15	decision support systems	17	0.79%
16	Java	17	0.79%
17	pattern classification	15	0.70%
18	software metrics	15	0.70%
19	software quality	15	0.70%
20	multi-agent systems	14	0.65%

Note: The controlled index terms were obtained from IEEE INSPEC. (The terms for IRI 2008 are not yet available)

period studied, Table 2 only shows the top 20 topics.

Table 2 also shows that the most popular IRI topics during the 6-year study period were Data Mining and Knowledge Discovery (8.82% of the articles), followed by Component-Based Design and Reuse (6.16%), Reuse in Software Engineering (4.66%), Fuzzy Neural Systems and Soft Computing (4.16%), and Knowledge Acquisition and Management (3.99%). Taken together, these topics represent 27.79% of the articles analyzed.

A controlled index term is an assignment of subject descriptors derived from a regulated set of words and phrases (a list of authorized descriptors) found in the INSPEC thesaurus. INSPEC, the world's leading bibliographic information service, and provides access to the world's scientific and technical literature. The thesaurus is produced by The Institution of Engineering and Technology (IET)(http://www.theiet.org/). In information retrieval field, a controlled index term is called controlled indexing. A controlled index term is useful for searching core subject areas and topics with numerous synonyms; while controlled indexing is used for standardized spelling (e.g., analysers – analyzers, analysers), punctuation (e.g., online—on line, on-line, online), and terminology (e.g., Internet – world wide web/www.).

Note that the controlled index terms for IRI 2008 are not yet available from IEEE Xplore. For the period 2003 to 2007, there were 594 distinct controlled index terms in the IRI conferences. Table 3 shows the most popular controlled index terms for that period. The top 10 controlled index terms were software reusability, object-oriented

Table 4. Authors with the most articles published in IRI (2003-2008)

Rank	AuthorName	Current Affiliation	IRI 2003	IRI 2004	IRI 2005	IRI 2006	IRI 2007	IRI 2008	Frequency	%
1	Stuart Harvey Rubin	SPAWAR Systems Center, USA	4	4	3	4	3	2	20	1.12%
2	Taghi M. Khoshgoftaar	Florida Atlantic University, USA		2	4	5	4	3	18	1.01%
3	Mohamed E. Fayad	San José State University, USA	4	3	4		5		16	0.89%
4	Shu-Ching Chen	Florida International University, USA	4	2	2	3	1	1	13	0.73%
5	Mei-Ling Shyu	University of Miami, USA	3	2	3	1	1	1	11	0.61%
6	Wen-Lian Hsu	Academia Sinica, Taiwan			1	2	2	4	9	0.50%
7	Reda Alhajj	University of Calgary, Canada	1	2	2		1	3	9	0.50%
8	Min-Yuh Day	National Taiwan University , Taiwan			1	2	2	3	8	0.45%
9	Du Zhang	California State University, USA	1	2	1	2	1	1	8	0.45%
10	Narayan C. Debnath	Winona State University, USA		5	3				8	0.45%
11	Jason Van Hulse	First Data Corp., USA			1	2	2	2	7	0.39%
12	Eric Gregoire	Universiti d'Artois, France	1	1	1	1	2	1	7	0.39%
13	Meiliu Lu	California State University, USA		3	1	2		1	7	0.39%
14	Waleed W. Smari	University of Dayton, USA	3	1	1	2			7	0.39%
15	Viktor K. Prasanna	University of Southern California, USA			1	1	1	3	6	0.34%
16	Roumen Kountchev	University of Sophia, Bulgaria	1	1		1	2	1	6	0.34%
17	Chengcui Zhang	University of Alabama at Birmingham, USA	3			1	1	1	6	0.34%
18	Chia-Chu Chiang	University of Arkansas at Little Rock, USA	1	1	1	1	1	1	6	0.34%
19	Seung-yun Kim	Shepherd University, USA	3	1		1		1	6	0.34%
20	Eduardo Santana de Almeida	Federal University of Pernambuco, Brazil		3	2		1		6	0.34%

Table 5. Institutions with the most articles published in IRI (2003-2008)

Rank	Institution	IRI2003	IRI2004	IRI2005	IRI2006	IRI2007	IRI2008	Frequency	%
1	California State University, Sacramento, USA	1	4	5	4	1	2	17	4.45%
2	Florida Atlantic University, USA		2	3	4	3	4	16	4.19%
3	San José State University, USA	4	1	3		5		13	3.40%
4	Florida International University, USA	3	1	1	2	1	1	9	2.36%
5	Tsinghua University, China	1	1		5	1	1	9	2.36%
6	University of Arkansas at Little Rock, USA	1	1		2	3	1	8	2.09%
7	SPAWAR Systems Center, USA	2	2	4				8	2.09%
8	Academia Sinica, Taiwan			1	2	1	2	6	1.57%
9	Dayton University, USA	2	1	1	2			6	1.57%
10	Southeast University, China	4	2					6	1.57%
11	University of Southern California, USA		1			1	3	5	1.31%
12	National Chiao Tung University, Taiwan		1	3			1	5	1.31%
13	CRIL, University d'Artois, France		1	1	1	2		5	1.31%
14	Calgary University, Canada		2	2	1			5	1.31%
15	Carleton University, Canada		3	1	1			5	1.31%
16	Nebraska University, USA	2	2		1			5	1.31%
17	Central Michigan University, USA	2		2	1			5	1.31%
18	National Taiwan University, Taiwan			1		1	2	4	1.05%
19	Wuhan University, China		2				2	4	1.05%
20	National Cheng Kung University, Taiwan	2				2		4	1.05%

programming, Internet, data mining, formal specification, software architecture, knowledge management, learning (artificial intelligence), XML, and information retrieval.

4.2. Authors

As noted in prior research [24], the most productive authors or leaders in a scientific discipline are important assets to that discipline. Treating scientific growth as a process of knowledge diffusion, leaders are often the ones who introduce new ideas and thus have a great impact on their respective research communities.

There were 1301 distinct authors in IRI between 2003 and 2008. Table 4 shows the authors who published the most articles during that period. The most productive authors were Stuart Harvey Rubin (20), followed by Taghi M. Khoshgoftaar (18), Mohamed E. Fayad (16), Shu-Ching Chen (13), Mei-Ling Shyu (11), Wen-Lian Hsu (9), Reda Alhajj (9), Min-Yuh Day (8), Du Zhang (8), and Narayan C. Debnath (8). Please note that the productivity data reported here is based on IRI records only.

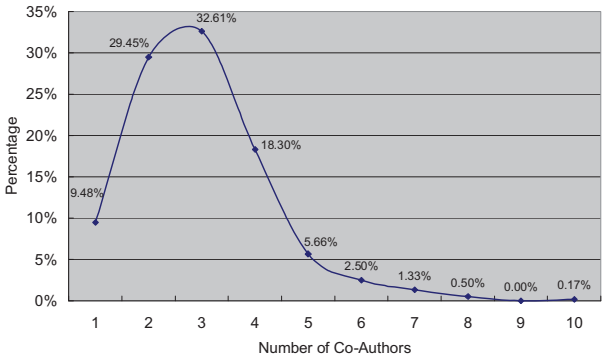

Figure 1. The distribution of the number of co-authors in IRI (2003-2008)

Figure 1 shows the distribution of the number of co-authors in IRI (2003-2008). The top 3 co-authors were No. 3 (32.61%), No. 2 (29.45%), and No. 4 (18.30%). Papers published by single author accounted for 9.48% of the total.

4.3. Institutions

In total, 381 institutions published papers in IRI between 2003 and 2008. Table 5 shows the institutions that published the most articles during that period. The most productive institutions were California State University, Sacramento, USA (17), Florida Atlantic University, USA (16), San José State University, USA (13), Florida International University, USA (9), Tsinghua University, China (9), University of Arkansas at Little Rock, USA (8), SPAWAR Systems Center, USA (8), Academia Sinica, Taiwan (6), Dayton University, USA (6), Southeast University, China (6). Please note that the productivity of the various institutions detailed here is based on the first author's affiliation according to IRI data.

5. Conclusion

In this paper, our goal has been to provide a summary of research to advance the field of information reuse and

integration. To this end, we have identified the most popular research topics, as well as the most productive researchers and organizations associated with the majority of research publications in the International Conference on Information Reuse and Integration (IRI) during the past six years (2003-2008). Based on a detailed analysis of those publications, we have identified the research topics most often investigated. Our findings show that the research conducted in the field of IRI covers a wide variety of topics.

The major contribution of this paper is that it is the one of the few empirical studies to focus on research in the field of information reuse and integration. Specifically, we present the findings of a six-year study of the popular research topics, as well as the top researchers and institutions in the field of Information Reuse and Integration. The top 10 topics were Data Mining and Knowledge Discovery, Component-Based Design and Reuse, Reuse in Software Engineering, Fuzzy Neural Systems and Soft Computing, Knowledge Acquisition and Management, Agent Based Information Systems, Information Assurance, Heuristic Optimization and Search, Multimedia Reuse and Integration, AI & Decision Support Systems. The top 10 controlled index terms were software reusability, object-oriented programming, Internet, data mining, formal specification, software architecture, knowledge management, learning (artificial intelligence), XML, and information retrieval. The top researcher was Stuart Harvey Rubin of the SPAWAR Systems Center, USA, and the top institution was California State University, Sacramento, USA.

In the future, we will extend our study to investigate the IRI scientific network though co-authorship analysis. By so doing, we hope to develop a more comprehensive view of the IRI research community.

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