A Foundation for Research in Computing in Civil Engineering

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Abstract

This paper provides a historical perspective on computing research in civil engineering, as reflected in the *Journal of Computing in Civil Engineering*. The paper reports the results of the ten-year analysis of the *Journal of Computing in Civil Engineering* for the 1987-1996 period. The main contributing authors, organizations, and countries are identified and their contribution patterns are brought to light. Focus areas covered by the journal from 1987 to 1996 are categorized and summarized with respect to engineering subdisciplines and computing areas. References cited by JCCE authors are categorized according to their sources, and the sources are ranked and their citation patterns are explicated.

Introduction

As a research field, civil engineering computing has attracted many talented individuals working towards advancing the use of existing and emerging computing tools and techniques in civil engineering. Researchers in this field usually publish results of their work in several national and international journals, one of which is *Journal of Computing in Civil Engineering*. This journal focuses primarily on civil engineering applications of computing techniques and technologies.

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The *Journal of Computing in Civil Engineering* (JCCE), established in 1987, is a quarterly journal which publishes technical papers, editorials, paper discussions, and technical notes. The journal covers emerging software and hardware issues relevant to civil engineering education, research and practice. The main computing areas covered by the journal include new programming languages; information management systems; computer aided engineering; artificial intelligence; robotics; data acquisition; remote sensing; and implementation strategies, management, and organizational impact of computing resources. The journal is intended to be of interest to researchers, professionals, and students in all civil engineering disciplines.

During the 1987-1996 period (the first decade of the journal) 453 national and international authors contributed to JCCE a total of 271 technical papers on a wide range of topics and engineering applications. At the end of ten years an analysis was made in order to acquire and disseminate a general perspective on the technical content and contributors of the journal. Such a perspective should help the reader gain a better understanding of the nature and dynamics of (1) the research community and research areas and (2) the literature forming the knowledge infrastructure of the published work. This paper reports the results of the analysis. The paper identifies the main

- contributing authors and organizations as well as their home countries,
- computing areas and CE subdisciplines that were the focus of the published papers during the first decade of the journal's life, and
- journals, conferences, reports, and theses that had been cited most frequently in JCCE articles from 1987 to 1996.

The paper also provides a general perspective on the nature of the editorials published in the journal during the same period. The remainder of the paper is organized in a manner to address each of these topics.

Contributors

In this section the main contributing authors and organizations, and their home countries are identified.

Authors

Four hundred fifty four authors contributed to the journal during its first ten years. Approximately one fifth of the authors made two or more appearances, the majority (81%) of the authors made a single appearance during that period. Table 1 shows the breakdown of the 454 authors by the number of their contributions (appearances), or, more definitively by the number of times they were listed as an author regardless of the number of co-authors. Thus, of the 454 contributors in the journal's first decade, 369 published only once, 55 published twice, and 30 published three or more times.

The authors with two or more appearances are listed in Tables 2 and 3. These tables identify both the authors and the years in which their articles appeared in the journal. For example, during the ten-year period, the first author listed in Table 2 (Levitt) made a total of 6 appearances, 1 in 1987, 1 in 1989, 1 in 1990, 2 in 1991, and 1 in 1993.

Table 2 also shows somewhat of a chronology of contributors. The table is organized by the year in which contributors published their initial paper. Thus, Table 2 gives the list of the pioneering

authors, those started contributing to the journal in its first five years at the top. At the bottom of the table are those authors who did not begin publishing in the journal until its 5th year (1991) and beyond.

Contributors who have appeared as sole authors or first authors of articles are also identified in the table. For each contributor three numbers appear in parenthesis at the right-hand side of the table. The first number indicates how many times the contributor was the sole author, the second number gives the number of times the contributor was the first author of articles with one or more co-authors, and the final number is simply the total number of articles for the author. For example, Skiebniewski, who had a total of 5 contributions during the 1987-1996 period, appeared once as the sole author and once as the first author.

Table 3 is a continuation of Table 2. It identifies the authors who started contributing to the journal in 1992 - the journal's second 5 years. Table 2 lists 12% (55 authors) and Table 3 lists 7% (30 authors) of the 454 total authors as main contributors; 19% (85 authors) of all the authors are characterized as main contributors of JCCE, i.e., they have published 2 or more technical articles.

In Table 4 the authors are ranked based on their adjusted number of appearances. For each author, this number is computed using the equation

$$\sum_{i=1}^n 1/m_i$$

where n is the number of papers published by the author and m_i is the number of authors for the i -th paper. For example, if an author published two papers, one with 2 authors and the other one with 4 authors, the adjusted number of appearances for the author is

$$\frac{1}{2} + \frac{1}{4} = 0.75.$$

With 3.67 adjusted appearances, Bernold is ranked 1. Rasdorf, Riggs, and Skibniewski, each with 3.00 adjusted appearances, are ranked 2. Oloufa with 2.83 adjusted appearances is ranked 3. Only authors with adjusted appearances of greater than one are listed and ranked in Table 4.

Table 5 draws data from Table 2, which lists 55 authors who began contributing to the journal in its early years. Of these 17 authors contributed regularly (with at least one appearance every four years) to JCCE in the ten-year period. These 17 authors, their numbers of appearances, and the years of their first and last appearances are listed in Table 5.

Organizations

Academicians were the main contributors of JCCE. Out of the 595 total appearances, 512 (86%) were made by authors from academia, 8% were made by industry researchers, and 6% were due to government authors. Figure 1 shows the history of author appearances from these three sectors from 1987 to 1996.

While the participation of government contributors had remained somewhat steady, the number of contributors from industry had a slightly upward trend over the past ten years. No significant change, however, is found with regard to the overall breakdown of the authors' affiliations among the three sectors over the ten-year period.

An overwhelming majority (86%) of the authors were affiliated with institutions of higher education. The universities that had contributed most significantly to JCCE are listed in Table 6. Stanford University, University of Maryland, and Carnegie Mellon University are ranked 1, 2,

and 3, respectively. This ranking is based on the adjusted number of papers from these universities. Only the universities with 10 or more appearances in the ten-year period are listed and ranked in the table.

Analysis of relevant data for the first and second five-years periods reveals change in the level of contributions of the universities listed in Table 6 from the first period to the second. The change in the number of appearances and the adjusted number of papers for each university is given in Table 7. The table indicates that the University of Wisconsin, Penn State, and the India Institute of Technology increased their contributions significantly in the second period, while Ohio State University and the University of Colorado had the most significant decrease in their contributions in that period.

Assistant, associate, and full professors as well as students contributed equally to the journal. The contribution of each of these groups was between 21% and 23%. Other contributors, including research associates, lecturers, and members of administration, constitute 13% of academic contributors. The distribution of the contributors in the three academic ranks remained generally constant over the ten years, as shown in Figure 2.

Table 8 shows the industry and government agencies that contributed to the journal with 2 or more appearances in the ten-year period. The table also shows the number of papers and the adjusted number of papers for the listed industry and government agencies.

Home Countries of Contributing Authors

Researchers from 26 countries contributed to the journal between 1987 and 1996. Table 9 identifies these countries. The table also contains the number of author appearances and the adjusted number of papers for each country.

The change in the level of contribution -- change in the number of appearances and adjusted number of papers -- for each country from the first to the second five-year period is shown in Table 10. The table indicates that most of the countries increased their level of contributions in the second period. For example authors from the United Kingdom appeared seven times more in the second period, compared to the first period. And, the UK authors published approximately four more papers in the second period compared to the first period.

Figure 3 shows the increase in the level of international participation over the ten-year period. While only an average of 10% of the appearances were made by international authors in the first period, the contribution level increased to 40% in the second period.

Focus Areas

Special Issues

Two hundred seventy one solicited and unsolicited papers were published in the journal between 1987 and 1996. Most of the solicited papers appeared in 9 special issues each focusing on a specific topic. The topic of each special issue, the number of papers related to each topic, and the year in which it was published are given in Table 11. The JCCE averages just under one special issue per year.

Technical Areas

For this analysis, we classified each published paper based on 1) its main computing area and 2) the main engineering subdiscipline it addresses. Although the theme of a paper may fall into one or more computing areas or engineering disciplines, we used one area and one subdiscipline only to classify the paper. Our analysis indicates 10 computing areas were widely represented by JCCE in the ten-year period. They are:

- Expert systems (ES) with 51 (19%) papers,
- Software engineering and development (Software) with 39 (14%) papers,
- Artificial intelligence (AI), other than ES and NN, with 35 (13%) papers,
- Neural Networks (NN) with 26 (10%) papers,
- Data modeling and databases (Databases) with 23 (8%) papers,
- Classical mathematical methods and numerical techniques (Numerical Methods) with 22 (8%) papers,
- Programming languages (Programming), mainly object oriented modeling and programming, with 18 (7%) papers,
- Computer aided modeling and design (CAD) with 14 (5%) papers,
- Geographic information systems (GIS) with 8 (3%) papers,
- Data acquisition, sensors, and bar coding (Data acquisition) with 7 (3%) papers,
- Parallel and super computing (Parallel Computing) with 5 (2%) papers,
- Hypermedia with 4 (1%) papers,
- General computing topics with 6 (2%) papers, and
- Others including algorithms, process modeling, and spreadsheet with 13 (5%) papers.

The published papers focus on applications of the above-mentioned computing areas to mainly six engineering subdisciplines. These are:

- Construction with 65 (24%) papers,
- Structures with 65 (24%) papers,
- Water resources and Environmental with 32 (12%) papers,
- Design (including Design Standards) with 30 (11%) papers,
- Transportation with 20 (7%) papers, and
- Geotechnical with 18 (7%) papers.

Several papers focusing on computing applications in surveying, urban planning, infrastructure, education, building, and geometric modeling also appeared in the journal. In addition, several papers dealt with general applications of computing in engineering without focusing on a specific subdiscipline. These papers are classified as “Others” and “General” in our analysis. There were a total of 22 papers in the “Other” category and 19 papers in the “General” category. Table 12 shows the distribution of the 271 papers according to the classification scheme outlined above.

Computing Area Trends

Our analysis of the compiled data for the first and second five-year periods reveals a significant decrease in the number of papers related to expert systems and classical numerical methods from the first period to the second. The same analysis indicates a significant increase in the number of papers in several other areas including: neural networks, data modeling/databases,

software engineering/development, programming languages, and geographic information systems.

Of the 123 papers published in the first five years, 37 (30%) were expert systems' related and 19 (15%) were related to applications of classical numeric techniques. In the second five years, of the 148 papers published, 13 (9%) were related to expert systems and 3 (2%) were related to classical numeric techniques. This is a decrease of 21% in expert systems papers and 13% in the classical numerical techniques papers.

The number of papers related to neural networks increased from zero in the first five years to 26 in the second five years. This is an increase of 18% (of the total number of papers) in the number of papers dealing with neural nets. Data modeling/database papers increased in numbers from 3 (2%) in the first five years to 19 (13%) in the second five years. The number of papers on software engineering/development increased from 18 to 31, an increase of 6% with respect to the total number of published papers. Programming languages (mainly object oriented) related papers increased in numbers from 2 to 16, an increase of 7% in the second five years. Finally, while no geographic information systems papers were published in the first five years, 8 such papers appeared in the journal in the second five years. This is an increase of 5%.

Engineering Subdiscipline Trends

A similar analysis was performed for the engineering subdisciplines covered by the 271 papers. This analysis indicates a slight decrease in the number of structures and geotechnical related papers. The number of structures papers decreased from 35 in the first five years to 30 in the second five years. This is a decrease of 8%; structures related papers in the first and second five

years were 28% and 20% of the total number of papers in these periods, respectively. The number of geotechnical papers decreased from 10 to 8, a decrease of 3%.

Papers related to environmental/water resources and transportation engineering increased in numbers during the second period. In the first five years 13 environmental and 6 transportation papers were published. In the second five years these numbers increased to 19 and 14, respectively. This is an increase of 2% of the total in environmental papers and an increase of 5% in transportation papers. Although the number of construction related papers increased from 29 to 36, the percentage of construction papers in the first and second five years remains constant at 24%. The number of general papers also increased from 6 to 13, an increase of 4%.

Citations

During the 1987-1996 period, approximately 4700 references were cited in JCCE articles. The average number of references per paper for each year in that period is shown in Figure 4. The figure presents a slight, but relatively uniform, increase in the average number of references over the ten-year period.

The majority of the references were made to journal articles and books. Conference proceedings and technical reports were cited significantly as well. References to theses and other literature (i.e., magazines, technical notes, and design manuals and codes) were also found in JCCE articles. The breakdown of the cited literature during the 1987-1996 ten-year period is: journals (34%), books (25.6%), conference proceedings (17%), technical reports (12%), theses (3.9%), and others (7.5%). Figure 5 shows the percent contribution of each of the listed items in the first and second five years during the 1987-1996 period.

Journals

Approximately 1600 journal references (34% of the total) were found in JCCE articles from 1987 to 1996. Approximately 40% of the references appeared in JCCE articles published from 1987 to 1991, the remaining references were found in articles published from 1992 to 1996. Some 354 refereed journals were cited by JCCE authors. Table 13 lists names of the journals cited most frequently (at least 2% of total number of journal citations) during the ten-year period. There are 346 other journals which were cited less frequently. Names of some of these journals appear in Appendix A.

Table 13 identifies JCCE as the most frequently cited journal. Approximately 11.1% of all the journal references were made to JCCE articles during the ten-year period. The analysis of the citation data during the first and second five-year periods reveals that in the first period 6.4% of the journal references were made to JCCE articles. The percentage increased to 14.3% during the second period.

Our analysis also reveals that the references made to JCCE articles were found in 23.7% of all the articles published in JCCE during the first five years. That is, out of the total of 123 technical papers published in JCCE between 1987 and 1991, 29 papers referenced other JCCE articles. In the second five years, 48.9% (72 out of 148) of the published papers made references to JCCE articles.

These percentages are shown graphically in Figure 6. The figure consists of two bar charts. The right-hand side bar chart shows the percent of total number of references made to each of the journal listed in Table 13 in the first and second periods. The left-hand side bar chart indicates

how well the references made to each journal were distributed in the JCCE articles. One can conclude from these numbers that as the JCCE became established it also became a growing resource base for researchers and has, therefore, had a measurable impact on new research.

Conference Proceedings

Approximately 800 conference proceedings references (17% of the total) were found in JCCE articles in the ten-year period. Approximately 39% of these references appeared in JCCE articles in the first five years, the remaining (61%) references appeared in the second five years.

Some 424 conferences were cited by JCCE authors during the ten-year period. The most frequently cited conferences are listed in Table 14. Names of some of the less frequently cited conferences are given in Appendix B.

As can be seen in Table 14, approximately 11.5% of all the conference references were made to articles in the proceedings of the Computing in Civil Engineering Conference/Congress during the ten-year period. The analysis of the citation data for the first and second five-year periods reveals that in the first period 10.1% of the conference references were made to papers in the proceedings of the conference. The percentage increased to 12.4% during the second period.

Our analysis also reveals that the references made to the Computing in Civil Engineering Conference/Congress were found in 11.9% of all the articles published in JCCE during the first five-year period. That is, out of the total of 123 technical papers published in JCCE between 1987 and 1991, 15 papers referenced papers in the proceedings of this conference. In the second

five years, 23.7% (35 out of 148) of the published papers made references to this conference proceedings. These percentages, as well as those for all the listed conferences, are shown graphically in Figure 7. The right-hand side bar chart in the figure shows the percentage of references made to the proceedings of each of the conferences listed in Table 14 in the first and second periods. The left-hand side bar chart indicates how well the references made to each conference were distributed in JCCE articles.

Technical Reports

Approximately 564 references to technical reports (12% of the total) were found in JCCE articles from 1987 to 1996. Approximately 47% of these references appeared in JCCE articles published from 1987 to 1991, the remaining (53%) references were found in articles published from 1992 to 1996.

Some 197 organizations were responsible for producing the cited technical reports. The organizations responsible for the most frequently cited technical reports are listed in Table 15. Names of some of the organizations responsible for producing less frequently cited reports appear in Appendix C.

Table 15 identifies Stanford University as the lead contributor to the technical reports cited in the JCCE articles. Approximately 8.7% of all the report references were made to reports produced at Stanford University. Further analysis of the citation data reveals that in the first period 9.3% of the referenced technical reports were produced at Stanford University. This percentage decreased to 8.3% during the second period.

Our analysis also reveals that the references made to reports generated at Stanford University were found in 11.9% of all the articles published in JCCE during the first five-year period. That is, out of the total of 123 technical papers published in JCCE between 1987 and 1991, 15 JCCE papers referenced Stanford University's reports. In the second five years, 11.5% (17 out of 148) of the published papers made references to the reports from Stanford University.

The right-hand side bar chart in Figure 8 shows the percentage of references made to the reports from each of the organizations listed in Table 15 in the first and second five years. The left-hand side bar chart indicates how well these references were distributed in JCCE articles.

Theses

References to 183 theses from 63 universities were found in JCCE articles. Approximately 46% of these references appeared in JCCE articles from 1987 to 1991, the remaining (54%) references were found in articles published from 1992 to 1996. Table 16 lists the institutions with the most frequently cited theses. Names of institutions producing some of the less frequently cited theses appear in the appendix. The results of the analysis of the theses citation data during the first and second five-year periods are shown in Figure 9.

Editorials

Editorials in JCCE mainly reflect the views of practitioners and academicians on emerging computing topics and issues as they relate to civil engineering practice. During the 1987-1996 period 31 editorials appeared in the journal. Table 17 shows the breakdown of the editorials by author affiliation and period of publication. The table clearly shows an increase in the number of editorials by industry contributors in the second five-year period. This is because of an initiative launched by the Editor to seek commentary from industry on critical issues. Every journal issue

now has from one to three professional editorials enabling greater industry participation in the process of research reporting and commentary.

Of the 31 editorials, 10 provide introduction to topics and/or papers in special issues of the journal. Special issues are generally organized and developed by academics; professionals contribute the majority of the remainder of the editorials. Of the remaining 21 editorials, 1 deals with the role of ASCE's Technical Council on Computer Practices, 1 provides an overview of the journal's technical content, and the remaining 19 provide perspectives on a variety of issues including:

- data exchange formats (2 editorials),
- data modeling and integration (7),
- computing education in civil engineering (1),
- progress and issues in structural design automation (1),
- the gap between research and practice in the construction industry (1),
- computing advances in civil engineering applications (6), and
- information highway use in civil engineering (1).

Most of these 19 editorials, which were written by researchers and practitioners from industry between 1992 and 1996, reflect the emerging interest of the industry in addressing computing issues pertaining to civil engineering practice.

number of appearances	authors		total number of appearances
	number	percentage	
1	369	81.3%	369
2	55	12.1%	110
3	14	3.1%	42
4	9	2.0%	36
5	4	0.9%	20
6	3	0.7%	18
Total	454	100.00%	595

Table 1: Number of authors and author appearances

Table 2: JCCE main contributors (beginning 1987)

author	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	
Levitt, R.E.	1		1	1	2		1				(0,0,6)
Adeli, H.	2	3									(0,4,5)
Hendrickson, C.	1		1		2						(0,2,4)
Ortolano, L.	2			1							(0,3,3)
Riggs, L.S.	1		2								(3,0,3)
Wright, J.R.	1				2						(0,0,3)
Aristizabal-Ochoa, J.D.	1		1								(1,0,2)
Balasubramanyam	1	1									(0,0,2)
Chameau, J.L.	1		1								(0,1,2)
Maier, M.L.	1							1			(1,1,2)
Rehak, D.	1					1					(0,0,2)
Santamarina, J.C.	1		1								(0,1,2)
Zozaya-Gorostiza, C.	1		1								(0,0,2)
Rasdorf, W.J.		1		2		1	1			1	(0,4,6)
Diekmann, J.		2		1		1			1		(0,2,5)
Skibniewski, M.J.		1		1	1			1	1		(1,1,5)
Sriram, D.		1			2	1			1		(0,0,5)
Logcher, R.		1			1	1			1		(0,0,4)
Cohn, L.F.		1			1				1		(0,1,3)
East, E.W.		1							1	1	(1,2,3)
Harris, R.A.		1			1				1		(0,2,3)
Law, K.H.		2					1				(0,0,3)
Soh, A.K.		1					1		1		(0,0,3)
Soh, C.K.		1					1		1		(0,3,3)
Thomas, H.R.		1			1					1	(0,3,3)
Faghri, A.		1							1		(0,2,2)
Kraiem, Z.M.		1		1							(0,0,2)
Spyrakos, C.C.		1	1								(1,1,2)
Bernold, L.E.			1	2		1	1		1		(2,3,6)
Austin, M.A.			1			2	1				(0,3,4)
Howard, H.C.			1		1	1		1			(1,3,4)
Proese, T.			1							2	(1,0,3)
Paulson, B.C.			2								(0,1,2)
Puckett, J.A.			1							1	(0,1,2)
Ramirez, J.			1			1					(0,0,2)
Simonovic, S.P.			1					1			(0,0,2)
Ibbs, W.				2		2					(0,0,4)
Kartam, N.A.				1	1			2			(0,2,4)
Russell, J.S.				1	1				2		(0,1,4)
Ross, T.J.				1		2					(0,3,3)
Bedard, C.				1	1						(0,2,2)
de la Garza, J.				1					1		(0,2,2)
Rogers, J.L.				1				1			(2,0,2)
Williams, T.P.				1					1		(0,2,2)
Goulter, I.					2		1		1		(0,0,4)
Oloufa, A.A.					1	2	1				(2,2,4)
Aravind, H.B.					2						(0,0,2)
Arciszewski, T.					1			1			(0,2,2)
Buehler, K.A.					2						(0,2,2)
Davidson, J.					2						(0,2,2)
Kao, J.J.					1					1	(0,2,2)
Li, C.L.					1					1	(0,0,2)
Muridharan, T.L.					2						(0,2,2)
Raman, N.V.					2						(0,0,2)
Suryakumar, G.V.					2						(0,0,2)

Table 3: JCCE main contributors (beginning 1992)

[illegible]

Table 4: Authors with the most number of appearances

rank	author's name	number of appearances	adjusted number of appearances
1	Bernold, L.E.	6	3.67
2	Rasdorf, W.J.	6	3.00
	Skibniewski, M.J.	5	3.00
	Riggs, L.S.	3	3.00
3	Oloufa, A.A.	4	2.83
4	Adeli, H.	5	2.50
5	Dickmann, J.	5	2.33
	Russell, J.S.	4	2.33
6	Levitt, R.E.	6	2.12
7	Howard, H.C.	4	2.03
8	East, E.W.	3	2.00
	Rogers, J.L.	2	2.00
9	Goulter, I.	4	1.83
	Kartam, N.A.	4	1.83
10	Froese, T.	3	1.75
11	Hendrickson, C.	4	1.70
	Ibbs, W.	4	1.70
12	Sriram, D.	5	1.67
	Austin, M.A.	4	1.67

rank	author's name	number of appearances	adjusted number of appearances
13	Thomas, H.R.	3	1.50
	Wright, J.R.	3	1.50
	Aristizabal-Ochoa, J.D.	2	1.50
	Lingras, P.	2	1.50
	Maher, M.L.	2	1.50
14	Logcher, R.	4	1.33
	Flood, I.	3	1.33
	Law, K.H.	3	1.33
	Ortolano, L.	3	1.33
	Adams, T.M.	2	1.33
	Kunigahalli, R.	2	1.33
	Spyrakos, C.C.	2	1.33
15	Beliveau, Y.J.	3	1.20
16	Cohn, L.F.	3	1.17
	Harris, R.A.	3	1.17
	Soh, A.K.	3	1.17
	Soh, C.K.	3	1.17

Table 5: JCCE regular contributors

author	number of appearances	period of contributions
Levitt	6	87-93
Rasdorf	6	88-96
Diekmann	5	88-95
Skiebniewski	5	88-95
Sriram	5	88-95
Logcher	4	88-95
Cohn	3	88-95
Harris	3	88-95
Bernold	6	88-95
Austin	4	89-93
Howard	4	89-94
Kartam	4	90-94
Russell	4	90-95
Rogers	2	90-94
Goulter	4	91-95
Oloufa	4	91-93
Arciszewski	2	91-94

Table 6: Main contributors (Universities)

rank	institution	number of appearances	number of papers	adjusted number of papers
1	Stanford	30	18	11.80
2	U of Maryland	26	13	10.63
3	CMU	22	13	9.53
5	NCSU	17	12	9.33
4	Purdue	17	13	8.50
7	U of Colorado	14	8	6.50
9	U of Wisconsin	12	7	6.00
6	MIT	16	9	5.83
8	India Institute of Technology	14	7	5.50
13	Ohio State	10	5	5.00
12	Penn State	10	6	4.67
10	UT - Austin	11	5	4.50
11	UC Berkeley	10	7	3.90
14	U of Louisville	10	4	3.67

Table 7: Change in contribution patterns for universities from 1987 to 1996

institution	change in number of appearances	change in adjusted number of papers
Stanford	-8	-1.64
U of Maryland	+8	+2.30
CMU	-6	-2.13
NCSU	+3	+1.33
Purdue	-5	-2.50
U of Colorado	-6	-3.50
U of Wisconsin	+8	+4.00
MIT	0	-0.50
India Institute of Technology	+8	+3.50
Ohio State	-10	-5.00
Penn State	+8	+4.00
UT - Austin	-1	-0.50
UC Berkeley	0	-0.44
U of Louisville	-4	-1.67

Table 8: main contributors (Government and Industry)

government/industry	number of appearances	number of papers	adjusted number of papers
US Army	15	9	6.73
NASA	4	4	3.00
Florida Water Management	3	2	2.00
Stone & Webster	3	2	1.50
Bechtel	2	2	1.00
Kachina Technologies	3	3	0.92
NY DOT	2	1	0.67
Jacobus Tech.	2	1	0.40

Table 9: Countries of contributing authors

country	number of appearances	number of papers	adjusted number of papers
US	432	206	194.00
Canada	38	25	20.33
UK	19	12	10.33
India	20	8	6.83
Australia	11	8	5.67
Singapore	13	6	5.33
Taiwan	13	6	4.83
Israel	7	5	3.75
Japan	8	4	2.83
Greece	4	2	2.00
Poland	4	2	2.00
Netherlands	2	2	2.00
Sweden	2	2	2.00
Morocco	4	2	1.17
Germany	3	1	1.00
Slovenia	3	1	1.00
Switzerland	2	1	1.00
Finland	1	1	1.00
South Africa	1	1	1.00
France	2	1	0.67
Norway	1	1	0.50
Saudi Arabia	1	1	0.50
Sudan	1	1	0.50
China	1	1	0.25
Cyprus	1	1	0.25
Malaysia	1	1	0.25
Total	595		271

Table 10: Change in contribution patterns for countries from 1987 to 1996

country	change in number of appearances	change in adjusted number of papers
UK	+7	+4.33
Taiwan	+11	+3.88
Australia	+7	+3.67
Japan	+8	+2.83
Israel	+5	+2.75
Greece	+4	+2.00
Netherlands	+2	+2.00
Poland	+4	+2.00
Sweden	+2	+2.00
Singapore	+1	+1.33
Morocco	+4	+1.17
Finland	+1	+1.00
Germany	+3	+1.00
Slovenia	+3	+1.00
South Africa	+1	+1.00
Switzerland	+2	+1.00
Norway	+1	+0.50
Sudan	+1	+0.50
Canada	-2	+0.33
China	+1	+0.25
Cyprus	+1	+0.25
India	-4	+0.17
Malaysia	-1	-0.25
Saudi Arabia	-1	-0.50
France	-2	-0.67
US	+10	-8.50

Table 11: Special issues from 1987 to 1996

special issue topic	number of papers	year
Expert Systems in Civil Engineering	8	1987
Computational Geometry	3	1990
Expert Systems in Planning and Design	7	1991
Databases	6	1992
Object Oriented Systems	7	1992
Geographical Information Analysis	8	1993
Neural Networks	8	1994
European Computing	9	1994
Data, Product, and Process Modeling	6	1996

Table 12: The breakdown of papers by engineering sub-disciplines and computing areas

	engineering disciplines								Total
	Const.	Struct.	Env.	Design	Trans.	Geotech.	General	Others	
ES	11	14	9	8	2	2	1	4	51
Software	15	11	5	2	2	1	1	2	39
AI	13	5		7	6		2	2	35
NN	5	9	2	1	4	2	3		26
Databases	5	3	1	5	2	2	1	4	23
Numerical Methods	1	8	3		1	7	2		22
Programming	2	6	3	2		1	3	1	18
CAD	3	6	1	2			2		14
GIS			5		1	1		1	8
Data acquisition	4	1						2	7
Parallel Computing			1		1	2	1		5
Hypermedia	1	1		1			1		4
General	1			1	1		2	1	6
Others	4	1	2	1				5	13
Total	65	65	32	30	20	18	19	22	

Table 13: The main journals referenced in JCCE articles

journal name	percent of total number of cited journal ref.
Journal of Computing in Civil Engineering (JCCE)	11.1%
Journal of Construction Engineering and Management (JCEM)	5.3%
Journal of Structural Engineering (JSE)	4.9%
Engineering with Computers (EC)	2.9%
Computers and Structures (CS)	2.7%
Artificial Intelligence (AI)	2.7%
Computer Aided Design (CAD)	2.6%
Microcomputers in Civil Engineering (MCCE)	2.1%
Communications of the ACM (CACM)	2.0%
Others	63.7%

Table 14: the main conferences referenced in JCCE articles

conference name	percent of total number of cited conf. papers
Computing in Civil Engineering (CCE)	11.5
International Joint Conference on Artificial Intelligence (IJCAI)	6.0
Annual Transportation Research Board Meeting (TRB)	3.8
International Joint Conference on Neural Network (IJCNN)	1.5
Automation and Robotics in Construction (ARC)	1.2
National Conference in Artificial Intelligence (NCAI)	1.3
Structures Conference/Congress (SC)	1.1
Others	73.8

Table 15: The most frequently cited Institutions producing the reports referenced in JCCE articles

organization name	percent of total number of cited reports
Stanford University	8.7
Carnegie Mellon University (CMU)	6.5
US Army	6.3
Massachusetts Institute of Technology (MIT)	5.1
National Institute of Standards (NIST)	3.6
University of California-Berkeley	3.2
University of Illinois	2.7
NASA	2.5
Purdue University	2.3
Federal Highway Administration	2.1
Others	57.0

Table 16: The most frequently cited Institutions producing the theses referenced in JCCE articles

university name	percent of total number of cited theses
CMU	13.1
Stanford	13.1
MIT	6.9
University of Illinois	5.7
University of California-Berkeley	4.6
University of Colorado	3.4
Purdue University	2.9
RPI	2.9
Others	47.4

Table 17: Editorial's authors affiliations

	87-91	92-96	Total
Academic	6	8	14
Industry	1	14	15
Government		2	2
Total	7	24	

Appendix A: Partial list of journals cited in JCCE articles from 1987 to 1996

Journal Name
Artificial Intelligence for Engineering Design, Analysis, and Manufacturing
Water Resources Research
Hydraulics Engineering
AI Expert
Engineering Mechanics
Water Resources Planning and Management
Transportation Engineering
The Computer Journal
ACM Transactions on Database Systems
Civil Engineering Systems
ACM Computing Survey
Concrete International
Geotechnique
Machine Learning
Cognitive Science
IEEE Journal of Robotics and Automation
Approximate Reasoning
IEEE Transactions on Neural Networks
Computational Intelligence
Cybernetics
European Journal of Engineering Education
Geophysics
Journal of American Medical Association
Law and Contemporary Problems
Parallel Computing

Appendix B: Partial list of conferences cited in JCCE articles from 1987 to 1996.

Conference Name
Very Large Databases
Simulation
Earthquake Engineering
Object Oriented Programming
Deductive and Object Oriented Databases
Design and Manufacturing Systems
Engineerng Construction and Operation in Space
Geotechnical Engineering
Construction Congress
Computer Science and Statistics
Workshop on Intelligent CAD
International Conference on GIS
International Conference on Genetics
AI in Engineering
Workshop on Case Based Reasoning
Hypercubes, Concurrent Engineering, and Applications
IEEE Conference on Robotics

Appendix C: Partial list of organizations publishing the reports cited in JCCE articles from 1987 to 1996.

Organization Name
American Concrete Institute
US Department of Commerce
Welding Research Council
US Geological Survey
Bell Labs
National Science Foundation
Environment Protection Agency
National Research Council of Canada
International Standards Organization
Kansas Department of Transportation
Microelectronics and Computer Inc.
Jacobus Technology, Inc.
Bureau of Reclamation
California Department of Water Resources
US Department of Agriculture
Xerox Palo Alto Research Center
National Technical Information Services

Appendix D: Partial list of universities producing the theses cited in JCCE articles from 1987 to 1996.

University Name
Virginia Tech.
Kansas State University
Georgia Tech.
North Carolina State University
University of Maryland
Technion
University of Toronto
University of Michigan
Ohio State University
Imperial College
Vanderbilt
Arizona State University
Harvard
Cornell
Lehigh
University of Belgrade
University of Wisconsin
University of British Columbia
University of Bristol
City University-London

Figure 1: Appearances comparison of author from academia, industry, and government

Figure 2: Appearance comparison of authors from academia

Figure 3: Appearance comparison for national and international authors

Figure 4: Average number of references per year

Figure 5: Sources of citations in JCCE articles

Figure 6: The most frequently cited journals and their citation distribution in JCCE articles

Figure 7: The most frequently cited conferences and their citation distribution in JCCE articles

Figure 8: Sources of the most frequently cited technical reports and their citation distribution in JCCE articles

Figure 9: Sources of the most frequently cited theses and their citation distribution in JCCE articles