An Analysis of the Most Cited Articles in Software Engineering Journals - 2000

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Abstract

Citations and related work are crucial in any research to position the work and to build on the work of others. A high citation count is an indication of the influence of specific articles. The importance of citations means that it is interesting to analyze which articles are cited the most. Such an analysis has been conducted using the ISI Web of Science to identify the most cited software engineering journal articles published in 2000. The objective of the analysis is to identify and list the articles that have influenced others the most as measured by citation count. An understanding of which research is viewed by the research community as most valuable to build upon may provide valuable insights into what research to focus on now and in the future. Based on the analysis, a list of the 20 most cited articles is presented here. The intention of the analysis is twofold. First, to identify the most cited articles, and second, to invite the authors of the most cited articles in 2000 to contribute to a special issue of Information and Software Technology. Five authors have accepted the invitation and their articles appear in this special issue. Moreover, an analysis of the most cited software engineering journal articles in the last 20 years is presented. The presentation includes both the most cited articles in absolute numbers and the most cited articles when looking at the average number of citations per year. The article introducing the SPIN model checker by G.J. Holzmann published in 1997 is first on both these lists.

1. Introduction

Citations are a common way of judging the most influential work in different fields. The most cited articles often provide new insights, open a new avenue of research, or provide a significant summary of the state-of-the-art in an area. Citations are a way to show how researchers build their work on existing research to evolve research further. Basically, they are the backbone of research and hence articles and authors being cited frequently deserve acknowledgment for their contribution. The analysis presented

here is intended to highlight which articles are most cited in software engineering in a given year. The analysis is intended to complement the work on ranking the most published scholars and institutions as done by Tse et al. [Tse06].

The objective of the analysis presented here is to list the most cited journal articles in the field of software engineering recorded as published in 2000. The analysis is based on the ISI Web of Science [ISI3]. The ISI web covers the major journals in the field, creating a web of references that ensures that the overall picture obtained from the web is likely to give a representative view of the most cited articles. In particular, it means that references from journals included in the ISI Web of Science also gets included in the web and hence included in information available from the created web of references.

The analysis is published as a list of the 20 most cited articles, or in case of ties the actual number of articles may be higher, for example, two articles may be tied for position 20 and hence the list would contain 21 articles. Authors of the top ranked articles have been invited to write a new article for this special issue. They have been asked to either write a follow-up article given that the previous work attracted high attention or some current research that they are conducting.

Two main issues should be kept in mind:

- The possible selection of journals is limited to what is available through the ISI Web of Science.
- The focus is on software engineering. This means that the actual selection of journals is based on selecting journals that are perceived as mainly publishing software engineering articles. All articles in these journals have been analyzed. This implies that no judgment has been made whether a specific article is within software engineering or not. The main reason being that it would not make the results from the analysis replicable and it would also create discussions of the borderlines between fields such as software engineering, computer science and information systems.

The intention is for the analysis provided here to be conducted and published on a yearly basis in a special issue of Information and Software Technology.

The article is structured as follows. Section 2 presents the ISI Web of Science and the actual selection of journals in the analysis. In Section 3, the analysis method is described. This includes some information about the ISI Web of Science in relation to the analysis method and a presentation of how the top 20 list was generated. Section 4 presents the results in relation to the top 20 list. In Section 5, lists of the most cited software engineering journal articles in the last 20 years are presented. A short summary of the findings is provided in Section 6.

2. Selection decisions

A key issue when looking at citations is what to count. This includes both, which publications and which references. When it comes to the publications, any analysis is constrained by the support given by different databases or search engines. In the analysis presented here, it was decided to use the ISI Web of Science. The actual count of citations is further discussed in Section 3.

2.1. Tool support

The selection of which tool to use to count citations has a major impact on the actual outcome and hence on the trustworthiness of the findings. It is worth noting that bibliometric research is a field of its own. In this field, publication patterns are studied including both descriptive (for example counting the number of publications from an organization) and evaluative (for example counting citations as a measure of impact). The Institute for Scientific Information (ISI) has been leading in the field since its establishment in 1961 [McBurney02]. The metrics provided by ISI are being used for determining impact factors for journals [Glänzel02], assess and drive bibliometric research [Zitt05], and support studies like ours in other fields such as medicine [Jones05]. Sample checks with some of the author's publications confirmed that ISI strengths apply to the software engineering domain as well as in medicine [Jones05]. Hence, the position of the ISI data as a leading source for bibliometric research and the actual use of it in

other fields were decisive factors when determining to use this tool for this study of the most cited articles in software engineering.

2.2. Journals

The objective of the ISI as a database is to provide a comprehensive coverage of the most important and influential research. The information about ISI is based on [Thomson05]. The database includes in total more than 8500 journals and some other sources, for example, Lecture Notes in Computer Science. However, journals are here used as a reference to the content of the database. The journals cover three areas: science, social sciences and arts & humanities. The ISI staff reviews close to 2000 journals yearly, but only 10-12% makes it into the database. An interesting feature is how the references build a web. ISI captures the cited references and citation information that is included both from journals in the database and for those journals not included in the database but which are cited from journals included. This ensures a good coverage of citations and also that the data extracted provides a good picture of actual citations.

The objective was to make a selection of journals that provide as fair picture as possible of the most cited articles in software engineering. No database or tool support was found that was capable of also including all references in conferences papers and book chapters and hence the analysis is made under the assumption that journals provide a representative picture of the most cited type of articles and authors.

The first column in Table 1 lists the journals selected from the database as a suitable set of software engineering journals. However not all of these journals were available in the database. Thus, the table also includes information about journals actually in the database in 2000 and remarks about journals when they appeared some other years, but not in year 2000. The journals in the database for 2000 are the journals actually used in the citation study for 2000.

Table 1. Journals considered in the analysis.

Journal	2000	Remarks
ACM Trans. on Software Engineering and Methodology (TOSEM)	Yes	
Annals of Software Engineering	No	One article was found, which was cited five times
Automated Software Engineering	No	Not in ISI at all
Empirical Software Engineering	No	From 2003
IEE Proceedings of Software Engineering[1]	No	Not in ISI at all
IEEE Software (Software)	Yes	
IEEE Trans. on Software Engineering (TSE)	Yes	
Information and Software Technology (IST)	Yes	
International Journal of Software Engineering and Knowledge Engineering	Yes	
Journal of Software Maintenance and Evolution - Research and Practice[2]	No	From 2001
Journal of Software Maintenance – Research and Practice	Yes	Until 2000
Journal of Systems and Software (JSS)	Yes	
Requirements Engineering Journal	No	Not in ISI at all
Software Architecture	No	Only in 2004
Software Engineering Journal	No	Last issue came in 1996
Software Process – Improvement and Practice	No	Not in ISI at all
Software Quality Journal	No	Some issues
Software Testing Verification & Reliability	Yes	
Software – Concepts and Tools	Yes	Not after 1998
Software – Practice and Experience (SPE)	Yes	

Several things may be observed from the table and some issues are worth commenting. A subset of journals has been in the database several years and appears every year. Some journals are added specific years and others are removed. Finally, some journals or issues of journals or specific articles can be found in the database based on that they are cited by articles in the database.

3. Method

The analysis is done focusing on the science part of the ISI Web of Science. The citation search is conducted as follows. The search is conducted for one specific year, for example, 2000. A list of journals is provided to the search engine within the Web of Science. This generates a complete list of articles published in the journals in 2000. It is then possible to sort the list based on the number of citations. This resulted in a sorted list of the most cited articles in the journals listed in Table 1.

The list was generated on December 21st, 2005, and hence it may not be possible to exactly replicate the results presented below. The actual order of articles sorted according to citations may have changed due to the fact that new citations are made and hence are added to the database. It may also be the case that some articles are referenced frequently shortly after publication, while other articles may rise in citation as the years pass. The latter may be the case when a particular article is novel and opens a new

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[1] These proceedings replaced Software Engineering Journal from 1997.
[2] The name of the journal changed in 2001.

avenue of research. Such articles may show an increase in citation as time goes by, since the article becomes accepted as a landmark in a specific area.

It should also be noted that some articles in the list appear as having been published in 1999. However, they appear when searching for articles in 2000. The reason for this may be that a specific issue from one year was actually released the year after. However, it was decided to not remove articles from the list, since this would cause other problems. If removing articles (due to that it shown as being published in 1999 although the ISI Web of Science lists it as being published in 2000) then there is a risk that some articles will not be covered at all in the analysis. Articles removed from 2000 will not appear when searching the database for 1999, and hence it was decided to use the list generated by the database.

Finally, self citations were removed. This was done manually, since no automatic way of filtering the citations was found. Self citation was defined as having at least one author in common with the original article. This means that research groups citing their own papers, but without any of the original authors have been kept.

Based on the rules above, the articles were sorted based on non-self citations and a "most cited" list emerged. When ties appear, the most cited article including self citation is listed first. However, the actual placement in terms of number in the list is not allowed to be affected by the self citations. It is worth mentioning that the removal of self citations only changed the internal order between articles slightly, and that the most cited articles were only marginally affected by removing the self citations. This is probably a result of that most researchers reference (for good reasons) their own work and hence no drastic changes in the list were observed when removing self citations.

4. Top 20 in 2000

The method described in Section 3 resulted in a list of the most cited articles in 2000 for software engineering. The list contains 24 articles, due to that six articles are tied for position 19 on the list. Three authors are represented twice on the list, namely Lionel Briand, Norman Fenton and Oliver Laitenberger. The complete list can be found in the Appendix A. An excerpt of the list is presented in Table 2, where the six most cited articles are listed. The table shows the rank of each article, basic information about the article and the number of times the article has been cited. The basic information contains the normal information provided when referencing research articles.

Table 2. Most cited software engineering articles in 2000 (top six).

Rank	Author Title of article Journal reference	Citations
1	Medvidovic N, Taylor RN A classification and comparison framework for software architecture description languages IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (1): 70-93 JAN 2000	72
2	Fenton NE, Neil M A critique of software defect prediction models IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 25 (5): 675-689 SEP-OCT 1999	36
3	Bush WR, Pincus JD, Sielaff DJ A static analyzer for finding dynamic programming errors SOFTWARE-PRACTICE & EXPERIENCE 30 (7):775-802 JUN 2000	35
4	Gansner ER, North SC An open graph visualization system and its applications to software engineering SOFTWARE-PRACTICE & EXPERIENCE 30 (11):1203-1233 SEP 2000	34
5	Laitenberger O, DeBaud JM An encompassing life cycle centric survey of software inspection JOURNAL OF SYSTEMS AND SOFTWARE 50 (1):5-31 JAN 15 2000	27
6	van den Brand MGJ, de Jong HA, Klint P, Olivier PA Efficient annotated terms SOFTWARE-PRACTICE & EXPERIENCE 30 (3):259-291 MAR 2000	25

The number of citations is overall rather low compared with articles in other fields. However, this comparison depends on for example the size and definition of the field as well as to traditions such as whether to cite only journal articles or both journal and conference articles. It is worth noting the exception of the article by Medvidovic and Taylor that has a high number of citations. In fact, the number of citations is high enough for the article to make it into the list of the most cited articles in 1986-2005 when ranking articles based on the average number of citations in per year. When it comes to the overall rather low number of citations, it should be noted that conference proceedings are very common in software engineering and references from conference papers to the journal papers are not included in the citation count. Moreover, the citation count is made after approximately five years (it depends slightly on when a specific article was made available) and the citations are expected to rise over the years. In particular, it should be noted that a citation means when an article has become published, then others should build on that work and also publish the article. This means that new research should be conducted and articles should have time to go through the process from submission to publication in a journal before resulting in a citation (as counted by the ISI Web of Science).

Based on the list in Table 2 and Appendix A, the first author was invited to contribute with an article to this special issue of Information and Software Technology. No requirements were put on the authors regarding the content, but they were informed that all articles would go through the normal review process. In the process of inviting authors, it turned that not all invited authors were able to contribute for different reasons. In one case, one of the co-authors was invited as a replacement. Thus five researchers accepted the invitation and their contributions can be found in this special issue, although in most cases with other co-authors than their article listed for 2000.

It is interesting also to study which journals appear on the list. It turns out that most articles listed among the top 20 are published in the journals also included in the study presented yearly by the Journal of Systems and Software [Tse06]. In addition, two entries on the list are from more specialized journals, i.e. International Journal of Software Engineering and Knowledge Engineering, and Journal of Software Maintenance – Research and Practice. It can be noted that the most cited articles are published in IEEE Transactions on Software Engineering, although some articles in Software – Practice & Experience are

also highly cited. However, it is probably not a matter of that articles in these journals get cited more than others per se. It is more a matter of that articles that are likely to get highly cited are submitted to the journals. On the other hand, most software engineering researchers today have access to most journals in Table 1 electronically. For example, Information and Software Technology is accessible through ScienceDirect, which a large number of university libraries have access to and hence the researchers at those universities. This means that articles published in any of the journals listed in Table 1 stands a fair chance of being highly cited.

Nevertheless, the top 20 list is dominated by the IEEE Transactions in Software Engineering in a similar way as the analysis published in [Wohlin05] for 1999. A possible trend noted in [Wohlin05] was that although IEEE Transactions on Software Engineering dominates, it is less dominant now than it was in 1994. A possible explanation is that the World Wide Web has made all journals more easily accessible. Before the advent of the Internet (or in its childhood), many researchers received the IEEE journals as members of IEEE, but the other journals meant more expensive subscriptions. The Internet access to most journals through, for example, university libraries may be one explanation to that the picture has changed between 1994 and 1999/2000. It will be interesting to see whether the domination of IEEE Transactions on Software Engineering will continue to decrease or if it will stabilize on a picture similar to the situation in 1999 and 2000.

5. Most cited articles in the last 20 years

This section presents an analysis of the most cited software engineering journal articles in the last 20 years (1986-2005). The analysis was conducted on July 6, 2006. Two analyses are presented. First, an analysis resulting in a ranking based on the total number of citations is presented. This type of analysis is bound to favor articles published some years ago since they have been available for citations longer, and hence a second analysis was conducted. The second analysis presents a ranking based on the average number of citations per year. This is one way of normalizing and hence making it easier for newer articles to make it onto the list. The first analysis is presented in Section 5.1 and the second analysis in Section 5.2.

The method described in Section 3 was applied to software engineering journal articles published in 1986-2005 with one exception. The exception is that self citations have not been removed. The decision not to remove self citations was taken based on several arguments. First, the analysis for both 1999 (published in [Wohlin05], and 2000 (see Section 4) showed that the removal of self citations only changed the internal order between articles slightly. Second, the number of citations is high for the most cited articles overall, which means that the self citations only represent a minor portion of the citations. Third, given that the identification of self citations is done manually there is also a risk for mistakes, in particular given that the large number of citations that have to be gone through.

5.1. Citations in absolute numbers

The analysis of the total number of citations results in the list published in Table B1 in Appendix B. An excerpt showing the top six articles is shown in Table 3. The total number of citations range from 97 to 353 to make it into the top 20 list. The highest ranked article is quite outstanding with 134 more citations than the article making it into the second spot. As can be expected, all articles with the highest counts in Table 3 and Table B1 are published more than 10 years ago with the exception of the article ranked first. The most cited article is the article by Holzmann introducing the SPIN model checker from 1997. It is expected that few newer articles would make it onto this list, since citations are added each year. However, it is remarkable that the only article published in the last 10 years that make it onto the list actually is ranked first.

It is also worth noting that the one of the articles listed when comparing citations in 1999 and 1994 in [Wohlin05] appear on the list in Table 3, i.e. the article by Chidamber and Kemerer. The article was last year listed with a citation count of 186, and this year the number of citations has increased to 219. Thus, the article is still of major interest for research in software engineering with an addition of about 30

citations in a year. This illustrates how a substantial number of citations can be added in a single year even if an article is more than 10 years old.

Table 3. Top six articles in 1986-2005 (total number of citations).

Rank	Author / Title of article / Journal reference	Citations
1	Holzmann GJ	353
	The model checker SPIN	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 23 (5): 279-295 MAY 1997	
2	Chidamber SR, Kemerer CF	219
	A metrics suite for object-oriented design	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 20 (6): 476-493 JUN 1994	
3	Eager DL, Lazowska ED, Zahorjan J	210
	Adaptive load sharing in homogeneous distributed systems	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 12 (5): 662-675 MAY 1986	
4	Harel D, Lachover H, Naamad A, Pnueli A, Politi M, Sherman R, Shtulltrauring A, Trakhtenbrot M	207
	Statemate – A working environment for the development of complex reactive systems	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 16 (4): 403-414 APR 1990	
5	Booch G	192
	Object-oriented development	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 12 (2): 211-221 FEB 1986	
6	Basili VR, Rombach HD	177
	The TAME project – Towards improvement-oriented software environments	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 14 (6): 758-773 JUN 1988	

5.2. Citations per year

The list in Section 5.1 obviously favors older articles, or more precisely articles published in the first 10 years of the studied period. To circumvent this, an analysis was conducted focusing on the average number of citations in per year. This resulted in a new ranking shown in Table B2 in Appendix B. An excerpt listing the top six articles is shown in Table 4.

As can be seen from the tables, it resulted in seven articles published in the period from 1998 to 2003 to enter the list. In addition, one article from 1996 also enters the list. The top nine articles from Table B1 also make it into the list in Table B2, although it results in some changes in the actual order between articles. It is noteworthy that the top two articles in terms of the total number of citations also are the top two articles when looking at the citations per year. The paper by Holzmann is outstanding; it has twice as many citations per year as the runner up. Three of the articles published in 1998 or later make it into the top six as can be seen in Table 4. The highest ranked article in 2000 by Medvidovic and Taylor makes it into fourth place when it comes to the number of citations per year. However, the highest ranked newer article is the article by Zambonelli et al. that make it into third place although published as late as 2003.

Given that the intention is to keep publishing the type of analysis presented in Section 4 on a yearly basis in Information and Software Technology, it is possible to get some indications on which articles that will do well in the analysis in the forthcoming years when analyzing 2001 and so forth.

Table 4. Top six articles in 1986-2005 (citations per year).

Rank	Author / Title of article / Journal reference	Average citations per year
1	Holzmann GJ The model checker SPIN IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 23 (5): 279-295 MAY 1997	39.2
2	Chidamber SR, Kemerer CF A metrics suite for object-oriented design IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 20 (6): 476-493 JUN 1994	18.3
3	Zambonelli F, Jennings NR, Wooldridge M Developing multiagent systems: The Gaia methodology ACM TRANSACTIONS ON SOFTWARE ENGINEERING AND METHODOLOGY 12 (3): 317-370 JUL 2003	16.3
4	Medvidovic N, Taylor RN A classification and comparison framework for software architecture description languages IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (1): 70-93 JAN 2000	15.3
5	Harel D, Lachover H, Naamad A, Pnueli A, Politi M, Sherman R, Shtulltrauring A, Trakhtenbrot M Statemate – A working environment for the development of complex reactive systems IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 16 (4): 403-414 APR 1990	12.9
6	Fuggetta A, Picco GP, Vigna G Understanding code mobility IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 24 (5): 342-361 MAY 1998	12.0

6. Summary

The analysis here is intended to highlight and acknowledge the articles attracting most citations within software engineering. Insights into what is viewed as important to build upon may provide valuable insights into both what research is important and where the field of software engineering is heading. The ISI Web of Science has been used to identify the most cited software engineering journal articles. The analysis has this year been focused on year 2000 and the most cited software engineering journal articles in the last 20 years.

A top 20 list for year 2000 (including 24 articles) has been presented. The authors of the most cited articles in 2000 were invited to contribute to a special issue of Information and Software Technology. Five such articles can be found in this issue.

Furthermore, two lists ranking the most cited articles in the last 20 years were presented. The first list provided a ranking based on the total number of citations independent of the year of publication. Thus, this list favored older articles that have had more time to build a high citation count. The second list provided a ranking based on the average number of citations per year. The highest ranked article in both these list was the article by Holzmann introducing the SPIN model checker from 1997. This type of list can be seen as a possible recommendation for students and researchers to read, since the articles represent the most influential software engineering research in the last 20 years.

The objective is to make the analysis of the most cited software engineering journal articles in a specific year to a yearly tradition for Information and Software Technology, and to invite the most cited authors to contribute to a special issue of the journal. This means that next year's analysis will focus on the most cited software engineering journal articles in 2001.

Acknowledgment

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Appendix A: Top 20 cited software engineering articles in 2000

The list in Table A1 shows a ranking of the most cited software engineering articles in 2000. The citations count was made 21 December 2005. The objective was to provide a top 20 ranking, but due to ties the total number of articles in the list is 24.

Table A1: Ranking of most cited articles.

Rank	Author Title of article Journal reference	Citations
1	Medvidovic N, Taylor RN A classification and comparison framework for software architecture description languages IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (1): 70-93 JAN 2000	72
2	Fenton NE, Neil M A critique of software defect prediction models IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 25 (5): 675-689 SEP-OCT 1999	36
3	Bush WR, Pincus JD, Sielaff DJ A static analyzer for finding dynamic programming errors SOFTWARE-PRACTICE & EXPERIENCE 30 (7):775-802 JUN 2000	35
4	Gansner ER, North SC An open graph visualization system and its applications to software engineering SOFTWARE-PRACTICE & EXPERIENCE 30 (11):1203-1233 SEP 2000	34
5	Laitenberger O, DeBaud JM An encompassing life cycle centric survey of software inspection JOURNAL OF SYSTEMS AND SOFTWARE 50 (1):5-31 JAN 15 2000	27
6	van den Brand MGJ, de Jong HA, Klint P, Olivier PA Efficient annotated terms SOFTWARE-PRACTICE & EXPERIENCE 30 (3):259-291 MAR 2000	25
7	Lupu EC, Sloman M Conflicts in policy-based distributed systems management IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 25 (6): 852-869 NOV-DEC 1999	23
8	Fenton NE, Ohlsson N Quantitative analysis of faults and failures in a complex software system IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (8): 797-814 AUG 2000	21
9	Briand LC, Wust J, Daly JW, Porter DV Exploring the relationships between design measures and software quality in object-oriented systems JOURNAL OF SYSTEMS AND SOFTWARE 51 (3):245-273 MAY 1 2000	19
10	Hagen C, Alonso G Exception handling in workflow management systems IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (10): 943-958 OCT 2000	18
11	Briand LC, Morasca S, Basili VR Defining and validating measures for object-based high-level design IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 25 (5): 722-743 SEP-OCT 1999	17

12	Cartwright M, Shepperd M	17
	An empirical investigation of an object-oriented software system	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (8): 786-796 AUG 2000	
13	Fabri A, Giezeman GJ, Kettner L, Schirra S, Schonherr S	15
	On the design of CGAL a computational geometry algorithms library	
	JOURNAL OF SYSTEMS AND SOFTWARE, 49 (2-3): 177-192 DEC 30 1999	
13	Ropponen J, Lyytinen K	15
	Components of software development risk: How to address them? A project manager survey	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (2): 98-112 FEB 2000	
13	Minsky NH, Ungureanu, V	15
	Law-governed interaction: A coordination and control mechanism for heterogeneous distributed systems	
	ACM TRANSACTIONS ON SOFTWARE ENGINEERING AND METHODOLOGY 9 (3): 273-305 JUL 2000	
16	Williams L, Kessler RR, Cunningham W, Jeffries, R	13
	Strengthening the case for pair programming	
	IEEE SOFTWARE 17 (4): 19-+ JUL-AUG 2000	
16	Wang EY, Cheng BHC	13
	Formalizing the functional model within object-oriented design	
	INTERNATIONAL JOURNAL OF SOFTWARE ENGINEERING AND KNOWLEDGE ENGINEERING 10 (1) 5-30 FEB 2000	
16	Kuhn DR	13
	Fault classes and error detection capability of specification-based testing	
	ACM TRANSACTIONS ON SOFTWARE ENGINEERING AND METHODOLOGY 8 (4): 411-424 OCT 1999	
19	Kitchenham BA, Travassos GH, von Mayrhauser A, Niessink F, Schneidewind NF, Singer J, Takada S, Vehvilainen R, Yang HJ	12
	Towards an ontology of software maintenance	
	JOURNAL OF SOFTWARE MAINTENANCE-RESEARCH AND PRACTICE 11 (6):365-389 NOV-DEC 1999	
19	van Lamsweerde A, Letier E	12
	Handling obstacles in goal-oriented requirements engineering	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (10): 978-1005 OCT 2000	
19	Laitenberger O, Atkinson C, Schlich M, El Emam, K	12
	An experimental comparison of reading techniques for defect detection in UML design documents	
	JOURNAL OF SYSTEMS AND SOFTWARE 53 (2):183-204 AUG 31 2000	
19	Dolado JJ	12
	A validation of the component-based method for software size estimation	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (10): 1006-1021 OCT 2000	
19	Cockburn A	12
	Selecting a project's methodology	
	IEEE SOFTWARE 17 (4): 64-+ JUL-AUG 2000	
19	Leveson NG	12
	Intent specifications: An approach to building human-centered specifications	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (1): 15-35 JAN 2000	

Appendix B: Top 20 cited software engineering articles in 1986-2005

The list in Table B1 shows a ranking of the most cited software engineering articles in 1986-2005 in terms of total number of citations. A count of the total number of publications favors older articles, since they have more time to get cited. Thus, to circumvent this, normalization was done where the average number of citations per year was used to rank the articles. The ranking based on the average number of citation per year is shown in Table B2. The citation count resulting in Tables B1 and B2 was made 6 July 2006.

Table B1: Ranking of most cited articles.

Rank	Author / Title of article / Journal reference	Citations
1	Holzmann GJ The model checker SPIN IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 23 (5): 279-295 MAY 1997	353
2	Chidamber SR, Kemerer CF A metrics suite for object-oriented design IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 20 (6): 476-493 JUN 1994	219
3	Eager DL, Lazowska ED, Zahorjan J Adaptive load sharing in homogeneous distributed systems IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 12 (5): 662-675 MAY 1986	210
4	Harel D, Lachover H, Naamad A, Pnueli A, Politi M, Sherman R, Shtulltrauring A, Trakhtenbrot M Statemate – A working environment for the development of complex reactive systems IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 16 (4): 403-414 APR 1990	207
5	Booch G Object-oriented development IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 12 (2): 211-221 FEB 1986	192
6	Basili VR, Rombach HD The TAME project – Towards improvement-oriented software environments IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 14 (6): 758-773 JUN 1988	177
7	Jahanian F, Mok AK Safety analysis of timing properties in real-time systems IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 12 (9): 890-904 SEP 1986	167
8	Koo R, Toueg S Checkpointing and rollback-recovery for distributed systems IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 13 (1): 23-31 JAN 1987	152
9	Fruchterman TMJ, Reingold EM Graph drawing by force-directed placement SOFTWARE-PRACTICE & EXPERIENCE 21 (11): 1129-1164 NOV 1991	135
10	Avizienis A The N-version approach to fault-tolerant software IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 11 (12): 1491-1501 1985	134
11	Casavant TL, Kuhl JG A taxonomy of scheduling in general-purpose distributed computing systems IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 14 (2): 141-154 FEB 1988	131

12	Berthomieu B, Diaz M Modeling and verification of time-dependent systems using time Petri nets IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 17 (3): 259-273 MAR 1991	127
13	Denning DE An intrusion-detection model IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 13 (2): 222-232 FEB 1987	126
14	Goel AL Software-reliability models – Assumptions, limitations, and applicability IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 11 (12): 1411-1423 1985	123
15	Chikofsky EJ, Cross JH Reverse engineering and design recovery – A taxonomy IEEE SOFTWARE 7 (1): 13-17 JAN 1990	115
16	Owre S, Rushby J, Shankar N, Vonhenke F Formal verification for fault-tolerant architectures – Prolegomena to the design of PVS IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 21 (2): 107-125 FEB 1995	113
17	Knight JC, Leveson NG An experimental evaluation of the assumption of independence in multiversion programming IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 12 (1): 96-109 JAN 1986	110
18	Luckham DC, Kenney JJ, Augustin LM, Vera J, Bryan D, Mann W Specification and analysis of system architecture using Rapide IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 21 (4): 336-355 APR 1995	100
18	Black A, Hutchinson N, Jul E, Levy H, Carter L Distribution and abstract types in Emerald IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 13 (1): 65-76 JAN 1987	100
20	Li W, Henry S Object-oriented metrics that predict maintainability JOURNAL OF SYSTEMS AND SOFTWARE 23 (2): 111-122 NOV 1993	97

Table B2: Ranking of most cited articles.

Rank	Author Title of article Journal reference	Average citations per year
1	Holzmann GJ The model checker SPIN IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 23 (5): 279-295 MAY 1997	39.2
2	Chidamber SR, Kemerer CF A metrics suite for object-oriented design IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 20 (6): 476-493 JUN 1994	18.3
3	Zambonelli F, Jennings NR, Wooldridge M Developing multiagent systems: The Gaia methodology ACM TRANSACTIONS ON SOFTWARE ENGINEERING AND METHODOLOGY 12 (3): 317-370 JUL 2003	16.3
4	Medvidovic N, Taylor RN A classification and comparison framework for software architecture description languages IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 26 (1): 70-93 JAN 2000	15.3
5	Harel D, Lachover H, Naamad A, Pnueli A, Politi M, Sherman R, Shtulltrauring A, Trakhtenbrot M Statemate – A working environment for the development of complex reactive systems IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 16 (4): 403-414 APR 1990	12.9
6	Fuggetta A, Picco GP, Vigna G Understanding code mobility IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 24 (5): 342-361 MAY 1998	12.0
7	Eager DL, Lazowska ED, Zahorjan J Adaptive load sharing in homogeneous distributed systems IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 12 (5): 662-675 MAY 1986	10.5
8	Owre S, Rushby J, Shankar N, Vonhenke F Formal verification for fault-tolerant architectures – Prolegomena to the design of PVS IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 21 (2): 107-125 FEB 1995	10.3
9	Basili VR, Rombach HD The TAME project – Towards improvement-oriented software environments IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 14 (6): 758-773 JUN 1988	9.8
9	De Nicola R, Ferrari GL, Pugliese R KLAIM: A kernel language for agents interaction and mobility IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 24 (5): 315-330 MAY 1998	9.8
11	Booch G Object-oriented development IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 12 (2): 211-221 FEB 1986	9.6
12	Luckham DC, Kenney JJ, Augustin LM, Vera J, Bryan D, Mann W Specification and analysis of system architecture using Rapide IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 21 (4): 336-355 APR 1995	9.1
13	Fruchterman TMJ, Reingold EM Graph drawing by force-directed placement SOFTWARE-PRACTICE & EXPERIENCE 21 (11): 1129-1164 NOV 1991	9.0
13	Bellifemine F, Poggi A, Rimassa G Developing multi-agent systems with a FIPA-compliant agent framework SOFTWARE-PRACTICE & EXPERIENCE 31 (2): 103-128 FEB 2001	9.0

15	Berthomieu B, Diaz M	8.5
	Modeling and verification of time-dependent systems using time Petri nets	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 17 (3): 259-273 MAR 1991	
15	Kitchenham BA, Pfleeger SL, Pickard LM, Jones PW, Hoaglin DC, El Emam K, Rosenberg J	8.5
	Preliminary guidelines for empirical research in software engineering	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 28 (8): 721-734 AUG 2002	
15	Krauter K, Buyya R, Maheswaran M	8.5
	A taxonomy and survey of grid resource management systems for distributed computing	
	SOFTWARE-PRACTICE & EXPERIENCE 32 (2): 135-164 FEB 2002	
18	Jahanian F, Mok AK	8.4
	Safety analysis of timing properties in real-time systems	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 12 (9): 890-904 SEP 1986	
18	Alur R, Henzinger TA, Ho PH	8.4
	Automatic symbolic verification of embedded systems	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 22 (3): 181-201 MAR 1996	
20	Koo R, Toueg S	8.0
	Checkpointing and rollback-recovery for distributed systems	
	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING 13 (1): 23-31 JAN 1987	