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Discovering the Novelty of Self-Citations

[1]M. Raja and [2]T. Ravichandran

[1]*Department of Computer Science & Engineering., CMS College Engineering and Technology, Coimbatore 641032, Tamilnadu, India.*
[2]*Principal of Hindustan Institute of Technology, Coimbatore 641032, Tamilnadu, India.*

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ABSTRACT

The significance of self citation is not appreciated very much in research. Self citations though used for genuine reasons are mostly misunderstood as a way to increase citation count and thereby the popularity of the author. To disprove this false allegation, we present a system to handle the cases of self citation as an indication of research progress in that area. The system was able to prove the worthiness of self citations on account of novelty and quality measures. By including self-citation a certain problematic effect called PIED-PIPER effect can be eliminated. PIED-PIPER effect can be explained by considering a situation where in a low cited but an important paper of a researcher doesn't acquire the proper recognition due to blind elimination of self-citations can affect the researcher.

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INTRODUCTION

Citation is defined as a reference to a scholarly work mostly from published or unpublished source. To be more specific, a citation is an abbreviated expression mentioned in the body of a work that denotes an entry in the bibliographic references section. It is used for the purpose of acknowledging the relation of the works of others to the topic of discussion at the spot where the citation appears. Citations represent semantic content of the full text articles. They help the documents to pin the source works to a particular concepts, propositions and arguments; identify and locate the source works; acknowledge evidence of research in the topic of concern and provide evidence for the findings of the author who originally contributed the concept or theory. In addition, Deepika and Mahalakshmi, (2011a) (2012) suggest that author self-citation also contributes to the overall citation count of an article and the impact factor of the journal in which it appears.

Self-citing is often portrayed as an attempt of self-advertising. But an author self cites because the nature of work is a progress of the previous findings. Costas *et al*., 2010 states that *"Given the cumulative nature of the production of new knowledge, self-citations constitute a natural part of the communication process."* By including self-citation a certain problematic effect called PIED-PIPER effect can be eliminated. PIED-PIPER effect can be explained by considering a situation where in a low cited but an important paper of a researcher doesn't acquire the proper recognition due to blind elimination of self-citations can affect the researcher.

Self-citations are often believed to be copied from the parental context and are not acknowledged truly to what they deserve. Deepika and Mahalakshmi, (2011a) (2012) suggest that journal impact factors do not measure the author quality whereas h-index has an inclusive measurement of self-citations. Google Scholar includes self-citations into the total citations measure and Scopus exclude the self-citations for calculation of h-index of a particular researcher. Mahalakshmi (2012a & 2012b) and Sendhilkumar *et al* (2012) showed that analysing the quality of self-citations helps to build the prestige of researcher thereby improving the researcher presence in research communities. Mahalakshmi and Sendhilkumar, (2013) agree that validity of self-citations needs to be explored since every self-citation is an indicative of continuing research.

This paper discusses a qualitative analysis of analyzing self-cited research publications from the perspective of novelty estimation. The research papers and their self-citations are tracked (Mahalakshmi and Sendhilkumar, 2008; Mahalakshmi *et al*., 2009; Mahalakshmi *et al*., 2011) and fed as input to the novelty estimator. The (self) citations are analysed for citation quality via citation

Corresponding Author: M. Raja, Department of Computer Science & Engineering., CMS College Engineering and Technology, Coimbatore 641032, Tamilnadu, India.
E-mail: rajajuly2014@gmail.com

sentiment analysis (Sendhilkumar and Mahalakshmi, 2011; Mahalakshmi *et al*., 2013; Sendhilkumar *et al*., 2013c) which ranks the self-citations qualitatively. Self-citations beyond a definite threshold are rejected. Thus every researcher is recommended with quality self-citations which shall be included prestigiously in total citations thereby genuinely improving the h-index of the researcher.

Literature Survey:

In the field of citation metrics, self citations have always been a topic of argument. Self Citations are not taken as a part of bibliometric evaluation of articles. James & Dag (2007) believed that these citations do not reflect the importance of their work or its impact on the rest of the scientific community. Early research on this was done on National Citation Report (NCR) for Norway ISI concluded that self-citations have impact on the article. The number of self citations was found to be directly proportional to the probability of that article being cited by others. Though it is already a known fact that citations are indicators of degree of contribution, this work suggests an even deeper problem – even counts of citations from others are sensitive to strategic manipulation by those who are willing to cite themselves frequently.

Isola *et al*, (2010) quotes that citation count and author's work is highly influenced by the number of self citations and recitations of the article. A study reports that the scientometric measures like JIF by Deepika and Mahalakshmi, (2011b), h–index by Hirsch, (2005) etc are greatly affected by the self citations and the pattern in which they are cited (Lievers, 2012). The forward-chronological reference resulted in large pool of potential articles that were prioritized based on relevance among citations. It was found that the f-N relationship was affected by self-citations. The experiment concluded that self references are more likely to be repeatedly cited and that these repeated citation of self-references can be an indicator reflecting the true relevance to the citing document.

In order to identify the nature of connection between the cited and citing articles, citation classification is used. Garfield's, (1965) citation scheme lists the reasons why authors cite other works. Moravcsik and Murugesan, (1975) divided citations in running text into four dimensions rather than one classification function namely: conceptual or operational use, evolutionary or juxtaposition, organic or perfunctory and confirmative or negation. Another scheme by Simon Teufel *et al*., (2006) classifies citations into Seven Argumentative Zones say, *Background*, *Other*, *Own*, *Aim*, *Textual*, *Contrast*, and *Basis*, according to their role in the author's argument. A completely diverse yet simple classification was proposed by Nanba and Okumura (1999, 2000) which composed of only three categories namely Type B (base), C (compare) and O (other than B and C) while Simone Teufel's, (2006) classification had 12 category framework based on the empirical work in citation content analysis. The classification are Weakness of cited approach, Contrast Comparison in Goal & Results, base, uses, modifies, motivate, similar, support and neutral. Yet another classification scheme by Pham *et al*, (2003) classifies citations into 4 categories, such as Basis, Support, Limitation and Comparison. Using Ripple Down rules citation context were categorized into these category.

Novelty of a sentence is usually calculated with respect to the number of new words appearing in them. This involves two tasks namely relevant sentence extraction and novelty estimation. Zhang (2009) claims that Named Entity Recognition (NER) method helps in identifying the meaning of a sentence by recognizing some key characteristics. Vector Spaced Model (VSM) is used to rank documents. Term co-occurrence and term weights along with term sets are used as term indices to capture semantic relationship of terms that appear close to each other. According to Bruno Pôssas *et al*., (2005) S*et-based vector model* refers a term set to a set of index terms of collection of documents. Schiffman *et al*., (2005) says cosine distance metric was used to compute novelty by assigning all non-stop words a value of 1. A Graph-based text representation model by Tomita *et al*., (2004) represents texts formally as Subject Graphs. Translation form text to subject graphs involved three steps: 1) term extraction from text, 2) term significance calculation, and 3) significance calculation for term-term association and making association vector. The similarity is then measured as a linear combination of inner products of term vectors and the association vectors. Later work by Michale Gamon, (2006) involved creating feature vector for each tagged sentence and set of sentences that has already seen information. These features captured the relationship between tagged sentences and set of background sentences. These sentences are then represented as *graphs* based on *21 graph features* and few *text rank features*. The novelty score for the sentence was computed based on *KL divergence, sentence graph* and *text rank.* Another major contribution by Zhao *et al*., (2006) for sentence level novelty detection using *overlap method*, defines novelty as a combination of partial overlap (PO) and complete overlap (CO. The overlaps were measures using similarity, pool method and selected pool method.

Soboroff *et al*., (2005) says that document level novelty detection is considered rarely useful, as nearly every document will have something new. Most work on document level novelty detection treats document as a set of sentences. Novelty of the document is determined by sentence novelty. The main focus by Zhang *et al*., (2004) is on information filtering system to retrieve relevant document based

on recall, precision and utility metrics. Newness of a document is dependent on relevance of the document with those retrieved previously. An adaptive information filtering system by Zhang *et al*., (2002) was used to identify novel documents based on document classification as redundant, relevant and non-relevant. Novelty mining in multi-lingual document by Zhang *et al*., (2011) say Malay (Kwee *et al*., 2009) and Chinese (Zhang and Tsai, 2009) language is done at document level. The novelty of a document is then quantitatively represented by calculating cosine similarity and taking the difference between 1 and similarity score (1-cosine similarity). A new framework by Tsai *et al*., (2010) for document level novelty detection using *document-to-sentence (D2S)* annotation was proposed. The document was first segmented into sentence, novelty score for each sentence was determined and novelty score of whole document was predicted based on fixed threshold. A Fuzzy Cognitive Map by Sendhilkumar *et al*., (2011) approach considers a document as a collection of topics. The document was represented as fuzzy concept maps that had concepts and information of the domain which was compared with domain specific ontology.

Methodology:

The following methodologies are proposed in our system for handling self-citations.

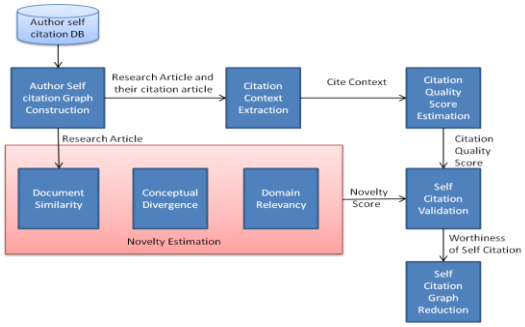

Fig. 1: Overall Framework for analyzing citation quality of Self-citations.

Citation Quality Score Estimation:

The quality of citation of a research article is calculated based three basic parameters. They are the Sentiment of the citation, their classification and finally the content relevancy of the article as shown by Raja and Ravichandran (2014). In case of sentiment analysis, the pos tagged citation contexts are fed to the SentiWordNet and the corresponding scores of adjectives are aggregated to get the overall sentiment score. In citation classification, the relationship between cited and citing article is put into categories such as compare, basis, support, use, modifies, weak and simple based on Naïve Bayes classifier. Finally the context relevancy is calculated by cosine similarity and outlier determination (Deepika *et al*., 2011; Deepika and Mahalakshmi, 2011b; Mahalakshmi *et al*., 2012). The aggregated citation quality score is the sum of these three parameters for the highest significant classification category.

Document Similarity:

Each research article is compared with their self-citation articles to identify similarity among them. This gives a measure of whether the topics discussed in the cited article are already been proposed or discussed on the citing article. The similarity is calculated using cosine similarity as

$$\cos(s_i, s_j) = \frac{\sum_{k=1}^{l} v_i k \times v_j k}{|s_i| . |s_j|}$$

where s_i represents Sentence vector$(v_{i1}, v_{i2}, \ldots, v_{il})$, l denotes number of documents retrieved from the reference corpus and s_j is another sentence vector (Tsai *et al*., 2004).

Domain Relevance:

The cited article and the citing articles are topic modeled. The topics of the cited article are then compared with the manually collected topics associated with the domain and the topics of the citing article. This helps us to identify the extent to which the given work is associated with the progress of the domain and variation in topic coverage of the cited and citing article. The inverse of the similarity will provide the measure of amount of new topics dealt with in the article of concern. This domain relevance will help to arrive at a solution for "What new topic the paper deals with in the domain of interest?" and/or "What new solutions the article suggests for the topic of concern?"

Conceptual Divergence:

The cited article and the citing articles are concept mapped. Concept mapping involves representing the documents as a set of concepts and relationships among them. Concepts include ideas, words, topics and new logical terms. Relationship represents the way in which the identified concepts are linked to one another. These are preserved in

XML files. The concept maps obtained are compared and the Kullback – Leiber divergence is measured between the concept maps.

$$D_{KL}(P||Q) = \sum_i \ln\left(\frac{P(i)}{Q(i)}\right)P(i)$$

Where, P denotes the citing article and Q denotes the citing article for comparison at a given point and i denotes the number of concepts.

Novelty Estimation:

Here novelty is treated as a combined representation of similarity, relevance and divergence.

$$Novelty = 1 - (Similarity + Relevance) + Divergence$$

The novelty thus obtained includes properties of input research article such as conceptual divergence, semantic relevance and contextual similarity.

Self Citation Graph Construction and Reduction:

Self citation network contain nodes and edges. Nodes represent the article. Edges represent the author self citation relationship between the articles. The graph representation for author Ying Dar Lin and his self-citations (as in Appendix table 6) is given in Figure 2.

The self citation network (figure 2) is reduced by considering the citation quality score across articles. This filtering will enable us to retain only the self citations that are semantically significant. The edges and the nodes that have less worthy citation to the cited article are removed from the graph. The articles retained after the filtration will have valid citations with significant improvement from the cited article.

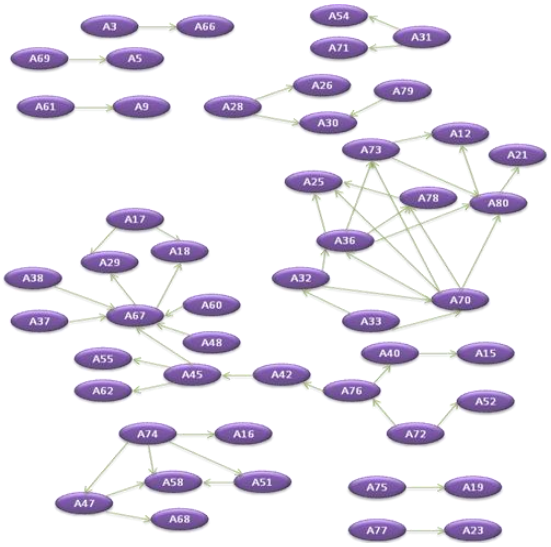

Fig. 2: Self Citation network of Author Ying Dar Lin.

Table 1: Novelty Score of articles.

Article Id	Novelty	Article Id	Novelty
A3	0.998298	A60	0.468765
A17	0.523635	A61	0.959772
A28	0.01079	A67	0.738487
A31	0.018311	A69	0.88393
A32	0.139981	A70	0.02806
A36	0.035781	A72	0.167694
A37	0.475836	A73	0.03741
A38	0.46599	A74	0.071525
A40	0.096009	A75	0.994413
A42	0.068336	A76	0.261531
A45	0.547087	A77	0.490442
A47	0.03741	A78	0.03741
A48	0.465546	A79	0.071525
A51	0.0361	A80	0.748911

Results:

Novelty Estimation:

The Fig 3 depicts the Self citation quality score for the self citation articles and novelty of work in the citing article compared to the cited article of an author Ying Dar Lin. Nearly 50 % of self citation quality is below average. But the remaining 50 % of citations shows a quality self citation score. Hence blindly remove such citation is not the correct thing. It is found that most of the articles had novelty score

at a very low level. From this it can be inferred that most of the self citations shows very little improvement in work compared to the previous. However this alone cannot be taken as a factor for excluding or including the self citations. Combining novelty and citation quality will help to decide whether or not to include the self citations and which citations are to be retained for further evaluations.

Graph Reduction:

Fig 4 is the graphical representation of author self-citation network. The directed edge starts at the cited article and ends at the citing article. The edge carries the citation quality score and novelty scores as weights. Their values are shown in table 2.

The network is initially reduced by Raja and Ravichandran (2014) using threshold on CQS score. The threshold is set as dynamic by considering the average of all CQS scores (table 3) obtained. The edges having CQS below the threshold is deleted.

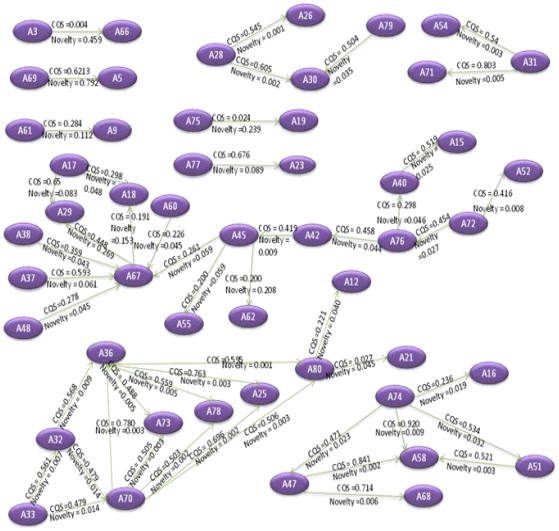

Fig. 3: Graph representation of Author self citation Network with CQS and Novelty.

Table 2: SCQS and Novelty scores of self cited articles.

SI.No	Article Id	Citing Article ID	SCQS	Novelty
1	A17	A18	0.2981937	0.048922
2	A17	A29	0.6506	0.083998
3	A28	A26	0.5458433	0.001234
4	A28	A30	0.6053341	0.001635
5	A3	A66	0.004526	0.459131
6	A31	A54	0.5404161	0.002676
7	A31	A71	0.8038475	0.004979
8	A32	A36	0.5684659	0.009564
9	A32	A70	0.4799559	0.014805
10	A33	A32	0.5612969	0.007095
11	A36	A25	0.7638528	0.002739
12	A36	A73	0.488958	0.005879
13	A36	A78	0.5593643	0.004542
14	A36	A80	0.5958332	0.001278
15	A37	A67	0.5830738	0.061721
16	A38	A67	0.3591753	0.04355
17	A40	A15	0.5192548	0.02563
18	A42	A45	0.4193213	0.009558
19	A45	A55	0.200565	0.059724
20	A45	A62	0.200565	0.208731
21	A45	A67	0.2619529	0.05934
22	A47	A58	0.8419364	0.001946
23	A47	A68	0.7140952	0.005648
24	A48	A67	0.2789418	0.045575
25	A51	A58	0.5211516	0.003498
26	A60	A67	0.2267947	0.045841
27	A61	A9	0.2843367	0.112862
28	A67	A18	0.191106	0.152799
29	A67	A29	0.4486462	0.269795
30	A69	A5	0.6213123	0.792909
31	A70	A25	0.6960017	0.001935

32	A70	A36	0.7808646	0.003002
33	A70	A73	0.5056398	0.003218
34	A70	A78	0.5039071	0.001877
35	A70	A80	0.5063536	0.002857
36	A72	A52	0.4164363	0.008767
37	A72	A76	0.4548092	0.027836
38	A73	A12	0.2330252	0.029437
39	A73	A80	0.3201237	0.029762
40	A74	A16	0.2365377	0.019883
41	A74	A47	0.4718693	0.023197
42	A74	A51	0.5346419	0.032123
43	A74	A58	0.9208537	0.009838
44	A75	A19	0.0241305	0.239973
45	A76	A40	0.2981866	0.046784
46	A76	A42	0.4589841	0.044587
47	A77	A23	0.6765528	0.089742
48	A78	A25	0.5995552	0.000578
49	A79	A30	0.5041364	0.035192
50	A80	A12	0.2211541	0.040123
51	A80	A21	0.0276352	0.045578

Table 3: Average SCQS scores of Articles.

Article Id	SCQS	Article Id	SCQS
A3	0.004526	A60	0.226795
A17	0.474397	A61	0.284337
A28	0.575589	A67	0.224323
A31	0.672132	A69	0.621312
A32	0.524211	A70	0.101271
A36	0.148958	A72	0.435623
A37	0.583074	A73	0.276574
A38	0.359175	A74	0.230213
A40	0.519255	A75	0.02413
A42	0.419321	A76	0.378585
A45	0.087318	A77	0.676553
A47	0.778016	A78	0.599555
A48	0.278942	A79	0.504136
A51	0.521152	A80	0.124395

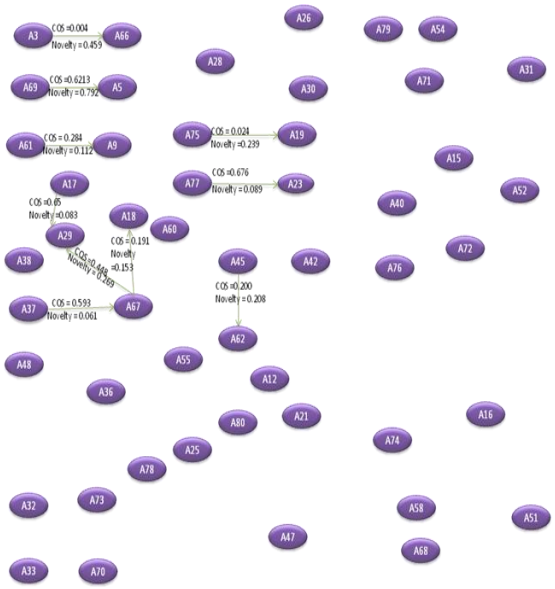

Fig. 4: Reduced Author Self Citation Network based on Novelty.

The graph Fig.4 shows the citing articles with significant improvements from the cited articles (table 4). The edges having novelty score less than the threshold (average of all) is deleted. As it is seen, most of the edges were removed. This can be inferred that most of the self cited articles had less significant improvement from the cited article. However, novelty is a factor that cannot be precisely measured. Though the other articles had less novelty score they should not be completely avoided as they also showed some significant work though below threshold.

Such discrepancies can be avoided by considering both CQS and Novelty as a combined metric. The above graph Fig.6 shows the cited and citing articles that are to be included in the citation count. Their corresponding values are in table 5. Here, the articles with CQS OR Novelty above the threshold are retained. The nodes that are disjoint neither have quality citations nor pose significant improvements, hence can be ignored in citation count. The quality citations and novelty equally contributes to self citation evaluation as discussed by Sendhilkumar *et al*., (2013a) (2013b).

Table 4: Reduced Author Self Citations based on Novelty.

S.No	Article Id	Citing Article ID	SCQS	Novelty
1	A17	A29	0.6506	0.083998
2	A3	A66	0.004526	0.459131
3	A45	A62	0.200565	0.208731
4	A61	A9	0.284337	0.112862
5	A67	A18	0.191106	0.152799
6	A67	A29	0.448646	0.269795
7	A69	A5	0.621312	0.792909
8	A75	A19	0.02413	0.239973
9	A77	A23	0.676553	0.089742
10	A37	A67	0.583074	0.061721

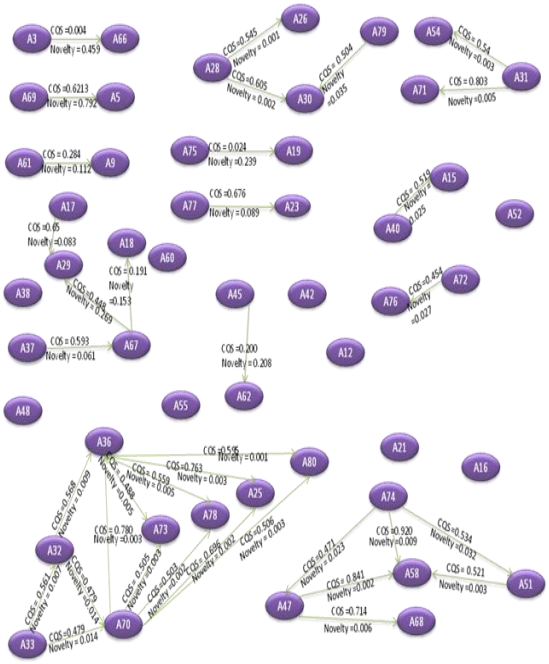

Fig. 5: Reduced Author Self Citation Network based on both SCQS and Novelty.

Table 5: Reduced Author Self Citations based on both SCQS and Novelty.

SI.No	Article Id	Citing Article ID	SCQS	Novelty
1	A17	A29	0.6506	0.083998
2	A28	A26	0.5458433	0.001234
3	A28	A30	0.6053341	0.001635
4	A3	A66	0.004526	0.459131
5	A31	A54	0.5404161	0.002676
6	A31	A71	0.8038475	0.004979
7	A32	A36	0.5684659	0.009564
8	A32	A70	0.4799559	0.014805
9	A33	A32	0.5612969	0.007095
10	A36	A25	0.7638528	0.002739
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19	A51	A58	0.5211516	0.003498
20	A61	A9	0.2843367	0.112862

21	A67	A18	0.191106	0.152799
22	A67	A29	0.4486462	0.269795
23	A69	A5	0.6213123	0.792909
24	A70	A25	0.6960017	0.001935
25	A70	A36	0.7808646	0.003002
26	A70	A73	0.5056398	0.003218
27	A70	A78	0.5039071	0.001877
28	A70	A80	0.5063536	0.002857
29	A74	A47	0.4718693	0.023197
30	A74	A51	0.5346419	0.032123
31	A74	A58	0.9208537	0.009838
32	A75	A19	0.0241305	0.239973
33	A77	A23	0.6765528	0.089742
34	A78	A25	0.5995552	0.000578
35	A79	A30	0.5041364	0.035192

We thereby put forth a strong argument that author self-citing articles with quality citations and significant improvement from the self-cited articles should definitely be considered for citation count.

Conclusion:

The importance of self citations in both quantitative and qualitative has been addressed by this paper. Self citations may be recommended based on the quality of citation and their contribution to the current paper without affecting the novelty of the citing paper. However, inclusion of self-citation is still a double-edged sword in bibliometrics research. Inclusion of self-citations will not cause a negative impact on the citation count as long as the paper address the problem in previous publication (self-cited article) from a different approach, identifies a new problem from the article or proposes a new methodology for the problem solved in previous publication with better results. Most self citing paper show very less improvement from the cited paper. But the citation cannot be completely dropped because of this factor alone. Novelty and citation quality can help to decide the significance of self citation in a context and for further evaluation.

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Annexure:

Table 6: Articles and Self Citation Articles of Ying Dar Lin.

Article ID	Article
A1	I-Wei Chen, Po-Ching Lin, Tsung-Huan Cheng, Chi-Chung Luo, Ying-Dar Lin, Yuan-Cheng Lai, Frank C. Lin: Extracting Ambiguous Sessions from Real Traffic with Intrusion Prevention Systems. I. J. Network Security 14(5): 243-250 (2012)
A2	Ying-Dar Lin, Chia-Yu Ku, Yuan-Cheng Lai, Chia-Fon Hung: In-Kernel Relay for Scalable One-to-Many Streaming. IEEE MultiMedia (IEEEMM) 20(1):69-79 (2013)
A3	Ying-Dar Lin, Po-Ching Lin, Tsung-Huan Cheng, I-Wei Chen, Yuan-Cheng Lai: Low-storage capture and loss recovery selective replay of real flows. IEEE Communications Magazine (CM) 50(4):114-121 (2012)
A4	Ying-Dar Lin, Erica Johnson, Eduardo Joo: Network testing series [Series Editorial]. IEEE Communications Magazine (CM) 50(3):138-139 (2012)
A5	Chun-Nan Lu, Ying-Dar Lin, Chun-Ying Huang, Yuan-Cheng Lai: Session Level Flow Classification by Packet Size Distribution and Session Grouping. AINA Workshops 2012:221-226
A6	Ying-Dar Lin, Chi-Heng Chou, Yuan-Cheng Lai, Tse-Yau Huang, Simon Chung, Jui-Tsun Hung, Frank C. Lin: Test coverage optimization for large code problems. Journal of Systems and Software (JSS) 85(1):16-27 (2012)
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A14	Ying-Dar Lin, Ching-Ming Tien, Shih-Chiang Tsao, Ruo-Hua Feng, Yuan-Cheng Lai: Multiple-resource request scheduling for differentiated QoS at website gateway. Computer Communications (COMCOM) 31(10):1993-2004 (2008)
A15	Shih-Chiang Tsao, Yuan-Cheng Lai, Le-Chi Tsao, Ying-Dar Lin: On applying fair queuing discipline to schedule requests at access gateway for downlink differential QoS. Computer Networks (CN) 52(18):3392-3404 (2008)
A16	Yi-Neng Lin, Ying-Dar Lin, Yuan-Cheng Lai: Thread allocation in CMP-based multithreaded network processors. Parallel Computing (PC) 36(2-3):104-116 (2010)
A17	Yi-Neng Lin, Ying-Dar Lin, Yuan-Cheng Lai: Thread allocation in CMP-based multithreaded network processors. Parallel Computing (PC) 36(2-3):104-116 (2010)
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A29	Ying-Dar Lin, Po-Ching Lin, Yuan-Cheng Lai, Tai-Ying Liu: Hardware-Software Codesign for High-Speed Signature-based Virus Scanning.IEEE Micro (MICRO) 29(5):56-65 (2009)
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A79	Mario Gerla, Ying-Dar Lin: Network management using database discovery tools. LCN 1991:378-385
A80	Yi-Neng Lin,Shih-Hsin Chien,Ying-Dar Lin,Yuan-Cheng Lai,Mingshou Liu :DYNAMIC BANDWIDTH ALLOCATION FOR 802.16E-2005 MAC, In Current Technology Developments of WiMax Systems pp 17-29 ,(2009)