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Application of Bradford's Law to Human-Computer Interaction Research Literature

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ABSTRACT

Bradford's law is about scattering of literature in different information sources on a narrow subject. The present study serves as a test of the two formulations of Bradford's law, verbal and graphical, using 137120 articles published on Human-computer interaction (HCI) research in the journals index in Science Citation Index-Expanded during 1987-2011. The data is divided into five five-year spans so that comparisons can be made between the percentage errors for each five-year period. List of the core journals is also prepared for all the five blocks of five-year period. Number of journals and their titles in the core group indicates continuous change in focus in HCI research from one five-year block to the next. In addition, the applicability of Leimkuhler model was also tested with the present data. Neither the verbal nor the graphical formulation provides results that are consistent with the practical situation.

Keywords: Bradford's law, Bradford bibliograph, Bradford multiplier, Leimkuhler model, core journals, human computer interaction

1. INTRODUCTION

Human-Computer Interaction (HCI) is defined as 'a discipline concerned with the design, evaluation, and implementation of computing systems for human use and with the study of major phenomena surrounding them'[1]. 'HCI can be viewed as two powerful information processors (human and computer) attempting to communicate with each other'[2]. The HCI focuses on the interactions between human users and computer systems, including the user interface and the underlying processes which produce the interactions. The contributing disciplines include computer science, cognitive science, human factors, software engineering, management science, psychology, sociology, and anthropology. 'Early research and development in HCI was on issues directly related to the user interface. Some typical issues were the properties of various input and output devices, interface learnability for new users versus efficiency and extensibility for experienced users, and the appropriate combination of interaction components such as command languages, menus, and graphical user interfaces. Recently, the field of HCI has broadened and become more attentive to the processes and context for the user interface. The focus of research and development is now on understanding the relationships among users' goals and objectives, their personal capabilities, the social environment, and the designed artifacts with which they interact. As an applied field, it is also concerned with the development processes used to create the interactive system and their values for the human user'[3].

2. LITERATURE REVIEW

The intellectual base of any discipline is revealed in its journal literature, which serves, among other things, as a vehicle for disseminating information, introducing innovations, and reporting the findings of research in the field[4]. However, 'the proliferation of journals and the consequent exponential growth of journal literature have laterally jeopardised their capacity to transmit information effectively and rapidly'[5]. Bradford[6] was first to observe a pattern in scattering of journal productivity of a given subject. Bradford's law of scattering is based on the principle that every scientific field is related, however remotely, to every other field. The verbal formulation Bradford's law states that "If scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject, and several groups or zones containing the same number of articles as the nucleus, where the number of periodicals in the nucleus and succeeding zones will be in a ratio of $1 : n : n^2$. The constant n is the property of the collection of periodicals called the Bradford multiplier. The graphical formulation of Bradford's law is obtained by plotting a curve in a

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plane whose coordinates are the cumulative number of articles (in the *y*-axis) and the logarithm of the cumulative number of journals (rank of journals) in the collection (in the *x*-axis), where journals are cumulated from most to least productive. This curve has invariably an ascending shape, which after a certain point approaches a straight line. Such a graph is called as 'Bradford Bibliograph'. 'Bradford's law has been used as an argument about how to build collections, how to select journals to be indexed in bibliographies, how to measure the coverage of bibliographies, how to solve practical problems related to information seeking and retrieval.'[7]

Bradford[8] examined two bibliographies prepared in the Science Library (Britain) on Applied Geophysics (1928-1931) and Lubrication (1932-1937). He identified three groups of periodicals in the list of periodicals ranked by diminishing productivity that produced approximately the same number of articles on the subject, but the number of periodicals in these three equi-productive zones increased by a constant factor. Vickery[9] extended the verbal formulation to show that it can be applied to any number of zones of equal yield, not to only the three zones that Bradford had used for his data. Stevens[10] found in Chemistry that 2 journals were needed to cover 25 %, 7 to cover 50 % and 24 to cover 75 % of the total 247 journals covering 3633 citations. Leimkuhler[11] suggested a model based on Bradford's law of scattering and it is called the Bradford's distribution. Brookes[12] also derived a formula which does not depend on groupings of journal titles. Gross[13] observed a droop while plotting the data on the journal literature of Physics. The droop refers to the shape of some Bradford's curves at their tail ends. The curve shows a downward deviation at the end of the log-linear portion. This phenomenon is known as the 'Gross droop'.

Goffman & Morris[14] showed that Bradford's law held good for literature, dispersion in the field of transplantation-immunology for the years 1965-1968, as well as periodical circulation in a medical library. Chakraborthy[15] studied the scatter of Indian geological literature in Indian and foreign periodicals and found that about 90 % of the literature is covered in Indian sources. Garvey[16] pointed out that authors would seek to publish their articles in certain journals and not in others. Eto[17] tested the applicability of the Bradford's law to firms expending on the R&D and successfully identified core firms, peripheral firms, and minor firms. Brookstein[18] observed the multidisciplinary character of journals and defined a simple model that indicates the evaluation of journals as a competition among subjects for space. Rao[19] pointed out that value of Bradford multipliers vary from zone to zone. Bandopadhyay[20] studied the scatter of journal literature in different disciplines for the period 1981 to 1990. Egghe[21] has given 'a note on different Bradford multipliers' showing that the multiplier *k* that appears in the law of Bradford is not the production of articles per author nor the average number of μ of articles per journal. However, the Bradford multiplier may be close to μ in many cases.

Now a day, most of the studied are being carried out to test the applicability of Bradford's law to literature related to various field of sciences. Some of the recent studies are mentioned here. Sudhier[22] carried out a study on five-year data of journals (2004-2008) cited by the physicists at the Indian Institute of Science to examine the applicability of Bradford's law of scattering, from 79 doctoral theses during the period 2004-08. The journal distribution pattern did not fit the Bradford's distribution pattern. Wardikar & Gudadhe[23] carried out a study on the data of journals cited by PhD. research scholars at the universities in Maharashtra for their doctoral research in the field of library and information science from 1982-2010. *Annals of Library Science and Documentation* took top place with 207 citations followed by *College and Research Libraries* with 184 citations and *Herald of Library Science* with 160 citations were the most preferred journals. Ram & Paliwal[24] applied Bradford's law of scattering to the Psoriasis literature published during 1960-2009 and found that theoretical aspect of Bradford law did not fit, but the Leimkuhler model holds good for Psoriasis literature.

3. OBJECTIVES

(i) To examine the applicability of Bradford's law of scattering to the pattern of journals productivity used by the researchers in field of HCI,

(ii) To identify the Bradford zones in the HCI literature used by researchers.

(iii) Test the applicability of Leimkuhler's model, on HCI literature journal productivity data.

4. METHODOLOGY USED IN APPLICATION OF BRADFORD'S LAW

Data for the present study is downloaded using principal keywords related to HCI research from Science Citation Index-Expanded for the period 1987-2011. The data were divided into five data sets of five-year period blocks, i.e., 1987-1991, 1992-1996, 1997-2001, 2002-2006 and 2007-2011. Journal titles were sorted in descending order of productivity. The verbal formulation of the Bradford's Law of Scattering is tested by dividing the total number of articles in each field into three zones. To test the graphical formulation of the Bradford's law, Bradford bibliograph were plotted for each period block.

Leimkuhler[11] developed a model based on Bradford's verbal formulation as:

$R(r) = a \log (1+ br)$, r = 1, 2, 3, (1)

In Egghe,[12] it is shown that constants 'a' and 'b' given in Eqn(1) can be calculated as follows:

$a = y_0 / \log k$ (2)

$b = k - 1/r_0$ (3)

Here, r_0 : Number of sources in the first Bradford group

y_0 : Number of items in every Bradford group (all these group of items being of equal sizes), and

k : Bradford multiplier.

If the sources are ranked in decreasing order of productivity, than y_m is the number of items in the most productivity sources (i.e., the source or rank 1); $R(r)$ is the cumulative number of items produced by the sources of rank 1,2, 3.....r,

a and b are constants appearing in the law of Leimkuhler.

In forming Bradford groups, it is shown that the number of groups 'p' is a parameter that can be chosen freely.

Once p is determined the value of k is:

$k = (e^{\gamma} y_m)\ 1/p$ (4)

where, γ is Euler's number ($e^{\gamma} = 1.781$)

Then y_0 and r_0 are calculated as:

$y_0 = y_m^2 \log k$, and (5)

$r_0 = (k-1)\ y_m$ (6)

In principle, choose any whole number of p of Bradford groups that one wants to obtain an element in the decision what p is going to be used is offered by the practical advantage of finding a value for r_0.

Once p is chosen, calculate the value of k by the following equation:

$k = (e^{\gamma} m)\ 1/p = (1.781\ y_m) 1/r$ (7)

Furthermore, $y_0 = A/p$

where, A denotes the total number of items (articles) in the bibliography; indeed one has p groups, each containing y_0 items.

Lets T be the total number of sources (journals). In Bradford group, these are $r_0 k^{i-1}$ sources (i=1,2,3.....)

$T = r_0 + r_0 k + r_0 k^2 + \ldots\ldots\ldots r_0 k^{p-1}$ (8)

So, $r_0 = T/(1+k+k^2+\ldots..+k^{p-1}) = (k-1)/(k^{p-1})$ (9)

Since A and T are known from the raw data r_0 and y_0 are easily calculated, once k is calculated by formula (7).

5. RESULTS

5.1 Verbal Formulations

Table 1 gives detail of Bradford zones for HCI research output during 1987-1991. For testing the verbal interpretation of the Bradford's law, the 5004 articles were divided into three zones. The Bradford's multiplier factor was arrived at by dividing journal titles of a zone by its preceding zone. The basis for choosing the three zones was that the percentage error in distribution of articles, among the three zones should be the least possible. In the present data set, 10 journals covered 1681 articles, next 39 journals covered 1670 articles and next 139 journals covered 1653 articles. That is about, one third of the total articles have been covered by each group of the journals. According to Bradford, the zones, thus identified will form an approximately geometric series in the form 1 : n : n^2. In the present study the relationship of each zone is 10 : 39 : 139. Here, 10 represent the number of periodicals in the nucleus and n= 3.75 is a multiplier. The mean value of multipliers is (3.9+3.6)/2=3.75.

Therefore, 1 : n : n^2:: 10 : 10 x 3.75 : 10 x 3.75^2 :: :: 6 : 37.5 : 140.6 » 188.1

The percentage error =((188-188.1)/188)*100 = 0.05 %

Table 1. Bradford's zones for HCI research output during 1987-1991

Zones	No. of articles (%)	Journals (%)	Bradford multipliers
1	1681 (33.6 %)	10 (5.3 %)	
2	1670 (33.4 %)	39 (20.7 %)	3.9
3	1653 (33 %)	139 (73.9 %)	3.6
Total	**5004 (100 %)**	**188 (100 %)**	

Table 2 gives detail of Bradford zones for HCI research output during 1992-1996. It has 16942 articles, which were divided into three zones. In this data set, 19 journals covered 5686 articles, next 56 journals covered 5626 articles and next 239 journals covered 5630 articles. It results into relationship of each zone as 19 : 56 : 239. Here, 19 represent the number of periodicals in the nucleus and n = 4.25 is a multiplier. The mean value of multipliers is (3.0+4.3)/2=3.7.

Therefore, 1 : n : n^2 :: 19 : 19 x 3.7^2 : 19 x 3.7^2 :: 19 : 70.3 : 260.1 » 349.4

The percentage error = ((314-349.4)/314)*100 = 11.3 %

Table 3 gives detail of Bradford zones for HCI research output during 1997-2001. It has 28646

Table 2. Bradford's zones for HCI research output during 1992-1996

Zones	No. of articles (%)	Journals (%)	Bradford multipliers
1	5686 (33.6 %)	19 (6.1 %)	
2	5626 (33.2 %)	56 (17.8 %)	3.0
3	5630 (33.2 %)	239 (76.1 %)	4.3
Total	**16942 (100 %)**	**314 (100 %)**	

Table 3. Bradford's zones for HCI research output during 1997-2001

Zones	No. of articles (%)	Journals (%)	Bradford multipliers
1	9651 (33.7 %)	13 (3.6 %)	
2	9545 (33.3 %)	65 (18.1 %)	5.0
3	9450 (33.0 %)	281 (78.3 %)	4.3
Total	**28646 (100 %)**	**359 (100 %)**	

articles, which were divided into three zones. It results into relationship of each zone as 13 : 65 : 281. Here, 13 represent the number of periodicals in the nucleus and n= 4.65 is a multiplier. The mean value of multipliers is (5.0+4.3)/2=4.65.

Therefore, $1 : n : n^2 :: 13 : 13 \times 4.65 : 13 \times 4.652$
$:: 13 : 60.5 : 281.1 » 354.6$

The percentage error = ((359-354.6)/359)*100
= 1.2 %

Table 4 gives detail of Bradford zones for HCI research output during 2002-2006. It has 37242 articles, which were divided into three zones as listed above. It results into relationship of each zone as 17 : 75 : 284. Here, 17 represent the number of periodicals in the nucleus and n= 4.1 is a multiplier. The mean value of multipliers is (4.4+3.8)/2 = 4.1.

Therefore, $1 : n : n^2 :: 17 : 17 \times 4.1 : 13 \times 4.12$
$:: 17 : 69.7 : 285.8 » 372.5$

The percentage error = ((399-372.5)/399)*100
= 6.6 %

Table 4. Bradford's zones for HCI research output during 2002-2006

Zones	No. of articles (%)	Journals (%)	Bradford multipliers
1	12493 (33.5 %)	17 (4.3 %)	
2	12243 (32.9 %)	75 (18.8 %)	4.4
3	12508 (33.6 %)	284 (71.2 %)	3.8
Total	37242 (100 %)	399 (100 %)	

Table 5 gives detail of Bradford zones for HCI research output during 2007-2011. It has 49286 articles, which were divided into three zones as listed above. It results into relationship of each zone as 29 : 88 : 355. Here, 29 represent the number of periodicals in the nucleus and n= 3.5 is a multiplier. The mean value of multipliers is (3.0+4.0)/2=3.5.

Therefore, $1 : n : n^2 :: 29 : 29 \times 3.5 : 29 \times 3.52$
$:: 29 : 101.5 : 355.3 » 485.8$

The percentage error = ((472-485.8)/472)*100
= 2.9 %

The percentage error for the initial period of 1987-1991 is negligible. It is also observed that, the number of periodicals contributing references to each zone increases by a multiplier of 3.75. Similar trend in observed in case of data relating to time period 1997-2001 and 2007-2011 with percentage error of 1.2 % and 2.9 % respectively. Whereas, the percentage error during the five-year period blocks of 1992-1996 and 2002-2006, is significantly higher at 9.5 % and 6.6 % respectively.

Table 5. Bradford's zones for HCI research output during 2007-2011

Zones	No. of articles (%)	Journals (%)	Bradford multipliers
1	16408 (33.3 %)	29 (6.1 %)	
2	16166 (32.8 %)	88 (18.6 %)	3.0
3	16712 (33.9 %)	355 (75.2 %)	4.0
Total	**49286 (100 %)**	**4729 (100 %)**	

It is clear from Table 1 to Table 5 that there are very small number of journals in the nucleus and they are the most productive journals devoted to HCI research ranging from 3.6 % during 1997-2001 and 6.1 % during 1992-1996 and 2007-2011, of total journals in the respective five-year blocks. The second zone is represented by a large number of journals which share 17.8 % during 1992-1996 and 20.7 % during 1987-1991 of total cited journals and the last zone is represented by around 80 % of total cited journals for all the five year blocks. Each zone has approximately one third (1/3) of the total citations. Hence, the journal distribution as per the Bradford's law reveals that there is a large difference in Bradford multiplier for the period block of 1992-1996 as compared to the other period blocks. Although, difference in the Bradford multiplier for other year blocks is much less, it is still far from the ideal one.

5.2 Graphical Formulation

The graphical approach was developed by Brookes[25] which tries to verify the verbal formulation of the Bradford's law. The graph should display three distinct regions:

(i) Initially a rapid rise, indicating core journals whose points lay on the initial curved part of the graph until tangentially becomes a straight line

(ii) Then a big portion of linear rise, and

(iii) A 'droop' towards the tail, Brookes argued that droop was an indication of the incomplete nature of the bibliography examined.

Figures 1-5 give the 'Bradford Bibliograph', for HCI research literature for five five-year period blocks, i.e., 1987-1991, 1992-1996, 1997-2001, 2002-2006, and 2007-2011. All the five graphs have clearly displayed the three distinct regions.

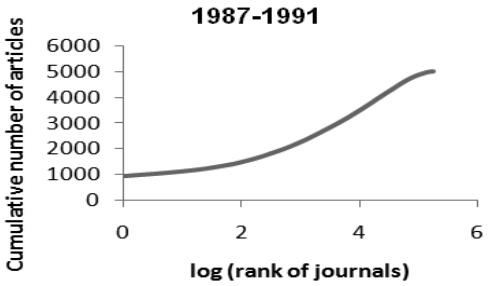

Figure 1. Bradford bibliograph for HCI research during 1987-1991.

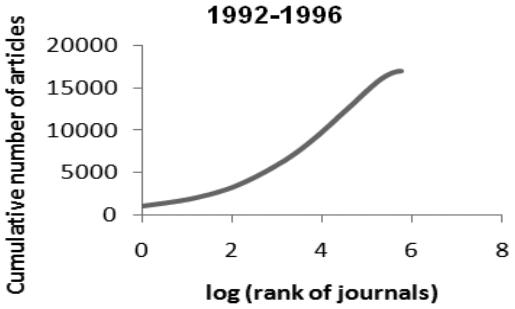

Figure 2. Bradford bibliograph for HCI research during 1992-1996.

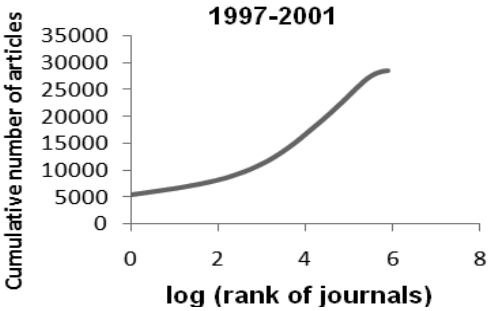

Figure 3. Bradford bibliograph for HCI research during 1997-2001.

5.3 Appilcation of Leimkuhler Model

Leimkuhler's model is applied on the data on all the HCI research for five five-year period blocks. K-S goodness-of-fit statistical test is applied to assert that the observed productivity distribution is not significantly different from a theoretical distribution. K-S test compares cumulative observed and cumulative expected frequencies of productivity distribution. The maximum deviation between the cumulative

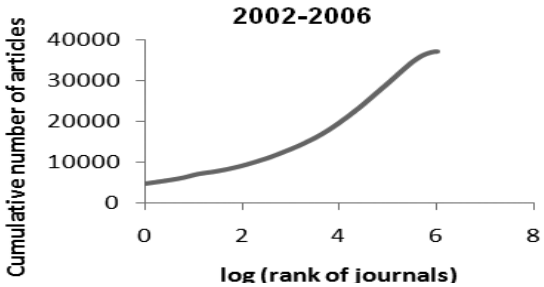

Figure 4. Bradford bibliograph for HCI research during 2002-2006.

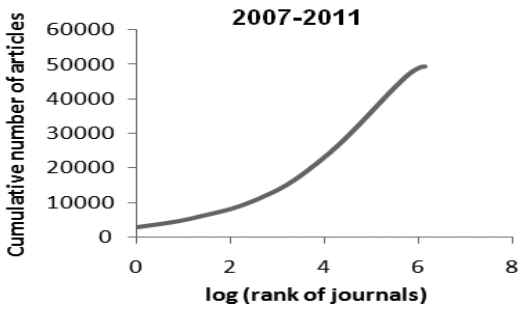

Figure 5. Bradford bibliograph for HCI research during 2007-2011.

proportions of the observed and theoretical frequency is determined by the following formula:

$$D_{max} = max|F_0 - F_e|$$

where, F_0 is the theoretical cumulative frequency; and F_e is the observed cumulative frequency.

The K-S test is performed at 0.01 level of significance. Results of the K-S test are given in Table 6. For all the five period blocks, the D_{max} value is more than the tabled K-S value at the 0.01 level of significance and hence Leimkuhler's model has not been able to explain the scattering of journal productivity in HCI literature.

5.4 Core Journals

Number and type of journals in the core group are indicative the focus of the subject at for period of study. Core journals for the entire five five-year span are listed in Appendix I. The core journals for the period 2007-2011 are *Expert Systems with Applications* as top ranked, which followed by *Bioinformatics; Neurocomputing* and *Pattern*

Table 6. Value of the parameters obtained from the application of Leimkuhler law for the journal productivity distribution of HCI research

Dataset	Parameters of the model					D_{max}	Critical K-S value
	k	r_0	y_0	*A*	*b*		
1987-1991	11.89	1.219	1668.0	1551.6	8.928	0.2705	0.1189
1992-1996	12.14	1.957	5647.3	5209.1	5.691	0.3134	0.0920
1197-2001	21.03	0.754	9548.7	7188.1	26.92	0.3017	0.0860
2002-2006	20.37	0.914	12414.7	9483.7	21.19	0.3193	0.0816
2007-2011	17.13	1.515	16428.7	13316.8	10.64	0.3603	0.0750

Recognition; etc. When these titles are compared with list of core journals for the earlier periods, it is observed that these journals have been going up steadily in the rank list. So, it can implied that the field of HCI research is evolving continuously and that its focus is shifting over different periods of the study.

6. CONCLUSIONS

'The principal application of Bradford's Law is probably only in organising and presenting data on subject literatures, for example, for the evaluation of search results, for the comparative study of subjects, and for scientometric investigations.'[26] The journal distribution pattern of the HCI research during 1992-1996 and 2002-2006 does not fit the Bradford's distribution pattern, i.e., $1 : n : n^2$ as the percentage of error is very high (6.6 % and 11.3 %). For the period blocks of 1987-1991, percentage error is negligible at 0.05 %. For block period of 1997-2001 and 2007-2011, the percentage error is 1.2 % and 2.9 % respectively, which is not significant. Bradford's multipliers have different values for different zones as well as different data sets. This is consistent with Roa's[19] view, that Bradford's multipliers vary from zone to zone. It is also observed from the Bradford multiplier that the number of journal in each zone is not increasing geometrically. Hence, it is concluded that the dispersion of journal titles in HCI literature does not satisfy the verbal formulation of Bradford's law of scattering.

From the Figs. 1-5, it is found that the data in HCI literature for the entire five five-year period blocks, have an initial raising curve and followed by linearity, except towards the end showing a 'droop' characteristic of incomplete data. This droops have also been reported by Afloabi[27] for library science literature. Leimkuhler model has failed to explain journal productivity distribution in the field HCI research, as values of D_{max} is much higher than the K-S critical values for all the five data sets.

Core journals of all five five-year period block are listed in Appendix I. The number of core journals is increased from 10 during 1987-1991 to 29 during 2007-2011. This indicates the gradual expansion of the field HCI research. Careful examination of the titles of sources indicates a constant shift in the focus of the literature in the field of HCI research. This has a the implication that extreme care should be taken while deciding the core journals for a narrow subject, otherwise it could lead to a selection sources which are not in use currently.

From the above discussion it is concluded that the journal usage pattern in HCI literature does fully satisfy either the verbal or the graphical formulation of the Bradford's law of scattering. This may be due to the heavy concentration of articles in a few journals. The productivity of journals in HCI literature shows the concentration of more number of articles in a few journals.

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Appendix I

Core journals in HCI research during 1987-1991

S. No.	Journal title	No. of articles
1.	*Lecture Notes in Computer Science*	943
2.	*Computers & Industrial Engineering*	122
3.	*IEEE Transactions on Systems Man and Cybernetics*	89
4.	*Sigplan Notices*	79
5.	*Computer Methods and Programs in Biomedicine*	77
6.	*Information Systems*	77
7.	*Neural Networks*	76
8.	*IEEE Transactions on Software Engineering*	74
9.	*Microprocessing and Microprogramming*	73
10.	*Pattern Recognition*	71

Core journals in HCI research during 1992-1996

S. No.	Journal title	No. of articles
1.	*Lecture Notes in Computer Science*	1004
2.	*IFIP Transactions A-Computer Science and Technology*	508
3.	*Pattern Recognition*	367
4.	*Fuzzy Sets and Systems*	359
5.	*Neural Networks*	303
6.	*IEEE Transactions on Neural Networks*	282
7.	*Lecture Notes in Artificial Intelligence*	282
8.	*IEEE Transactions on Knowledge and Data Engineering*	272
9.	*IEICE Transactions on Information and Systems*	266
10.	*Computers & Industrial Engineering*	248
11.	*Expert Systems with Applications*	244
12.	*Journal of Chemical Information and Computer Sciences*	229
13.	*Decision Support Systems*	211
14.	*Pattern Recognition Letters*	205

Core journals in HCI research during 1997-2001

S. No.	Journal title	No. of articles
1.	*Worldwide Computing and its Applications*	5427
2.	*Pattern Recognition*	812
3.	*IEEE Transactions on Neural Networks*	497
4.	*Fuzzy Sets and Systems*	429
5.	*Neural Networks*	325
6.	*Bioinformatics*	324
7.	*IEICE Transactions on Information and Systems*	280
8.	*Neurocomputing*	277
9.	*IEEE Transactions on Knowledge and Data Engineering*	272
10.	*Journal of Chemical Information and Computer Sciences*	266
11.	*Pattern Recognition Letters*	266
12.	*Information Sciences*	246
13.	*Theoretical Computer Science*	193
14.	*IFIP Transactions B-Applications in Technology*	191
15.	*Engineering Applications of Artificial Intelligence*	176
16.	*Computer Methods and Programs in Biomedicine*	173
17.	*Computer Networks And ISDN Systems*	173

Core journals in HCI research during 2002-2006

S. No.	Journal title	No. of articles
1.	*Topics in Artificial Intelligence*	4747
2.	*Bioinformatics*	1266
3.	*Pattern Recognition*	1137
4.	*IEICE Transactions on Information and Systems*	499
5.	*Neurocomputing*	468
6.	*IEEE Transactions on Neural Networks*	457
7.	*IEEE Transactions on Knowledge and Data Ngineering*	445
8.	*Expert Systems with Applications*	427
9.	*Pattern Recognition Letters*	422
10.	*Fuzzy Sets and Systems*	375
11.	*Computer Communications*	369
12.	*Theoretical Computer Science*	328
13.	*Neural Networks*	320
14.	*Decision Support Systems*	317
15.	*IEEE Transactions on Systems Man and Cybernetics Part B*	316
16.	*Information Sciences*	308

Core journals in HCI research during 2007-2011

S. No.	Journal title	No. of articles
1.	*Expert Systems with Applications*	2821
2.	*Bioinformatics*	1316
3.	*Neurocomputing*	977
4.	*Pattern Recognition*	937
5.	*Information Sciences*	690
6.	*Computers & Education*	583
7.	*International Journal of Innovative Computing Information and Control*	527
8.	*IEEE Transactions on Neural Networks*	513
9.	*Applied Soft Computing*	511
10.	*IEICE Transactions on Information and Systems*	511
11.	*Pattern Recognition Letters*	508
12.	*Journal of Chemical Information and Modeling*	454
13.	*Decision Support Systems*	442
14.	*IEEE Transactions on Knowledge and Data Engineering*	440
15.	*Computer Communications*	419
16.	*Computer Networks*	395
17.	*IEEE Transactions on Visualisation and Computer Graphics*	372
18.	*IEEE Transactions on Image Processing*	357
19.	*IEEE Transactions on Pattern Analysis and Machine Intelligence*	349
20.	*ACM Transactions on Graphics*	346
21.	*Journal of Universal Computer Science*	346
22.	*ACM Sigplan Notices*	337
23.	*Neural Networks*	335
24.	*IEEE Transactions on Systems Man and Cybernetics Part B*	327
25.	*Journal of Biomedical Informatics*	327
26.	*Multimedia Tools and Applications*	324
27.	*IEEE Transactions on Multimedia*	322
28.	*Computer Graphics Forum*	312
29.	*Engineering Applications of Artificial Intelligence*	310