

# A scientometric study of human computer interaction research in India

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## ABSTRACT

The research output of India in human computer interaction (HCI) research during 1987-2011 is analyzed in this paper on several parameters including total research output, its growth, rank and global publication share, citation impact. It also analyses the characteristics of most productive institutions, authors and high-cited papers. India is at 16<sup>th</sup> position in the world in HCI research publications with 2656 papers by 3691 Indian authors from 693 institutions of India. The Transformative activity index suggests that India's research activity in the field of HCI is improved greatly in the last 5 years. Although highest number papers are contributed by Indian Statistical Institute, about half of publications are contributed by engineering colleges. All the papers published by Indian researchers have appeared in journals with impact factors between 0.090 and 5.211 with an average impact factor of 1.455. Indian authors preferred to publish in journals originated from United Kingdom, the Netherlands, USA and Germany. Citation analysis for Indian publications gives 9.8 citations/paper.

**Keywords:** Citations, human computer interaction, India, relative citation index, scientometrics

## INTRODUCTION

A significant feature of scientific and technological knowledge is that the cognitive boundaries of fields keep on changing. At the same time, certain new specialties emerge while some existing merges together.<sup>[1]</sup> This has important implications on science policy. Funding agencies need to take into cognizance the development of new specialties and linkages among the specialties. Human computer interaction (HCI) is a new specialty, which involves the study, planning and design of the interaction between people (users) and computers.<sup>[2]</sup> HCI is an area of research and practice that emerged in the early 1980s, initially as a specialty area in computer science embracing

cognitive science and human factors engineering. It has expanded rapidly and steadily for three decades, attracting professionals from many other disciplines and incorporating diverse concepts and approaches.<sup>[3]</sup> From its inception, the field of HCI has focused on ease of use as a primary determinant for user acceptance of computer applications.<sup>[4]</sup> The original HCI research in the 1980's was often about how people interact with simple office automation programs, such as word-processing, databases and statistical software. The basic of interfaces, such as widgets, dialog boxes, error messages, were the focus of much research.<sup>[5]</sup> Toward the late 1980's, graphical user interface started to take place. In the late 1980s and early 1990s, there was growth in the area of usability engineering methods, but there was a major shift in the field of HCI research during the early 1990s. As the internet and the web gained wide acceptance, there was a need to research new type of interfaces and communication, such as web pages, E-mail, instant messaging and groupware.<sup>[6]</sup> This caused an increase of research fields to be included under the umbrella of HCI, especially communication. These days the hot area of HCI is Computer-Supported Cooperative Work, sometimes known as groupware. It deals with how groups of people work or interact together using computational technologies.

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## LITERATURE REVIEW

Several scientometric studies dealing with HCI research have been reported in the literature. For instance, Lokman and Rogers<sup>[7]</sup> examined the differences between Scopus and Web of Science (WoS) in the citation counting, citation ranking and h-index of 22 top HCI researchers from Equator-a large British interdisciplinary research collaboration project. Hunt<sup>[8]</sup> reviewed five leading HCI journals for a period of 10 years from 1990 to 99 and identified the predominant sub-fields that are discussed under the umbrella HCI. A study done by Dee *et al.*<sup>[9]</sup> analyzed 1682 papers and 2413 authors published in the journal “Human Factors” from 1970 to 2000. The results showed that the journal ‘Human Factors’ has substantial relative scientific influence, as measured by impact, immediacy and half-life, exceeding the influence of comparable journals. Kaye<sup>[10]</sup> presented a simple metric for looking at changes in papers submitted to CHI conferences over the course of 25-year and analysis is done for the number of authors per paper, distribution of authors by their gender and repeat authors over the years. Bartneck and Hu<sup>[11]</sup> used a bibliometric approach to identify trends including, among others, geographical origin of authors and prolific institutions. Oulasverta<sup>[12]</sup> used bibliometric analysis to determine statistics like the most cited first authors, most influential sites of research, the most cited papers and the most prolific authors. Clemmensen<sup>[13]</sup> analyzed papers published in ‘HCI journal’ from 1985 to 2001. He analyzed most published authors, coverage of psychology versus computer science and gender coverage. Henry *et al.*<sup>[14]</sup> in their study presented several analyzes and visualizations of the field of HCI as seen by four of the major conferences in the field: the ACM Conference on Human Factors and Computing Systems (CHI), the ACM symposium on User Interface Software and Technology, the “Advanced Visual Interfaces” conference and the Institute of Electrical and Electronics Engineers (IEEE) Symposium on Information Visualization. The aim was to show some global and local trends discovered while visually exploring the metadata of the conferences provided by the digital libraries. It is observed from the literature survey that no study is undertaken to measure the strength of an individual emerging economy such as India. The same concern was raised in Engineering and Physical Sciences Research Council report.<sup>[15]</sup> The report noted that “research remains North America and Europe focused – what about countries such as China or India? This could also constitute an opportunity”. The present scientometric study on Indian scientific output in the discipline of HCI is an effort to fill that gap.

## METHODOLOGY

Data for the present study was downloaded from Thomson Reuters’ WoS (formerly Institute of Scientific Information). Publications are assigned to countries on the basis of their affiliation. The methodology of integer counting has been followed. This approach results in counting of publications with (at least) one author with an affiliation in the corresponding country or institute. This counting scheme is best suited for analyzing both the countries’ weight and their international co-publication links, but as a consequence of its application, publications cannot be summed up over countries to the world total, as it would result in more than the total number of papers.

A study by Agarwal *et al.*<sup>[16]</sup> carried out a review of HCI literature using terms often used as keywords in HCI papers. Data for the Indian output was downloaded using these keywords. On the bases of downloaded data, most occurring keywords were identified. Appendix I give all the keywords used for the search. The search was carried out in the topic field “TS” of WoS for period 1987-2011. The search resulted in 2764 records published during 1987-2011. The downloaded data was converted into dbase relational database. Only document types indexed as articles, letters and reviews were taken into account for the final analysis. After determining a list of journals to ensure that each article indeed focused on HCI and had theoretical or empirical content related to HCI, 2656 articles were selected for analysis. After standardization of the addresses and value addition in terms impact factor, etc., the same was analyzed to meet the objectives of the study. The year wise data of the world output on HCI research was also noted down to find the position of Indian effort in comparison of the world.

## OBJECTIVES

Following are the specific objectives of the study:

- To examine the publication output of most prolific countries in HCI research during 1987-2011 and how it has changed during different blocks of 5 years each using transformative activity index (TAI);
- To examine the pattern of growth of publications in HCI research in India during 1987-2011;
- To study the contribution of different Indian scientific agencies involved in HCI research;
- To examine the impact of research output of the most prolific institutions of India;
- To examine the communication behavior of Indian authors and to identify the most commonly used

- journals by them;
- Identification of most prolific authors and the highly cited papers on HCI research of India;
- To examine the pattern of citations received by papers on HCI research in India.

## RESULTS AND DISCUSSION

### Country-wise Distribution of Publication

Publications are an indicator that can be used for the detailed analysis of scientific output of a country. These can be used as a proxy measure to examine the relative strengths and weaknesses of a country. There were as many as 83 countries actively engaged in HCI research which produced 167708 publications during 1987-2011. Figure 1 lists top 20 countries actively pursuing research in this field. USA is the top publishing country with 28.6% of the total output, followed by China with 8.9% publications which are closely followed by the UK with 8.7% publications and Germany with 6.9% publications. These four nations account for more than half of the total HCI research publications of the world output. India with 2656 (1.7%) publications is at 16<sup>th</sup> position.

### TAI

To examine the change in output of different countries over a period of time authors used TAI, suggested by Guan and Nan<sup>[17]</sup> and used by Kumar and Garg.<sup>[18]</sup>

Mathematically:

$$TAI = \{(N_{ij}/N_{io})/(N_{oj}/N_{oo})\} \times 100$$

Where,

- $N_{ij}$ : Number of publications of country  $i$  in a period  $j$ ;
- $N_{io}$ : Number of publications of country  $i$  during all periods;
- $N_{oj}$ : Number of publications of all countries in a period  $j$ ;
- $N_{oo}$ : Number of publications of all countries during all periods.

- $TAI = 100$  indicates that a country's research effort in the given period corresponds precisely to the world average,
- $TAI > 100$  reflects higher than average activity and
- $TAI < 100$  indicates lower than average effort by the country.

To calculate the TAI, entire data is divided into five blocks of 5 years each, i.e. 1987-1991, 1992-1996, 1997-2001, 2002-2006 and 2007-2011. Table 1 presents a number of publications and values of TAI for 20 most prolific countries in different blocks. There are three different trends visible from the values of TAI. First group of countries are those whose TAI is indicating a gradual decrease. This group includes four top publishing countries, i.e. USA, UK Germany, Italy and France. Similar is the case with Netherlands. In the first 3 year blocks, i.e. 1987-91, 1992-96 and 1997-2001, these countries were devoting more effort than the world average. In the later year block of 2002-2006, effort of Germany, Italy and France became equal to the effort of the world and in the last block of 2007-2011, effort of these countries reduced to a level below the world average. There is a second group of countries, whose TAI during the initial year block was far below the world average and it remained so until

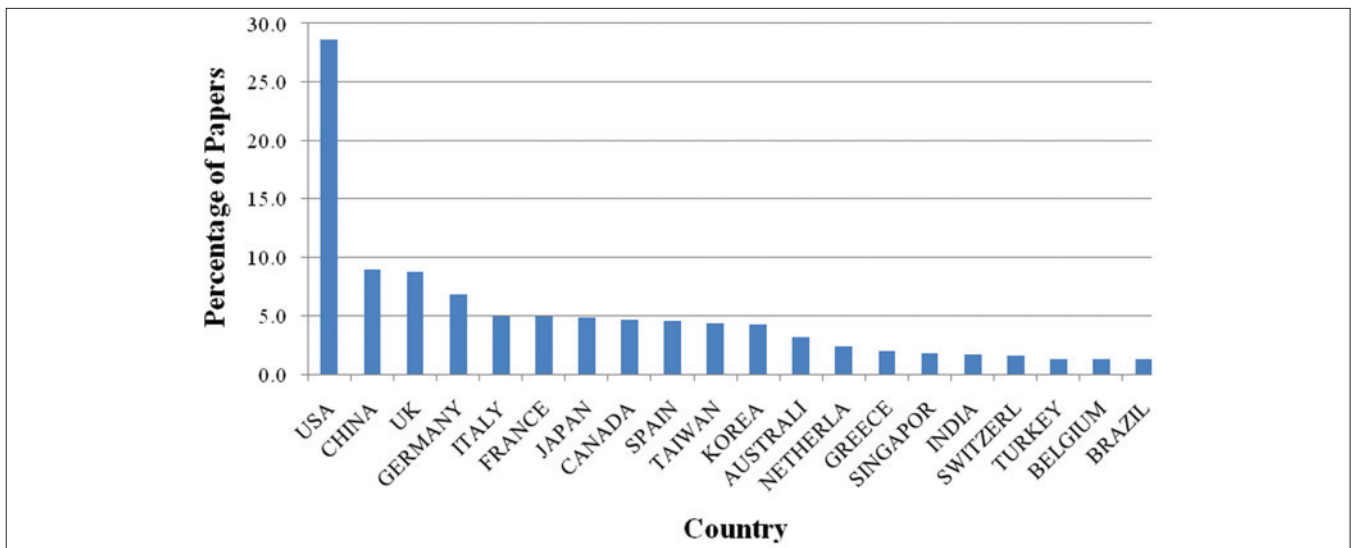
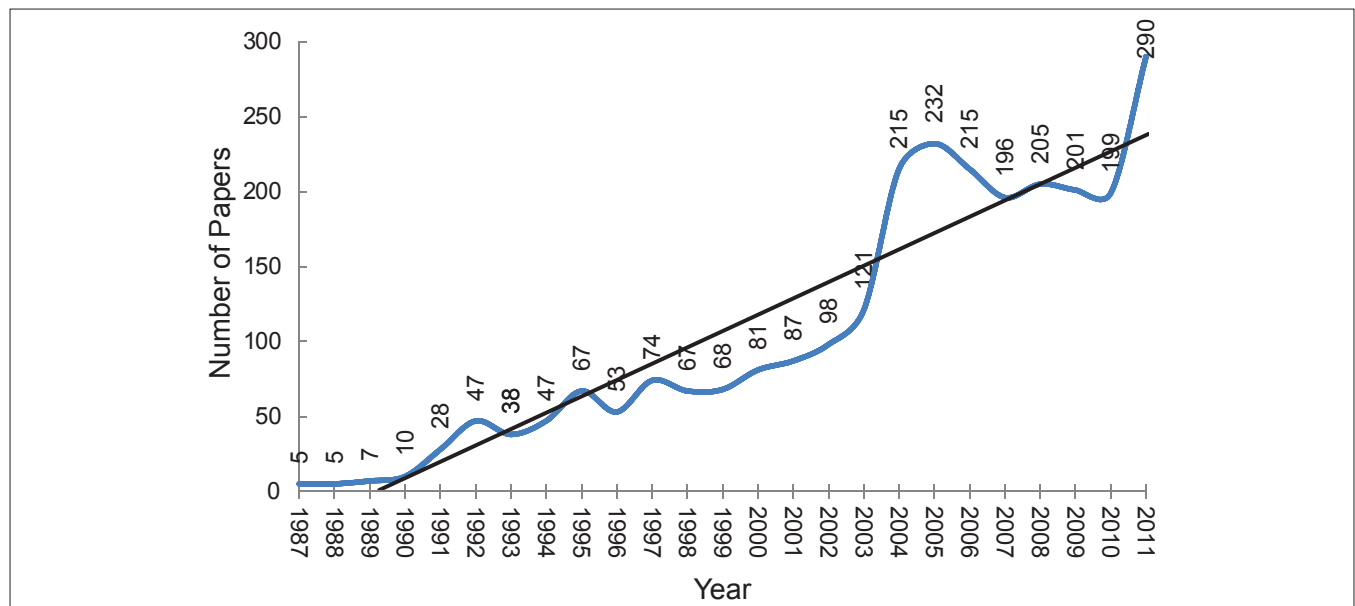


Figure 1: Publication output of top 20 countries in human computer interaction research

**Table 1: Publication output and TAI of top 20 countries in the HCI research**

Country	Number of publications (TAI)					Total
	1987-1991	1992-1996	1997-2001	2002-2006	2007-2011	
USA	2185 (176)	6495 (146)	9530 (123)	14596 (91)	12427 (87)	45233
China	36 (9)	236 (17)	935 (39)	6200 (124)	6694 (150)	14101
UK	467 (124)	1660 (123)	2841 (120)	4725 (97)	4087 (94)	13780
Germany	413 (139)	1283 (120)	2311 (124)	4156 (108)	2698 (79)	10861
Italy	256 (118)	817 (105)	1611 (118)	2994 (106)	2259 (90)	7937
France	228 (106)	850 (110)	1528 (113)	2882 (104)	2351 (95)	7839
Japan	145 (68)	1179 (155)	1687 (127)	2911 (104)	1810 (74)	7732
Canada	260 (126)	821 (111)	1265 (98)	2652 (106)	2513 (106)	7511
Spain	76 (38)	291 (41)	952 (77)	2928 (114)	2979 (130)	7226
Taiwan	35 (18)	372 (54)	1011 (84)	1994 (80)	3608 (163)	7020
Korea	19 (10)	273 (40)	773 (65)	3689 (152)	2113 (97)	6867
Australia	90 (65)	421 (85)	967 (112)	1953 (109)	1607 (101)	5038
Netherlands	158 (154)	519 (141)	727 (113)	1273 (96)	1069 (90)	3746
Greece	39 (46)	204 (67)	503 (95)	1190 (109)	1151 (118)	3087
Singapore	14 (17)	241 (85)	513 (104)	1103 (109)	997 (110)	2868
India	55 (76)	252 (97)	377 (83)	881 (94)	1091 (130)	2656
Switzerland	46 (66)	253 (101)	508 (116)	983 (109)	750 (93)	2540
Turkey	10 (17)	43 (20)	149 (41)	638 (84)	1295 (192)	2135
Belgium	47 (81)	196 (94)	357 (98)	812 (108)	714 (106)	2126
Brazil	14 (25)	81 (40)	280 (80)	868 (120)	802 (124)	2045
Total	4814 (100)	16865 (100)	29711 (100)	65085 (100)	51233 (100)	165052

TAI=Transformative activity index, HCI=Human computer interaction



**Figure 2:** Distribution of publication output of human computer interaction research in India

1997-2001. But in the later year blocks their TAI increased to a level equal or more than the world average. There are nine countries showing this trend namely, China, Singapore, Turkey, Taiwan, Brazil, Spain, Greece, India and Belgium. The third group of countries with yet another trend in TAI, whose activity was lower in the initial as well as later periods. However, TAI of these countries was more than

the world average in the middle year blocks. These countries are South Korea, Australia, Switzerland and Japan.

### Pattern of Publication Output for India during 1987-2011

Indian authors have published 2656 papers during 25 years period of 1987-2011. Figure 2 presents the year-wise

publication and trend of growth rate of Indian HCI research output. It indicates that initially from 1987 to 1990, there is hardly any notable output. Thereafter, from 1991 to 2003, publications output grew gradually and reached at a level of 121 papers in 2003. In 2004 onwards, publication output improved significantly almost double of the previous year at 215. Publications output remained around that level until 2010. In 2011, it reached to 290 publications, suggests a substantial effort is now being devoted toward HCI research in India. An increasing trend in growth rate is observed from the Figure 2.

### Agency-wise Distribution of Publications

Agency-wise categorization of the R and D Institutions is based on Directory of R and D Institutions 2010, Government of India.<sup>[19]</sup> The term R and D Institution, used in this directory refers to either a national laboratory or a research institute or a research station or private and public sector in-house R and D unit or a nonprofit Scientific and Industrial Research Organization or an academic institution. The agency wise distribution presented in the Table 2 indicates that Indian Institutes of Technology's and other engineering colleges top the list with 1251 (47.1%) publications. This is followed by academic institutions (Universities and Colleges) with 1239 (36.7%) publications. Other significant contributors are private research organizations with 280 (10.5%) publications. Council of Scientific and Industrial Research, Department of Atomic Energy, Research organizations under different ministries of central government and Defense R and D Organization also register their presence in the list of agencies but with a meager 8% of the total output. The pattern of output by different agencies support the observations made by Myers.<sup>[20]</sup> He pointed out that virtually today's entire major interface styles and applications have had significant influence from research at universities and labs, often with government funding.

### Institution-wise distribution of publications

The total Indian output came from 693 institutions scattered all over the country. Table 3 presents publication productivity of top 20 institutions which have produced more than 1% of the total Indian publications during the period 1987-2011. These top 20 institutions contributed about two-third of the total Indian output in the field of HCI research. Among these institutions, Indian Statistical Institute, Calcutta topped the list with 300 publications followed by Indian Institute of Science, Bangalore with 211 publications and Indian Institute of Technology, Kharagpur with 203 publications. These three institutes published more than one-fourth of the Indian output. The top 20 institutions list has a prominent presence of top engineering education institutions like Indian Institutes of Technology's (7), National Institute of technology (1) and International Institute of Information technology (1) among others. The impact of research output of these institutions has been examined using two bibliometric indicators. These are relative citation index (RCI) and citation per paper (CPP). These have been described below.

RCI was developed by the Institute of Scientific Information (now Thomson Reuters, USA) to calculate Science and Engineering indicators and has been used by Kumari.<sup>[21]</sup> RCI is a measure of both the influence and visibility of a nation's research in global perspective. It is defined as the ratio of a country's share of world citations to the country's share of world publications ( $C\%/P\%$ ).

RCI = 1 indicates that country's citation rate is equal to world citation rate;

RCI > 1 indicates that country's citation rate is higher than world's citation rate and

RCI < 1 indicates that country's citation rate is less than world's citation rate.

**Table 2: Agency-wise distribution of publications**

Agencies	Number of papers in different 5 year blocks					Total	%
	1987-1991	1992-1996	1997-2001	2002-2006	2007-2011		
IITs including Engineering Colleges	25	100	160	406	560	1251	47.1
Academic Institutions	26	122	181	398	512	1239	36.7
Private Research Organizations	5	10	36	110	119	280	10.5
Council of Scientific and Industrial Research	1	3	11	32	35	82	3.1
Department of Atomic Energy	2	4	10	25	7	48	1.8
Central Government Organizations	0	6	4	13	15	38	1.4
Defense Research and Development Organization	0	5	14	6	9	34	1.3
Others	0	14	10	21	39	84	3.2
Total	55	252	377	881	1091	2656	100.0

IIT=Indian Institutes of Technology



The value of RCI for Indian Institute of Technology, Kanpur is 4.65, which is much higher than the rest of the institutes in the list of top 20 institutions. It is followed by Indian Institute of Science with RCI 2.08 and Indian Statistical Institute with RCI 1.7. In the top twenty institutes only four institutes have RCI greater than one.

CPP is a measure of the average quality of articles since it is assumed that the more citations a paper receives the better it is. CPP follows the same trend as it is the ratio of a number of citations and number of papers. However, very high value of CPP for Indian Institute of Technology, Kanpur is due to the fact that one of its papers is cited

3164 times and same is the case for Indian Institute of Science, Bangalore. (One of its papers is cited 2170 times).

### Journals Used for Communication of Research Results

Out of 2656 papers 2213 have been published in journals and rest 443 papers were presented at different conference proceedings. Table 4 gives the distribution of Indian output in HCI research according to the journal publishing countries. It indicates that the Indian authors have published in journals originated from 24 countries. Highest number of 771 (29.03%) papers are published

**Table 3: Institution-wise distribution of publications of India in HCI research**

Institute	Percentage of papers	Percentage of papers	Percentage of citations	Percentage of citation	RCI	CPP
Indian Statistical Institute Calcutta	300	11.3	4998	19.2	1.70	16.7
Indian Institute of Science Bangalore	211	7.9	4274	16.4	2.08	20.3
Indian Institute of Technology Kharagpur	203	7.6	1833	7.0	0.92	9.0
Indian Institute of Technology Delhi	168	6.3	1511	5.8	0.92	9.0
Indian Institute of Technology Bombay	157	5.9	1098	4.2	0.71	7.0
Indian Institute of Technology Madras	135	5.1	970	3.7	0.73	7.2
Indian Institute of Technology Kanpur	90	3.1	3751	14.4	4.65	41.7
Jadavpur University, Kolkata	76	2.9	511	2.0	0.69	6.7
Anna University, Chennai	58	2.2	256	1.0	0.45	4.4
Indian Institute of Technology Roorkee	57	2.1	372	1.4	0.67	6.5
IBM India	44	1.7	282	1.1	0.65	6.4
University of Hyderabad	39	1.5	234	0.9	0.60	6.0
University of Mysore	31	1.2	186	0.7	0.58	6.0
National Institute of Technology Rourkela	30	1.1	294	1.1	1.00	9.8
Jawaharlal Nehru University Delhi	30	1.1	301	1.2	1.09	10.0
International Institute of Information Technology Hyderabad	30	1.1	133	0.5	0.45	4.3
Tata Institute Fundamental Research	29	1.1	163	0.6	0.55	5.6
Indian Institute of Technology Guwahati	27	1.0	135	0.5	0.50	5.0
University Delhi	26	1.0	115	0.4	0.40	4.4
Annamalai University Chidambaram	25	0.9	83	0.3	0.33	3.3
Sub total	1766	66.5	21500	82.6	1.24	12.2
Others (673 institutes)	890	33.5	4524	17.4	0.52	5.1
Total	2656	100.0	26024	100.0		9.8

HCI=Human computer interaction, RCI=Relative citation index, CPP=Citation per paper

**Table 4: Distribution of Indian HCI publications in journals originating from different countries**

Journal publishing country	Number of journals	Percentage of journals	Number of papers	Percentage of papers	Average impact factor
UK	81	15.6	771	29.0	1.895
Netherlands	77	14.9	710	26.7	1.373
USA	131	25.3	654	24.6	1.927
Germany	185	35.7	345	13.0	0.110
Singapore	14	2.7	75	2.8	0.932
Others (19 countries)	33	6.8	101	3.8	0.604
Total	518	100.0	2656	100.0	1.455

HCI=Human computer interaction

in 81 journals originated from the UK which is closely followed by 710 (26.7%) papers published in 77 journals originated from the Netherlands, 654 (24.62%) papers from 131 journals from the USA and 345 (12.99%) of paper from 185 journals published from Germany. It indicates that the majority of papers 2280 (93.37%) are published in 474 (91.51%) journals from these four nations. According to the India Science and Technology<sup>[22]</sup> highest number Indian S and T research is published in journals originated from the USA but in case of HCI, highest S and T research output is published in journals originated from United Kingdom. Highest numbers of journals used are from Germany. Rest of the nations attract a very few Indian authors for communicating their research results.

High impact factor journals usually attract high quality contributions. Scientists give top priority to high impact journals to increase their visibility, prestige and influence among their peers. Last column in Table 5 gives average impact factor of different journal publishing countries where Indian authors have published their research results on HCI. Highest average impact factor (1.927) is reported by the journals published from the USA and closely followed by UK with an average impact factor 1.895. Average impact factor of journals published from the Netherlands is 1.373 which a little less than the overall average 1.455 of Indian HCI research output. Based on this, one can infer that Indian scientific output is well connected to the mainstream science as about 80% of the published papers appeared in journals whose impact factor was about equal to or higher than the national average impact factor.

The distribution of publications (2656) was spread over 518 journals and conferences. Table 6 gives the list of top 16 journals with 25 or more publications where Indian scientists published their research results during the period of 1987-2011. Of these 16 journals, 6 journals are published from the UK, five from the Netherlands, four from the USA and one from Germany and accounts for about one-third (35%) of the Indian S and T output in the field of HCI research and can be considered core journals.

### Most Prolific Authors

In all, 3691 authors have contributed 2656 papers on HCI research in India. Table 5 lists 11 most prolific Indian authors, who have contributed 20 or more papers during 1987-2011. Four prolific authors are from four different Indian Institute of Technology (s), two are from Indian Institute of Science, Bangalore and one author is affiliated with Gandhigram Rural Institute, Gandhigram.

**Table 5: Most prolific authors in HCI research in India**

Author's name	Number of papers	Institution
Pal, Sankar Kumar	83	Indian Statistical Institute, Calcutta
Pal, Nikhil Ranjan	30	Indian Statistical Institute, Calcutta
Murty, Narasimha	30	Indian Institute of Science, Bangalore
Mitra	30	Indian Institute of Technology, Delhi
Chaudhuri	30	Indian Statistical Institute, Calcutta
Murthy	26	Indian Statistical Institute, Calcutta
Ramamritham, Krithi	24	Indian Institute of Technology Bombay
Majumdar, Arun	22	Indian Institute of Technology, Kharagpur
Balasubramaniam	21	Gandhigram Rural Institute, Gandhigram
Pratihari, Dilip Kumar	21	Indian Institute of Technology, Kanpur
Tiwari, Manoj Kumar	20	Indian Institute of Science, Bangalore

HCI=Human computer interaction

**Table 6: Most preferred journals by Indian authors 1987-2011**

Journal	Journal publishing country	Number of papers	Impact factor
Pattern Recognition	UK	145	2.554
Expert Systems with Applications	UK	119	2.908
Applied Soft Computing	Netherlands	102	1.537
Pattern Recognition Letters	Netherlands	101	1.303
Fuzzy Sets and Systems	Netherlands	63	2.138
Advances in Plan-based Control of Robotic Agents	Germany	54	0.000
Neurocomputing	Netherlands	52	1.440
Information Sciences	USA	42	3.291
Bioinformatics	UK	38	5.039
Engineering Applications of Artificial Intelligence	UK	38	1.444
IEEE Transactions on Neural Networks	USA	31	2.289
IEEE Transactions on Systems Man and Cybernetics Part B-Cybernetics	USA	27	3.007
IEEE Transactions on Knowledge and Data Engineering	USA	26	2.285
Computer Communications	Netherlands	25	0.701
Engineering Intelligent Systems for Electrical Engineering and Communications	UK	25	0.205
International Journal of Systems Science	UK	25	0.918

IEEE=Institute of Electrical and Electronics Engineers

### Citations Analysis

According to Garfield<sup>[23]</sup> there is no commonly available fully satisfactory “measure of quality” of research. However, citation rates reflect the impact of published work on the international community. Scientific tradition requires articles to refer to earlier articles related to the theme of the paper.

Scientists are supposed to identify those earlier researchers whose concepts, methods, equipment, etc., inspired or were used by the author in developing his or her article. Citations provide an objective measure of significance, quality, utility, influence, effectiveness or impact of scientists and their scholarly products. Citation data for Indian HCI research was downloaded in 2<sup>nd</sup> week of April 2013. Table 7 presents the range of citations received by the publications on HCI research by the Indian authors. It indicates that 26.9% publications remained un-cited. 41% publications received citations in the range of 1-5 citations, 13.1% got citations in the range of 5-10 citations and 19% papers attracted more than 10 citations. Based on the pattern of citations it can be concluded that the Indian scientific output is connected to the mainstream science as about three-fourth of the papers were cited one or more times.

### Highly Cited Papers

Table 8 presents the list 20 papers which are cited 100 times or more in the field of HCI during 1987-2011. Out of these 20 papers, 10 papers are published in journals of IEEE. All the papers are produced with international collaboration. Papers listed at the top position is cited 3164 times published in the year 2002 which is followed by a paper cited 2170 times published in the year 1999, can be considered as all-time classics. Two authors, figured in the list of highly cited namely Pal and Mitra, are also among the most prolific authors as well.

**Table 7: Distribution of citation of Indian HCI research output during 1987-2011**

Number of citations	Number of papers	Percentage of papers	% of papers for different range of citations	
0	714	26.9	Zero citations	26.9
1	341	12.8	1-5 citations	41.0
2	266	10.0		
3	213	8.0		
4	164	6.2		
5	106	4.0		
6	88	3.3	6-10 citations	13.1
7	87	3.3		
8	66	2.4		
9	49	1.8		
10	56	2.1		
11-20	282	10.6	11 and more citations	19.0
21-30	90	3.4		
31-40	40	1.7		
41-50	31	1.7		
More than 50	57	2.1		
Total	2656	100.0		

HCI=Human computer interaction

## SUMMARY AND CONCLUSION

India published 2656 (1.7%) out of 165052 papers published in the world on HCI research during 1987-2011. USA is clearly the country with most publications with around 27% of the total world publications, which is consistent with the Bartneck,<sup>[11]</sup> followed by China, United Kingdom and Germany. However, India's publication output is comparable with countries like Singapore, Switzerland, Turkey, Belgium and Brazil. India ranked 16<sup>th</sup> among the top 20 publishing countries in HCI research. The output of HCI research in India has gradually increased over the years. More than 40% of the

**Table 8: Highly cited papers by Indian authors in the field of HCI during 1987-2011**

Bibliographic detail	Citations
Deb K, Pratap A, Agarwal S, <i>et al.</i> , IEEE Transactions on Evolutionary Computation, 6 (2), 2002, 182-197	3164
Jain AK, Murty MN, Flynn PJ, <i>et al.</i> , ACM Computing Surveys 31 (3) 1999, 264-323	2170
Srinivas M, Patnaik LM. IEEE Transactions on Systems Man and Cybernetics 24 (4) 1994, 656-667	454
Reddy BS, Chatterji BN. IEEE Transactions on Image Processing 5 (8) 1996, 1266-1271	397
Mitra S, Hayashi Y. IEEE Transactions on Neural Networks 11 (3) 2000, 748-768	284
Maulik U, Bandyopadhyay S. Pattern Recognition 33 (9) 2000, 1455-1465	262
Pal SK, Mitra S. IEEE Transactions on Neural Networks 3 (5) 1992, 683-697	230
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total research papers in HCI research of India have been published in last 5 years only which indicates that India has basic infrastructure and human manpower to carry out research in this field of knowledge. A large number of institutions and significant numbers of researchers are involved in this field of research in India.

Most of the research papers originated from universities and research institutions funded by the central government. This is similar to the case of the USA as pointed out by Myers.<sup>[20]</sup>

In terms of impact, the average CPP registered by India's publication output in HCI during 1987-2011 was 9.8. However, 26.9% of paper received no citations, which also indicated by Meho. The average impact factor by journals where Indian authors published their research is at 1.455 during the period of 1987-2011. Indian authors publish most of their work in the field of HCI in high impact journals mostly originated from advanced countries of the West. This indicates that their work is of a certain quality and important to the world.

The cumulative publication output of 20 most productive institutions in India's total research output in HCI science during 1987-2011 was 1766 papers (66.5% of the India's total output in the field of HCI), with an average number of papers per institution as 88.3. RCI of these 20 institutions vary from 0.33 to 2.08 and overall RCI for these top 20 institutions is at 1.24.

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## APPENDIX I

### Keywords used for downloading the Bibliographic data

Human Computer Interaction, User Interface\*, User Centered Design, Virtual Reality, GUI, Human Factors, User Experience, Augmented Reality, Interaction Design, Semantic Web, Affective Computing, Image Processing, Information Visualization, Decision Support System\*, Ubiquitous Computing, Usability Evaluation, Bioinformatics, Emotion Recognition, Interface Design, Assistive Technology, Mobile Computing, Natural Language Processing, Web Services, Data Mining, Information Retrieval, Middleware, Speech Recognition, Usability Testing, Internet, Pattern Recognition, Data Management, Face Detection, Fitts' Law, Gesture-Based Interaction, Multimodal Interaction, Multimedia, Open Source, Navigation, Pervasive Computing, Social Media, Teleoperation, User Modeling, User Interaction, Web 2.0, Data Analysis, Data Acquisition, Decision Making, Facial Expression, Eye Tracking, Expert System, Gesture Recognition, Grid Computing, Interaction Techniques, Man-Machine Interaction, Neural Networks, Participatory Design, Ajax, Ambient Intelligence, Artificial Intelligence, Animation, Context-Awareness, Decision Support Systems, E-Learning, Embedded System, Educational Software, Fuzzy Logic, Graphical User Interfaces, Human-Computer Interface, Human-Robot Interaction, Knowledge Acquisition, Mixed Reality, Multimodal, Semantics, Virtual Environments, Adaptive User Interfaces, Cloud Computing, Computer Graphics, E-Commerce, Face Recognition, Graphic User Interface, Icon, Information Extraction, Image Registration, Interoperability, Robotics, Social Network, Virtual World.

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