

Global pervasive and ubiquitous computing during 2005-14

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The paper examines world publications output on ubiquitous & pervasive computing as indexed in Scopus database covering the period 2005-2014. The total world output in 10 years cumulated to 22328 publications, averaging to 9.88% annual growth and citation impact to 3.38 citations per paper. The distribution of world output on ubiquitous & pervasive computing is skewed. For instance, top 15 most productive countries accounted for 91.92% global share. The distribution is also skewed by subject. Computer science accounted for the largest publication share (86.53%). The paper provides scientometric profile of most productive top 20 organizations and most productive top 20 authors on a series of indicators including global publications share, global citation share, average productivity per author, citations per paper, h-index, and share of international collaborative papers during 2005-2014. The paper also reveals most productive top 20 journals on ubiquitous and pervasive computing during 2005-2014. India ranked 13th in its research output in this area. Its performance measured on various indicators has been the least: world share (2.56%), average citations per paper (1.41), relative citation rate (0.42), h-index (11), and highly cited papers (0). The paper suggests that India must evolve a research policy to realize its agenda of expanding economic competitiveness and transforming the country into a ubiquitous modern society in near future.

Keywords: Pervasive computing; Ubiquitous computing; Scopus; Research output

Introduction

Computing technology is moving beyond the personal computer to everyday devices with growing embedded technology and connectivity even as computing devices become progressively smaller and more powerful. Also called *ubiquitous computing*, pervasive computing is the result of computer technology advancing at exponential speeds -- a trend toward all man-made and some natural products having hardware and software. Pervasive computing goes beyond the realm of personal computers: it is the idea that almost any device, from clothing to tools to appliances to cars to homes to the human body to the coffee mug, can be imbedded with chips to connect the device to an infinite network of other devices. The goal of pervasive computing, which combines current network technologies with wireless computing, voice recognition, Internet capability and artificial intelligence, is to create an environment where the connectivity of devices is embedded in such a way

that the connectivity is unobtrusive and always available¹.

A very few scientometric studies have been carried out so far on ubiquitous & pervasive computing, both at global and national level. Yi and Chi² assessed research on ubiquitous computing, using Engineering Index database during 1993-2009. The cumulative literature on ubiquitous computing does confirm the typical S-shape for Bradford's plot. Republic of Korea is the biggest contributing country on ubiquitous computing (19.91%). National Institute of Informatics (Japan), Sungkyunkwan University (Korea) and Korea University (Korea) are ranked as the top three author affiliations. Liu, Goncalves, Ferreira and Hosio³ constructed the intellectual map of the field as reflected by 6858 keywords extracted from 1636 papers published in the HUC, UbiComp and pervasive computing conferences during 1999-2013. Using correspondence analysis, the authors were identified in two major periods: 1999-2007 and

2008-2013. The evolution of the field by applying graph theory and social network analysis methods to each period was examined. The article's findings refute the assertion that Ubicomp research is suffering an identity crisis. Zhao and Wang⁴ identified the status quo prevailing on research in pervasive and ubiquitous computing. Information visualization and knowledge domain visualization techniques were adopted to determine how the study of pervasive and ubiquitous computing has evolved. A total of 5,914 papers published between 1995 and 2009 were retrieved from the Web of Science with a topic search of pervasive or ubiquitous computing. Using CiteSpace, the authors generated the subject category network to identify the leading research fields, the research power network to find out the most productive countries and institutes, the journal co-citation map to identify the distribution of core journals, the author co-citation map to identify key scholars and their co-citation patterns, the document co-citation network to reveal the ground-breaking literature and detected the co-citation clusters on pervasive and ubiquitous computing. Lee and Chen⁵ used different perspectives and methods to analyze leading research theme in particular in ubiquitous computing field. Factor analysis, pathfinder network and context-based ontology techniques were presented to display research directions by clustering scientific papers taken from the ISI web (CiteSeer papers).

Objectives of the study

- To study the growth and distribution of research output by source type and publication sources;
- To understand scientometric profile of top 15 most productive countries;
- To study the distribution of global research output by broad subject areas and by narrow sub-fields;
- To study the publication productivity and citation impact of top twenty most productive organizations and authors; and
- To study the leading media of communication.

Methodology

The study sourced publication data of the world and of 15 most productive countries on ubiquitous & pervasive computing from the Scopus database

(<http://www.scopus.com>) covering 10 years period 2005-2014. The main search string comprised two keywords “ubiquitous computing” and “pervasive computing” used in “title, abstract and keyword” tag and restricting the search output to the period 2005-14 in “date range tag” for searching the global publication data. Further, the main search string was restricted to 15 most productive countries in “country tag”, to obtain publications data on these individual most productive countries. Besides, the main search string was further restricted to “subject area tag”, “country tag”, “source title tag”, “journal title name” and “affiliation tag” to get information on distribution of publications by subject, collaborating countries, affiliating organizations and reporting journals, etc. The citation data was collected from date of publication till the end of April 2015.

Analysis

The global publications output on pervasive & ubiquitous computing cumulated to 23238 papers in 10 years during 2005-14. The annual output on this topic showed steady rise from 1201 in year 2005 to 2186 publications in 2014, registering 9.88% average annual growth. On quinquennial basis, the global publications output on this topic increased from 10755 during 2005-09 to 11573 papers during 2010-14, registering 7.61% quinquennial growth. The citation impact of publications on pervasive and ubiquitous computing averaged to 3.38 citations per paper during 2005-14. Out of total publications output on pervasive & ubiquitous computing, 17738 papers (79.44%) appeared as conference papers, 3384 (15.16%) as articles, 437 (1.96%) as conference reviews, 274 (1.23%) as book chapters, 216 (0.97%) as reviews, 175 (0.78%) as editorials and others as book (47), articles in press (38), short surveys (10), notes (5), and erratum (4) (Table 1, Figure 1).

Global publication share and citation impact of top 15 most productive countries

The top 15 most productive countries cumulatively contributed 20524 papers on pervasive & ubiquitous computing during 2005-2014 accounting for 91.92% global share. Individually these countries contributed 430 to 3548 papers in 10 years during 2005-14. On quinquennial basis their combined share increased marginally from 87.43% during 2005-09 to 96.09% during 2010-14. The United States accounted for the

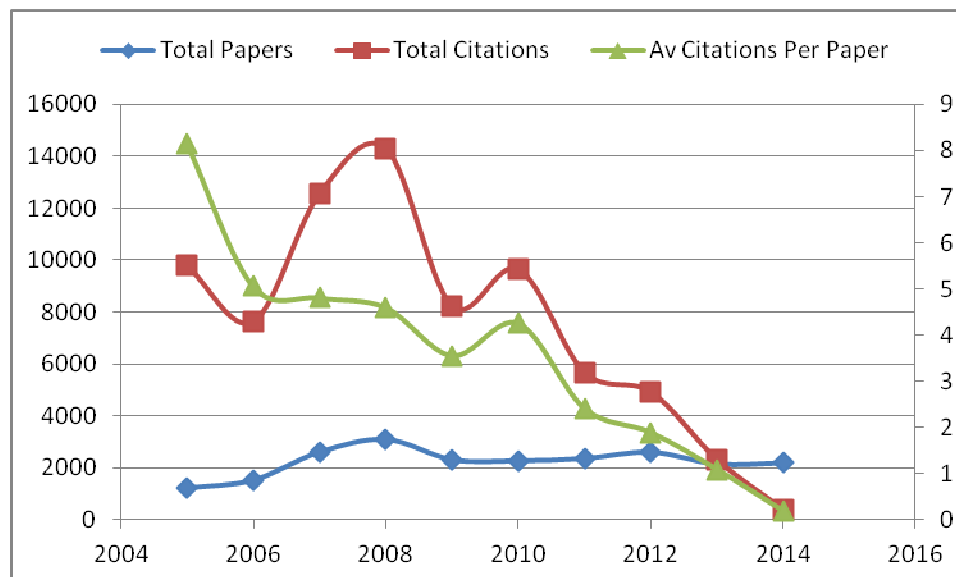


Fig. 1—Annual growth and citation impac

Table 1—Annual growth and citation impact of publications

Period	TP	TC	ACPP
2005	1201	9800	8.1599
2006	1511	7641	5.0569
2007	2613	12564	4.8083
2008	3113	14313	4.5978
2009	2317	8235	3.5542
2010	2271	9664	4.2554
2011	2361	5684	2.4075
2012	2612	4934	1.889
2013	2143	2325	1.0849
2014	2186	400	0.183
2005-09	10755	52553	4.8864
2010-14	11573	23007	1.988
2005-14	22328	75560	3.3841

largest global publication share (15.89%), followed by China (15.31%), South Korea (10.70%), U.K (7.76%), Germany (7.15%), , Japan (6.54%), Taiwan, Spain, Italy and France (from 4.02% to 4.27%), Australia, Canada, India and Finland (from 2.11% to 2.81%) and Switzerland (1.93%) during 2005-14. On quinquennial basis, these countries witnessed increase in their individual global share between 0.03% and 6.9%. China registered the largest increase (6.9%) in its global share, followed by India (1.57%), Taiwan (1.37%), Switzerland (1.36%), Spain (0.78%), Italy

(0.74%), U.K. (0.46%), Germany (0.41%), USA (0.40%), Finland (0.29%) and Australia (0.03%), as against decrease in South Korea (3.3%), Japan (1.5%), Canada (0.41%) and France (0.40%) during the period from 2005-09 to 2010-14. The citation impact of publications by these countries varied from 1.41 to 6.85 citations per paper. Italy registered the highest citation impact with 6.85 citations per paper, followed by USA (6.15), Canada (5.51), Switzerland (5.27), U.K. (4.94), Australia (4.62), Germany (4.26), Taiwan (3.64), France (3.41), Finland (3.45), Spain

(3.03), South Korea (2.51%), Japan (2.40%), China (1.54) and India (1.41) during 2005-14. Ten countries scored relative citation index above the world average of 1: Italy (2.02), USA (1.82), Canada (1.63), Switzerland (1.56), U.K. (1.46), Australia (1.36), Germany (1.26), Taiwan (1.08), Finland (1.02) and France (1.01) during 2005-14. Eight countries registered their share of highly cited papers above the group average of 0.29%: Switzerland (0.70%), USA (0.68%), Italy (0.66%), Australia (0.64%), Germany (0.44%), Taiwan (0.42%), Canada (0.34%) and France (0.33%) during 2005-14 (Table 2).

International collaboration

The top 15 most productive countries differed in their individual share of international collaborative papers from 12.59% to 51.37% during 2005-2014. Canada accounted for the highest share (51.37%), followed by Switzerland (51.16%), France (40.65%), U.K (38.80%), Finland (36.31%), Germany (33.81%), Italy (30.92%), Spain (30.58%), USA (30.44%),

Australia (24.36%), Japan (19.10%), China (18.70%), India (18.36%), South Korea (15.48%) and Taiwan (12.59%) (Table 3).

Subject-wise distribution of papers

The global publications output on pervasive & ubiquitous computing during 2005-14 was organized into seven subject sub-fields (as reflected in Scopus database classification). Computer science accounted for the largest publications share (86.53%), followed by engineering (21.45%), social sciences (4.65%), biochemistry, genetics & molecular biology (4.97%), medicine (2.68%), decision science (2.63%) and business, management & accounting (1.14%) during 2005-14. Amongst these seven subjects, engineering registered the highest citation impact of 5.01 citations per paper, followed by decision science (4.81), medicine (4.22), business, management & accounting (3.66), social science (3.58), biochemistry, genetics & molecular biology (3.35) and computer science (3.24) during 2005-14 (Table 4).

Table 2—Profile of top 15 most productive countries in pervasive & ubiquitous computing

Country	TP			%TP 2005-09	%TP 2010-14	TC	ACPP	%TP	%TC	RCI	HI	HCP	%HP
	2005-09	2010-14	2005-14										
USA	1685	1863	3548	15.70	16.10	21807	6.15	15.89	28.86	1.82	62	24	0.68
China	1263	2155	3418	11.70	18.60	5269	1.54	15.31	6.973	0.46	27	1	0.03
South Korea	1337	1053	2390	12.40	9.10	6002	2.51	10.7	7.943	0.74	31	3	0.13
U.K.	809	923	1732	7.52	7.98	8562	4.94	7.76	11.33	1.46	43	1	0.06
Germany	746	851	1597	6.94	7.35	6810	4.26	7.15	9.013	1.26	34	7	0.44
Japan	787	674	1461	7.32	5.82	3513	2.40	6.54	4.649	0.71	23	1	0.07
Taiwan	383	570	953	3.56	4.93	3472	3.64	4.27	4.595	1.08	26	4	0.42
Spain	406	526	932	3.77	4.55	2823	3.03	4.17	3.736	0.9	24	1	0.11
Italy	398	514	912	3.70	4.44	6243	6.84	4.08	8.262	2.02	31	6	0.66
France	455	443	898	4.23	3.83	3059	3.41	4.02	4.048	1.01	24	3	0.33
Australia	301	327	628	2.8	2.83	2900	4.62	2.81	3.838	1.36	24	4	0.64
Canada	303	279	582	2.82	2.41	3204	5.50	2.61	4.24	1.63	26	2	0.34
India	188	384	572	1.75	3.32	807	1.41	2.56	1.068	0.42	11	0	0
Finland	211	260	471	1.96	2.25	1623	3.45	2.11	2.148	1.02	20	0	0
Switzerland	131	299	430	1.22	2.58	2266	5.27	1.93	2.999	1.56	23	3	0.7
Total	9403	11121	20524										
World	10755	11573	22328			75560	3.82				28.6	60	0.29
	87.43	96.09	91.92										

TP=Total Papers; TC=Total Citations; ICP=International Collaborative Papers; RCI=Relative Citation Index

Areas in pervasive and ubiquitous computing

Under pervasive and ubiquitous computing major emphasis has been on computer technology. The hardware aspects of technology accounted for 3958 papers (17.73%): covering areas including Radio frequency identification (RFID)(1052 papers), near field communication (NFC)(117 papers), sensor network (2404 papers), actuators (282 papers) and internet protocol including IPv6 (644 papers) during 2005-14. The software aspects of technology accounted for 1863 papers (7.10%): covering areas including Middleware (1356 papers) and searching/browsing (528 papers) during 2005-14. The

second major area under “pervasive and ubiquitous computing” has been the applications which accounted for 6862 (30.73%) papers: covering areas Intelligent buildings (533 papers), mobile devices (455 papers), health (402 papers), smart homes (282 papers), education (240 papers, learning systems (177 papers), e-learning (124 papers), students (124 papers), teaching (116 papers), energy efficiency (106 papers), energy utilization (101 papers), online social networks (100 papers), smart homes (99 papers), electronic commerce (96 papers), industry (94 papers), vehicles (93 papers), smart environment (89 papers), telemedicine (89 papers), medical computing

Table 3—Share of international collaborative papers of top 15 most productive countries on pervasive & ubiquitous computing

Country	Total Papers	Total International Collaborative Papers (ICP)	% ICP
USA	3548	1080	30.44
China	3418	639	18.70
South Korea	2390	370	15.48
U.K.	1732	672	38.80
Germany	1597	540	33.81
Japan	1461	279	19.10
Taiwan	953	120	12.59
Spain	932	285	30.58
Italy	912	282	30.92
France	898	365	40.65
Australia	628	153	24.36
Canada	582	299	51.37
India	572	105	18.36
Finland	471	171	36.31
Switzerland	430	220	51.16
World	22328		

Table 4—Subject-wise break-up of global publications output on pervasive & ubiquitous computing

Subject*	Number of papers			Activity Index		TC 2005-14	ACPP 2005-14	%TP 2005-14
	2005-09	2010-14	2005-14	2005-09	2010-14			
Computer Science	8720	10600	19320	93.7	105.9	62654	3.24	86.53
Engineering	3400	1390	4790	147	55.99	24011	5.01	21.45
Social Science	1107	571	1678	137	65.65	6001	3.58	7.51
Biochemistry, Genetics & Molecular Biology	1050	59	1109	197	10.26	3712	3.35	4.97
Medicine	207	392	599	71.7	126.3	2530	4.22	2.68
Decision Sciences	285	302	587	101	99.26	2825	4.81	2.63
Business, Management & Accounting	123	131	254	101	99.5	931	3.66	1.14
Global Total	10755	11573	22328					

*Please note that there is a duplication of papers under various subjects and as a result there total is more than the actual total output

Table 5—Top 20 most productive organizations in pervasive and ubiquitous computing

Sl. no.	Name of organization	TP	TC	ACPP	ICP	%ICP	HI	HCP
1	Carnegie Mellon University, USA	231	2132	9.23	76	32.9	22	2
2	Electronics & Telecommunication Research Institute, South Korea	226	761	3.37	18	7.965	14	0
3	Sunak Yunkwan University, South Korea	194	431	2.22	9	4.639	9	0
4	Beijing University of Posts & Telecommunications, China	187	266	1.42	21	11.23	7	0
5	Tsinghua University, China	184	320	1.74	42	22.83	8	0
6	Korea University, South Korea	183	804	4.39	23	12.57	14	1
7	University of Tokyo, Japan	166	1010	6.08	23	13.86	10	1
8	Eidgenossische Technische, Switzerland	161	997	6.19	82	50.93	17	0
9	Lancaster University, U.K.	139	1114	8.01	68	48.92	16	2
10	Zhejiang University, China	136	332	2.44	29	21.32	10	0
11	Georgia Institute of Technology, USA	135	1259	9.33	41	30.37	18	1
12	Yonsei University, South Korea	133	549	4.13	15	11.28	10	2
13	Shanghai Jiaotong University, China	131	293	2.24	20	15.27	8	0
14	Nokia, Finland	131	556	4.24	32	24.43	12	0
15	University of Oulu, Finland	130	438	3.37	44	33.85	9	0
16	Korea Advanced Institute of Science & Technology, South Korea	128	440	3.44	29	22.66	11	0
17	Kyung Hee University, South Korea	127	476	3.75	26	20.47	11	0
18	Harbin Institute of Technology, China	123	106	0.86	16	13.01	5	0
19	Nippon Telegraph & Telephone, Japan	111	191	1.72	5	4.505	7	0
20	Keio University, Japan	110	158	1.44	20	18.18	7	0
	Total of 20 top organizations	3066	12633	4.12	639	20.84	11.25	9
	Total of the world	22328	75560					
	Share of top 20 organizations in global output	13.73	16.72					

(79 papers), hospitals (77 papers), healthcare (76 papers), ubiquitous learning (75 papers), engineering education (72 papers), etc during 2005-14. The third major area under “pervasive and ubiquitous computing” covers the challenges faced: Security (2941 papers, 13.17%), privacy (1488 papers, 6.66%), legal aspects and accountability (80 papers, 0.36%) and governance (26 papers, 0.12%) and among other areas include business models (111 papers, 0.50%) during 2005-14.

Top 20 most productive organizations

Individually, publication productivity by top 20 most productive organizations on ubiquitous computing varied from 110 to 231 publications in 10 years during 2005-14. Together they accounted for 13.73% (3066) publications share and 16.33% (12633) citation share during 2005-14. The

scientometric profile of these 20 organizations is presented in Table 5. Eight organizations registered productivity above the group average of 153 papers per organization: Carnegie Mellon University, USA (231 publications), Electronics & Telecommunication Research Institute, South Korea (226 publications), Sunak Yunkwan University, South Korea (194 publications), Beijing University of Posts & Telecommunications, China (187 publications), Tsinghua University, China (184 publications), Korea University, South Korea (183 publications), University of Tokyo, Japan (166 publications) and Eidgenossische Technische, Switzerland (161 publications). Eight organizations registered citation impact above the group average of 4.12 citation per publication: Georgia Institute of Technology, USA (9.33), Carnegie Mellon University, USA (9.34), Lancaster University, U.K. (8.01), Eidgenossische

Technische, Switzerland (6.19), University of Tokyo, Japan (6.08), Korea University, South Korea (4.39), Nokia, Finland (4.24) and Yonsei University, South Korea (4.13) during 2005-14. Seven organizations registered h-index above the group average of 11.25: Carnegie Mellon University, USA (22), Georgia Institute of Technology, USA (18), Eidgenossische Technische, Switzerland (17), Lancaster University, U.K. (16), Korea University, South Korea and Electronics & Telecommunication Research Institute, South Korea (14 each) and Nokia, Finland (12) during 2005-14. Eight organizations had their share of international collaborative publications above the group average of 20.84%: Eidgenossische Technische, Switzerland (50.93), Lancaster University, U.K. (48.92%), University of Oulu, Finland (33.85%), Carnegie Mellon University, USA (32.90%), Georgia Institute of Technology, USA (30.37%), Nokia, Finland (35.00%), Universidad de Murcia, Spain (24.43%), Tsinghua University, China (22.83%),

Korea Advanced Institute of Science & Technology, South Korea (33.66%) and Zhejiang University, China (21.32%) during 2005-14 (Table 5).

Profile of top 20 most productive authors

The top 20 most productive authors together accounted for 4.18% (933 publications) share and 7.96% (6013 citations) share on ubiquitous computing during 2005-14. Individually they published 37 to 67 publications in 10 years during 2005-14. The scientometric profile of these 20 authors is presented in Table 6. Eight authors registered publications productivity above the group average of 46.65 papers per author: F. Zamboneli (67 publications), S.I. Ahmad (60 publications), D Zhang (57 publications), S. Lee and G. Troster (55 publications each), M. Guo (53 publications), A. Schmidt (52 publications) and Z. Yu (47 publications) during 2005-14. Eight authors registered citation impact above the group average of

Table 6—Scientometric profile of top 20 most productive authors on pervasive & ubiquitous computing

Sl. no.	Name	Affiliation	TP	TC	ACPP	ICP	%ICP	HI
1	F. Zamboneli	Universita di Modena e Reggio Emilia, Italy	67	382	5.7	18	26.87	11
2	S.I. Ahmad	Marquette University, USA	60	340	5.67	13	21.67	11
3	D Zhang	Institute for Infocomm Research, Singapore	57	742	13	14	24.56	10
4	S. Lee	Kyung Hee University, South Korea	55	216	3.93	14	25.45	7
5	G. Troster	Swiss Federal Institute of Technology, Institute of Electronics, Zurich, Switzerland	55	561	10.2	29	52.73	10
6	M. Guo	Shanghai Jiao Tong University, China	53	118	2.23	39	73.58	6
7	A. Schmidt	University of Duisburg, Essen, Germany	52	420	8.08	24	46.15	10
8	Z. Yu	Washington State University, USA	47	160	3.4	34	72.34	6
9	L.T.Lang	St. Francis Xavier University, Canada	46	78	1.7	34	73.91	4
10	J. Cao	Hong Kong Polytechnic University	44	229	5.2	8	18.18	8
11	M. Mamei	Universita di Modena e Reggio Emilia, Italy	43	233	5.42	9	20.93	8
12	V. Callaghan	University of Essex, U.K.	43	348	8.09	10	23.26	7
13	J. Riecki	University of Oulu, Finland	42	124	2.95	9	21.43	5
14	P. Lukowicz	University of Passau, Germany	41	391	9.54	25	60.98	8
15	H.Y.Youn	Sungkyunkwan University, South Korea	39	56	1.44	0	0	5
16	A.K. Dey	Carnegie Mellon University, USA	39	435	11.2	15	38.46	11
17	V.Issarny	INRIA-Rocquen Court, France	38	378	9.95	9	23.68	10
18	V.C.Tseng	National Chiao-Tung University, Taiwan	38	688	18.1	1	2.632	11
19	T.Nakajima	Waseda University, Japan	37	102	2.76	4	10.81	5
20	T.H. Kim	Hannam University, South Korea	37	12	0.32	26	70.27	2
	Total Output		933	6013	6.44	335	35.91	7.75
	Total Global Output		223	75560				28
	Share of 20 authors in Global Output		4.18	7.96				

TP=Total publications; TC=Total citations; ACPP=Average citation per publication; ICP=International collaborative publications; HI=h-index

6.44 citations per paper: V.C.Tseng (18.10), D Zhang (13.0), A.K. Dey (11.2), G. Troster (20.20), V.Issarny (9.95), P. Lukowicz (8.54), V. Callaghan (8.09) and A. Schmidt (8.08) during 2005-14. Eleven authors registered h-index above the group average of 7.75: V.C.Tseng, A.K. Dey, F. Zamboneli and D Zhang with h-index of 11 each, followed D Zhang, G. Troster, V.Issarny and A. Schmidt (10 each), P. Lukowicz, M. Mamei and J. Cao(8 each) during 2005-14. Eight authors contributed international collaborative publications above the group average share of 35.91%: L.T.Lang (73.91%), M. Guo (73.58%), Z. Yu (72.34%), T.H. Kim (70.27%), P. Lukowicz (60.98%), G. Troster (52.73%), A. Schmidt (46.15%) and A.K. Dey (38.46%) during 2005-14.

Medium of communication

The distribution of world output on pervasive & ubiquitous computing in terms of source type shows that the largest number of publications (14696)

appeared as conference proceedings, followed by journals papers (3727), book series (3476), books (326) and trade publications (103) during 2005-14. The top 20 most productive journals accounted for 32.22% share (1201 papers). Individually these journals reported 23 to 291 during 2005-14. On quinquennial basis, the publication share of top 20 most productive journals increased from 27.33% to 35.81% from 2005-09 to 2010-14. Of these 20 journals, *IEEE Pervasive Computing* published the largest number of papers (291), followed by *Personal & Ubiquitous Computing* (240 papers), *Pervasive & Mobile Computing* (102 papers), etc during 2005-14 (Table 7).

Conclusion

The study characterizes research publications activity in the field of ubiquitous and pervasive computing with data collected from Scopus database covering the period 2005-2014. Given the fact that top

Table 7—Top 20 journals on pervasive & ubiquitous computing

Sl. no.	Journal	Number of papers		
		2005-09	2010-14	2005-14
1	<i>IEEE Pervasive Computing</i>	91	200	291
2	<i>Personal & Ubiquitous Computing</i>	72	168	240
3	<i>Pervasive & Mobile Computing</i>	45	57	102
4	<i>Journal of Supercomputing</i>	5	52	57
5	<i>International Journal of Ad Hoc & Ubiquitous Computing</i>	10	40	50
6	<i>International Journal of Pervasive Computing & Communication</i>	29	18	47
7	<i>Computer Communication</i>	32	7	39
8	<i>IEEE Transactions on Mobile Computing</i>	14	23	37
9	<i>Wireless Personal Communication</i>	11	22	33
10	<i>Journal of Universal Computer Science</i>	15	18	33
11	<i>Expert Systems & Applications</i>	12	20	32
12	<i>IEEE Transactions on Consumer Electronics</i>	25	5	30
13	<i>International Journal of Multimedia & Ubiquitous Engineering</i>	11	18	29
14	<i>Journal of Systems & Software</i>	15	13	28
15	<i>IEICE Transactions on Information Systems</i>	12	16	28
16	<i>Multimedia Tools & Applications</i>	7	20	27
17	<i>Sensors Switzerland</i>	1	25	26
18	<i>Future Generation Computer Systems</i>	4	21	25
19	<i>Journal of Ambient Intelligence & Smart Environment</i>	4	20	24
20	<i>Mobile Networks & Applications</i>	16	7	23
	Total of 20 journals	431	770	1201
	Total of World in journal output	1577	2150	3727
	Share of 20 journals in World journal output	27.33	35.81	32.22

20 most productive organizations accounted for publications share as low as 13.7% coupled with the fact that top 20 authors accounted for publications share also as low as 4.18%, it is evident that research output on ubiquitous & pervasive computing is still highly distributed and scattered. That top 20 most productive journals accounted for just 1/3rd (32.2%) of global output on ubiquitous and pervasive computing further strengthens this view. Research on ubiquitous and pervasive computing does not interact highly with other disciplines. This view emerges from the fact that computer science field contributed significantly as much as 86.53% subject share of the global publication output in this area. Secondly, the field notably lacks in research on applications to other disciplines. From the analysis, it is concluded that ubiquitous and pervasive computing as a research field is still in developing stage, still to evolve itself as an interdisciplinary subject with potential for building application for economic, industrial, and social development in the society. Large scale investments in R&D, both in terms of R&D investments and manpower development are needed to develop this field. National R&D strategies need to be developed by various countries to achieve their desired goals in terms of both technological developments as well as in terms of developing applications in different fields. Besides, given the fact that top 15 countries overwhelmingly contributed as much as 91.92% of global output, it is imperative countries should focus also on collaborative research on ubiquitous and pervasive computing with international hubs in this field like the USA with 15.89% share, China (15.31%), and South Korea (10.70%).

India is far behind the world countries in research on pervasive & ubiquitous computing. India ranked 13th country in the world in terms of research output

in pervasive and ubiquitous computing. Its performance on various indicators has not been impressive: world share (2.56%), average citations per paper (1.41), relative citation rate (0.42), h-index (11), and highly cited papers (0). Given the innovative roles that ubiquitous computing seeks to play in retail industry, industrial production, material management, personal identification and authentication, transport logistics, health care and such other societal applications, it is important India should aim to build and maintain a scientific and technological position of excellence in pervasive and ubiquitous computing as well. India must introspect and assess its strengths and weakness in this area and evolve an appropriate research policy to realize its agenda of expanding economic competitiveness and transforming the country into a ubiquitous modern society in near future.

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