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Patterns of Productivity in Information Retrieval (IR) Literature: A Study of the Scientometric Distributions

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ABSTRACT

The present paper aims to analyse the patterns of productivity in the information retrieval literature during the period of ten years i.e. (2009-2018). The study covers a total number of 4238 records indexed in the Scopus database. Out of a total of 4238 publications, a maximum 1915 records were contributed by two authors, followed by three authors with 1176 contributions. A total of 17829 citations were recorded on 4238 publications and the maximum (29.67) annual growth was recorded in 2010 from the marked period of study. The overall relative growth was shown in fluctuating trend and lie between (0.16 to 0.83) while the doubling time was lies between (0.83 to 4.42). The average degree of authors collaborations was (0.94) recorded. The average collaboration coefficient (CC) and the collaborative index was (0.58) and (2.76) recorded respectively. Varma, V. from (International Institute of Information Technology, Hyderabad) was the most productive author with 45 publications; h-index 15; and a total citation 864. The maximum 2847 (67.18%) of publications in information retrieval were published in conference. In the field of computer science, the maximum 3370 publications were published. However, the maximum 177 research papers were contributed by Anna University while the maximum 15 publications were funded by the department of science and technology, Ministry of science and technology. Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics was the most prolific source title with 224 publications while the most significant keyword was 'Information Retrieval' with 2963 publications during the period of study.

Keywords: Scientometrics, Information Retrieval (IR), Relative Growth Rate (RGR), Collaboration Coefficient (CC), Collaborative Index (CI).

1. INTRODUCTION

Information retrieval (IR) is the way toward looking for data in records, scanning for archives themselves, looking for metadata which portrays reports, or looking inside hypertext accumulations, for example, the Internet or intranets. A discipline that concerns the effective transfer of information and user of information. In the system perspective, representation, storage, association, access, and circulation of information are studied, while, in the user point of view, different information looking for models and how to fulfil users' information

need are examined. “An information retrieval system is therefore defined here as any device which aids access to documents specified by subject, and the operations associated with it. The documents can be books, journals, reports, atlases, chapters, sections, tables, diagrams, or even particular words. The retrieval devices can range from a bare list of contents to a large digital computer and its accessories. The operations can range from simple visual scanning to the most detailed programming.” <https://www.nap.edu/read/10866/chapter/80>. The study shows that the literature output of information retrieval research during the period of ten years i.e. (2009-2018).

2. SCOPE OF THE STUDY

The present study is limited to only ‘Information Retrieval’ research literature from the marked period of 10 years i.e. 2009-2018. The study is further limited to analysis of Indian authors literature which is published in the Scopus database.

3. LITERATURE REVIEW

Verma and Shukla (2019)¹ conducted a scientometric study on information literacy of selected countries from the marked period (2008-2017). The study analysed and found that the maximum 1234 (12.99%) of research papers were published in the year 2016 and the highest annual growth was (25.68%) recorded in 2010 while the maximum relative growth was (0.795) in 2009 and doubling time was (5.824) in the year 2017. Wolf, M. S. was the most prolific author with 65 publications and the maximum 5770 publications were contributed by the United States’ scientist from the marked period of study.

Vinay et al (2019)² carried out a scientometric analysis of the trends in library and information science research during (2008-2017) in which a total 459 research papers were published in these LIS journal and the maximum 195 (42.48%) of publications were contributed by single author. The collaborative index lies between “1.52 to 2.09” while the collaborative coefficient carried from “0.26 to 0.37”. However, the average degree of collaboration was 0.57 which clearly indicates that multiple authors were dominance over the single author during the period of study.

Shukla and Gupta (2019)³ investigated a scientometric study of web mining research during the period (2009-2018). The primary data was collected by the Scopus database and found that the maximum 291 publications came in 2010 while the highest 15 publications were contributed by Zhu, Q. and computer science subject was contributed a maximum 1835 publications. The relative growth was shown in decreasing trend while the doubling time has been shown in the increasing trend. Out of a total of 2218 publications, a highest 1384 (62.40%) of publications were published in the conference while the most significant keyword was web mining with the frequency of 1587 during the period of study.

Gupta and Dhawan (2018)⁴ carried out a scientometric analysis of artificial intelligence research in India from (2007-2016). The study examines various scientometric patterns and found that the maximum 2221 of publications came in 2016 and the highest publication came in a computer science subject. Anna University, Chennai was the most productive institution with 294 contributions while S. Das was the most prolific authors with the maximum 36

publications. However, the Artificial intelligence keyword frequency was 9496 during the period of study.

Rorissa and Yuan (2012)⁵ carried out a study on visualizing and mapping the intellectual structure of information retrieval during the period of ten years i.e. (2000-2009). A total of 56160 records were found in which the maximum 46 publications were contributed by Thelwall, M. from the University of Wolverhampton, School of computing and information technology. The most cited Journal was J AM SOC INFORM SCI, 1900, SO, V, P with 1522 citations and got the rank first. The most frequently used keywords were 'information retrieval' with 854, followed by 'internet' with 401. However, the most productive institution was the University of Wisconsin with 66 publications and got the rank first from the marked period of study.

4. OBJECTIVES OF THE STUDY

The main objectives of the present study are as follows:

1. To analysis the annual growth of the IR literature.
2. To identify the relative growth and doubling time of publications.
3. To find out the degree of authors collaboration in IR research literature.
4. To analysis the collaboration coefficient and collaborative index.
5. To identify productive authors, h-index, and total citations.

5. METHODOLOGY

The primary data was collected to using the Scopus database, it is an international online bibliographic database owned by Elsevier and available online by subscription basis. The following keywords used for extracting the primary data- ("Information Retrieval") AND (LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2009)) AND (LIMIT-TO (AFFILCOUNTRY, "India")). There are a total 4238 records available in the Scopus database on 29 July 2019. These records along with full bibliographical details such as year wise distribution, authors, affiliation, document types etc. The data is tabulated in MS Excel, VOS viewer software and tested by the various scientometrics tools to achieve the objectives.

6. DATA ANALYSIS

6.1 Year-wise distribution of publications, annual growth and citations

Table and figure 1 show the year-wise distribution, annual growth and total citations in information retrieval research during the period of 10 years i.e. (2009-2018) in which out of a total of 4238 publications, a maximum 680 research papers were published in the year 2016, followed by 615 publications in 2018 while the annual growth has been shown in flatulating trend lie between (3.86 in 2012 to -25.88 in 2017) and a total 17829 citations was found in publications in which a highest 2642 citations were found in 271 records in 2010. The overall data of the year-wise distribution of publications, annual growth and citations were shown in below table and figure 1. The annual growth rate is a useful method to evaluate the yearly trends in research productivity (Kumar & Kaliyaperumal, 2015)⁶.

$$AGR = \frac{EndValue - FirstValue}{FirstValue} \times 100$$

Table 1: Year-wise distribution of publications, annual growth and citations

Year	No. of Publications	Cumulative Sum	Annual Growth	Citations
2009	209	209	0	2136
2010	271	480	29.67	2642
2011	311	791	14.76	2257
2012	323	1114	3.86	2477
2013	366	1480	13.31	1870
2014	426	1906	16.39	1454
2015	533	2439	25.12	1789
2016	680	3119	27.58	1522
2017	504	3623	-25.88	1243
2018	615	4238	22.02	439
Total	4238			17829

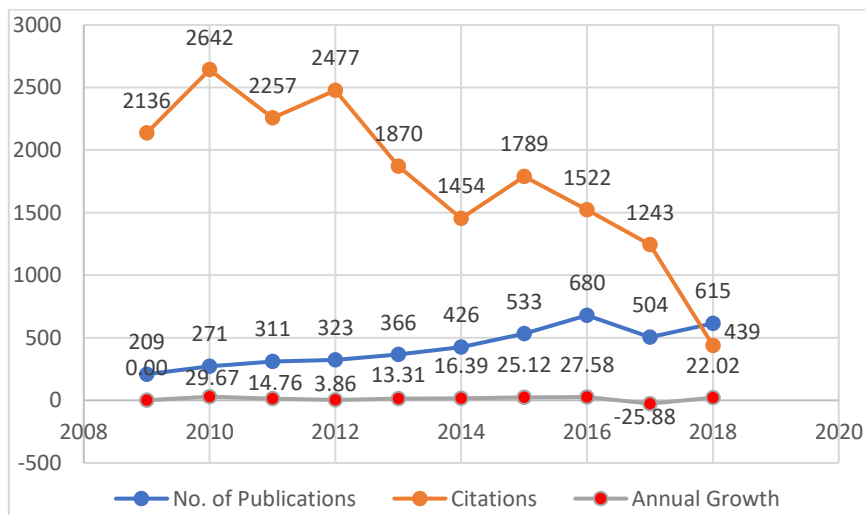


Figure 1: Year-wise distribution of publications, annual growth and citations

6.2 Relative growth rate and doubling time in information retrieval research

Table 2 depicts the relative growth rate and doubling time in information retrieval research during the period (2009-2018). The RGR model developed by Mahapatra⁷ in the year 1985. On the observation of the particular table, it has been shown that the relative growth rate was found in decreasing trend lies between (0.16 in 2018 to 0.83 in 2010) while the doubling time was shown in increasing trend and lie between (0.83 in 2010 to 4.42 in 2018). The whole data of relative growth and doubling time has been shown in below table 2. The mathematical representation of the mean relative growth rate of articles over a specific period is derived from the following formula:

$$RGR = \frac{W2 - W1}{T2 - T1}$$

RGR = Growth Rate over the specific period of the interval,
W1 = Log_e (natural log of the initial number of contributions)
W2 = Log_e (natural log of the final number of contributions)
T1 = the unit of initial time
T2 = the unit of the final time

The following formula used to analysis the doubling time.

$$DoublingTime(Dt) = \frac{0.693}{R}$$

Table 2: Relative growth rate and doubling time in IR research

Year	No. of Publications	Cumulative Sum	W2	W1	RGR	Dt
2009	209	209	5.34	0	0	0
2010	271	480	6.17	5.34	0.83	0.83
2011	311	791	6.67	6.17	0.50	1.39
2012	323	1114	7.02	6.67	0.34	2.02
2013	366	1480	7.30	7.02	0.28	2.44
2014	426	1906	7.55	7.30	0.25	2.74
2015	533	2439	7.80	7.55	0.25	2.81
2016	680	3119	8.05	7.80	0.25	2.82
2017	504	3623	8.20	8.05	0.15	4.63
2018	615	4238	8.35	8.20	0.16	4.42

6.3 Degree of author's collaborations

Table 3 illustrates the degree of author's collaboration in information retrieval research in India from (2009-2018). The highest 3993 of publications were published by multiple authors while the rest 245 of publications were contributed by a single author. The average degree of collaboration was (0.94) recorded during the period of study. It is also observed that the degree of author's collaboration has been shown in the fluctuating trend. The overall data of the author's collaboration was shown in below table 3. The degree of author collaboration was clearly shown its dominance on multiple author contributions. (K. Subramanyam, 1983)⁸ is given the DC formula to determine the degree of author collaboration in quantitative terms. The following formula used to analyse the degree of authors collaborations.

$$DC = \frac{Nm}{Nm + Ns}$$

Table 3: Degree of author's collaborations

Year	Single Authored Publications (Ns)	Multiple Authored Publications (Nm)	Degree of Collaboration (DC)= Nm/(Nm+Ns)
2009	14	195	0.93
2010	20	251	0.93

2011	27	284	0.91
2012	14	309	0.96
2013	16	350	0.96
2014	24	402	0.94
2015	32	501	0.94
2016	35	645	0.95
2017	31	473	0.94
2018	32	583	0.95
Total	245	3993	0.94

6.4 Authorship pattern, collaboration coefficient (CC) and collaborative index (CI)

Table 4 shows the authorship pattern, collaboration coefficient and collaborative index in information retrieval research in India during (2009-2018). The maximum 1915 of publications were contributed by two authors, followed by three authors with 1176 contributions. It is also observed that the average collaboration coefficient was (0.58) recorded while the maximum (0.60) CC was recorded in the year 2012, however, the average collaborative index was (2.76) recorded and the maximum (2.92) CI was recorded in 2012, followed by (2.85) in 2013. The whole data of authorship pattern, collaboration coefficient and the collaborative index was shown in below table 4 and figure 2.(Ajiferuke, Burrel and Tague, 1988)⁹ suggested collaborative coefficient and it is used by (Karki and Garg, 1997)¹⁰.The collaboration coefficient (CC) counted by the following formula:

$$CC = 1 - \frac{\sum_{j=1}^A \left(\frac{1}{j}\right) fj}{N}$$

Where,

j = the number authors in an article i.e. 1, 2, 3, more than 3.

fj = the number of j authored articles

N = the total number of articles published, and

A = the total number of authors per articles.

The collaboration index (CI) counted by the following formula suggested by the (Lawani, 1980)¹¹:

$$CI = \frac{\sum_{j=1}^A j fj}{N}$$

Where,

j = the number authors in an article i.e. 1, 2, 3, more than 3.

fj = the number of j authored articles

N = the total number of articles published, and A = the total number of authors per articles.

Table 4: Authorship pattern, collaboration coefficient (CC) and collaborative index (CI) in IR research

Year	1 Author	2 Authors	3 Authors	4 Authors	5 Authors	5< Authors	Total	Collaboration Coefficient (CC)	Collaborative Index (CI)
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2009	14	93	57	25	13	7	209	0.57	2.77
2010	20	107	90	34	14	6	271	0.57	2.75
2011	27	126	86	37	23	12	311	0.57	2.80
2012	14	136	91	45	18	19	323	0.60	2.92
2013	16	164	94	55	24	13	366	0.59	2.85
2014	24	194	128	49	21	10	426	0.57	2.72
2015	32	273	125	70	24	9	533	0.56	2.64
2016	35	323	189	85	25	23	680	0.57	2.72
2017	31	238	127	66	25	17	504	0.57	2.74
2018	32	261	189	80	29	24	615	0.58	2.81
Total	245	1915	1176	546	216	140	4238	0.58	2.76

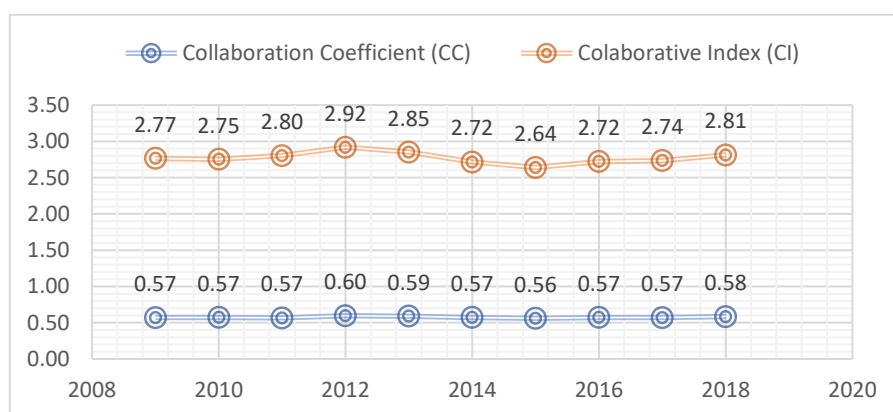


Figure 2: Authorship pattern, collaboration coefficient (CC) and collaborative index (CI)

6.5 Productive Authors, h-index, and total Citations

Table 5 depicts the top ten most productive authors, h-index and total citation. The maximum 45 of research papers; 15 h-index; 864 citations were contributed by Varma, V. (International Institute of Information Technology, Hyderabad), followed by Soman, K.P. (Amrita School of Engineering, Coimbatore) with 33 publications; 16 h-index; 1679 citations, and Anand Kumar, M. (National Institute of Technology Karnataka, Mangalore) contributed 32 research papers; 10 h-index; and 387 citations while Bandyopadhyay, S. (Jadavpur University, Computer Science and Engineering, Kolkata) with 30 contributions; 13 h-index; and 814 citations. A total of 233 items were found including 20 clusters in IR research during the period of study. The overall data of the top ten most prolific authors were shown in below table 5 and figure 3.

Table 5: Productive Authors, h-index, and total Citations

Rank	Authors Name and Affiliation	No. of Publications	h-index	Citations
1	Varma, V. (International Institute of Information Technology, Hyderabad)	45	15	864
2	Soman, K.P. (Amrita School of Engineering, Coimbatore)	33	16	1679

3	Anand Kumar, M. (National Institute of Technology Karnataka, Mangalore)	32	10	387
4	Bandyopadhyay, S. (Jadavpur University, Computer Science and Engineering, Kolkata)	30	13	814
5	Pal, U. (Indian Statistical Institute, Kolkata)	26	31	4376
6	Sharan, A. (Jawaharlal Nehru University, School of Computer and Systems Sciences, New Delhi)	26	7	189
7	Ghosh, K. (Indian Institute of Technology Kanpur, Kanpur)	25	5	65
8	Geetha, T.V. (College of Engineering, Guindy, Department of Computer Science and Engineering, Chennai)	24	9	346
9	Majumder, P. (DhirubhaiAmbani Institute of Information and Communication Technology, Gandhinagar)	24	6	178
10	Sharma, A.K. (BSAITM, Department of Computer Science and Engineering, Faridabad)	22	9	326

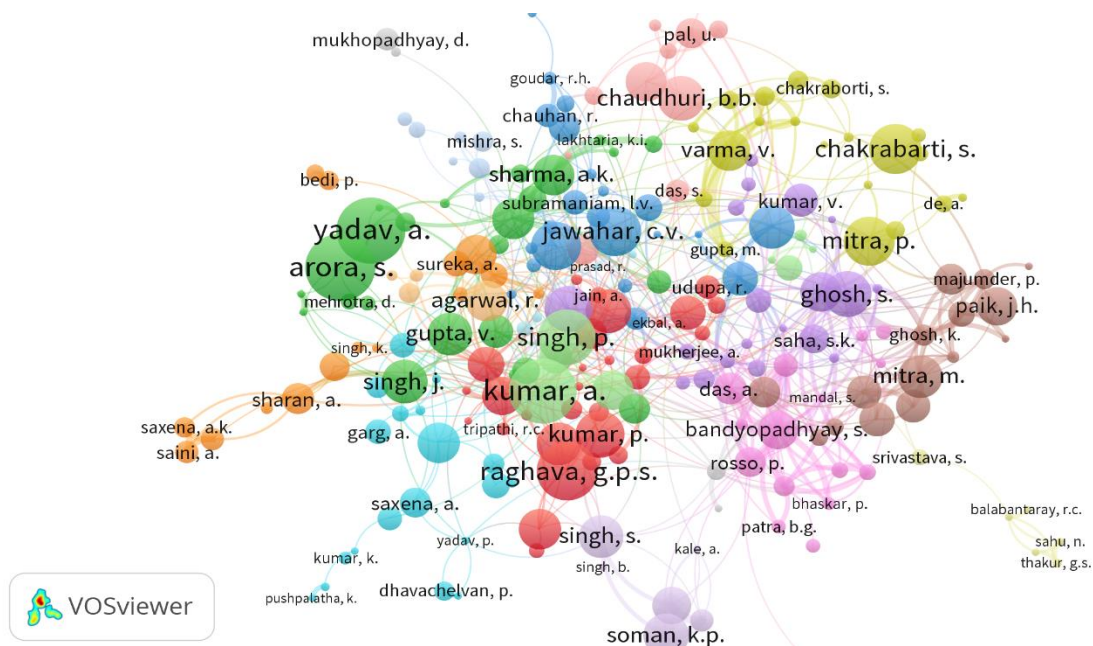


Figure 3: Cluster of authorship pattern in IR research

6.6 Document-wise distribution of the publication in IR research

Table 6 and figure 4 reveals the document wise distribution of information retrieval research in India during (2009-2018). The maximum 2847 (67.18%) of records were published in conference, followed by 1162 (27.42%) of records were found articles type documents and

91 (2.15%) of records were published in the book chapter. The whole data of document wise distribution of publication was shown in below table 6 and figure 4.

Table 6: Document-wise distribution of the publication in IR research

Type of Records	No. of Publications	Percentage
Conference Paper	2847	67.18
Article	1162	27.42
Book Chapter	91	2.15
Review	83	1.96
Book	8	0.19
Letter	6	0.14
Editorial	5	0.12
Note	5	0.12
Short Survey	2	0.05
Undefined	29	0.68
Total	4238	100.00

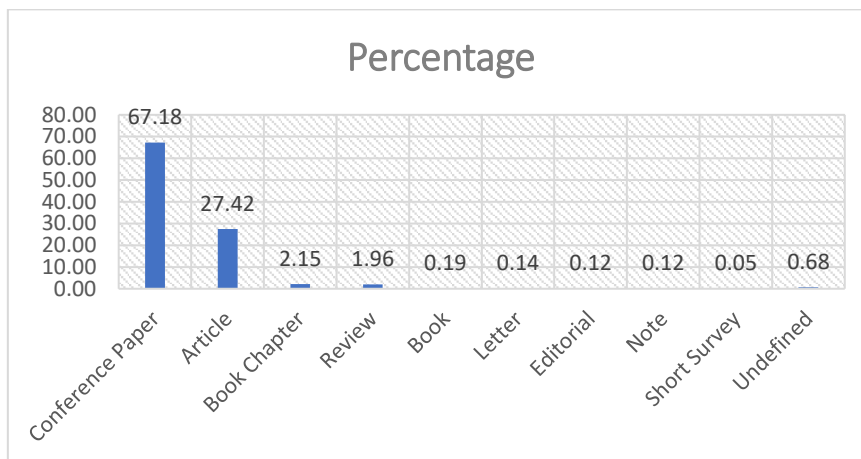


Figure 4: Document-wise distribution of the publication in IR research

6.7 Subject-wise distribution of publications in information retrieval research

Table 7 illustrates the subject-wise distribution of publications in information retrieval research in India from (2009-2018). The maximum 3370 of publications came in the computer science subject area, followed by Engineering with 1129 publications while in Mathematics subject a total of 684 publications. The overall data of the subject-wise distribution of publications were shown in below table 7.

Table 7: Subject-wise distribution of publications in IR research

Subject Area	No. of Publications	Subject Area	No. of Publications
Computer Science	3370	Arts and Humanities	51
Engineering	1129	Earth and Planetary	43

Mathematics	684	Sciences	
Medicine	249	Agricultural and Biological Sciences	40
Social Sciences	220	Chemical Engineering	34
Decision Sciences	179	Neuroscience	26
Biochemistry, Genetics and Molecular Biology	163	Chemistry	23
Physics and Astronomy	142	Immunology and Microbiology	22
Business, Management and Accounting	130	Economics, Econometrics and Finance	18
Pharmacology, Toxicology and Pharmaceutics	95	Health Professions	17
Materials Science	85	Dentistry	7
Energy	80	Psychology	5
Multidisciplinary	63	Nursing	4
Environmental Science	53	Veterinary	3

6.8 Productive organisations and funding agency in information retrieval research

Table 8 shows the top ten most productive organisations and funding agency in information retrieval research in India during the period of ten years i.e. (2009-2018). The maximum 177 publications were contributed by Anna University, followed by International Institute of Information Technology, Hyderabad with 111 contributions and Indian Institute of Technology Kharagpur contributed 98 publications in information retrieval research while the maximum 15 of publications were funded by Department of Science and Technology, Ministry of Science and Technology, followed by University Grants Commission with 11 publications while Central Mechanical Engineering Research Institute, Council of Scientific and Industrial Research, Ministry of Human Resource Development, National Science Foundation and Science and Engineering Research Board funded 10 publications each. The whole data of the top ten organisations and funding agency was shown in below table 8.

Table 8: Productive organisations and funding agency in IRresearch

Sl. No.	Organisations Name	No. of Publications	Funding Agency	No. of Publications
1	Anna University	177	Department of Science and Technology, Ministry of Science and Technology	15
2	International	111	University Grants Commission	11

	Institute of Information Technology, Hyderabad			
3	Indian Institute of Technology Kharagpur	98	Central Mechanical Engineering Research Institute, Council of Scientific and Industrial Research	10
4	Indian Statistical Institute, Kolkata	95	Ministry of Human Resource Development	10
5	Sathyabama Institute of Science and Technology	82	National Science Foundation	10
6	Jadavpur University	69	Science and Engineering Research Board	10
7	Vellore Institute of Technology Amrita	67	Department of Biotechnology, Government of West Bengal	9
8	VishwaVidyapeetham	61	Department of Science and Technology, Government of Kerala	8
9	Tata Consultancy Services India	57	Microsoft Research	5
10	Indian Institute of Technology, Bombay	55	Ministry of Electronics and Information technology	5

6.9 Source Title and Significant Keywords in IR Research

Table 9 and figure 5(a), (b) depicts the top ten source title and significant keywords in information retrievals research. The maximum 224 of publications were published in source title “Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics”, followed by “Advances in Intelligent Systems and Computing” with 200 publications and 183 publications were published in the source title “Ceur Workshop Proceedings” while the most common significant keyword is ‘Information Retrieval’ with 2963 publications, followed by ‘Search Engines’ keyword with 986 publications and ‘Data Mining’ keyword used in 658 publications. The whole data of top ten source title and significant keywords was shown in below table and figure.

Table 9: Source Title and Significant Keywords in IR Research

Sl. No.	Source Title	No. of Publications	Keyword	Frequency
1	Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial	224	Information Retrieval	2963

	Intelligence and Lecture Notes in Bioinformatics			
2	Advances in Intelligent Systems and Computing	200	Search Engines	986
3	Ceur Workshop Proceedings	183	Data Mining	658
4	ACM International Conference Proceeding Series	166	Information Retrieval Systems	583
5	Communications in Computer and Information Science	106	Semantics	535
6	International Journal of Applied Engineering Research	72	Natural Language Processing Systems	532
7	Procedia Computer Science	66	Artificial Intelligence	411
8	Indian Journal of Science and Technology	37	Text Processing	400
9	International Conference on Information and Knowledge Management Proceedings	30	Classification (of Information)	387
10	International Journal of Pharmacy and Technology	29	Websites	372

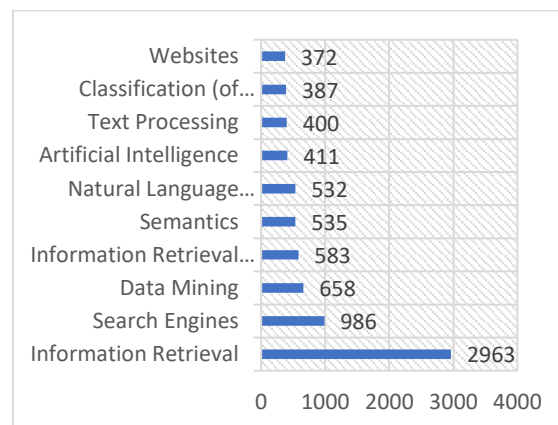
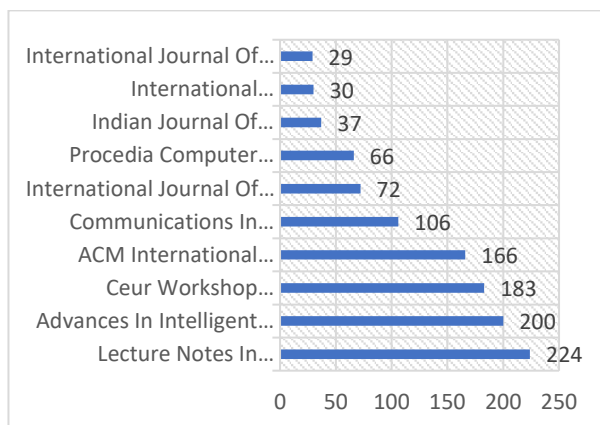


Figure 5(a): Source Title in IR research Figure 5(b): Significant Keywords in IR research

7. CONCLUSION

The present study analysed the growth rate of information retrieval research output based on the Scopus database during the period of last ten years i.e. (2009-2018). Information retrieval is the techniques of storing, recovering and often circulating recorded information especially through the use of a computerized system. A total of 4238 records were published by the Indian scientists in which the maximum 1176 publications were published by three authors, followed by two authors with 1915 publications. The information retrieval research annual

growth is increasing year by year from the marked period of study. A total 17829 citations were found on 4238 publications and the relative growth was shown in decreasing trend while the doubling time has been shown in increasing trend and lies between (0.83 to 0.16) and (0.83 to 4.63) respectively. The average degree of authors collaboration (DC) was (0.94) recorded during the period of study. Out of a total of 4238 publications, the maximum 3993 publications were contributed by multiple authors while 245 papers were published by a single author. The average collaboration coefficient (CC) and collaborative index (CI) was 0.58 and 2.76 respectively. Varma, V. from (International Institute of Information Technology, Hyderabad) contributed a maximum 45 publications in IR research and a total h-index was 15 while a total number of citations was 864 got the rank first. It was also observed that the maximum 2847 (67.18%) of the records were conference paper wise documents, followed by article type documents with 1162 (27.42%). Computer science subject published a maximum of 3370 publications while the minimum 3 records were published in the field of Veterinary. Anna University was the most productive University with 177 publications, however, Department of science technology, Ministry of science and technology was the most famous funding agency with 15 contributions. The maximum records were published in Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics i.e. 224 while the most common keyword is Information Retrieval records in 2963 publications during the period of study (2009-2018).

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