

Indian Scientist Research Productivity in Cloud Robotics: A Scientometric Analysis

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Abstract - This study analyses the Indian contributions of research papers related to Cloud Robotics was undertaken from Web of Science Databases has been used to retrieve the data for 15 years (1999-2013) by the searching the keyword "Cloud Robotics". Most of the researchers preferred to publish their research results in 586 journal articles. The authorship trend shows that, out of total 629 research literatures published, 97% of them or published under the joint author of publications in Cloud Robotics research output. This study aims to examine the emergence of research areas, research groups and countries and the pattern of publication, authorship, institutions, growth rate of publication and journals coverage of the scientists in the field of Cloud Robotics.

Keywords: Cloud Robotics, Scientometrics, Citation, India

I. INTRODUCTION

The published literature is taken as a yardstick to measure the knowledge in a discipline. The growth rate analysis of publication would yield some useful results regarding growth pattern of literature.¹ The growth of their scientific output depends upon their members, motivation and resources available to them in a particular society at a specific time or during certain period of time. Every day there is a huge proliferation of literature gushing out of the press continuously that poses grave problems to everybody to organize and preserve the published literature.² The scientometric studies play a vital role in the process of information research.

Scientometrics studies are gradually becoming interdisciplinary in nature and are used to identify the pattern of publication authorship and citation analysis with the hope that such regularities can give an insight into the dynamic of the area under consideration. Cloud robotics is a field of robotics that attempts to invoke *cloud* technologies such as cloud computing, cloud storage, and other Internet technologies centred on the benefits of converged infrastructure and shared services for robotics. The present study examines Cloud Robotics research in India using a search strategy comprising of specific keywords denoting different types of Cloud Robotics and covers a period of twenty one years from 1998-2018 to retrieve the data from Web of Science (WoS).³ This study aims to examine the emergence of research areas, research groups and countries with a view to map the cognitive or intellectual structure of research.⁴ Further, this study spells out the relationship between authors, institutions, journals and articles growth

rate, author productivity and other means of assisting the peer review procedure.

II. OBJECTIVES OF THE STUDY

1. To identify and analysis the pattern of distribution of Cloud Robotics research output in India.
2. To examine the year wise distribution of Publications
3. To examine the various sources of research publications in Cloud Robotics
4. To study the Institution wise distribution of Publications
5. To study the Ranking of Authors and citation based on Publications
6. To identify journal wise distribution of publications on Cloud Robotics research output in India
7. To assess the Institution wise research concentration on Cloud Robotics research output in India.
8. To identify Country – wise Collaborative Distribution of Publications;
9. To identify the word frequency research output in Cloud Robotics.

III. METHODOLOGY

The present study aims at analyzing the research output of Researchers in the field of Cloud Robotics. The growth rates of output in terms of research productivity are analyzed from 1998 to 2018. Further; the research has downloaded the bibliographical data in the form of notepad files. Then the bibliographical details are converted to using Histcite software.⁵ Overall data retrieved by the researcher are 629 records and the researcher chosen only 629 records for analyzing the present study.

A. Collection of Data

For this particular study, all the publications were retrieved from Web of Science database on Green chemistry, which covers a time span of 21 years starting from 1st January 1998 to 31st May 2018. The researcher has downloaded the bibliographical data in the form of notepad files. Overall data retrieved by the researcher are 629 records taken for analyzing the present study.

IV. ANALYSIS AND DISCUSSION

To analysis the year wise publication of research on Cloud Robotics, the data has been presented in Table-1. It could

clearly see that during the period 1998 - 2018 a total of 629 publications were published in India level. The highest publication is 142 in the year of 2017. The highest publication is 142 in 2017 with 145 Global Citation Scores followed by 103 papers in 2016 with 567 Global Citation Score and 78 papers in 2015 with 911 Global Citation Scores. The lowest publication is one in 1999 and 2000 with 8 Global Citation Scores and 804 Global Citation Scores.

TABLE I SHOWS YEAR WISE DISTRIBUTION OF CITATION SCORE

S. No.	Publication Year	Recs	Percent	TLCS	TGCS
1	1998	3	0.5	7	179
2	1999	1	0.2	0	8
3	2000	1	0.2	83	804
4	2001	-	-	-	-
5	2002	10	1.6	11	896
6	2003	4	0.6	2	167
7	2004	7	1.1	4	81
8	2005	17	2.7	94	2168
9	2006	10	1.6	8	346
10	2007	10	1.6	4	290
11	2008	11	1.7	13	528
12	2009	18	2.9	20	546
13	2010	18	2.9	10	659
14	2011	27	4.3	31	630
15	2012	35	5.6	76	894
16	2013	39	6.2	77	1004
17	2014	54	8.6	40	768
18	2015	78	12.4	85	911
19	2016	103	16.4	32	567
20	2017	142	22.6	15	145
21	2018	41	6.5	0	3
	Total	629	100	612	11594

B. Source Wise Distribution of Publications

The table II indicates the source wise distribution of research output in Cloud Robotics has observed a total of 629 publications during the period of twenty one years from 1998 to 2018. Out of various sources of publications in Cloud Robotics, journal articles that appeared in the journals have shown a predominant contribution (93.2%) with Global citation score is 10976 and this source occupies the first position. The source of Article: Proceeding Paper comes second in order (4.5 %) of sharing total research output in Cloud Robotics during the period of analysis. The source of Review comes in the third position (1.9%) with respect to total output in Cloud Robotics research during the study period.

TABLE II SHOWS SOURCE WISE DISTRIBUTION OF PUBLICATIONS

S. No.	Document Type	Records	%	TLCS	TGCS
1	Article	586	93.2	591	10976
2	Article; Proceedings	28	4.5	20	473
3	Review	12	1.9	1	139
4	Editorial Material	2	0.3	0	3
5	Article; Book Chapter	1	0.2	0	3
	Total	629			

C. Ranking of Authors Productivity based on Publications

TABLE III RANKING OF AUTHORS PRODUCTIVITY BASED ON PUBLICATIONS

S. No.	Author	Publications	%	TLCS	TGCS	TLCR
1	Holben BN	32	5.1	193	3974	44
2	Smirnov A	18	2.9	106	1377	38
3	Reid JS	13	2.1	33	382	37
4	Eck TF	12	1.9	171	2739	21
5	Dubovik O	11	1.7	89	1144	7
6	Hsu NC	11	1.7	41	478	35
7	Sayer AM	10	1.6	43	444	32
8	Wang Y	10	1.6	7	110	13
9	Kaufman YJ	9	1.4	90	2470	4
10	Torres O	9	1.4	14	209	20
11	Lee J	8	1.3	4	44	28
12	Redemann J	8	1.3	11	244	7
13	Wang J	8	1.3	1	105	10
14	Campbell JR	7	1.1	27	163	22
15	Holben B	7	1.1	7	99	16
16	Kim J	7	1.1	2	42	20
17	Remer LA	7	1.1	93	2192	6
18	Zhang JL	7	1.1	12	213	27
19	Ansmann A	6	1.0	8	165	9
20	Giles DM	6	1.0	27	220	11
21	Jeong MJ	6	1.0	38	401	14
22	Kahn RA	6	1.0	5	227	11
23	Li ZQ	6	1.0	0	36	8
24	Marshak A	6	1.0	5	107	4
25	Alam K	5	0.8	10	66	23
	Total	235	37.6	1037	17651	467

Table III indicates ranking of authors by number of publications. It is observed that the authors "Holben BN" published highest number of articles for the study period

with 32 publications, consecutive authors “Smirnov A” are published next highest number of articles for the study period with 18 records. “Eck TF” having highest Global Citation Scores of 2739 with just 12 publications followed by “Kaufman YJ” is having Global Citation Score of 2470 with just 9 publications, while Kim J having lowest Global Citation Score of 42 with just 7 publications.

D. Ranking of Journals and their Published Articles

The study found that the total research output of the Cloud Robotics for the study period (1998 – 2018) published in 272 journals. Table III indicates the major portion of the

research productivity (51.7%) covered by 25 journals that is coinciding with the theory of Bradford’s Law of scattering of journals in research productivity.

The journal “Journal of Geophysical Research-Atmospheres” topped with 61 publications with the Global Citation Score of 2185, next “Atmospheric Chemistry and Physics” has 44 publications with the Global Citation Score of 873 and “Robotics and Autonomous Systems” with 24 publications with the Global Citation Score of 364 respectively. “Journal of the Atmospheric Sciences” has scored the highest Global Citation Score of 1834 with 9 publications.

TABLE IV RANKING LIST OF JOURNALS AND THEIR PUBLISHED ARTICLES

S. No.	Journal	Recs	%	TLCS	TGCS	TLCR
1	Journal of Geophysical Research-Atmospheres	61	9.7	85	2185	102
2	Atmospheric Chemistry And Physics	44	7.0	51	873	67
3	Robotics And Autonomous Systems	24	3.8	23	364	13
4	Atmospheric Measurement Techniques	22	3.5	9	154	43
5	International Journal of Robotics Research	16	2.5	16	373	3
6	Atmospheric Environment	15	2.4	32	308	24
7	IEEE Transactions on Automation Science And Engineering	11	1.7	52	232	30
8	International Journal of Remote Sensing	11	1.7	5	139	15
9	Remote Sensing of Environment	10	1.6	87	940	10
10	Sensors	10	1.6	0	8	9
11	Geophysical Research Letters	9	1.4	0	772	7
12	Journal of The Atmospheric Sciences	9	1.4	101	1834	10
13	Remote Sensing	9	1.4	2	65	22
14	Advanced Robotics	8	1.3	0	32	1
15	International Journal of Advanced Robotic Systems	8	1.3	0	13	11
16	Computers & Electrical Engineering	7	1.1	0	2	8
17	IEEE Robotics and Automation Letters	7	1.1	0	14	2
18	Automation in Construction	6	1.0	3	150	2
19	IEEE Access	6	1.0	8	25	21
20	IEEE Transactions On Geosciences and Remote Sensing	6	1.0	5	69	6
21	Journal of Field Robotics	6	1.0	1	55	7
22	Aerosol and Air Quality Research	5	0.8	5	42	15
23	Atmospheric Research	5	0.8	6	57	6
24	Autonomous Robots	5	0.8	2	68	10
25	Industrial Robot-An International Journal	5	0.8	2	13	1
Total		325	51.7	495	8787	445

E. Institution Wise Distribution of Publications

The table V analysis indicates Institution-wise research productivity. It is noted that top twenty five institutions were contributed 388 of the total research productivity. It is

noted that NASA contributed the highest number of research publications in 93 at the same time it ranks first in terms of Global Citation Score 5726. Scientific System & Application Incorporation terms Second in order 33 publication of the total Global Citation score in 1937.

TABLE V INSTITUTION WISE DISTRIBUTION OF PUBLICATIONS

S. No.	Institution	Recs	(%)	TLCS	TGCS
1	NASA	93	14.8	304	5726
2	Scientific System & Application Incorporation	33	5.2	159	1937
3	Chinese Acad Science	31	4.9	13	304
4	University Maryland	24	3.8	14	689
5	University Space Res Assoc	17	2.7	60	630
6	CALTECH	15	2.4	13	357
7	NOAA	15	2.4	41	482
8	University Maryland Baltimore City	14	2.2	16	455
9	Naval Res Lab	13	2.1	20	219
10	Sigma Space Corp	13	2.1	18	311
11	Columbia University	9	1.4	4	133
12	University Sao Paulo	9	1.4	2	261
13	University Tokyo	9	1.4	4	66
14	CNR	8	1.3	9	152
15	Georgia Inst Technology	8	1.3	1	301
16	MIT	8	1.3	1	230
17	Tech University Munich	8	1.3	17	244
18	Tsinghua University	8	1.3	2	29
19	University Bremen	8	1.3	8	142
20	University Oxford	8	1.3	8	155
21	University Washington	8	1.3	12	243
22	Yonsei University	8	1.3	2	72
23	Colorado State University	7	1.1	2	139
24	Harvard Smithsonian Ctr Astrophysics	7	1.1	1	53
25	Indian Inst Technology	7	1.1	9	228
Total		388	61.8	740	13558

F. Country – Wise Collaborative Distribution of Publications

The study of Country wise distribution of a number of research output is an important factor in highlighting the research and development in any discipline of science.

The below given table VI indicates that among the country wise collaborative distribution of Cloud Robotics covered by the study top in USA contributed publications with 235(37.4%) publications followed by Peoples R China with 98(15.6%), Germany with 58(9.2%) and India ranked 12th position in the world with 21 Publication and received 277 Citations respectively.

First place goes to India Collaborative with to USA having total Global Citation Score of 8071 with 253 publications. France secured second rank in terms of GCS with 2867 but with only 45 publications and also collaboration with more than 60 Countries.

TABLE VI COUNTRY-WISE COLLABORATIVE DISTRIBUTION OF PUBLICATIONS

S. No.	Country	Recs	%	TLCS	TGCS
1	USA	235	37.4	392	8071
2	Peoples R China	98	15.6	35	597
3	Germany	58	9.2	41	1245
4	UK	54	8.6	26	908
5	Spain	47	7.5	22	731
6	France	45	7.2	98	2867
7	Italy	45	7.2	21	308
8	Japan	29	4.6	34	265
9	Australia	27	4.3	5	227
10	Canada	27	4.3	6	243
11	South Korea	27	4.3	42	472
12	India	21	3.3	16	277
13	Brazil	20	3.2	4	396
14	Sweden	20	3.2	19	237

15	Switzerland	15	2.4	21	240
16	Greece	14	2.2	7	157
17	Portugal	14	2.2	4	75
18	Poland	13	2.1	3	45
19	Taiwan	12	1.9	1	114
20	Netherlands	10	1.6	4	218
21	Israel	9	1.4	5	216
22	Finland	8	1.3	5	118
23	Singapore	8	1.3	50	238
24	Unknown	8	1.3	3	86
25	Cyprus	7	1.1	6	65
Total		871	138.7	870	18416

G. Direction of Research Trends: Keyword

TABLE VII KEY WORD APPEARED IN THE PUBLICATIONS

S. No.	Word	Records	%	TLCS	TGCS
1	Aerosol	167	26.6	263	5585
2	Cloud	112	17.8	250	2307
3	Based	105	16.7	67	1091
4	Optical	102	16.2	90	2330
5	Using	94	14.9	35	698
6	Robotic	68	10.8	26	770
7	Data	57	9.1	71	937
8	Depth	53	8.4	56	1530
9	Point	44	7.0	30	570
10	Robotics	43	6.8	102	527
11	Modis	40	6.4	124	2969
12	Aeronet	39	6.2	131	1868
13	Dust	39	6.2	24	895
14	Robot	35	5.6	4	130
15	Satellite	35	5.6	21	724
16	System	35	5.6	6	280
17	Ground	34	5.4	19	506
18	Observations	34	5.4	31	944
19	Properties	34	5.4	18	449
20	Retrieval	34	5.4	49	957
21	Analysis	31	4.9	18	518
22	Measurements	31	4.9	16	373
23	Algorithm	29	4.6	108	2022
24	Clouds	28	4.5	21	510
25	Model	27	4.3	7	403
Total		1350	214.7	1587	29893

A keywords analysis was undertaken to gain an insight into direction of research trends and frontier areas as to in which type of Cloud Robotics the Indian scientists were putting

their efforts. The keywords analysis search was made in the web of science separately with all the keywords used in the search strategy. The most commonly occurring keywords that appeared in the research articles presented in table-7 which depicts only those keywords which yielded five or more than five total publications. The high frequency keywords were “AEROSOL” is topped with 167 publications with the Global Citation Score of 5585, next “CLOUD” with 112 publications with the Global Citation Score of 2307 respectively. “MODIS” has scored the highest Global Citation Score of 2969 with 40 publications.

V. MAJOR FINDINGS

Based on the analysis undertaken the present study, the following findings are drawn.

1. The findings of Indian research productivity in Cloud Robotics has the highest publication is 142 in the year of 2017. The highest publication is 142 in 2017 with 145 Global Citation Scores followed by 103 papers in 2016 with 567 Global Citation Score and 78 papers in 2015 with 911 Global Citation Scores. The lowest publication is one in 1999 and 2000 with 8 Global Citation Scores and 804 Global Citation Scores. But the lowest publication is 1 in 2000 with highest Global Citation Scores (804).
2. The findings of authorship pattern of Indian research productivity on Cloud Robotics has identified that majority of papers are multi-authored.
3. The findings of research output of the Cloud Robotics for the study period (1998 – 2018) published in 272 journals. As the major portion of the research productivity (51.7%) covered by 25 journals that is coincide with the theory of Bradford’s Law of scattering of journals in research productivity.
4. Top 15 institutions were contributed 318(45%) articles of the total research productivity.
5. The findings of distribution of Indian Cloud Robotics scientists published articles in the journals of various countries.. The countries such as USA, United Kingdom and Australia have considerably recognized the research articles of Indian Cloud Robotics scientists and published the same in their journals. It is not up to the mark in the case of other countries.

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