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Research trend on Robotics during 2009-2018: Ascimentometric analysis based on Scopus database

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Abstract

The present study aims to analysis the research productivity trend on the title “Robotics” research publications worldwide during 2009-2018 on the base of the Scopus database. A total of 97480 articles has been published on the title “Robotics” in the worldwide during 2008-2018. The highest 11950 (12.26%) articles were published in the year 2018 and the publication pattern was gradually in increasing order during the period of study. The maximum AGR 15.36 was calculated in the year 2010, the RGR has been counted 0.77 to 0.13 during the period of study. The relative growth rate was always in decreasing order and respective doubling was always in the increasing order during the period of study. Conference type of document was in the leading position with 53506 articles, Computer Science was the leading subject with 53675 articles and robotics 61157 was the highest using keyword during the period of study. Chinese Academy of Sciences with 1577 articles was the highest contributed affiliation, the United States with 36159 was the leading country of publications and Caldwell, D. G. with 216 articles was the most productive author during the period of study.

Keywords: Scientometrics, Robotics, Annual Growth Rate, Compound Annual Growth Rate, Relative Growth Rate and Doubling time.

Introduction

Robotics is the branch of science and engineering and its treaties as the design, construction, operation, and use of robots. The science of robots by which humans working in this area are called robotics. Robotics is the science and technology of robots, their design, manufacture, and application. Robotics requires a working knowledge of electronics, mechanics, and software, and is usually accompanied by a large working knowledge of many subjects. Robotics is the study of robots, robots are machines that can be used to do jobs. Some robots can do work by themselves and other robots must always have a person telling them what to do.

“Although the science of robotics only came into existence about in the 20th century, the history of human-invented automation has a much longer past. In fact, the ancient Greek engineer Hero of Alexandria, formed two texts, Pneumatic, and Automata that testify to the existence of hundreds of different kinds of “wonder” machines capable of automated movement. Of course, robotics in the 20th and 21st centuries has advanced radically to include machines capable of assembling other machines and even robots that can be mistaken for human beings.

The word *robotics* was accidentally coined by science fiction author Isaac Asimov in his 1941 story “Liar!” Science fiction authors throughout history have been interested in man’s capability of constructing self-motivating machines and life forms, from the ancient Greek myth of Pygmalion to Mary Shelley’s Dr. Frankenstein and Arthur C. Clarke’s HAL 9000. Basically, a robot is a re-programmable machine that is capable of movement in the completion of a task.”

Literature review

Sab et al. (2018) have analysed the publishing trends of Indian Chemical Science research during 2002-2016 with the help of Web of Science database which shown that the publication share of India was 5.46% during study which was increased from 3.94 to 6.99 and it was observed from the study that the percentage of India's articles compared to that of the world's articles. The study shows that the average growth of 5.30% per year during the study period. It was observed that the international collaboration trend consistently increasing and the USA was the highest collaborative country during the period of study. Computer Science was the broadest subject among all the subjects contributed the largest publication share of 67.69% articles during the study period. The maximum share of articles was with journal articles with 45213 articles and a total of 503 articles were registered as a highly cited paper with 100 to 100⁺ citation per articles during the period of study.

Gupta et al. (2017) have examined the publishing trends of world mobile research based on Scopus database during 2007-2016. A total of 140375 globally articles were founded for the study with an annual average growth rate of 1.68%. China was the largest globally contributing country with 20.52% articles and top 20 most productive countries published 95.05% articles globally during the period of study.

Dhawan et al. (2016) conducted a scientometric study on research in the electronic publishing field during 2005-2014. The major findings of the study was a total 7010 articles published and it was found that the e-publishing is still growing at a slow pace with 3.14% compound annual growth rate and averaged 1.08 citation per articles. The top 15 most productive organizations publication share was 5.72% and citation share is 12.73% during 2005-2014. The average productivity rate per organization during the study was low 26.7, citation impact per pater was 2.41, h-index was 6.93 and international collaborative share was 23.44% during the period of study.

Santhakumar and Kalitaperumal (2014) directed a scientometric study on mobile technology publications and focus on the growth and development of mobile technology in terms of publication output available on engineering index database during 2003-2012. They found that a total of 144567 publications were published during the period of study. The average 14456.7 articles published per year and the highest number of publications 20318 were published in the year 2011. China's authors have contributed a maximum number of publications compared to the other countries during the study period. The most creative author was Wang. Wei who contributed 223 articles during the study. Institute of Electrical and Electronic Engineering (IEEE) New York (USA) was the highly donated institution with 1248 publications. The relative growth rate (RGR) has reduced from 2004(0.98) to 2012(0.13) and doubling time (Dt) has gradually enlarged from 2004(0.71) to 2012(5.15) throughout the study.

Kumar (2014) analyze a scientometric study on digital literacy in online library information science and technology abstracts (LISTA) during 1997-2011. A total of 137 articles were published during the study period. 53.28% of articles focus significantly on digital literacy. Academic journal and periodicals 69.34% primarily publish articles on digital literacy in the field of library and information science. Triple authorship pattern 35.04% was dominating, 35-40 age group authors publish a high number of 39.42% articles. U.K. (27.01%) and U.S.A. (24.82%) were generated more numbers of articles. International journal of information and library review 8.03% have published a maximum number of articles.

Objectives of the study

The objectives of the study are to:

1. Analysis year wise distribution of publications.

2. Examine the annual growth rate and compound annual growth rate of publications.
3. Calculate the relative growth rate and doubling time for articles.
4. Find out the most productive authors and organizations top 10 in the study.
5. Identify major keywords and country top 10 during the study period.

Methodology

The present study is based on the research output published on the topic Robotics. The raw data has been collected by an international online bibliographic database of peer-reviewed scientific literature named Scopus (<http://www.scopus.com>) during 2009-2018 owned by Elsevier. The search string for collection of raw data is (TITLE-ABS-KEY("Robotics") AND (LIMIT-TO(PUBYEAR,2018) TO (PUBYEAR,2009)) AND (LIMIT-TO(AFFILCOUNTRY,"United States") TO (AFFILCOUNTRY,"Spain")) AND (LIMIT-TO(LANGUAGE,"English))). A total of 97480 records were counted on the Scopus database. The obtained data were analyzed and tabulated in an MS-excel sheet and tested by the various scientometric tools to fulfill the objectives of the study.

Data analysis

Year wise distribution of the publication

Table 1 provides year-wise distribution of publications and it resolves that a total of 97480 articles were published with an average of 9748 articles per year during 2009-2018. Observation of the table it found that the highest 11950 (12.26%) articles were published in the year 2018, followed by the year 2017 with 11660 (11.96%) articles and the lowest 6980 (7.16%) articles were published in the year 2009 during the study period. It also shows that the publication trend on the title Robotics was always in increasing order, only two years i.e. 2010 and 2012 years publications were in decreasing order.

Table 1: Year-wise distribution of publications

Year	No. of Publication	Percentage
2009	6980	7.16
2010	8052	8.26
2011	9278	9.52
2012	8629	8.85
2013	10040	10.30
2014	9683	9.93
2015	10323	10.59
2016	10885	11.17
2017	11660	11.96
2018	11950	12.26
Total	97480	100.00

Annual Growth Rate (AGR) of publication

Table 2 describes the annual growth rate of robotics research for the time frame of 2009-2018. On the basis of the particular table, it was counted that the maximum annual growth rate was 16.35 in the year 2013, followed by 15.36 in the year 2010, while the minimum AGR was counted -7.00 in the year 2012. The average annual growth rate was counted 5.80 per year during the period of study. The annual growth rate (AGR) is calculated by the formula given by Kumar and Kaliyaperumal(2015) it mentions below:

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

Table 2: Annual growth rate of publications

Year	No. of Publication	AGR
2009	6980	0
2010	8052	15.36
2011	9278	15.23
2012	8629	-7.00
2013	10040	16.35
2014	9683	-3.56
2015	10323	6.61
2016	10885	5.44
2017	11660	7.12
2018	11950	2.49

Compound Annual Growth Rate (CAGR) of publication

Table 3 arrange fora compound annual growth rate of publications of the robotics research output during 2009-2018. It was seen that the highest 0.074(7.405%) compound annual growth rate of publication in the year 2010, followed by 0.048 (4.838%) CAGR in the year 2011 and the minimum -0.018 (-1.787%) compound annual growth rate was calculated in 2012 during the period of study.

The compound annual growth rate was calculated by the following formula available on the website (<https://www.investopedia.com/terms/c/cagr.asp>)

$$CAGR = [(EndingValue / BeginningValue)^{1/n} - 1]$$

Table 3:Compound annual growth rate of publications

Year	No. of Publication	CAGR	CAGR Percent
2009	6980	0	0
2010	8052	0.074	7.405
2011	9278	0.048	4.838
2012	8629	-0.018	-1.797
2013	10040	0.031	3.075
2014	9683	-0.006	-0.602
2015	10323	0.009	0.919
2016	10885	0.007	0.665
2017	11660	0.008	0.767
2018	11950	0.002	0.246

Relative growth rate and doubling time of publication

Table 4 explains the relative growth rate and doubling time of Robotics publications during 2009-2018. On the observation of current table, it found that the maximum RGR 0.77 has been recorded in the year 2009 and minimum RGR 0.13 has been counted in the year 2018, while the maximum

doubling time 5.30 has been counted in the year 2018 and the minimum doubling time 0.90 has been counted in the year 2009. Which shows that the RGR was always in decreasing order from 2010 (0.77) to 2018 (0.13) while the respective doubling was always in increasing order from 2010 (0.90) to 2018 (5.30) during the period of study. The relative growth rate and doubling time of publications has been measured on the basis of RGR and Dt model, the particular modelis developed by Mahapatra in 1985.

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

The formula of corresponding Dt for contributions and pages measurement.

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

Table 4: Relative growth rate and doubling time of publications

Year	No. of publication	Cumulative sum	W1	W2	RGR	Dt
2009	6980	6980	0	8.85	0	0
2010	8052	15032	8.85	9.62	0.77	0.90
2011	9278	24310	9.62	10.10	0.48	1.44
2012	8629	32939	10.10	10.40	0.30	2.28
2013	10040	42979	10.40	10.67	0.27	2.60
2014	9683	52662	10.67	10.87	0.20	3.41
2015	10323	62985	10.87	11.05	0.18	3.87
2016	10885	73870	11.05	11.21	0.16	4.35
2017	11660	85530	11.21	11.36	0.15	4.73
2018	11950	97480	11.36	11.49	0.13	5.30

Document-wise distribution of publications

Table 5 demonstrated the document wise distribution of publication for the study of robotics publications and it found that the conference papers were dominating over all the available documents with 53506 (54.89%) records counted, followed by articles 33816 (34.69%) and the minimum records were counted with business articles with only one record during the period of study.

Table 5: Document wise distribution of publications

Document type	No. of articles	Percent
Conference Paper	53506	54.89
Article	33816	34.69
Review	3557	3.65
Book Chapter	2537	2.60
Editorial	983	1.01
Note	893	0.92
Article in Press	773	0.79
Letter	655	0.67
Book	404	0.41
Short Survey	292	0.30
Erratum	61	0.06
Retracted	2	0.00
Business Article	1	0.00
Total	97480	100.00

Subject wise (top 10) distribution of publications

Table 6 express about the top 10 subjects wise distribution of publication during the period of study. On the observation of the table, it found that the maximum 53675 (55.06%) articles have been founded on Computer Science subject, followed by Biochemistry, Genetics and Molecular Biology subjects with 6329 (6.49%) articles and the subject with 10th rank minimum 81 (0.08%) articles was founded on Dentistry. It shows that there was a gap and more than 50% of articles contributed in only one subject i.e. Computer Science during the study period.

Table 6: Subject wise (top 10) distribution of publications

Subject area	No. of articles	Percent
Computer Science	53675	55.06
Biochemistry, Genetics and Molecular Biology	6329	6.49
Earth and Planetary Sciences	2937	3.01
Chemistry	1444	1.48
Chemical Engineering	1426	1.46
Agricultural and Biological Sciences	1269	1.30
Decision Sciences	703	0.72
Arts and Humanities	567	0.58
Business, Management, and Accounting	411	0.42
Dentistry	81	0.08

Top 10 most productive author

Table 7 provides the top ten productive authors during the study period. Among these authors, it can be seen that the author Caldwell, D. G. secure first position contributed 216 articles, while the author Dario, P. secure second position contributed 191 articles. The author Rha, K. H. with 10th rank contributed 141 articles during the study period.

Table 7: Most productive author (top 10)

Author name	Publication
Caldwell, D.G.	216
Dario, P.	191
Kaouk, J.H.	175
Dasgupta, P.	165
Guo, S.	161
Yang, G.Z.	156
Takanishi, A.	155
Kumar, V.	154
Rus, D.	143
Rha, K.H.	141

Major keywords (top 10)

Table 8 depicts the top 10 major keywords which were used in robotics research publications. The maximum 61157 times robotics keyword was used, followed by a robot keyword with 19044 times

and the minimum 5843 times procedures keyword was used and secure 10th rank during the study period.

Table 8: Major keywords (top 10)

Keyword	No. of articles
Robotics	61157
Robots	19044
Human	17978
Humans	14908
Article	13221
Priority Journal	9836
Male	8633
Female	7790
Adult	7206
Procedures	5843

Profile of the top 10 most productive organization

Table 9 shows the profile of the top 10 most productive organization which was contributed to research publications during the period of study. The maximum 1577 articles were contributed by the Chinese Academy of Sciences, followed by 1257 articles contributed by Massachusetts Institute of Technology and 1250 articles were contributed by CNRS Centre National de la Recherche Scientifique and with 10th position Shanghai Jiao Tong University 853 articles contributed during the study.

Table 9: Most productive organization (top 10)

Organization	No. of articles
Chinese Academy of Sciences	1577
Massachusetts Institute of Technology	1257
CNRS Centre National de la Recherche Scientifique	1250
Carnegie Mellon University	1249
Harbin Institute of Technology	1089
Istituto Italiano di Tecnologia	1077
Technical University of Munich	1067
Georgia Institute of Technology	1045
University of Tokyo	914
Shanghai Jiao Tong University	853

Top 10 most productive country

Table 10 delivers about top 10 most productive country in the world during the period of study. From the table it shows that the United States was secured 1st rank with 36159 articles and it is dominating over all the country which are contributed articles during the study, then China was the 2nd rank holder of the study with 16713 articles and Spain was the 10th rank holder with 4353 articles during 10 years period 2009-2018.

Table 10: Most productive country (top 10)

Country	No. of articles
United States	36159
China	16713
Germany	10069
Japan	9973
Italy	8057
United Kingdom	7918
South Korea	6382
France	5663
Canada	5214
Spain	4353

Conclusion

Scientometrics is a distinctive set of systems using for different purposes such as determination of diverse scientific indicators, analyzing scientific output, monitoring and evaluating of information resources, etc. A total of 97480 articles were published on “Robotics” title in the world during 2009-2018. The highest 11950 (12.26%) articles were published in the year 2018, and the lowest 6980 (7.16%) articles were published in the year 2009 during the study and the publication pattern was in gradually in increasing order during study but in the years 2012 and 2014 publication of articles was decreasing with 8629 and 9683 respectively. The maximum AGR 15.36 was calculated in the year 2010 and the lowest AGR -7.00 was calculated in the year 2012. The highest RGR has been counted 0.77 and the lowest RGR 0.13 has been calculated during the period of study. The relative growth rate was always in decreasing order and respective doubling was always in the increasing order during the period of study. Conference type of document was in the leading position with 53506 articles, Computer Science was the leading subject with 53675 articles and robotics 61157 was the highest using keyword during the period of study. Chinese Academy of Sciences with 1577 articles was the highest contributed affiliation, the United States with 36159 was the leading country of publications and Caldwell, D. G. with 216 articles was the most productive author during the period of study.

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