Mapping of Artificial Intelligence Publications: A Scientometric Study

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Abstract

The scientometric study attempts to highlight the Artificial Intelligence research in globally as per the number of publications that appeared in Web of Science database during the period 2012-2021. A total of 32526 publications were published on artificial intelligence and the average number of publications per year was 3252.6. The highest number of publications (12206) was published in the year 2021 and the lowest (604) in 2012. The exponential growth of publications was observed during the period. It is found that 21,861 different institutions were in the publication of articles. Chinese Academy of Science, China contributed the highest number of 571 articles. India 4th ranks among the countries publishing artificial intelligence publications. Engineering contributed the largest share (27.42%) among subjects, followed by Computer Science (20.76%) and Automation Control Systems 10.29%.

Keywords: Artificial intelligence, annual growth rate, relative growth rate and doubling time

1 Introduction

Artificial intelligence is the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions. Specific applications of Artificial intelligence include expert systems, natural language processing, speech recognition and machine vision. Researchers and developers in the field are making surprisingly rapid strides in mimicking activities such as learning, reasoning, and perception, to the extent that these can be concretely defined. Artificial intelligence applications are endless, and this technology can be applied to many different sectors and industries. Artificial intelligence is

used in the healthcare industry for dosing drugs and different treatment in patients, and for surgical procedures in the operating room.

Artificial intelligence has applications in the financial industry, where it is used to detect and flag activity in banking and finance such as unusual debit card usage and large account deposits all of which help a bank's fraud department. The technology is currently deployed in numerous sectors, including transportation, manufacturing, finance, health care, education, and urban planning. This is clear from the scientometric evidence from 2012 to 2021, that the number of publications in the Web of Science database was increased from 604 to 12206. Therefore, the present study has been undertaken to know the growth and development of publications in the field of Artificial intelligence.

2 Review of Literature

Yuh-Shan Ho & Ming-Huang Wang analyzed the characteristics of artificial intelligence-related publications in Science Citation Index Expanded from 1991 to 2018. The analyzed aspects covered distribution of annual publications, citations per publication, journals, Web of Science categories, countries, institutions, as well as research foci and their trends. A total of 13,251 artificial intelligence-related articles were found. Sumit Kumar Banshal, Ashraf Uddin, Khushboo Singhal and Vivek Kumar Singh studied the Scientometric analysis of research output on computer science in India for 15 years. They collected data for research from the database of WoS and performed analysis on computers and obtained important indicators such as total output of research paper, citation report, collaboration pattern, area of research concentration. The analytical results presented a detailed and useful picture of competence and status of computer science and technology research in India. Santhakumar and Kaliyaperumal analysed the growth and development of mobile technology research publication output as reflected in Web of Science database during 2000–2013, and a total of 10,638 publications were published in the field. The average number of publications published per year was 759.86 and the highest number of publications 1495 were published in 2013. Output of total publications, 9037 were produced by multiple authors and 1601 by single authors. Authors from USA have contributed maximum number of publications compared to the other countries and India stood 16th ranking in terms of productivity in this study period.

Vinay Kumar, Santhosh Kumar and Biradar analysed the research output in Quantum Computing and the data for this study was downloaded from Web of Science (WoS) database for the period 2011-2017. A total of 10,551 records were yielded for the period of seven years. The growth of literature, the degree of collaboration, prolific authors and journal distribution, were discussed. The average degree of collaboration was 0.875. Gupta and Bansal examined the green computing global research output on a series of quantitative and qualitative indicators, deriving publication data from Scopus database. The global output on green computing consisted of 7335 publications during 10 years from 2009 to 2018, registering fastest 108.06% growth and low citation impact of 4.10 citations per paper. The paper presented a profile of top 10 most productive countries, 15 most productive organizations and 15 most productive authors on a series of indicators, including publications output, citations, citation impact, h-index, international collaborative papers and relative citation index, top 15 most productive journals in green computing research.

3. Objectives for the Study

The main objectives of the present study are:

- Forms of publications
- Year wise growth of publications
- Most prolific authors
- Highly productive countries
- Highly productive institutes
- Language-wise distribution of publications
- Most preferred source titles for publication and
- High productive subject areas

4 Materials and Methods

The Web of Science database was used for retrieving data on Artificial intelligence in topic field. A total of 32526 publications were downloaded and analysed by using the Microsoft excels per the objectives of the study. The Web of Science database allows us to refine the results in terms of publication years, countries, institutes, authors, language, subjects, and source titles.

5 Data analysis and interpretations

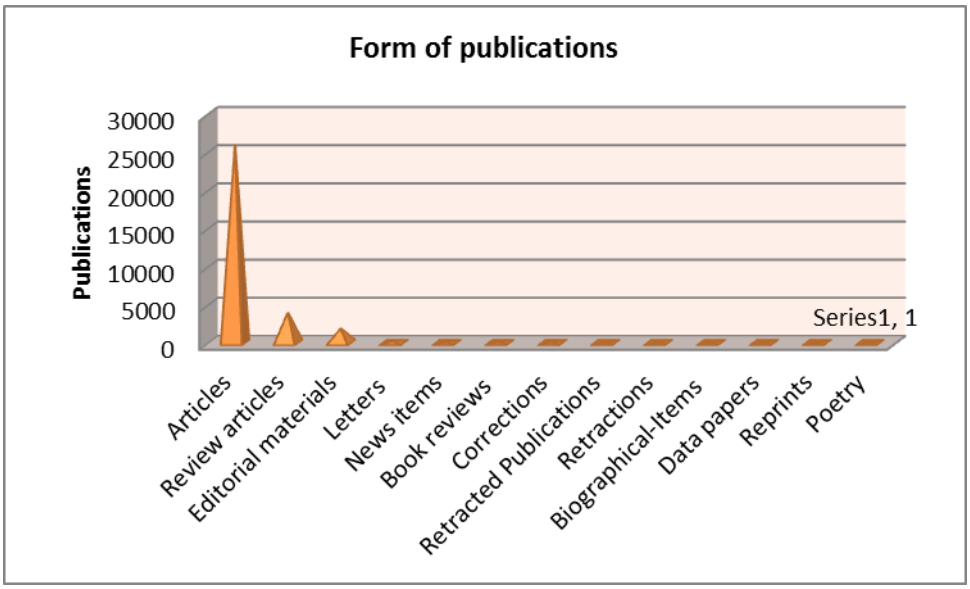
5.1 Form of publications

Table 1 - Form of Publications

S. No.	Title	Articles	Percentage
1	Articles	26037	80.05
2	Review articles	4005	12.31
3	Editorial materials	1907	5.86
4	Letters	245	0.75
5	News items	99	0.30
6	Book reviews	97	0.30
7	Corrections	80	0.25
8	Retracted Publications	23	0.07
9	Retractions	19	0.06
10	Biographical-Items	6	0.02
11	Data papers	5	0.02
12	Reprints	2	0.01
13	Poetry	1	0.00
Total		**32526**	**100.00**

Artificial intelligence literature has been published in different forms of publications in the world. Out of the 32526 published papers, 26037 (80.05%) were Journal articles followed by Review articles with 4005 (12.31%), Editorial materials with 1907 (5.86%), and the remaining forms are less than 1% of the publications. It could be noted from the study that artificial intelligence literature researchers have contributed more in the form of journal articles.

Figure 1 Form of Publications



5.2 Relative Growth Rate (RGR) and Doubling Time

The Relative Growth Rate (RGR) is the increase in number of articles or pages per unit of time. This definition derived from the definition of relative growth rates in the study of growth analysis in the field of air pollution. The mean relative growth rate (R) over the specific period of interval can be calculated from the following equation.

Relative Growth Rate (RGR)

$1 - 2R = \text{Log } W_2 - \text{Log } W_1 / T_2 - T_1$

Whereas

1-2 R- mean relative growth rate over the specific period of interval

$\text{Log}_e W_1$ - log of initial number of articles

$\text{Log}_e W_2$ - log of final number of articles after a specific period of interval

T_2-T_1- the unit difference between the initial time and the final time

The year can be taken here as the unit of time.

Doubling Time (DT) = 0.693/R

Table 3 Relative growth rate (RGR) and Doubling time (DT) of publications

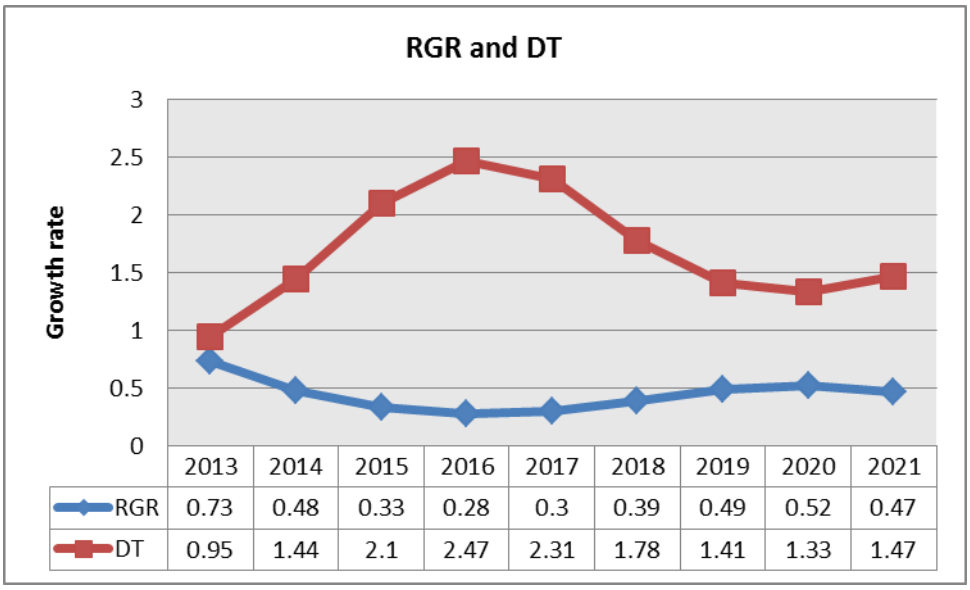
Year	No. of Publications	Cumulative	Percentage	W1	W2	RGR	DT

		Total					
2012	604	604	1.86	-	6.40	-	-
2013	649	1253	1.99	6.40	7.13	0.73	0.95
2014	763	2016	2.35	7.13	7.61	0.48	1.44
2015	782	2798	2.40	7.61	7.94	0.33	2.10
2016	921	3719	2.83	7.94	8.22	0.28	2.47
2017	1315	5034	4.04	8.22	8.52	0.30	2.31
2018	2391	7425	7.35	8.52	8.91	0.39	1.78
2019	4638	12063	14.26	8.91	9.40	0.49	1.41
2020	8257	20320	25.39	9.40	9.92	0.52	1.33
2021	12206	32526	37.53	9.92	10.39	0.47	1.47

A total of 32526 publications were published during 2012-2021. The average number of publications per year was 3252.6. There were only 604 publications in 2012 and a continuous growth of publications was observed during the study period. The highest publications (12206) were in 2021. It was observed that there was a steady growth of publications during 2012-2021.

The year wise RGR is found to be in the range of 0.73 to 0.28. It has been observed from Table 2 and figure 2 that RGR is downward trend from 2013 (0.73) to 2016 (0.28) and increased from 2017 (0.30) to 2020 (0.52). The doubling time (DT) was upward trend from 2013 (0.95) to 2016 (2.47) and decreased from 2017 (2.31) to 2020 (1.33).

Figure 2 Relative growth rate for research output



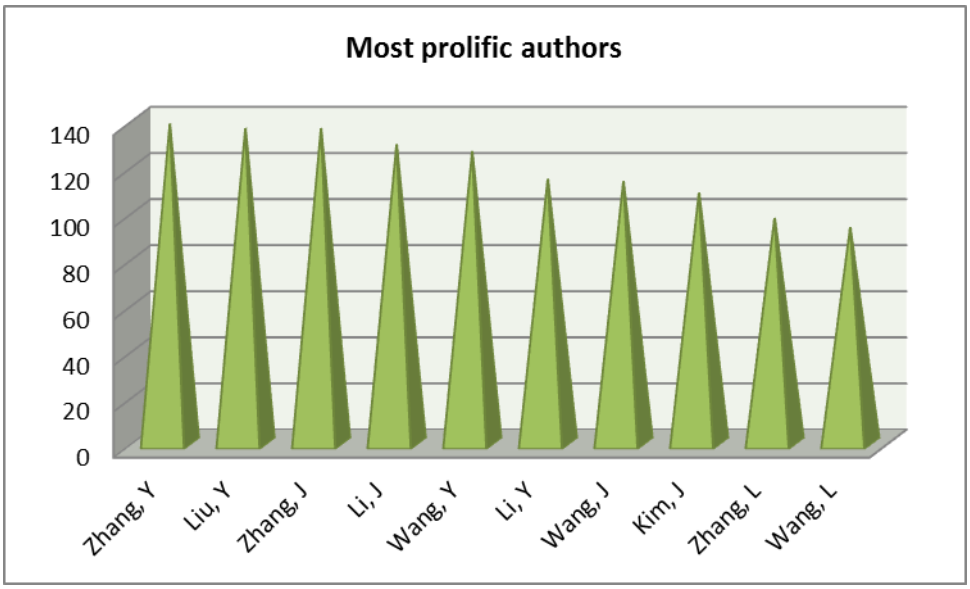
5.3 Identification of most prolific authors

Table 3 Identification of most prolific authors

S. No.	Author	No. of publications	Percentage
1	Zhang, Y	139	0.43
2	Liu, Y	137	0.42
3	Zhang, J	137	0.42
4	Li, J	130	0.40
5	Wang, Y	127	0.39
6	Li, Y	115	0.35
7	Wang, J	114	0.35
8	Kim, J	109	0.34
8	Zhang, L	98	0.30
10	Wang, L	94	0.29

The authors having 90 or more publications during 2012-2021 are given in Table 3. Zhang, Y is the most productive author with 139 (0.43%) publications followed by Liu, Y with 137 (0.42%) publications, Zhang, J with 137 (0.42%) publications, Li, J with 130 (0.40%) publications, Wang, Y with 127 (0.39%) publications, Li, Y with 115 (0.35%) publications, Wang, J with 114 (0.58%) publications and Kim, J with 109 (0.34%) publications respectively. And a total of 94,670 authors are contributed entire research output of the period under study.

Figure 3 Most prolific authors



5.4 Highly productive institutes

Table 4 Highly productive institutes

S. No.	Institutions	Country	No. of Publications
1	Chinese Academy of Science	China	571 (1.76%)
2	Harvard Medical School	USA	350 (1.08%)
3	Stanford University	USA	349 (1.07%)
4	Islamic Azad University	Iran	331 (1.02%)
5	Duy Tan University	Vietnam	296 (0.91%)
6	Tsinghua University	China	290 (0.89%)
7	University of Chinese Academy of Science	China	258 (0.79%)
8	University of Oxford	USA	251 (0.77%)
9	Huazhong University of Science and Technology	China	248 (0.76%)
10	Massachusetts Institute of Technology	USA	246 (0.76%)

Table 4 presents the top 10 institutes that have contributed 240 or more publications on artificial intelligence during 2012-2021. A total of 21,861 institutions are contributed entire research output of the study. Among these top 10 institutions each 4 are from China and USA and each one from Iran and Vietnam. Chinese Academy of Science, China topped the list with 571 (1.76%) publications followed by Harvard Medical School, USA with 350 (1.08%) publications, Stanford University, USA with 349 (1.07%) publications, Islamic Azad University, Iran with 331 (1.02%) publications and Duy Tan University, Vietnam with 296 (0.91%) publications respectively.

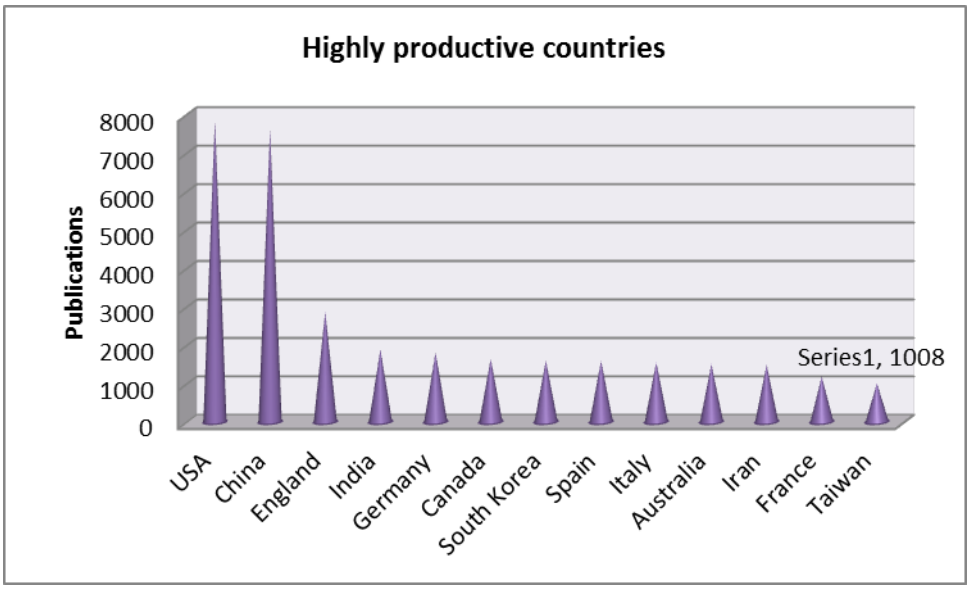
5.5 Highly productive countries

Table 5 Highly productive countries

S. No.	Country	Total Publications	Percentage
1	USA	7853	24.14
2	China	7625	23.44
3	England	2871	8.83
4	India	1887	5.80
5	Germany	1809	5.56
6	Canada	1637	5.03
7	South Korea	1599	4.92
8	Spain	1597	4.91
9	Italy	1562	4.80
10	Australia	1507	4.63
11	Iran	1488	4.57
12	France	1179	3.62
13	Taiwan	1008	3.10

In all, there were 155 countries involved in the research in artificial intelligence field and which published at least one publication. The publications share of highly productive countries (≥1000 publications) in artificial intelligence varies from 3.10% to 24.14% as seen in the table 5 and figure 4. USA topped the list with highest share 7853 (24.14%) of publications. China ranked second with 7625 (23.44%) share of publications followed by England 2871 (8.83%) share of publications, India with 1887 (5.80%) share of publications, Germany with 1809 (5.56%) share of publications, Canada with 1637 (5.03%) share of publications and South Korea with 1599 (4.92%) share of publications respectively. However, USA and China together accounts for 47% of world artificial intelligence research publications. India 4th ranks among the countries publishing artificial intelligence publications.

Figure 4 Highly productive countries



5.6 Language-wise distributions

Table 6 Language-wise distribution of publications

S. No.	Language	No. of Publications
1	English	32127 (98.77%)
2	German	198 (0.61%)
3	French	57 (0.17%)
4	Spanish	38 (0.12%)
5	Chinese	33 (0.10%)
6	Russian	30 (0.09%)
7	Italian	11 (0.03%)
8	Japanese	9 (0.03%)
9	Czech	8 (0.02%)
10	Polish	6 (0.01%)
11	Portuguese	5 (0.01%)
12	Slovak	2 (0.01%)
13	Croatian	1 (0.00%)
14	Dutch	1 (0.00%)

Publications on artificial intelligence are spread over 14 languages. The study reveals that the maximum number of publications have been published in English language with 32127 (98.77%) publications, followed by German language with 198 (0.61%) publications, French language ranks third position with 57 (0.17%) publications, Spanish language with 38 (0.12%) publications, Chinese language with 33 (0.10%) publications and Russian language with 30

(0.09%) publications. The most predominant language used for communication was English in every year in total productivity on the artificial intelligence subject during the study period.

5.7 Most preferred source titles

Table 7 Source Title of Publications

S. No.	Source Title	No. of Publications	Percentage	Impact Factor
1	IEEE Access	1371	4.21	4.34
2	Applied Sciences Basel	558	1.72	-
3	Sensors	407	1.25	4.35
4	Sustainability	379	1.16	3.25
5	Scientific Reports	315	0.97	4.38
6	Expert Systems with Applications	307	0.94	6.95
7	Journal of Intelligent Fuzzy Systems	307	0.94	1.74
8	Energies	280	0.86	3.34
9	IET Image Processing	249	0.77	2.37
10	Neural Computing Applications	222	0.68	5.61

Table 7 provides the leading journals each with number of publications and impact factor. The scientific literature on artificial intelligence is spread over 4549 different web of science source journals. It reveals that IEEE Access the list with the highest number of publications 1371 (4.21%) and the impact factor is 4.34, followed by Applied Sciences Basel with a share of 558 (1.72%) publications. Sensors occupy the third position with 407 (1.25%) publications and the impact factor is 4.35. The fourth highest source title is Sustainability with 379 (1.16%) publications and the impact factor is 3.25, Scientific Reports with 315 (0.97%) publications and the impact factor is 4.38 and Expert Systems with Applications with 307 (0.94%) publications and the impact factor is 6.95.

5.8 High productivity subject areas

Table 8 High productivity subject areas

S. No.	**Subject**	**No. of Articles**	**Percentage**
1	Engineering	8918	27.42
2	Computer Science	6751	20.76

3	Automation Control Systems	3348	10.29
4	Robotics	3348	10.29
5	Materials Science	1978	6.08
6	Physics	1935	5.95
7	Environmental Sciences Ecology	1813	5.57
8	Research Experimental Medicine	1643	5.05
9	Science and Technology	1407	4.33
10	Telecommunications	1364	4.19

The scientific literature on artificial intelligence is spread over 96 different subjects. Table 8 shows high productivity subjects which are contributing more than 1300 articles. It is found that Engineering has highest number of articles with 8918 (27.42%) followed by Computer Science contributing 6751 (20.76%) articles. Automation Control Systems occupies the third position with 3348 (10.29%) articles. The fourth highest articles belonged to the subject Robotics with 3348 (10.29%), Materials Science with 1978 (6.08%) and Physics with 1935 (5.95%) articles respectively.

6 Conclusions

The present study attempted to highlight the growth and development of research publications on artificial intelligence. A total of 32526 publications were published during 2012-2021 and the average number of publications per year was 3252.6. There was a steady growth of publications during the study period. Out of the 32526 published papers, 26037 (80.05%) were Journal articles followed by Review articles with 4005 (12.31%). The USA had the highest share (24.14%) of publications followed by China with 23.44% of publications, England with 8.83% of publications, and India with 5.80% of publications. Chinese Academy of Science, China topped the list with 571 (1.76%) publications followed by Harvard Medical School, USA with 350 (1.08%) publications, and Stanford University, USA with 349 (1.07%) publications. The scientific literature on artificial intelligence is spread over 4549 different web of science source journals. IEEE Access has the highest number of publications 1371 (4.21%) followed by Applied Sciences Basel with a share of 558 (1.72%) publications. Publications on artificial intelligence are spread over 14 languages.

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