Winter 2021

Mapping of Artificial Intelligence Research Output : A Scientometric Study

krish praveena
praviedu@gmail.com

Mapping of Artificial Intelligence Research Output : A Scientometric Study

K. Praveena[1], R. Veerakumar[2] & Dr.S.Rajeswari[3],

Abstract

. The present study analyzes the research in progress regarding the subject of artificial intelligence. The data are collected from Web of Science in the end of November 2020. The period considered for the study is from from 1999 to 2019. It is found that a total of 21643 papers are published in the subject of Artificial Intelligence during this period. An analysis has been made and the following results are concluded and that the research productivity on Artificial Intelligence exhibits a gradual growth from 2008 to 2019. The collection is exported to HistCite to obtain a large list of 20743 articles and 341247 times cited references along with their local and global citation scores (LCS and GCS). It is found that the Degree of Collaboration 0.83. In addition to this scientographical mapping of data is presented through graphs using VOS viewer software mapping technique.

Key Words : Artificial Intelligence, Scientometric Study, Histcite, VoS Viewer.

Introduction

Artificial Intelligence (AI) plays a key role in the age of digitalization in which intelligent systems and technologies are used to establish an active link between the physical and virtual (digital) worlds. Artificial Intelligence refers to the development of intelligent machines that represent reasoning, learning, information, communication, perception, planning and the capacity to transfer and operate objects in science and engineering[1]. It has many advantages which have been thoroughly reported in the literature. For example, it can use advanced algorithms to "learn" from "big" data and then use the knowledge acquired to support industry/practice [2]. Artificial Intelligence (AI) offers tremendous opportunities for major efficiency improvements by rapidly and accurately analyzing large quantities of data [3]. In addition, Artificial Intelligence systems and technologies can solve complex, non-linear practical issues and once educated can make high-speed predictions and generalizations [4].

---

1. Associate Professor, Dept of LIS, Annamalai University
2. Research scholar, Dept of LIS, Annamalai University
3 .Assistant Professor ,University College of Engineering BIT Campus**,** Anna University**,** Trichy

A scientometric analysis was performed in the field of computer sciences on the research output of India and china from 1971 to 2000. It is noticed that in the field of computer science research India was leading china significantly. Researchers in china were also found to have published studies in their domestic journals, while researchers in India opted for opportunities for publication in the west. No major variations in the research effect of the two countries were observed [5]. Brazilian computer science research output was compared with some Latin American, Latin European, BRIC Countries (Brazil, Russia, India and China) and other countries (South Korea, Australia and the USA). Among South American Countries, Brazil is found to have the largest production and India and Brazil had about the same production in the region [6]. Aggregated journal citations is used to characterize Artificial Intelligence as journal sets. Factor analytical approaches were also used to evaluate the growth of Artificial Intelligence from 1982 to 1992 in terms of the stability and coherence of the journal sets. They found that it was only after 1988 that Artificial Intelligence appeared as a discipline with a series of journals with the characteristics of a discipline [7]. They also noted that research on neural networks was neither part of Artificial Intelligence nor of its direct citation environment. An analysis of scientometric with regard to Machine Translation(MT) Publications, It was found that MT related research is mainly published in (refereed) proceedings compared to other fields and that serial journal publications do not play the same role. It was further discovered that MT research groups carried out research without being related to other groups [8].

There are many science mapping tools with each tool having its own capabilities and strengths. Consequently, adequate use of different methods for different types of research is important to thoroughly analyse every domain [9]. The strengths and weaknesses of various science mapping tools like VoS Viewer, Geph, Cite-Space, Sci2 and Histcite are addressed in this study [10].were evaluated, leading to selecting VOSviewer, Gephi, and CiteSpace. VOSviewer is a software tool that offers the basic functionality required for producing, visualizing, and exploring bibliometric networks [11]. Gephi is a leading open source software platform for the discovery, visualization and manipulation of all forms of graphs and networks that can be used to provide in-depth insight into the knowledge obtainable from a particular graph or network [12]. It offers opportunities to answer critical questions about a field of Knowledge : What are the key research priorities and how they are connected [13].Information

on the technical applications of the VOS viewer, Gephi, and Cite- Space can be found in Refs. [11,13,14] respectively.

Objectives of the study

- ✓ To identify the source wise and year wise distribution of Artificial Intelligence research output during period between 1999 and 2019.
- ✓ To compare and measure the analysis of Journal-wise and Keywords of Artificial Intelligence research output performance.
- ✓ To identify the prolific journals and journal distribution of Artificial Intelligence research Output.
- ✓ To classify the prolific authors and authorship patterns and author productivity.
- ✓ To identify the nature of collaboration and co authorship pattern and determine the degree of collaboration in Artificial Intelligence research.

Methodology

The data are retrieved from online version of Web of Science database in November 2020 and it is indexed in 21643 major records across many different scientific disciplines. This study presents the topics covered, patterns in the journals and authors cited and the status of institutions and thus studies the development in this area, providing a broader view of the current status of literature from 1999-2019. The WoS Core Collection was retrieved for this analysis and used as the source data. The exact keyword being used in the search as a consequence of the method is: “Artificial Intelligence”. The types of documents included the articles, review and proceeding paper etc., Reference to a total 21643 research publications were downloaded from Web of Science Core Collection database. The retrieved publications were saved in “Plain text” with “full record and cited references”. The Web of Science is considered as most comprehensive and reliable bibliographic source. Histcite was used for descriptive analysis concerned with authors ranking, document number, journals etc. and VOSviewerv.1.61 was used for the most frequent terms and their visualization.

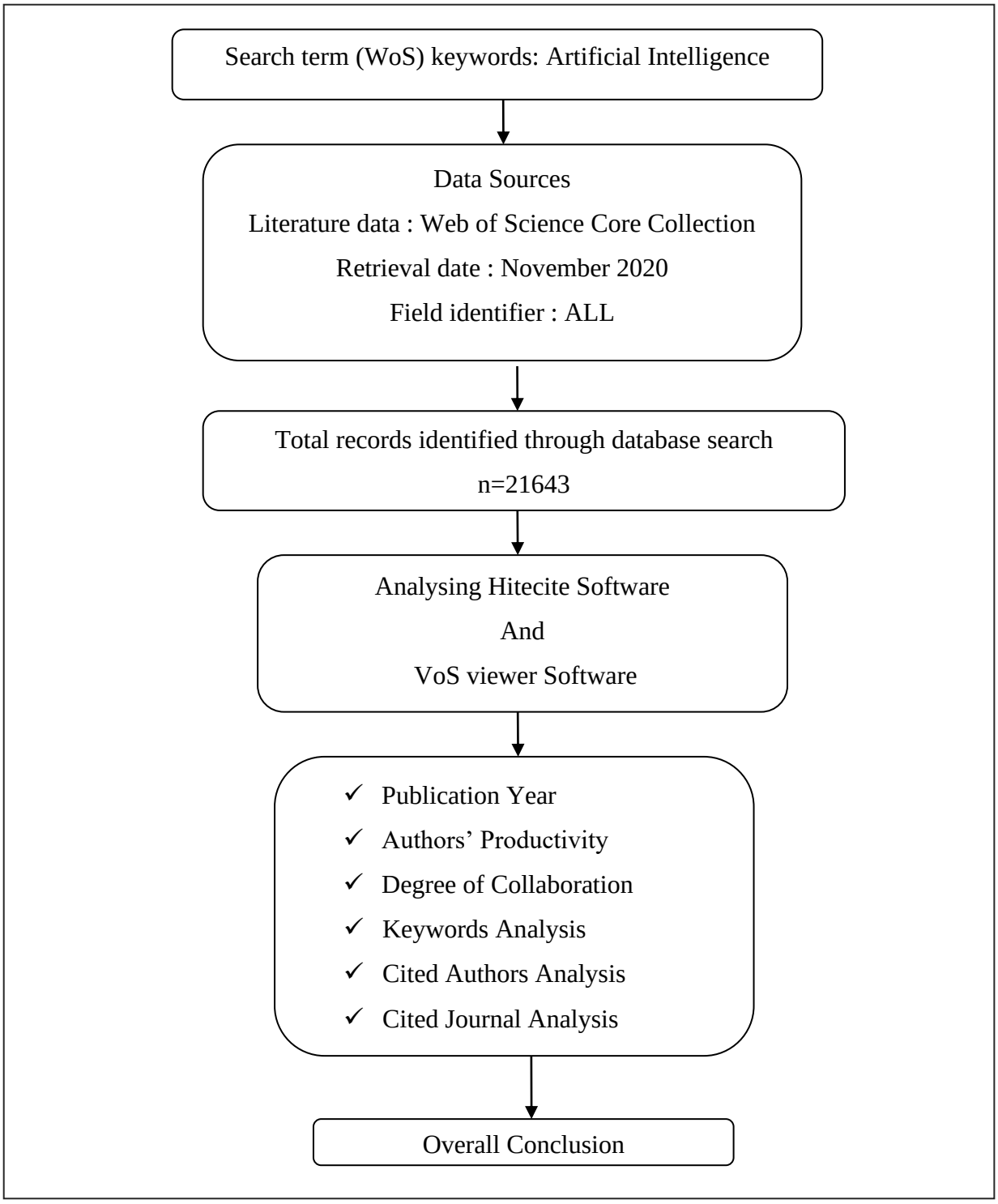

Figure 1 : A Schematic of the present research work

Table 1

Details of the Important Points of the Data Sample During 1999 to 2019

S.No.	Details about Sample	Observed Values
1	Duration	1999-2019
2	Time Span	21 Years
3	Total No. of Records	21643
4	Total No. of Authors	53798
5	Contributed Journals	4796
6	Document Types	27
7	Languages	24
8	Frequently Used Words	17456
9	Contributing Countries	138
10	Contributing Institutions	12960
11	Local Citation Score	20743
12	Global Citation Score	341247

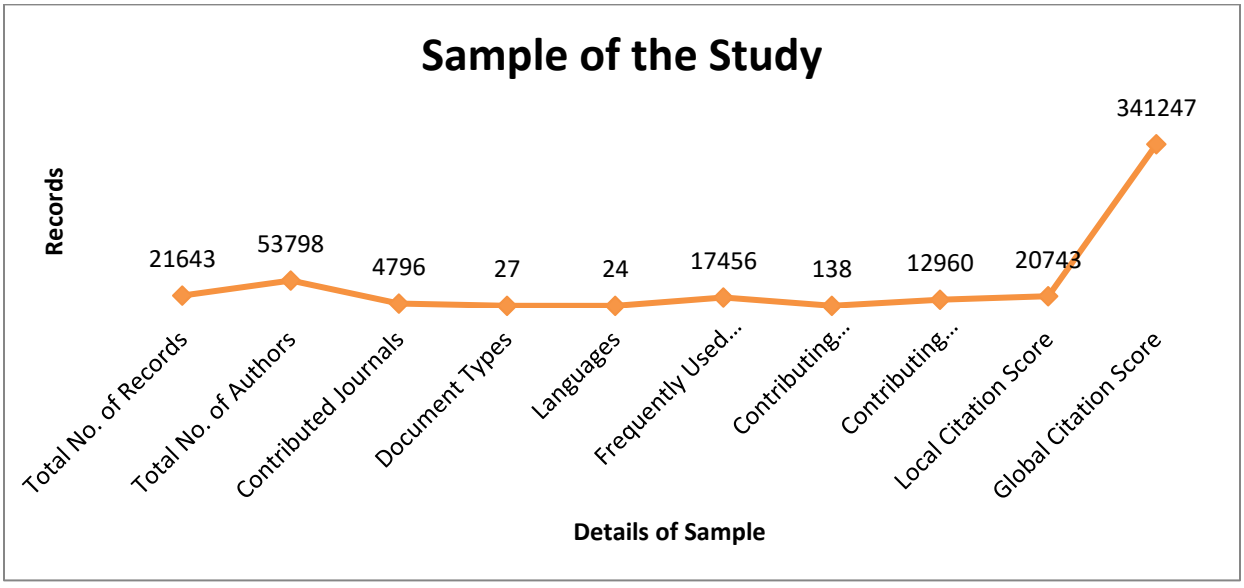

Figure 2 : Distribution of the Important Points of the Data Sample During 1999 to 2019

Data Sample of the study

Table 1 and Figure 2 represents the data for the present study and this was downloaded from Web of Science database in November 2020. A total of 21643 research publications were

downloaded from 1999-2019. The data downloaded were enhanced with different parameters like title, authors, years, countries, and research institutions. Furthermore, the downloaded data were analyzed by using Histcite and Vosviewer software applications.

Table 2

Annual Contribution of the Publication

S.No	Publication Years	Records	%	TLCS	TGCS
1	1999	385	1.8	457	14254
2	2000	370	1.7	449	10391
3	2001	412	1.9	535	14658
4	2002	389	1.8	162	9087
5	2003	465	2.1	438	14451
6	2004	463	2.1	480	13855
7	2005	490	2.3	377	11045
8	2006	564	2.6	558	13912
9	2007	493	2.3	829	16620
10	2008	526	2.4	908	14806
11	2009	599	2.8	1024	18720
12	2010	596	2.8	840	16068
13	2011	669	3.1	874	15609
14	2012	751	3.5	1229	16447
15	2013	830	3.8	995	16217
16	2014	941	4.3	1253	16844
17	2015	989	4.6	1297	17301
18	2016	1155	5.3	1480	21126
19	2017	1676	7.7	2503	24818
20	2018	3027	14.0	2665	27285
21	2019	5853	27.1	1390	17733
	Total	21643	100	20743	341247

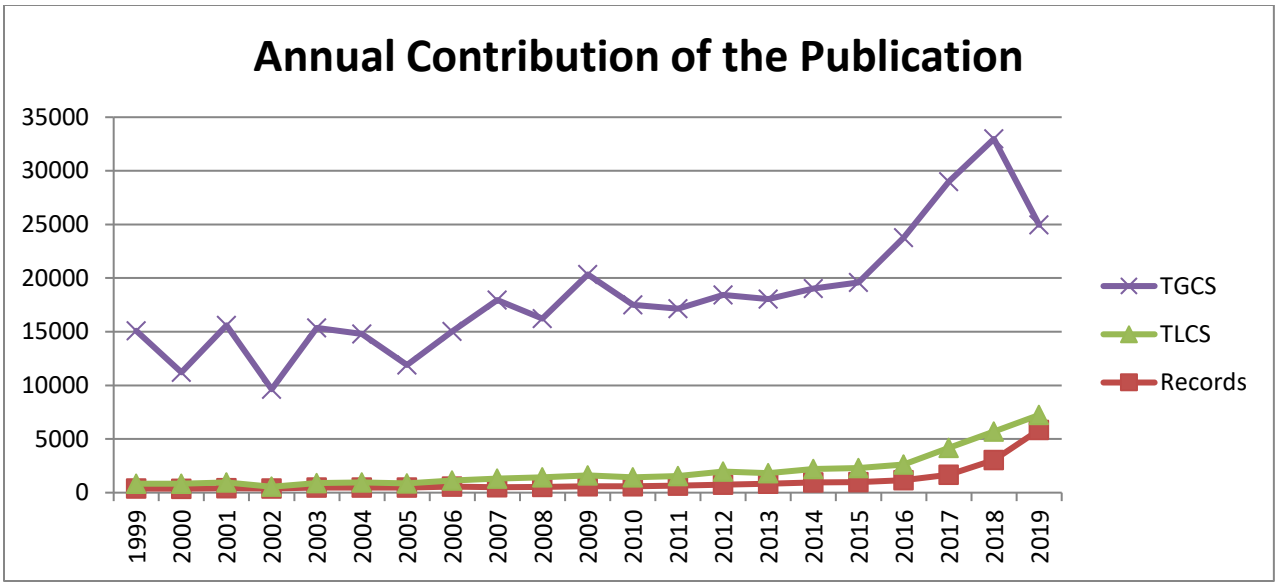

Figure 3 : Distribution of the number of documents by Annual of publication

Evaluate the Annual Output of Publications

Table 2 and Figure 3 reveals that the numbers of research documents published from 1999 to 2019 and are gradually increasing . According to the publication output from the Table 2 the year wise distribution of research documents, 2019 has the highest number of research documents 5853 (27.10%) with 1390 of total local citation score and 17733 of total global citation score values and being prominent among the 21 years output and it stood in first rank. The year 2018 has 3027(14.00%) research documents and it stood in second position with 2665 of total local citation score and 27285 of total global citation score were scaled. It is followed by the year 2017 with 1676 (7.70 %) of records and it stood in third rank position along with 2503 of total local citation score and 24818 of total global citation score measured. It is noticed that the increase in publications hole period of the study.

Table 3

Distribution of documents by authors' productivity

Authors	Records	Percentage
Single	3658	16.90
Double	4617	21.33
Three	4542	20.99
Four	3385	15.64
Five	2107	9.74

Six	1152	5.32
Seven	622	2.87
Eight	396	1.83
Nine	296	1.37
Ten and More than Ten	868	4.01
	21643	100

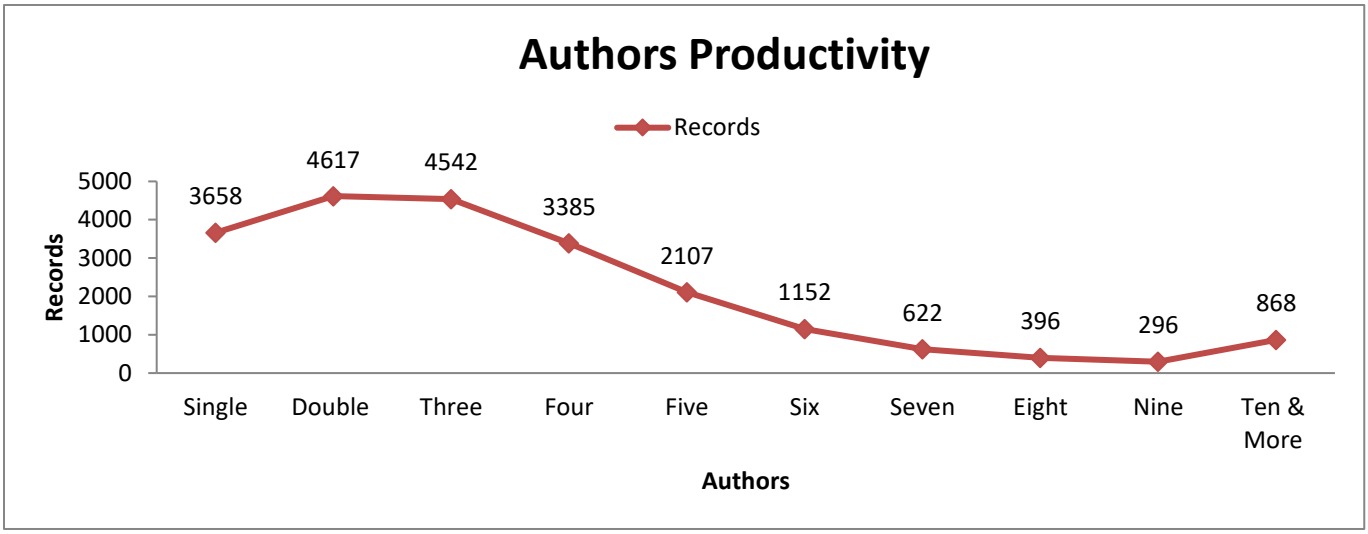

Figure 4: Distribution of documents by authors' productivity

Authorship Pattern of Single vs Joint Authors

Table 3 and Figure 4 shows the details about the single and joint-authored papers. A total of 3658 contributions (16.90%) has been contributed by single authors, 17985contributions (83.10 %) by joint authors. It shows that the highest number of contributions are joint authored papers.

Table 4

Calculation of degree of Collaboration

Authors	Publication	Percentage
Single Author	3658	16.90
Multiple Authors	17985	83.10

	21643	100

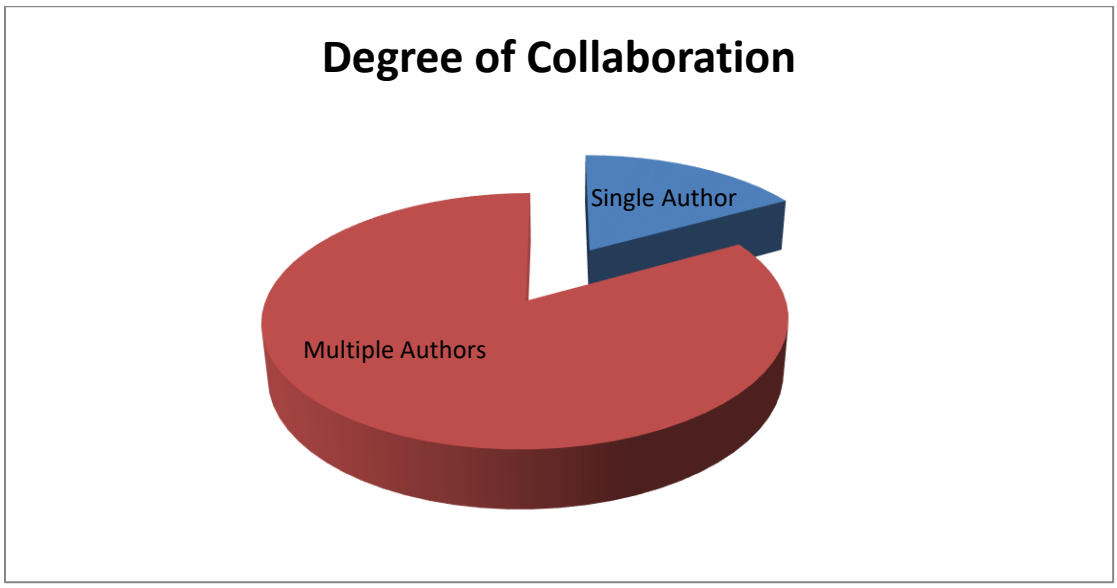

Figure 5: Calculation of Degree of Collaboration

Degree of Collaboration

Table 4 and Figure 5 shows that the result of the degree of collaboration C = 0.83.i.e, 83percent of collaborative authors articles are published during the study periods. The degree of collaboration is calculated by using the following formula (K.Subramanyam, 1982) [15]:

C= Degree of Collaboration

Nm = Number of multiple authors

Ns = Number of single authors

$$C = Nm \div (Nm + Ns)$$

$$C = 17985/21643$$

$$C = 0.83$$

In the present study the value of C is C= 0.83 As a result, it is found that the degree of collaboration in the field of Artificial intelligence is 0.83. This openly indicates its dominance upon multiple contributions

Table 5

Top 15 Words contributing to Artificial intelligence

S.No	Words	Records	TLCS	TGCS
1	Artificial	6075	8776	73940
2	Intelligence	5416	6530	50619
3	Based	3533	2348	45236
4	Using	3028	2855	40932
5	Learning	2224	2369	32786
6	Neural	1829	2969	37395
7	System	1593	1107	20694
8	Networks	1276	2161	28020
9	Network	1224	1087	17729
10	Approach	1195	1246	18528
11	Data	1135	863	14316
12	Machine	1105	1403	17189
13	Prediction	1079	1308	16624
14	Systems	1072	996	23316
15	Algorithm	1071	2239	31083

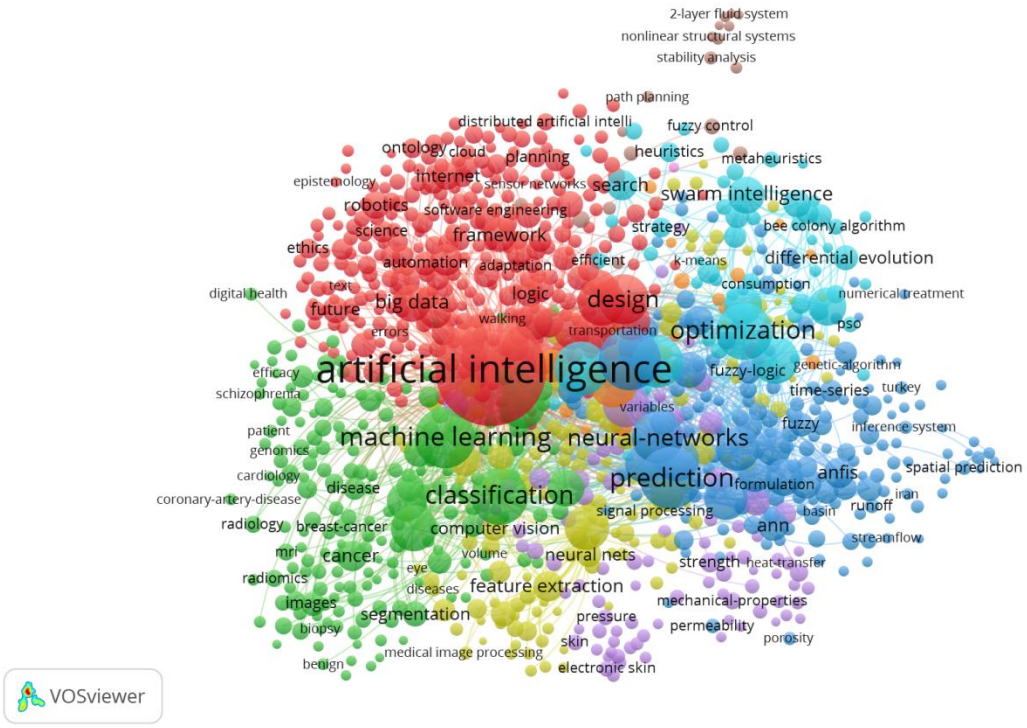

Figure 6 : Distribution of the using authors' keywords

Ranking list of leading words in the field of Artificial intelligence

Table 5 and Figure 6 shows that top keywords contribution of Artificial intelligence. The top most keyword is Artificial with 6075 records and Second Place is Intelligence 5416 records.

Table 6

Top 15 Journals contributing to Artificial intelligence

S.No	Journal	Records	TLCS	TGCS
1	IEEE Access	403	116	1792
2	Expert Systems with Applications	402	570	11158
3	AI Magazine	227	217	1533
4	Applied Soft Computing	171	860	7802
5	Engineering Applications Of Artificial Intelligence	171	214	3715

6	Artificial Intelligence	151	220	4982
7	Sensors	147	19	1641
8	Neuro computing	126	132	2236
9	Journal Of Intelligent & Fuzzy Systems	120	24	344
10	Neural Computing & Applications	120	165	1323
11	Artificial Intelligence Review	109	187	3503
12	Energies	105	18	1007
13	IET Image Processing	105	7	218
14	Minds And Machines	99	146	1096
15	Applied Sciences-Basel	96	0	425

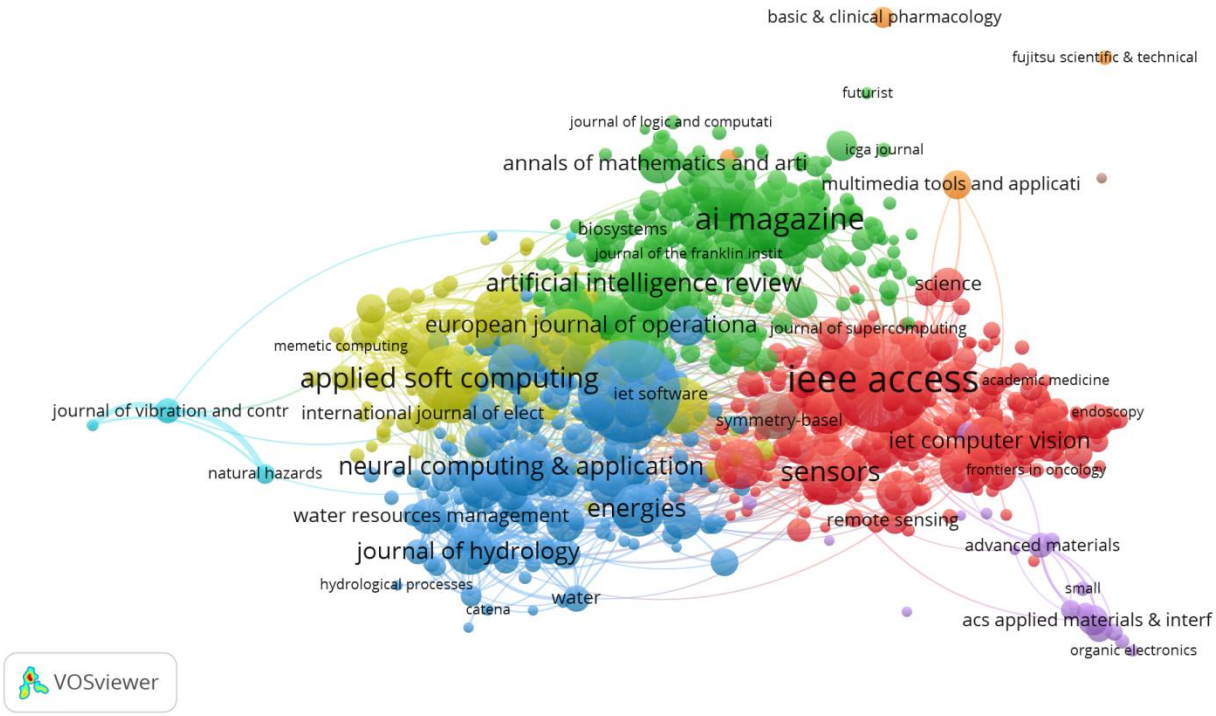

Figure 7 : Distribution of the number of articles published by journals

Ranking list of leading journals in the field of Artificial intelligence

Table 6 and Figure 7 reveals that top prolific journal of Artificial Intelligence research output during the sample time span. The IEEE Access has produced 403 records, Total Local

Citation Score 116 and Total Global Citation Score 1792 being first position. The second rank is occupied by the Expert Systems with Applications journal possess 402 and the third rank is the Ai Magazine with 227 records.

Table 7

Top 15 Authors contribution to Artificial intelligence

S.No	Authors	Records	TLCS	TGCS
1	Zhang Y	70	53	1119
2	Zhang J	65	44	768
3	Wang J	54	21	423
4	Li Y	51	45	727
5	Liu Y	51	100	1113
6	Kisi O	48	356	1756
7	Wang Y	48	53	893
8	Wang H	46	39	738
9	Li J	43	20	315
10	Kim J	42	11	322
11	Lee J	42	26	361
12	Wang L	42	19	370
13	Li L	41	25	497
14	Li X	41	55	666
15	Nourani V	41	248	1026

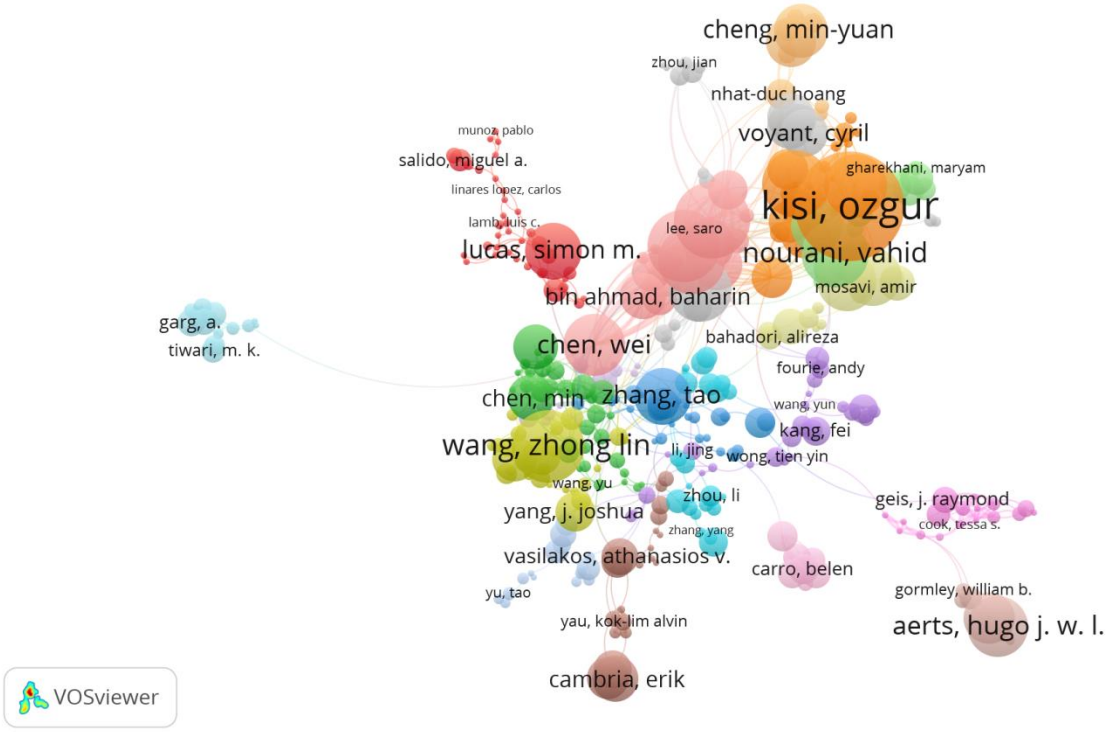

Figure 8 : Distribution of articles by authors' contribution

Ranking list of leading authors in the field of Artificial intelligence

Table 7 and Figure 8displays the ranking of authors of research articles. In the rank analysis the authors who have published more than 41 articles or more are considered into account to avoid a long list. It was observed that there is total of 53798 authors for 21643 records and it shows the top 15 most productive authors during 1999-2019. Zhang Y published 70 articles with 1119 TGCS articles in the leading place. The data clearly depicts that no matter how many publications that an author brings out yet the quality publications alone shows impact in the form of total local citations score and total global citations score.

Findings

- ✓ The finding of the growth rate of Artificial Intelligence research output during period is increasing trends.

- ✓ The finding of the annual contribution of Artificial Intelligence is highest in the year of 2019.
- ✓ The finding of the most productive authors and authorship patterns and author productivity is Multiple Authors.
- ✓ The finding of the Degree of Collaboration is 0.83.
- ✓ The finding of the Language wise maximum contribution is English language.
- ✓ The finding of the IEEE Access journal is taking the first place and Applied Sciences-Basel journal has taken the 15th place.
- ✓ The finding of the Zhang Y author is taking the first place and Nourani V author has taken the 15th place.

Conclusion

The present work explores the characteristics of Artificial Intelligence literature from 1999 to 2019 from the database of Web of Science and its implication using the Scientometric techniques. Artificial Intelligence (AI) has gradually increased during the study period has shown that 21643 research documents have been published**.** It could be identified that the author's wise analysis the following authors Zhang Y, Zhang J, Wang J, Li Y, Liu Y, and Kisi O have been acknowledged as the most prolific authors based on the number of research papers contributed. . Artificial Intelligence is progressively in increasing trend towards positive direction based on the results obtained from year wise growth rate during 2009 to 2019. This study is very useful to the young person who are working in the field of AI and Web of Science database is covering peer reviewed journals only. The highest number of researchers and scientists are pursuing their research in the field of Artificial Intelligence.

Reference

[1] J. McCarthy, The inversion of functions defined by turing machines, in: C.E. Shannon, J. McCarthy (Eds.), Automata Studies, Annals of Mathematical Studies, Number 34, Princeton University Press, Princeton, New Jersey, 1956, pp. 177–181, http://jmc.stanford.edu/articles/inversion/inversion.pdf Accessed 16th Dec 2019.

[2] F. Jiang, Y. Jiang, H. Zhi, Y. Dong, H. Li, S. Ma, Y. Wang, Q. Dong, H. Shen, Y. Wang, Artificial intelligence in healthcare: past, present and future, Stroke and Vascular Neurology 2 (4) (2017) 230–243, https://doi.org/10.1136/svn-2017- 000101.

[3] D.I. Patricio, R. Rieder, Computer vision and artificial intelligence in precision agriculture for grain crops: a systematic review, Comput. Electron. Agric. 153 (2018) 69–81, https://doi.org/10.1016/j.compag.2018.08.001.

[4] A. Mellit, S.A. Kalogirou, Artificial intelligence techniques for photovoltaic applications: a review, Prog. Energy Combust. Sci. 34 (5) (2008) 574–632, https://doi.org/10.1016/j.pecs.2008.01.001.

[5] Kumar, S., and K. C. Garg. 2005. Scientometrics of computer science research in India and China. Scientometrics 64 (2): 121–32. doi:10.1007/s11192-005-0244-9.

[6]. Wainer, J., E. C. Xavier, and F. Bezerra. 2009. Scientific production in computer science: A comparative study of Brazil and other countries. Scientometrics 81 (2): 535–47. doi:10.1007/s11192-008-2156-y.

[7] Van den Besselaar, P., and L. Leydesdorff. 1996. Mapping change in scientific specialties: A scientometric reconstruction of the development of artificial intelligence. Journal of the American Society for Information Science 47 (6): 415–36. doi:10.1002/(SICI)1097-4571 (199606)47:6<415::AID-ASI3>3.0.CO;2-Y.

[8] Voss, S., and X. Zhao. 2005. Some steps towards a scientometric analysis of publications in machine translation. In Proceedings of the 23rd IASTED International Multi-Conference Artificial intelligence and applications, ed. M.H. Hamza, 651–55.

[9] M.J. Cobo, A.G. Lopez-Herrera, E. Herrera-Viedma, F. Herrera, Science mapping software tools: review, analysis, and cooperative study among tools, J. Am. Soc. Inf. Sci. Technol. 62 (7) (2011) 1382–1402, https://doi.org/10.1002/asi.21525.

[10] C. Chen, Science mapping: a systematic review of the literature, Journal of Data and Information Science 2 (2) (2017) 1–40, https://doi.org/10.1515/jdis-2017-0006.

[11] N.J. van Eck, L. Waltman, VOSviewer manual: manual for VOSviewer version 1.6.11, https://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.11.pdf, (2019) Accessed 16th Dec 2019.

[12] M. Bastian, S. Heymann, M. Jacomy, Gephi: an open source software for exploring and manipulating networks, Proceedings of the Third International ICWSM Conference, 2009, pp. 361–362, https://gephi.org/publications/gephi-bastianfeb09. pdf Accessed 16th Dec 2019.

[13] C. Chen, CiteSpace Manual, http://cluster.ischool.drexel.edu/~cchen/citespace/ CiteSpaceManual.pdf, (2014) Accessed 18th Sep 2018.

[14] Gephi, Gephi tutorial quick start, https://gephi.org/users/quick-start/, (2017) Accessed 18th Sep 2018.

[15] Subramanyam, K. (1983) Bibliometric Studies of Research Collaboration A review: *Journal of Information Science* , 6, 33-38.