

Trend and Visualization of Artificial Intelligence Research in the Last 10 Years

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Abstract – Technology is permeating every aspect of our everyday lives, and businesses are increasingly turning to learning algorithms. These technologies are commonly associated with Artificial Intelligence (AI), Deep Learning (DL), Machine Learning (ML), and Artificial Neural Network (ANN). Due to previous research exciting findings, implications, and limitations, the research publication on AI, ML, DL, and ANN will increase each year. Finally, the growth analysis of AI, ML, DL, and ANN publications in last 10 years brings up the results that the publications significantly increase each year. This research utilizes descriptive analyses and bibliometrics. Implications of the investigation of specific keyword mapping visualization results on AI, ML, DL, and ANN, can be created and enhanced for more study. A different area of future research might focus on using fewer terms, particularly to study learning methods like AI, ML, DL, and ANN in a convolutional neural network.

Keywords – artificial intelligence, bibliometric, deep learning, machine learning.

1. Introduction

Every facet of our daily life is infiltrated by technology and businesses are increasingly the example in digital learning.

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The ease of adaptability and regeneration must be considered while developing learning approaches [1], [2]. Integrating institutional theory of learning and comprehensive institutional theory can help with learning growth.

Turning to learn algorithms to streamline processes and keep up with consumer expectations. These technologies are commonly associated with Machine Learning (ML), Artificial Intelligence (AI), Deep Learning (DL), and Artificial Neural Network (ANN) [1], [2], [3]. However, there is still ambiguity surrounding AI, DL, ML [4], and ANN. AI is the imitation by automated systems, especially computers, in the functions of human intellectual ability [5]. Several feasible applications of AI include computer vision, expert systems, natural language processing, and speech recognition [6], [7]. The area of computing science known as AI is concerned with simulating computer-intelligent behavior [8], [9], [10].

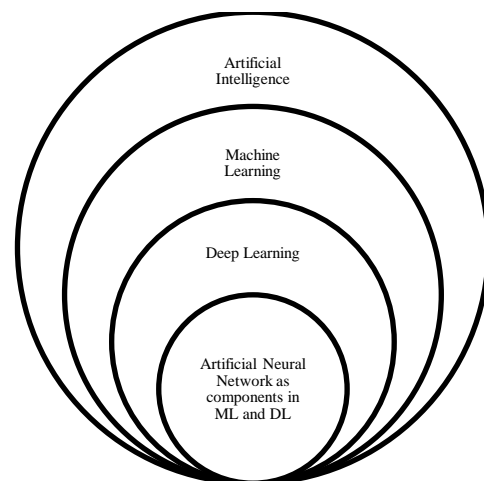


Figure 1. Scheme of AI, DL, ML, and ANN

ML is a discipline and application of AI that is commonly mistaken with AI [11], [12], [13]. Using algorithms that iteratively discover patterns in the information and adapt from them, ML is a technique for automating data analysis [14]. Applications for ML can be broadly categorized into three groups: supervised learning is the first step, followed by unsupervised learning and reinforcement learning [15].

Meanwhile, DL is an area of ML whose algorithms are captivated by the biological neural network. This structure is referred to as ANN. It's a neural network having three or more ANN layers. It can learn and adapt to large amounts of data and solve problems that are difficult to solve with other ML algorithms [16], [17], [18]. To facilitate the reader's understanding of AI, ML, DL, and ANN, the author describes the concept of these keywords as shown in Figure 1.

Figure 1 explains that AI is everything that belongs to all automated systems. In it, there is ML which in its use still requires humans to run the program. Whereas in DL, artificial intelligence can automatically classify and run programs automatically without human assistance. Then, ANN is a program or network that exists in ML and DL. Thus, ANN is the building block of AI. Hence, AI is defined by Winston and Dean et al. describe AI as the creation as well as investigation of automated systems that start behaving intellectually [19].

However, the previous research found that audiences interested in technology management, science policy, and public administration will find information about AI approaches to bridging the knowledge [20]. While there is research on bibliometrics of AI in the field of tourism [21], maritime industry [22], health and medicine [23], [24], engineering [25], and specifically, Hu et al. examine the development, potential directions, and considerable trends of global cooperation towards the domain of AI from 1985 to 2019 [26].

Due to previous research exciting findings, implications, and limitations, the research publication on AI, ML, DL, and ANN is about to increase each year. Hence, the authors are interested in conducting bibliometrics research to explore the research trends of AI, ML, DL, and ANN and find novelty in the AI field from a decade. Therefore, it is necessary to locate and comprehend the status and trends of the study issue to build and appropriately support it [27], [28]. Bibliometric analyses may offer a strong base, field advancement objective, and pertinent scientific publications data [29], [30]. The author will distinguish findings between conference papers and articles through journal websites in this research. This is done to characterize this research from previous research and to analyze the topic areas.

2. Methods

This research utilizes descriptive analyses and bibliometrics. The research requires an organized database to assess the publishing data [31] on Scopus. Scopus provides the most centralized repository, containing submissions from numerous subjects and a variety of information and file formats [32]. Hence, the database used for this research was Scopus.

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(TITLE-ABS-KEY artificial intelligence OR machine learning OR deep learning OR artificial neural network) AND ( LIMIT-TO ( PUBYEAR,2022) OR LIMIT-TO ( PUBYEAR,2021) OR LIMIT-TO ( PUBYEAR,2020) OR LIMIT-TO ( PUBYEAR,2019) OR LIMIT-TO ( PUBYEAR,2018) OR LIMIT-TO ( PUBYEAR,2017) OR LIMIT-TO ( PUBYEAR,2016) OR LIMIT-TO ( PUBYEAR,2015) OR LIMIT-TO ( PUBYEAR,2014) OR LIMIT-TO ( PUBYEAR,2013) ) )
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Figure 2. Keywords used in data gathering

The data was collected on 11th March 2023 on Scopus with keywords as Figure 2. Specifically, authors also obtain data for the highly cited conference paper and article journal categories.

Figure 3. Shown in the first filtering, authors applied first term to all documents types and gathered 809,045 documents. On the second filtering, authors specified to conference paper type and gathered 405,154 documents. The third filtering is to article type and gathered 337,884 documents. All the filtering are exported to ris and .csv files for 2,000 highly cited document due to the limitations of the Scopus exporting systems.

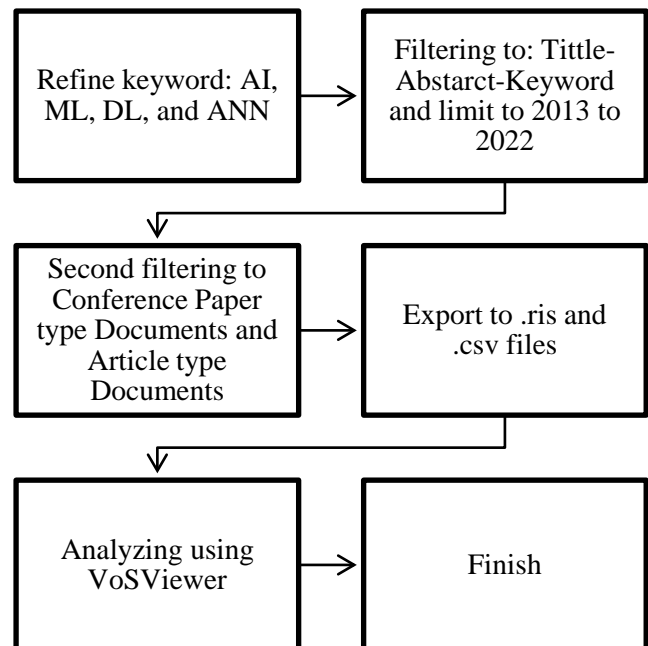


Figure 3. Scheme of AI, DL, ML, and ANN

3. Results and discussion

Based on the data that has been obtained and processed, several aspects will be analyzed to find out the opportunities for using AI, ML, DL and ANN in its development.

3.1. Research Trends of AI, ML, DL and ANN During a Decade

Table 1. Distribution of publications of AI, ML, DL and ANN during a decade

Year	Paper	Cited	ACPP	ACPPY	Citable Years
2013	772	113,698	147.28	14.73	10
2014	1,240	170,133	137.20	15.24	9
2015	1,661	285,661	171.98*	21.50*	8
2016	2,341	338,843*	144.74	20.68	7
2017	3,114	297,350	95.49	15.91	6
2018	4,757	179,215	37.67	7.53	5
2019	6,149	102,347	16.64	4.16	4
2020	8,217	36,854	4.49	1.50	3
2021	11,452	10,907	0.95	0.48	2
2022	14,176*	239	0.02	0.02	1
Total	53,879	1,535,247	756	102	-

*Description: ACPPY= Average Citation Per Paper Per Year; ACPP= Average Citation Per Paper; *=the highest number*

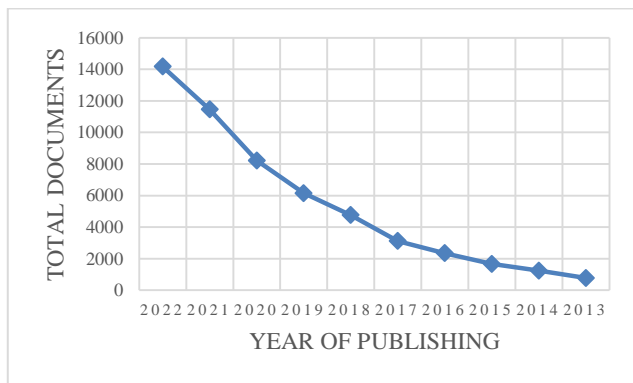


Figure 4. Research trends to AI, ML, DL and ANN during a decade

Based on metadata of the published paper information on AI, ML, DL and ANN obtained on Scopus during a decade. An intriguing discovery seems to be that the research trend for AI, ML, DL, and ANN is growing yearly. It is depicted in Figure 4. The metadata gathered are total 809,045 documents in all type of documents. According to Figure 4, investigation in the fields of AI, ML, DL, and ANN has grown in importance during the previous few decades. In the beginning of 5.0 industry revolution, there are a lot of researchers who are interested to start developing every type of AI that can work alongside with human [33].

From 809,045 documents, there are 405,154 conference paper and 337,884 article journals. This is due to the practicality of conference papers. It also has a more significant and obvious effect since it is presented at a conference for experts from other fields to see [34].

The breakdown of publications on AI, ML, DL, and ANN is shown in Table 1. From a decade, research was carried out has over million citations in journals. As per Table 1, 2022 was the year that produced the greatest number of publications. Moreover, 2016 was the year where the most referenced papers (338,843) and 2022 being the fewest cited publication year (239). In addition, 2015 being the highest citation paper per year within 21.50 index.

3.2. Top Cited Author and Publishing on Conference Paper and Article Journal

Using Scopus' information, it is possible to compare the top five most-cited authors. As a result, Table 2 compares the publications of the top five most referenced authors to those in conference papers and article journal papers.

Table 2 and Table 3 have shown that conference paper written by He et al. [35] published to Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition are known as mostly cited with 78,511 citation over the six years. Whilst, Pedregosa et al. [36] are being mostly cited paper on article journal published to Journal of Machine Learning Research. Since conference papers are being shown among many specialists from other fields to see, they have a more accessible influence [34], hence, conference papers or proceeding types of document can lead to top citations. Also, the proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition are trusted source in the field of AI, ML, DL and ANN.

Table 2 Top cited authors

Conference Paper		Article Journal	
Authors	Cited Total	Authors	Cited Total
He et al.	78,511	Pedregosa et al.	35,584
Long et al.	15,536	Chang, C.-C., Lin, C.-J.	24,581
Love, S., Szegedy, C.	13,863	Srivastava et al.	21,746
Chen, T., Guesterin, C.	11,953	Mnih et al.	12,037
Nair, V., Hinton, G.E.	10,777	Everingham et al.	9,221

Table 3. Top cited publisher

Conference Paper	Article Journal
Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition	Journal of Machine Learning Research
32 nd International Conference on Machine Learning, ICML 2015	ACM Transactions on Intelligent Systems and Technology
Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining	Nature
ICML 2010-Proceedings, 27 th International Conference on Machine Learning	International Journal of Computer Vision

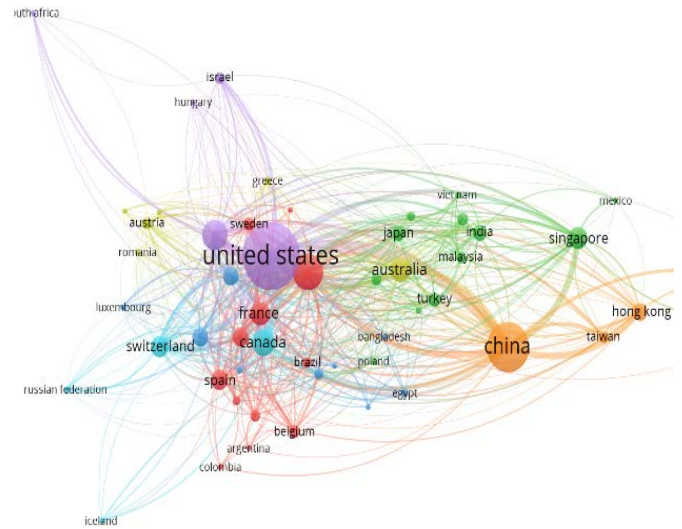


Figure 6. Top countries to article journal

3.3. Top Language and Countries on Conference Paper and Article Journal

Table 4. Top language in top cited publications

Conference Paper		Article Journal	
Language	n	Language	n
English	402,193	English	319,419
Turkish	1,402	Chinese	13,646
Chinese	494	Spanish	1,138
Spanish	312	Russian	769
Portuguese	267	Japanese	653

Based on Table 4, English is the most widely spoken language [37],[38],[39],[40], to conference paper it is used by 402,193 documents, to article journal it is used by 319,646 documents. Meanwhile, for conference paper the second top language is Turkish, followed by Chinese, Spanish and Portuguese. Furthermore, Chinese being the second top language to article journal. Spanish being the third top language, then Russian, followed by Japanese.

In line with Figure 5 and Figure 6 shown that United States are being the top contributed countries to publications of AI, ML, DL, also ANN publications during the last ten years. Also, the United States had a total 1,077,218 citation during period of a decade. It is undeniable that the industrial revolution has grown very rapidly in the United States since the 19th century. Therefore, many scientists and researchers are interested in writing about the industrial revolution, especially the 5.0 industrial revolution such as AI, ML, DL and ANN. Representation of research activities could be utilized as an option for forthcoming AI research. This research provides new insights to librarians, researchers, educators, digital developers, health professional, lawyer, and policymakers around the world and including Indonesia into research trend and activities in Scopus document. Future researchers can perform deeper insights research development and partnership with other affiliations to enhance AI publications and referrals in the economy, health, and other significant fields.

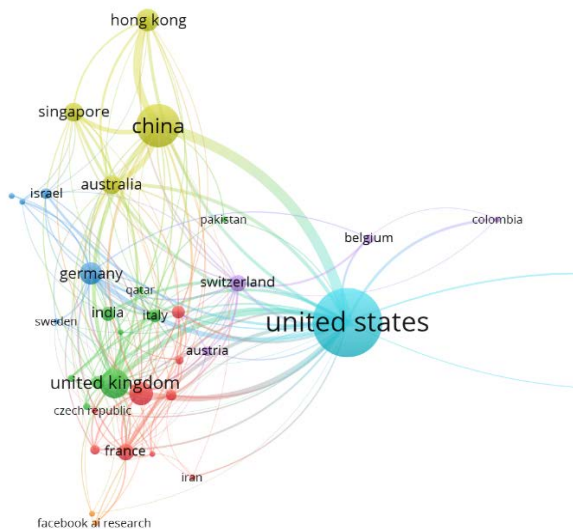


Figure 5. Top countries to conference paper

3.4. Trend Mapping Representation to AI, ML, DL, and ANN Publications During a Decade

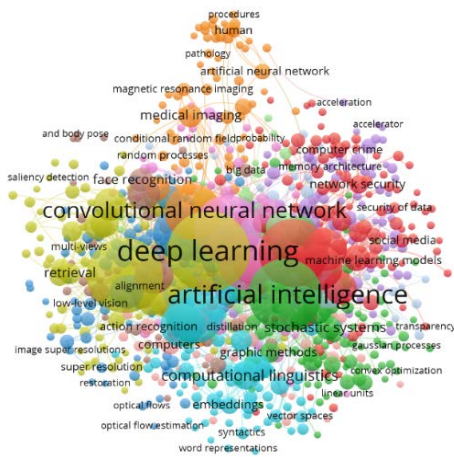


Figure 7. Keyword mapping visualization to conference paper

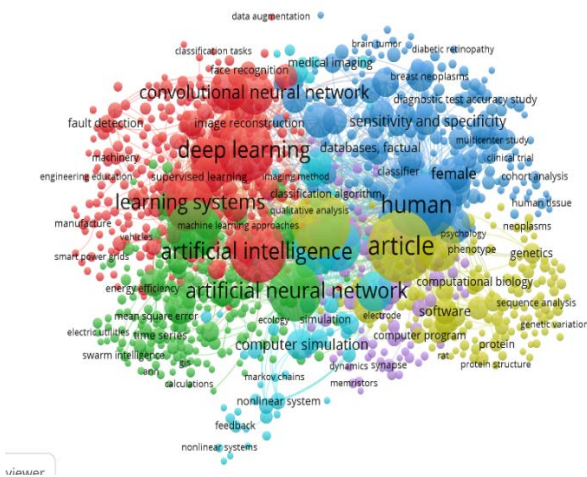
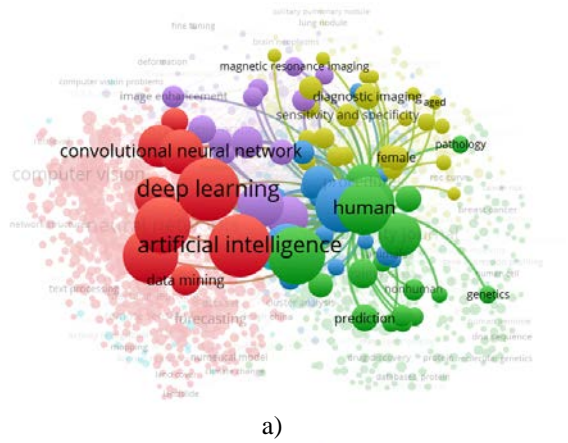


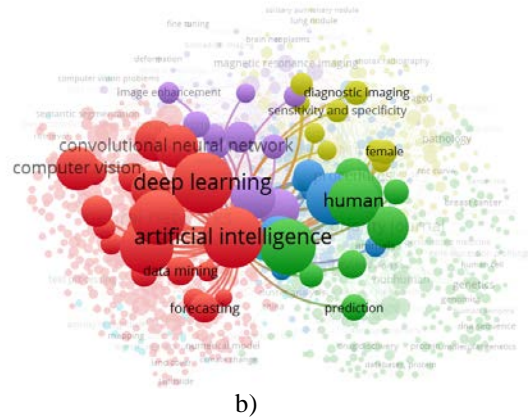
Figure 8. Top countries to article journal

Table 5. Trend mapping representation of AI, ML, DL, and ANN research during a decade

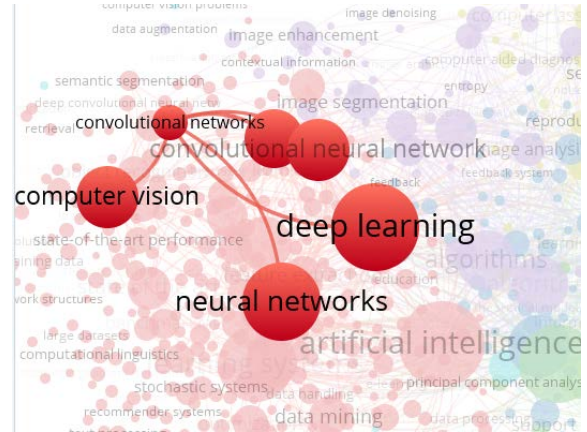
Keyword	Occurrence	Total Link Strength
Human	402	8,612
Article	396	8,140
Humans	363	8,028
ML	479	7,132
DL	562	7,004
AI	570	6,468
ANN	297	5,737
Neural Network	445	5,375
Algorithm	251	5,204
Algorithms	279	5,201
Learning Systems	432	4,241
Convolutional Neural Network	275	4,078
Deep Neural Network	236	2,630
Learning Algorithms	206	2,407



a)



b)



c)



d)

Figure 9. Disparity of mapping representation to a) most often occurring, b) most frequently occurring, c) less frequently occurring, d) less frequently occurring keyword

To determine the novelty of the AI, ML, DL, and ANN research, we may look at the keywords of each paper. As indicated in Figure 9 and Table 5, before sketching out the representation of AI, ML, DL, and ANN research during the past 10 years, the most common phrases are analyzed.

Table 5 shows that keyword 'Human' are mostly related to AI, ML, DL, and ANN research with the highest total link strength. 'Article' in second place with 8,140 total link strength. But, from the ten most strength keyword, AI has the highest occurrences with 570. In second place there are DL with 562 occurrences. The overall link strength reflects the number of articles whereby the multiple keywords appear together. The top terms in research on AI, ML, DL, and ANN from a decade are shown in Figs. 9a and b, whereas the inverse is true for Figs. 9c and d.

Future researchers that are interested in researching AI, ML, DL, and ANN on the top keyword still have the opportunity to do so, because the most often occurring keyword still has a large range and a variety of phrases. For future study, several instances of precise keyword mapping visualization outcomes on AI, ML, DL, and ANN may be built and enhanced.

In contrast, for terms that appear less often, as those in Figure 9c) and d), they can be utilized as a substitute research area in the future, particularly to study AI, ML, DL, and ANN in convolutional neural networks or in learning approaches. The development of AI, ML, DL, and ANN research based on keyword mapping visualizations is therefore feasible in a prospective study. There are undoubtedly opportunities to do research in AI, ML, DL, and ANN on less popular keywords or to enhance more popular phrases.

3.5. Top Subject Areas in AI, ML, DL, and ANN Research

Table 6. Top subject areas in AI, ML, DL and ANN research

<i>Conference Paper</i>		<i>Article Journal</i>	
<i>Subject Areas</i>	<i>Total Documents</i>	<i>Subject Areas</i>	<i>Total Documents</i>
Computer Science	335,704	Computer Science	150,026
Engineering	133,865	Engineering	121,865
Mathematics	113,508	Mathematics	43,333
Decision Sciences	40,807	Medicine	42,623
Physics and Astronomy	34,622	Biochemistry, Genetics and Molecular Biology	34,235
Social Sciences	19,856	Physics and Astronomy	33,822
Medicine	19,592	Materials Science	29,163
Energy	18,176	Social Sciences	25,324
Materials Science	14,755	Environmental Science	23,438
Earth and Planetary Sciences	8,256	Earth and Planetary Sciences	22,367

We provide the most popular topic area statistics to show what areas of AI, ML, DL, and ANN research are often published in. The variations in topic areas and affiliations in the AI, ML, DL, and ANN research are then listed in Table 6. However, Table 6 shows that the order of the top subject areas from

both conference papers and article journal are not much different. Computer science become the top subject areas that were used in publication (n=335,704 to Conference Paper) and (n=150,026 to Article Journal).

3.6. Top Affiliation and Countries in AI, ML, DL, and ANN Research

Table 7. Top affiliation in AI, ML, DL and ANN research

<i>Conference Paper</i>		<i>Article Journal</i>	
<i>Affiliation</i>	<i>n</i>	<i>Affiliation</i>	<i>n</i>
Chinese Academy of Sciences	5241	Chinese Academy of Sciences	7610
Tsinghua University	3432	Ministry of Education China	6914
CNRS Centre National de la Recherche Scientifique	3297	University of Chinese Academy of Sciences	3269
Carnegie Mellon University	3019	Tsinghua University	3157
Carnegie Mellon University	2589	Zhejiang University	2837
Ministry of Education China	2457	CNRS Centre National de la Recherche Scientifique	2757
Shanghai Jiao Tong University	2439	Shanghai Jiao Tong University	2417
Beijing University of Posts and Telecommunications	2297	Wuhan University	2290
Nanyang Technological University	2020	Stanford University	2088
Peking University	2015	Huazhong University of Science and Technology	2081

Table 8. Top funding sponsor In AI, ML, DL and ANN research

<i>Conference Paper</i>		<i>Article Journal</i>	
<i>Affiliation</i>	<i>n</i>	<i>Affiliation</i>	<i>n</i>
National Natural Science Foundation of China	25980	National Natural Science Foundation of China	46876
National Science Foundation	13574	National Science Foundation	11648
European Commission	5862	National Institutes of Health	9442
National Key Research and Development Program of China	5042	National Key Research and Development Program of China	8692
Horizon 2020 Framework Programme	4727	Fundamental Research Funds for the Central Universities	7320
Fundamental Research Funds for the Central Universities	3549	National Research Foundation of Korea	5454
Japan Society for the Promotion of Science	3345	European Commission	4958
National Institutes of Health	2991	Horizon 2020 Framework Programme	4553
Engineering and Physical Sciences Research Council	2825	Ministry of Education of the People's Republic of China	4202
U.S. Department of Defense	2735	Ministry of Science and Technology of the People's Republic of China	4044

Table 7 and Table 8 have shown the comparative top affiliation and top funding sponsorship to conference paper and article journal type in AI, ML, DL and ANN Research. Chinese Academy of Sciences become the most top affiliate in both conference paper or article journal with total of documents 5,241 and 7,610 to each type. In the conference paper, Tsinghua University being the second top affiliate with total document 3,432. CNRS Centre National de la Recherche Scientifique being the third top affiliate with 3,297.

Also, Carnegie Mellon University being the fourth top affiliate with total 3,019 documents. Carnegie Mellon University being the fifth top affiliation with 2,589. Meanwhile, to article journal publication, Ministry of Education in China being the second affiliation with 6,914 documents and University of Chinese Academy of Sciences with 3,269 documents. Furthermore, Tsinghua University being the third top affiliation and CNRS Centre National de la Recherche Scientifique being the fifth top affiliation with each document are 2,637 and 2,757.

Meanwhile, for the top funding sponsorship, National Natural Science Foundation of China being to each conference paper and article journal. Also, National Science Foundation being the second top sponsorship to each conference paper and article journal.

4. Conclusion

Finally, based on the analysis of the growth in AI, ML, DL, and ANN publications through the years in the period of a decade bring up the results that the publications are significantly increase each year. Conference paper written by He et al. published to Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition are known as highly cited. Whilst, Pedregosa et al. are being most cited paper on article journal published to Journal of Machine Learning Research. Being the most referenced publisher of both document kinds, the IEEE Computer Society Conference on Computer Vision and Pattern Recognition proceedings are a dependable source in the fields of AI, ML, DL, and ANN. Additionally, because conference papers are displayed for many specialists from other fields to see, they often have a more accessible influence. Keyword 'Human' are mostly related to AI, ML, DL, and ANN research with highest total link strength. 'Article' in second place of total link strength. But, from the ten most strength keyword, AI has the highest occurrences. In second place there are DL. The overall link strength reflects the amount of articles whereby a multiple terms appear concurrently. The order of the top subject areas from both conference paper and article journal are not much different. Computer science become the top subject areas that were used in publication The second place, is engineering, continue by mathematics. In the forth place there are 'Decision Sciences' to conference paper and 'Medicine' to article journal. The United States had the most citation by countries during the period of a decade. It is undeniable that the industrial revolution has grown very rapidly in the United States since the 19th century. Therefore, many scientists and researchers are interested in writing about the industrial revolution, especially the 5.0 industrial revolution such as AI, ML, DL and ANN. The implications of specialized keyword mapping representation research findings on AI, ML, DL, and ANN can be expanded and enhanced for future research.

Whilst the for less often occurring terms, can be employed as an alternate forthcoming study topic, particularly to examine AI, ML, DL, and ANN in convolutional neural networks or learning approaches.

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