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Bibliometric analysis on the evolution of applied intelligence

Dejian Yu[1] · Zeshui Xu[2,3] · Hamido Fujita[4]

Abstract

The *Applied Intelligence* (APIN) published its first issue in 1991 and it is one of the important academic journals in the field of computer science. This study aims to examine the structure and citation landscape as well as the evolution of the APIN journal based on all the APIN articles included in web of science core collection database. Research results of this study including the author characteristics, manuscript characteristics, productive and influential institutions and countries. Various kinds of networks are provided to visualize the complex relationships from different perspectives, including institutions and countries. The co-occurrence network and detection of the bursting keywords are used to explore the research hotspots in the APIN journal. The main advantage of this study is that it provides a comprehensive and objective view of the APIN journal. This study is very helpful for scholars to grasp the content structure and development process of APIN journal. It is also valuable for scholars in the field of artificial intelligence to identify the research hotspots in this field.

Keywords Bibliometric analysis · Citation structure · Applied intelligence · Keywords co-occurrence · Burst detection

1 Introduction

The *Applied Intelligence* (APIN) focuses on the research in artificial intelligence and neural networks, is one of the important academic journals in the field of computer science. The journal homepage shows that it addresses issues involving solutions of real-life manufacturing, defense, management, government and industrial problems which are too complex to be solved through conventional approaches (https://www.springer.com/computer/ai/journal/10489). It received its first impact fact (IF) in the 1997 according to the Journal Citation Reports (JCR), and its latest IF is 1.983. As the APIN journal has been established for nearly 30 years and it has published about 1500 articles, it is necessary to make a summary and review of the development of the APIN journal with scientific methods. This study provides a multiple view to explore the inner structure and citation landscape as well as the evolution of the APIN journal based on the bibliometric methods.

By filtering and processing massive information, the bibliometric method finds out the knowledge association between documents, thus mining out the potential knowledge value. As a discipline that applies mathematics, statistics and computer science to all kinds of literature data, bibliometric has the ability to discern the development context and trends of various disciplines [3, 40]. Whether in theory or practical application, it has important guiding significance for the development of many disciplines [18, 54].

Up to now, the application fields of bibliometric have been very extensive, and there are successful application cases of bibliometric in the fields of humanities and social sciences [34, 47], engineering technology [22, 31, 52], economic management [38, 39, 43], biomedicine [20, 46] and so on. It is one of the important topics in bibliometric to analyze scientifically a specific journal by using bibliometric theory and method. A large number of documents have recently emerged to find the knowledge structure and development of certain journals. Table 1

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Table 1 Bibliometric studies on single journals

References	Research object	Authors
[11]	American Journal of Roentgenology	Chen, M. Y., Jenkins, C. B., & Elster, A. D.
[49]	Journal of Management	Van Fleet, D. D., Ray, D. F., Bedeian, A. G., Downey, H. K., Hunt, J. G., Griffin, R. W., ... & Feldman, D. C.
[10]	Data & Knowledge Engineering	Chen, C., Song, I. Y., Yuan, X., & Zhang, J.
[9]	European Financial Management	Chan, K. C., Chang, C. H., & Lo, Y. L.
[7]	Studies in Higher Education	Calma, A., & Davies, M.
[36]	Journal of Business Research	Merigó, J. M., Mas-Tur, A., Roig-Tierno, N., & Ribeiro-Soriano, D.
[21]	International Journal of Hospitality Management	García-Lillo, F., Úbeda-García, M., & Marco-Lajara, B.
[8]	Academy of Management Journal	Calma, A., & Davies, M.
[17]	European Space Agency	Eito-Brun, R., & Rodríguez, M. L.
[29]	European Journal of Operational Research	Laengle, S., Merigó, J. M., Miranda, J., Słowiński, R., Bomze, I., Borgonovo, E., ... & Teunter, R.
[35]	International Journal of Intelligent Systems	Merigó, J. M., BlancoMesa, F., GilLafuente, A. M., & Yager, R. R.
[56]	Knowledge-based Systems	Zhang, Y., Chen, H., Lu, J., & Zhang, G.
[53]	Information Sciences	Yu, D. J., Xu, Z. S., Pedrycz, W., & Wang, W. R.
[37]	Information Sciences	Merigó, J. M., Pedrycz, W., Weber, R., & De la Sotta, C.
[55]	IEEE Transactions on Fuzzy Systems	Yu, D. J., Xu, Z. S., Kao, Y., & Lin, C. T.
[50]	International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems	Wang, W., Laengle, S., Merigó, J. M., Yu, D., Herrera-Viedma, E., Cobo, M. J., & Bouchon-Meunier, B.
[48]	Journal of Psychology	Tur-Porcar, A., Mas-Tur, A., Merigó, J. M., Roig-Tierno, N., & Watt, J.
[30]	Group Decision and Negotiation	Laengle, S., Modak, N. M., Merigo, J. M., & Zurita, G.
[33]	European Journal of Marketing	Martínez-López, F. J., Merigó, J. M., Valenzuela-Fernández, L., & Nicolás, C.
[45]	Journal of Religion and Health	Şenel, E., & Demir, E.

illustrates some representative bibliometric papers that aimed at the performance of journals.

The above studies show that the bibliometric methods play an important role in grasping the development of journals. In addition, there has been no research on the APIN journal using bibliometric methods. In this study, a bibliometric analysis on all the APIN publications included in Science Citation Index EXPANDED (SCIE) and social science citation index (SSCI) databases are presented. First, the basic characteristics of the authors and manuscripts are analyzed, including the number of authors, the countries of the authors, the length of the paper, and the number of references in the APIN publications. Then, the productive and influential countries, institutions and authors are studied. The country co-authorship and institutions bibliographic coupling networks in the APIN journal are also illustrated to explore the complex relationships of the institutions and countries. Finally, the burst detection and co-occurrence networks of keywords are used to identify the research hotspots in the APIN journal.

Applying the theory and method of bibliometric and deeply analyzing the relevant publications of the APIN journal can accurately grasp the status quo and development trend of the journal, and clarify the gap between the APIN journal and international top journals in this field, and provide reasonable countermeasures for promoting the development of this journal.

The rest of this study is organized as follows: After this introduction, the general analysis about the basic characteristics of the authors and manuscripts are presented in Section 2. The key contributors of the APIN journal including productive and influential countries, institutions and authors are studied in Section 3. Section 4 discusses the research hotspots in the APIN journal, and the conclusion of this study is presented in Section 5.

2 General analysis of APIN publications

In this section, the general analysis about the basic characteristics of the authors and manuscripts based on all the APIN publications included in SCIE and SSCI databases are presented. The APIN publications were retrieved from the above two databases on June 29, 2018. SCIE mainly includes the most influential and important journals in the field of natural science and engineering technology. SSCI is an authoritative citation index database widely used in humanities and social sciences. It is located on the Web of knowledge platform together with SCIE. The document types of the APIN publications include articles (1,446), proceedings papers (50), editorial materials (38), corrections (8), and reviews (5). Although the APIN journal published its first issue in 1991, the web of Science only included its publications from 1993 to now. It should be noted that only the types of articles and reviews are selected to form the dataset of this study.

2.1 Author characteristics

Author characteristics encompass many aspects such as the number of authors, and the author location [42]. As shown in Table 2, only a small part of the APIN publications are published by one author, and it accounts for only 10.13% of the total. Over time, the proportion of single-authored publications has decreased from 21.58% in 1993-2001 to 12.32% in 2002-2010 and 5.98% in 2011-2018. The trend

Table 2 Author characteristics of APIN publications

Author characteristics	Total (n = 1451)%	Time period		
		1993-2001 (n_1 = 241)%	2002-2010 (n_2 = 357)%	2011-2018 (n_3 = 853)%
Number of authors				
One	10.13%	21.58%	12.32%	5.98%
Two	32.67%	37.34%	39.50%	28.49%
Three	29.91%	29.88%	25.21%	31.89%
Four	16.75%	5.81%	15.97%	20.16%
Five and more	10.54%	5.39%	7.00%	13.48%
Number of Countries				
One	79.88%	91.70%	83.19%	75.15%
Two	16.95%	8.30%	13.73%	20.75 %
Three	2.55%		2.80%	3.17%
Four and more	0.62%		0.28%	0.94%

and magnitude of the decline in the proportion indicated that the authors of the APIN journal have become more and more cooperative. It can be seen that in the period of 1993-2001 and 2002-2010, the proportion of the two authors occupied the largest share, which was 37.34% and 39.50% respectively. However, in the period of 2011-2018, the largest share was 3 authors, accounting for 31.89%. Furthermore, the shares of four as well as five and more authors have been rising all the time. Their proportions have increased from 5.81% and 5.39% in 1993-2001 to 20.16% and 13.48% in 2011-2018, respectively.

We also analyzed the number of countries of the APIN publications. The majority of the APIN publications (79.88%) were written by authors from a sole country. However, the contributions from sole countries have been continuously decreasing from a peak of 91.70% in 1993–2001 to 83.19% in 2002–2010 and finally 75.15% in the period of 2011-2018. The share of the publications from two countries increased from 8.30% in 1993–2001 to 20.75% in 2011–2018. In the period of 1993-2001, there are no

publication that had authors from more than two countries. Only 0.62% of publications resulted from collaborations between four or more countries. To summarize, the APIN articles published by authors from one country occupied the absolute share, however, this proportion is gradually decreasing. Although the share of the publications had authors from three or more countries are relatively low, they are constantly increasing.

2.2 Manuscript characteristics

In this section, the characteristics of the APIN publications are investigated, including the length of the publications, number of the references and the citations [42]. Table 3 shows that 42.52% of the APIN publications range in length from 11-15 pages and 30.25% are 16-20 pages. Only 11.37% of the publications are less than or equal to 10 pages. The share of this kind of publications declined from 16.81% in the period of 2002-2010 to 8.21% in 2011-2018. Similarly, the publications with 11-15 pages decreased from 49.02%

Table 3 Manuscript characteristics of APIN publications

Manuscript characteristics	Total (n = 1451)%	Time period		
		1993-2001 (n1=241)%	2002-2010 (n2=357)%	2011-2018 (n3=853)%
Number of pages				
10 or less	11.37%	14.52%	16.81%	8.21%
11-15	42.52%	37.34%	49.02%	41.27%
16-20	30.25%	31.12%	24.37%	32.47%
21 or more	15.85%	17.01%	9.80%	18.05%
Number of references				
10 or less	1.10%	3.73%	1.40%	0.23%
11-20	13.30%	27.39%	22.69%	5.39%
21-30	27.29%	29.46%	33.05%	24.27%
31-40	25.02%	17.43%	23.53%	27.78%
41-50	16.68%	9.54%	10.92%	21.10%
51-100	16.13%	11.20%	8.40%	20.75%
101 or more	0.48%	1.24%	0.00%	0.47%
Number of citation				
0	17.51%	12.45%	3.92%	24.62%
1-5	38.87%	38.59%	31.65%	41.97%
6-10	17.71%	12.86%	24.09%	16.41%
11-20	15.09%	15.35%	22.69%	11.84%
21-30	4.27%	7.05%	6.44%	2.58%
31-40	2.69%	4.15%	4.48%	1.52%
41-50	1.72%	3.73%	2.80%	0.70%
50-100	1.52%	4.56%	2.52%	0.23%
101 or more	0.62%	1.24%	1.40%	0.12%

in the period of 2002–2010 to 41.27% in 2011–2018. However, the share of the publications with 16-20 pages or more than 21 pages are gradually increasing during these two periods. In other words, the proportion of long articles has gradually increased, while short-length articles have shown the opposite trend.

Table 3 also shows that 52.31% of the APIN publications had 21-40 references, while only 1.10% contained ten or fewer references. Meanwhile, the proportion of the publications had 101 or more references is also very low (0.48%). The trend seems that APIN publications are inclined to more references. The proportion of publications containing 31-40, 41-50 and 51-100 references substantially increased. For example, the share of publications having 31-40 references has increased from 17.43% in 1993-2001 to 27.78% in 2011-2018. During the same time-period, the share of the publications containing 41-50 references increased from 9.54% to 21.10%, while the share containing 51-100 references increased from 11.20% to 20.75%. The trend of more and more references is not surprising, as artificial intelligence research has grown tremendously over the past few decades. The accessibility of various database resources makes it possible for relevant scholars to access more literature and may also contribute to this trend.

In total, the 1541 APIN publications have been cited 13400 times, and average citation per paper is 9.24. Furthermore, 17.51% of the APIN publications have not been cited and 0.62% received more than 100 citations. More than half of the publications' citation range in 1-10 (38.87% range in 1-5 and 17.71% range in 6-10). Table 4 illustrates the detailed information about the top 10 most cited publications in APIN according to WOS.

The most cited APIN publication is about inductive machine learning algorithms and it was authored by Kononenko, Simec and RobnikSikonja with 185 citations [28]. The second one investigated the efficiency of population-based direct global optimization method, which has received 179 citations. It's worth pointing out that these two publications are the only two in APIN journals with more than 150 citations. The publication titled "Generalized evidence theory" authored by Deng from Northwestern Polytechnic University, China has 38 citations per year. In this paper, the authors proposed the generalized evidence theory. The top 1 most cited APIN publications are shown in Table 4, including the authors, published year, TC, and TC/Year.

3 The most productive and influential countries/territories/institutions/authors

The APIN journal is an international academic journal that has attracted the attention of relevant scholars and research institutions around the world. In this section, the productive and influential countries, institutions and authors are studied.

3.1 The most productive and influential countries/territories

Table 5 lists the 15 most productive countries/territories of the APIN journal in terms of the Total publication (TP). China has occupied the first position and is far ahead of other countries. The USA (192) and Spain (109), occupy the positions of the second and the third respectively. The following three countries/territories are South Korea, Taiwan and Canada with at least 80 publications. Six Asian countries and five European countries are in the top 15 respectively and there is no African country in the table. The USA leads the countries/territories according to the total citation (TC), although China has more publications. The China, USA, Spain and South Korea have more than 1000 citations.

The h-index was proposed by Hirsch in 2005, which takes into account the two elements of the author's

Table 4 Top 10 most cited publications in APIN according to WOS

Rank	Title	Author(s)	Year	TC	TC/Year
1	[28]	Kononenko, I; Simec, E; RobnikSikonja, M	1997	185	8.81
2	[5]	Brest, J; Maucec, MS	2008	179	17.90
3	[12]	Chen, SJ; Chen, SM	2007	142	12.91
4	[16]	Dubois, D; Fargier, H; Prade, H	1996	141	6.41
5	[41]	Ombuki, B; Ross, BJ; Hanshar, F	2006	140	11.67
6	[14]	Deng, Y	2015	114	38.00
7	[15]	Diederich, J; Kindermann, O; Leopold, E; Paass, G	2003	114	7.60
8	[44]	Schaal, S; Atkeson, CG; Vijayakumar, SV	2002	109	6.81
9	[6]	Burke, E; Cowling, P; De Causmaecker, P; Vanden Berghe, G	2001	106	6.24
10	[1]	Aha, DW; Breslow, LA; Munoz-Avila, H	2001	92	5.41

Table 5 Most productive countries/territories in the APIN journal

Country/Territory	TP	TC	TC/TP	h	≥ 100	≥ 50	≥ 2	≥ 1	≥ 1
China	299	2084	6.97	21	1	4	21	39	170
USA	192	2168	11.29	26	1	6	24	33	108
Spain	109	1155	10.60	18	0	3	14	37	36
South Korea	100	1058	10.58	18	0	3	15	25	47
Taiwan	98	931	9.50	16	1	0	10	17	58
Canada	84	891	10.61	16	1	1	10	10	51
Iran	77	450	5.84	14	0	0	6	13	33
India	75	316	4.21	11	0	0	5	6	33
England	68	856	12.59	15	1	1	9	13	39
Australia	52	551	10.60	13	1	1	5	10	28
France	49	611	12.47	13	1	0	8	11	20
Japan	49	482	9.84	11	1	1	4	6	30
Germany	44	684	15.55	14	1	3	6	6	23
Italy	40	475	11.88	13	0	2	7	6	20
Brazil	38	202	5.32	8	0	0	2	4	17

publication quantity and their citations [26, 27]. For example, if an author has published a total of N articles, each of the h articles has been cited at least h times, while the other (N-h) articles have no more than h citations per article, then the h-index value of this author is h. The definition of the h-index has a certain balance between "quality" and "quantity" [2, 13]. Table 5 shows that the USA also leads the countries/territories according the h-index. Some other indicators such as the publications with citations equal to 100 or more (≥100), equal to 50 or more (≥50), equal to 20 or more (≥20), equal to 10 or more (≥10) and equal to 1 or more (≥1) are also used to measure the top 15 productive countries/territories.

In order to understand the evolution of the APIN journal, the study interval of this paper is divided into three different time periods, namely 1993-2001, 2002-2010 and 2011-2018. Table 6 gives the relevant characterization data for the top 5 countries for these three different time periods. In the first two stages, the USA takes an absolute advantage in all aspects except TC/TP. However, in the third stage, this

Table 6 Most productive ad influential countries/territories in three different stages

| Rank	Countries/ territories	TP	TC	TC/TP	H	≥ 500	≥ 200	≥ 100	≥ 50
1993-2001	USA	71	968	13.63	16		5	9	10
	England	22	373	16.95	10	1		4	5
	Spain	19	320	16.84	9		2	4	2
	Canada	17	213	12.53	8			5	
	France	14	307	21.93	7	1		3	3
2002-2010	USA	57	746	13.09	13	1		11	12
	Taiwan	37	568	15.35	12	1		7	8
	China	31	516	16.65	14		3	6	9
	Spain	31	419	13.52	12		1	5	8
	South Korea	28	388	13.86	11		2	5	8
2011-2018	China	266	1531	5.76	18	1	1	14	30
	Iran	75	422	5.63	13			6	11
	India	69	204	2.96	8			1	5
	USA	64	455	7.11	12		1	4	11
	South Korea	60	531	8.85	14			6	16
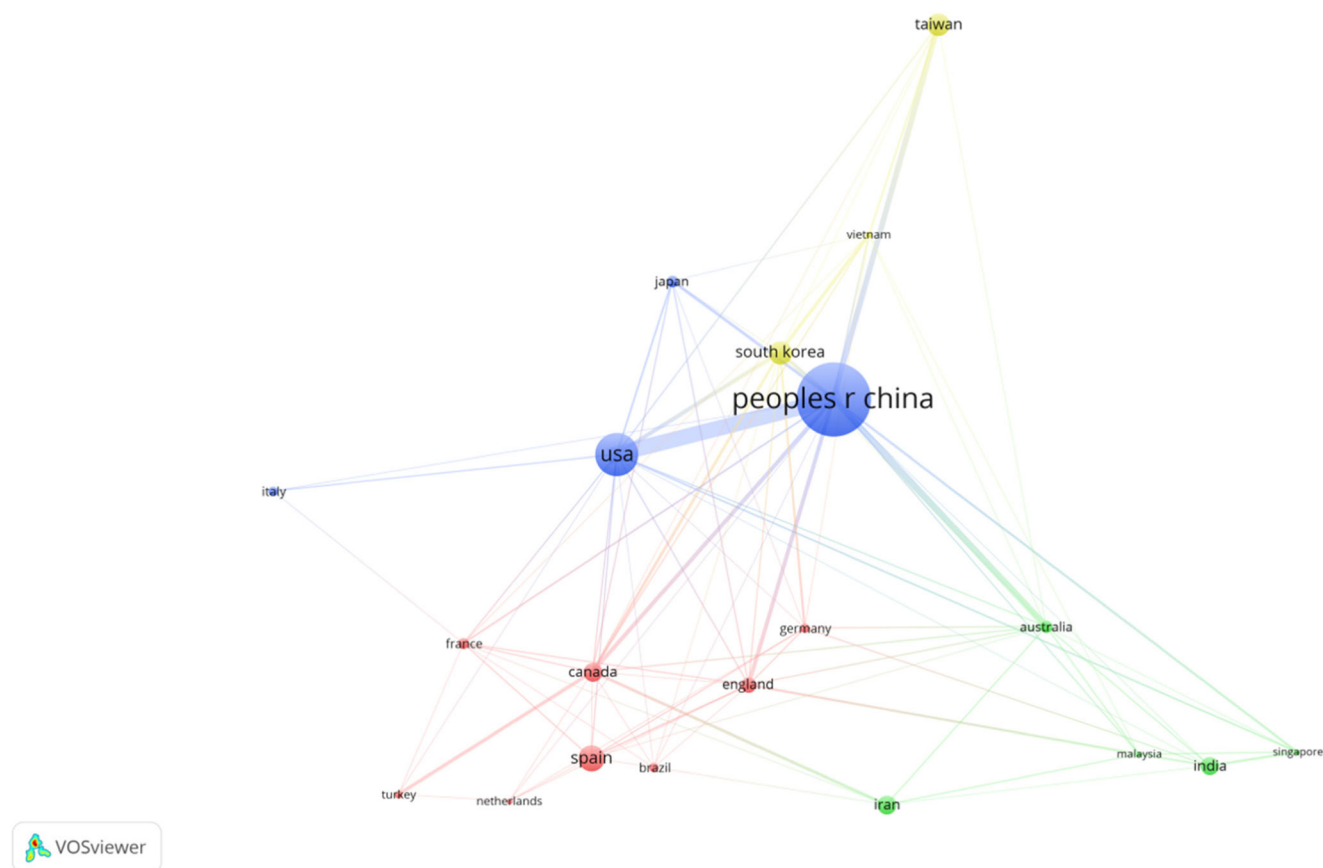
**Fig. 1** Countries/territories co-authorship of the APIN publications

position was replaced by China. At this stage, China is far ahead of other countries in terms of TC, TP, h index and some other aspects.

In the following, the co-authorship of APIN publications between countries/territories is studied and the co-authorship network is shown in Fig. 1. As the most pro-

Table 7 Top 15 productive institutions during 1993-2018

No.	Institution name	Country/Territory	TP	SP (%)	CP (%)	FP (%)	RP (%)	h
1	Kyung Hee University	South Korea	23	8(34.78%)	15(65.22%)	16(69.57%)	19(82.61%)	9
2	Amirkabir University Of Technology	Iran	22	10(45.45%)	12(54.55%)	12(54.55%)	12(54.55%)	7
3	Islamic Azad University	Iran	20	6(30.00%)	14(70.00%)	16(80.00%)	13(65.00%)	8
4	Centre National De La Recherche Scientifique Cnrs	France	19	9(47.37%)	10(52.63%)	17(89.47%)	13(68.42%)	8
5	Universidad Carlos Iii De Madrid	Spain	17	12(70.59%)	5(29.41%)	15(88.24%)	15(88.24%)	7
6	Indian Institute of Technology System Iit System	India	16	10(62.50%)	6(37.50%)	13(81.25%)	13(81.25%)	5
7	National Taiwan University of Science Technology	Taiwan	16	10(62.50%)	6(37.50%)	13(81.25%)	13(81.25%)	8
8	Vrije Universiteit Amsterdam	Netherlands	16	7(43.75%)	9(56.25%)	12(75.00%)	14(87.50%)	6
9	Nanjing University	China	15	4(26.67%)	11(73.33%)	12(80.00%)	10(66.67%)	7
10	National University Kaohsiung	Taiwan	15	1(6.67%)	14(93.33%)	3(20.00%)	5(33.33%)	7
11	Polytechnic University of Catalonia	Spain	15	7(46.67%)	8(53.33%)	13(86.67%)	13(86.67%)	7
12	Universidade De Sao Paulo	Brazil	15	8(53.33%)	7(46.67%)	11(73.33%)	12(80.00%)	4
13	University System of Georgia	USA	15	8(53.33%)	7(46.67%)	9(60.00%)	10(66.67%)	9
14	National Sun Yat Sen University	Taiwan	14	5(35.71%)	9(64.29%)	5(35.71%)	5(35.71%)	5
15	National University of Singapore	Singapore	14	7(50.00%)	7(50.00%)	11(78.57%)	12(85.71%)	9

Fig. 2 Four kinds of proportions for productive institutions during 1993-2018
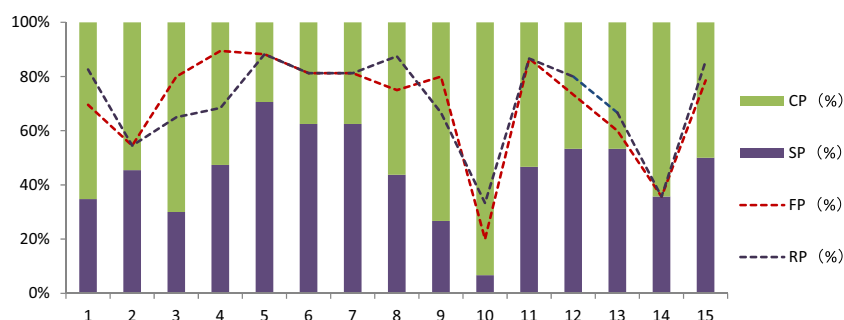
ductive country, China and its cooperation with the USA are very noticeable in this figure. China, USA, Australia, Taiwan and Canada had obvious co-authorships.

3.2 The most productive and influential institutions

In this section, the most productive institutions are studied. Table 7 shows the top 15 institutions in the APIN journal with at least 14 publications. Besides the TP and the h-index, some other indicators such as single institution publication number and its proportion (SP (%)), institution cooperation publication number and its proportion (CP (%)), first author institution publication number and its proportion FP (%), as well as corresponding author

institution publication number and its proportion RP (%) are also used to describe these productive and influential institutions. There are 3 institutions from Taiwan, two from Spain and two from Iran. Although China is the most productive country in the APIN journal, there is only one institution (Nanjing University) in this list. Kyung Hee University from South Korea, University System of Georgia from USA and National University of Singapore from Singapore ranked first together according to the value of h-index. According to the indictor of CP (%), National University Kaohsiung from Taiwan ranked first, and it was followed by Nanjing University from China (73.33%), Islamic Azad University from Iran (70.00%), Kyung Hee University from South Korea (65.22%) and
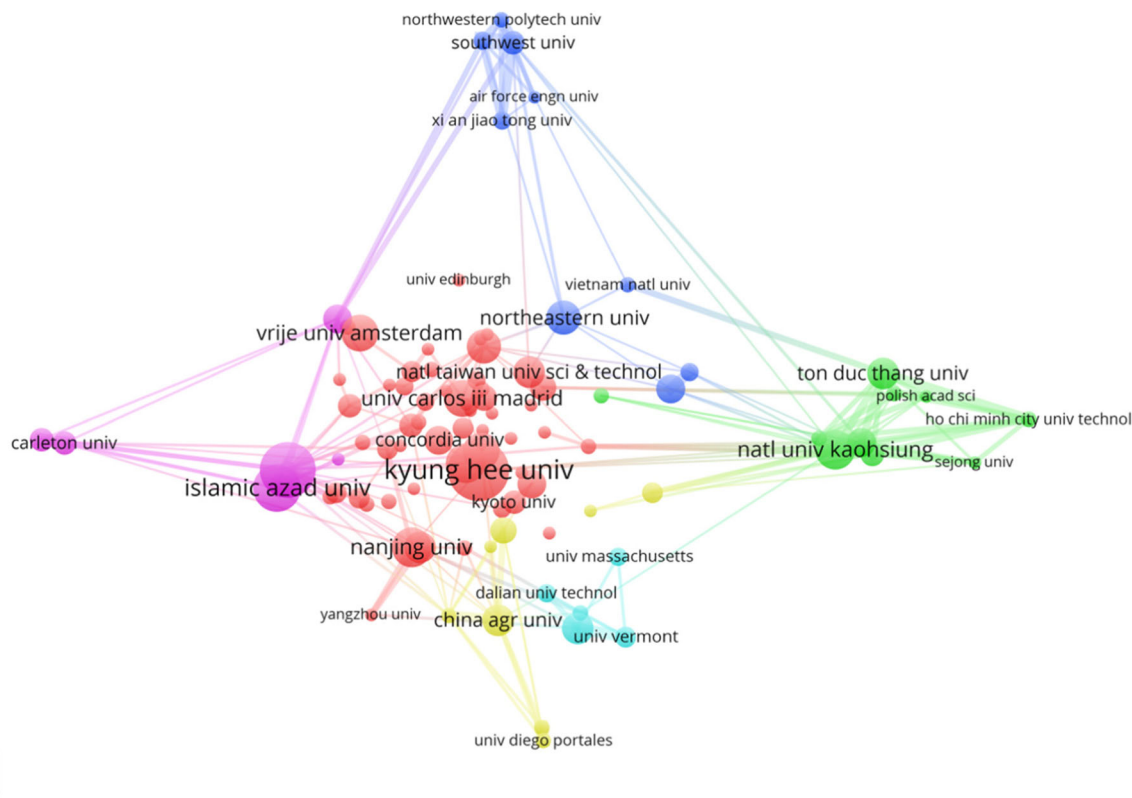

Fig. 3 Bibliographic coupling analysis of institutions in the APIN journal

National Sun Yat Sen University from Taiwan (64.29%). These institutions have a high rate of cooperation with other institutions. Figure 2 presents four kinds of proportions (SP (%), CP (%), FP (%) and RP (%)) of the top 15 productive institutions during 1993-2018.

In addition to describing the basic characteristics of these institutions, it is also necessary to study the relationship of these institutions. Bibliographic coupling method [24] is one of the effective means to analyze the complex relationship between institutions, countries and papers [4, 19, 32]. The couplings network of the institutions in the APIN journal with a minimum threshold of five publications was presented in Fig. 3. The results in this figure show that they are in accordance with Table 7 in which Kyung Hee University from South Korea is the most productive institution. Some other productive institutions in Table 7 are also highlighting their presence in Fig. 3 such as Amirkabir University of Technology and Islamic Azad University. Furthermore, Fig. 3 indicated that the productive institutions are highly connected.

3.3 The most productive and influential authors

Next, let us investigate the productive and influential authors of the APIN journal. Table 8 presents the information of the top 14 most contributing authors of the APIN journal, including their institutions, countries/territories, citation structures and positions of the publications. Hong TP from National University of Kaohsiung, Taiwan leads the rank in TP. Deng Y from Northwestern Polytechnical University, China leads the list in TC/TP. Six authors have at least 10 publications. It is interesting to note that although the USA and Spain are highly productive countries, there are no prolific authors from these two countries.

According to the number of publications by the first author, Cuevas E from University of Guadalajara, Mexico ranked the first position, followed by Jonker CM from Vrije Universiteit Amsterdam, Netherlands with 5 publications. In terms of the number of publications by the corresponding authors, Deng Y from Northwestern Polytechnical University, China leads the list and Cuevas E from University of Guadalajara, Mexico ranked the second position with 7 publications.

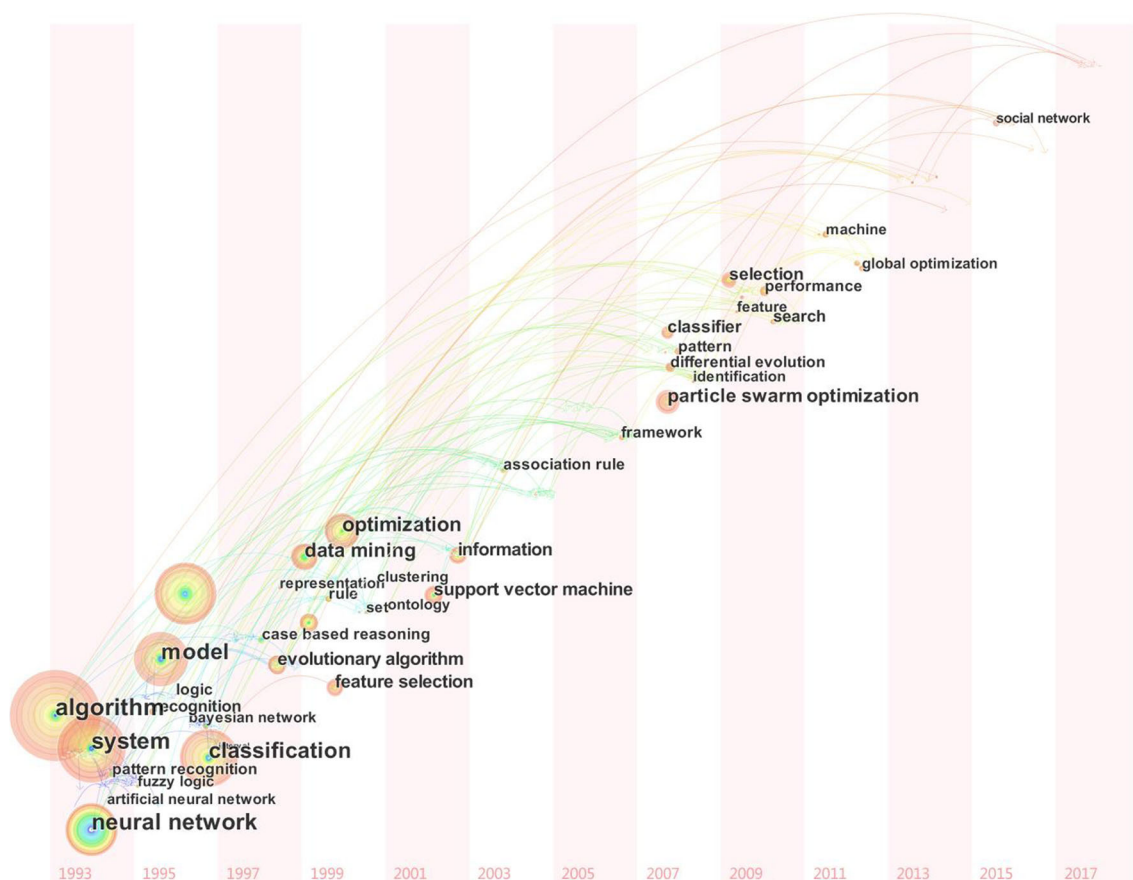## 4 Analysis of research hotspots in the APIN journal

The keywords of academic papers highly summarize the main content of the paper, so it can be used to reveal the characteristics of the content, and the development direction of academic research. In this section, the co-occurrence network and detection of the bursting keywords are used to

Table 8 Most prolific authors in the APIN journal (1993–2018)

Rank	Name	Institution	Country/Territory	TP	TC	TC/TP	h	≥ 40	≥ 20	≥ 10	≥ 1	Author rank 1st	Author rank 2nd	Author rank 3rd	Author rank other	RP
1	Hong TP	National University of Kaohsiung	Taiwan	15	164	10.93	8		3	5	7	3	3	3	6	4
2	Lee S	Kyung Hee University	South Korea	14	195	13.93	7	1	2	4	7	1	2	4	7	6
3	Meybodi MR	Amirkabir University of Technology	Iran	14	132	9.43	7		3	2	5		9	4	1	5
4	Alhajj R	University of Calgary	Canada	11	162	14.73	8	1	2	2	6		6	4	1	6
5	Treur J	Vrije Universiteit Amsterdam	Netherlands	11	63	5.73	5			1	10	1	4	4	2	4
6	Vo B	Ton Duc Thang University	Vietnam.	10	29	2.90	3			1	6	1	3	4	2	4
7	Deng Y	Northwestern Polytechnical University	China	9	228	25.33	5	2	3	1	4	1	3	3	2	8
8	Granmo OC	University of Agder	Norway	9	56	6.22	5			2	7	2	5	2	0	3
9	Lee YK	Kyung Hee University	South Korea	9	121	13.44	6		2	3	4			5	4	5
10	Wu XD	Hefei University of Technology	China.	9	49	5.44	4						2	2	5	0
11	Cuevas E	University of Guadalajara	Mexico	8	98	12.25	4	1			3	6	2	0	0	7
12	Jonker CM	Vrije Universiteit Amsterdam	Netherlands	8	33	4.13	4				8	5	0	2	1	2
13	Lee HM	National Taiwan University of Science and Technology	Taiwan	8	56	7.00	5			2	5	3	4	1	0	3
14	Qu R	University of Nottingham	England	8	119	14.88	7	1		3	4	1	5	2	0	1

Table 9 Top 20 keywords used in APIN in three different stages

1993–2001		2002–2010		2011–2018	
Keywords	Frequency	Keywords	Frequency	Keywords	Frequency
Neural networks	63	genetic algorithms	72	classification	300
Model	40	neural networks	46	genetic algorithm	289
Genetic algorithms	32	optimization	43	system	254
Machine learning	24	classification	36	model	209
Knowledge-based systems	19	model	36	optimization	165
Artificial intelligence	19	systems	35	particle swarm optimization	165
Fuzzy logic	19	machine learning	32	support vector machine	159
Classification	18	data mining	28	feature selection	132
Systems	18	design	22	design	97
Case-based reasoning	17	prediction	20	differential evolution	84
Temporal reasoning	16	agent	18	data mining	76
Diagnosis	14	support vector machines	16	evolutionary algorithms	74
Expert systems	14	recognition	14	global optimization	68
Knowledge representation	14	information	13	prediction	66
Pattern recognition	13	regression	13	performance	65
Acquisition	11	classifiers	12	machine learning	62
Constraint satisfaction	11	combinatorial optimization	12	framework	56
Design	11	identification	12	search	52
Planning	11	case-based reasoning	11	recognition	46
Software	11	convergence	11	sets	44

Fig. 4 Topic map of timezone mode in the APIN journal

explore the research hotspots in the APIN journal. In order to further study the research topics of different stages, this section divides 1993-2018 into three phases: 1993-2001, 2002-2010 and 2011-2018.

The results in Table 9 present the 20 high frequency keywords that appear in the APIN publications for three different time periods. As listed in Table 9, the top three frequently used keywords are 'neural networks', 'model' and 'genetic algorithms' in the first stage. In addition, 'genetic algorithms' is also the top two frequently used keywords during the next two stages. This shows that the theory of genetic algorithms has always been the research hotspot of the APIN journal. Although the 'neural network' is active in the first two stages, it has disappeared in the third stage. This indicates that in recent years, the focus of the APIN journal has shifted from neural network to other research hotspots.

Through Table 9, we also found that the attention of the APIN journal to 'machine learning' continues to decline. This keyword was ranked fourth in the first stage, seventh in the second stage, and the 16th place in the third stage.

Some other keywords such as 'knowledge-based systems', 'artificial intelligence' and 'fuzzy logic' which are active in the first stage (1993-2001) has disappeared in the next two stages. In contrast, the keyword 'classification', has received more and more attention at three different stages, which rose from the 8th during 1993-2001 to the first position during 2011-2018.

Compared with the three different stages, although there are certain consistencies in some major research issues, such as genetic algorithms, systems, models and other major areas and issues of system science, there has been a noticeable change in the focus of some research areas, such as classification, particle swarm optimization, support vector machine, feature selection, etc. Moreover, various research algorithms such as optimization algorithms and support vector machines have received high attention, reflecting that data mining methods have received more and more attention from scholars in the field of artificial intelligence in recent years. Figure 4 shows the topic map of timezone in the period of 1993-2018, and this reflects the conceptual drift of the APIN journal.

Table 10 Top 17 keywords with strongest citation bursts in APIN publications

Keywords	Strength	Begin	End	1993-2018
Neural networks	16.8253	1993	2004	
Expert systems	4.5601	1993	1998	
Knowledge Representation	4.475	1994	2000	
Pattern recognition	3.5644	1994	1998	
Case-based reasoning	6.5412	1997	2008	
Genetic algorithms	4.9555	2004	2012	
Identification	4.0579	2008	2012	
Optimization	3.9793	2010	2012	
Algorithm	8.469	2013	2016	
Framework	3.4028	2013	2014	
Image segmentation	3.3602	2014	2018	
Association rules	3.3012	2014	2016	
Particle swarm optimization	8.6705	2015	2018	
Decision-making	3.814	2015	2018	
Selection	3.2976	2015	2018	
Social networks	3.4768	2016	2018	
Feature selection	3.3652	2016	2018	

4.1 Bursting keywords detection

CiteSpace, developed by Chaomei Chen from Drexel University, is a visual document analysis software that can show the development trend of a certain knowledge field in a certain period of time, and explore the frontiers of the researches. It provides a function of burst detection for keywords which is useful for research hotspot exploration [23, 25, 51]. Through the analysis of the co-occurrence of keywords, the top 17 keywords with strongest citation burst in APIN publications are identified which are shown in Table 10. The strongest bursting keyword is 'neural networks' with the value of 16.8253. This keyword burst began in 1993 and ended in 2004 which indicated that the research on neural networks was very active during this period. The second and third keywords, according to the strength, were 'particle swarm optimization' and 'algorithm', respectively.

There are five bursting keywords began in 2015, which indicate the current research hotspots of APIN publications, including 'particle swarm optimization', 'decision-making', 'selection', 'social networks', and 'feature selection'. The last two keywords were began in 2016 and ended in 2018. Among these five keywords, the strength of the keyword 'particle swarm optimization' is the highest with the value of 8.6705, which began in 2015.

Based on the top 20 keywords used in three different stages and top 17 keywords with strongest citation bursts in APIN publications, it can be concluded that the APIN journal is paying more and more attention to the problems of decision-making, social networks, particle swarm optimization and so on.

5 Concluding remarks

Bibliometric analysis of the articles published in the APIN journal was conducted. In total, 1541 APIN publications from 1993 to 2018 were investigated along several different dimensions, including author and manuscript characteristics, productive and influential countries/territories/institutions/ authors, and research hotspots. The research results in this study indicated that the journal has undergone significant changes during the period 1993-2018.

Our investigation revealed that only a small part of the APIN publications were published by one author. Over time, the proportion of single-authored publications had decreased significantly, towards more frequent collaboration in the APIN journal. Additionally, the APIN articles published by authors from one country occupied the absolute share, however, this proportion was gradually decreasing. Although the share of the publications had authors from three or more countries were relatively low, they were

constantly increasing. We also noted a trend that the proportion of longer articles had gradually increased, and the APIN publications were inclined to more references.

There are three productive institutions from Taiwan, two from Spain and two from Iran. Although China was the most productive country in the APIN journal, there was only one institution (Nanjing University) in this list. Furthermore, the research indicated that the productive institutions were highly connected. Hong TP from National University of Kaohsiung, Taiwan led the productive authors in the APIN journal. We also noted that although the USA and Spain were highly productive countries, there were no prolific authors from these two countries.

We also found that the focus of the APIN journal had shifted from neural network to other research hotspots such as classification, particle swarm optimization, support vector machine, feature selection, etc. Furthermore, the APIN journal was paying more and more attention to the problems of decision-making, social networks, particle swarm optimization and so on.

There are some minor limitations in this study. The literature data used in this paper was derived from Web of science, and did not consider other APIN journal publications not included in the SCI or SSCI database. Future research will focus on a more complete data set for more comprehensive bibliometric results. Although there are some shortcomings, however this study provided authors, reviewers, and editors with deeper insights into the internal structure, evolution, and trajectory of the APIN journal to date.

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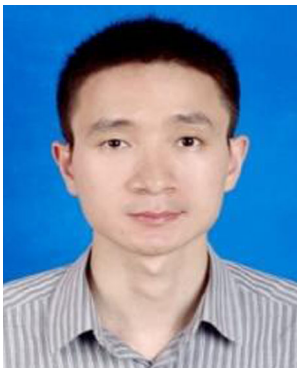
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