The Co-authorship Network of Published Articles in Conferences on Web Research Based on Social Network Analysis

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***Abstract*— Collaboration in writing scientific articles with the growth of academic exchanges and social interactions of researchers is increasingly expanding. Scientific collaboration gives researchers the opportunity to combine the capabilities and abilities of different scientific and research disciplines, which cannot be done individually. Co-authorship is the most formal manifestation of intellectual collaboration between authors in the production of scientific research. On the other hand, the study of the trend of scientific activities and its dynamics in any specialized field is one of the most important concerns of researchers in that field. In recent years, the use of the social network analysis approach has been proposed as a suitable solution to map the scientific structure of specialized fields and the co-authorship network of researchers. In this research, the papers published in six web research conferences have been analyzed to discover the scientific network and the co-authorship based on the social network analysis approach. The results of the analysis show that in the period, concepts such as social network analysis, Internet of Things, cloud computing, and deep learning have the largest share in articles. Also, based on the number of communities formed, the authors of the conference papers were more inclined to form small scientific groups in the form of universities or research institutes of their respective organizations.**

Keywords*— *Co-Authorship Network; Scientific Map; Conference on Web Research; Social Network Analysis

1. INTRODUCTION

Science is the product of curiosity, thinking, reasoning, wisdom, and individual and group experience. Science in terms of production can be divided into two categories of individual and group scientific production. Group scientific production means the cooperation of individuals to do scientific work that increases the innovation, creativity, progress and advancement of the group. This requires constant, reciprocal and close communication between group members [1]. Today, collaboration in publishing scientific articles with the growth of academic exchanges and social interactions of researchers is increasingly expanding [2]. Scientific collaboration allows researchers the opportunity to combine the capabilities and abilities of different scientific and research disciplines, which leads to greater effectiveness of scientific research and the increased production of scientific articles of great impact [3].

As a result of scientific collaborations between researchers in a field, a co-authorship network is formed. [1] Co-authorship is one of the most tangible and documented forms of scientific collaboration. Co-authorship is the collaboration of two or more authors in the production of a scientific article [3], which leads to the production of scientific outcomes with a higher quantity and quality than the individual writing mode [4]. Co-authorship constitutes a collaborative network in which authors consider nodes and shared actions as vertices. From this point of view, a cooperation network can be considered as a special type of social networks [2]. In recent years, social network analysis has emerged as a useful method of evaluating interdisciplinary sciences by evaluating several types of collaboration networks, including co-author networks. [5].

Keeping this in mind, the principles of social networks can be used to analyze this type of network. Analysis of social networks, both theoretically and statistically, is a privileged and prominent approach to study the pattern of cooperation of authors in various fields [6]. On the other hand, the study of the trend of scientific activities and its dynamics in any specialized field is one of the key concerns of activists and researchers in that field. [7] In this regard, drawing a scientific map or structure can be helpful. A scientific map refers to drawing the results of analyzing the publications of a scientific field from different angles and the general attitude of a field with the aim of discovering its hidden relationships. The scientific map provides a new perspective for revealing scientific boundaries and their dynamic structure using illustrative methods [8]. One of the tools that has been able to help researchers to draw the scientific structure in recent years is co-word analysis.

Co-word analysis is a content analysis technique that expresses both the frequency of topics and the relationship between them [9]. This method is a tool to discover hidden patterns and emerging conceptual events through which the main concepts of a field of science can be identified and through this knowledge, the conceptual categories of that field can be discovered, drawn and managed [10]. Since scientific maps have a structure similar to the structure of social networks, social network analysis techniques are used to visualize and analyze and interpret them. [11] Social network analysis is an interdisciplinary subject between different disciplines of sociology, mathematics and computer science that is used in various sciences such as sociology, economics, communication sciences, psychology, physics and computer. [12] Graph theory is used in the network analysis method. Criteria such as degree centrality, betweenness centrality and closeness centrality are among the most important indicators in

network analysis [13]. Degree centrality means the number of connections of each node with other nodes and betweenness centrality indicates the most effective node as a communication interface with other network nodes [14]. The present study aimed to analyze the scientific network and co-authorship and inter-university collaboration of articles published in six periods (310 articles) of the International Conference on Web Research from 2015 to 2020.

The general structure of this article is as follows. The second part reviews the previous literature. In the third part of the research, the methodology will be described. The fourth section analyzes and evaluates the results. The fifth section deals with conclusions and future work.

2. LITERATURE REVIEW

In recent years, the participation of authors in writing research works has increased and research has tended more towards scientific collaborations [3]. Although co-authorship was initially used historically in social science-related fields, it has been growing in other scientific fields since 1990 [14].

The first recorded study of the co-authorship network has been attributed to mathematical societies [15]. Various researches in the field of scientific collaborations and co-authorship have been done in different fields, some of which refer to co-authorship networks in the scientific communities of Iranian universities. In [1], the co-authorship network of Iranian medical researchers has been analyzed using social network analysis. The study population included Iranian authors who had published articles in medical journals indexed on the ISI database. The results of this study showed that there is little connection between these authors. In another study, the network of co-authorship of foreign articles of faculty members in the field of educational sciences has been analyzed. The findings of this study showed that the tree authorship pattern was the most important model of cooperation in the articles [16].

[17] examines and analyzes the collaboration network of Iranian researchers in the field of basic medical sciences in the science citation database from 1996 to 2013. In another study, the co-authorship patterns and trends of scientific research in Iran and the world in the field of information and knowledge organization from 2001 to 2020 have been analyzed [18]. Of other research, the study of co-authorship communities in the collaboration network of tourism researchers can be mentioned. The results of this study show that the scientific collaborations of researchers in this field have been effective in higher profitability and productivity of tourism [19]. In [5] co-authorship network analysis was used to investigate the application of machine learning techniques in cardiovascular disease and recognition of active researchers in this field, based on 2857 articles published in this regard between 2009 and 2019. Also, in [20], the internal structure of the co-authorship network in China researchers has been analyzed. In this research bibliographic data of 166 authors from three top higher education institutions of Shanghai was collected and the method of social network analysis was performed to analyze the data. In [21], the collaboration network of countries and research institutes in the field of coronavirus research has been analyzed. The study population included documents related to coronavirus published from 2003 to 2020 indexed on the WoS. The results of this study showed that China and the United States have contributed the most coronavirus studies.

In the field of drawing and analyzing the scientific network of subjects, various researches have been done so far, such as drawing the map of the structure of the Internet of Things and examining its development between 2001 and 2014 by reviewing 758 articles from the WoS database [22], review of the scientific business map, innovation and related concepts based on articles from 2015 to2019 [23], analysis of issues related to epidemiology based on 400 articles from the WoS database in the field of epidemiology using Co-word analysis [24] and the study of the scientific map of articles in the field of data mining in Iran from 1388 to 1398 [25].

The literature review shows that no independent research has been done on the analysis of the scientific structure and co-authorship network of the conference on web research papers. In this regard, this study aims to analyze the articles published in the conference using analytical techniques of c-word and co-authorship in an attempt to analyze the articles published in the last six conferences on web research.

Therefore, this study seeks to answer the following questions:

- What is the scientific network of articles published in six web research conferences?
- According to the articles published in the mentioned periods, which areas have received more attention from the authors and which areas have received less attention?
- What was the share of participation of universities and research institutes in terms of the number of published articles?
- What was the authors' collaboration network like and who were the most prolific researchers in the published articles?
- What was the collaboration network between the participating universities in different periods of this conference?

3. RESEARCH METHODOLOGY

In this research, the method of co-word and co-authorship analysis as the method of scientometrics has been used. The research population is 310 published articles of the web research conference that are indexed in the database of Scientific Information Database(SID).

To conduct this research, all the keywords of the articles, authors and their respective organizations were collected from the SID database, using the “Scrapy” library in “Python”. To draw the scientific network, the keywords of the articles have been used as network nodes and for the co-authorship network, the names of the authors of the articles have been used. Edges are also defined based on the coming together of keywords and authors shared in an article. In the scientific network mapping section, since researchers do not consider a certain standard for selecting keywords and the selection of these words is done arbitrarily, many keywords, despite being the same in terms of concept and meaning are considered in different articles, like the words "IoT" and "Internet of things", which both convey

the same concept. In addition to creating isolated nodes in the network and forming very small communities with a maximum of 3 or 4 nodes, this makes it impossible for the results of the analysis to reflect the reality of the problem. To solve this problem, all words are examined in terms of appearance and concept and words with the same meaning are considered as a single node. This is done as a combination of machine and manual.

After the synonymization stage, which is part of the preprocessing stage, the corresponding network is drawn based on the preprocessed data, and finally, the relevant analysis and interpretation is performed. The stages of research are shown in Fig.1.

4. Analysis and Evaluation of Results

As mentioned earlier, 310 conference papers from the SID database have been reviewed to map the network. Table 1 shows the information of the six web research conferences.

Studies indicate that the University of Tehran in terms of the level of participation of universities in papers published in six conferences on web research with 47 titles of articles is ranked first and in this regard, the University Science and Culture and University of Science and Technology have won the second and third place, respectively. Table 2 shows the contribution of the top 10 universities in terms of the number of papers published in the web research conference.

Also, among the authors of six conference articles, Ali Kamandi had the highest number of published articles. Table 3 presents the authors with the highest number of published articles.

A review of the conference papers shows that the highest number of papers written in the six web research conferences was with the participation of two authors, as shown in Table 4.

The collaboration indicator is calculated by specifying the average number of active authors in writing articles. This indicator is 2.66 for the articles studied in the research, which indicates the average level of collaboration of the authors in each article. On the other hand, the degree of cooperation is obtained by dividing group papers into all papers written in the six conferences. This value is between zero and one, and the closer it is to one, the more scientific participation of authors in scientific productions. The degree of collaboration for the

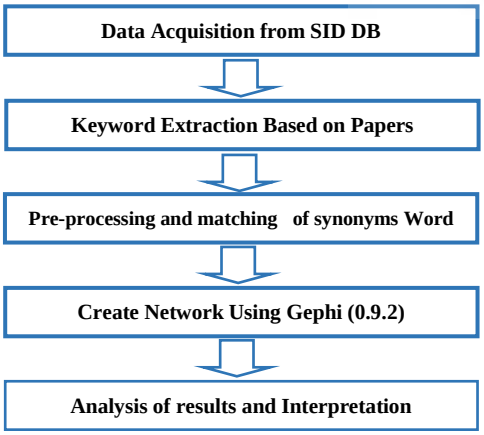

Fig. 1. steps of research

TABLE 1. INFORMATION OF THE SIX WEB RESEARCH CONFERENCES

conference	Year	No. of papers	No. of authors
first	*2015*	*9*	*18*
second	*2016*	*37*	*87*
third	*2017*	*31*	*83*
fourth	*2018*	*60*	*126*
fifth	*2019*	*89*	*198*
sixth	*2020*	*84*	*196*

TABLE 2. CONTRIBUTION OF UNIVERSITIES AND RESEARCH INSTITUTES

University name	Number of papers published
University of Tehran	*47*
University of Science and Culture	*31*
University of Science and Technology	*15*
Shahid Beheshti University	*13*
University of Kashan	*13*
Amirkabir University of Technology	*12*
Alzahra University	*11*
Isfahan University of Technology	*10*
Shahrekord University	*10*
Tarbiat Modares University	*9*

TABLE 3. AUTHORS IN TERMS OF HIGHEST NUMBER OF PUBLISHED ARTICLES

Author name	Number of papers published
Ali Kamandi	*12*
Fattaneh Taghiyareh	*8*
Mohammad Javad Kargar	*8*
Mohammad Reza Keyvanpour	*8*
Behrouz Minaei Bidgoli	*7*
Mohammad Ehsan Basiri	*6*
Alireza Yari	*6*
Mohammad Reza Meybodi	*5*

TABLE 4. AUTHORS` COLLABORATION IN SIX CONFERENCES

Collaboration of authors	Frequency in total papers
One author	*20*
Two authors	*158*
Three authors	*82*
Four authors	*31*
Five authors	*11*
Six authors	*4*
Seven authors	*4*

papers of the six conferences studied is 0.92, which indicates that the authors have a high willingness to collaborate to write joint papers.

4-1. Analysis and review of the co-authorship network of the articles

To analyze the network, the articles of the network research conference were drawn using Gephi software version 0.9.2. Fig.2 shows the co-authorship network of articles published in the six conferences.

4-2. Indicators of the centrality of co-authorship network

As mentioned, centralities are one of the important indicators in network analysis. In the case of the co-authorship network, the degree centrality means the degree of the node of the authors of the articles. Also, the author's betweenness centrality shows what part of the indirect communication of other writers has been through this author [12]. Table 5 shows the most indicators of degree and betweenness centrality for the article co-authorship network.

As can be seen in Table 5, based on the degree of centrality indicator, it can be stated that Ali Kamandi, Nasser Ghadiri, Mohammad Reza Meybodi, Mojgan Farhoodi and Ali Moeini have the highest level of co-authorship with other authors and, in other words, the most highly contributors on the network. Also, the study of the co-authorship network of the authors of the articles shows that Ali Kamandi, Farzaneh Shoeleh, Mojgan Farhoodi, Mohammad Reza Zahedi and Ali Moeini are in a good position in the network and the probability of their being in the shortest path between the other two authors is high. These people, while having a high betweenness centrality, play an important role in connecting nodes and transmitting information in network communities. For a deeper study of the co-authorship network, the structure of the communities in this network can also be examined. The research findings show that the co-authorship network of the reviewed articles consists of 155 communities. Table 6 shows information about the five main communities of the network under study. Outstanding person of each community are listed based on the between centrality indicator. Due to having a high betweenness indicator, these people play an important role in connecting their community nodes and transmitting information in the network.

As can be seen in Table 6, community 1 has the highest number of authors (node 28) and the highest number of co-authors (146 edges). Also, the ratio of edge to node in community 4 is the highest value, which indicates the intensity of communication between members of the community. As can be seen in Fig.2, in addition to the five mentioned clusters, there are a large number of small clusters in a separate and island form, which in total show the low relationship of the authors of the articles of one community with other communities and the creation of the structure of communication islands in the network under study. Also, Table 7 shows the highest two-member collaboration based on articles of six web research conferences.

4-3. Analysis of inter-university cooperation network on articles

In the following analyses, the inter-university collaboration network was drawn in order to identify the most participatory

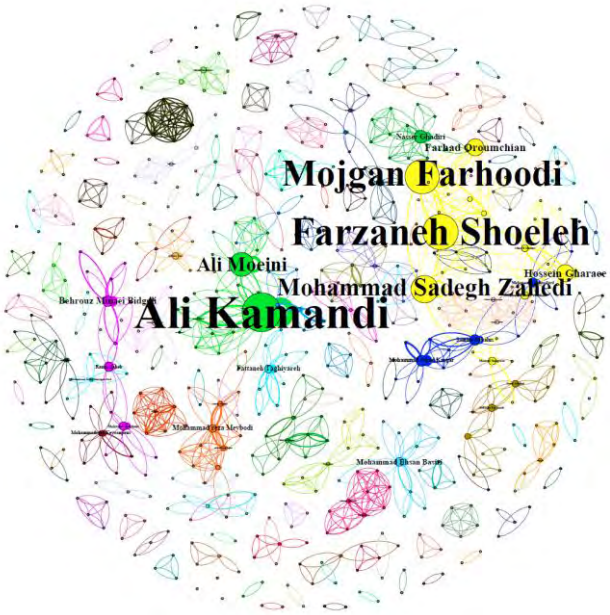

Fig. 2. Co-authorship network of articles from six web research conferences

TABLE 5. CENTRALITY INDICATORS

Degree Centrality		Betweenness Centrality	
Node Name	***Value***	***Node Name***	***Value***
Ali Kamandi	36	Ali Kamandi	385
Nasser Ghadiri	26	Farzaneh Shoeleh	324
Mohammad Reza Meybodi	22	Mojgan Farhoodi	313
Mojgan Farhoodi	22	Mohammad Sadegh Zahedi	244
Ali Moeini	20	Ali Moeini	211

TABLE 6. INFORMATION ON FIVE MAIN COMMUNITIES OF THE NETWORK IN THE RESEARCH

Community	#1	#2	#3	#4	#5
Percentage of total network	4.61%	3.78%	2.3%	2.14%	2.14%
No. of nodes	28	23	14	13	13
No. of edges	146	107	56	69	45
Ratio of edge to node	5.214	4.652	4	5.307	3.461
Community density	0.386	0.422	0.615	0.884	0.576
Person (based on betweenness centrality)	Mojgan Farhoodi (313)	Ali Kamandi (358)	M.Javad Kargar (84)	M.Reza Meybodi (52)	Behrouz Minaei (80)

TABLE 7. HIGHEST TWO-MEMBER COLLABORATION

Authors Name	**Number of collaborations**
Ali Kamandi and Mahmood Shabankhah	3
Mohammad Javad Kargar and Roya Hassanian Esfahani	3
Mohammad Reza Meybodi and Alireza Rezvanian	3
Mohammad Reza Meybodi and Ali Mohammad Saghiri	3
Seyed Morteza Babamir and Fatemeh Ebadifard	3
Jafar Habibi and Issa Annamoradnejad	3
Kamariah Yunus and Radzuwan ab Rashid	3

university centers, which is shown in Fig. 3.

In the inter-university collaboration network, degree centrality and betweenness centrality indicators were measured to deepen the analysis and review the results which are presented in Table 8.

Among the universities participating in different rounds of web research conferences, the University of Science and Culture has had the most collaboration with other national universities, and the University of Tehran and Qazvin Azad University are in the next ranks. The Sharif University of Technology and the University of Science and Culture have been leaders in collaboration with foreign universities. The research findings also show that the university collaboration network of the studied articles consists of 58 communities. Table 9 shows the information related to the five main inter-university collaboration network communities of the present study.

4-4. Analysis and review of the scientific network of articles

In order to analyze the scientific network of web research conference papers, the mentioned network was drawn based on the technique of co-word analysis. Fig.4 presents the scientific network of articles published in the six the conference.

4-5. Indicators of the centrality of the scientific network of articles

In this section, network analysis is based on degree and betweenness centrality. Table 10 shows the most indicators of degree and betweenness centrality for the scientific network of articles.

As can be seen in Table 10, based on the degree centrality indicator, it can be stated that social networks, IoT, cloud

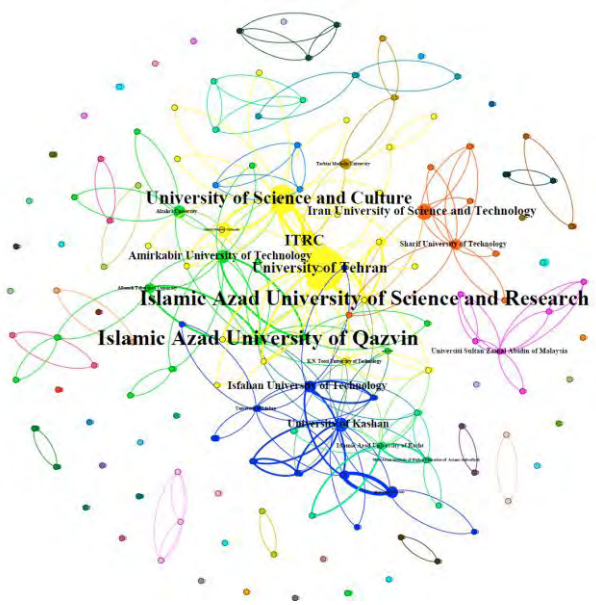

Fig. 3. Inter-university collaboration network of research articles

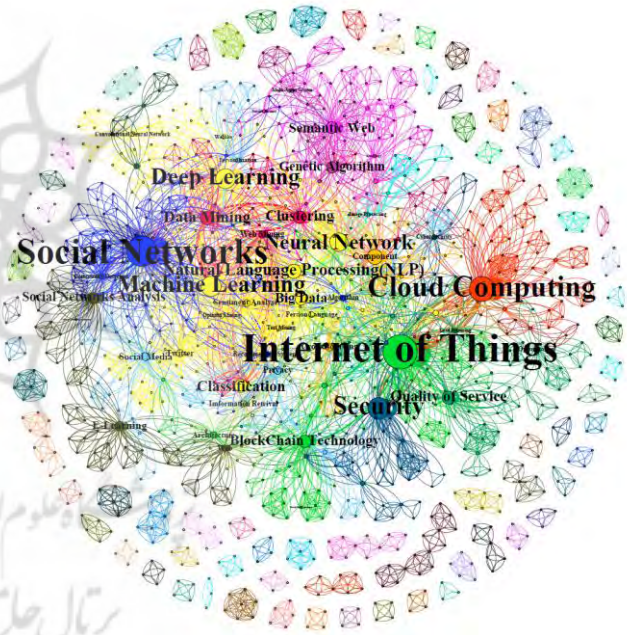

Fig. 4. Scientific network of articles from six web research conferences

TABLE 8. CENTRALITY INDICATORS

Degree Centrality		Betweenness Centrality	
Node Name	***Value***	***Node Name***	***Value***
University of Science and Culture	28	Islamic Azad University of Qazvin	1484
University of Tehran	24	Islamic Azad University of Science and Research	1459
Islamic Azad University of Qazvin	20	University of Science and Culture	1254
University of Science and Culture	18	University of Tehran	1019
Islamic Azad University of Science and Research	16	University of Science and Technology	838

TABLE 9. INFORMATION ON FIVE MAIN COMMUNITIES OF NETWORK IN RESEARCH

Community	#1	#2	#3	#4	#5
Percentage of total network	15.07%	10.27%	8.9%	5.4%	4.11%
No. of nodes	22	15	13	8	6
No. of edges	92	54	50	25	20
Ratio of edge to node	4.18	3.6	3.84	3.125	3.33
Community density	0.398	0.514	0.641	0.892	1.333
University (based on betweenness centrality)	University of Science and Culture (1254)	Islamic Azad University of Qazvin (1484)	Isfahan University of Technology (745)	University of Science and Technology (838)	Islamic Azad University of Rasht (386)

TABLE 10. CENTRALITY INDICATOR

Degree Centrality		Betweenness Centrality	
Node Name	***Value***	***Node Name***	***Value***
Social Network	156	Internet Of Things	125408
Internet Of Things	156	Social Network	110949
Cloud Computing	124	Cloud Computing	89007
Deep Learning	112	Security	76230
Data Mining	95	Machine Learning	69990
Machine Learning	94	Deep Learning	68949
Security	78	Neural Network	62573
Semantic Web	74	Nlp	47522
Neural Network	72	Data Mining	44328
Nlp	71	Classification	42324

computing, deep learning, and data mining have the highest values, respectively. They have been the most widely used topics in the articles studied. The study of the scientific network of articles also shows that the Internet of Things, social networks, cloud computing, security and machine learning are topics that play an important role in connecting nodes and transmitting information in network communities due to their high intermediate centrality. In the scientific network of articles, in order to deepen the analysis, the structure of the formed communities was examined. The results show that the scientific network of the articles studied in this research consists of 89 communities. Table 11 shows information about the five main communities of the scientific network under study.

Regarding keywords and high frequencies in the articles of the six conferences on web research as one of the research questions, as shown in Fig.5, "social networks", "Internet of things" and "Cloud Computing" have the highest frequency of repetition in their articles.

Fig.6 shows the trend of using the keywords mentioned in the articles in six conferences.

5. Conclusion

Knowledge production is facilitated through the formation of scholarly collaborations of researchers within formal and informal societies. In this study, the co-authorship network, the inter-university cooperation network and the scientific network of articles published in six international conferences on web research were examined using the social network analysis approach. The results of this study showed that based on the number of communities formed, the authors of the conference articles were more inclined to form small scientific groups in the form of universities or research institutes of their respective organizations and the number of inter-university collaborations was much less than within the university. Also, the results of drawing the scientific network of web research conference papers in the previous six periods showed that more attention has been paid to new concepts such as social networks, IoT, and cloud computing.

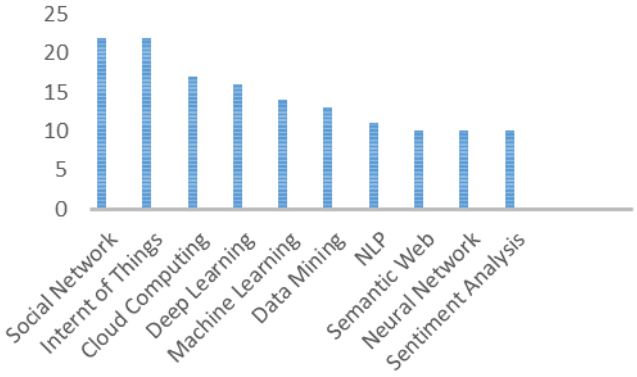

Fig. 5. keywords of high frequency in six conferences

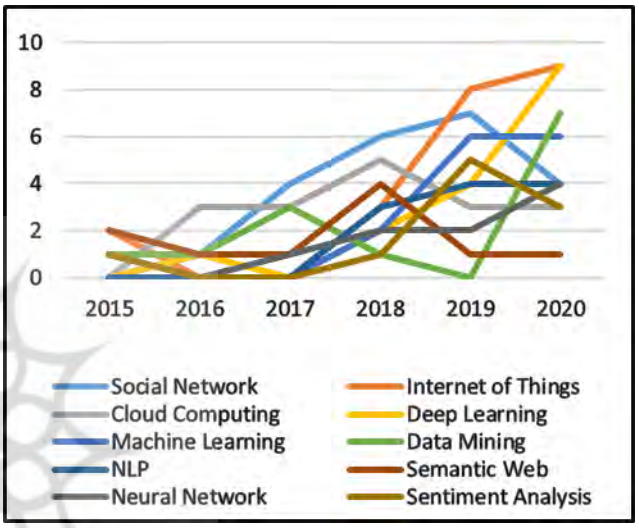

Fig. 6. trend of keywords

TABLE 11. INFORMATION ABOUT THE FIVE MAIN COMMUNITIES OF THE SCIENTIFIC NETWORK UNDER STUDY.

Community	#1	#2	#3	#4	#5
Percentage of total network	11.4%	7.72%	5.75%	5.48%	5.21%
No. of nodes	127	86	64	61	58
No. of edges	947	612	435	382	350
Ratio of edge to node	7.456	7.116	6.796	6.262	6.034
Community density	0.118	0.167	0.215	0.208	0.211
Keyword (based on betweenness centrality)	Machine Learning (69990)	Internet of Things (125408)	Social Network (110949)	Cloud Computing (89007)	Semantic Web (37326)

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