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Conceptual Network Evolution of Cybernetic area in Middle East Countries

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Abstract

The aim of the present study is to visualize the dynamics of conceptual clusters, hidden patterns and emerging knowledge of "cybernetics in Middle Eastern countries" subject area in a global scale based on the co-word analysis of scientific outcomes indexed in the Web of Science database. This research is an applied one, performed with the co-word analysis method and analytical approach. The population includes 2280 keywords from 705 records in the cybernetics subject area in Middle Eastern countries, published in 7 journals indexed in the Web of Science database until 2018. To have a coherence set of data and create the co-occurrence matrix, RavarPreMap software applied. Then, using SPSS 16 and VOSViewer, the subjects were clustered and mapped. Specifications of co-word networks such as centrality and density illustrated using UCInet software in the form of a strategic diagram. Thereby, the situation and evolutionary branches of the cybernetics subject area revealed in Middle Eastern countries. The trend of scientific productions in cybernetics in Middle Eastern counties is incremental. Computer science, with 444 records, is the core subject in the mentioned studies. Researchers' intellectual structures are identifiable in 12 clusters. The most significant cluster is the twelfth one, named master data mining algorithms and including 20 keywords. The distribution of clusters in the strategic diagram shows that Clusters 1, 2, and 4 are core issues in the subject area.Furthermore, they are mature and coherent, being studied at the core of the research area, having a core and developable role. The co-word analysis is a proper and powerful method in discovering and visualizing science and knowledge, tracking sciences, studying the trend of conceptual dynamicity, identifying and analyzing researchable fields in the subject area of cybernetics. This strategic approach can drastically help research planners and policy-makers as well as governmental authorities.

Keywords: Cybernetics, Middle Eastern countries, Scientometrics, Strategic Diagram, Co-Occurrence, Co-Word Analysis.

Introduction

Cybernetics is a transdisciplinary science (Nicolau, 1995), attempting to discover adjusting systems in which some type of self-regulation mechanism exists. This science, due to its transdisciplinary nature, crosses many disciplines' boarders to create a holistic approach (Scott, 2001).In other words, transdisciplinarity attempts to make interactions between disciplines and beyond expertise.Its goal is to understand the current world, and one of its prerequisites is "unity of cognition" and its unique goal is solving the problem through making convergence and building coherence in scientific disciplines and composing them (Nicolescu, 2010). Besides, cybernetics is considered an interdisciplinary science and of no independent nature as a science (Motamedinejad, 2007). However, it is named an independent science (Malmir, 2018). In the twentieth century, cybernetics extended to enter other sciences with its rapid growth and influenced different realms (Hosseini & Baradar, 2017). Historically, various science expertise considered cybernetics as a giant scientific intersection and made use of it in their expertise and disciplines (Motamednejad, 2007; Kokol, 2018; vonFoerster, 2003). Cybernetics is a broad concept, which has been in place for years, and it has developed with many scientific fields and disciplines (Selen, 2015). The main subject of cybernetics is to study the nature of control in human beings, animals, and machines (JamaliMahmui and Asadi, 2005). It correlate with scientific disciplines such as biology, psychology, mechanics, engineering, management, and any other scientific branches (Malmir, 2018).Considering the interdisciplinary and transdisciplinaryof the cybernetics,we are witnessing convergence and coherence, interaction between disciplines, and between different disciplines and specialized disciplines (JamaliMahmuei, 2000).With this view, new knowledge is created by combining the two sciences, In fact, specialized disciplines are recombined in the development of collaboration between specialties and intermediaries (Nichols, 2014).In other words, the "unity of knowledge" creates new realms in knowledge (Khosrowjerdi&Bayat, 2013). Investigating the Performance of transdisciplinarity Communications makes it possible to examine the reflection of the area performance (JamaliMahmuei, 2000).

Today, research and production of science is the main priority of development for any country and a prerequisite for development in other sectors (Janavi and Shahmoradi, 2019). A quantitative and qualitative study of published science productions indexed in prestigious reference databases, is one of the most crucial evaluation indexes for scientific and research activities in many countries (Baji, ParsaiMohammadi & Sabaghinejad, 2011). One of the most important and most frequent methods for evaluating the quality and the quantity of scientific productions is scientometric (Baji et all., 2011, AbediJafari, AbooyeeArdakan, Aghazadeh, & DelbariRagheb 2011).As two important scientometrics methods, cluster analysis and Co-word analysis (Sedighi, 2014).Co-word analysis, as a frequently-used method for evaluating sciences make enables researchers to reveal subjective clusters for research areas (here, cybernetics).Co-word analysis that uses co-occurrence analysis patterns and it could identify the relationship between network and ideas, concepts, and subjects that have hitherto been the subject of research (He, 1999; Callon, Courtial, Turner & Bauin, 1983).As a scientometrics powerful tool, it represents the possibility of examining interdisciplinary studies. Visualizing Global Knowledge of the Concepts' Dynamics, common and hidden Patterns, and Emerging Events, topics and concepts of research. The scientific progress of countries is measured by examining the scientific output of those countries. Scientific progress is defined as the possibility of producing, applying, and transferring knowledge (Merton, 1957).Studying conceptual

relations, identifying and categorizing concepts, discovering hidden patterns and emerging events for concepts and subjective inclinations, identifying and analyzing researched areas, and finally, determining the intellectual structure of knowledge in a subject area and studying the relationship between cybernetic sciences and other sciences using content analysis of passages and published documents has always been considered by researchers to manage this area (Ahmadi & Osareh, 2017).

Studying conceptual relations, identifying and categorizing concepts, discovering hidden patterns and emerging events for concepts and subjective inclinations, identifying and analyzing researched areas, and finally, determining the intellectual structure of knowledge in a subject area and studying the relationship between cybernetic sciences and other sciences using content analysis of passages and published documents has always been considered by researchers to manage this area (ibid).Therefore, interdisciplinary scientific productions that lead to the production of new knowledge are important.

The Middle East is extremely important in terms of geographical divisions, scientific and political changes, and geopolitical conditions (Merton, 1957).its region has undergone various changes in recent years, and since it is one of the most unstable and challenging parts of the world.

In this regard, considering the importance of the cybernetics area and related sciences and the importance of the Middle East region, this study aims to use co-word techniques and show the interdisciplinary concepts of research and identify emerging concepts.

The Studies about this region is overgrowing. Hereupon, the growth of publications seen in the Middle East.

The main problem of this research is to study conceptual relations and identify intellectual structures for the knowledge in the area of cybernetics in Middle Eastern countries. Using the result of the mentioned analysis, researches will be able to research in the area of cybernetics more insightfully and dominantly and with clearer direction. The results will feed planning and decision-making in the Middle East for governmental decision-makers at the top level, and researchers at the bottom level. In addition, it will direct scientific movements and help determine priorities for researchers and identify weaknesses and deficits in the process of producing scientific information, making them more effective.

Scientific productions related to the Middle East and the subject of cybernetics are important. Meanwhile, there is a lack of sufficient up-to-date and comprehensive studies and research in the potential strategic area of scientometrics in the region. In this line, the importance of cybernetics and its related sciences subject as well as the importance of the Middle East in terms of geographic divisions and scientific, political developments, the current research is to study the scientific outcomes of cybernetics in Middle Eastern countries using scientometrics techniques, especially co-word analysis.

The following sections of this research cite some of the criticaland aligned backgrounds about scientometrics analyses related to cybernetics and related sciences and "scientometrics in the Middle East region in various fields of knowledge" with an analytical approach.

Literature Review

In this research, an attempt has been searched, "co-word" and "network collaborations" and "Middle East" and "Cybernetics" and "co-word" and "Middle East" in Scientometrics Journal. Some related items are provided.

In the realm of scientometrics analyses related to cybernetics in Iran, several researchers observed (AzgandiShahr, Mohammadi & Badiezadegan, 2018) who used bibliographic word and content analyses for studying documents and resources in cybernetics cited in ISI database during a 36 years period. The results of this research showed that 5472 research during this period had been published at this database belonging to 98 countries. Also, this research introduced some other issues related more and less to cybernetics. Hosseini & Baradar (2017) concluded that "interdisciplinary"interactions in the field of "cybernetics" in ISI in 2007-2015 have been done with the method of *layer mapping of science*, which includes three main clusters, consisting of 8 fields, namely computer science, management, engineering, electrical engineering, neuroscience, social science, physics, and biology. Computer science has a core role with seven groups and has the most potent and considerable influence in comparison with other fields. Following that, management computer science, artificial intelligence, electrical engineering, and electronics have been the most cited areas, respectively. Two words of "system" and "approach" are the most frequent words. Fazelivarzaneh, Bahmani & Ghaderi Azad (2018) described the situation for scientific productions in the field of *energy* and compared them with Middle Eastern countries for the period of 1998-2017 in the ISI database. Results showed that Iran has 10870 documents indexed in this database in the fields of energy and fuel. The highest number of documents is for 2018. Iran ranked 13th in the world and 1stin the Middle East. Likewise, in terms of international cooperation in the Middle East and the world, most cooperation has occurred between Iran and Turkey, and the USA. The most common keyword used by Iranian researches was optimization genetic algorithm and energy, respectively. Emami, Hariri, Khamseh, Nooshinfard (2016) studied scientific results for thyroid disease Iran and the Middle East during 2007-2013 with the analytical method and scientometrics approach. From the entire2294 documents retrieved in this research, 7374 authors affiliated to 1339 institutes in 700 journals with six formats, have published their works. The *Journal of Thyroid* has had the most frequent references. The highest scientific outcomes, Turkey ranked1st with a total 60.7 percent of all publications, and Iran ranked 2nd with a total 17 percent in the Middle East. In the scientific map, according to regional and global reference indexes for all five clusters, Bandalizadeh (2015) has studied regional capabilities and the geography of science production in scientific fields such as sea sciences, oceanography, agriculture, medical science, petrochemical and energy in Iran with the method of bibliography and subject analyses during 2007-2011. Results showed that experts focus on scientific research and scholar centers in Tehran, and they have and the most cooperation with this province. Furthermore, Tehran, as the scientific pole of Iran, has the most density of scientific production and wealth. Rahimi & Didegah (2010) to study *hot* research papers in Middle Eastern countries in the database of Essential Science Indexes (ESI), concluded that, from 19 countries located in the Middle East, only nine countries have hot research papers, among which Turkey ranked 1st with 27 hot research papers (with 48.21%).The Results of this research also revealed that the average of referencing to these articles has been between 13 to 73 citations for each research paper. The main subject area is *engineering*, while chemistry and clinical medicine rank second and third, respectively. Most countries in the region havebeen participated with each other in producing hot papers at the hottest papers from these countries that havebeen published internationally in cooperation with several other countries.

Several articles found in the area of scientometrics analyses related to cybernetics in Iran. For example, such articles as Iqbal, Qadir, Tyson, Mian, Hassan & Crowcroft (2019) that using

bibliometrics methods, have studied papers master data of four important papers in the fields of computer networks and electronics through master data analysis, content analysis, and citation analyses. Studies show that to generals of COMST and TON are the most creditable journals, and SIGCOMM and INFOCOM publish the most recent original research. Doing bibliographic analyses of cybernetics, KoKol (2018) has provided a snapshot from production in this area. Results showed that the growth of production and revealed that common subjects in this area are engineering and computer science. Moreover, cybernetics research in 2013 has been budgeted and financed by Australia, the United States, and European Financing Agencies. Ye (2018) studied international research about big data during 2012-2017 on 4569 articles, with the aim of discovering the network of co-citation and co-occurrence. As this research concluded, "Big data research"including eight individual clusters and "computer science, information systems" has been recognized as the main subject. Luo, Sun, Erdt, Raamkumar & Theng (2018) have particularly worked on referencing to articles, especially QS referencing in the field of computer science in creditable universities with bibliometrics and altmetrics approach. Nobre & Tavares (2017) studied big data and internet applications in the circular economy (CE) with a bibliographic approach on 30577 documents in the period of 2006 -2015 in Scopus. Their findings showed that China and the United States are the most interesting countries, and Brazil and Russia still lack studies in this area. Khasseh, Soheili, Moghaddam & Mousavi Chelak (2017), using the co-word analysis method, dealt with subjective and conceptual analyses of IMetrics intellectual structure in the period of 1988-2014.Research on papers for six journals of IMetrics Studies showed that 11 clusters exist, namely "information bank and scientist criteria", "reference analysis", "science sociology", "information visualization and retrieval", "webometrics", "Technometrics", "innovation and patents registration", etc. Heilig & Vob (2014) studied the interdisciplinary area of cloud computing using scientometrics. In this area, computer science, engineering, mathematics were the main three subjects. Singh, Perdigones, García, Cañas-Guerrero & Mazarrón (2014) studied scientometrics in computer science and cybernetics from 1997 to 2000 on 16445 papers, under the category of "computer science, cybernetics" in the ISI. Results showed that 30 countries at the top of the list in this area account for 90.3% of global production. Studying cooperative relationships, the number of documents in the computer science area in Spain in the period of 2000-2009, Ibáñez, Bielza & Larrañaga (2013) concluded that the most percentage belongs to three authors, while single-authored papers have the least percentage. In terms of reference numbers, no positive correlation between authors' personalities and the impact of reference found. Furthermore, documents with two authors receive more citations than documents with more than two authors each year. In a scientometrics study of computer science papers in IEEE Transactions in the period of 1980-2010, Hamadicharef (2011) reported growth in productions and cooperation between authors from the same country as well as international cooperation. Co-word analysis results for this research proposed for creating Tag Clouds, hoping to help the area of software engineering through historical studies. Franceschet (2010) studies the role of computer sciences in conferences. The short history of computer science, the important role of conferences in empowering and promoting the area emphasized, and several ways were studied. Bartneck and Hu (2009) studied CHI Proceedings in 26 years with a scientometrics approach. Results showed that only 7.8 percent of countries account for 80 percent of CHI Proceedings papers. Moreover, the United States is the country with the most papers. However, the success of a country or an organization does not depend only on the number of accepted papers. McCain

(1998) has dealt with the outcomes of neural networks and creating an interdisciplinary field for it. This research done on 36 journals during three consequent periods, and cluster analysis and MDS maps showed that physics/optics, computer science, neuroscience, expert systems cognition, and understanding neural networks and mathematical modeling of neural systems mentioned in research papers. In a bibliometric analysis on research papers in ICT area in developed CWTS ICT, Tijssen and Van Wijk(1998) showed that the main source for developing and making use of ICT is the scientific and engineering database. Bilateral comparison of countries in terms of scientific production level and cooperation patterns showed that most countries are active in publication. However, the number of three regions' publications is higher than in other countries, namely the United States, Europe, and Japan. Finally, scientometric analysis of systems science and cybernetics by Lewicka-Strzalecka(1986) showed that this analysis lead to the statement that science is an information system in which scientific publications are the carriers of information.

Overall, studying research background shows that, a Research that focused on "Cybernetics" and "co-word" and "Middle East topic has not been seen. In recent years, various experts have used different methods of scientometrics in order to study different subject matters. This approach has a more extended history than research in Iran. Scientometrics analyses bibliography and co-word analysis are proper methods for visualizing the structure of science and creating subject maps in various scientific areas. Various experts in different knowledge areas have consistently and increasingly used analytical methods related to scientometrics and bibliography, especially in cybernetics and related areas, in which we observe more and more research papers with a scientometrics and bibliographic approach in Iran and other countries.

Objectives

According to the illustrated theoretical framework, the main goal of this research is to study the trend of conceptual dynamics in the area of cybernetics in Middle Eastern countries based on co-word analysis of scientific outcomes in Web of Science. In order to achieve the main goal of this research, answering the following questions is necessary.

1) How is the trend of producing scientific outcomes in the area cybernetics in Middle Eastern countries?
2) Which are core journals in the area of cybernetics in Middle Eastern countries?
3) How is the ranking of outstanding keywords in the area of cybernetics in Middle Eastern countries based on co-word analyses like?
4) How is the clustering of subjects in the area of cybernetics in Middle Eastern countries based on cluster analysis?
5) According to the results of cluster analyses and the subject of the cybernetics area,what does researchers' intellectual structure look like in Middle Eastern countries?
6) According to the strategic diagram, what does the structure of the cybernetics subject field in Middle Eastern countries look?

Research method

The research is applied research, regarding objectives scientometrics approach, with descriptive-analytical method and it has been done using co-word analysis. This method based on the fact that a set of documents' words and concepts show its contents (Khazanehaet

Heaidary, Mostafavi 2019). Looking at the level of collocations of concepts, one can depict the subjective structure of various sciences (Mostafavi et al., 2018). Co-word analysis is a proper method for discovering communications between science's research areas and a powerful tool for discovering knowledge that shows the possibility of following structural developments and evolution of understanding and social networks and essential binds that otherwise would be very difficult to be this covered (Ahmadi & Osareh, 2017).This method used for emphasizing main subjects and illustrating hidden relationships of the cybernetics subject area. In order to gather data, the WOS database, as the most credited, broadest, and oldest scientific database, is used (Birkle, Pendlebury, Schnell & Adams, 2020). This website is a suitable platform for providing key and outstanding scientific papers (Soheili, Danesh, Mesrinejad & IsfandyariMoghadam, 2012) following the approach introduced by Milojevic & Leydesdorff (2013), the statistical population of this research included all papers published in "Cybernetics"subject field and"Middle East"papers published in seven journals (Table 1).These seven journals indexed in JCR (Journal Citation Reports) (which has a unique approach in indexing articles). The reason for choosing these journals is that they publish most of the papers in the field of iMetrics (ibid).

A relatively comprehensive method introduced by Milojevic & Leydesdorff (2013) was employed for data collection in this study. Initially, all documents in the WoS that were published in the seven journals were extracted. To do the research, first, the journal Cybernetics in the determinant section of WoS database, JCR, by searching for "Cybernetics" in the journal section, 15 journals were called, of which only 7 journals were indexed in this database until 2018. The rest of the publications did not have the necessary points to be indexed until 2018, and in a way, they were looking for a database without any results. Then, 7 selected journals were retrieved in the advanced search section of WoS database and the selection of three citation indexes of basic sciences, social sciences, arts and citation index of conference papers was 10,850 records. Because the purpose of this study was to cover the articles of the Middle East countries in the field of Cybernetics, by creating restrictions on Middle Eastern countries, 705 records were set, and the following search strategy indicates how to search:

we searched for: SO = ("Biocybernetics and Biomedical Engineering" OR "Biological Cybernetics" OR "Cybernetics and Systems" OR "Economic Computation and Economic Cybernetics Studies and Research" OR "IEEE Transactions on Cybernetics" OR "IEEE Transactions on Systems Man Cybernetics-Systems" OR "International Journal of Machine Learning and Cybernetics").Refined by: countries/regions: (Qatar OR Egypt OR Iran OR Oman OR Turkey OR Israel OR Saudi Arabia OR Jordan OR Iraq OR Kuwait).Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH.

Most of the scientific outputs of the Cybernetics realm of the Middle East were of the article type (97.872%) and included 690 records. In order to refine data and build a co-occurrence matrix, the Ravar Matrix: Ravar Pre Mapco-word network application used. Then, using SPSS 16 and VOS viewer 1.6.11, subjects in this area were mapped, clustered, and visualized. Then, specifications of co-word matrix network such as centrality and density, using UCINET and VOSviewer software, in the form of a strategic diagram (Figure 3).with the horizontal axis of centrality (i.e. The level of correlation between clusters) and the vertical axis of density (i.e. The level of internal relations in every cluster) is shown (Ke, Yunjiang, Xiao & Weichan, 2013; Melcer, Nguyen, Chen, Canossa, El-Nasr M & Isbister, 2015). In Strategic Diagram, the higher the Centrality of a cluster, the more critical that cluster is in the research

topic, and the higher the Density of a thematic cluster, the more capable or mature that cluster is. The Strategic Diagram can show in 4 quadrants, each with different densities and centralities, and each cluster in each quadrant has a different status (He, 1999). Thereby, the situation and evolutional trends for the subject area of cybernetics in Middle East illustrated. This search has done in December 2019. In this research, co-word means co-occurrence of keywords in scientific papers.

Findings

The trend of producing scientific publicationsin the area of cybernetics in the Middle East The trend of scientific production in this area (figure 1) has been started from 1975 and has risen proximately from 2013 to 2019 consistently. A significant increase in the level of production in this area seen.In 2019, 98 records (approximately 13 % of the total 7045 records) belonged to this area.

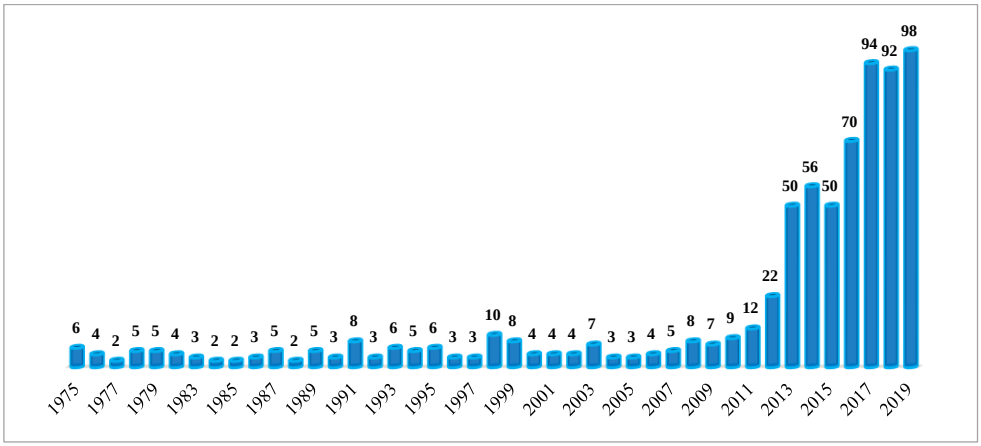


Figure 1. The trend of publications in cybernetics area in Middle Eastern countries in 1975-2019

- Core journals of cybernetics area in the Middle East in the WOS database

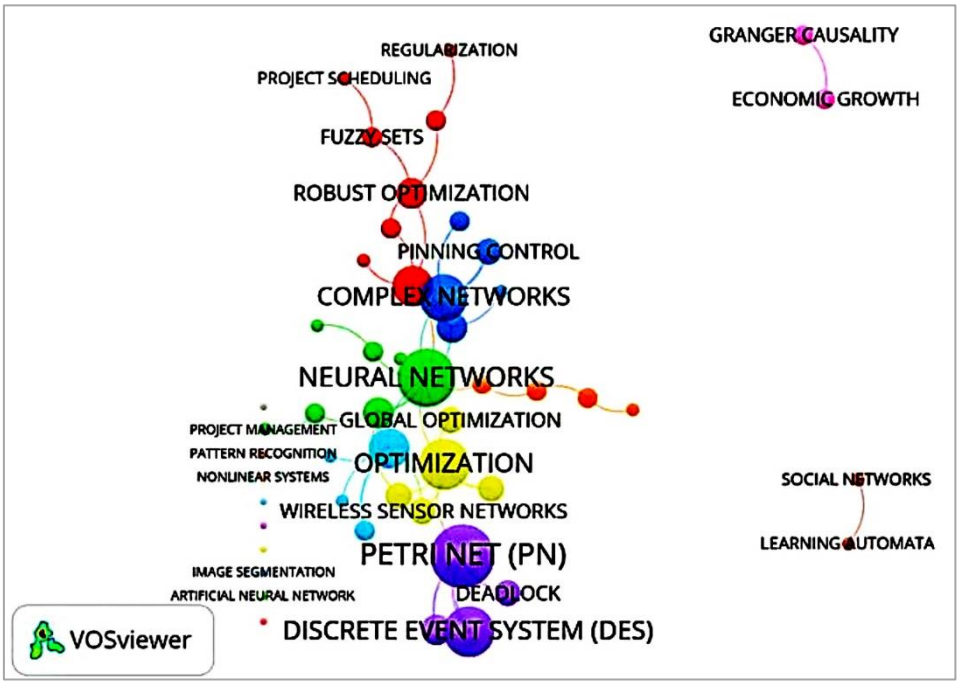
The seven core journals in table 1, in which all scientific outcomes in the area of cybernetics published in the Middle East are provided. In order to evaluate and rank these journals, some criteria are mentioned. The number of articles varies from 78 to 137 article titles. Three journals with Q1 rank have articles related to cybernetics in Middle Eastern countries. Most articles have been published in the journal of *Biological Cybernetics*withQ3 rank and IF- 1.305 belonging to the United States. Following that, two journals in the field of electronics with Q1 rank titled "IEEE Transactions on Cybernetics" and "IEEE Transactions on Systems Man Cybernetics-Systems "have the highest number of articles. In this table, the number of articles published in each journal, impact factors, Q-index and every journal's country are seen. The table below is based on Journal's IF.

Table 1
Core journals of cybernetic area in the Middle East in WOS database

Source Titles/ Journal's name	Records	% of 705	IF	Quartile rankings	Country
IEEE Transactions on Cybernetics	123	17.447	10.387	Q1	USA
IEEE Transactions on Systems Man Cybernetics-Systems	108	15.319	7.351	Q1	USA
International Journal of Machine Learning and Cybernetics	82	11.631	3.844	Q1	Germany
Biocybernetics and Biomedical Engineering	77	10.922	2.159	Q3	Netherlands
Cybernetics and Systems	76	10.78	1.681	Q3	USA
Biological Cybernetics	137	19.433	1.305	Q3	USA
Economic Computation and Economic Cybernetics Studies and Research	102	14.468	0.973	Q3	Romania

Top-ranked keywords in the area of cybernetics in Middle Eastern countries bases on co-word analysis

In order to cluster and map the subject for the cybernetics area in Middle Eastern countries, from the total number of 2280 keywords, 51 keywords with the frequency of at least three selected. Map 1 shows the most frequent words in cybernetics area research papers in Middle Eastern countries based on the co-word analysis. In this map, the size of nodes shows the weight of scientific production for every author, and colors show the clusters.



Map 1. The structure of the top keywords network in cybernetics area in Middle Eastern countries based on co-word analysis

Clustering subjects in cybernetics area in Middle Eastern countries with the cluster analysis method

In order to cluster subjects based on subject similarity, a word frequency matrix produced. Then, the correlation matrix derived from the co-word frequency matrixentered into SPSS. Using SPSS and retrieving the co-occurrence matrix, applying WARD and calculating Euclidean distance, hierarchical clustering performed, and a Dendrogram for subjects was

produced (figure 1). Hierarchical clustering of this subject area in 12 clusters in table 2.

Table 2
Clustering subjects in cybernetics area in Middle Eastern countries with the cluster analysis method

cluster	keywords	NO.
C1	Petri Net (PN); Discrete Event System (DES); Semiconductor manufacturing; Deadlock	4
C2	Complex network; Pinning control; State estimation	3
C3	Heuristic Algorithms; Wireless Sensor Network	2
C4	Optimization; Mission Cost; Global Optimization	3
C5	Economic growth; Granger causality	2
C6	Portfolio Optimization; Regularization	2
C7	Evolutionary Algorithms; Metric learning; Multi-objective Optimization; Robust Optimization	4
C8	fuzzy Control; Takagi- Sugeno (T-S) fuzzy Systems	2
C9	Neural networks (NNS); Stability Analysis; Concept Drift	3
C10	Genetic Algorithm (GA); Simulated annealing; Particle Swarm Optimization (PSO); Optimal Control	4
C11	fuzzy set; Project scheduling	2
C12	Machine learning; Support Vector Regression; Support Vector Machine; Electroencephalography Signals (EEG); learning Automaton; Social Networks; Multi-Agent Systems (MASS); Containment Control; Reinforcement Learning (RL); Clustering; Project Management; Sensor Networks (SNS); MCDM (Multiple-criteria decision-making); Nonlinear System; Pattern Recognition; Big data; Decision trees; Image segmentation; Artificial bee Colony Algorithm; Artificial Neural Networks	20

Researchers' intellectual structures derived from the results of cluster analysis in cybernetics area in Middle Eastern countries

Analyzing each of the 12 clusters derived from hierarchical cluster analysis of table 2 (Dendrogram, Figure 2), one can achieve those subjects that have been mostly considered by Middle Eastern researchers. These clusters and subjects are as follows:

The first cluster: **system modeling for performance evaluation**. Results of the co-word analysis showed that four keywords had contributed tithe creation of this cluster (as seen in Figure 2), those keywords that acted as causes for naming this cluster are Petri Nets and discrete-event simulation.

The second cluster: complex network, including three keywords, namely complex networks, Pinning control, and State Estimation. The name of this cluster chosen according to the mentioned keywords.

The third cluster: heuristic algorithms of wireless sensor networks. This cluster has two keywords, namely heuristic algorithm and Wireless sensor network.

The fourth cluster: operational costs optimization. This cluster includes three keywords, namely optimization, mission Cost, and Global optimization.

The fifth cluster: economic growth in the light of Granger's causality test, including two keywords, namely Economic growth and Granger causality.

The sixth cluster: The reason for this naming is two keywords of portfolio optimization and regularization.

The seventh cluster: regularization of portfolio optimization", multi-objective robust evolutionary optimization based on algorithms. This cluster includes four keywords, namely

evolutionary algorithm, metric learning, multi-objective optimization, and robust regularization of portfolio optimization. The cluster name derived from the algorithm.

The eighth cluster: Fuzzy control systems. This cluster's name is because of two keywords: FUZZY control Takagi–Sugeno fuzzy systems.

The ninth cluster is named neural networks. This cluster consists of three keywords, and the cluster name chosen from two of them, namely neural networks and concept drift.

The tenth cluster: genetic algorithm. This cluster includes four keywords, but its name derived from the keyword genetic algorithm and other related words.

The eleventh cluster: project scheduling with fuzzy sets. This cluster named because of the presence of two keywords in it: project scheduling and FUZZY Sets.

The twelfth cluster: knowledge management and master data mining. The biggest cluster of the Dendrogram, including 20 keywords (table 2).Such keywords as Machine Learning, BIG Data, Decision Trees, Artificial Bee ColonyAlgorithm, and Artificial Neural Networks were affective in naming this cluster.

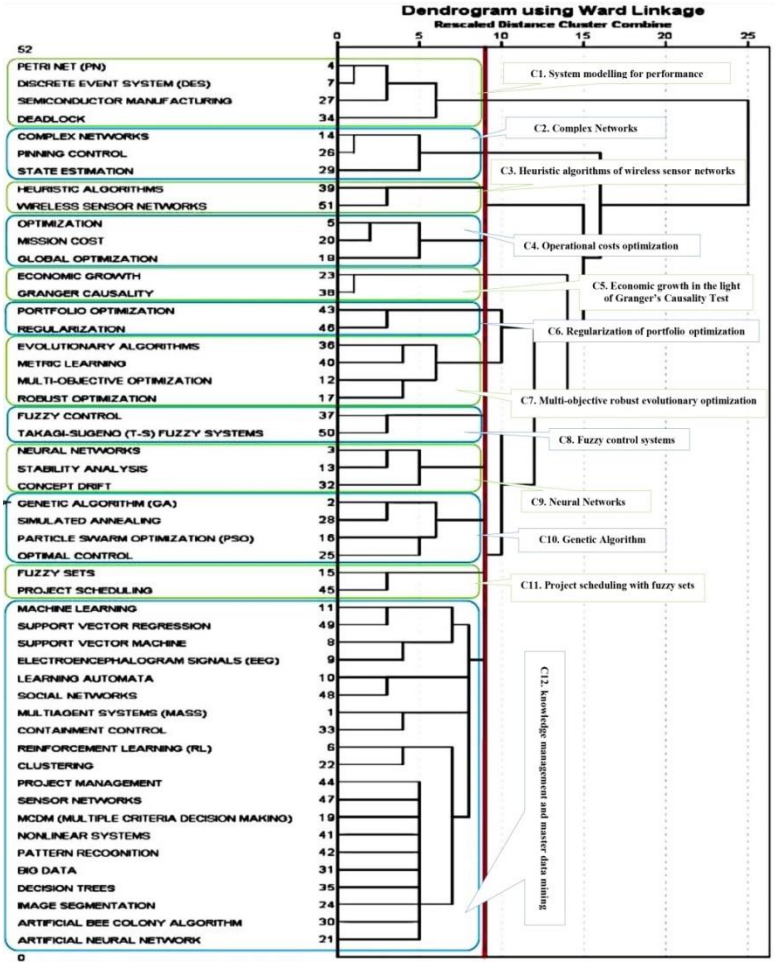


Figure 2. The dendrogramfor clustering subjects derived from the results of cluster analysis of cybernetics area in Middle Eastern countries

The structure of the subject area of cybernetics in Middle Eastern countries according to the strategic diagram

In a strategic diagram, the higher the centrality of a subject cluster is, the more critical that cluster is in the studied research area. Moreover, the more is the density of a subject cluster, the

more mature and capable it is that cluster. Hereupon, as seen in figure 3, is divided into four quarters (Wu et al., 2013).

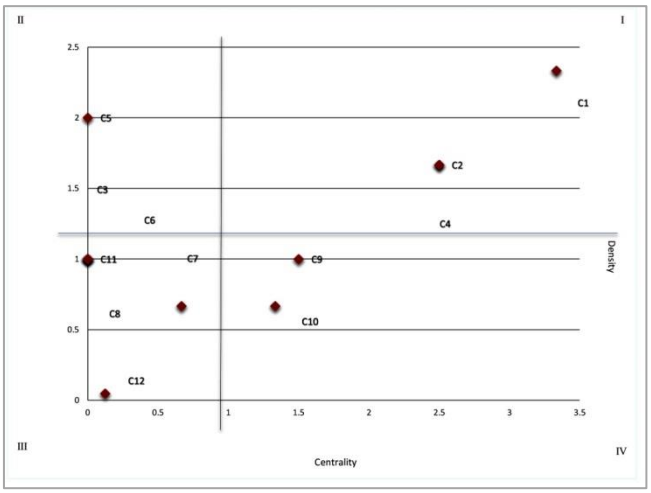


Figure 3. Strategic diagram of cybernetics area in Middle Eastern Countries

The horizontal axis of this matrix is Degree / Centrality, and the vertical Y-axis is density (the internal communication power of each cluster).

Dimension I includes adult and central clusters, where dimension II has been developed but in separate clusters. Dimension III includes emerging or declining cluster, and dimension IV including central but underdeveloped clusters (Melcer et al., 2015).

Distribution of clusters in the strategic area (figure 3) shows that Clusters 1, 2, and 4 are into the I quarter. Clusters 3, 5, and 6 are into the II quarter. Clusters 7, 8, 11, and 12 are in quadrant III. Clusters 9 and 10 are into the IV quarter.

Discussion

scientometric and bibliometric tools have become an important and desirable tool for evaluating research activities and scientific outputs (Biglu, 2008) and can play a role as a powerful tool of science policy (Ivancheva, 2008). Scientific models and maps have been able to act as suitable methods for illustrating the increasing growth of scientific activities and organizing intellectual structures consisting of a subject area (i.e., cybernetics in middle eastern countries) in order to provide insights for researchers and help correct policy-making.

Accordingly, in this study, through using word co-occurrence analysis techniques, the structure of concepts and research topics in "Cybernetic area in Middle East countries" and its dynamics, emerging events' discovery, and conceptual relationships hidden patterns in 44 years (1975-2019) were examined.

Bibliographic analysis of scientific outcomes in the area of cybernetics shows an increase in the production of papers and scientific outcomes in cybernetics area, an increase in the use of cybernetic concepts in more research areas more desirably. This shows the tendency and importance of cybernetics in the Middle East.

The results also showed that *Biological Cybernetics* with Q3 Rank, is the most productive but *IEEE Transactions on Cybernetics* with the highest Impact Factor (Table 1). From the point of view of scientometrics, further citation, followed by an increase in the Impact Factor index, does not necessarily imply a higher value and quality of the author's work. In the present study, the leading scientist and producer of the mentioned field does not have the highest H-index.

This indicates that the H-index can increase with self-citation. Therefore, H-index is a common indicator for evaluation, but it does not determine the level of the author, because it can easily change and increase on a large scale with the amount of self-citation (Shaibu, Anthony & Emmanuel, 2020; Hirsch, 2019).

Based on co-word analysis, the intellectual structure governing research in the subject area of cybernetics in the Middle East shown in 12 subject and concept clusters. The results of the present study showed that in the period of 1975 to 2019, the main and superior concepts of this realm, respectively"Computer Science Cybernetics","automated control system", "computer science artificial intelligence", "Neuroscience", "economics", "Mathematics, Interdisciplinary Applications", and "Biomedical engineering", are frequent." Computer Science Cybernetics" was at the core of cybernetics in the Middle East. This is also stated in the research of Hosseini & Baradar (2017), Heilig & Vob (2014) and Ye (2018).On the basis of co-word analysis, the intellectual structure governing research in the subject area of cybernetics in the Middle East is shown in 12 subject and concept clusters, namely "system modelling for performance evaluation", "complex networks", "heuristic algorithms of wireless sensor networks", "operational costs optimization", "economic growth in the light of Granger's Causality Test", "regularization of portfolio optimization", "multi-objective robust evolutionary optimization", "fuzzy control systems", "neural networks", "genetic algorithm", "project scheduling with fuzzy sets", "knowledge management and master data mining". Looking at the twelve clusters, we also see a focus on computer science-related topics in cybernetics.

Distribution of clusters in the strategic area (figure 3) shows that Clusters 1, 2, and 4 are core, and mainstream Clusters in the subject area in Middle Eastern countries fall into the first quarter

Furthermore, those clusters have high centrality and high density, then they are mature and studied at the center of the research area and having a core and developable role; Clusters 3, 5, and 6 are developed but isolated. While clusters in quadrant II are also coherent, they tend to be specialized and separate from the overall focus (Melcer, 2015); Clusters 7, 8, 11, and 12 are emerging and declining. Clusters in quadrant III are in flux, representing emerging or declining portions of the network (Melcer, 2015).Clusters 9 and 10 are general and broad. Quadrant IV contains clusters that represent a standard, broad focus, or have not yet matured but have the potential to be a primary network focus (ibid).Regarding the centrality of researches in this area, researchers, on the one hand, seek emerging subjects, and on the other hand, the current studies will be eroded sooner their place in the area of information technology. Paying attention to new subjects that can be emerging and move in the path of maturity is necessary (the fourth quarter of the figure).

Discovering conceptual relationships between scientific outcomes in an area is a complicated process. Results need a deep understanding and maybe analyzable with every viewpoint and may not be acceptable by the public. However, the trend provided by this research can lead to a better understanding of the cybernetics area in the Middle East. With the results of this research, researchers will be able to provide a more different solution for scientific and technical idea creation and synchronize the general structure of this area with international developments more quickly and influentially.

Emphasizing on the interdisciplinary nature of cybernetics, this research aligned with Hosseini & Baradar (2017), who have studied the interdisciplinary interactions in cybernetics with a method named "layer mapping of science".That research studied three main clusters,

including eight subject areas, while this research dealt with 12 clusters in the area of cybernetics. Like the present research, their results explain this reality that cybernetics deals with computer science more than any other science, which deals with a systematic study using smart accounting mechanisms (algorithms). Electronics has the second rank of alignment with cybernetics. In Kokol (2018), engineering, computer science, medicine, mathematics reported as the most studied subjects in the cybernetics area, respectively.

Furthermore, the research by AzgandiShahr et al. (2018) and Kokol (2018), dealing with documents and researches in the area of cybernetics, is aligned with this research, who has dealt with providing a profile of the scientific structure of cybernetics area, especially when one pays attention to the fact that in this research, scientific outcomes in the forms of journals and scientific papers in WOS studied. Kokol's study, dealing with the cybernetics area in the international arena, shows that the Massachusetts Institute of Technology is the top producer of scientific outcomes in this area. In terms of research method, the current research is similar to and aligned with those of (Khasseh et al., 2017; Fazelivarzaneh et al., 2018; Iqbal et al., 2019; Ye, 2018; Luo et al., 2018); Nobre & Tavares, 2017; Heilig, & Voß, 2014; Singh et al., 2014; Ibáñez et al., 2013; Hamadicharef, 2011; Franceschet, 2010; Bartneck & Hu, 2009; McCain, 1998; Tijssen & Van Wijk ,1998).

The results of such research can affect research policy-making positively. Applying the results of this research and similar works taking other machinations, And the definition of the circle of concepts and subjects that have been worked in the realm of cybernetics (Table 2), research authorities can be more successful in growing and developing concepts related to this subject area and may act more creative strategies in the light of proper macro-level planning activities.

Conclusion

Using scientometric tools, the intellectual structure governing the Cybernetic area in Middle East countries thematic area in the form of 12 thematic and conceptual clusters and the maturity and coherence of each cluster in the strategic diagram show the current global trends of research in this subject area. Overall, co-word analysis is an efficient method for discovering and depicting science and knowledge maps, tracking sciences, visualization, studying conceptual evolution and dynamics as well as identifying researchable fields in subject areas. This method can help authorities take more rational and realistic strategies in their national-level decision-making. The word co-occurrence analysis techniques, the structure of concepts and research topics in Cybernetic area in Middle East countries and its dynamics, emerging events' discovery, and conceptual relationships hidden patterns were examined. It suggested that other scientometrics metrics such as co-authoring, co-citation, and content analysis applied for similar and different periods in the Middle East in future research. Furthermore, future researchers could study highly-cited papers and hot papers in cybernetics in the Middle East with similar approaches.

Conflicts of interest

This paper is the result of an independent study with no financial support. The authors have no conflict of interest in doing this study.

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