ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/sportsci.2022-93356

A Bibliometric Analysis on Machine Learning in Sports Studies From 1999 to 2021

1999-2021 Yılları Arasında Yapılmış Spor Araştırmalarında Makine Öğrenmesi Üzerine Bir Bibliometrik Analiz

Halil Orbay ÇOBANOĞLU[a], Eren AKDAĞ[b], Muhammed Akif KURTULUŞ[c]

[a]Department of Coaching Education, Alanya Alaaddin Keykubat University Faculty of Sports Sciences, Antalya, Türkiye
[b]Department of Physical Education and Sports Teaching, Alanya Alaaddin Keykubat University Faculty of Sports Sciences, Antalya, Türkiye
[c]Department of Mathematics and Science Education, Alanya Alaaddin Keykubat University Faculty of Education, Antalya, Türkiye

ABSTRACT Objective: The aim of the research is to make a bibliometric analysis of articles published using machine learning-sports key concepts. For this purpose, 654 studies published in the sources scanned in the Web of Science Core Collection database between 1999-2021 will be examined bibliometrically and the trend in the last 23 years will be revealed. **Material and Methods:** The database was searched using the keywords "machine learning" and "sports" and the number of studies for years, the average number of citations per year, the journals and authors that published the most on this subject, the citation burst values of the authors, the countries and cooperation status of the responsible authors, the most the cited articles, word cloud and word tree map and conceptual structures were examined under their sub-titles. **Results:** According to the results obtained, it can be said that the interest in the subject has increased after 2014. The journal in which the articles on this subject were published the most was "Sensors", and it was determined that Musa RM was the author who wrote the most articles. The most cited work was written by Li and Wu in 2010. **Conclusion:** In the articles written, it has been determined that Australia and the United Kingdom are the countries most open to cooperation, and the most used concepts in the keyword and title section are "performance" and "learning". It is believed that the results obtained will shed light on researchers who want to conduct research on this subject.

Keywords: Machine learning; sports; bibliometric analysis; network analysis

ÖZET Amaç: Bu çalışmanın amacı, "machine learning-sports" anahtar kavramları kullanılarak yayımlanan makalelerin bibliyometrik analizini yapmaktır. Bu amaç doğrultusunda 1999-2021 yılları arasında Web of Science Core Collection veri tabanında taranan kaynaklarda yayımlanan 654 çalışma bibliyometrik açıdan incelenerek son 23 yıldaki eğilim ortaya koyulacaktır. **Gereç ve Yöntemler:** Veri tabanında "machine learning" ve "sports" anahtar kavramı kullanılarak tarama gerçekleştirilmiş ve yıllara ilişkin çalışma sayısı, yıllık ortalama alıntı sayısı, bu konuda en çok yayın yapan dergiler ve yazarlar, yazarların atıf patlama değerleri, sorumlu yazarların ülkeleri ve iş birliği durumları, en çok atıf alan makaleler, kelime bulutu ve kelime ağacı yapıları ve kavramsal yapıları alt başlıklarında incelenmiştir. **Bulgular:** Elde edilen sonuçlara göre konuya olan ilginin 2014 yılından sonra arttığı söylenebilir. Bu konudaki makalelerin en fazla yayımlandığı dergi "Sensors" olup, Musa RM'nin en fazla makale yazan yazar olduğu belirlenmiştir. En fazla atıfı alan çalışma 2010 yılında Li ve Wu tarafından yazılmıştır. **Sonuç:** Yazılan makalelerde Avustralya ve Birleşik Krallık'ın iş birliğine en açık ülkeler olduğu, anahtar kelime ve başlık kısmında en çok kullanılan kavramların "performance" ve" learning" olduğu tespit edilmiştir. Elde edilen sonuçların bu konuda araştırma yapmak isteyen araştırmacılara ışık tutacağına inanılmaktadır.

Anahtar Kelimeler: Makine öğrenmesi; spor; bibliometrik analiz; ağ analizi

With the arrival of the new millennium (particularly the late 2000s and the early 2010s), data science, which had been lacking interest and investment due to insufficient infrastructure, saw significant improvements in fields such as machine learning and artificial intelligence.[1,2] Developments in computer hardware, increased use and dependence on integrated circuits, high-performance data processing, cluster calculation, parallel data processing and cloud data processing emerged in the late 20th century and the early 21st century. These developments made it possible to analyze data sets, which are increasingly complex by nature and consist of hundreds of gigabytes and terabytes.[3,4]

Correspondence: Eren AKDAĞ
Department of Physical Education and Sports Teaching, Alanya Alaaddin Keykubat University Faculty of Sports Sciences, Antalya, Türkiye
E-mail: e.erenakdag@gmail.com

Peer review under responsibility of Turkiye Klinikleri Journal of Sports Sciences.

Received: 13 Sep 2022 ***Received in revised form:*** 23 Nov 2022 ***Accepted:*** 29 Nov 2022 ***Available online:*** 05 Dec 2022

Data science is a machine learning principle that uses various tools and algorithms to find patterns among raw data. In terms of data science, sports analysis is the use of data related to a game or sport to find prediction-based machine learning models. The main goal in obtaining these data is to improve the general performance of the team and increase the chances of winning.[5]

When the related literature is reviewed, it is observed that studies were conducted on numerous subtopics such as the prediction of match results using the machine learning approach, the use of artificial neural networks in sports biomechanics, the creation of algorithms through collecting electrocardiography and electromyography signals to determine exercise fatigue and the prevention of fatigue and injury during exercise, the creation of soccer teams and transfer support using the machine learning approach, making strategic decisions and building the best team, the investigation of professional soccer players' wages, the direction of coaching experience, and the enhancement of player performance.[6-13]

Artificial intelligence refers to the technology that imitates human tasks and uses machine learning to identify how these tasks will be imitated.[14] The data analytics focus of machine learning involves artificial intelligence making inferences from computer experience as well as learning by itself and playing a supporting role.[15] One of the sectors widely utilizing artificial intelligence systems, which are helpful in many subjects ranging from training to player monitoring, tactical decision-making and doping detection, is the sports sector.[16]

In the present study, "bibliometric analysis" was used. Bibliometrics is an effective method in analyzing the research trends of a specific field. Using bibliometric analysis, publications can be grouped according to features such as the number of citations received, author name, journal name, country (or region) of origin, institution name, type of article and research field. Bibliometric studies enable journals to make their own internal evaluations and direct scientific publication policies. They also provide researchers with the opportunity to obtain information regarding the subject fields they study.[17] It is observed that bibliometric analysis is a very effective method in identifying and evaluating countries, institutions, subject fields, journals and specific study subjects.[18] To make a more comprehensive and broad definition, bibliometric can be defined as the set of methods used in the quantitative analysis of information such as the author, field, subject, citations, country and institution of scientific publications such as print journals, books and articles using mathematical and statistical tools, providing certain clues regarding the related discipline, field, subject, institutions, countries, authors and collaboration between authors.[19-21] Bibliometrics is concerned with the examination of various elements of academic publications with the help of numerical analyses and statistics. While bibliometric analyses can be descriptive in the form of determining the number of articles published in a specific year, they can also be evaluative in the form of citation analyses to reveal how an article affects subsequent studies.[22] Borgman and Furner state that bibliometrics offers strong tools in defining, clarifying, evaluating and predicting the structure and functioning of academic communication, therefore being frequently used in a wide range of scientific fields, particularly those based on numerical methods.[23]

In the literature, numerous bibliometric studies on various subjects are found.[24-26] When the related literature is reviewed, to the best of authors' knowledge, there is no bibliometric studies combining machine learning and sports are found. In this context, the present study aims to introduce the leading researchers in the field and their work, the journals that publish articles on the issue, and the most frequent keywords used when researching related literature on databases. It is believed that the findings of this study can guide researchers interested in this line of research.

MATERIAL AND METHODS

In the present study, which adopts the descriptive study model, the bibliometric features of studies found on the Web of Science (WoS) Core Collection database using the keywords "machine learning" and "sports" were determined.

SAMPLE

The study data consist of previous studies on the WoS database published in various journals between 1999 and 2021 and related to the keywords "machine learning" and "sports". Based on the data obtained on the subject field reviewed within the framework of the present study, the year 1999 was selected as the starting date as the first study in the database was published in that year. The studies published in 2022 were not included in order not to affect the analysis, as the year is not over at the time of the present study. In bibliometric studies, the most important sources of data are international citation indexes such as the Science Citation Index, the Social Science Citation Index and the Art & Humanities Citation Index. In this context, the present study was conducted through the WoS database as it is one of the databases providing access to these indexes and the bibliometric analysis system operated through the R-Studio program is compatible with this database.[27,28]

DATA COLLECTION

In the present study, the database was scanned using the keywords "machine learning" and "sports", and a total of 718 studies were found. Limitations on document type and time frame were applied in line with the purpose of the study, and a total of 654 studies were found. The distribution of these 654 studies by year was identified as well as the mean number of citations, journals with the most publications, authors with the most publications, the citation burst values of authors, h-indices, the scientific productivity of countries, the most cited sources, collaboration networks, word clouds, word tree maps and conceptual structures.

DATA ANALYSIS

In obtaining findings related to the publications reviewed within the scope of the present study, the R-Studio program was used. The R environment provides numerous packages used for bibliometric analyses on https://cran.r-project.org/, its official repository. These package programs used in bibliometrics are very functional for quantitative studies.[29] The R program was used in the bibliometric analyses as it possesses more findings and detailed demonstrations.

In the preparation of the data file from the WoS database based on the criteria of the study, first, the "export" option was selected. After the WoS export option was selected, the full record and cited references option was selected and the bibtex file was prepared. In this phase, due to the fact that the database downloads up to a total of 500 studies at once, an additional data file between 500 and 654 was created and combined. Afterwards, the "bibliometrix" package was downloaded on the R-Studio program and activated. The "bibliometrix" package was run on R-Studio. Finally, the R-Studio program redirected to a bibliometric analysis page over an address. Here, the "bibtex" file was uploaded to the data section and analyses were performed.

RESULTS

Table 1 shows the information regarding a total of 654 studies on machine learning by year.

It is observed that in accordance with the scanning limitations, the studies on machine learning started to be published in 1999, and the highest number of studies on the related field were published between the years 2019 and 2021 (f=399). It is seen that the studies published after 2014 constitute 89.76% of the total. Figure 1 shows the three-fields plot graphic. Three fields-plot summarizes important information on the subject field combining 3 different graphs. The section on the left of Figure 1 shows the authors who conducted a large number of studies on the subject while the middle section shows the keywords most frequently used by the authors and the section on the right shows the journals that published a large number of studies on the subject.

It is indicated that the authors "Musa", "Abdullah", and "Wang" are important figures in the field,

TABLE 1: The number of studies by year.

Year	Number of studies (f)	Percentage (%)
1999-2002	1	0.15
2003-2006	10	1.53
2007-2010	20	3.06
2011-2014	36	5.51
2015-2018	188	28.75
2019-2021	399	61.01

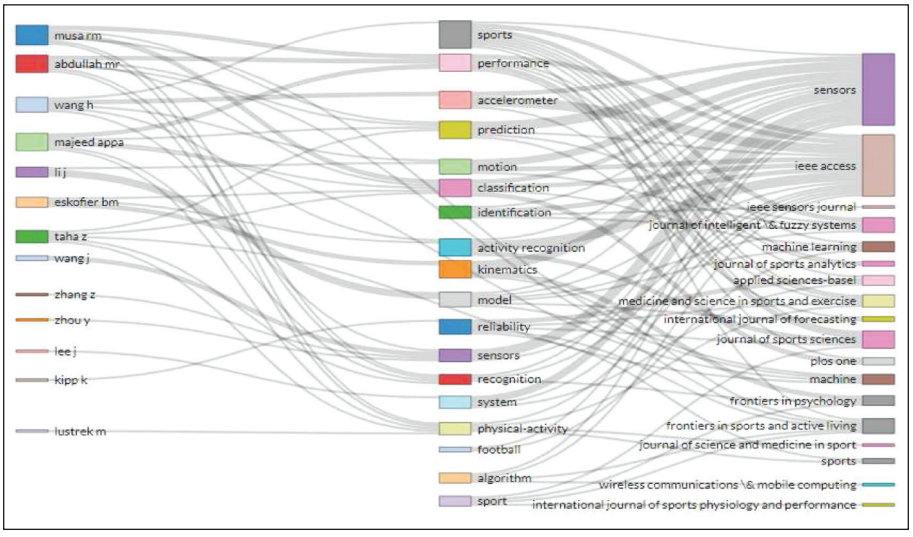

FIGURE 1: Three fields plot.

that the keywords "sports", "performance", and "accelerometer" are frequently used, and that the journals "Sensors" and "IEEE Access" show interest towards the field. Figure 2 shows the top 20 journals in terms of the number of publications.

It was determined that the publications found by scanning the keywords "machine learning" and "sports" were published in 451 different sources. It is seen that the journals with the most publications on the subject are *Sensors* (f=31), *IEEE Access* (f=24) and *Journal of Intelligent & Fuzzy Systems* (f=16). Figure 3 shows the authors with the highest number of studies on the subject.

It is seen that the authors with the highest number of studies on machine learning are Musa (f=9), Abdullah (f=6) and Majeed Appa (f=6). Figure 4 shows the citation burst values of the authors.

When the authors' citation burst values are examined, it is seen that the authors with the highest citation burst values are Zhang (48.66) between 2016 and 2020, and Barshan (14.33) between 2014 and 2021. Although Zhang and Barshan are not the most

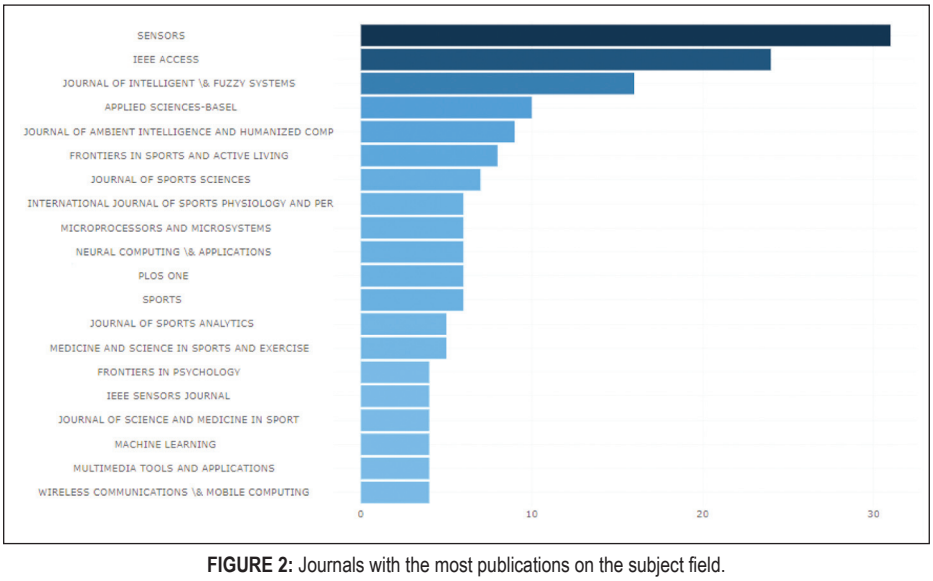

FIGURE 2: Journals with the most publications on the subject field.

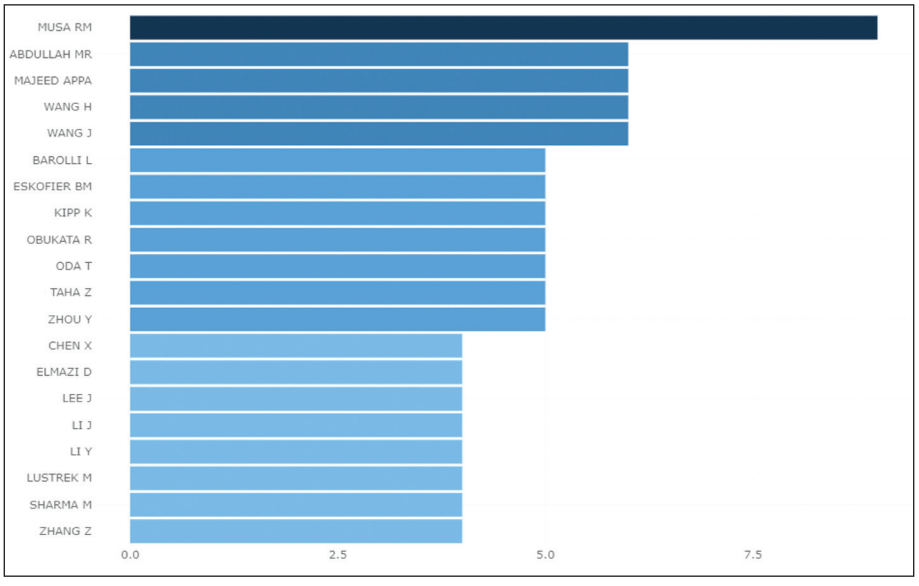

FIGURE 3: Authors with the highest number of studies on the subject.

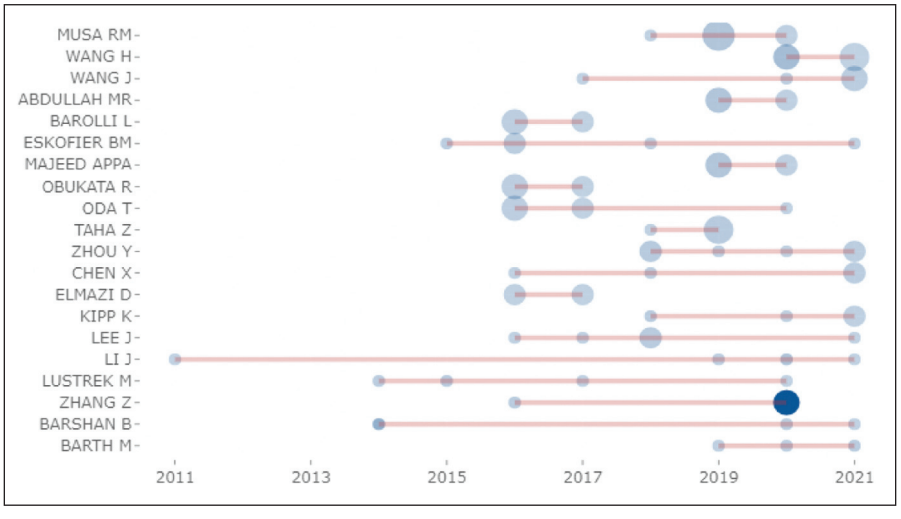

FIGURE 4: Citation burst values.

cited authors, this situation is caused by the high number of citations their studies received within the time range constituting the citation burst value. It is observed that the author named Li was the leading figure in the field between the years 2011 and 2021. This is understood by the fact that the author consistently received citations between the said years. Table 2 shows the top four authors in terms of citation burst value.

It is observed that, although machine learning is a new subject field, the authors' citation burst values are high.

Figure 5 shows the countries of the corresponding authors. The section titled Single Country Publications (SCP) shows the number of publications by the authors from the same country while Multiple Country Publications (MCP) shows the number of publications prepared in collaboration by authors from multiple countries. When the top three countries in terms of the number of publications are examined, China is on the first place with a total of 116 (SCP: 106, MCP: 10), followed by the United States with 101 publications (SCP: 86, MCP: 15) and India with 47 publications (SCP: 44, MCP: 3) (Table 3).

TABLE 2: Citation burst values by author and start-end interval.

Authors	Burst	Start	End
Zhang Z	48.66	2014	2021
Barshan B	14.33	2014	2021
Wang H	9.33	2020	2021
Li J	6.00	2011	2021

Table 3 shows the top 20 countries in terms of the number of studies by corresponding authors. Although Pakistan is ranked 17th among 20 countries, it stands out for having the highest MCP rate. Australia and Great Britain are among the countries with high MCP rates. This shows that researchers in Australia and Great Britain are more open to international collaborative studies. India and China stand out as countries with the lowest MCP rates. This is notable as these countries rank in the top 3 in terms of the number of studies. Figure 6 shows the most cited studies.

When Figure 6 is examined, it is seen that the studies related to the keywords "machine learning" and "sports" receiving the highest number of citations around the world are those conducted by Li and Wu with a total of 261 citations, Barshan and Yüksek with 129 citations and Zhang et al. with 129 citations.[30-32] Figure 7 shows the graph regarding the keywords most frequently used in the related studies.

Word clouds, a text mining method, show the most frequently used words in a text or paragraph. The word at the center indicates the most frequently used word in the context of the subject field. The size of the words and their proximity to the center indicate the frequency of their use within the subject field. It is indicated that words with smaller size and further distance from the center are used less frequently. When Figure 7 is examined, it is observed that the most frequently used words are performance (f=25), sports (f=23), model (f=21), prediction (f=16) and physical activity (f=15). Figure 8 shows the graphic displaying the most frequently used words in the title section of the studies.

Another text mining method is the word tree map. Word tree maps show the most frequently used words in a text or paragraph. The words displayed in Figure 8 show the most frequently used words in the title section of the studies on machine learning. Based on the figure, the most frequently used words can be listed as learning (f=215), machine (f=176) and sports (f=109).

In common citation network analyses, recognition of the related study/authors/sources and their use in documents play a key role. In short, common cita-

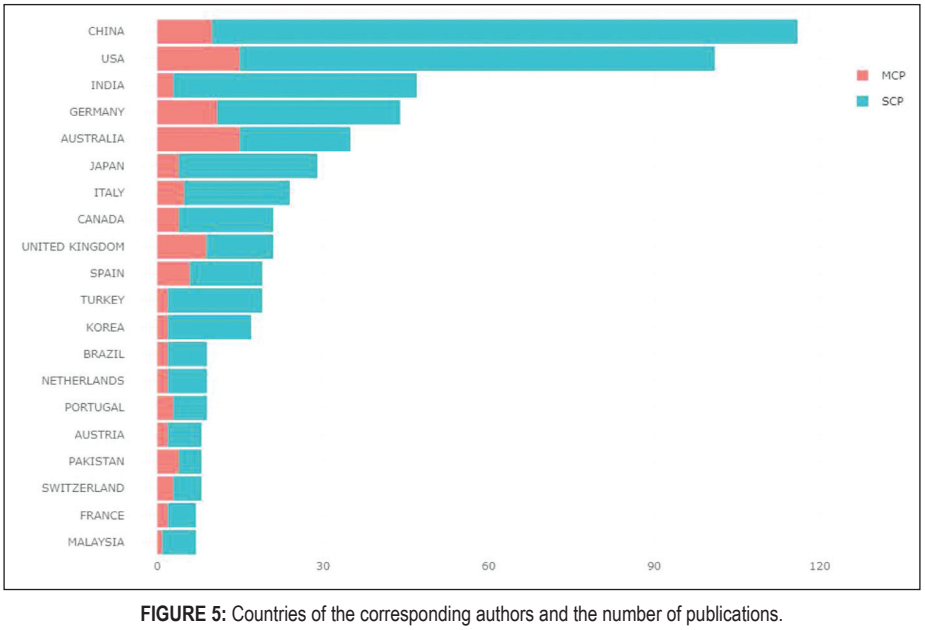

FIGURE 5: Countries of the corresponding authors and the number of publications.
MCP: Multiple Country Publications; SCP: Single Country Publications.

TABLE 3: The number of publications, SCP and MCP values by country.

Country	Number of studies	Frequency	SCP	MCP	MCP rate
CHINA	116	0.17084	106	10	0.0862
USA	101	0.14875	86	15	0.1485
INDIA	47	0.06922	44	3	0.0638
GERMANY	44	0.0648	33	11	0.25
AUSTRALIA	35	0.05155	20	15	0.4286
JAPAN	29	0.04271	25	4	0.1379
ITALY	24	0.03535	19	5	0.2083
CANADA	21	0.03093	17	4	0.1905
UNITED KINGDOM	21	0.03093	12	9	0.4286
SPAIN	19	0.02798	13	6	0.3158
TÜRKİYE	19	0.02798	17	2	0.1053
KOREA	17	0.02504	15	2	0.1176
BRAZIL	9	0.01325	7	2	0.2222
NETHERLANDS	9	0.01325	7	2	0.2222
PORTUGAL	9	0.01325	6	3	0.3333
AUSTRIA	8	0.01178	6	2	0.25
PAKISTAN	8	0.01178	4	4	0.5
SWITZERLAND	8	0.01178	5	3	0.375
FRANCE	7	0.01031	5	2	0.2857
MALAYSIA	7	0.01031	6	1	0.1429

SCP: Single Country Publication (SCP values refers to the number of published articles by the researchers from the same country); MCP: Multiple Country Publication (MCP values represent the number of the articles by the researchers from different countries).

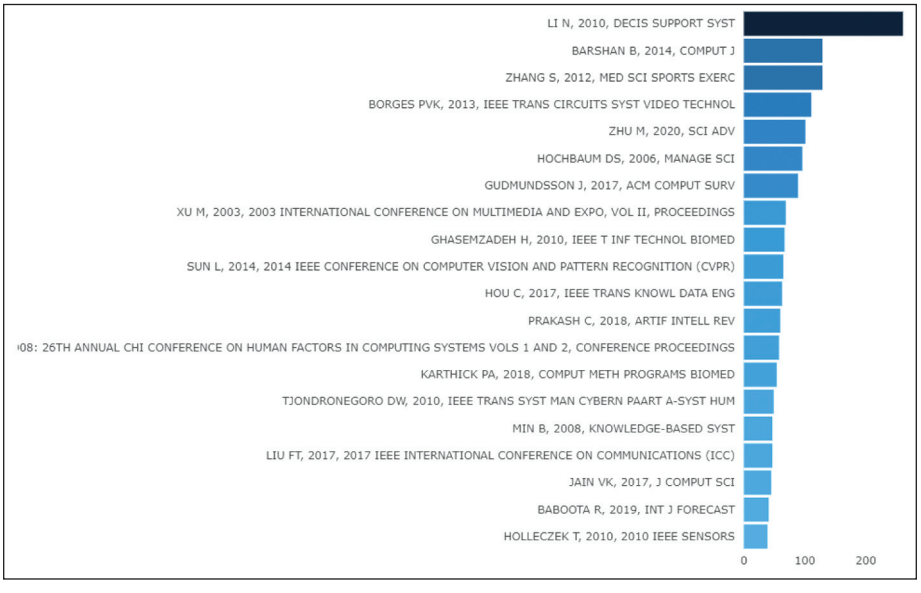

FIGURE 6: Most cited studies.

tion network analyses reveal the starting point of a study. In common citation network analysis, the relationship between two studies/authors/sources is calculated using the number of co-citations between them. Generally, co-cited studies/sources/authors are clustered and placed at a certain point on the map. Figure 9 includes 50 journals. Clusters of different colors show the names of the journals and their connection to other journals. Additionally, the size of the clusters indicates the dominance of the network.

FIGURE 7: Word cloud.

In the analysis divided into a total of 3 different clusters, each cluster is represented in a different color. It was determined that the largest cluster is "Lecturer Notes in Computer Science", represented in blue. The second largest cluster was found to be "Sensors-basel" represented in green and the third largest cluster was determined as "Plos One" represented in red. It can be said that the last cluster received fewer citations compared to the other two and has weaker connections.

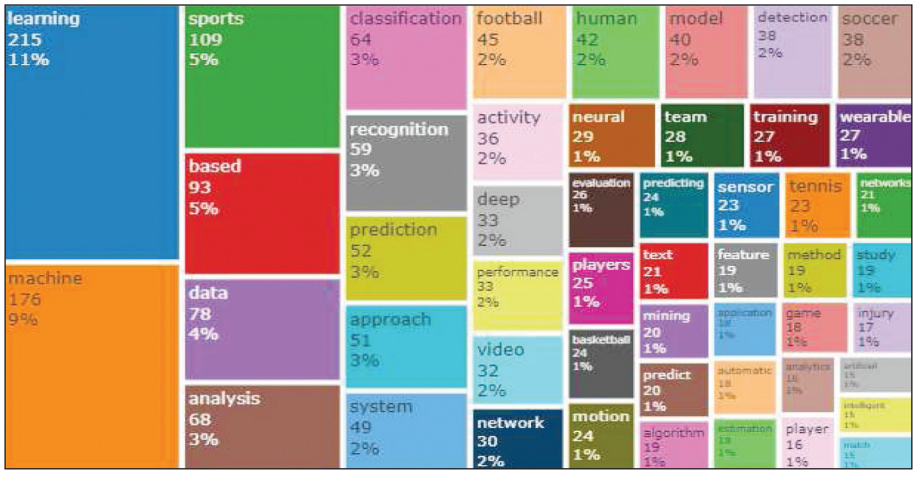

FIGURE 8: Word tree map.

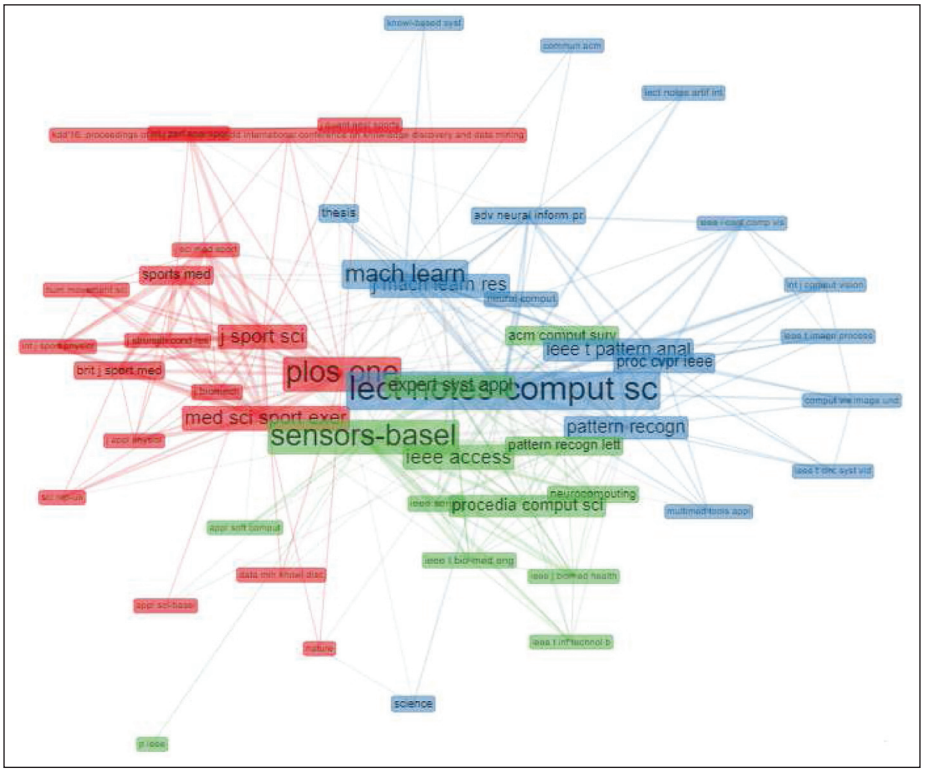

FIGURE 9: Common citation network analysis.

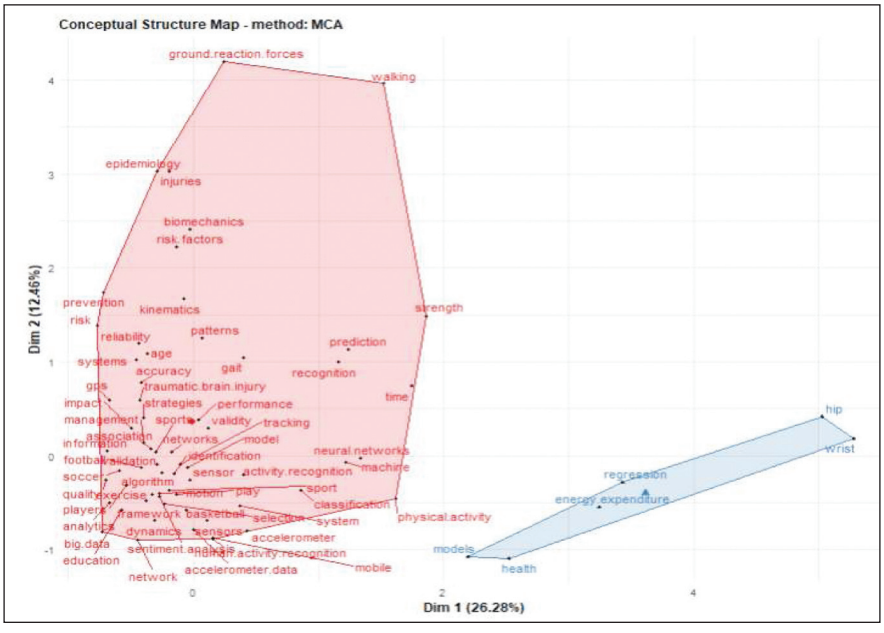

FIGURE 10: Conceptual structure mapping.
MCA: Multiple correspondence analysis.

One of the important analyses conducted within bibliometric analyses is conceptual structure mapping of the publications. As a result of the factor analysis of the concepts, the dynamics of the conceptual structure and the conceptual milestones in the related literature could be revealed by analyzing the keywords used by the authors. The 2 dimensions of the multiple correspondence analysis plot explain 38.74% of the total variance of the keywords (dimension 1=26.28%, dimension 2=12.46%). The analysis shows the formulation of 2 clusters, which express common concepts. Figure 10 presents conceptual structure mapping on the topic.

As a result of the factor analysis, the clusters displayed in Figure 10 were formed. The bigger group represented in red includes articles related to sports such as football, soccer, strength, physical activity etc.

DISCUSSION

In the present study, the WoS database, which provides access to international publications and citation indices, was scanned using the keywords "machine learning" and "sport". As a result, a total of 718 studies were accessed. With certain limitations applied in line with the purpose of the study, bibliometric analysis was performed using the R-Studio program with a total of 654 studies. The distribution of the studies by year was identified as well as the mean number of citations, journals with the most publications on the subject, authors with the most publications, the citation burst values of authors, the authors' h-indices related to the subject field, the scientific productivity of countries, the most cited articles, collaboration networks, text mining methods of word cloud and word tree map structures, and conceptual structures.

According to the findings of the present study, it was found that the oldest article in the database was published in 1999. This article titled "A fuzzy inductive learning strategy for modular rules" published in the journal "Fuzzy Sets and Systems" was written by Wang et al. It was found that the number of studies on the subject, which has been increasing since 2014, peaked in the period between 2019 and 2021 (61.01%).[33] The highest number of studies on the subject was recorded in 2021 (f=331). The annual article production rate on the subject was calculated as 32.93%. When the annual growth rate is examined, it is predicted that there will be an increase in the number of articles on the subject in 2022, and that 2022 will be the year with the highest number of articles published on the subject.

It was determined that the studies on the subject were published in 451 different sources. This indicates that a large number of publishing sources give importance to the subject field. It was found that the journal with the highest number of publications on the subject is "Sensors" (f=31). It is observed that the other sources on the list also included articles on the subject and are prestigious journals in the related field. It was determined that a total of 2093 authors published individual or collaborative studies on the subject. The author with the highest number of publications on the subject was found to be Musa and the author with the highest h-index (4) was found as Zhang. An increase is predicted in the number of publications and h-indices of researchers due to the popularity of the subject and the interest towards it.

The year with the highest mean number of annual citations is 2010. According to citation burst values, the author with the highest citation burst value was Zhang with 3 studies published in 2020.[34] The author's studies that contributed to this can be listed as; the article titled "Haptic-feedback smart glove as a creative human-machine interface for virtual/augmented reality applications" published in the journal "Applied Sciences and Engineering", "Deep learning-enabled triboelectric smart socks for IoT-basedgait analysis and virtual reality applications" published in "Flexible Electronic" and "Data-driven framework for delineating urban population dynamic patterns: Case study on Xiamen Island, China" published in "Sustainable Cities and Society". Citation bursts do not necessitate the highest number of citations. Instead, periodic citation density is focused on for citation bursts. Therefore, citation bursts take shape based on the studies with the highest number of citations received within certain time periods in the references of the 654 studies examined on WoS. The other author with a leading citation burst value is Barshan, who began publishing at the same time. The author's 2014 article titled "Recognizing Daily and Sports Activities in Two Open Source Machine Learning Environments Using Body-Worn Sensor Units" published in the journal "The Computer Journal" can be referred to for this finding.[31]

The data obtained using the word cloud and word tree methods show both the keywords used in the scans made on the subject and the concepts most frequently used by researchers in abstract sections. When these findings are examined within the scope of the present study, it is observed that the researchers associated the fields of football, strength and physical activity with the subject of machine learning.

CONCLUSION

The findings of the present study indicate that there is an increasing interest towards the subject of machine learning. It will be important for researchers who aim to conduct studies on this subject to follow the aforementioned studies.

SUGGESTIONS

Based on the findings obtained in the present study, certain suggestions can be proposed to researchers.

1. The subject of the relationship between machine learning and sports is one that researchers give importance to, and it is suggested to conduct further studies on the subject.

2. The WoS Core Collection database was used in the present study. Similar studies can be conducted using databases such as Scopus and Proquest, as well. Therefore, publications such as theses, conference proceedings and books can be examined in addition to articles.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Halil Orbay Çobanoğlu, Eren Akdağ, Muhammed Akif Kurtuluş;* ***Design:*** *Muhammed Akif Kurtuluş;* ***Control/Supervision:*** *Halil Orbay Çobanoğlu;* ***Data Collection and/or Pro-***

cessing: *Muhammed Akif Kuruluş, Eren Akdağ;* ***Analysis and/or Interpretation:*** *Muhammed Akif Kurtuluş;* ***Literature Review:*** *Muhammed Akif Kurtuluş;* ***Writing the Article:*** *Halil Orbay Çobanoğlu, Muhammed Akif Kurtuluş;* ***Critical Review:*** *Eren Akdağ;* ***References and Fundings:*** *Muhammed Akif Kurtuluş, Halil Orbay Çobanoğlu;* ***Materials:*** *Eren Akdağ.*

REFERENCES

1. Pandya R, Nadiadwala S, Shah R, Shah M. Buildout of methodology for meticulous diagnosis of K-complex in EEG for aiding the detection of Alzheimer's by artificial intelligence. Augmented Human Research. 2020;5(1):1-8. [Crossref]
2. Parekh V, Shah D, Shah M. Fatigue detection using artificial intelligence framework. Augmented Human Research. 2020;5(1):1-17. [Crossref]
3. Patel D, Shah D, Shah M. The intertwine of brain and body: a quantitative analysis on how big data influences the system of sports. Annals of Data Science. 2020;7(1):1-16. [Crossref]
4. Ahir K, Govani K, Gajera R, Shah M. Application on virtual reality for enhanced education learning, military training and sports. Augmented Human Research. 2020;5(1):1-9. [Crossref]
5. Analytic Sinsight [Internet]. © 2021 Analytics Insight [Cited: April 11, 2021]. Data science and artificial intelligence is revolutionizing the sports industry. Available from: [Link]
6. Baboota R, Kaur H. Predictive analysis and modelling football results using machine learning approach for English Premier League, International Journal of Forecasting. 2019;35(2):741-55. [Crossref]
7. Ievoli R, Palazzo L, Ragozini, G. On the use of passing network indicators to predict football outcomes. Knowledge-Based Systems. 2021;222:106997. [Crossref]
8. Bartlett R. Artificial intelligence in sports biomechanics: new dawn or false hope? J Sports Sci Med. 2006;5(4):474-9. [PubMed] [PMC]
9. Dai X, Li S. Application analysis of wearable technology and equipment based on artificial intelligence in volleyball. Mathematical Problems in Engineering. 2021;5572389:10. [Crossref]
10. Ćwiklinski B, Giełczyk A, Choraś M. Who will score? A machine learning approach to supporting football team building and transfers. Entropy (Basel). 2021;23(1):90. [Crossref] [PubMed] [PMC]
11. Analyticssteps [Internet]. ©Analytics Steps Infomedia LLP 2020-2022 [Cited: April 9, 2021]. How Artificial Intelligence Plays Football? Available from: [Link]
12. Medium [Internet]. [Cited: April 10, 2021]. Current AI/machine learning trends in football. Available from: [Link]
13. ThinkML [Internet]. © 2021 ThinkML [Cited: April 13, 2021]. Artificial intelligence (AI) in football. Available from: [Link]
14. Sport Performance Analysis [Internet]. © 2018 Sport Performance Analysis [Cited: April 10, 2021]. Artificial Intelligence (AI) in Sports. Available from: [Link]
15. Fusioninformatics [Internet]. © 2019 Fusion Informatics Copyright [Cited: April 13, 2021]. Impact of Artificial Intelligence in the Sports Industry. Available from: [Link]
16. LawInSport [Internet]. © 2010 - 2022 LawInSport Limited [Cited: April 12, 2021]. Artificial intelligence in sports-the legal and ethical issues at play. Available from: [Link]
17. Al U, Soydal İ, Yalçın H. Bibliyometrik özellikleri açısından Bilig'in değerlendirilmesi [An evaluation of the bibliometric features of bilig]. Bilig, Güz. 2010;(55):1-20. [Link]
18. Huang YL, Ho YS, Chuang KY. Bibliometric analysis of nursing research in Taiwan 1991-2004. J Nurs Res. 2006;14(1):75-81. [Crossref] [PubMed]
19. Al U, Tonta Y. Atıf analizi: Hacettepe Üniversitesi Kütüphanecilik Bölümü tezlerinde atıf yapılan kaynaklar [Citation analysis: sources cited in dissertations completed at Hacettepe University Department of Librarianship]. Bilgi Dünyası. 2004;5(1):19-47. [Crossref]
20. Osareh F. Bibliometrics, citation analysis and co-citation analysis: A review of literature I. Libri. 1996;46(3):149-58. [Crossref]
21. Zan BU. Türkiye'de bilim dallarında karşılaştırmalı bibliyometrik analiz çalışması [Doktora tezi]. Ankara: Ankara Üniversitesi; 2012. [Link]
22. McBurney MK, Novak PL. What is bibliometrics and why should you care. In Proceedings. IEEE International Professional Communication Conference. 2002. p.108-14. [Link]
23. Borgman CL, Furner J. Scholarly communication and bibliometrics. Annual Review of Information Science and Technology. 2002;36(1):2-72. [Crossref]
24. Bilgiç M, Işın A. Embarking on a journey: a bibliometric analysis of the relative age effect in sport science. German Journal of Exercise and Sport Research. 2022;1-8. [Crossref]
25. Doğru M, Güzeller CO, Çelik M. Geçmişten günümüze sürdürülebilir kalkınma ve eğitim alanında: bibliyometrik bir analiz [A bibliometric analysis in the field of sustainable development and education from past to present]. Adıyaman University Journal of Educational Sciences. 2019;9(1):42-68. [Crossref]
26. Jiménez-García M, Ruiz-Chico J, Pe-a-Sánchez AR, López-Sánchez JA. A bibliometric analysis of sports tourism and sustainability (2002-2019). Sustainability. 2020;12(7):2840. [Crossref]
27. Kurtuluş MA, Bilen K. A bibliometric analysis on nature of science: a review of the research between 1986-2019. Scientific Educational Studies. 2021;5(1):47-65. [Link]
28. Kurtuluş MA, Tatar N. An analysis of scientific articles on science misconceptions: a bibliometric research. Ilkogretim Online. 2021;20(1):192-207. [Crossref]
29. Aria M, Cuccurullo C. Bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics. 2017;11(4):959-75. [Crossref]
30. Li N, Wu DD. Using text mining and sentiment analysis for online forums hotspot detection and forecast. Decision Support Systems. 2010;48(2):354-68. [Crossref]
31. Barshan B, Yüksek MC. Recognizing daily and sports activities in two open source machine learning environments using body-worn sensor units. The Computer Journal. 2014;57(11):1649-67. [Crossref]
32. Zhang S, Rowlands AV, Murray P, Hurst TL. Physical activity classification using the GENEA wrist-worn accelerometer. Med Sci Sports Exerc. 2012;44(4):742-8. [Crossref] [PubMed]
33. Wang CH, Liu JF, Hong TP, Tseng SS. A fuzzy inductive learning strategy for modular rules. Fuzzy Sets and Systems. 1999;103(1):91-105. [Crossref]
34. Zhang Z, He T, Zhu M, Sun Z, Shi Q, Zhu J, et al. Deep learning-enabled triboelectric smart socks for IoT-based gait analysis and VR applications. npj Flexible Electronics. 2020;4(1):1-12. [Crossref]