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Research Article 

# Machine Learning and Internet of Things (IoT): A Bibliometric Analysis of Publications Between 2012 and 2022

**Hamdan Gani [a,1,*]; Annisa Dwi Damayanti [b,2]; Nurani [c,3] ; Sitti Zuhriyah [d,4] ; St. Nurhayati Jabir [a,5]; Helmy Gani [e,6]; Feng Zhipeng [f,7]; Aisyah Sri Rejeki [b,7]**

[a] *Politeknik ATI Makassar Polytechnic, Jl. Sunu No.220, Makassar and 90211, Indonesia*
[b] *Universitas Hasanuddin, Jln Jl. Perintis Kemerdekaan No.KM.10, Makassar and 90245, Indonesia*
[c] *Institut Teknologi dan Bisnis Nobel Indonesia, Jl. Sultan Alauddin No.212, Makassar and 90221, Indonesia*
[d] *Universitas Handayani Makassar, Jl. Adyaksa Baru No.1, Makassar and 90231, Indonesia*
[e] *Sekolah Tinggi Ilmu Kesehatan, JL. Cendrawasih, No. C13, Makassar and 90121, Indonesia*
[f] *Hangzhou Normal University, Yuhang District, Hangzhou, Tiongkok and 310030, China*
[1] *hamdangani@atim.ac.id;* [2] *annisa.dd@unhas.ac.id;* [3] *nurani@stienobel-indonesia.ac.id;* [4] *zuhriyahi@handayani.ac.id;* [5]*nurhayati.djabir@atim.ac.id;* [6]*helmy.gani@mail.com;* [7]*20200058@hznu.edu.cn;* [8]*aisyahsrirejeki03@gmail.com*
* *Corresponding author*

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**Abstract**

The implementation between machine learning and the Internet of Things (IoT) has been scientifically investigated in many studies. However, not many bibliometric studies categorize the output in this area. By keeping an eye on the publications posted on the Web of Science (WoS) platform, this study aims to give a bibliometric analysis of research on Machine Learning and IoT, identifying the state of the art, trends, and other indicators. 6.170 different articles made up the sample. The VOS viewer software was used to process the data and graphically display the results. The study examined the concurrent occurrence of publications by year, keyword trends, co-citations, bibliographic coupling, and analysis of co-authorship, countries, and institutions. several prolific authors are discovered. However, the body of literature on machine learning and IoT issues is expanding quickly; only five papers accounted for more than 2193 citations. Then, 40.34 percent of the articles from the 694 sources reviewed were published as the most important paper. At the same time, the USA is the top nation for research on this subject area. In addition to identifying gaps and promising areas for future research, this study offers insight into the current state of the art and the field of machine learning and IoT.

**Keywords:** Bibliometric Analysis, IoT, Machine Learning, Web of Science.

## Introduction

Modern computer systems, internet protocols, and developing technologies have made communication between numerous devices more accessible. Between 25 and 50 billion devices are expected to be connected to the Internet by 2020. Hence, the recently developed concept of IoT was born. The IoT is a group of embedded technologies that includes wired and wireless communications, hardware for sensors and actuators, and actual objects connected to the Internet [1]. One of computing's main aims has long been to improve and simplify human activities and experiences (for instance, have a look at the visions associated with "The Computer for the 21st Century" [2] or "Computing for Human Experience" [3]). In order to provide consumers with improved services or to enhance the functionality of the IoT framework, IoT needs data. Systems should be able to use the network to access raw data from diverse sources, then analyze the data to generate knowledge.

IoT is one of the primary sources of new data. Therefore, machine learning is crucial in making IoT applications smarter today. Machine learning or data mining aims to find patterns and new insights in data. It is a synthesis of various scientific fields. These techniques include numerous algorithms that can be used in numerous disciplines. Applying data analytics methodology to particular regions involves identifying data categories, such as volume, variety, and velocity; data models, such as neural networks; classification; and clustering methods; and employing workable algorithms that match the data properties [4].

Bibliometrics is a multidisciplinary science that uses mathematical and statistical techniques to analyze all forms of knowledge [5]. It is an approach that is frequently used to determine how a particular field is developing [6]. The most apparent benefit of bibliometrics is that it enables researchers to analyze a particular field of study by examining

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citations, co-citations, geographic distribution, and word frequency and then come to incredibly insightful conclusions. Bibliometrics has been widely used in hotspot research, co-authorship analysis, co-citation analysis, and the development of the whole subject field.

The concept of machine learning and IoT has been applied by more and more research. However, the related works primarily concentrate on engineering implementation, specifically data collection, algorithm improvement, and data storage. However, there is little research on machine learning and IoT from the perspectives of bibliometrics and visualization [1], [4], [7]. The visualization extracts relevant information from the data using machine learning technology and presents the information to consumers naturally. Consequently, we need to thoroughly analyze this study area and identify some fundamental trends in machine learning and IoT-related research. In order to study the peculiarities of this field, this paper is motivated by this notion. It adopts bibliometric analysis and visualization on machine learning and IoT research.

The rest of this paper is organized as follows: In Section 2, this study introduces the data source and methods used in this study. Section 3 presents the data analysis regarding machine learning and IoT research. Section 4 gives the discussion, and the last section 5, presents the significant results of this study.

## Method

This study is based on a bibliometric analysis of machine learning and IoT. Three steps are recommended for systematic reviews of the literature in the management field: planning, carrying out the review, and reporting/disseminating the findings. This review methodology is used in this investigation. The bibliometric review methodology is significant because it offers a classified perspective of the publications in each study field based on impartial standards for evaluating and categorizing publications. In turn, using the VOS viewer software gives the option to exhibit the data graphically using category maps.

Data were gathered in September 2020 from the Web of Science, one of the most significant bibliographic databases. The WoS Core Collection database, which contains several sub-databases, was used to collect the data. The most popular and dependable databases are WoS and Scopus. Conversely, WoS "collects scientific articles having the most important impact and is utilized as the main criterion in academic decision-making." As a result, we used WoS by earlier investigational protocols.

There were 6.170 papers when the term "machine learning" and "Internet of Things" was searched. The results were filtered using Boolean operators: Articles, reviews, and early access publications in the English language; set time-period: 2012–2022; indexes: SCI–EXPANDED, SSCI, AHCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH ESCI. We chose the WoS categories engineering, electrical electronics, biotechnology applied microbiology, and mining mineral processing.

The mechanisms employed to analyze and interpret the data gathered were bibliometric indicators used in the bibliometric analysis [5]. 6.170 bibliographic items were collected and examined in the current study. A similarity visualization application (VOS viewer) was used to analyze the data and graphically illustrate some potential outcomes. The study used co-citation, bibliographic coupling, the simultaneous appearance of publications by year, keyword trends, and authorship analysis between countries and institutions. The findings identified the development status and key trends according to influence, influential journals, publications, themes, authors, institutions, and nations. Analysis and graphical depiction are crucial because they may aid academics and professionals in understanding what has been studied in machine learning and IoT and mapping the main trends in the field. Two texts that contain a quotation from the same article are said to have cited it. This strategy is put into practice by documents, journals, and authors. Keywords that are often used in documents are measured by author co-occurrence. This is bibliographic coupling when two documents cite the same document. Co-authorship describes the number of publications for a group of variables and how they relate. Both institutions and nations can make use of this strategy.

## Results and Discussion

### *A. Publications by Year*

The earliest publication about machine learning and IoT based on Web of Science (WoS) information found was dated 2013 and was titled "IoT Service Platform Enhancement through 'In-Situ' Machine Learning of Real-World Knowledge" by [8]. It was published at the 38th Annual IEEE Conference on Local Computer Networks (LCN).

Between 2012 and 2013, only six papers were published annually in production (2 in 2012). Since then, the quantity of publications has significantly increased (shown in **Figure 1**). Fifteen articles were released in 2014, 41 in 2015, and 109 in 2016. With 271 articles, there was an increase in 2017. 2018 saw the publication of 593 publications, followed by 1041 papers in 2019, 1427 articles in 2020, 1831 articles in 2021, and 839 articles by 2022.

The annual trends in publications on this subject are shown in **Figure 1**. It is derived from a sample of 6170 articles. With 1831 papers published, 2021 marked the highest number of publications. Additionally, data gathering began in 2020, and the subject is expanding. More articles are anticipated to have been published in 2020 than in 2019. The number of publications on machine learning and IoT that have been published over time will be analyzed, and the study will be furthered to reveal data that will allow for a better understanding of the applicability of earlier studies.

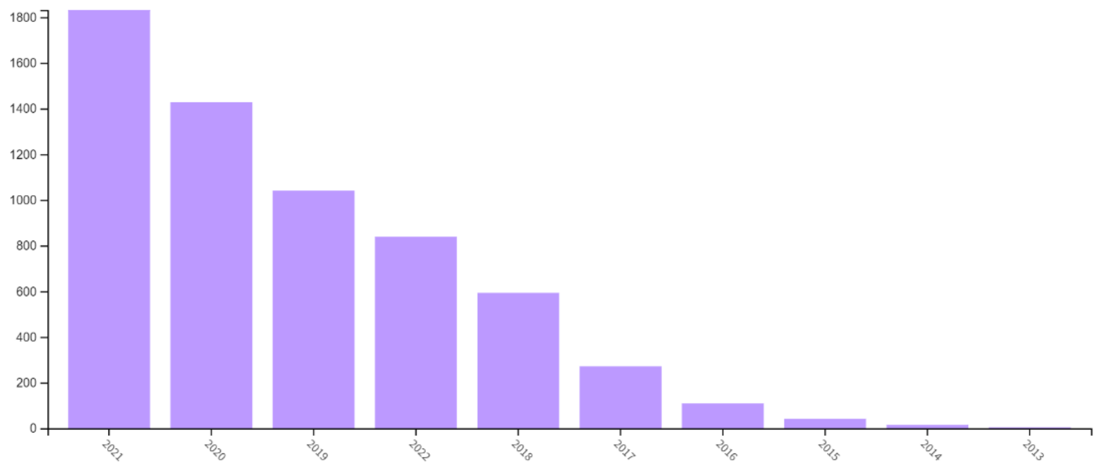


**Figure 1.** Publications by year (2012–2022).

The eight categories shown in **Table 1** are used to group the 6170 articles. The primary category, "Science Citation Index Expanded (SCI-EXPANDED)," contains 32014 related articles or 51.929% of the total. Conference Proceedings Citation Index – Science (CPCI-S) is the second category with the most significant number of related articles, with 2535, followed by "The Emerging Sources Citation Index (ESCI)," with 402. The fact that a single article might be categorized under multiple headings should be considered, as it may affect both partial and overall statistics.

**Table 1.** The number of publications by category (2012–2022).

| Web of Science Categories | Number | % Of 6,170 |
|---|---|---|
| Science Citation Index Expanded (SCI-EXPANDED) | 3204 | 51.929 |
| Conference Proceedings Citation Index – Science (CPCI-S) | 2535 | 41.086 |
| Emerging Sources Citation Index (ESCI) | 402 | 6.515 |
| Social Sciences Citation Index (SSCI) | 221 | 3.582 |
| Book Citation Index – Science (BKCI-S) | 40 | 0.648 |
| Conference Proceedings Citation Index – Social Science & Humanities (CPCI-SSH) | 38 | 0.616 |
| Book Citation Index – Social Sciences & Humanities (BKCI-SSH) | 5 | 0.081 |
| Arts & Humanities Citation Index (A&HCI) | 2 | 0.032 |

### *B. Publications by Journal*

We discover nine distinct document types by examining the 6.170 articles' published publications (**Table 2**).

**Table 2.** Summary of Document types of papers (2012–2022).

| Document Types | Journals | % Of 6.170 |
|---|---|---|
| Articles | 3328 | 53.938% |
| Proceedings Papers | 2547 | 41.28% |
| Review Articles | 290 | 4.7% |
| Early Access | 181 | 2.934% |
| Editorial Materials | 42 | 0.681% |
| Book Chapters | 40 | 0.648% |
| Data Papers | 2 | 0.032% |
| Corrections | 1 | 0.016% |
| Letters | 1 | 0.016% |

The most common type of publication is articles, with 3.328 total journals, accounting for 53.938 percent of all 6.170 publications; Proceeding papers are the second most common type of publication, accounting for 2.549 papers and 41.28 percent of all publications. Also included are review articles (290), early access (181), editorial materials (42), book chapters (40), data papers (2), corrections (1), and letters (1) (see Table 2). Additionally, as shown in

Figure 2, this study issue is highly interdisciplinary and has the potential to be published in publications with a variety of perspectives.

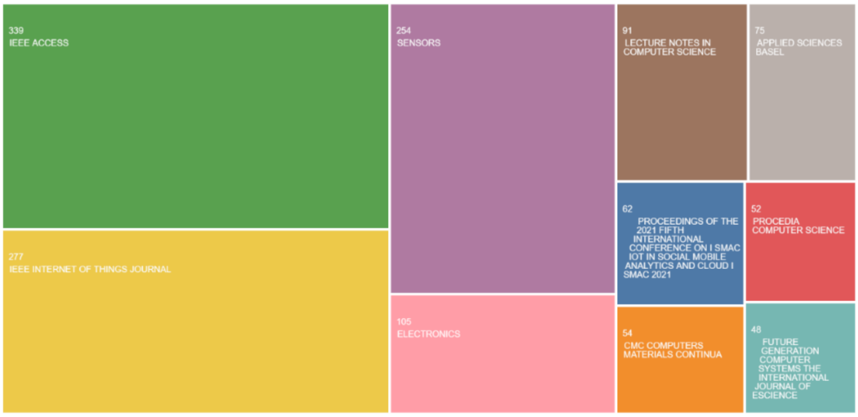


**Figure 2**. Publications by year (2012–2022).

As shown in Table 3, we looked at nine journals that have 50 or more publications published on the topic. Together, these journals released 1440 papers. As can be seen, "IEEE Access" leads the field in terms of the number of articles published (339), accounting for 5.494% of the entire sample, followed by "IEEE Internet of Things Journal" (277 articles), "Sensors" (254 articles), and "Electronics," (1.702%) (105 articles).

### *C. Keyword Analysis*

The 6.170 items in the sample were categorized using an analysis of the most used keywords. The subjects that come up more frequently in the analyzed area stand out because of this analysis. The keywords are grouped into eleven clusters on the map shown in Figure 3. Security (light green cluster), big data (purple cluster), edge computing (red cluster), artificial intelligence (brown cluster), classification (yellow cluster), cloud computing (brown cluster), framework (purple cluster), privacy (light green cluster) and optimization (green cluster) are the primary keywords for each cluster. This map also demonstrates that the research appears to be moving toward security, big data, edge computing, and potential areas for further study opportunities.

**Table 3.** The number of publications by the journal (2012–2022).

| R | Publication by Journal | Number | % Of 6.170 |
|---|---|---|---|
| 1 | IEEE Access | 339 | 5.494% |
| 2 | IEEE Internet of Things Journal | 277 | 4.489% |
| 3 | Sensors | 254 | 4.117% |
| 4 | Electronics | 105 | 1.702% |
| 5 | Lecture Notes in Computer Science | 91 | 1.475% |
| 6 | Applied Sciences Basel | 75 | 1.216% |
| 7 | Proceedings of the 2021 Fifth International Conference on I SMAC IoT in Social Mobile Analytics and Cloud 2021 | 193 | 1.005% |
| 8 | CMC Computers Materials Continua | 54 | 0.875% |
| 9 | Procedia Computer Science | 52 | 0.843% |

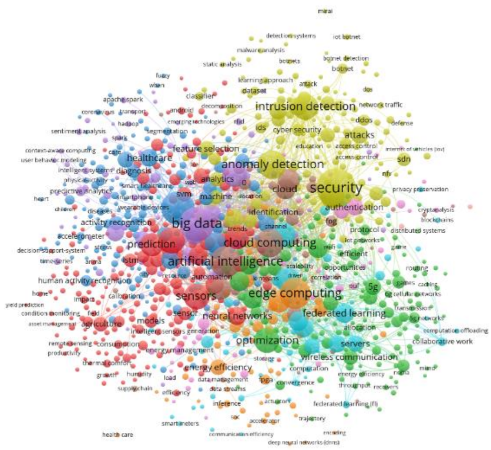


**Figure 3.** Keyword trends (2012–2022).

14.695 keywords were found throughout the 6.170 articles, and 1.150 words met the threshold. More than 200 times were devoted to the terms "Security," "Big Data," "Edge Computing," "Artificial Intelligence," "Classification," and "Cloud Computing." The word that is most frequently used to summarize the main subject of the articles under analysis is "Security," which appears in 464 articles, followed by "Big Data" (359 occurrences) and "Edge Computing" (294 occurrences).

### *D. Geographical Analysis of Publications*

The 6.170 publications that comprise the sample are spread out among 122 different countries, indicating that this study issue is international when the authors' countries of affiliation are examined. This indicates that each of these nations has at least one article published.

The top 15 countries for producing academic papers in the field of research are shown in **Table 4**; collectively, they account for 106.14 percent of all published publications. The figures show that the USA, with 1118 publications, has the mons overall, followed by India with 1092 publications and China with 950 publications. Regarding publications, Taiwan stands in the 14th spot, barely ahead of France and below Spain.

**Table 4.** The number of publications in co-authorship by country (1997–2020).

| R | Co-authorship By Countries | Number | % Of 6.170 |
|---|---|---|---|
| 1 | USA | 1118 | 18.12% |
| 2 | India | 1092 | 17.69% |
| 3 | Peoples R China | 950 | 15.39% |
| 4 | South Korea | 465 | 7.53% |
| 5 | England | 392 | 6.35% |
| 6 | Saudi Arabia | 349 | 5.65% |
| 7 | Italy | 317 | 5.13% |
| 8 | Australia | 311 | 5.04% |
| 9 | Canada | 282 | 4.57% |
| 10 | Pakistan | 266 | 4.31% |
| 11 | Japan | 244 | 3.95% |
| 12 | Germany | 202 | 3.27% |
| 13 | Spain | 195 | 3.16% |
| 14 | Taiwan | 190 | 3.07% |
| 15 | France | 180 | 2.91% |

**Figure 4** displays the co-authorship map created by the nation using a sample of 6.170 articles. The group of nations that includes the USA, India, and China may be seen. This occurs because these three nations combined account for 51.20% of publications. The distance between the clusters and the lines connecting the spots on the map represent the strength of the relationships between the countries and the amount of co-authorship these countries publish. This gives a decent picture of the strength of international partnerships in machine learning and IoT research.

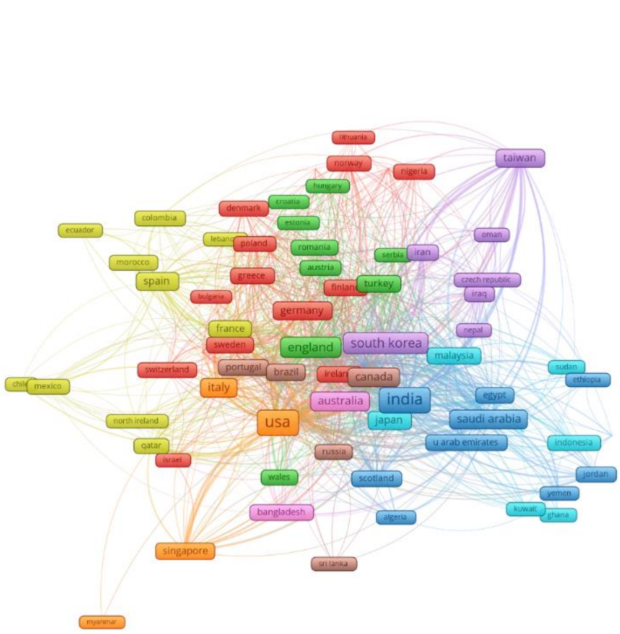


**Figure 4.** Co-authorship by country.

### *E. Analysis of Publications by Organization*

The University of California System, Chinese Academy of Sciences, King Saud University, Indian Institute of Technology System IIT System, and State University System of Florida are the top five institutions that published the 340 papers. However, the occurrences are extremely dispersed regarding the volume of papers the organization produces, unlike in journals or nations of publication. Most papers are not produced by just one university (or two, three, or four). The University of California System and the Chinese Academy of Sciences are tied for first place with more than 60 publications each, or 2.314 percent of the 6.170 articles. The ten organizations with the most significant scholarly output in the field of research are listed in **Table 5**.

**Table 5.** Publications by the organization.

| R | Organization | Number | % Of 6.170 |
|---|---|---|---|
| 1 | University Of California System | 74 | 1.197% |
| 2 | Chinese Academy of Sciences | 69 | 1.117% |
| 3 | King Saud University | 68 | 1.1% |
| 4 | Indian Institute of Technology System III System | 65 | 1.052% |
| 5 | State University System of Florida | 64 | 1.036% |
| 6 | Vellore Institute of Technology | 61 | 0.987% |
| 7 | King Abdulaziz University | 57 | 0.922% |
| 8 | University of Texas System | 57 | 0.922% |
| 9 | Nanyang Technological University | 56 | 0.906% |
| 10 | Nanyang Technological University National Institute of Education Nie Singapore | 56 | 0.906% |

The key universities that published publications on this subject and the collaboration between the institutions are displayed on the map created by the VOS viewer software (**Figure 5**). A sample of 6.170 articles was used in this research to create the map. Figure 5 can be analyzed to determine the organizations in charge of the publications and their relationships. The University of California System stands out in the Web of Science-generated results shown in **Figure 5**, along with the Chinese Academy of Sciences, King Saud University, and Indian Institute Of Technology System IIT System, among others.

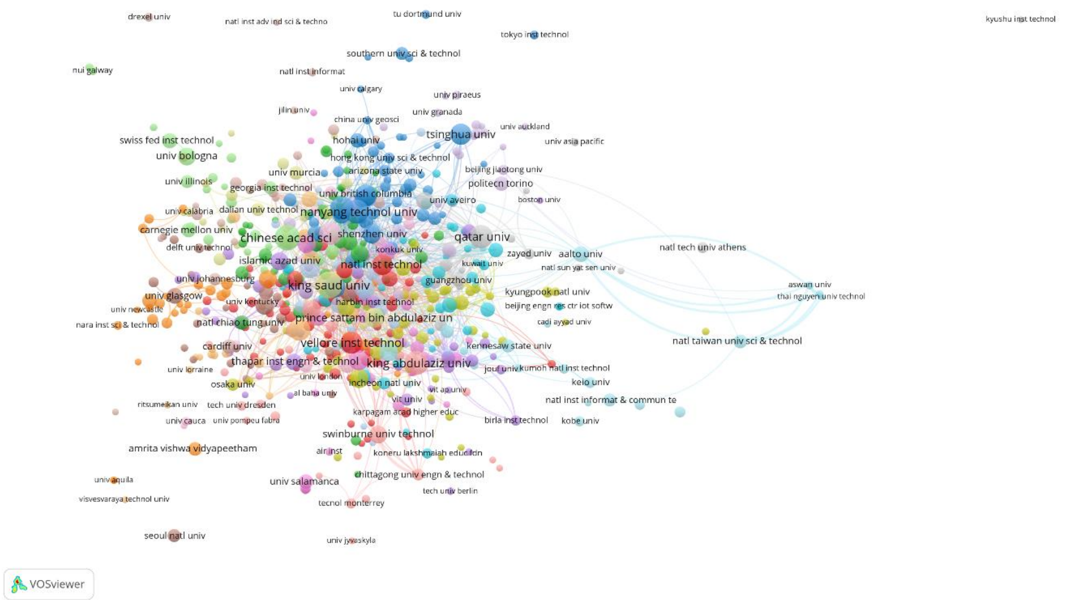


**Figure 5.** Publication volume—relevance of organizations.

### *F. Analysis by Citation*

Since it identifies the essential papers in the field of study, analyzing article citations is the most popular technique for evaluating the influence of authors, journals, and publications. **Table 6** studies the citation structure in the relevant field of study. The reference work, “Deep Learning for IoT Big Data and Streaming Analytics: A Survey,” has 432 citations, making it easy to discover which articles are most frequently mentioned in this field.

Researchers can identify the foundational content that can be utilized as a reference to support their studies by understanding the most often referenced articles in terms of both historical average and annual average so that there is, in advance, a clear starting point.

Determining the author citation network is feasible by looking at **Figure 6**. When two documents refer to the same document, a citation is generated. This method illustrates a document's applicability to a specific topic area and applies to papers, journals, and authors. Along with other names like Mahdavinejad, the gray cluster of authors with the highest mentions is Mohammadi.


**Figure 6.** Author citation network.

### *G. Analysis by Author*

The last analysis discusses author production and publication. The most prolific author is seen in **Table 7**. Guizani Mohsen, a professor at Qatar University, comes with 41 of the 6.170 publications, followed by Al-Turjman Fadi, a professor at Near East University, Nicosia.

**Table 6.** Citations by articles.

| Title | Authors | Journal | Year | Citation |
|---|---|---|---|---|
| Deep Learning for IoT Big Data and Streaming Analytics: A Survey | Mehdi Mohammadi; Ala Al-Fuqaha; Sameh Sorour; Mohsen Guizani | IEEE Communications Surveys & Tutorials | 2018 | 432 |
| Machine Learning for Internet of Things Data Analysis: A survey | Mohammad Saeid Mahdavinejad; Mohammad Reza Rezvan; Mohammadamin Barekatain; Peyman Adibi; Payam Barnaghi; Amit P. Sheth | Digital Communications and Networks | 2018 | 317 |
| Federated Learning in Mobile Edge Networks: A Comprehensive Survey | Wei Yang Bryan Lim; Nguyen Cong Luong; Dinh Thai Hoang; Yutao Jiao; Ying-Chang Liang; Qiang Yang; Dusit Niyato; Chunyan Miao | IEEE Communications Surveys & Tutorials | 2018 | 311 |
| Artificial Neural Networks-Based Machine Learning for Wireless Networks: A Tutorial | Mingzhe Chen; Ursula Challita; Walid Saad; Changchuan Yin; Mérouane Debbah | IEEE Communications Surveys & Tutorials | 2019 | 310 |
| Distributed Attack Detection Scheme Using Deep Learning Approach for Internet of Things | Abebe Abeshu Diro; Naveen Chilamkurti | Future Generation Computer Systems | 2018 | 308 |
| A Survey on IoT Security: Application Areas, Security Threats, and Solution Architectures | Vikas Hassija; Vinay Chamola; Vikas Saxena; Divyansh Jain; Pranav Goyal; Biplab Sikdar | IEEE Communications Surveys & Tutorials | 2018 | 308 |
| Towards The Development of Realistic Botnet Dataset in The Internet of Things for Network Forensic Analytics: Bot-IoT Dataset | Nickolaos Koroniotis; Nour Moustafa; Elena Sitnikova; Benjamin Turnbull | Future Generation Computer Systems | 2019 | 254 |
| Deep Learning with Edge Computing: A Review | Jiasi Chen; Xukan Ran | Proceedings of the IEEE | 2019 | 248 |

| Title | Authors | Journal | Year | Citation |
|---|---|---|---|---|
| Smart Electricity Meter Data Intelligence for Future Energy Systems: A Survey | Damminda Alahakoon; Xinghuo Yu | IEEE Transactions on Industrial Informatics | 2015 | 243 |
| Blockchain and Federated Learning for Privacy-Preserved Data Sharing in Industrial IoT | Yunlong Lu; Xiaohong Huang; Yueyue Dai; Sabita Maharjan; Yan Zhang | IEEE Transactions on Industrial Informatics | 2019 | 220 |

**Table 7.** Publications by author.

| R | Authors | Number | % of 6.170 |
|---|---|---|---|
| 1 | Guizani Mohsen | 41 | 0.665% |
| 2 | Al-Turjman Fadi | 35 | 0.567% |
| 3 | Kumar Neeraj | 26 | 0.421% |
| 4 | Khan MA | 25 | 0.405% |
| 5 | Kumar A | 24 | 0.389% |
| 6 | Kim D | 23 | 0.373% |
| 7 | Kim H | 23 | 0.373% |
| 8 | Kim J | 23 | 0.373% |
| 9 | Kumar R | 22 | 0.357% |
| 10 | Rahmani AM | 22 | 0.357% |

When two documents cite the same source, this is known as bibliographic coupling, which can highlight a particular publication's value compared to a group of other publications. This strategy can be used with articles, journals, writers, institutions, and nations. It is feasible to identify the articles and writers who are frequently cited by looking at the bibliographic coupling of authors.

The bibliographic coupling of authors is represented in **Figure 7**, which enables us to see and gauge the strength of the relationship between them. The map shows 14 distinct clusters, and the lines show where the authors have concurrent citations to one another.

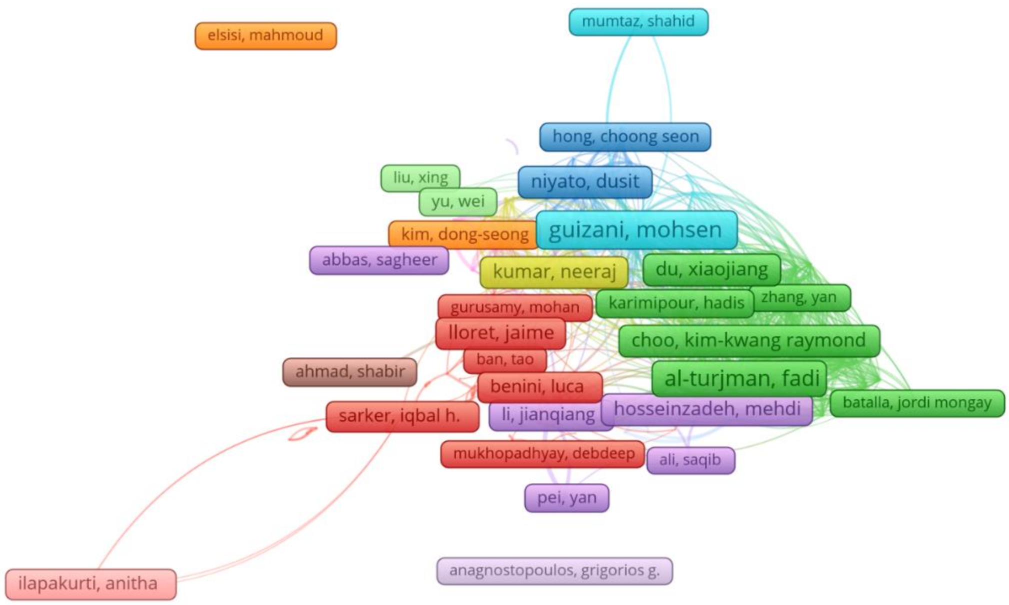


**Figure 7.** Bibliographic coupling of authors.

### *H. Analysis of Research Opportunities*

This research aims to identify the critical research possibilities in this area. In addition, it gives an outline of the research and directions in investigating machine learning and IoT. As a result, this section aims to examine and suggest research trends and directions in this area based on content analysis.

The most recent articles recommended by the Web of Science were analyzed, and the 12 papers mentioned in Table 8 were selected. They were the most mentioned and pertinent because they were published in the last five years.

**Table 8.** Research opportunities in machine learning and IoT.

| N | Opportunities | Description | Suggested Articles |
|---|---|---|---|
| 1 | Security | The research in this area focuses on securing IoT devices (e.g., physical devices, wireless transmission, mobile, and cloud architectures). The development of numerous analytical techniques that can be utilized to improve IoT security has been made possible by the advancements in ML and DL. | [1]–[8] |
| 2 | Big Data | Deep learning (DL) is applied for streaming and fast data analytics. IoT and DL constitute a chain of data producer consumers, in which IoT generates raw data that DL models analyze, and DL models produce high-level abstraction and insight fed to the IoT systems for fine-tuning and improvement of services. | [9] |
| 3 | Edge Computing | The methods for training deep learning models over many edge devices are discussed, along with several strategies for swiftly executing deep learning through a mixture of end devices, edge servers, and the cloud. Deep learning is applied at the network edge. | [10], [11] |
| 4 | Artificial Intelligence | ML can be used for network control, resource management, user association, interference alignment, and intelligent data analytics for signal detection, spectrum sensing, channel state detection, energy prediction, and user behavior and classifications. | [12] |

The four research topics of security, big data, edge computing, and artificial intelligence were used to segment the 12 papers. The goal is to identify the needs and goals they want to meet. As seen in the reviewed literature, the four categories listed in **Table 8** offer significant hints regarding research opportunities that are evident and expanding, suggesting possible disciplines and study contexts to be established. Relationships to the advancement in ML and DL for the development of various analytical methods can be used to enhance IoT security, as well as research regarding the improvement of services of big data using ML or DL technique, the various approaches for quickly executing deep learning across a combination of end devices/servers/cloud and describe the procedures for deep learning model training on various edge devices as well as present new research opportunities using AI for signal detection, spectrum sensing, channel state detection, energy prediction, as well as user behavior predictions and classifications.

## Discussion

The current study presents our understanding of the state-of-the-art in machine learning and IoT fields. The most prolific publishing nations and organizations, journals focusing on machine learning and IoT, particularly those connected to security, keyword-based trends in the topics covered, and the applicability of publications from co-citation networks are all easily found. As a result, it is crucial to identify knowledge gaps in this domain and likely future trends in research.

This study analyzes the top journals, authors, institutions, and keywords, demonstrating that: (a) the body of knowledge on machine learning in the field of security is significantly expanding; (b) ten papers alone accounted for more than 2.951 citations and several prolific authors make up a significant portion of the research; (b) the research on security, big data, edge computing, and artificial intelligence is significantly expanding. (c) USA is the top country in publications and citations on this subject; (d) according to keyword trend network analysis, ML and IoT are evolving into focuses on securing IoT devices using ML, ML for fast data analytics and intelligent data analytics, and various approaches for quickly executing ML. Finally, this ML and IoT literature area has much potential and is predicted to increase significantly over the next few years.

Due to the increased-on machine learning and IoT, the results show a clear trend of several keywords. More people are concerned about security in machine learning and IoT. People are more concerned about intrusion detection [11], cyber security [14], distributed attack detection [15], and security techniques [12]. IoT and deep learning constitute a system chain in which IoT produces raw data that DL models analyze, and DL models produce high-level abstraction and insight from the data [16]. While in other for edge computing, researchers discuss how deep learning at the network edge can help understand the techniques for speeding up deep learning inference and performing distributed training on edge devices [7], [17]. Finally, machine learning is used for intelligent data analytics for signal detection, spectrum sensing, channel state detection, energy prediction, user behavior predictions, and classifications [18].

## Conclusion

The current study understands the body of existing research by giving information on the current state of the art and identifying trends, gaps, and research opportunities through the selection and content analysis of the most recent and pertinent publications published in this research field. This study analyzes the top journals, authors, institutions, and keywords, demonstrating that: (a) the body of knowledge on machine learning in the field of security is significantly expanding; (b) ten papers alone accounted for more than 2.951 citations and several prolific authors make up a significant portion of the research; (b) the research on security, big data, edge computing, and artificial intelligence is significantly expanding. (c) USA is the top country in publications and citations on this subject; (d) according to keyword trend network analysis, ML and IoT are evolving into focuses on securing IoT devices using ML, ML for fast data analytics and intelligent data analytics, and various approaches for quickly executing ML. Finally, this ML and IoT literature area has much potential and is predicted to increase significantly over the next few years.

Future research may examine the entire year to fully comprehend the output of science in 2023. Technical decisions, such as language paper and subject area, can exclude essential publications from the bibliometric study. Another drawback is that Web of Science was chosen while other databases were not used. A different strategy that compares several databases could offer a complete analysis of the research in this field and a better comprehension of the critical differences and implications of using different databases. Another drawback of this study is that the scope of bibliometric analyses to analyze the research contexts is constrained. Nevertheless, even if only the best publications were considered, other works like dissertations, book chapters, or conference papers may offer insightful suggestions regarding future research directions. A bibliometric analysis is primarily descriptive and may not contain adequate content analysis to enhance the capacity for explanation and provide a more thorough assessment of the results and implications.

### Acknowledgment

We thank the Web of Science (WoS) database journal for providing the information on their webpage.

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