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Unraveling The Research Trends of Artificial Intelligence in Aviation: A Bibliometric Analysis

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ABSTRACT

This study employs bibliometric methods utilizing VOSviewer analysis of Scopus data from 2013 to 2023 to investigate trends in artificial intelligence (AI) research within the aviation industry. The analysis reveals a substantial increase in publication volume over time, peaking at 406 articles in 2022, signifying a heightened interest in AI implementation within the aviation sector. Key publication sources notably include conferences such as AIAA IEEE Digital Avionics Systems Conference Proceedings and ACM International Conference Proceeding Series. Leading contributions in publications emerge from countries such as the United States, China, India, Germany, the United Kingdom, and France, reflecting global involvement in AI research within the aviation industry. Citation analysis identifies highly cited articles addressing topics such as Digital Twin (DT) optimization processes in aviation, AI application in aircraft navigation, and machine learning for weather forecasting. These findings underscore researchers' interest in fundamental topics such as aviation, aircraft-related artificial intelligence, flight delay, and deep learning. Furthermore, co-citation analysis delineates research clusters, illustrating thematic similarities within AI research in the aviation industry. Overall, this bibliometric analysis provides comprehensive insights into the evolution of AI research in the aviation industry, potentially guiding researchers, practitioners, and stakeholders in directing research efforts, formulating policies, and understanding current trends in the application of artificial intelligence within the aviation sector.

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1. INTRODUCTION

The aviation industry continues to experience rapid development with the emergence of new technologies and changes in operational systems (Chen et al., 2021; Sulung et al., 2023). One of the key developments in the industry is the use of artificial intelligence (AI) to improve efficiency, safety and performance in various aspects of aviation (He et al., 2021) AI has been applied in various applications in the aviation industry, ranging from surveillance and control systems (Basora et al., 2021), flight data analysis (Tsai & Lai, 2021), air traffic management (Zinkhan et al., 2021), to the development of unmanned aircraft (Kvasnikov et al., 2021; Yu et al., 2021).

In this scope, it is important to understand the latest research trends related to the application of AI in the aviation industry. Bibliometric analysis is an effective approach to uncover trends and patterns in scientific publications (Rejeb et al., 2022). By comprehensively analyzing publications related to AI in aviation, we can

identify recent developments, hot research topics, researcher collaborations, and significant contributions to the field (Dixit & Jakhar, 2021; Rejeb et al., 2022; van Eck & Waltman, 2010).

The purpose of this study is to unravel the research trends on AI in the aviation industry through bibliometric analysis. We will use a powerful bibliometric analysis tool, VOSviewer, to visualize and analyze the patterns of connectedness between scientific publications, authors, institutions, as well as keywords used in the publications (van Eck & Waltman, 2010). By mining information from reliable sources such as databases of indexed journals, conferences, and publication repositories, recent developments in AI research in the context of the aviation industry can be identified.

The results of this bibliometric analysis will provide valuable insights for researchers, practitioners, and stakeholders in the aviation industry. They will gain a better understanding of recent research trends, shifts in focus, collaborative developments, and significant contributions in the field of AI in the aviation industry. This information will help them in directing research and development, designing policies, and understanding the latest developments in the application of artificial intelligence in the aviation context. In this study, a comprehensive bibliometric analysis approach was conducted to unravel AI research trends in the aviation industry. It is expected that the results of the analysis in this study will make an important contribution to the development of research and innovation in this industry, as well as provide a clear direction for researchers and other stakeholders in developing better and more effective AI solutions in the context of aviation.

2. RESEARCH METHOD

The method used in this study is a quantitative method, so that research trends in artificial intelligence covering the aviation industry can be identified. Scopus, as a comprehensive bibliographic database of scientific journals owned by Elsevier, was chosen as the main data source in this bibliometric analysis (Lancho-Barrantes & Cantu-Ortiz, 2021). Based on research conducted by (Verma et al., 2021), it is known that Scopus has a wider range, covering more than 20,000 peer-reviewed journals from various publishers. Therefore, we chose Scopus as the data source in this study due to its wider coverage. In addition, Scopus also provides advanced search features and data analysis grids that help in efficient data management. The initial stage of this research involved a literature search using the keywords "artificial intelligence" and "aviation". In an attempt to obtain a comprehensive set of relevant articles, various synonyms related to artificial intelligence such as machine learning, deep learning, natural language processing, and the like, were applied using the boolean operator "OR". This step aims to obtain a broad coverage of articles that are related to the topic under investigation. Furthermore, the boolean operator "AND" is used to generate a collection of articles that are the result of the intersection between two fields, namely aviation and artificial intelligence. (Verma et al., 2021). This process is depicted in Figure 1, which visualizes the research steps as well as the keywords applied in the search phase. The time span of the research was limited from 2013 to 2023 to accommodate the latest literature developments related to artificial intelligence in the aviation industry. As for mapping the obtained metadata, the research used VOSviewer software (version 1.6.18, Nees Jan van Eck and Ludo Waltman, Leiden, The Netherlands) (van Eck & Waltman, 2010), which makes it possible to analyze and visualize patterns of relationships between keywords, authors, and topics in the collected literature.

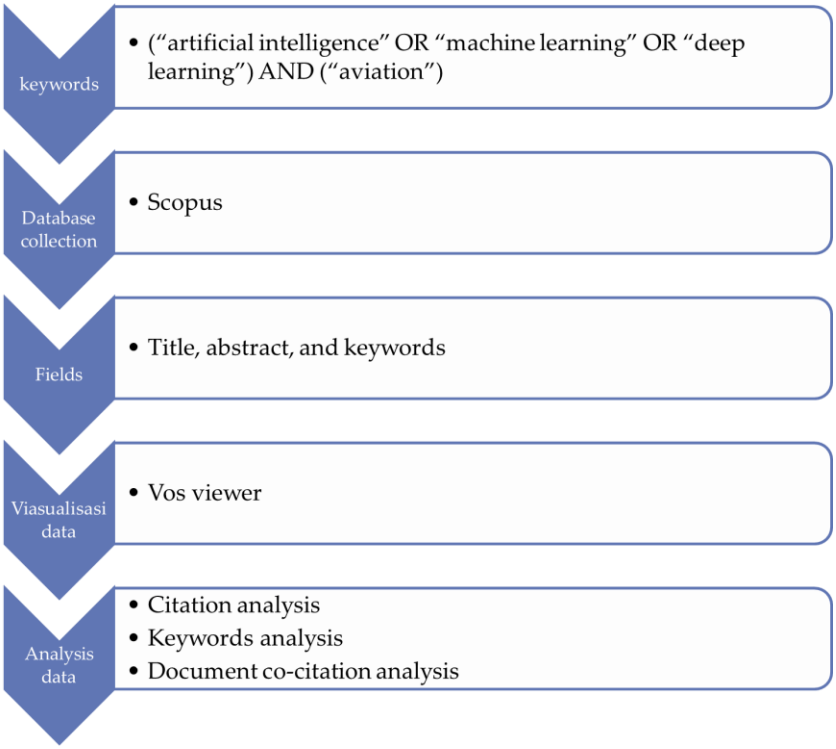


Figure 1. Research process flowchart

From the results of the data visualization that has been obtained, the next step is to conduct a review to sort out the data needed for the preparation of the article. After the article is created, and submitted until the publication of the article, the final report will be compiled. This report will combine the results of bibliometric analysis and findings from data visualization. The results will be presented in the form of a comprehensive bibliometric analysis, providing an in-depth overview of the development of artificial intelligence in the aviation industry and its impact on scientific literature.

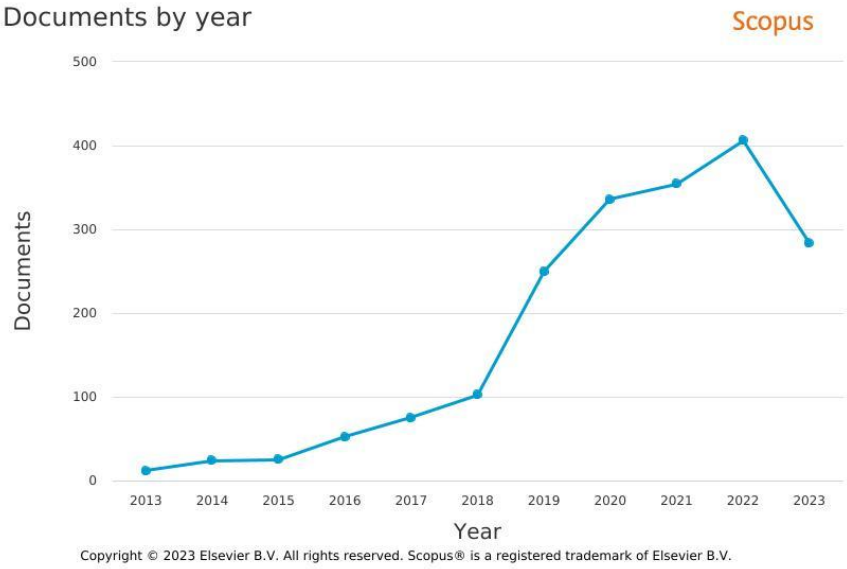
3. RESULTS AND DISCUSSIONS

Researchers can obtain research gaps through the formulation of bibliometric analysis. In addition, bibliometrics are also used to present the contributions of researchers to be displayed in the form of domains, so that a strong basis can be found for research subjects in the field of interest (Zarei et al., 2023). Therefore, from this description, the bibliometric review method is taken to describe the research trends of world researchers in artificial intelligence in the field of aviation. The techniques used for bibliometric analysis include performance analysis and scientific mapping. Performance analysis examines publication information from authors and institutions, which will be used to assess the quantity and quality of research based on the total number of publications and citations (Donthu et al., 2021; Song et al., 2021).

Scientific mapping involves a number of techniques to understand the structure and development of knowledge in a field of study. Among them are bibliographic coupling, citation analysis, co-citation analysis, co-authorship analysis, and keyword co-occurrence analysis. Bibliographic coupling compares similar references among scholarly articles to identify topic similarities. Citation analysis measures how often a document is cited, while co-citation analysis highlights the interrelationships between co-cited documents. Co-authorship analysis examines patterns of collaboration between authors, while keyword co-occurrence analysis helps uncover relationships between keywords that frequently co-occur in scholarly literature. All of these aim to help map the structure, interconnectedness and evolution of knowledge within a field of study (Donthu et al., 2021; Zarei et al., 2023).

3.1 PUBLICATION PROGRESS

The discussion first starts by showing the number of documents per year. In the research domain of artificial intelligence in the aviation industry, the growth trend of the number of publications shows a consistent increase from year to year. Figures 2a and 2b show the publication document data from 2013 to 2023. It can be seen that there is a significant growth trend. In 2013, the number of publications was only 12 documents related to AI in the field of aviation. However, since then, there has been a considerable spike in this research activity. In 2023, as the data was collected before 2023 ended, the number of publications decreased to 284 documents, but this is still an indicator of a more than twenty-fold increase in the last ten years. The highest number of publications was in 2022, where 406 articles were found. This significant growth trend demonstrates the growing interest and intense focus of the research community on the applications of artificial intelligence in the aviation industry. This reflects a strong drive to investigate the potential of AI to improve efficiency, safety and innovation in the aviation sector.



(a)

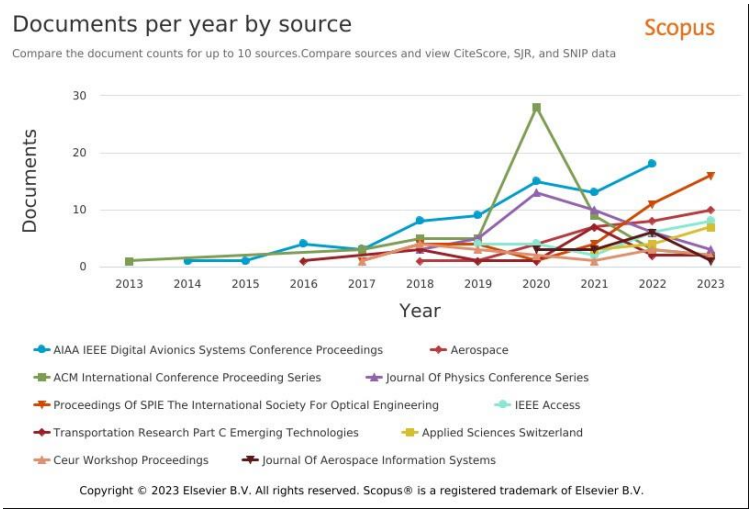
No	Year	Documents
1	2023	284
2	2022	406
3	2021	354
4	2020	336
5	2019	250
6	2018	102
7	2017	75
8	2016	52
9	2015	25
10	2014	24

(b)

Figure 2. a) Graphic publication statistics by year b) Table publication statistics by year

This number of publications can be achieved with the help of a number of journals that help this publication. Figures 3a and 3b display the top ten statistical number of document articles from year to year based on the source of publication. It can be seen from the data that there are a number of publication sources that contribute significantly. For example, the AIAA IEEE Digital Avionics Systems Conference Proceedings stands out with a significant number of documents, reaching 72 publications, signifying a strong contribution in providing knowledge related to artificial intelligence and its applications in the aviation industry. Meanwhile, ACM International Conference Proceeding Series and Proceedings Of SPIE The International Society For Optical Engineering contributed 56 and 41 documents respectively, demonstrating the important role of conferences and proceedings in informing research developments in this field. With further analysis, it can be concluded

that sources such as the AIAA IEEE Digital Avionics Systems Conference Proceedings play a key role in driving knowledge and innovation in artificial intelligence in the aviation industry.



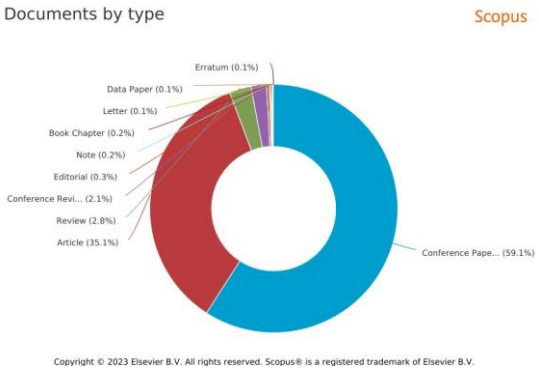
(a)

No	Source	Documents
1	AIAA IEEE Digital Avionics Systems Conference Proceedings	72
2	ACM International Conference Proceeding Series	56
3	Proceedings Of SPIE The International Society For Optical Engineering	41
4	Journal Of Physics Conference Series	40
5	Aerospace	31
6	IEEE Access	24
7	Transportation Research Part C Emerging Technologies	17
8	Ceur Workshop Proceedings	16
9	Applied Sciences Switzerland	14
10	Journal Of Aerospace Information Systems	13

(b)

Figure 3. a) Graphic document by source, b) document by source table

Figures 4a and 4b show the number of publications per document type. The majority of publications consist of Conference Papers, reaching 1135 documents, signifying the great role of conferences in discussing and disseminating research findings and developments related to artificial intelligence in the aviation industry. Articles also had a significant contribution with 674 documents, showing the importance of research in this format in providing in-depth insights into AI in the context of aviation. In addition, there are other document types such as Review 54 documents, Conference Review 40 documents and Editorial 6 documents. This shows the diversity of information and approaches in reporting research results in this field.



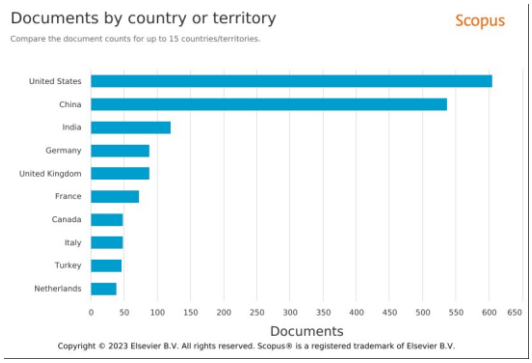
(a)

No	Document type	Documents
1	Conference Paper	1135
2	Article	674
3	Review	54
4	Conference Review	40
5	Editorial	6
6	Note	4
7	Book Chapter	3
8	Letter	2
9	Data Paper	1
10	Erratum	1

(b)

Figure 4. a) Graphic document by country, b) Table document by country

Figure 5a and 5b show a visualization of the top 10 countries' contributions to research on this topic. An analysis of the contribution of researchers to a country can show how researchers in different countries are collaborating to carry out the exchange of ideas (Wei et al., 2023). It can be seen that the United States and China lead in the number of publications, with 604 and 536 documents respectively, indicating the high interest and investment of these two countries in AI research in the aviation industry. In addition, India also has a significant contribution with 120 documents, indicating the increasingly important role of this country in developing artificial intelligence in the context of aviation. Burak et al (Burak & Küsbeci, 2023)., in publications with articles on the internet of things (IOT), the contributors of publication documents in the web of science database are China, America and India. This is likely because Chinese researchers themselves prefer WOS as an indexation for some of their research (Shu et al., 2019). In addition to these countries, European countries such as Germany, the UK, and France have considerable contributions, showing the global diversity of AI research in the aviation industry.



(a)

No	Country/Territory	Documents
1	United States	604
2	China	536
3	India	120
4	Germany	88
5	United Kingdom	88
6	France	72
7	Canada	48
8	Italy	48
9	Turkey	46
10	Netherlands	38

(b)

Figure 5. a) Graphic document by country, b) Table document by country

3.2 Citation Analysis

Citation analysis has an important role in understanding communication and relationships between researchers in a particular field. To see the impact given by researchers, one of them can be seen by monitoring the h-index, m-index, and g-index, some of these things can be used as indicators of the quality of an article (Gülhan & Kurutkan, 2021). When an author cites a particular article, it indicates a relationship or connection between the citing and the cited article. This citation analysis helps in identifying influential articles in a research domain. A high number of citations indicates the significance and contribution of a paper to the research discipline. By tracking the popularity and growth of cited articles over time, citation analysis allows researchers to recognize important articles and identify changes in topics or research directions in a particular field. Overall, Citation analysis serves as a valuable tool in conducting literature reviews and understanding the scientific landscape of a specific research area. (Gundolf & Filser, 2013; Pournader et al., 2020).

Bibliometric analysis of research understanding and identification outlines depends on the number of citations obtained for each article (Okine et al., 2024). The data in Table 1 shows 10 articles with the highest number of citations. The article with the highest number of citations, with 527 citations, was published in 2019 with the title "A survey on digital twin: Definitions, characteristics, applications, and design implications", this article discusses the Digital Twin (DT) method in optimizing processes in the aviation field. The publication with the second highest number of citations is a study that discusses a review of where artificial intelligence technology can help the world of aviation including in terms of navigation such as GPS, to analyzing aircraft aerofoils, research with the title "Human-Robot Interaction" gets 359 citations (Sheridan, 2016). The article title with the third highest number of citations is "DeepDeSRT: Deep Learning for Detection and Structure Recognition of Tables in Document Images", with a total of 235 citations, this research published in 2017 discusses a technology called DeepDeSRT. This system is a new system that enables understanding of tables in document images using a deep learning-based approach. This table structure recognition has the potential to make a meaningful contribution to information management, data analysis, and operational efficiency in the aviation sector (Schreiber et al., 2017).

Table 1. Top cited article

No	Tittle	Year	Source	Cited by
1	A survey on digital twin: Definitions, characteristics, applications, and design implications	2019	IEEE Access	527
2	Human-Robot Interaction	2016	Human Factors	359
3	DeepDeSRT: Deep Learning for Detection and Structure Recognition of Tables in Document Images	2017	Proceedings of the International Conference on Document Analysis and Recognition, ICDAR	235
4	Introduction to artificial intelligence in medicine	2019	Minimally Invasive Therapy and Allied Technologies	219
5	Deep Learning with Spatiotemporal Attention-Based LSTM for Industrial Soft Sensor Model Development	2021	IEEE Transactions on Industrial Electronics	215
6	Energy storage emerging: A perspective from the Joint Center for Energy Storage Research	2020	Proceedings of the National Academy of Sciences of the United States of America	186
7	Flight delay prediction based on aviation big data and machine learning	2020	IEEE Transactions on Vehicular Technology	177
8	Multi-Radar Multi-Sensor (MRMS) severe weather and aviation products: Initial Operating Capabilities	2016	Bulletin of the American Meteorological Society	155
9	Adaptive automation triggered by EEG-based mental workload index: A passive brain-computer interface application in realistic air traffic control environment	2016	Frontiers in Human Neuroscience	146
10	A deep learning approach to flight delay prediction	2016	AIAA/IEEE Digital Avionics Systems Conference - Proceedings	128

3.3 Keywords Analysis

Keywords analysis plays an important role in identifying research topics that are being widely discussed, so that research trends can be identified from this data (Zhang et al., 2022). Keyword analysis was conducted using VOSviewer. The method used is co-occurance analysis. This is important because, keyword co-occurance is an important method for knowledge mining and provides a broad view of the knowledge structure and trends in related studies that will be discussed in this case is artificial intelligence in the world of aviation (Wang et al., 2020). At least from 13562 keywords from 1920 documents obtained from the Scopus database, only the number of co-occurance 30 was selected, so that 93 keywords were obtained, then filtered to match the interconnected documents into four clusters. Where each cluster represents data on interrelated topics (Okine et al., 2024).

As can be seen in Figure 6, the green cluster represents the keyword used in this article, the word "aviation", with an occurance of 632, which means that in 1920 documents found, 632 documents used this word as their keyword. This cluster discusses a lot about air traffic controllers, which can be seen in Table 1 also that the article that discusses this keyword appears as the ninth article that has the most citations (Aricò et al., 2016). The red cluster represents the discussion of artificial intelligence about aircraft, starting from learning about Boeing 737 aircraft maintenance (Siyaev & Jo, 2021), up to accident reports (Kuhn, 2018). The yellow cluster discusses more about flight delay, which one of these keywords appears in the top 10 cited documents (Gui et al., 2020). Another interesting topic is about machine learning that helps in weather forecasting by using Multi-Radar Multi-Sensor (MRMS) which involves a number of integrated weather warning products using machine learning to monitor and predict potentially dangerous weather phenomena such as storms, hail, tornadoes, lightning, as well as providing the latest forecast of storm location, height and intensity (Smith et al., 2016). Finally, the blue cluster discusses a lot about deep learning. One of the interesting topics is the detection of damage to aircraft engines when inspected using a borescope (Shen et al., 2019).

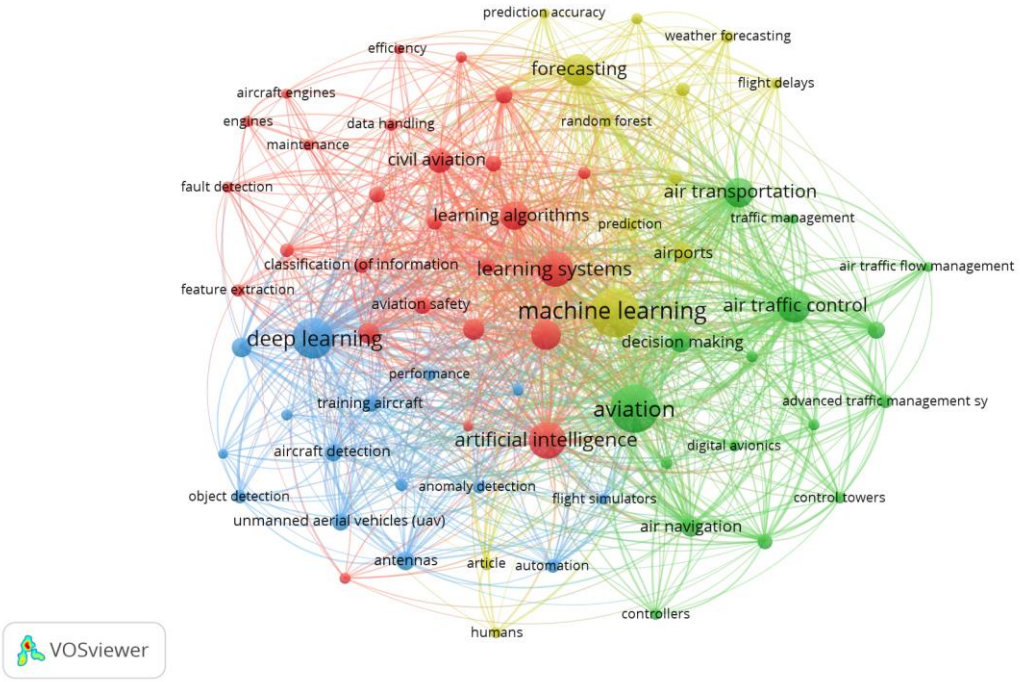


Figure 6. Bibliometric mapping of co-occurrence

3.3 Document Co-Citation Analysis

Co-citation analysis is a valuable method in bibliometric research to understand the relationship between publications and uncover the intellectual structure within a given research field. The approach involves identifying publications that are frequently co-cited and examining the relationships between them to identify distinct research clusters. Publications within the same cluster often share similar ideas and contribute to the same topic or theme. It is important to note that being in the same cluster does not necessarily mean that publications have coherent findings or agree with each other; they are grouped based on topic similarity, even though they may have conflicting views. Co-citation analysis provides valuable insights into scholarly communication and influence within a research field, allowing researchers to identify influential publications, emerging research trends, and areas of active debate or collaboration. By exploring the Co-citation network, researchers can gain a deeper understanding of the intellectual landscape and dissemination of knowledge within a particular research field [8], [17].

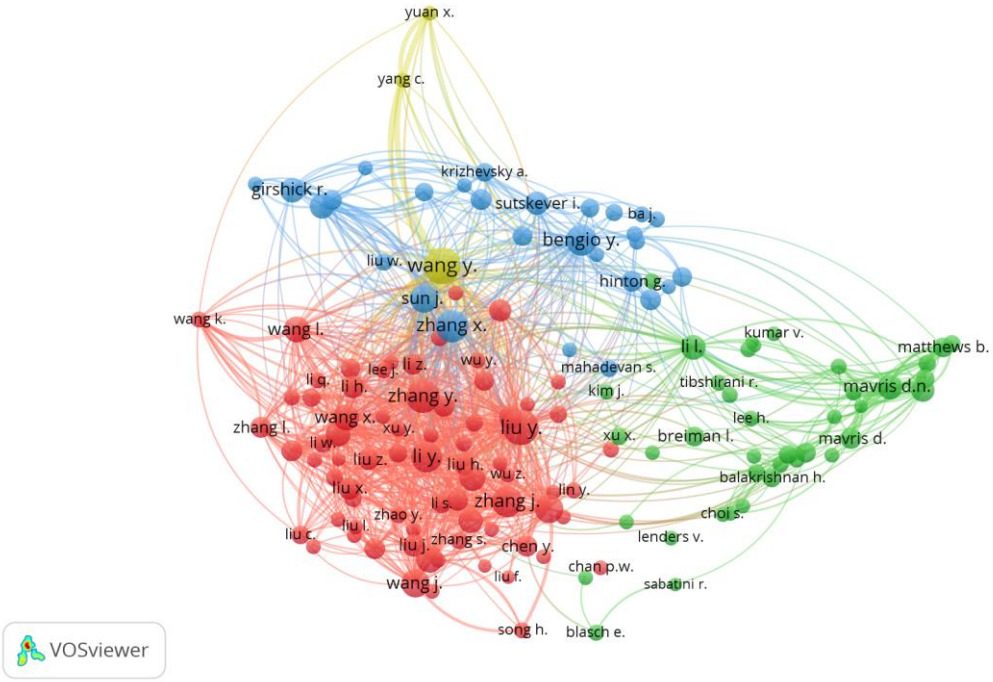


Figure 7. Bibliometric mapping of co-citation

4. CONCLUSION

This study aims to analyze research trends on artificial intelligence (AI) in the aviation industry using bibliometric methods. The research was conducted through the use of VOSviewer analysis tool on Scopus data from 2013 to 2023. Based on bibliometric analysis, the results obtained illustrate the development of AI research in the aviation industry. AI research trends in the aviation industry show significant growth from year to year, with an increase in the number of publications. The highest number of publications was recorded in 2022, reaching 406 articles, signaling the increasingly intense interest and focus of researchers on the application of AI in the aviation industry. Significantly contributing publication sources are conferences such as AIAA IEEE Digital Avionics Systems Conference Proceedings, ACM International Conference Proceeding Series, and Proceedings Of SPIE The International Society For Optical Engineering. The analysis shows that the research is led by countries such as the United States, China, and India, with significant publication contributions from European countries such as Germany, the United Kingdom, and France.

Citation analysis of the articles revealed several publications that had a high number of citations. These articles cover diverse topics, such as Digital Twin (DT) in process optimization in aviation, AI implementation in aircraft navigation and analysis, and the use of machine learning in weather forecasting. Keyword co-occurrence analysis highlights key topics including aviation, artificial intelligence related to aircraft, flight delay, and deep learning, indicating researchers' interest in these areas. In addition, the co-citation analysis provides insight into the relationship between publications and shows different research clusters within the AI domain in the aviation industry. The clusters reflect the similarity of topics and research themes explored by researchers. Overall, this bibliometric analysis provides a deep insight into the development of AI research in the aviation industry. The findings are useful for researchers, practitioners, and stakeholders in directing research, planning policies, and understanding current trends in the application of artificial intelligence in the aviation sector.

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