

# Bibliometric Analysis of Academic Publications on Artificial Intelligence and Aviation Keywords with VOSviewer

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## Abstract

This study seeks to show the distribution of academic studies relating to the keywords “artificial intelligence” and “aviation” by years, by authors, by countries, and by organizations using bibliometric data of scientific publications indexed in the Web of Science database between 2005-2023. In this direction, a total of 215 publications were analyzed and categorized in terms of bibliometric indicators by doing an online search on the Web of Science, and VOSviewer, a bibliometric analysis technique was used. As a result of the bibliometric analysis of 215 articles published with the keywords “artificial intelligence” and “aviation” between 2005 and 2023, it has been observed that significant developments have been recorded after 2014 and that the most broadcasts were made in 2022. In order to obtain healthier results and to avoid information pollution, some limitations were introduced to the analysis, such as “minimum number of publications” and “minimum number of citations”. “People’s Republic of China” is the country with the highest number of publications, with 98 articles in compliance with at least 6 publication conditions. The organization that published at least 4 articles with the keywords “artificial intelligence” and “aviation” became “Chinese Civil Aviation University” with 12 publications. The authors who have at least 4 publications in the articles made with the keywords “artificial intelligence” and “aviation” are “Pietro Aricò, Gianluca Borghini and Gianluca Di Flumeri” who have 10 publications.

## 1. Introduction

The century we live in is characterized as the age of technology, and the rapid technological developments in this century shape people's lifestyles and business policies. While people enjoy the convenience of using technological devices, businesses turn the data they collect into opportunities for marketing purposes (Çankaya, 2020).

Studies and investments in artificial intelligence that emerged with the rapidly developing technology are increasing day by day in many sectors, such as health, education, and aviation. Artificial intelligence studies, which are the result of imitating human intelligence, can be described as the modeling of human learning by machines. Considering that human learning processes occur in the brain, it seems possible to analyze the structure of the brain and create it on machines. Based on the fact that the learning event in humans occurs through the interaction in brain cells called neurons, artificial neural networks were created on computers and the learning event was simulated (Yılmaz & Kaya, 2007). According to McCarthy, who is considered one of the pioneers of artificial intelligence studies, if human intelligence and learning phenomena are understood and defined in detail, machines will have the ability and intelligence to learn by imitating this situation (McCarthy, 2007).

Artificial intelligence systems, which have been included in the daily lives of people from all walks of life since the beginning of the twenty-first century, have become an indispensable part of life. Artificial intelligence systems are utilized in a wide range of day-to-day activities, from computerized systems used at work to vacuum cleaners used for housekeeping, from car navigation systems that plan travel routes to bank accounts that manage investment transactions, from shopping websites where orders are placed to phones used for calls (Coşkun & Gülleroğlu, 2021).

Today, small businesses, large companies, organizations and governments that want to survive for many years and aim to be permanent and successful have to develop and use artificial intelligence systems. Artificial intelligence systems are generally cognitive regulators that can help institutions and organizations make more accurate and effective decisions by processing big data. These systems can be used in every field from the planning of human resources to the development steps to be taken by the states. The use of artificial intelligence systems is mandatory in order to process, classify, control, measure, regulate and make correct decisions, which are important for states (Aydın, 2019).

The aviation industry is a pioneer in technological developments compared to other industries. Along with the increase in globalization from year to year, the aviation sector

also has a rapid growth momentum (Kalakou et al., 2015). With this growth, artificial intelligence is also increasingly adopted in the aviation industry and is now used in various aspects of airports due to its ability to process large amounts of data and streamline tasks and procedures (Seçkiner et al., 2021).

There are many tasks in an airline that have a repetitive or routine nature. These tasks cost valuable time, reduce motivation, and increase the risk of human error. Artificial intelligence applications increase an airline's efficiency, make airlines more competitive, and can reduce or even eliminate human error (Seçkiner et al., 2021).

Obtaining meaningful and useful information about publications that are increasing day by day is becoming increasingly difficult in direct proportion to the increase in the number of publications. Numerous studies that are related to the topics under investigation can be accessed collectively thanks to bibliometric analysis, which has grown in importance as a result of these challenges. For this reason, the aim of the study is to examine the distribution of academic studies on "artificial intelligence" and "aviation" in the literature by year, distribution according to author, and distribution according to country and organization. In order to achieve this goal, the "bibliometric analysis method", one of the qualitative research methods, is used.

## 2. Artificial Intelligence (AI)

When artificial intelligence is done by humans, it is the behavior that is called intelligent when it is done by the machine. The purpose of artificial intelligence is to imitate human intelligence through computers (Pirim, 2006). While doing this, it fulfills its tasks related to higher logic processes such as finding a solution, understanding, inferring a meaning, generalizing and learning from past experiences (Öztürk & Şahin, 2018). Yapay sinir ağları ve yapay zekâ'ya genel bir bakış. Takvim-i Vekayi, 6(2), 25-36.). Artificial intelligence, which facilitates people's work by doing all these, can be grouped as in Figure 1 (Pilon, 2023).

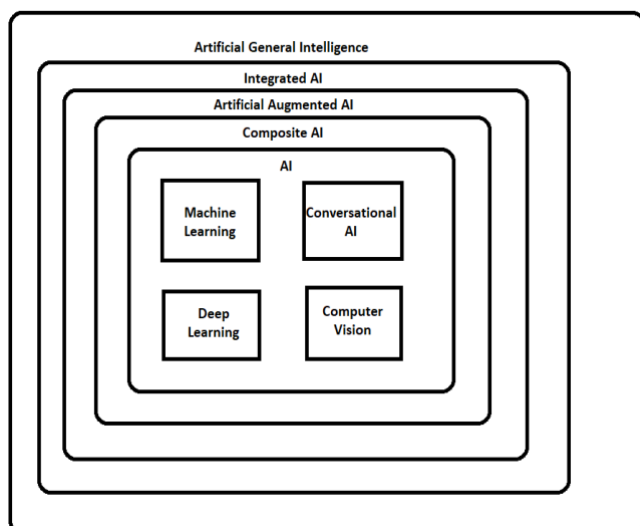


Figure 1. Categories of artificial intelligence (Pilon, 2023)

The common point of all artificial intelligence applications and categories is that they work with data and use more than one technique (Table 1) (Pilon, 2023).

Table 1. Different types of artificial intelligence (Pilon, 2023)

Type of AI Technology	Illustration
Machine learning	Email filters, predictive maintenance for jet engines
Computer vision	Retina scans, fingerprint recognition
Movement sensors	Park distance control
Voice recognition	Siri, Alexa
Search using natural language processing	Google, Yahoo, Amazon
General Narrow Intelligence	Robotics, bottling
Virtual Assistants	

AI objectives:

- Reasoning (explain something)
- Information presentation (tracking intelligence in an easy-to-interpret way)
- Better and faster planning
- Better and faster learning
- Understanding and working with natural language (Natural Language Programming)
- Detection (interpreting difficult environments)
- Ability to move and manipulate objects (robot science).

In artificial intelligence, goals are determined by people and are basically built in accordance with the process of thinking, analyzing and making decisions using people's knowledge (nervous systems). It often requires multiple models to come up with the "final pattern" in achieving goals.

AI is an emerging technology that is rapidly transforming business models in the aviation industry, as in other industries. By using data and mimicking how humans solve problems, AI helps speed up and automate processes with machine and deep learning. From smart search to autonomous vehicles, the combination of smart technologies empowers self-service applications and generates deep insights into patterns. These technologies provide many efficiencies, cost savings and new revenue potential. It is also a powerful tool to guide sustainability efforts. AI helps deliver better customer service and is estimated to generate over \$13 trillion in value each year for customers, businesses and society.

### 2.1. Artificial Intelligence Applications in Aviation

Artificial intelligence, whose foundation and first concrete steps date back to the 17th century and which was first expressed in terms by John McCarthy in 1956 at Dartmouth College, finds more and more fields of study within the disciplines day by day. Artificial intelligence, the use of which is increasing day by day in various industries, is also rapidly involved in the aviation industry. The airline industry prioritizes digitalization and artificial intelligence investments to deal with many uncertainties, such as the difficulty of keeping up with volatile consumer behavior, variable fuel rates, government regulations, declining margins, competition from low-cost flights, and weather conditions.

Artificial intelligence has found many uses in aviation in recent years due to three simultaneous factors. These are the factors

- Large data collection and storage capacity,
- Increase in computational power,
- Development of increasingly powerful algorithms and architectures.

As a result of these;

- It is used in the use of interfaces for all operators in the aviation industry.
- Collecting information about air traffic, the number of which is increasing day by day, processing this collected information and using it in air traffic control systems by making analysis.

- The materials, designs and technology used in the production processes in the aviation industry are more complex and advanced than in other industries. It requires more advanced systems to manage and verify them. At this stage, artificial intelligence comes into play.
- air navigation and flight operations.
- aircraft operations, including fuel management.
- customer contact management and customer service.
- inflight service management and cabin service operations.
- IoT connected devices and sensory applications in cabins.
- Payload Optimization
- Aircraft and Engine Maintenance
- Fuselage corrosion detection
- Pilot relief for simple operations
- Runway throughput improvement
- Meals and Beverages Provisioning
- Network and Schedule Planning,
- Aircraft Assignment
- Demand Forecasting, Pricing, Ancillary, and Revenue Management
- Loyalty Management
- Sales and Distribution
- Retailing and Digital Assistants
- Total Revenue Optimization
- Brand Management, Reputation, and Social Media
- Cargo Warehouse and Handling
- Cargo Commercial Management
- Human Resources Management

Looking at the studies in the literature, the main topics are given in Figure 2. The data are arranged according to the topics taken from Web of Science. Accordingly, the most cited and publications are related to Safety and Maintenance. Other topics are given in the chart.

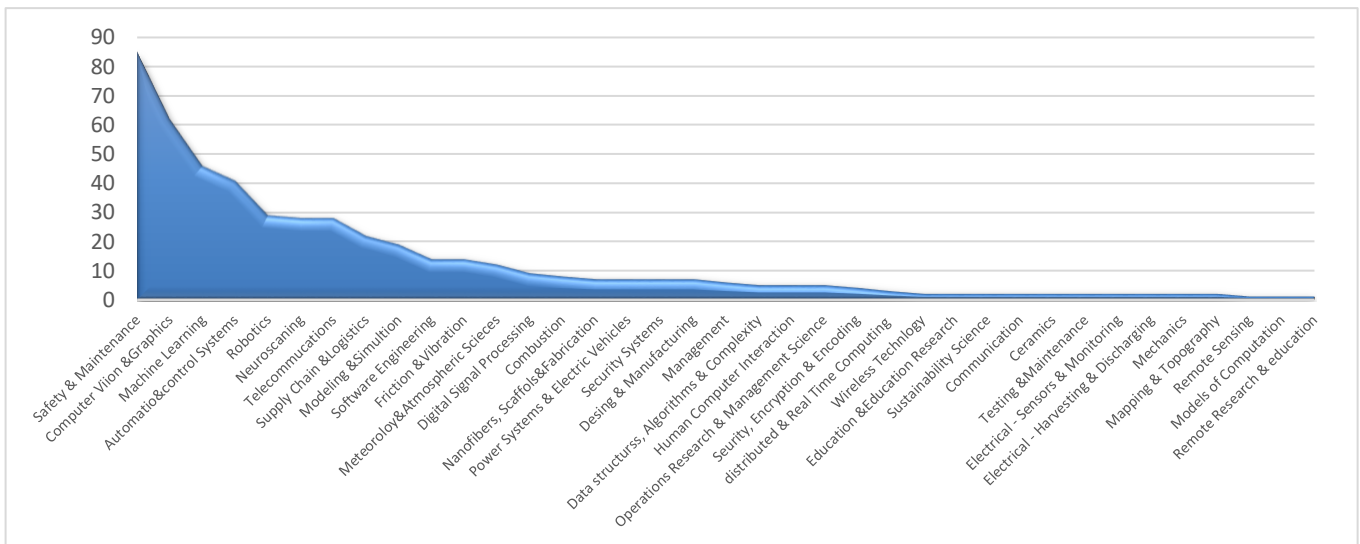


Figure 2. Distribution of main topics in articles on “artificial intelligence” and “aviation” (Reference: Web of Science)

When looking at the more detailed sub-headings in addition to the main topics, the topics related to Situation Awareness, Deep Learning, Airlines, Safety Climate and Multi Agent

Systems were studied with the highest number of publications. These are given in Figure 3.

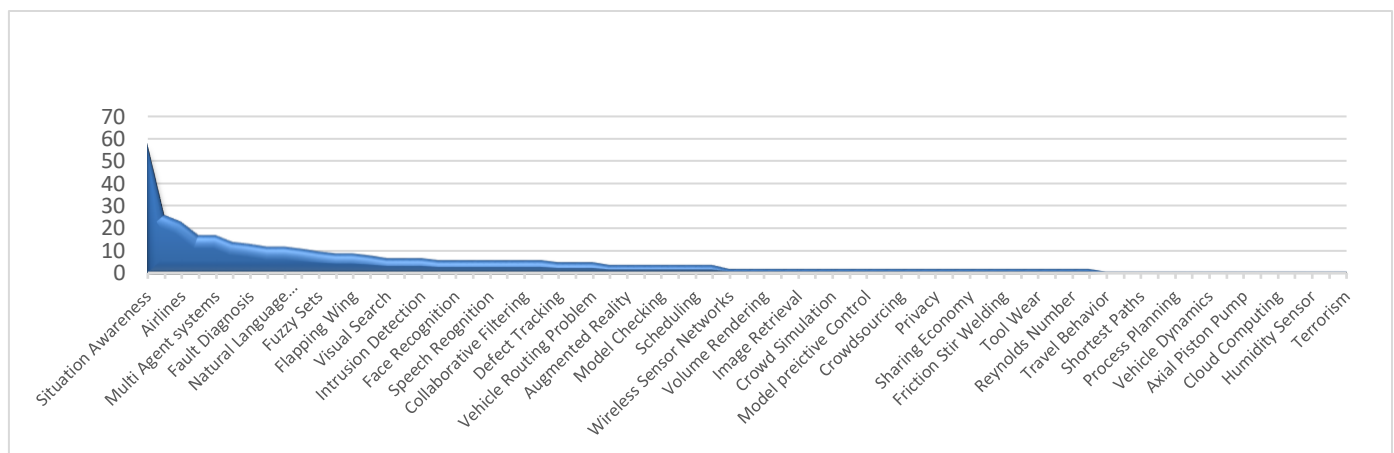


Figure 3. Distribution of detailed topics in articles on “artificial intelligence” and “aviation” (Reference: Web of Science)

### 3. Bibliometric Analysis

Bibliometric analysis, which is expressed as the application of mathematical and statistical methods to books and scientific communication tools, can be applied to scientific outputs, processes and studies (Cronin, 2001). With the bibliometric analysis technique, all the accumulations in the literature or parts covering certain periods are discussed and concrete data about the related discipline are presented (İnceoğlu, 2014). Scientific and academic publications determined within the scope of this method are brought together, the data of the publications are classified and interpreted by making research-oriented analyzes (Baker et al., 2020). Accordingly, bibliometric analysis, active journals published in the study, the total number of publications, the institutions of the authors, the language of publication, the countries where active research was conducted, the types of sources in the study can be examined as keywords, networks, citations from studies, and the bibliometric variable (Gürdin, 2020). Bibliometric analysis consists of 5 different types. These; citation analysis, co-citation analysis and bibliographic matching, co-author analysis and common word analysis (Zupic & Čater, 2015). In this study, the distribution of academic studies on the keywords “artificial intelligence” and “aviation” in the literature by years, distribution according to authors, distribution according to countries and organizations were examined.

### 4. Method

In this section, the purpose and importance of the study, the data collection process, the analysis of the data and the limitations of the study are mentioned.

#### 4.1. Purpose and Importance of the Research

The aim of this study is to be able to reach many studies together with the bibliometric analysis method, which has become more important with the increase of these difficulties, and to present healthier information and visual content to researchers by creating a visual map. In this study, the articles related to the keywords "artificial intelligence" and "aviation" were classified as years, countries, institutions and authors and analyzed. This study is important in terms of providing a broader perspective on the subject to researchers working in the field of artificial intelligence and aviation.

#### 4.2. Scope of the Research

Within the scope of this study, answers to the following research questions were sought:

- What is the number of articles about the keywords “artificial intelligence” and “aviation” in the international index between 2005-2023.
- The years in which the articles about the keywords “artificial intelligence” and “aviation” were published in the international index between 2005-2023.
- By whom the articles about the keywords “artificial intelligence” and “aviation” in the international directory between 2005-2023 were made.
- How many citations have articles on the international directory “artificial intelligence” and “aviation” keywords been cited in the international directory between 2005-2023.

- In which countries the articles about the keywords “artificial intelligence” and “aviation” were written in the international directory between 2005-2023.
- The organization that wrote the articles about the keywords “artificial intelligence” and “aviation” in the international directory between 2005-2023.
- The most cited authors and citation numbers for the keywords “artificial intelligence” and “aviation” in the international index between 2005-2023.

#### 4.3. Research Data Collection Process

During the literature review, data mining, software selection, data analysis, findings and discussions were made. Data for analysis were collected from the Web of Science website and analysis was done by evaluating 215 articles.

#### 4.4. Analysis of Research Data

Analysis and data visualization of the data collected in the study were analyzed using version 1.6.18 of the package program "VOSviewer". The selected software offers state-of-the-art visualizations, especially for the study of bibliometric networks. The VOSviewer program gives information such as how many academic studies have been carried out according to the selected keywords, years, how many researchers work in the field according to the selected keywords, how many of these studies are carried out in which countries and how. VOSviewer helps to generate findings that are visually easy to understand and to analyze the results. It is preferred because it provides information with network relations. In this study, information about articles, journals, authors, common citation network, author common citation network, countries and institutions and organizations where publications are made and keywords were analyzed and graphs were created.

#### 4.5. Limitations of the Study

The data used in the study were obtained from the Web of Science database. There is a time decrement because the articles in the Web of Science database will be used between 2005-2023. Other limitations are that the document scanning was done only in the Web of Science database and other databases were not examined, the language of the articles studied was only English, only the articles were being examined as a document type, and the data processed in the VOSViewer program used was accepted to be correct.

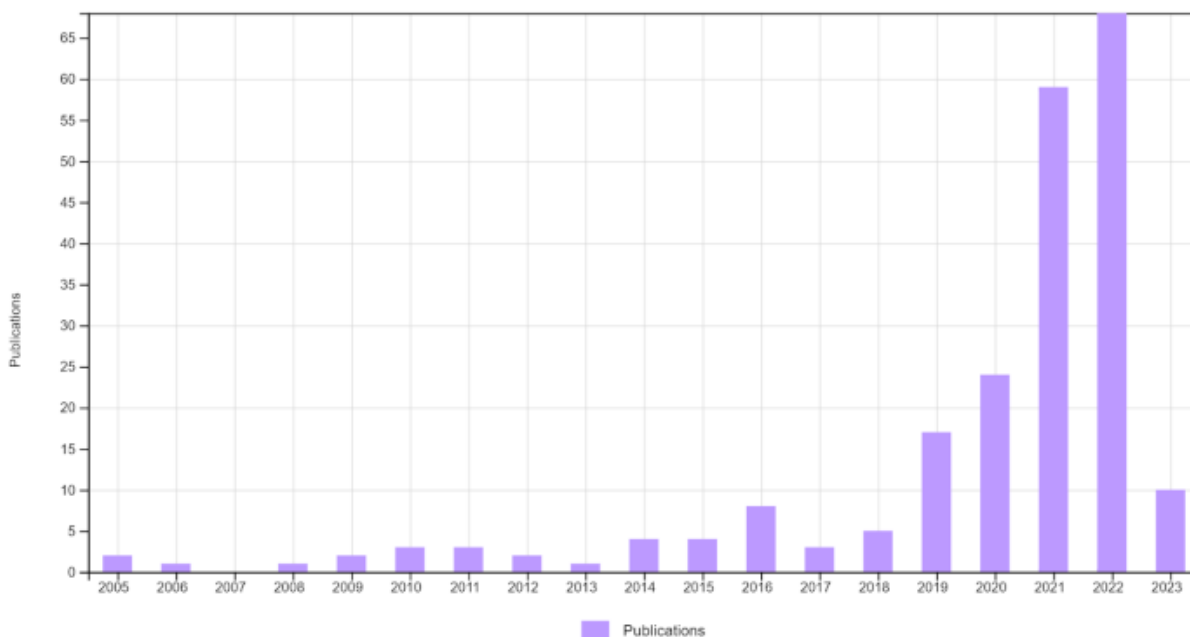
### 5. Findings

In the study, information about articles, information about journals, information about authors, journal co-citation network, author co-citation network, information about countries were analyzed and graphics were created.

#### 5.1. Distribution by Years

AI is a relatively old field of computer science that encompasses several techniques and covers a wide range of applications. AI is a broad term and its definition has evolved as technology has evolved. For this reason, the number of publications has been increasing over the years. In the study publications related to “artificial intelligence” and “aviation” were taken into account, a total of 215 articles were examined between the years 2005-2023. The distribution of publications by year is given in Graph 3. According to Graph 1, the most publications were made in 2022. When we consider the

number of articles by year, it is seen that there has been an increase in recent years.



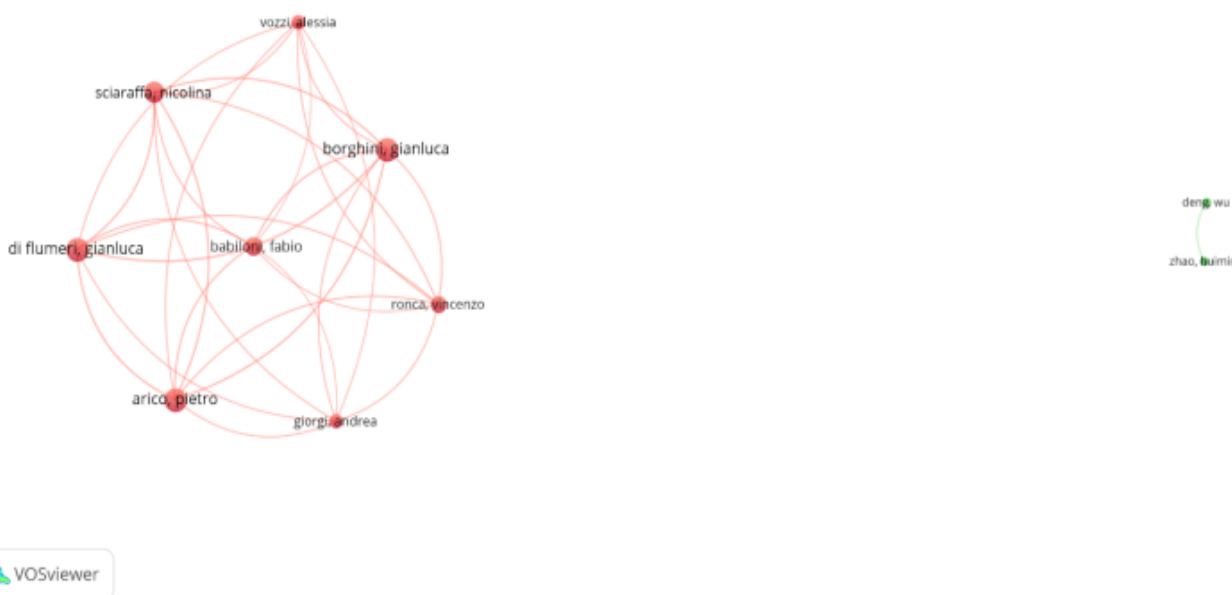
**Figure 4.** Distribution of articles on the keywords “artificial intelligence” and “aviation” by Years in the Period 2005-2023. (Reference: Web of Science)

When the distribution of articles related to the keywords "artificial intelligence" and "aviation" for the 2005-2023 period is examined, it is seen that the year 2022 was the year with the most publications, with 116 articles. Following 2022, 2021 is the second year with the most publications with 104 articles. There is fluctuation in the number of articles published between 2009 and 2014. It cannot be said that there has been a continuous increase or decrease between these years. After 2014, it is seen that there is a regular increase in the articles published about these keywords. It can be said that the increase in the number of articles published on this subject

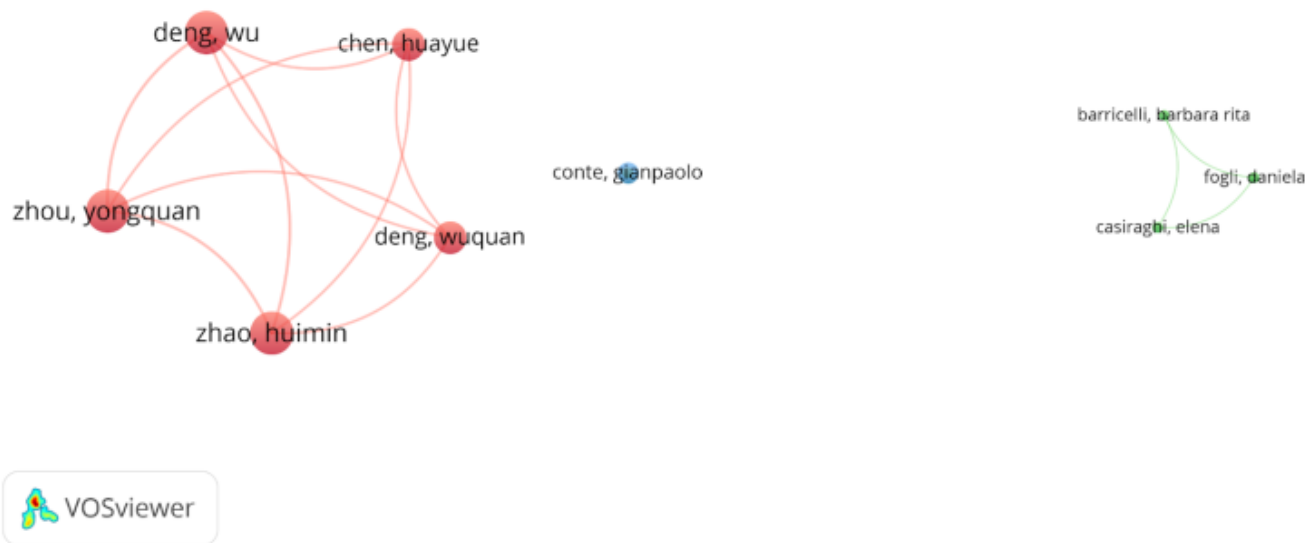
after 2014 is a result of the importance given to artificial intelligence in aviation and the increasing research and investments in this subject. In recent years, "artificial intelligence" and "aviation" research have gained momentum. 2023 data belongs to March 2023 and is increasing day by day.

### 5.2. Authors with the most publications

The ten authors with the most publications in this section are given in Figure 5.



**Figure 5.** The authors who published the most articles between 2005-2023 and the relationship between them.



**Figure 6.** The most cited authors between 2005-2023 and the relationship between them.

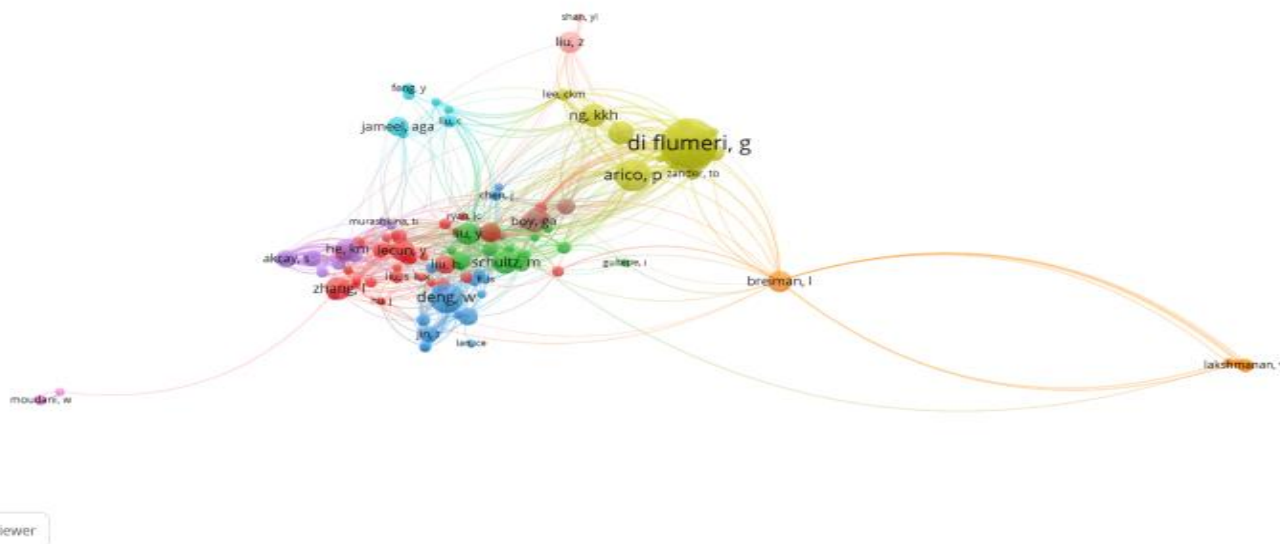
Considering the distribution of the authors who published the most articles on the keywords “artificial intelligence” and “aviation” obtained from the VOSviewer program, the authors with at least 4 publications related to these keywords were taken into account. Out of a total of 915 authors who published on the keywords “artificial intelligence” and “aviation”, 10 authors with at least 4 publications were found. Nodes grow according to the number of articles belonging to authors. In this direction, according to Figure 5, the authors who have published the most on the keywords “artificial intelligence” and “aviation” are Pietro Aricò, Gianluca Borghini and Gianluca Di Flumeri with 10 publications. These authors are followed by Nicolina Sciaraffa (9), Fabio Babiloni (8), Vincenzo Ronca (7), Andrea Giorgi (6), Alessia Vozzi (6), Wu Deng (4) and Huimin Zhou (4). The fact that the node colors are the same indicates the existence of the authors working together; the lines indicate the relationship of the authors to each other.

### 5.3. Most cited authors

The ten most cited authors in this section are given in Figure 6. In order to obtain the top 10 most cited authors out of 915 authors, the minimum number of citations for an author was determined as 208. Wu Deng, Huimin Zhou and Yongquan Zhou are the most cited authors with 391 citations. These authors are followed by Huayue Chen and Wuquan Deng with 237 citations. The citations received by other authors are as follows, respectively; Barbara Rita Barricelli (233), Elena Casiraghi (233), Daniela Fogli (233), Thomas B. Sheridan (230), Gianpaolo Conte (208).

### 5.4. Author Co-Citation Analysis

In this section, the author co-citation analysis is listed in Figure 7.



**Figure 7.** Co-Citation Network of publication authors on the keywords “artificial intelligence” and “aviation”.

It was visualized using the “citation-based analysis” technique in the VOSviewer program to identify the most cited authors in studies in this field. It can be learned through co-attribution analysis of the intellectual structure of scientific disciplines. In other words, author co-citation analysis means that the series of articles published by an author is understood as the "author". Authors whose publications are often seen as interrelated and repeatedly cited as such in their later work tend to converge on the map. On the other hand, authors who are rarely or never mentioned together are located relatively further away on the map. In other words, authors' co-citation analysis concludes that the more frequently two authors are cited together, the closer the relationship between them (White

& Griffith, 1981). Authors with at least 5 publications related to the keywords “artificial intelligence” and “aviation” were evaluated. In Figure 7, 128 out of 7588 authors meet the threshold. The authors were divided into 10 different groups. As a result of the analysis, the author who established the most common networks is Gianluca Di Flumeri with 28 common connections. Then Gianluca Borghini (27), Pietro Aricò (18), Wu Deng (17) and NG, Kam K.H. It comes from (13).

### 5.5. Distribution by Country

In this section, the ten countries with the most studies and the network of relations between them are given in Figure 8.



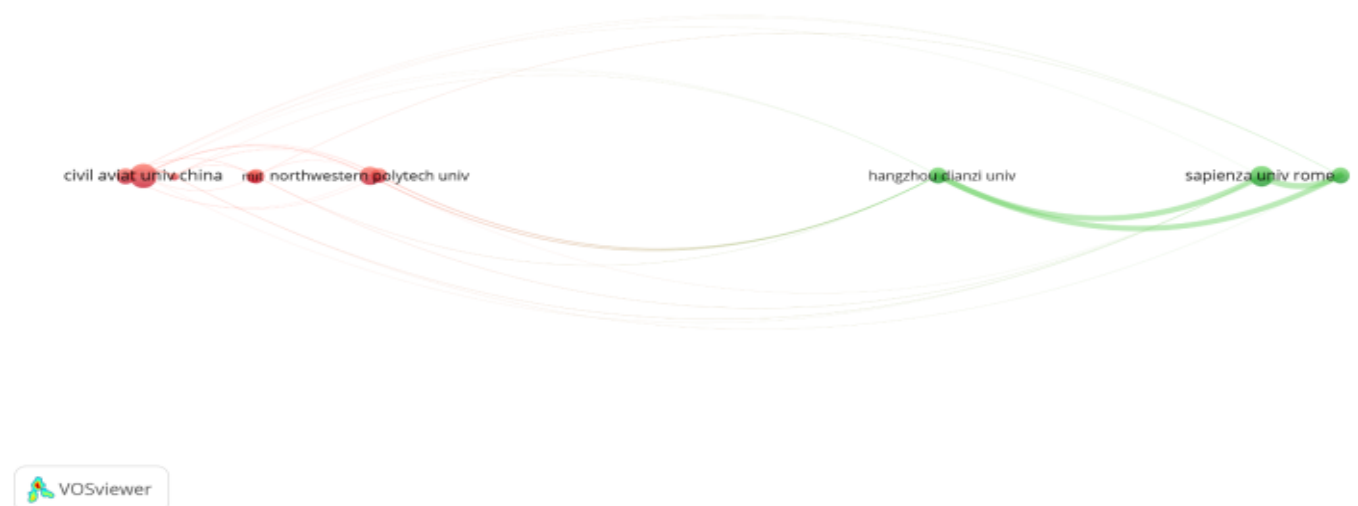
**Figure 8.** Distribution of Articles on “artificial intelligence” and “aviation” Keywords Published in 2005-2023 by Country.

When considering the distribution of the articles obtained from the VOSviewer program regarding the keywords “artificial intelligence” and “aviation” according to the countries in which they were published, countries with at least 6 publications related to these keywords were taken into account. Of the 44 countries that have studies on the keywords “artificial intelligence” and “aviation”, only 12 countries have at least 6 publications and these countries are shown in Figure 8. Circle sizes in colored visual network analysis increase as the number of publications per country increases. While the node (circle) colors in the network show whether there are cross-country citations in the studies, the lines between the

circles show the relationships between the countries. According to Figure 8, the top 10 countries with the most articles on the keywords “artificial intelligence” and “aviation” are in order; People's Republic of China (98), United States of America (34), England (14), Italy (13), France (13), Germany (9), South Korea (9), India (9), Spain (8), Turkey (7).

### 5.6. Distribution by Organizations

The ten organizations most studied in this section are given in Figure 9.



**Figure 9.** Bibliometric Network Analysis Showing the Distribution of Articles on “artificial intelligence” and “aviation” Keywords Published in 2005-2023 by Institutions.

When considering the distribution of the articles obtained from the VOSviewer program regarding the keywords “artificial intelligence” and “aviation” according to the organizations in which they were published, organizations with at least 4 publications related to these keywords were taken into account. Out of a total of 410 organizations analyzed, only 13 organizations have at least 4 publications on the keywords “artificial intelligence” and “aviation”. As mentioned before, node sizes indicate the number of publications belonging to institutions. While the node colors indicate inter-institutional collaborations, the lines between the nodes indicate the inter-institutional relationship. Accordingly, when we look at Figure, the top 10 organizations with the most articles on the keywords “artificial intelligence” and “aviation” are respectively; Civil Aviation University of China (12), Sapienza University of Rome (10), Northwestern Polytechnical University (9), Brainsigns SRL (8), Hangzhou Dianzi University (8), Nakai University (8), Shanghai Jiao Tong University (7), Beihang University (7), Massachusetts Institute of Technology-MIT (6), Chinese Academy of Sciences (7).

## 6. Conclusion

Within the scope of the research carried out for the keywords “artificial intelligence” and “aviation”, a total of 215 articles were accessed from the “Web of Science” database and included in the analysis. The visualization of the data related to the articles was realized by the “VOSviewer” scientific maps visualization program. In order to obtain healthier results and to avoid information pollution, some limitations were introduced to the analysis, such as “minimum number of publications” and “minimum number of citations”. As a result of the bibliometric analysis of 215 articles published with the keywords “artificial intelligence” and “aviation” between 2005-2023; It was observed that important developments were recorded after 2014 and the most articles were published in 2022. “People’s Republic of China” is the country with the highest number of publications, with 98 articles in accordance with at least 6 publication conditions. The organization that published at least 4 articles on the keywords “artificial intelligence” and “aviation” became the “Civil Aviation University of China” with 12 publications. In the articles on the keywords “artificial intelligence” and “aviation”, the authors with at least 4 publications are “Pietro Aricò, Gianluca Borghini and Gianluca Di Flumeri” with 10 publications. This study, which provides data on the countries, institutions, authors and the years with the most articles published on the keywords “artificial intelligence” and “aviation”, and which creates a systematic infrastructure, is important in terms of providing information in general terms. It provides researchers who will work in the field of “artificial intelligence” and “aviation” the opportunity to study the subject in depth by providing a broader perspective on this issue. The fact that the document scanning was carried out only in the Web of Science database and other databases were not examined constitutes the first limitation of the study, while the fact that the language of the articles studied is only English constitutes the second limitation, and the fact that only the articles are examined as a

document type constitutes the third limitation. In the studies to be carried out later; Scopus, etc. other databases, such as publications made in languages other than English and document types, papers, book chapters, editorial materials, etc. a more extensive research can also be carried out by including it in the analysis.

## Ethical approval

Not applicable.

## Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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