Utilisation of AI in the Automotive Industry. Bibliometric Analysis

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Abstract

Aim: The aim of this paper is to analyse research trends on the use of artificial intelligence in the automotive industry, with a focus on geographical distribution, key publication sources and thematic changes over time.

Methodology: A systematic bibliometric analysis was conducted using the Bibliometrix tool in R, covering publications from 2013-2023 available in the Scopus database. This approach enabled a quantitative assessment of research trends, the geography of the most influential authors and thematic changes in scientific publications.

Results: The analysis reveals a significant shift in research focus from basic information science and computer simulation to advanced applications of AI, particularly in autonomous vehicles and machine learning methods. There is a notable concentration of research efforts in developed countries with strong automotive and technological sectors, such as the United States, China, Germany, and India.

Implications and recommendations: The findings suggest a need for further research addressing the practical challenges of implementing AI in real-world automotive environments. Future studies should focus on evaluating the long-term effects of AI on vehicle performance, safety, and user experience. Additionally, expanding research beyond leading technological regions could provide a more comprehensive understanding of global trends and challenges.

Originality/value: This research provides a novel bibliometric perspective on the integration of AI in the automotive industry, offering valuable insights into current research trends and identifying significant gaps in the literature. By highlighting the geographical concentration of research and the shift towards advanced AI applications, this study contributes to a deeper understanding of how AI is shaping the future of automotive technology.

Keywords: Artificial Intelligence, automotive, bibliometric analysis, AI applications, vehicle technology

1.   Introduction

The first mention of artificial intelligence in the Scopus database dates back to 1961, when the world was experiencing a technological revolution: the first human flight into space, satellite data transmission tests, and the creation of the IBM 7090 computer. In 2024, the database already contained 42,048 articles on AI. Over these 63 years, humanity has achieved a lot, but the greatest changes have occurred in the automotive industry. The transformations, from the introduction of automatic transmissions in 1961 to autonomous vehicles in 2024, are related to the rapid development of information and communication technologies, which have been significantly integrated with vehicles (Ammal et al., 2021).

The topic of using AI in the automotive industry results from the dynamic development of technology and its impact on the transformation of the sector. AI, as a key element of the fourth industrial revolution, has enormous potential to improve efficiency, safety, and innovation in the automotive industry (Kim & Duffy, 2021). Despite the growing interest, there is a research gap related to the rapid development of AI and the automotive industry, which is constantly adapting to new challenges. Research to date has focused mainly on the technical aspects of AI, omitting the broader context of its use in the automotive industry, which makes it difficult to fully understand the global trends and progress in the industry.

The aim of this paper is to analyse research trends on the use of artificial intelligence in the automotive industry, with a focus on geographical distribution, key publication sources and thematic changes over time.

In the context of this study, the following research questions were formulated:

1.   What trends have been observed in the context of AI use in automotive?
2.   Which countries have published frequently in the context of the use of AI in the automotive industry?
3.   Which journals have published articles specifically on the use of AI in the automotive industry?

This study used bibliographic tools to extract, filter and analyse articles on the utilisation of AI in the automotive industry published in two different periods 2013-2017 and 2018-2023 in order to show historical and current trends in research and development. Bibliometric research was carried out by analysing the content of the scientific database Scopus. The results were analysed using the R language programming library Bibliometrix.

2.   Methodology

The research is mainly quantitative in nature, due to the need to process and analyse a large number of scientific publications in order to obtain representative results. The quantitative approach is also more objective, allows for the use of sophisticated analytical tools and facilitates replication of the research by other researchers (Biggi, 2021).

The Scopus Elsevier database was used to assemble an initial set of articles. The following keywords were used to search the 'Topic' [Article title, Abstract, Keywords] describing artificial intelligence in the automotive industry:

(("AI" OR "Artificial Intelligence") AND automotive)

The search conducted on 6.07.2024 yielded more than 2,700 results. These results were filtered using filters such as Document Type 'Conference paper', 'Article' and 'English language', narrowing the dataset to 2230 articles.

(((("AI" OR "Artificial Intelligence") AND automotive))) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))

The term 'AI' was excluded, as well as 'game', 'healthcare', 'finance', 'education' to avoid broad, unspecified AI-related research in general technology fields that could overflow the dataset with irrelevant information. This additional step aimed to focus exclusively on AI applications in the automotive sector. This yielded 1,748 articles from all years.

((("Artificial Intelligence" AND automotive) AND NOT (game OR healthcare OR finance OR education))) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))

At this stage, the dataset was divided into two time periods: 2013-2017 – historical dataset, and 2018--2023 – current dataset, in order to analyse historical and current trends in research and development.

((("Artificial Intelligence" AND automotive) AND NOT (game OR healthcare OR finance OR education))) AND PUBYEAR > 2012 AND PUBYEAR < 2018 AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))

((("Artificial Intelligence" AND automotive) AND NOT (game OR healthcare OR finance OR education))) AND PUBYEAR > 2017 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))

Filtering the range of years yielded two sets with a total of 245 articles for the period 2013-2017 and 1011 articles for the period 2018-2023. The keyword list used to group AI research articles was developed as a single keyword list and applied to find related AI research articles applied to the automotive industry over the years 2018-2023 (total of 1011 articles) as well as 2013-2017 (total of 245 articles). Therefore, two clusters of datasets were used in this study. One is the main study period covering the last five full years (2018-2023) and a comparative dataset selected from an equivalent five-year period from ten years ago (2013-2017). The resulting database was exported to the final database for further analysis of bibliographic information.

The detailed search queries, inclusion/exclusion criteria, and the number of results obtained at each stage are presented in Table 1.

Table 1. Search queries

Query	Inclusion/exclusion criteria	Results
(("AI" OR "Artificial Intelligence") AND automotive)	None	2715
((("AI" OR "Artificial Intelligence") AND automotive)) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))	Publication type: articles and conference papers Language: English	2230
((("Artificial Intelligence" AND automotive) AND NOT (game OR healthcare OR finance OR education))) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))	Excluding keywords: "AI", "game", "healthcare", "finance", "education"	1748
((("Artificial Intelligence" AND automotive) AND NOT (game OR healthcare OR finance OR education))) AND PUBYEAR > 2012 AND PUBYEAR < 2018 AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))	Year: 2013-2017	245
((("Artificial Intelligence" AND automotive) AND NOT (game OR healthcare OR finance OR education))) AND PUBYEAR > 2017 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))	Year: 2018-2023	1011

Source: own elaboration.

The selected group files were uploaded as a raw bibliographic file (CSV file type with the extension '.csv') for further analysis. The open source bibliographic analysis tool Bibliometrix was used in R (v4.4.1) to analyse bibliographic information using the 'biblioshiny' platform (González-Sarmiento et al., 2021). Information on reference quality, word frequency in the abstract, title and source, as well as information on publishing journals, authors and publication trends, and other available information were used for full bibliographic analysis.

This research represents the authors' first attempt at conducting a systematic bibliometric review. Despite this, the methodology adheres to established guidelines and employs advanced tools to ensure objectivity and reproducibility.

3. Results

The systematic bibliometric review started by checking the completeness of the data for the 2018-2023 collection. The analysis showed that most of the metadata is complete and of high quality, with the exception of the correspondent author information and the scientific categories. Deficiencies in these categories do not affect the accuracy of our intended analytical work. The results for the 2013--2017 collection were similar, so no metadata disparity was shown in our collections.

In the analysis of the 2013-2017 papers, we see a lower number of publications but a higher average annual increase in the number of articles compared to 2018-2023. This is in line with the trend of increasing interest in AI topics in the automotive industry in recent years.

The analysis of annual scientific production shows a clear increase in the number of articles published on AI in the automotive industry from 2013 to 2022 (see Figure 1). In 2013, 35 articles were published, and this number gradually increased, reaching 216 articles in 2021 before dropping to 190 in 2022.

This increase indicates the growing interest and importance of artificial intelligence in the automotive industry, especially in recent years. A clear jump can be seen from 2016 onwards, suggesting that during this time the technology began to be researched and developed more intensively in the automotive context.
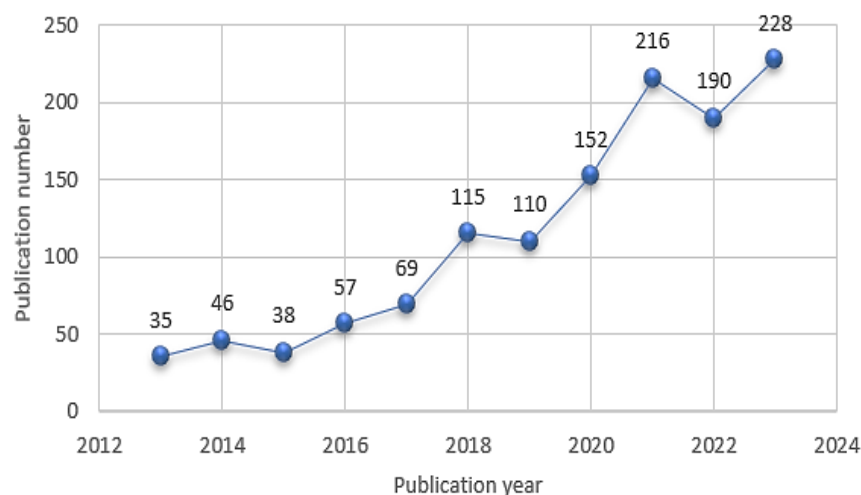
Fig. 1. Annual scientific production
Source: own elaboration.

Analysing the thematic trends, which also provides valuable information on the evolution of research in this field, a clear division into two periods can be observed: 2013-2017 and 2018-2023 (Fig. 2). The 2013-2017 period was dominated by themes such as 'information science', 'computer simulation', 'design', 'algorithms', 'computers' and 'engines'. These themes indicate that the focus of research was on basic information technologies and tools, which provide the foundation for more advanced AI applications.
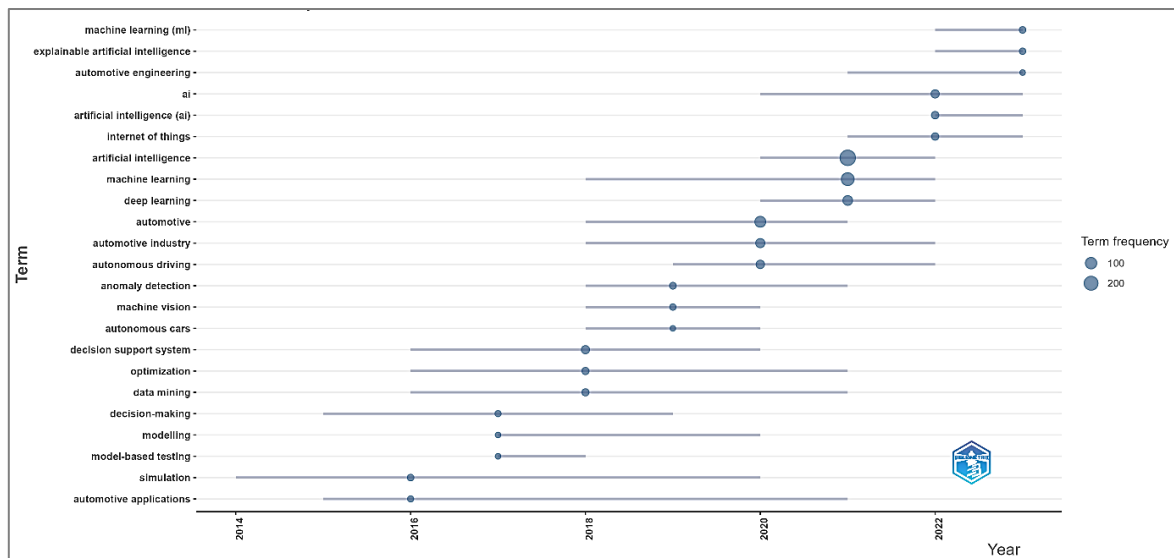
Fig. 2. Trend topic per year

Source: own elaboration.

In the second period under review, there was a significant shift in research. Topics such as 'learning systems', 'artificial intelligence', 'decision support systems', 'manufacturing', 'intelligent vehicle highway systems', 'automotive applications', 'vehicles', 'autonomous driving', 'forecasting', 'autonomous vehicles', 'deep learning', 'machine learning', 'reinforcement learnings' and 'controller-area network' emerged. The increase in frequency of terms related to autonomous vehicles, deep learning, machine learning and decision support systems suggests that research has shifted towards more advanced and specific AI applications in the automotive industry.

In an analysis of key research areas in the field of artificial intelligence and the automotive industry, the top five research topics were identified based on the frequency of occurrences in the scientific literature between 2013 and 2023 (see Figure 3). 'Artificial Intelligence' ranks first with 632 occurrences, confirming the central role of AI in the development of automotive technologies. AI is the foundation for innovations that range from driver assistance systems to full vehicle automation.
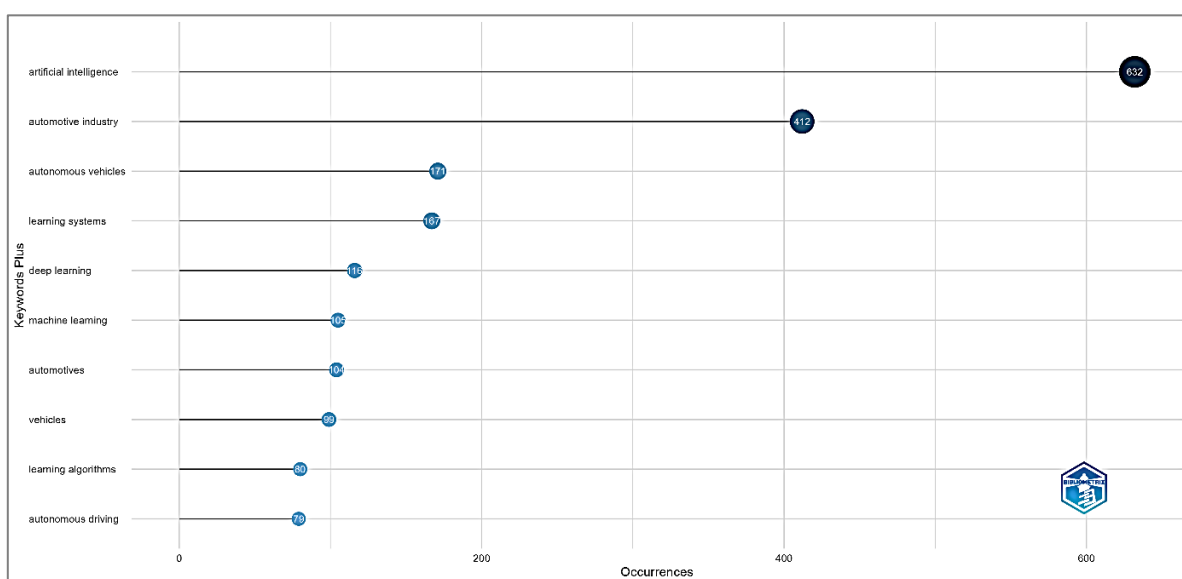

Fig. 3. Most relevant words for the period 2013-2023

Source: own elaboration.

Another key area is 'Automotive Industry' (412 contributions), which points to the growing importance of the automotive industry as a major application field for new technologies such as AI. In particular, research on 'Autonomous Vehicles' (171 contributions) shows the growing interest in autonomous vehicles, which represent one of the most rapidly growing segments of the automotive market. In this field, research on 'Learning Systems' (167 contributions) and 'Deep Learning' (116 contributions) are particularly relevant, providing the technological basis for the development of advanced autonomous systems.

Broken down by time period, the analysis shows the evolution of these trends. Between 2013 and 2017, AI (214 contributions) was already a dominant theme, and research into learning systems (57 contributions) was an important part of the integration of new technologies into automotive (Fig. 4).
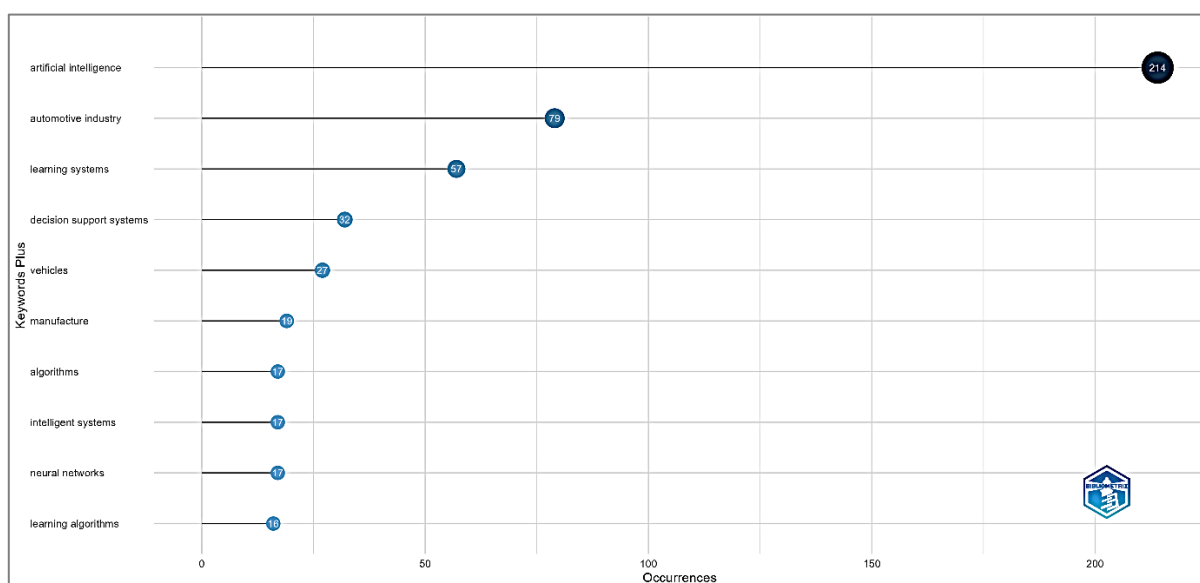

Fig. 4. Most relevant words for the period 2013-2017
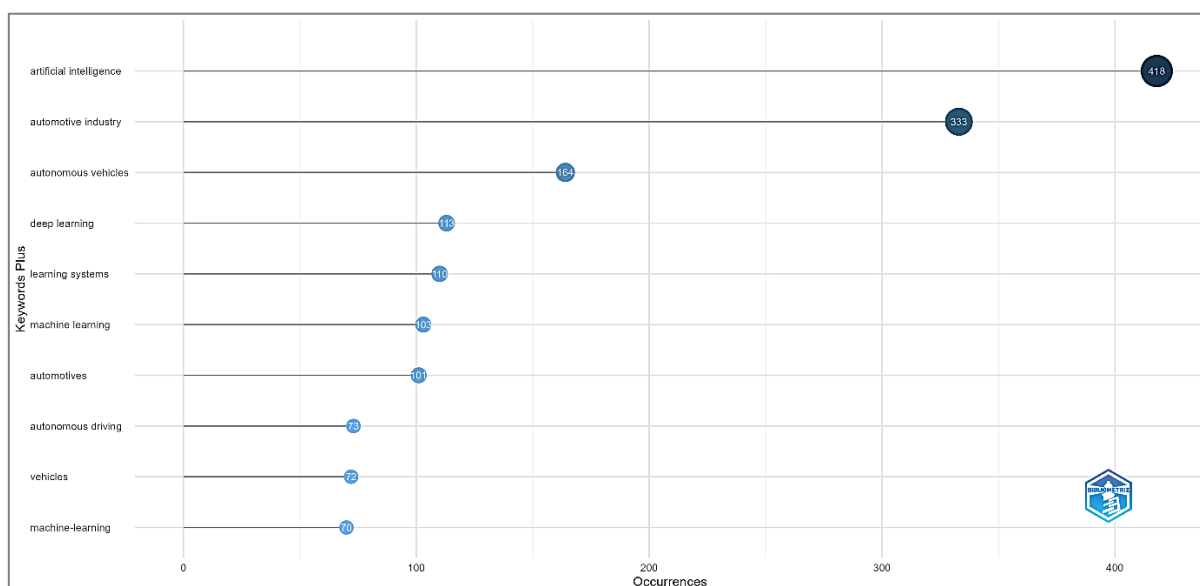
Source: own elaboration.

Fig. 5. Most relevant words for the period 2018-2023

Source: own elaboration.

In the second part of the analysed period (2018-2023), a dynamic increase in interest in AI (418 contributions) and the automotive industry (333 contributions) is noticeable, suggesting an acceleration of research into AI applications in the automotive industry. The increase in the number of publications on autonomous vehicles (164 contributions) further highlights the intensity of research and development in this area (see Figure 5).

These figures suggest that artificial intelligence research in the context of the automotive industry is focused on several key areas, the most important of which are the development of autonomous vehicles and advanced learning systems. This suggests a continuation and intensification of research work in these areas in the future, which could lead to significant advances in automotive technology.

The analysis of the thematic map of AI research in the automotive industry indicates four key clusters that shape the development of this field (Fig. 6). The first cluster, 'Control System Synthesis', focuses on network security and control system synthesis. Among the topics such as 'Network Security' (26 contributions), 'Cybersecurity' (19 contributions), and 'Intrusion Detection' (18 contributions), the main goal is to ensure the protection of autonomous automotive systems from cyber threats (Thayyib, 2023).
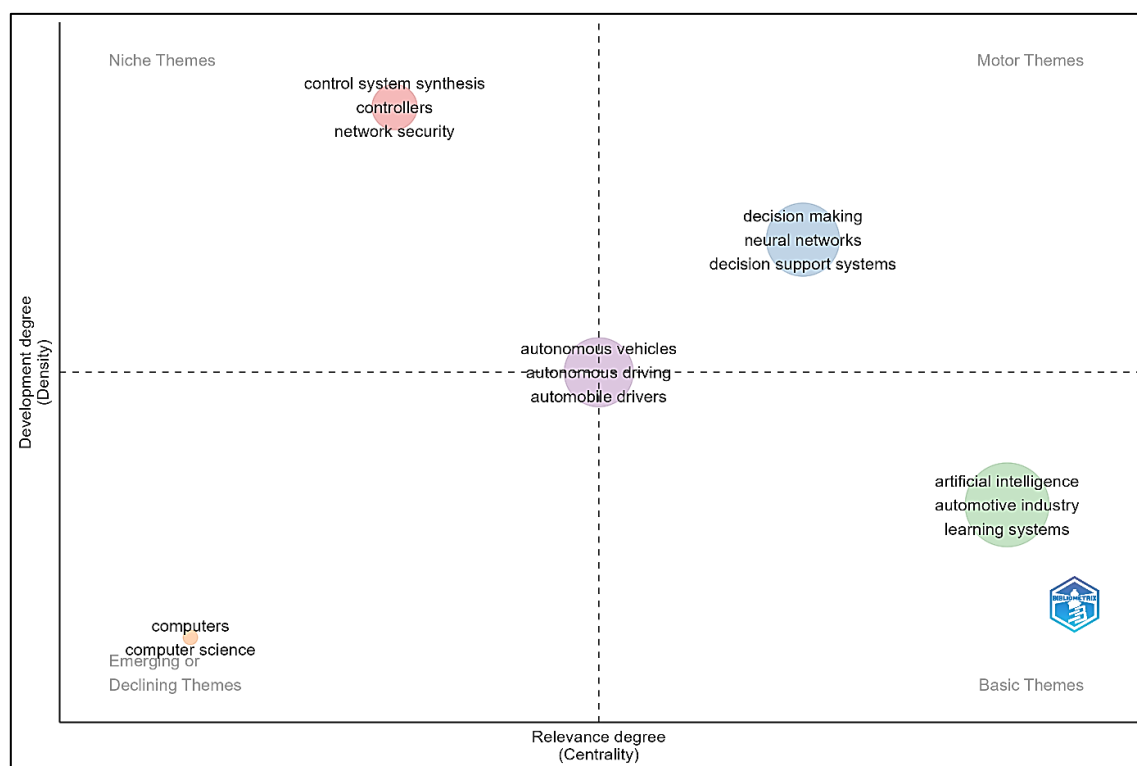

Fig. 6. Thematic map

Source: own elaboration.

The second cluster, 'Decision Making', emphasises the role of neural networks and decision-making processes in the development of intelligent automotive systems. Topics such as 'Decision Making' (76 papers) and 'Neural Networks' (74 papers) indicate the pursuit of autonomous decision-making systems. 'Decision Support Systems' (72 papers) and 'Forecasting' (66 papers) show the importance of these technologies in the optimization of automotive processes.

In the third cluster, 'Artificial Intelligence', research focuses on the role of AI in the automotive industry. 'Artificial Intelligence' (613 papers) is the dominant topic, while intensive research on 'Learning Systems' (167 papers) and 'Deep Learning' (92 papers) indicates the development of algorithms supporting autonomous systems.

The fourth cluster, 'Autonomous Vehicles', focuses on autonomous vehicle technology and accident prevention. Topics such as 'Autonomous Vehicles' (128 papers) and 'Autonomous Driving' (78 papers)

indicate the growing importance of this technology, while 'Accident Prevention' (64 papers) and 'Intelligent Systems' (61 papers) emphasise the role of road user safety.

The analysis of these clusters shows the interdisciplinary nature of AI research in the automotive industry and outlines the directions of future research that will be crucial for the development of automotive technologies and their integration into the global transport ecosystem (Gandia et al., 2018; Munim, 2020).

The analysis of the geographical concentration of scientific publications on artificial intelligence (AI) and the automotive industry (see Figure 7) reveals the key roles of individual countries in the development of these technologies (Chauhan, 2023). China dominates the global research landscape, publishing 606 articles, and its share of articles with corresponding authors of 10.1% underlines its strong position and leading role in the field of automotive AI. This result indicates that Chinese researchers are not only active in publishing, but also have numerous research projects underway.
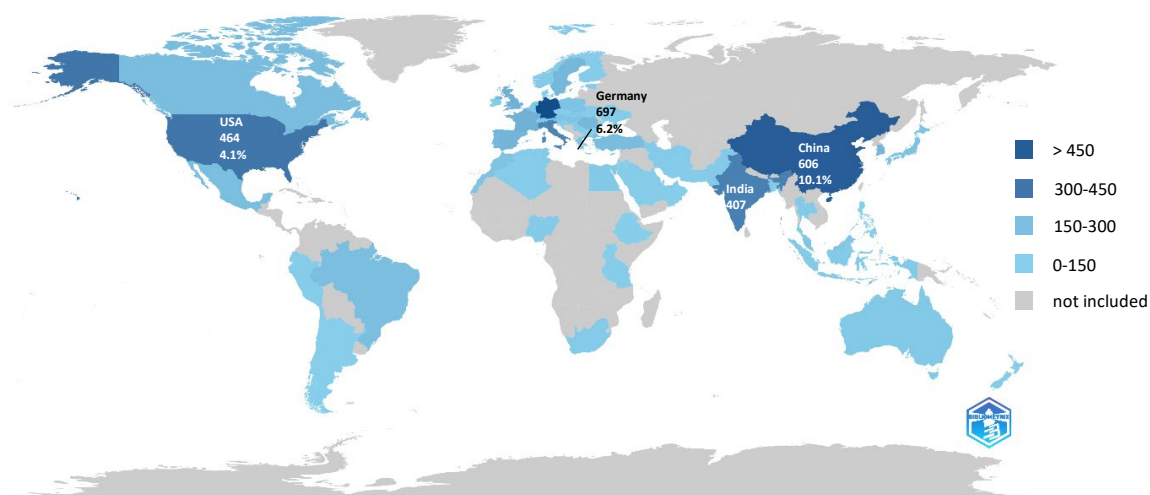

Fig. 7. Country scientific production

Source: own elaboration.

Germany, with 697 articles, is also in the lead, although its share of articles with corresponding authors (6.2%) is lower, suggesting a more diverse research base where research may be more dispersed. In contrast to China, research in Germany is characterized by greater interdisciplinarity and the integration of AI into various sectors of the automotive industry.
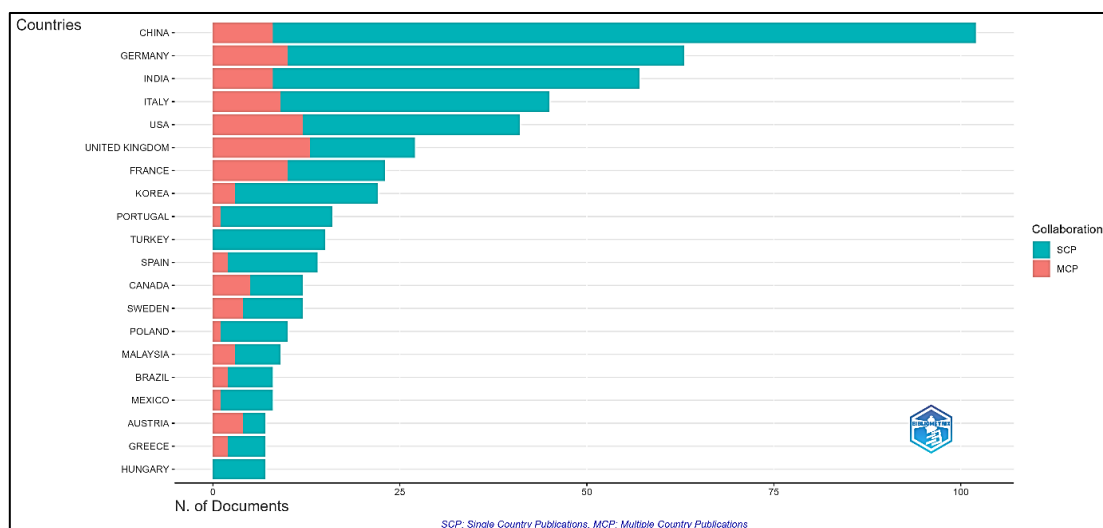

Fig. 8. Corresponding author's countries

Source: own elaboration.

The United States and India, with 464 and 407 publications, respectively, also account for a significant share of the global research. In the case of the USA, the low percentage of articles with corresponding authors (4.1%) may suggest a greater dispersion of research, whereas India shows a higher concentration of publications with corresponding authors, which may indicate a more centralized research structure in that country (see Figure 8).

A comparison of the number of scientific articles with corresponding authors shows a mixed picture of research on artificial intelligence (AI) in the automotive industry. Germany and China dominate, but countries such as the UK and France, despite having fewer publications, stand out with a high share of articles with corresponding authors. This indicates a broad but uneven distribution of global research.

The journal analysis reveals key research platforms in this field (Dhamija, 2020) (see Figure 9). The most important journal is *Lecture Notes in Computer Science* (LNCS), including the subseries *Lecture Notes in Artificial Intelligence* and *Lecture Notes in Bioinformatics*, with 60 articles. This prestigious Springer publishing house offers a wide range of AI-related topics, crucial for research in the automotive industry.

The *Journal of Physics: Conference Series* published 32 articles on AI in the automotive industry. This conference journal focuses on interdisciplinary applications of AI, providing an important medium for researchers and practitioners in the automotive industry.

Another important journal is the *ACM International Conference Proceedings Series* with 29 articles that cover technological innovations in AI, especially in the context of autonomous vehicles, with strong computational connections.

SAE Technical Papers, with 27 articles, are key to practical applications of AI in automotive. Publications issued by the Society of Automotive Engineers provide valuable information about technologies and their implementation (Muhuri et al., 2019).
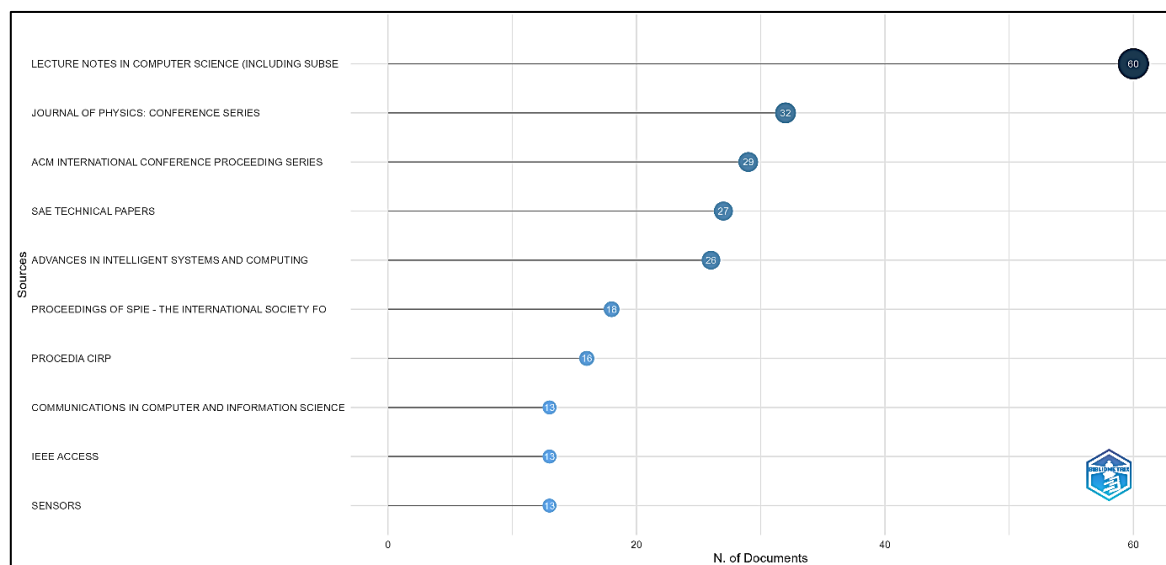

Fig. 9. Most relevant sources

Source: own elaboration.

The analysis of the publications in these leading journals shows the diverse and rich sources from which researchers working in the field of automotive artificial intelligence draw. Journals such as *Lecture Notes in Computer Science*, the *Journal of Physics: Conference Series* and the *ACM International Conference Proceeding Series* play a key role in disseminating the latest research results, as well as promoting technological innovation in this rapidly evolving field.

The analysis of the tree maps for both periods shows the evolution of AI research in the automotive industry, with the growing interest in more advanced and specialised topics in recent years. Between 2013 and 2017, research focused more on fundamental technologies such as algorithms, neural networks and intelligent systems (Fig. 10). Between 2018 and 2023, a shift towards more advanced technologies, such as deep learning, and more specific applications, such as autonomous vehicles, is evident (see Figure 11).
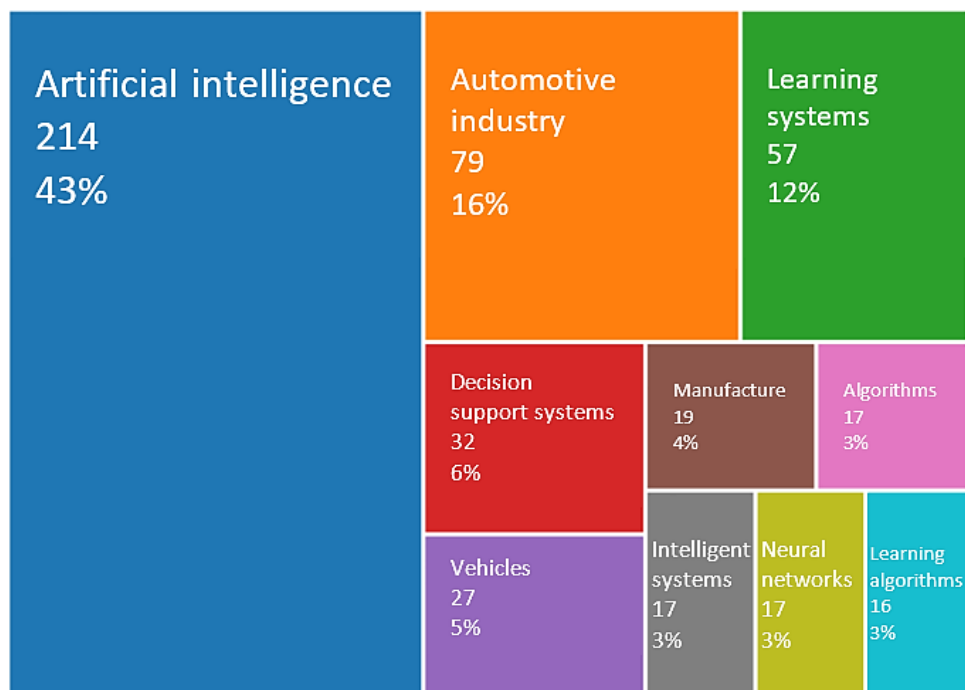

Fig. 10. Tree map for the period 2013-2017
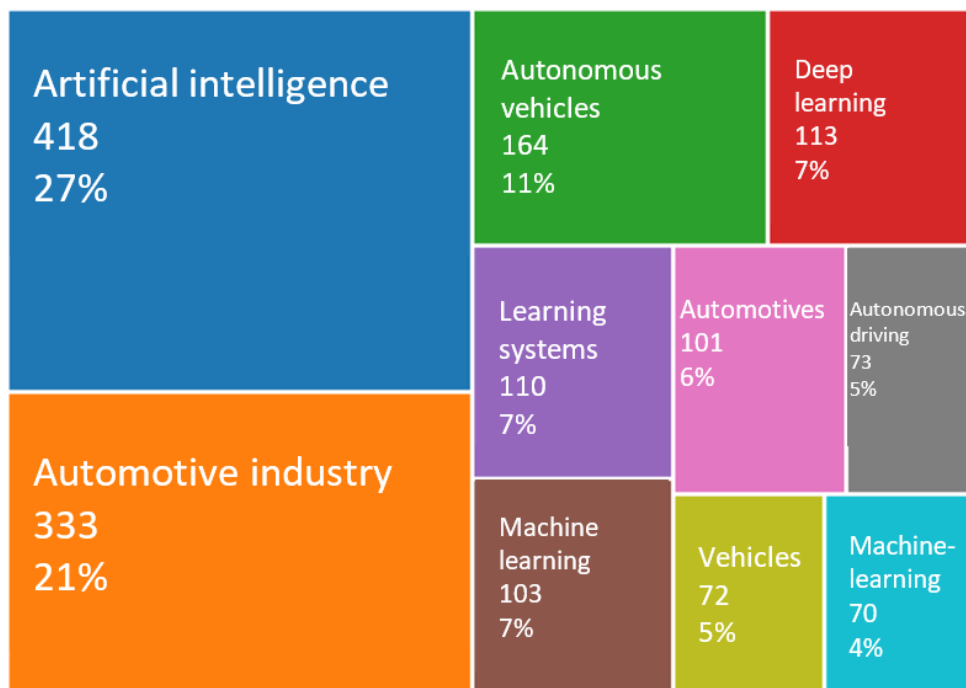
Source: own elaboration.

Fig. 11. Tree map for the period 2018-2023

Source: own elaboration.

Between 2013 and 2017, research was more focused on fundamental aspects of artificial intelligence and its applications in the automotive industry. The interest in learning systems and decision support systems suggests that these were key research areas during this period.

For the period 2018-2023, research has mainly focused on artificial intelligence, with a strong emphasis on automotive applications and technologies related to autonomous vehicles. The increased interest in deep learning and learning systems suggests that these technologies are key to the future of AI in automotive.

4. Discussion and Conclusions

The bibliometric analysis of the application of artificial intelligence (AI) in the automotive industry shows significant changes in this field. Over the past decade, there has been a noticeable shift in research from basic technologies to more advanced applications, especially in the context of autonomous vehicles, machine learning, and deep learning. Studies by Patra and Mahalwar (2020) and Agrawal (2023) illustrate the growing importance of these technologies in the development of autonomous systems and decision support in vehicles.

This change is related to the growing importance of AI in autonomous vehicles, where special attention is paid to image recognition and neural networks. According to Ammal et al. (2021), AI plays a key role in the development of autonomous vehicles, responding to the needs of safety and autonomy. Similarly, the study by Cho et al. (2021) indicates the role of speech recognition in autonomous vehicles, which highlights the integration of AI with modern automotive technologies.

Despite the development of AI, significant research gaps still exist. Kamran et al. (2022) indicate a lack of research on the long-term impact of AI on vehicle safety and performance, especially in the context of real-world traffic conditions. This indicates the need for further research on the practical implementation of AI in the daily use of autonomous vehicles.

According to Crețu et al. (2024), the demand for skills related to AI implementation in the automotive industry is growing. The transformation of the labour market, as well as the challenges related to AI implementation in production, are described in detail by Espina-Romero et al. (2024), who emphasise the challenges in integrating AI into automotive engineering processes.

Specialised journals such as *Artificial Intelligence Review* and *Journal of Automotive Engineering* play a key role in disseminating knowledge on AI integration in the automotive industry. US, China, Germany, and India dominate the research in this field, which may lead to inequality in access to technology, as indicated by Sushkevich (2018) and Mohammad Nazir (2019).

Our research, similar to previous analyses, emphasises that, despite the dynamic development of AI in the automotive industry, the implementation of these technologies faces a number of challenges. In the future, research should focus on the long-term impact of AI on the automotive industry, especially in the context of software production and autonomous systems.

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Wykorzystanie AI w przemyśle motoryzacyjnym. Analiza bibliometryczna

Streszczenie

Cel: Celem niniejszego artykułu jest analiza trendów badawczych dotyczących wykorzystania sztucznej inteligencji w przemyśle motoryzacyjnym, ze szczególnym uwzględnieniem rozmieszczenia geograficznego, kluczowych źródeł publikacji i zmian tematycznych w czasie.

Metodyka: Przeprowadzono systematyczną analizę bibliometryczną przy użyciu narzędzia Bibliometrix w R, obejmującą publikacje z lat 2013-2023 dostępne w bazie Scopus. Takie podejście umożliwiło ilościową ocenę trendów badawczych, geografii najbardziej wpływowych autorów i zmian tematycznych w publikacjach naukowych.

Wyniki: Analiza ujawnia znaczne przesunięcie punktu ciężkości badań z podstawowej informatyki i symulacji komputerowej na zaawansowane zastosowania sztucznej inteligencji, w szczególności w pojazdach autonomicznych i metodach uczenia maszynowego. Zauważalna jest koncentracja wysiłków badawczych w krajach rozwiniętych o silnym sektorze motoryzacyjnym i technologicznym, takich jak Stany Zjednoczone, Chiny, Niemcy i Indie.

Implikacje i rekomendacje: Wyniki sugerują potrzebę dalszych badań nad praktycznymi wyzwaniami związanymi z wdrażaniem sztucznej inteligencji w rzeczywistych środowiskach motoryzacyjnych. Przyszłe badania powinny koncentrować się na ocenie długoterminowego wpływu sztucznej inteligencji na osiągi pojazdu, bezpieczeństwo i wrażenia użytkownika. Ponadto rozszerzenie badań poza wiodące regiony technologiczne mogłoby zapewnić bardziej kompleksowe zrozumienie globalnych trendów i wyzwań.

Oryginalność/wartość: Niniejsze badanie zapewnia nowatorskie spojrzenie bibliometryczne na integrację sztucznej inteligencji w przemyśle motoryzacyjnym, oferując cenny wgląd w obecne trendy badawcze i identyfikując istotne luki w literaturze. Podkreślając geograficzną koncentrację badań i przesunięcie w kierunku zaawansowanych zastosowań sztucznej inteligencji, badanie to przyczynia się do głębszego zrozumienia, w jaki sposób sztuczna inteligencja kształtuje przyszłość technologii motoryzacyjnej.

Słowa kluczowe: Sztuczna inteligencja, motoryzacja, analiza bibliometryczna, zastosowania AI, technologia pojazdów