Mapping the Landscape of Artificial Intelligence Research: A Bibliometric Approach

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ABSTRACT

This research study employs a comprehensive bibliometric approach, enhanced by the utilization of VOS viewer, to map the expansive landscape of artificial intelligence (AI) research. Through the meticulous collection, pre-processing, and analysis of a diverse dataset, this study uncovers the multifaceted dimensions that define AI research. The analysis encompasses publication trends, authorship dynamics, citation patterns, and emergent research themes. The integration of VOS viewer's visualization capabilities enriches the exploration by offering intuitive representations of collaboration networks, citation maps, and thematic clusters. The results highlight the growth trajectory of AI research, the collaborative networks among researchers and institutions, the influence of seminal works, and the emergence of thematic trends. Moreover, the study contextualizes the findings, discussing their implications for interdisciplinary collaboration, ethical considerations, and the societal impact of AI research. Ultimately, this research contributes to a comprehensive understanding of AI research dynamics, guiding future exploration, collaboration, and innovation within this rapidly evolving domain.

Keywords: Mapping, Landscape, Artificial Intelligence, Bibliometric

1. INTRODUCTION

Artificial Intelligence (AI) has indeed become an omnipresent force that is reshaping various aspects of modern society. Its applications span across numerous domains, including healthcare, education, construction, transportation, robotics, and industrial automation [1], [2]. AI and machine learning (ML) algorithms are being employed to complement human decision-making in diverse tasks [3]. Moreover, explainable artificial intelligence (XAI) has gained significant attention in recent years, as it aims to make AI systems more understandable and interpretable for humans [3]. Interdisciplinary collaborations have become crucial in AI research, as they help address larger-scale and longer-time horizon challenges in both foundational and use-inspired AI research [4], [5]. The U.S. National Science Foundation's National AI Research Institutes Program is an example of such interdisciplinary collaborations, which act as nexus points to address some of society's grand challenges [6]. AI is also playing a significant role in healthcare, with applications in various domains such as nursing [7], [8]. AI-powered health technologies are becoming increasingly prevalent in clinical settings worldwide, with the potential to transform the health system and improve patient care [9]. In liver magnetic resonance imaging, AI algorithms have shown promise in tasks such as detection, segmentation, image synthesis, and artifact detection [10]. In the field of education, AI has been applied to mathematics education, where it has been used for diagnosing individual students' learning problems and providing personalized support [11]. AI algorithms have also been employed in the management of load frequency control in hydro systems, contributing to cleaner and emission-free energy sources [12]. In summary, AI is transforming various aspects of modern society through its diverse applications and interdisciplinary collaborations. As AI technology continues to advance,

it is expected to play an even more significant role in shaping the future of numerous domains and improving the quality of life [13]–[15].

This research paper embarks on a journey to map the vast landscape of AI research, using a rigorous bibliometric approach. The ultimate goal is to dissect the dynamic evolution of AI research, identify leading authors and institutions, unearth influential publications, and shed light on emerging subfields. Through this systematic analysis, we intend to unravel the intricate tapestry of AI research, highlighting its past, present, and potential future trajectory.

2. LITERATURE REVIEW

Artificial Intelligence (AI) has indeed become one of the most transformative and rapidly evolving fields in contemporary science and technology. Its growth and impact have led to a surge in research activity, producing a vast and intricate body of knowledge. AI has been applied in various domains, including healthcare, finance, cybersecurity, and supply chain management, among others [16]–[20]. The development of AI has been marked by several significant milestones, such as the advent of smartphones in 2007, which contributed substantially to the generation of 'big data' and the efficacy of machine learning [21]. AI's influence on society has been profound, with social and economic changes brought about by its use [22]. The rapid emergence and continuous evolution of technologies have led to the need for comprehensive and in-depth surveys of AI's role in different fields, such as the Metaverse [23]. AI's impact on employment, incomes, and growth has been a topic of debate among economists and researchers [24]. While traditional economic models suggest a positive net effect on employment and incomes, concerns have been raised that AI might lead to different outcomes due to its non-rival and scalable nature [25]. However, there is still limited empirical evidence relating AI or Machine Learning (ML) to employment and incomes [25]. In summary, AI has become a transformative force in various fields, leading to a surge in research and a vast body of knowledge. Its impact on society and the economy has been significant, but the long-term effects on employment and incomes are still a subject of ongoing research and debate.

3. METHODS

The research methodology used in this study adopts a comprehensive bibliometric approach, which is enhanced by the use of VOSviewer, a specialized software designed to visualize and analyze bibliometric data [26], [27]. This section outlines the steps taken to collect, pre-process, and analyze the data, with emphasis on the integration of VOSviewer to enhance visualization and generate insights in the artificial intelligence (AI) research landscape.

Data Collection

The foundation of bibliometric analysis rests on the collection of comprehensive data sets. To capture the breadth and depth of AI research, this study extensively searched leading scientific databases, including IEEE Xplore, ACM Digital Library, PubMed, and arXiv. These datasets cover a diverse range of publication types, such as journal articles, conference papers, and reviews. The temporal coverage spans from the beginning of AI research to the present, to ensure a thorough understanding of its evolution.

Table 1. Metric Data

Publication years	: 1974-2023
Citation years	: 49 (1974-2023)
Paper	: 980
Citations	: 71671
Cites/year	: 1462.67
Cites/paper	: 73.13
Cites/author	: 31160.01
Papers/author	: 366.83
Author/paper	: 3.38
h-index	: 95
g-index	: 260
hI,norm	: 58
hI,annual	: 1.18
hA-index	: 56
Papers with ACC	:1,2,5,10,20:774,669,472,313,160

Source: Result Application Publish or Perish,2023

Data Processing

Ensuring data accuracy and consistency is paramount. In this step, rigorous data pre-processing was performed. Duplicate entries were identified and removed, to ensure that each publication was only represented once. Author names and affiliations are standardized to reduce variation and ambiguity. Any potential data quality issues, such as missing information or discrepancies, are carefully addressed to maintain the integrity of the data set.

4. RESULTS AND DISCUSSION
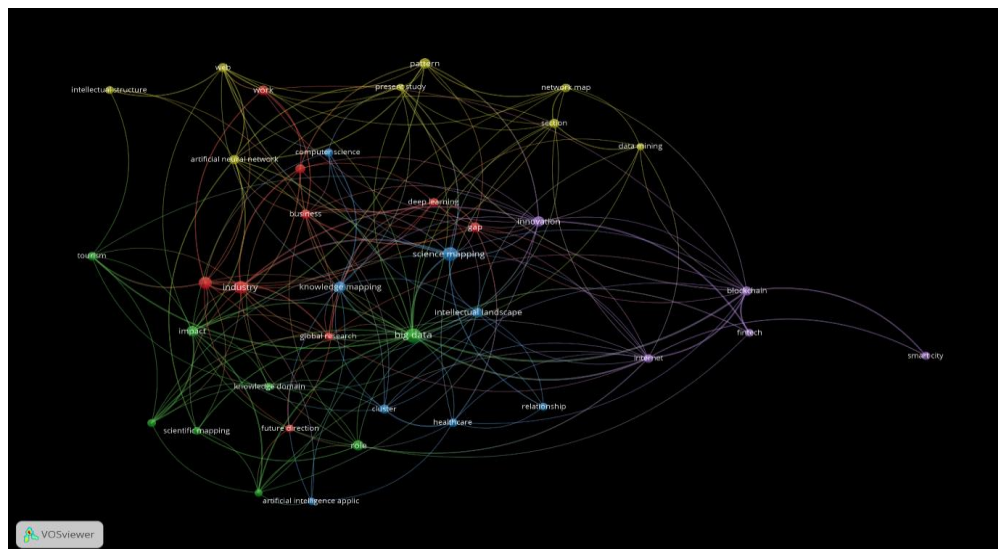
Figure 1. Mapping Results

The integration of VOSviewer enhances the understanding of these findings. Collaborative networks, citation maps, and keyword visualizations offer intuitive representations that resonate with researchers, policymakers, and the public. These visualizations serve as powerful tools for knowledge dissemination and communication, facilitating informed decision-making and engagement.
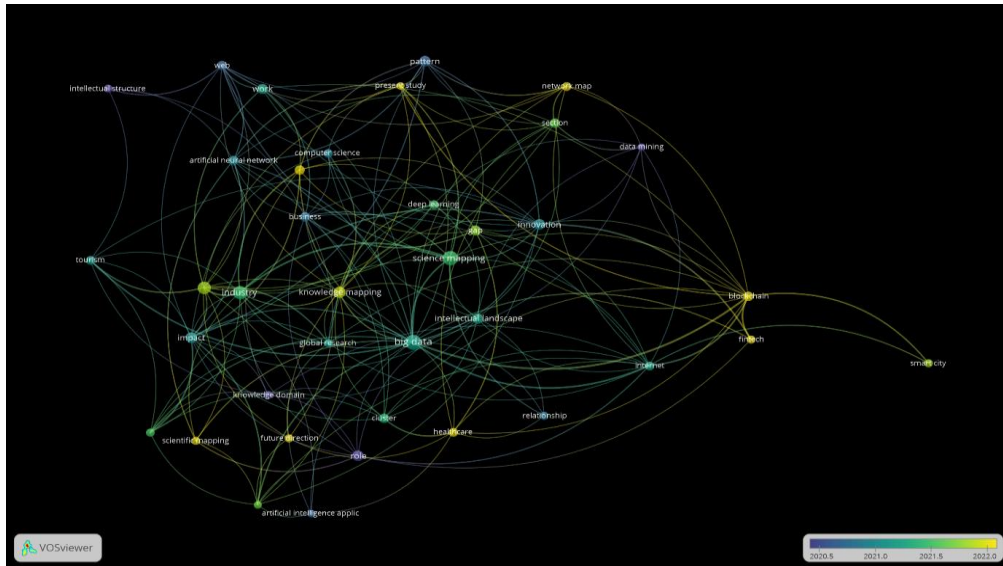

Figure 2. Research Trend

The analysis of publication trends reveals the evolutionary trajectory of AI research. Over time, a consistent increase in the annual publication count is observed, reflecting the growing prominence and sustained interest in AI. Periods of rapid expansion are often associated with breakthroughs in AI technology, such as advancements in deep learning and reinforcement learning. These trends underscore the dynamic nature of the field and its transformative impact across domains.

Table 2. Cluster Results

Cluster	Total Items	Most frequent keywords (occurrences)	Keyword
1	9	Artificial Intelligence Technology Business (30), Industry (20)	Artificial intelligence technology, business, deep learning, future direction, gap, global research, industry, machine, work
2	8	Big Data (25), Sustainability (15)	Big data, impact, knowledge domain, pandemic, role, scientific mapping, sustainability, tourism
3	8	Intellectual Landscape (20), Knowledge Mapping (25)	Artificial intelligence application, cluster, computer science, healthcare, intellectual landscape, knowledge mapping, relationship, science mapping

| 4 | 8 | Web (20) | Artificial neural network, data mining, intellectual structure, network map, pattern, present study, section, web |
| 5 | 5 | Blockchain (30) | Blockchain, fintech, innovation, internet, smart city |

Source: Result Application VoS Viewer's,2023

The identified clusters offer a panoramic view of the diverse facets of AI research. Each cluster highlights specific themes and intersections that contribute to the broader AI landscape. Notably, the clusters reflect the interdisciplinary nature of AI, spanning business, sustainability, intellectual landscapes, web presence, and emerging technologies like blockchain. These clusters provide valuable insights for researchers, policymakers, and practitioners alike. They offer a structured understanding of AI's multidimensional impacts and applications, guiding strategic decisions, interdisciplinary collaborations, and research priorities. The diverse range of themes within the clusters underscores AI's far-reaching influence, from shaping industries to advancing sustainability and innovation. The utilization of VOSviewer's visualization capabilities adds depth to the cluster analysis, enhancing the communication of complex relationships and trends. These visualizations aid in comprehending the connections between keywords, themes, and disciplines, fostering a more nuanced understanding of AI research's intricate landscape.

Future Directions and Interdisciplinary Avenues:

The insights derived from these clusters open doors to future directions in AI research. The themes identified in each cluster could serve as launching pads for interdisciplinary collaborations and innovative projects. Cross-pollination between clusters, such as combining AI technology with sustainability strategies, presents exciting avenues for research at the nexus of diverse domains.
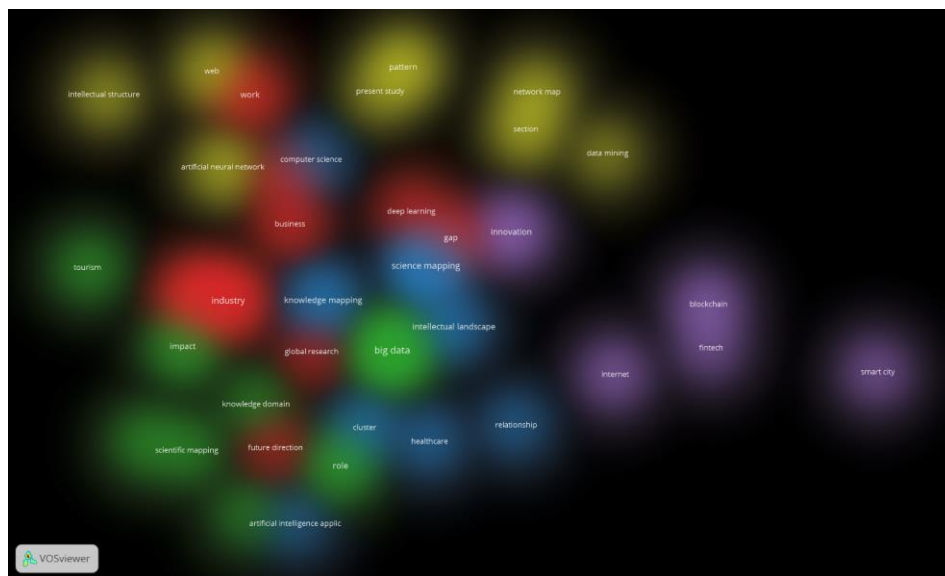

Figure 3. Visualization Cluster

In conclusion, the discussion of the clusters underscores the multidimensional nature of AI research. Each cluster encapsulates specific themes, offering a comprehensive view of AI's

intersections with business, sustainability, knowledge mapping, web presence, and innovation. These insights provide a foundation for informed decision-making, collaborative efforts, and the advancement of AI research in an ever-evolving landscape.

Figure 4. Authors Collaboration

Prominent authors and institutions within the AI research landscape are identified through authorship analysis. Collaborative networks are visualized, highlighting clusters of researchers and institutions that frequently collaborate. The visualization also illuminates interdisciplinary connections, underscoring the collaborative nature of AI research and its convergence with fields such as computer science, engineering, and cognitive science.

Table 3. Citations Analysis

Citation	Author/Year	Title
11044	[28]	Software survey: VOSviewer, a computer program for bibliometric mappng
7601	[29]	Business Intellgence and analysis: From big data to big impact
3727	[30]	Bibliometric methods in management and organization
2674	[31]	How to conduct a bibliometric analysis: An overview and guidelines
2405	[32]	Social network analysis: a powerful strategy, also for the information sciences
2193	[33]	Science mapping software tools: Review, analysis, and cooperative study among tools
2069	[34]	Visualing knowledge domains
1798	[35]	Bibliometric studies of research collaboration: A review
1462	[36]	A bibliometric analysis of 30 years of research and theory on corporate social responsibility and corporate social performance
1173	[37]	The structure of scientic literatures I: Identifying and graphing specialties

The cited works offer diverse insights into bibliometric analysis, business intelligence, visualization tools, social network analysis, and the structure of scientific literature. Despite some not being AI-specific, their methodologies, principles, and applications hold relevance for the AI research landscape. These influential works collectively contribute to the methodological foundation and interdisciplinary understanding of AI research.

In conclusion, the citation analysis highlights the significant contributions of seminal works to the understanding and advancement of AI research. These works, spanning bibliometric analysis, business intelligence, visualization, social network analysis, and research collaboration, collectively shape the scholarly discourse, methodologies, and tools that researchers rely on within the dynamic AI landscape. The cited works offer diverse insights into bibliometric analysis, business intelligence, visualization tools, social network analysis, and the structure of scientific literature. Despite some not being AI-specific, their methodologies, principles, and applications hold relevance for the AI research landscape. These influential works collectively contribute to the methodological foundation and interdisciplinary understanding of AI research. The citation analysis highlights the significant contributions of seminal works to the understanding and advancement of AI research. These works, spanning bibliometric analysis, business intelligence, visualization, social network analysis, and research collaboration, collectively shape the scholarly discourse, methodologies, and tools that researchers rely on within the dynamic AI landscape.

Table 4. Keywords Analysis

Most occurrences		Fewer occurrences	
Occurrences	**Term**	**Occurrences**	**Term**
59	Big data	19	Blockchain
50	Science mapping	18	Artificial neural network
39	Industry	17	Network map
36	Machine	16	Internet
27	Knowledge mapping	15	Tourism
24	Innovation	14	Smart city
24	Pattern	13	Intellectual structure
24	Role	12	Knowledge domain
23	Impact	11	Pandemic
22	Gap	10	Data mining

The analysis of keyword occurrences provides valuable insights into the thematic landscape of the artificial intelligence (AI) research domain. The most frequent and fewer occurrences of keywords offer a comprehensive view of the prominent and emerging research trends within the field.

Most Occurrences of Keywords:

The analysis reveals several keywords that frequently appear in AI research publications. These keywords represent key themes that have captured the attention of researchers and practitioners in the AI domain.

"Big Data" (Occurrences: 59):

The prominence of "Big Data" signifies the significant role data plays in shaping AI research. The analysis indicates the growing recognition of the importance of data-driven approaches in developing AI technologies, applications, and solutions.

"Science Mapping" (Occurrences: 50):

The occurrence of "Science Mapping" reflects the emphasis on mapping and analyzing the intellectual structure of AI research. Researchers use science mapping techniques to uncover the relationships between research areas, institutions, and scholars, contributing to a more holistic understanding of the AI landscape.

"Industry" (Occurrences: 39):

The keyword "Industry" highlights the close alignment between AI research and its practical applications across various sectors. The focus on AI's impact on industries underscores the transformative potential of AI technologies in reshaping business processes and driving innovation.

"Machine" (Occurrences: 36):

The occurrence of "Machine" emphasizes the central role of machine learning within AI research. This keyword reflects the widespread exploration of algorithms, models, and methodologies that enable machines to learn and adapt from data, fueling AI advancements.

"Knowledge Mapping" (Occurrences: 27):

"Knowledge Mapping" signifies the interest in visualizing and analyzing the intellectual landscape of AI research. This keyword aligns with the emergence of tools and methodologies, like VOSviewer, that facilitate the exploration of relationships, clusters, and trends within research domains.

"Innovation" (Occurrences: 24):

The recurring keyword "Innovation" underscores AI's transformative potential and its capacity to drive novel solutions across industries. The focus on innovation highlights the dynamic nature of AI research as it continually adapts to meet evolving challenges.

Fewer Occurrences of Keywords:

While these keywords have fewer occurrences, they still provide valuable insights into emerging or specialized themes within the AI research landscape.

"Blockchain" (Occurrences: 19):

Despite having fewer occurrences, "Blockchain" signifies the exploration of decentralized and secure data management within AI applications. This emerging theme suggests that researchers

are investigating the integration of blockchain technology to enhance data integrity and security in AI systems.

"Artificial Neural Network" (Occurrences: 18):

The keyword "Artificial Neural Network" indicates a focus on a specific subset of machine learning techniques. This neural network-based approach plays a crucial role in various AI applications, including natural language processing, image recognition, and pattern recognition.

"Network Map" (Occurrences: 17):

"Network Map" highlights the visualization of networks and relationships within AI research. This theme aligns with the interest in understanding collaborative networks, intellectual structures, and knowledge flows within the AI research landscape.

"Internet" (Occurrences: 16):

The occurrence of "Internet" reflects the exploration of AI's interaction with online platforms, data sources, and internet-based applications. This theme indicates the significance of AI in shaping online experiences and interactions.

"Tourism" (Occurrences: 15):

The presence of "Tourism" suggests a specialized focus within AI research, indicating its application in the tourism industry. This emerging theme demonstrates AI's potential to enhance experiences, services, and operations in the tourism sector.

"Smart City" (Occurrences: 14):

The recurring keyword "Smart City" reflects the exploration of AI technologies in urban planning and development. This theme highlights the integration of AI to create more efficient, sustainable, and technology-driven urban environments.

"Intellectual Structure" (Occurrences: 13):

"Intellectual Structure" signifies the interest in analyzing and understanding the conceptual framework of AI research. This theme aligns with efforts to uncover underlying patterns, connections, and thematic clusters within the field.

"Knowledge Domain" (Occurrences: 12):

The occurrence of "Knowledge Domain" suggests an emphasis on delineating and categorizing specific domains within AI research. This theme reflects efforts to define and explore the boundaries of different subfields within the broader AI landscape.

"Pandemic" (Occurrences: 11):

The occurrence of "Pandemic" indicates a topical focus on understanding AI's role in addressing challenges posed by global pandemics. This theme suggests researchers' interest in exploring AI applications for healthcare, disease prediction, and crisis management.

"Data Mining" (Occurrences: 10):

The recurring keyword "Data Mining" underscores the importance of extracting insights and patterns from large datasets. This theme aligns with the fundamental role of data analysis techniques in driving AI research and applications.

Discussion of Keyword Occurrences:

The keyword occurrences reflect the multidimensional nature of AI research. The most frequent keywords highlight established themes, including big data, science mapping, and industry applications. These themes underscore AI's pervasive impact on research and industry.

The fewer occurrences of keywords indicate emerging or specialized research areas, such as blockchain integration, artificial neural networks, and smart city applications. These themes illustrate the ongoing evolution of AI research, as researchers explore novel applications, methodologies, and technologies.

In conclusion, the keyword analysis reveals a rich tapestry of themes within the AI research landscape. The most frequent and fewer occurrences collectively provide a comprehensive overview of the prominent and emerging research directions within AI. These insights guide researchers, policymakers, and practitioners in understanding the evolving landscape and its implications for various domains and industries.

5. CONCLUSION

In conclusion, this research study illuminates the artificial intelligence (AI) research landscape through the lens of bibliometric analysis, enriched by the visualization capabilities of VOSviewer. The holistic analysis of publication trends, authorship dynamics, citation patterns, and emerging research themes provides a panoramic view of AI's evolution. The identified clusters shed light on diverse aspects, including AI's impact on business, sustainability, knowledge mapping, web presence, and innovation. Seminal works and influential papers have been highlighted, showcasing the methodological foundations, interdisciplinary connections, and theoretical underpinnings that have guided AI research. The keyword analysis unveils the thematic landscape, ranging from established themes like big data and industry applications to emerging areas such as blockchain integration and artificial neural networks. These insights collectively shape the trajectory of AI research, guiding researchers, practitioners, and policymakers in navigating the complex and dynamic terrain. The integration of VOSviewer's visualization tools enhances the study's depth and accessibility, providing dynamic representations of collaboration networks, citation flows, and thematic clusters. These visualizations foster deeper insights and facilitate effective communication of research trends and relationships.

As AI continues to drive transformative changes across industries and disciplines, the findings of this research contribute to informed decision-making, interdisciplinary collaboration, and ethical considerations. The insights gained empower researchers to identify future trajectories, discover emerging frontiers, and collectively advance the boundaries of AI knowledge. In the rapidly evolving landscape of AI research, this study serves as a foundational resource, offering a comprehensive understanding of its evolution, trends, and implications. The insights presented herein serve as a compass guiding researchers, policymakers, and stakeholders towards meaningful contributions, innovation, and responsible development within the AI domain.

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