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A Bibliometric Analysis of Research Trends in AI Integration within Cloud Computing

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Abstract

The integration of Artificial Intelligence (AI) and cloud computing has emerged as a rapidly expanding research area, driven by the need for scalable, elastic, and cost-efficient intelligent systems. Cloud infrastructures enable dynamic resource allocation and pay-as-you-go models, making them ideal environments for AI model training and deployment. Despite the growing volume of publications, a structured mapping of the intellectual landscape of AI–cloud integration remains necessary. This study aims to analyze the research landscape of AI integration in cloud computing using a bibliometric approach. Data were collected from the Scopus database for the period 2021-2026 using the query "Artificial Intelligence" AND "Cloud Computing", focusing on English-language articles. The analysis was conducted using the Bibliometrix package in R to examine Annual Scientific Production, Countries Collaboration World Map, Most Relevant Affiliations, Co-occurrence Network, Thematic Map, Most Relevant Words, Trend Topics. The findings reveal a significant increase in publications after 2021, indicating accelerating academic interest in AI–cloud convergence. International collaboration is dominated by countries such as India, China, Saudi Arabia, the United States, and the United Kingdom. Thematic analysis shows that artificial intelligence and cloud computing function as foundational themes, with machine learning acting as a key driving force. Emerging topics such as edge computing and real-time systems suggest a shift toward intelligent, distributed, and data-intensive cloud environments.

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INTRODUCTION

Cloud computing has evolved from traditional distributed computing systems into a dominant paradigm in modern information systems. Its development was driven by foundational technologies such as grid computing, utility computing, service-oriented architecture (SOA), and particularly virtualization, which collectively enabled the aggregation and dynamic provisioning of computing resources as utility-based services (Gupta & Sohal, 2022). Virtualization plays a central role by abstracting physical hardware into multiple virtual resources, forming scalable and pooled infrastructures that support flexible allocation and multi-tenant architectures (Ageed & Zeebaree, 2024; Gupta & Sohal, 2022).

These technological advancements transformed conventional distributed computing into scalable, elastic, and service-oriented cloud environments (Gupta & Sohal, 2022; Judijanto, Yuli Vandika, et al., 2024). The evolution of virtualization technologies, network infrastructure, and resource management mechanisms further strengthened cloud computing as a mature and foundational infrastructure for contemporary digital services (Angel et al., 2022; Judijanto, Yuli Vandika, et al., 2024). Cloud computing enables dynamic resource allocation, cost efficiency, and broad network accessibility, reinforcing its role as a dominant infrastructure model (Ageed & Zeebaree, 2024; Angel et al., 2022). These characteristics align with the definition provided by the National Institute of Standards and Technology (NIST), which describes cloud computing as a model that enables ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort.

The evolution of cloud computing also reflects the advancement of earlier computing paradigms such as grid computing, utility computing, and virtualization. According to Lins et al. (2021), cloud computing provides on-demand access to configurable computing resources within a shared pool, characterized by scalability, flexibility, and a pay-per-use model, and supported by service models such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). Similarly, Shahzad & Zhou (2020) explains that the integration of distributed systems, grid computing, and virtualization enables the delivery of elastic and scalable services, while Dritsas & Trigka (2025) emphasize that cloud architecture supports modern computing needs through flexible service models. Furthermore, cloud resource management continues to evolve through machine learning-based optimization Khan et al. (2021), and advancements in virtualization techniques strengthen the performance and elasticity of IaaS services (Admassu, 2024). Overall, this evolution has positioned cloud computing as an elastic, scalable, and adaptive computing system that meets modern user demands.

Building upon this scalable infrastructure, Artificial Intelligence (AI) has experienced exponential growth driven by advancements in machine learning, deep learning, and big data analytics. The integration of AI into cloud environments has become a major research focus, enabling scalable service deployment, elastic resource provisioning, and cost-efficient computing models (Bains, 2024). Cloud-based infrastructures support pay-as-you-go mechanisms and dynamic allocation strategies, significantly reducing infrastructure barriers for AI implementation (Bains, 2024).

AI integration enables intelligent automation, predictive analytics, and cognitive services, particularly when combined with cloud computing environments. According to Radhakrishnan et al. (2025), the convergence of AI-as-a-Service (AIaaS) and cloud-native architectures supports scalable, flexible, and cost-efficient intelligent enterprise solutions. Similarly, Walia (2024) emphasizes that cloud infrastructure provides elastic CPU/GPU/TPU resources and large-scale storage, enabling complex AI model training and seamless deployment without on-premises limitations. Furthermore, Anand & Ravichandran (2008) highlight that cloud platforms facilitate workflow automation and model lifecycle management, enhancing efficiency in AI/ML implementation, while Bhavsagar (2025) emphasize improvements in advanced analytics and intelligent business automation. Moreover, cloud-based AI platforms offering managed services and hardware accelerators further democratize AI development and deployment at scale (Durga, 2025).

The rapid increase in AI publications reflects its growing academic and practical relevance across disciplines (Judijanto, Mayasari, et al., 2024; Ziane & Khazzar, 2025). In this context, the convergence of AI and cloud computing has facilitated scalable AI deployment while democratizing access to advanced analytics tools. The emergence of Artificial Intelligence as a Service (AIaaS) represents a significant milestone in this integration, allowing organizations to access machine learning and intelligent services without substantial upfront investments. By leveraging cloud infrastructures, AIaaS enables elastic resource utilization and cost-efficient implementation models (Lins et al., 2021). Major cloud providers such as Amazon Web Services, Microsoft Azure, and Google Cloud Platform now offer AI capabilities through cloud platforms, further expanding accessibility.

In parallel, bibliometric analysis has been widely used to map the development of emerging technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and cloud computing. This method helps identify publication trends, influential authors, collaboration networks, and thematic evolution. For example, Valencia-Arias et al. (2024) applied a PRISMA-based bibliometric approach to analyze trends in machine learning and blockchain, revealing publication growth, key contributors, and emerging keywords including cloud computing. Likewise, Wang et al. (2024) demonstrated that bibliometric techniques effectively capture multidisciplinary connections among AI, IoT, and cloud computing through keyword and cluster analysis.

From an applied perspective, Wisnu et al. (2024) emphasized that the integration of cloud computing and AI can enhance efficiency across sectors such as education, manufacturing, banking, and healthcare, although challenges related to data security, privacy, and potential information leakage remain. Furthermore, large-scale bibliometric studies by Ayaz et al. (2021) show that cloud computing research has grown significantly, with increasing focus on security, resource management, IoT, and big data. Although AI-related keywords are emerging more frequently, bibliometric studies specifically examining AI integration within cloud environments remain limited. This indicates a research gap and the need for a more focused bibliometric analysis on AI-driven cloud computing.

Given the rapid expansion of research in AI–cloud integration, a systematic mapping of the intellectual landscape is necessary. Bibliometric analysis provides a structured approach to examine publication growth trends, identify leading countries, authors, and journals, and analyze collaboration networks, keyword co-occurrence patterns, and thematic evolution (Bains, 2024; Ziane & Khazzar, 2025). Therefore, this study aims to map the research landscape of AI integration in cloud computing through a comprehensive bibliometric approach with the following objectives: (1) to analyze publication growth trends; (2) to identify leading countries, authors, and journals; (3) to map keyword co-occurrence and research clusters; and (4) to examine thematic evolution in AI–cloud integration research.

RESEARCH METHODS

This study employs a quantitative approach using bibliometric analysis to map the development of research on the integration of Artificial Intelligence (AI) and Cloud Computing. The analysis aims to identify publication growth trends, scientific collaboration patterns, country and institutional productivity, as well as the structure and thematic evolution of the research field.

Data Collection

The data were collected from the Scopus database due to its broad international coverage and credible indexing standards. The search process was conducted using the query: TITLE-ABS-KEY ("artificial intelligence" AND "cloud computing"). The inclusion criteria were: publication years 2021–2026, document type article, English language, and subject area Computer Science. Based on these filtering criteria, a total of 801 documents were retrieved and analyzed in this study.

The limitation to the Computer Science subject area was applied to ensure the relevance of the study to the disciplines of computing and information technology. All eligible metadata, including author information, affiliations, countries, publication years, journal sources, and keywords, were exported in CSV/BibTeX format for further analysis.

Data Analysis Tool

The bibliometric analysis was conducted using the Bibliometrix package in R via RStudio. Bibliometrix is an open-source R-based package specifically designed for comprehensive bibliographic data analysis. It enables the calculation of bibliometric indicators, network analysis, and visualization of the intellectual structure of a research field. RStudio was used as the integrated development environment (IDE) to run the analysis scripts, import Scopus data, and generate various scientific visualizations and mappings.

RESULTS AND DISCUSSION

This section presents and discusses the findings derived from the bibliometric analysis conducted using the Bibliometrix package in RStudio. The results are organized based on several key bibliometric indicators, including annual scientific production, international collaboration patterns, institutional productivity, keyword co-occurrence networks, thematic mapping, keyword frequency distribution, and trend topics analysis.

Through these visualizations and quantitative indicators, this study aims to provide a comprehensive overview of the intellectual structure, collaborative landscape, and thematic evolution of research on AI integration in cloud computing. The following subsections explain each figure in detail and interpret their implications for understanding the development and future direction of this rapidly growing research field.

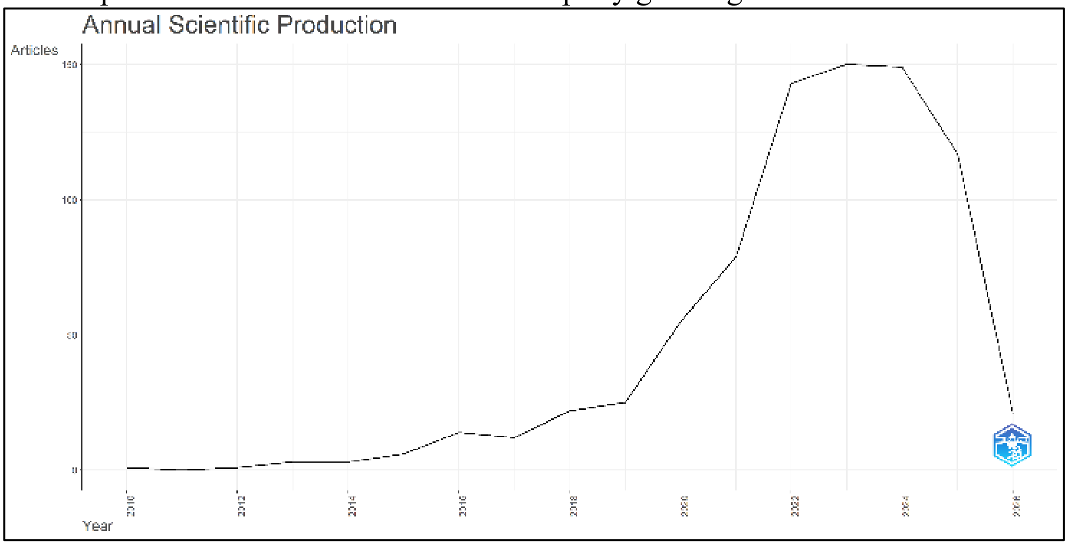

Fig. 1 Annual Scientific Production on AI Integration in Cloud Computing

Based on Figure 1 above, which illustrates the Annual Scientific Production generated using the Bibliometrix tool, publications related to AI integration in cloud computing demonstrate a significant upward trend over the past decade. During the period 2010–2017, the number of published articles remained relatively low and increased gradually. However, starting in 2019, a sharp surge is clearly visible, with a dramatic rise that peaks around 2022–2023. This pattern reflects the growing academic interest in the convergence of Artificial Intelligence and cloud technologies, particularly in response to accelerated global digital transformation. Although a slight decline appears in the most recent years (2025–2026), this is likely due to incomplete indexing or ongoing publication cycles rather than an actual decrease in research interest. Overall, Figure 1 highlights that AI integration in cloud computing is currently in a rapid growth phase and has become one of the fastest-developing research areas in information technology and intelligent computing.

From	To	Frequency
All	All	All
INDIA	SAUDI ARABIA	20
CHINA	UNITED KINGDOM	19
CHINA	USA	17
INDIA	USA	15
SAUDI ARABIA	EGYPT	14
INDIA	UNITED KINGDOM	12
SAUDI ARABIA	PAKISTAN	11
USA	UNITED KINGDOM	11
CHINA	INDIA	10
CHINA	SAUDI ARABIA	10

Fig. 2 Countries' Collaboration World Map in AI Integration in Cloud Computing Research

As shown in Figure 2 above, the Countries' Collaboration World Map reveals a high level of international cooperation in research on AI integration in cloud computing. The strongest collaborative pairs include India–Saudi Arabia (20 collaborations), China–United Kingdom (19), China–USA (17), and India–USA (15). This pattern indicates that Asian countries, particularly India and China, play central roles in the global research network, supported by strategic partnerships with Western countries such as the USA and the United Kingdom. More broadly, the figure illustrates strong interregional connections between Asia and developed Western nations, alongside increasing collaboration within the Middle East. This suggests that the research landscape is highly global and collaborative, with emerging economies actively strengthening international partnerships to accelerate innovation and scientific output in digital technology fields.

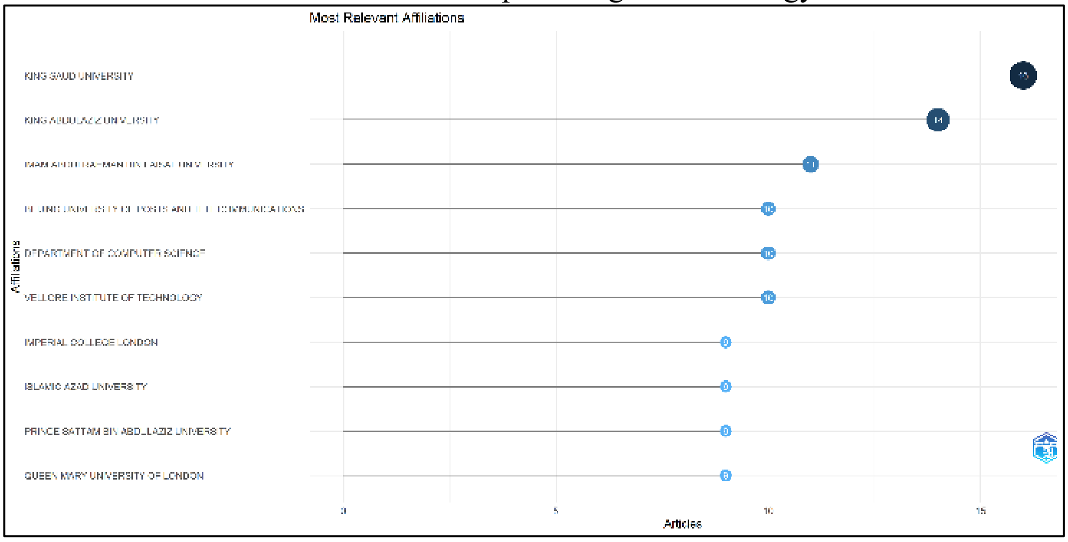

Fig. 3 Most Productive Institutions in AI Integration in Cloud Computing Research

Figure 3 above presents the most productive institutions in the field. The results indicate that universities from Saudi Arabia dominate institutional productivity. King Saud University ranks first with 16 publications, followed by King Abdulaziz University with 14 publications, and Imam Abdulrahman Bin Faisal University with 11 publications. This dominance reflects strong investment and research focus in the Middle East on AI-driven cloud technologies.

Significant contributions also come from institutions in Asia and Europe, including Beijing University of Posts and Telecommunications, Vellore Institute of Technology, Imperial College London, and Queen Mary University of London. Collectively, the figure demonstrates that research productivity is globally distributed across leading technology research centers.

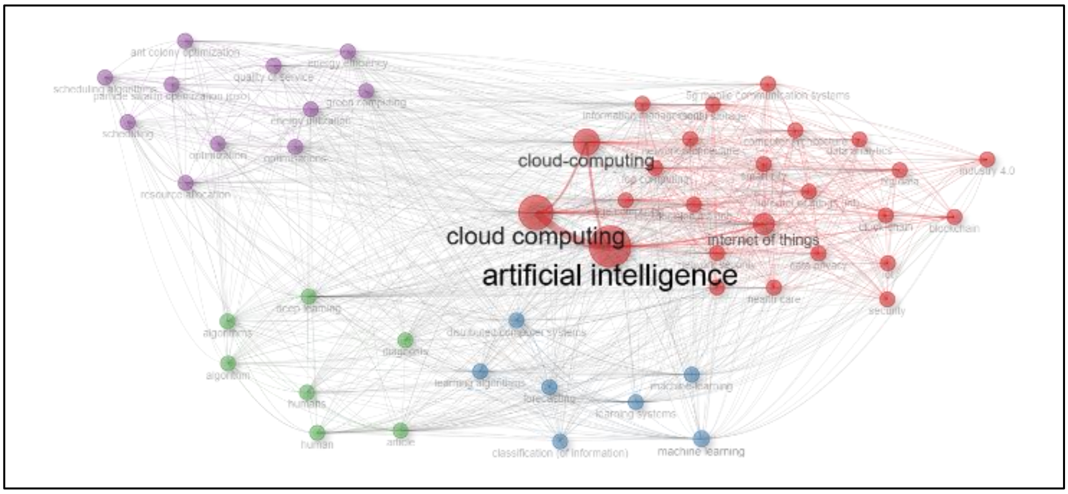

Fig. 4 Keyword Co-occurrence Network in AI Integration in Cloud Computing

Figure 4 above depicts the Co-occurrence Network of keywords. The visualization shows that *cloud computing* and *artificial intelligence* function as the most dominant and central nodes within the network. Their larger node sizes indicate high frequency, while their numerous connections demonstrate strong thematic linkages with other research areas.

The red cluster highlights AI integration with supporting technologies such as Internet of Things (IoT), edge computing, network architecture, and smart cities-suggesting a strong research focus on distributed computing ecosystems and intelligent cloud-based systems. Other clusters reveal more specialized themes, including system optimization and efficiency (purple cluster), data analytics and distributed computing (green cluster), and machine learning and forecasting (blue cluster). Overall, the network structure confirms that AI integration in cloud computing is multidisciplinary, spanning infrastructure, data analytics, and intelligent applications, with highly interconnected and complex thematic relationships.

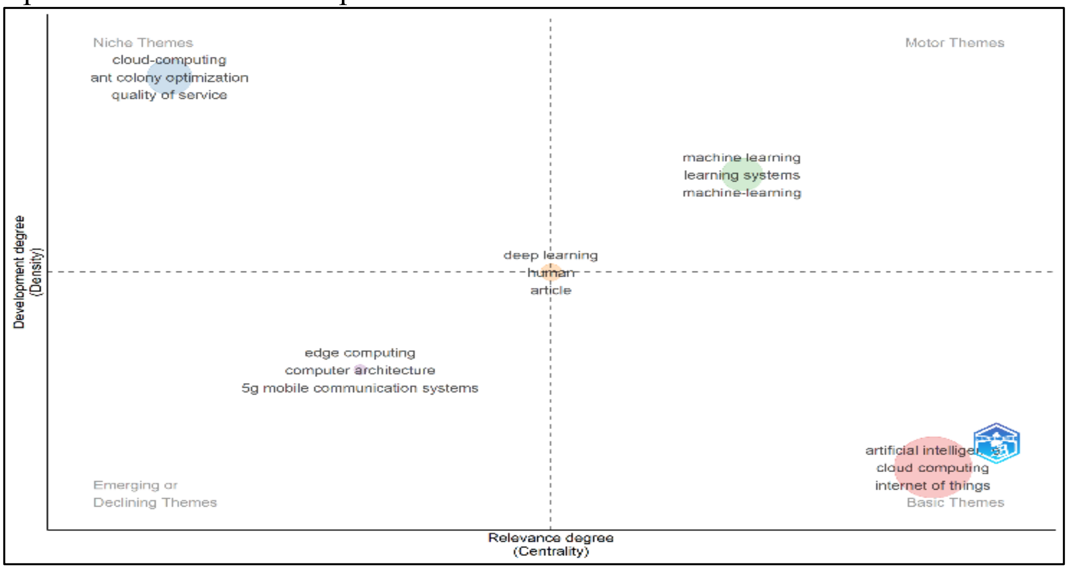

Fig. 5 Thematic Map of AI Integration in Cloud Computing Research

As illustrated in Figure 5 above, the Thematic Map provides insight into the conceptual structure of the field. Artificial intelligence, cloud computing, and Internet of Things appear in the *Basic Themes* quadrant (high centrality but relatively low density), indicating that these topics form the foundational pillars of the research landscape. They are highly relevant and strongly connected to other themes but continue to develop in conceptual depth.

Meanwhile, machine learning and learning systems are positioned within the *Motor Themes* quadrant, meaning they are both highly relevant and well-developed, serving as the primary driving forces of research evolution. In contrast, cloud-computing, ant colony optimization, and quality of service appear as *Niche Themes*, reflecting specialized yet internally developed topics with limited broader connections. Edge computing, computer architecture, and 5G mobile communication systems fall within the *Emerging or Declining Themes* quadrant, suggesting potential new research directions or shifting scholarly focus. Overall, Figure 5 indicates that AI integration in cloud computing is in an expansion phase, with machine learning acting as the core engine of innovation.

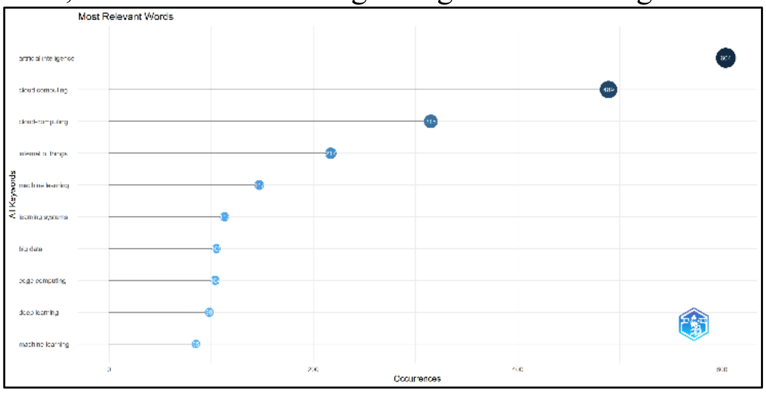

Fig. 6 Keyword Frequency Distribution in AI Integration in Cloud Computing

Based on Figure 6 above, which presents keyword frequency analysis, *artificial intelligence* emerges as the most dominant term with 604 occurrences, followed by *cloud computing* (489) and *cloud-computing* (315). The high frequency of these core terms reinforces the centrality of AI-cloud integration within the research landscape. Additionally, *Internet of Things* (217 occurrences) highlights its strong association, indicating that IoT ecosystems represent a key application domain.

Other frequently appearing keywords-such as machine learning, learning systems, big data, edge computing, and deep learning-demonstrate that the field is evolving toward intelligent data analytics and distributed computing frameworks. Variations in terminology (e.g., "machine-learning" versus "machine learning") also reveal metadata inconsistencies that may influence bibliometric outcomes. Overall, the keyword distribution confirms a strong emphasis on intelligent data processing, machine learning systems, and integration with modern digital infrastructures.

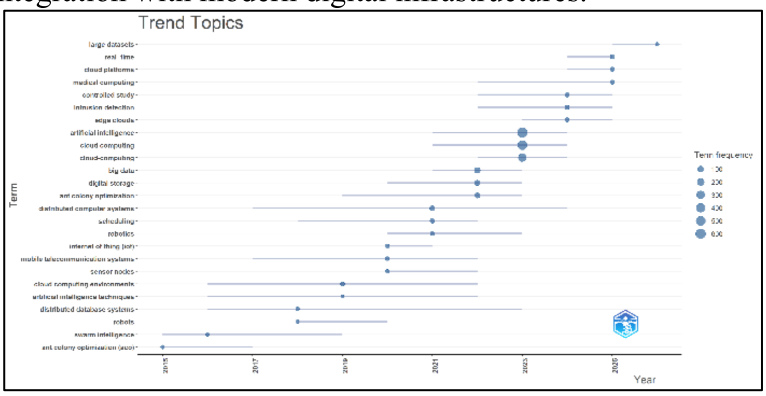

Fig. 7 Trend Topics Evolution in AI Integration in Cloud Computing Research

Finally, Figure 7 above illustrates Trend Topics over time, revealing a clear shift in research focus. In the early period (2015-2018), studies concentrated on foundational infrastructure themes such as ant colony optimization, swarm intelligence, distributed database systems, and cloud computing environments-indicating an emphasis on system optimization and distributed architecture.

During 2019-2021, attention expanded toward Internet of Things (IoT), mobile telecommunication systems, big data, and digital storage, reflecting the growth of data ecosystems and connectivity. In the most recent period (2022–2025), topics such as artificial intelligence, cloud computing, machine learning, real-time systems, and large datasets became dominant with higher frequency levels. This progression demonstrates a transition toward more applied, large-scale, and real-time AI integration within cloud and edge platforms. Overall, Figure 7 confirms that the research landscape continues to evolve toward adaptive, distributed, and data-driven intelligent systems, positioning AI-enabled cloud computing as a core pillar of next-generation digital innovation.

CONCLUSIONS AND SUGGESTIONS

This study mapped the research landscape of AI integration in cloud computing using a bibliometric analysis of 801 Scopus-indexed articles published between 2021 and 2026. The findings reveal a significant upward trend in scientific production, particularly after 2019, with peak growth observed in 2022–2023. This pattern indicates accelerating global academic interest in scalable, intelligent, and data-driven cloud infrastructures aligned with digital transformation initiatives. The collaboration analysis demonstrates that AI-cloud research is highly globalized, with India, China, Saudi Arabia, the United States, and the United Kingdom acting as central contributors within the international research network. Institutional productivity is notably dominated by universities in Saudi Arabia, reflecting strong regional investment in AI-driven cloud technologies. These patterns highlight the strategic importance of cross-regional partnerships in advancing intelligent cloud innovation. Keyword co-occurrence and thematic mapping show that artificial intelligence and cloud computing function as foundational themes with high centrality, while machine learning emerges as the primary motor theme driving research development. Emerging topics such as edge computing, real-time systems, IoT, and 5G communication indicate a shift toward distributed, latency-sensitive, and large-scale intelligent ecosystems supported by cloud and edge platforms.

Overall, AI integration in cloud computing is evolving from infrastructure-oriented research toward advanced, application-driven, and data-intensive intelligent systems. This field is increasingly positioned as a core pillar of next-generation digital innovation. Future research may broaden database coverage and apply more advanced network analyses to further explore emerging subfields and interdisciplinary connections within AI-enabled cloud computing.

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