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The Latest Developments in Chatbots: A Bibliometric Review Over the Past 15 Years

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Abstract

The growing integration of chatbots across industries—including customer service, healthcare, education, and entertainment—has spurred extensive academic. This study aims to analyse current developments in chatbots. The information visualization software CiteSpace was used to analyse chatbot-related data on the Web of Science from 2010--2024, which spans 15 years and focuses on both macro- and microperspectives of representative keywords. The paper elucidates articles number of annual published, major, research directions, significant documents, and emerging frontiers in chatbot research through visualization analysis while also forecasting future development trends. This study shows the recent hotspots and research frontiers of chatbot and will provide important reference value for researchers, governments, and enterprises for the latest developments in chatbot research.

Keywords: Chatbot, CitSpace, Scientific Knowledge Graph

Introduction

A chatbot is 'a computer program, which simulates human language with a text-based dialogue system' (Zumstein & Hundertmark, 2017) and machine conversation systems that engage with human users through natural conversational discourse (Liu & Duffy, 2023). Initially, chatbots were engineered to serve as the quintessential virtual assistants for entertainment, facilitating functions such as answering enquiries, providing navigation, and

personalizing the user experience (Liu & Duffy, 2023). Improvements in AI, machine learning (ML), data science, and natural language processing (NLP) are now making it easier to construct conversational bots for a variety of applications, helping human beings, and contributing to the rapid growth in chatbot numbers (Bataineh et al., 2023). Currently, chatbots have been created for diverse functions, ranging from executing basic orders to serving as advanced digital assistants and interactive agents (Liu & Duffy, 2023).

Originally created as basic rule-based systems, chatbots have evolved into advanced AI models proficient in contextual comprehension, delivering human-like responses, and executing intricate tasks (Casheekar et al., 2024). According to a recent report, the Chatbot Market size was estimated at USD 15.54 billion in 2023 and USD 17.74 billion in 2024 and is expected to grow at a CAGR of 14.29% to reach USD 39.62 billion by 2030, as shown in Figure 1 (Markets, 2024). North America clearly dominates, accounting for the largest chatbot market share, but Asia Pacific (China, Japan, India, South Korea, Australia, Indonesia, and others) is estimated to expand further in this domain because of the increasing emergence of e-commerce platforms selling products and services online (Markets, 2023).

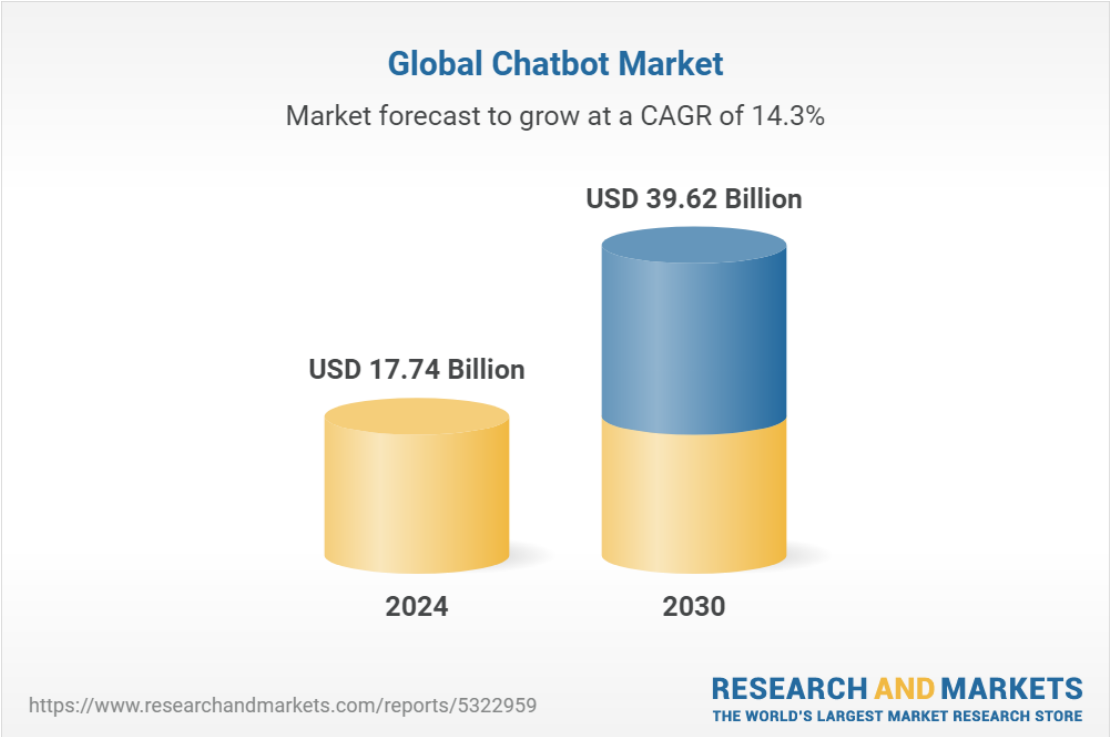

Figure 1 Global Chatbot Market

The growing integration of chatbots across industries—including customer service, healthcare, education, and entertainment—has spurred extensive academic and industrial research, making it a critical area of study in AI and human–computer interaction (Akpan et al., 2025).

However, chatbots are an emerging field of artificial intelligence, and the Chinese government lacks special deployment of chatbots. However, plans for AI and its derivative industries have been developed. For example, the 2024 Government Work Report requires that the Chinese government deepen the research and development and application of big

data, artificial intelligence, etc., carry out the "artificial intelligence +" action, and build a digital industry cluster with international competitiveness (Council, 2024). In addition, many papers have conducted bibliometric reviews on chatbots in specific fields, providing deep insights into the development of robots in specific fields. For example, AI applications include chatbots (Liu & Duffy, 2023), ChatGPT (Nan et al., 2025), Chatbots and conversational agents (Io & Lee, 2017), implementation of chatbot technology in health care (Ni et al., 2024), service chatbots (Lee et al., 2023), and chatbots in business and information systems (Li et al., 2025). However, the literature lacks a more comprehensive perspective on the latest developments of robots, which may lead to bias or short-sightedness toward chatbots.

To address the gaps in the literature, we propose the following research questions.
- How has the focus of chatbot research evolved?
- What are the hotspots of chatbots?
- What are the emerging themes and future directions in chatbot development?

The purpose of this paper is to present a bibliometric review of the latest developments in chatbot research over the past 15 years (2010–2024) from a more comprehensive perspective, which will help to explore and understand the historical evolution of robots, research hotspots and cutting-edge areas of change.

The significance of this paper is that mapping the evolution of chatbot technologies, highlight major breakthroughs, and uncover gaps in the literature. The findings will provide researchers, developers, and policymakers with a comprehensive understanding of the state of chatbot research and its future directions.

The remainder of this paper is organized as follows: Sections 2 and 3 present the methodology, which details the data collection, bibliometric tools, and analysis techniques. Section 4 presents the findings, which include key findings on publication trends, keyword networks, thematic evolution, interpretation of results, comparison with prior studies, and implications. Section 5 further discusses our findings. Finally, the conclusion and future directions, which is a summary of findings and recommendations for researchers and practitioners, are presented.

Methodology

Bibliometric analysis is a quantitative method used to evaluate academic literature, identifying trends, influential publications, key contributors, and emerging research themes by analysing a large corpus of scholarly articles (Donthu et al., 2021). Bibliometrics is also the quantitative analysis of scholarly publications via the use of statistical methods to measure research impact, trends, and relationships within a field, which involves studying publication patterns and collaborations to evaluate academic productivity and influence (Ninkov et al., 2022). CiteSpace, a bibliometric analysis tool that can analyse and visualize cocitation networks, is a citation visualization analysis software that was developed in the context of scientometrics and data visualization with a focus on analysing the potential knowledge contained in scientific analysis (Wang & Lu, 2019).

Source of Data

This research primarily utilizes data from the Web of Science (WoS) core database, a comprehensive, multidisciplinary citation database encompassing over 8,500 academic publications across the natural sciences, engineering, social sciences, and arts and humanities (Wang & Lu, 2019). This paper uses ‘‘chatbot*’’ as the topic. The time range was set to 2010--2024, the document type was selected as the article, and the search date was updated to 2 April 2025. Finally, 4545 document records were retrieved. The document saving mode is set to ‘‘full record’’, the file format is ‘Export Records to Plain Text File’, and the file is saved and renamed with the name ‘‘download*.txt.’’.

The information of 4545 articles was subsequently imported into CiteSpace software for further visual analysis. The relevant analysis options were set as follows: time slicing, 2010–2024; time per slice, 1 year; node type, keyword; time slice threshold, 50; and line algorithm, pathfinder, pruning sliced networks, and pruning merged networks (Wang & Lu, 2019; Yubo et al., 2023). To improve the accuracy of the results, we merged synonyms as follows:

Table 1
Synonymous keyword merging

The keywods of before the merger	The keywods of after the merger
artificial intelligence (ai)	artificial intelligence
ai	artificial intelligence
generative artificial intelligence (ai)	generative artificial intelligence
generative ai	generative artificial intelligence
generative artificial intelligence (genai)	generative artificial intelligence
ai chatbot	artificial intelligence chatbot
ai chatbots	artificial intelligence chatbot
artificial intelligence (ai) chatbots	artificial intelligence chatbot
conversational agents	conversational agent
large language model	large language models

The Findings

Evolution of Chatbots

Figure 1 shows the research progress on chatbots over the past 15 years. We can see that before 2016, there were relatively few discussions about chatbots, and the growth rate was close to 0. However, from 2017--2022, robots gradually received attention, and the number of publications increased significantly. In particular, an exciting trend is that after 2023, chatbots received great attention, and the growth rate nearly doubled. Given the exponential growth in chatbot-related publications, a systematic bibliometric review is essential to further understand chatbots.

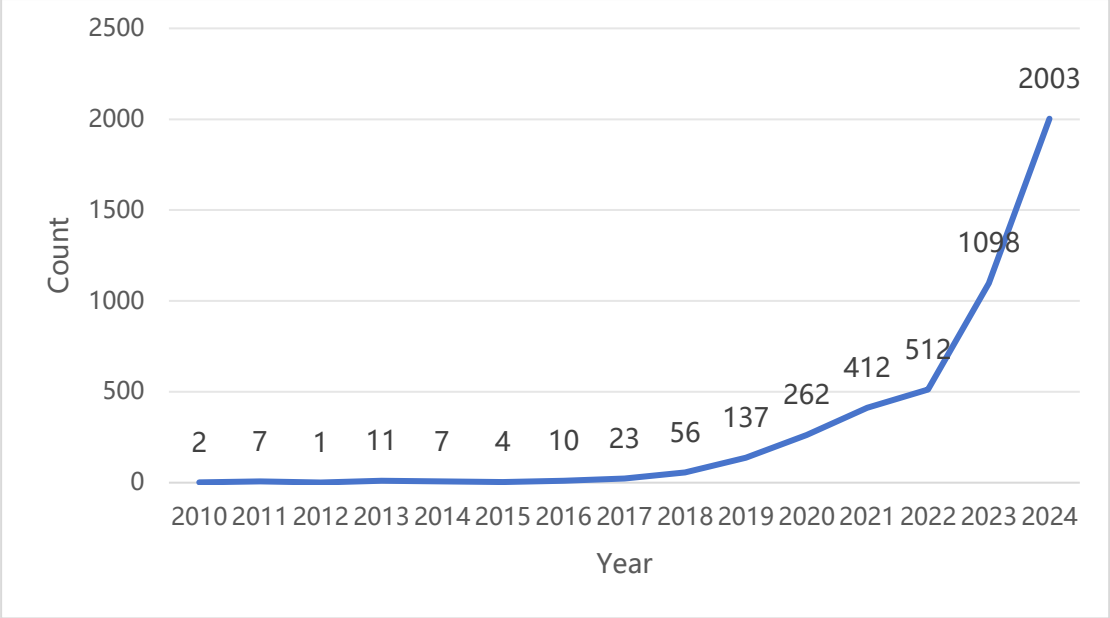

Figure 2 Annual publication count pertaining to chatbots

The concept of chatbots dates back to the mid-20th century, with early examples such as ELIZA (Weizenbaum, 1966), a rule-based program that mimicked a psychotherapist by using pattern matching and scripted responses. However, the past 15 years have witnessed unprecedented progress in chatbot capabilities, driven by advancements in machine learning (ML), deep learning (DL), and large language models (LLMs). According to the trend of publication growth, we can divide the development of chatbots into three stages.

Early Rule-Based Systems (Before 2010)

Before 2010, the number of articles published each year ranged from 1--6. In the seven years from 2003--2009, only 21 articles were published in total. Discussions about chatbots were very rare. Most chatbots rely on rule-based and retrieval-based models. Therefore, this stage was called early rule-based systems (Abbate & Thiel, 2003). These systems follow predefined scripts or decision trees, limiting their ability to handle unstructured conversations (McCallum, 2005). Examples include customer service bots that can respond only to specific keywords. While they are effective for narrow applications, these chatbots lack flexibility and contextual understanding (Sha, 2009).

Machine Learning Revolution (2010–2016)

During this period, although the number of articles published on chatbots was still slow, the introduction of statistical NLP and machine learning marked a turning point in chatbot development. Researchers began using supervised learning and sequence-to-sequence (Seq2Seq) models to improve response generation. The rise of neural networks enabled chatbots to learn from large datasets, improving their ability to generate coherent replies. Key developments during this period include recurrent neural networks (RNNs) (Hermans & Schrauwen, 2013) and long short-term memory (LSTM) networks for better context retention (Mikolov et al., 2014). The introduction of word embeddings (Word2Vec, GloVe) allows chatbots to understand semantic relationships between words (Wang et al., 2015). Early commercial chatbots, such as Apple's Siri (Corti & Gillespie, 2015) and Google Now (Nelson, 2014), brought conversational AI into mainstream use.

Deep Learning and Transformer Era (2017–2024)

The breakthrough moment for chatbots came with the introduction of transformer-based models, which revolutionized NLP by enabling parallel processing and long-range dependency modelling (Annepaka & Pakray, 2025). For example, Google's transformer architecture, which introduces self-attention mechanisms, drastically improves language understanding (Ghojogh & Ghodsi, 2020). OpenAI's GPT series starts with GPT-1 and culminates in GPT-4, ChatGPT, and beyond. These models demonstrated unprecedented capabilities in generating human-like text (Alto, 2023). Google's BERT and its variants improved contextual understanding in chatbots (Babu & Boddu, 2024). The rise of multimodal chatbots integrates text, voice, and vision (e.g., ChatGPT with DALL·E for image generation) (Naik et al., 2024). Today, chatbots are no longer limited to scripted interactions but can engage in open-domain conversations, assist in complex problem solving, and even exhibit empathetic responses (Raamkumar & Yang, 2022).

Keyword Cooccurrences of Chatbots

Keyword cooccurrences refer to the analysis of how frequently specific keywords appear together in the same research publications, and keyword frequency provides insights into the hotspots of different time periods. The hotspots for chatbots can be discovered by the frequency of co-occurrence of keywords (Jie & Chaomei, 2017; Li & Li, 2024; Wang & Lu, 2019; Yubo et al., 2023). Keyword cooccurrences help identify key research themes, conceptual relationships, and emerging trends (Narong & Hallinger, 2023). This helps researchers identify core topics and interdisciplinary links. This reveals shifts in research focus over time and supports bibliometric and science mapping studies (Marrone & Linnenluecke, 2020). Therefore, according to Figure 2 and Table 2, the top 10 keywords with the highest co-occurrence frequency are artificial intelligence, conversational agent, large language models, natural language processing, technology, model, impact, machine learning, generative artificial intelligence, and mental health.

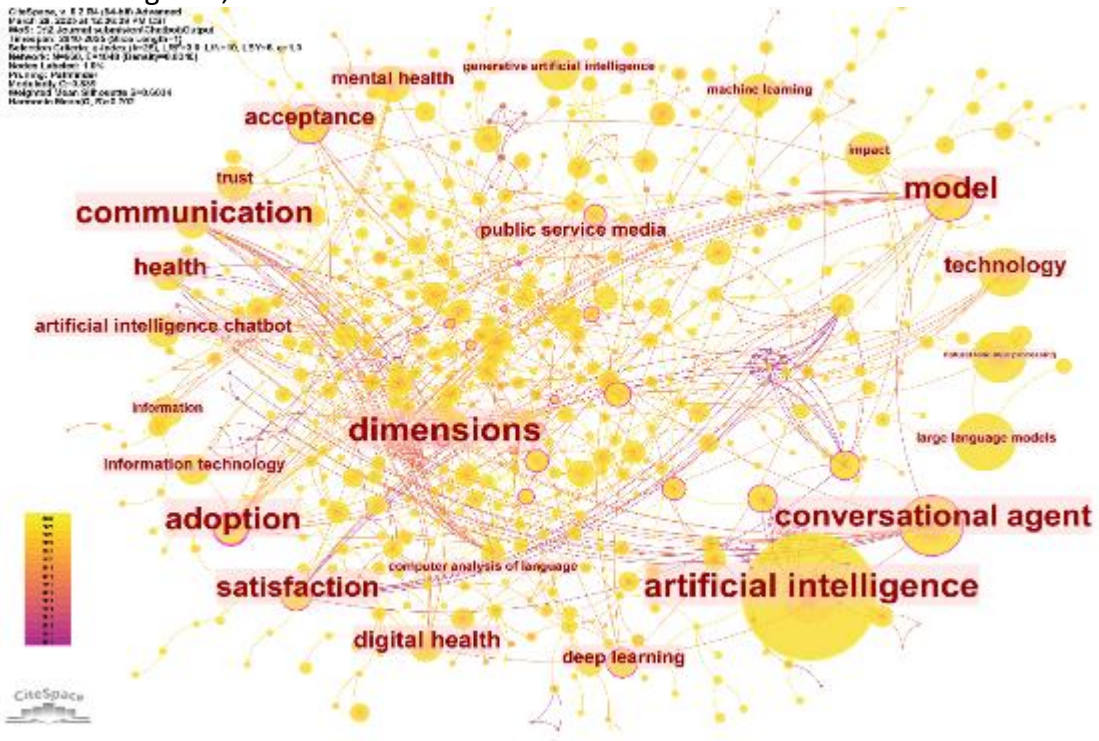

Figure 3 Keyword co-occurrence

Table 2
Top 10 keywords in terms of co-occurrence

No.	Count	Centrality	Year	Keywords
1	1571	0.09	2012	artificial intelligence
2	362	0.12	2011	conversational agent
3	307	0.01	2023	large language models
4	275	0	2019	natural language processing
5	253	0.05	2018	technology
6	216	0.15	2014	model
7	203	0.02	2019	impact
8	161	0.01	2015	machine learning
9	161	0.01	2023	generative artificial intelligence
10	157	0.03	2018	mental health

The Changing Trend of Chatbots

The time zone view is a visualization mode that displays nodes along a timeline, where their positions correspond to their time of occurrence or citation (Beck et al., 2017), which helps identify trends and shifts in research focus, thereby helping detect emerging topics, declining themes, and collaboration shifts (McCallen et al., 2019). Figure 4 shows that the research on chatbots between 2010 and 2014 focused mainly on artificial intelligence, conversational agents, models, health, satisfaction, chatbots, quality, the internet, education, and agents. Subsequently, (2015--2019), the focus of chatbot research shifted to natural language processing, technology, impact, machine learning, mental health, acceptance, trust, communication, information, adoption, and digital health. However, recently (2020--2024), the focus of chatbot research has been on large language models, generative artificial intelligence, artificial intelligence chatbots, information technology, user acceptance, performance, task analysis, anthropomorphism, mobile phones, and patient education.

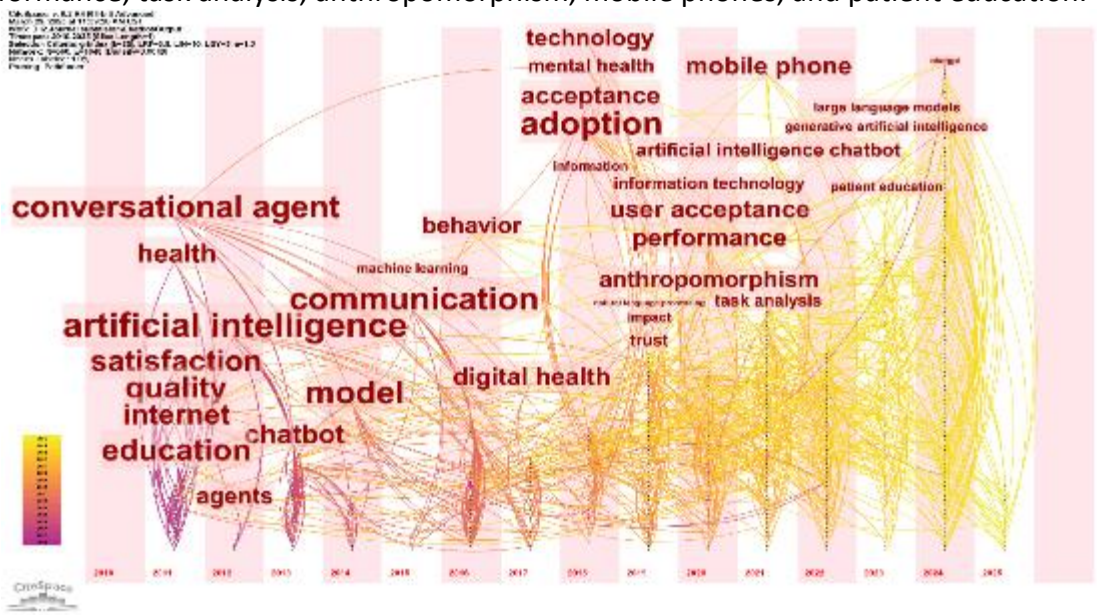

Figure 4 The changing trend of chatbots

Discussions

The current research landscape on chatbots is shaped by rapid advancements in artificial intelligence (AI), natural language processing (NLP), and human–computer interaction (HCI), which reflect both technological progress and evolving societal needs. First, chatbots fundamentally rely on AI techniques to simulate human-like conversations (Chandra et al., 2022). Early systems used rule-based logic, but modern chatbots leverage machine learning (ML) and deep learning (DL) for dynamic responses (Izadi & Forouzanfar, 2024). Second, the release of ChatGPT and other LLMs revolutionized chatbot capabilities (Casheekar et al., 2024). Generative AI enables open-ended dialogue, creative content generation, and fewer scripted responses (Antony & Huang, 2025). Third, NLP bridges human language and machine understanding, enabling chatbots to parse intent, sentiment, and semantics (Chao et al., 2021). Advances in transformer models (e.g., BERT and GPT) have drastically improved language comprehension (Zhou et al., 2024). Fourth, rising mental health crises (e.g., postpandemic anxiety and depression) have increased the demand for accessible, low-cost therapy bots (Lima et al., 2021). Finally, even advanced chatbots fail if users do not trust or adopt them (Zhang et al., 2024).

Research focused on chatbots has evolved significantly over the past 15 years, reflecting advancements in artificial intelligence (AI), user interaction, and application domains. The early stage (2010–2014) focused mainly on foundations in AI and basic applications. For example, early research primarily explored rule-based chatbots and simple dialogue systems, focusing on foundational AI techniques (Ji et al., 2014). However, during this stage, chatbots are mostly scripted, with limited natural language understanding (NLU), leading to research on improving response accuracy and usability (Griol & Callejas, 2013). The following is the growth phase (2015–2019); this stage focuses on NLP, machine learning, and user trust. For example, the shift from rule-based to data-driven chatbots (e.g., using seq2seq models) improved conversational abilities (Balyan et al., 2019). and User Adoption Studies, which research expanded into human–computer interaction (HCI), examining factors such as acceptance, privacy, and perceived usefulness (Hornbæk & Hertzum, 2017). In the recent phase (2020–2024), the focus was on LLMs, generative AI, and anthropomorphism. For example, the rise of GPT, Bard, and Claude revolutionized chatbots, enabling human-like text generation (Hornbæk & Hertzum, 2017). Studies have explored how human-like chatbots should balance engagement with ethical risk (e.g., deception). Research has focused on fine-tuning LLMs for specialized tasks (e.g., medical diagnosis and customer service) (Chow & Li, 2024). and Mobile & Accessibility, which chatbots are increasingly integrated into messaging apps (WhatsApp, Telegram) and voice assistants (Siri, Alexa) (Hasal et al., 2021).

Conclusions

The exponential growth of chatbots in recent years shows that chatbots are a thriving topic with considerable potential, having a significant impact on many industries. This study conducted a bibliometric analysis of papers related to chatbots in the Web of Science over the past 15 years. The findings showed that: (1) research on chatbots has shown significant growth in recent years and has become a potential emerging field. (2) the research hotspots of chatbots are artificial intelligence, conversational agents, large language models, natural language processing, technology, models, impact, machine learning, generative artificial intelligence, and mental health. (3) chatbot research has transitioned from technical development to real-world adoption and now advanced AI integration. The next frontier may

involve multimodal AI (voice + text), personalized assistants, and stricter AI governance. This study shows the recent hotspots and research frontiers of chatbot and will provide important reference value for researchers, governments, and enterprises, etc.

Limitations

First, this paper relies on only a single WoS database, which may introduce some bias. In addition, nuanced research themes may be missed because of the reliance on author-provided keywords. Preprints, technical reports, and policy documents are omitted despite their influence in this study. Moreover, static bibliometric snapshots may miss rapid shifts (e.g., post-ChatGPT AI research explosion). Furthermore, bibliometrics identifies associations but cannot explain why trends emerge.

Recommendations for future research

First, future bibliometric analysis should be expanded to more databases, such as Combine WoS/Scopus with Dimensions, Google Scholar, or PubMed, and future research should include more types of literature, such as books, reports, etc. Second, for a topic such as chatbots, which is growing exponentially, there will be an explosion in the short term, deriving multiple knowledge paradigms, so future researchers are advised to review the latest developments in chatbots in a timely manner to understand their dynamic changes. Finally, bibliometrics can be supplemented with content analysis or expert surveys.

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