Comprehensive Bibliometric Literature Review of Chatbot Research: Trends, Frameworks, and Emerging Applications

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***Abstract*—This study aims to conduct a comprehensive bibliometric literature review of chatbot research by examining key trends, frameworks, and influential applications across various domains. It seeks to map the evolution of chatbot technologies, identify influential works, and analyze how the research focus has shifted over time, particularly towards AI-driven chatbot frameworks. An expanded dataset was compiled from the Scopus database, and bibliometric analyses were conducted using n-gram reference analysis, network mapping, and temporal trend visualization. The analysis was performed using R Studio with Biblioshiny, allowing for the identification of thematic clusters and the progression from rule-based to advanced retrieval and generative language model paradigms in chatbot research. Chatbot research has grown significantly from 2020 to 2024, with rising publication volumes and increased global collaboration, led by contributions from the USA, China, and emerging regions, such as Southeast Asia. Thematic analysis highlights a shift from foundational AI and NLP technologies to specialized applications such as mental health chatbots and e-commerce systems, emphasizing practical and user-centered solutions. Advances in chatbot architectures, including generative AI, have demonstrated the field's interdisciplinary nature and trajectory towards sophisticated, context-aware conversational systems. The analysis primarily used data from Scopus, which may limit the breadth of the included research. Future studies are encouraged to integrate data from other sources, such as the Web of Science (WoS) and PubMed, for a more comprehensive understanding of the field.**

Keywords*—Chatbot research; bibliometric literature review; retrieval and generative; trend visualization

I. Introduction

Current technological trends indicate that chatbots are popular applications that use Artificial Intelligence [1], Machine Learning [2], Deep Learning [3], and Natural Language Processing [4]. They are used in various fields, including education, health, universities, schools, nursing, and business. Computers are becoming increasingly capable of performing tasks that humans perform. With artificial intelligence and machine learning technology, computer systems have become more compact and efficient in understanding voice and text interactions, leading to an effective speed [5].

Numerous prominent chatbots utilizing deep learning techniques have been created by major corporations, including ChatGPT by OpenAI, Alexa by Amazon, Siri by Apple, Google Assistant by Google, Cortana by Microsoft, and Watson by IBM [6]. These chatbots serve as personal assistants in daily activities. They communicate through voice and integration with devices, such as smartphones, smartwatches, and cars. Owing to the rapid growth of chatbot applications, technical analysis methods are required, and a framework that is widely used in building chatbots today classifies chatbots into two distinct categories: task-oriented and non-task-oriented [7]. Task-oriented aspects operate according to human instructions, whereas non-task-oriented aspects have multiple objectives but cannot carry out specific activities. Non-task-oriented chatbot architectures can be classified into generative-based and retrieval-based. Chatbots are generally used to answer the questions asked by users. Typically, users initiate a conversation with this application and provide answers after analyzing the questions. Chatbot users must have convenient, flexible, and real-time access to ensure successful use [8].

This study investigates the trend of chatbot development, the sectors that use chatbots, and the frameworks and methodologies applied to chatbot development. Several research initiatives in the field of chatbots have used bibliographic analyses conducted by previous scholars. Io et al. [9] conducted an extensive bibliometric analysis of chatbot literature, emphasizing the growth of research beginning in 2015. This study suggests that future research should investigate new technologies and uses for chatbots, focusing on both user and business viewpoints to optimize chatbot functionality. The authors used traditional methodologies in chatbot development, focusing solely on Natural Language Processing techniques, such as natural voice, facial emotions, and body movements. Recent advances in deep learning require additional research to explore the potential applications of this cutting-edge technology for chatbot development across several domains.

Adomopoulou et al. [10] analyze the evolution of chatbots, focusing on their transition from simple rule-based systems to sophisticated machine-learning models. Researchers have critically analyzed various applications of chatbots in different domains, focusing on the importance of natural language processing and user interaction. It examines the current obstacles and potential future directions of chatbot technology, and suggests further research and development avenues to improve chatbot effectiveness and user satisfaction. The analysis conducted in this study reveals a persistent trend towards a high preference for basic authors. However, there is a

noticeable lack of comprehensive investigation into specific health topics, such as 'older people' or 'mHealth,' which are overshadowed by a broader emphasis on AI-based outcomes.

Pears et al.[11] conducted a bibliometric analysis to examine the increasing prevalence of chatbot applications in the healthcare sector. The increase in patient interactions has been attributed to advancements in AI and ML, particularly in NLP. Since 2016, there has been a substantial surge in research productivity, characterized by a transition from technology to studies centered around artificial intelligence and its practical applications. The research potential of advanced AI approaches has been emphasized by researchers who have specifically focused on developing user-friendly interfaces, tailored interactions, and integrating chatbots within various healthcare contexts. Furthermore, our analysis underscores the need to employ co-creation techniques that include stakeholders to enhance the efficacy of conversational agents designed for healthcare applications.

The objective of this study was to examine the trends and suggestions found in publications on chatbots, utilizing a bibliometric analysis approach. This study also presented visualizations of the current movement in chatbot development on different topics. The following research problems were addressed using data from the Scopus database.

RQ1: Who are the most prolific authors in chatbot, and what are their key research themes and topics?

RQ2: What are the most active countries in chatbot, and how does this vary across different regions and time periods?

RQ3: What are the prevalent keywords employed in the field of chatbots developed through bibliometric analysis?

RQ4: What research trends relate to chatbots (thematic and evolution trends), including journals, fields, countries, and universities?

RQ5: Which components, techniques, and frameworks are most widely used in chatbot development?

II. Literature Review

This literature review provides a comprehensive, updated overview of research developments in chatbot technology, focusing on recent innovations in AI, ML, NLP, and deep learning. This section surveys studies that address the expansion and application of chatbots across various domains, emphasizing the intellectual and social structures that shape current trends. By highlighting methodologies, frameworks, and analytical approaches from previous studies, this review aims to establish a foundation for understanding the gaps, advancements, and emerging directions in chatbot research, thereby framing the significance and context of the present study.

A. Historical Development

The history of chatbot development has evolved significantly from early rule-based systems to sophisticated AI-driven models. Over the years, advancements in machine learning, natural language processing, and neural networks have revolutionized chatbot capabilities. By the 2010s, major companies such as Apple, Amazon, and Google had introduced intelligent virtual assistants—Siri, Alexa, and Google Assistant—that leveraged voice recognition and vast data processing to perform more complex tasks. These developments signaled a shift towards conversational AI with greater versatility, accuracy, and personalization. In recent years, deep learning and transformer models such as OpenAI's GPT series have marked significant milestones, enabling chatbots to generate human-like responses and comprehend contexts with remarkable accuracy. Studies often employ advanced research designs, such as bibliometric analyses, to map intellectual and social trends in chatbot development. This evolving landscape demonstrates a continued effort to optimize conversational agents for diverse applications, including healthcare, education, and customer service, with an emphasis on user-centric frameworks that balance functionality with ethical considerations.

B. Recent Development

Recent developments in chatbot research reflect a shift towards integrating emerging technologies, such as advanced NLP, deep learning, and transformer models, notably the architecture underlying OpenAI's GPT series. Researchers are increasingly examining chatbot applications in diverse fields, including healthcare, government, and education, where the demand for real-time, personalized, and secure interactions has grown. This expansion has led to new concerns, especially regarding data privacy and cybersecurity, because chatbots handle sensitive user data. In the healthcare sector, chatbots now assist in patient management and mental health support, whereas in the government, they provide accessible public service information. These applications underscore the importance of secure, efficient, and adaptable chatbot systems that can respond to domain-specific requirements. In terms of methodology, recent research has often used mixed methods, combining quantitative and qualitative data to capture user satisfaction and chatbot performance insights. Machine learning and NLP integration have become essential, enabling chatbots to process and understand complex queries more effectively. These trends indicate that future research will likely focus on enhancing chatbot trustworthiness, expanding their usability across contexts, and addressing ethical considerations in AI-driven interactions, ensuring that chatbot systems align with user expectations and privacy needs.

C. Previous Studies on Bibliometric Analysis

Previous studies on the bibliometric analysis of chatbots and conversational agents have primarily focused on mapping the field's growth, identifying prominent authors, and analyzing keyword trends. For instance, Io et al. [9]. conducted a bibliometric analysis that emphasized the rapid rise in chatbot research since 2015, focusing on NLP and AI advancements. However, their methodology is limited by its reliance on traditional NLP techniques, and the lack of integration of emerging deep-learning methods is now central to chatbot development. Similarly, Adomopoulou et al. [10] examined the transition of chatbots from rule-based to machine-learning-driven systems, highlighting applications across various sectors, but noting an underrepresentation of specific areas, such as health-related chatbots tailored for older adults.

Pears et al. [11] analyzed chatbots in healthcare and revealed the increasing role of conversational agents in enhancing patient interaction. However, further research on ethical considerations and patient data security is required. Collectively, these studies provide valuable insights into the evolution of chatbot research. However, they are limited by their focus on specific technologies or sectors and often overlook broader applications or recent AI advancements. Notably, there is a gap in the comprehensive frameworks that assess chatbot adoption across multiple domains. Future research could address these gaps by incorporating advanced bibliometric techniques, examining ethical implications in more depth, and exploring the diverse applications of chatbots in emerging fields, such as government services and personalized education.

Manigandan et al. [12] conducted a bibliometric analysis for mapping research landscapes across various fields. Chatbots, conversational agents, and virtual assistants were employed to identify publication trends, key research themes, and collaborative networks among authors and institutions. Recent studies have revealed a significant increase in chatbot-related research since 2018, highlighting its growing importance in business, management, and accounting. Common themes include chatbot design, customer experience enhancement, and business operations automation, although ethical concerns such as privacy and transparency remain underexplored. Despite increased interest, the field is characterized by limited collaboration among researchers and nations, underscoring the need for more inclusive partnerships. Future studies should address underrepresented areas such as the ethical implications of chatbot use, user perceptions, and long-term organizational impacts. Expanding research into industries such as healthcare and education could also uncover the unique challenges and opportunities for chatbot adoption.

A similar study was conducted by Tawar et al. [13], who focused on the field of business management, although this research is rooted in computer science applications. Bibliometric analyses have proven valuable for systematically reviewing research trends, themes, and gaps across disciplines. In chatbot research, these analyses reveal the growing adoption and application of chatbots in areas such as customer service, marketing, and other sectors, showing their positive impact on customer engagement, trust, and business efficiency. However, significant limitations remain, including a focus on developed countries and insufficient exploration of ethical concerns such as privacy and transparency. Moreover, many studies rely on short-term data, lacking the longitudinal insights necessary to understand the evolving user behavior and technological progress. Addressing these gaps requires exploring cross-cultural contexts, developing ethical frameworks for chatbot use, and expanding applications in underexplored fields, such as healthcare and education. Future research integrating interdisciplinary theoretical approaches and longitudinal studies could deepen understanding and drive innovative developments in chatbot technologies. The summary of previous studies is presented in Table I.

TABLE I. SUMMARY OF PREVIOUS STUDIES

Author	Domain & Search Query	Objective of the Study	Total Document, Data Source & Coverage	Attributes Examined	Main Findings
Tanwar et al.[13]	The range of subject areas was restricted to "Business, Management and Accounting", "Social Sciences", "Psychology" and "Multidisciplinary".	science mapping, performance analysis, and bibliographic coupling to identify significant trends and areas of research emphasis	798 articles from Scopus.	Publication Trends, Most Productive and Influential Countries, Most Prolific Authors, Most Prolific Contributing Institutions, Most Prolific Journals, Intellectual Structure of Chatbots.	Key areas of chatbot research include: applications of chatbots, behavioral and relational effects of chatbot use, and factors influencing chatbot adoption, including barriers. The United States leads in contributions, with the highest number of research articles and citations in this field.
Agarwal et al.[16]	Domain: Chatbots in Computer areas. Search Query: (TITLE-ABS-KEY ("chatbots" AND "virtual assistants")	to examine the past research, to provide a conclusive mark. to explore the combination of keywords used in chatbots	130 articles from Scopus.	Theoretical contributions, Research implications, Managerial implications, Social implications.	The authors with maximumnumber of citations are Yan, Zaho, Bengio, Weizenbaum, Song, Zhou and Maedche with jointly 180 citations.
L et al. [12]	Domain: Chatbot in Business Management and Accounting	to identify key publication metrics, examine the intellectual structure, and explore the social structure of research in this field.	378 articles from scopus	number of publications and citations over time, productive authors, country productivity, h -index and intellectual structure	The keywords "Chatbot", "conversational agent" and "virtual assistant" emerged as the most frequently employed terms in the majority of publications.
Io et al.[9]	consider the two terms "chatbot" and "conversational agent"	s to help researchers to identify research gaps for the future research agenda in chatbots	4,246 articles from wos and proQuest	Clustering keywords, co-occurrences.	The results of the analysis found a potential research opportunity in chatbot
Xia et al.[17]	Domain "AI Chatbo"	to offer bibliometric assessments of the expanding literature about AI chatbot services	571 article from scopus	the most influential work, authors, and co-cited authors on AI chatbots	based on the author's cocitation analysis and the intellectual structure, Computer science is the most critical discipline regarding AI applications

III. METHODS

This Bibliometric Literature Review (BLR) utilized the bibliography analysis and meta-analysis approach. Bibliometric analysis is a crucial and effective method for comprehending the progression and patterns of research. Science mapping analysis is an integral part of bibliometric analysis that aims to provide a structured examination of trends periodically, studied themes, changes in fields of knowledge, and productive researchers [14], [15].

A. Search Strategy

Search Strategy: Explain how you identified the relevant literature for bibliometric analysis. This may include details such as the databases and search terms used, and any inclusion or exclusion criteria applied to the search results. The period covered in your analysis should also be described.

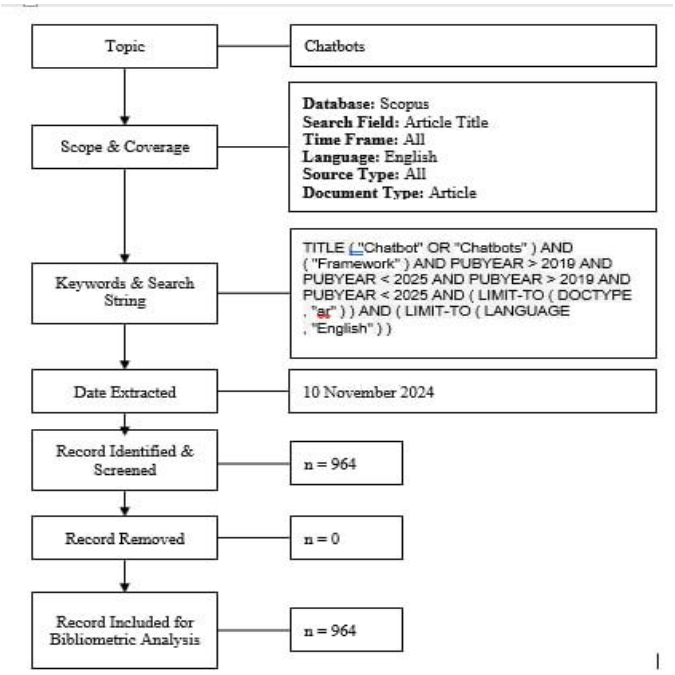

Fig. 1. Flow diagram of the search strategy.

Fig. 1 shows the stages in collecting data starting from topic and scope, keywords and search query, date extracted, record removed, record identified, and record included for bibliometric analysis.

B. Data Collection

The Search Strategi stages encompass distinct procedures: data extraction, identification, screening, record removal, and record inclusion in bibliometric analysis. We used Search Strategi stages to determine entries from the Scopus database by executing a query. The search yielded 964 documents.

C. Data Cleaning and Harmonization

To ensure the accuracy and consistency of the data imported into Biblioshiny, rigorous data cleaning was performed using the OpenRefine tool. The BibTeX file generated by Biblioshiny was exported to OpenRefine, and the dataset was verified to match the original source. Specific adjustments included standardizing author data by converting them to lowercase data. The integrity of the dataset was validated through a series of analytical processes using OpenRefine, ensuring that it was clean and suitable for bibliometric analysis.

D. Tools

The Scopus database was used to obtain studies for a comprehensive evaluation of chatbot research. The identification process began with a well-defined search strategy that was used to query the Scopus database and retrieve relevant entries. Following data collection, the articles were analyzed using the Biblioshiny tool in R Studio, enabling a detailed bibliometric analysis and visualization of research trends.

IV. RESULTS

This section examines publications, research activities, journals, papers, and references, providing an analytical overview. Following the analysis, the findings are further explored and discussed to offer deeper insights into the subject matter.

A. Analysis of Publications

The main information from the article was entered into R bibliometric software for bibliometric analysis. From the analysis results, a significant increase in research in the field of chatbots was found from year to year. The growth of this research is depicted in the following Table II.

TABLE II. MAIN INFORMATION DATA

Main Information	Data
Publication Years	2010 - 2024
Total Publications	955
Annual Growth Rate %	60.28
Document Average Age	1.13
Average citations per doc	20.61
Keywords Plus (ID)	3061
Author's Keywords (DE)	2848
Single-authored docs	66
Co-Authors per Doc	3.91
International co-authorships	27.64

From 2010 to 2024, there were 955 publications with an impressive annual growth rate of 60.28%, indicating a rapidly expanding field. The average document age is 1.13 years, and each publication receives an average of 20.61 citations, reflecting substantial academic impact. Collaboration is prevalent, with 3.91 co-authors per document on average, and 27.64% of publications involve international co-authorships, highlighting the global nature of the research.

Fig. 2 shows Annual scientific production has grown consistently from 2020 to 2024, reflecting a substantial increase in research activity. Starting with 60 articles in 2020, the output increased to 98 articles in 2021 and 142 in 2022. This upward trend continues with 259 articles in 2023 and peaks at 396 articles in 2024, indicating an accelerating interest and investment in the field over the five-year period.

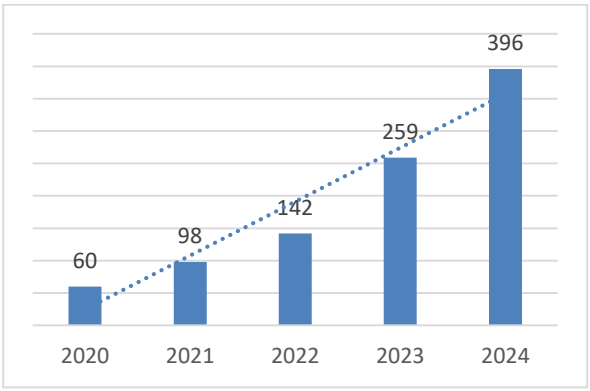

Fig. 2. Annual scientific productions.

TABLE III. AVERAGE CITATIONS PER YEAR

Year	Mean TCperArt	N	Mean TCperYear	CitableYears
2020	84.27	60.00	16.85	5
2021	49.37	98.00	12.34	4
2022	30.42	142.00	10.14	3
2023	15.67	259.00	7.84	2
2024	3.55	396.00	3.55	1

Table III provides information on the Mean Total Citations per article (MeanTCperArt), the number of articles (N of article), and the resulting Mean Total Citations per year (MeanTCperYear) for these years 2020 to 2024. In 2020, the mean total number of citations per article was 84.27, with eight articles contributing to a mean total number of citations per year of 18.85. Subsequently, there is a noticeable increase in the mean total citations per article per year in 2020, 2021, and 2022, followed by a significant decrease in 2023 and 2024. Measure an author's impact using the citation count, average citation rate, h-index, g-index, m-index, total citations, number of documents, and py_start, as shown in Table IV.

TABLE IV. AUTHORS' LOCAL IMPACT

Authors	h_index	g_index	m_index	TC	NP	PY_start
FØLSTAD A	6	9	1.200	286	9	2020
ZHU Y	6	10	2.000	235	10	2022
MOU J	5	5	1.667	305	5	2022
CHEN Q	4	5	1.333	145	5	2022
CHEN Y	4	4	1.000	201	4	2021
HOBERT S	4	5	0.800	156	5	2020
JEON J	4	7	2.000	220	7	2023
KIM H	4	5	0.800	146	5	2020
LI Y	4	5	2.000	34	7	2023
LIU Y	4	5	1.333	145	5	2022

Table IV provides an analysis of the top authors in chatbot-related research, based on bibliometric indices. FØLSTAD A and ZHU Y demonstrate the highest h-index scores (6), indicating consistent citation impact, with ZHU Y leading in g-index (10) and m-index (2.000), showcasing sustained productivity and influence since 2022. MOU J stands out with the highest total citations (305) despite having a lower g-index (5), reflecting impactful but fewer publications. JEON J and LI Y show notable m-index values (2.000), suggesting rapid citation growth relative to their research duration, particularly with recent publications in 2023. Meanwhile, CHEN Q and LIU Y exhibit balanced productivity and citation metrics, while HOBERT S and KIM H display consistent contributions since 2020. Overall, the data revealed diverse patterns of research impact, emphasizing both sustained contributions and emerging influencers in the field. Meanwhile, the influence of countries contributing to this field is dominated by the USA and China, as shown in the picture of the country scientific production below.

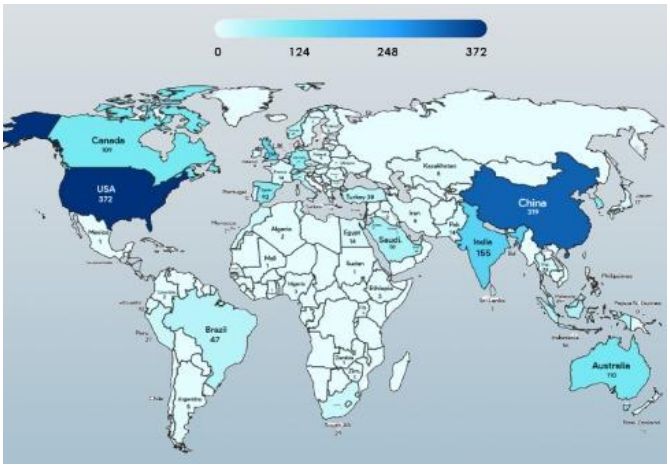

Fig. 3. Countries' scientific productions.

The Fig. 3. highlights the regional distribution of publications on chatbot research, revealing significant contributions from the USA (372), followed by China (319), and India (155), demonstrating their leadership in the field. Notable contributions also come from the UK (134), Australia (110), and Canada (109), indicating strong engagement from English-speaking countries. Asian nations such as South Korea (97), Indonesia (56), and Malaysia (49) also feature prominently, showing increasing research activity in the region. European countries, including Spain (92), Germany (77), and Italy (50), have contributed substantially, reflecting their growing interest in the domain. While regions such as the UAE (38), Brazil (47), and Turkey (38) indicate moderate contributions, countries with emerging research activities such as Morocco (21) and Thailand (24) highlight the global expansion of chatbot research. Smaller contributions from nations such as Ethiopia, Zambia, and Fiji emphasize the nascent but widespread adoption of chatbot research across diverse geographical areas.

B. Analysis of References

In bibliometric analysis, the purpose of analyzing references is to examine and scrutinize citations in academic publications, aiming to uncover insights into the intellectual structure and progression of a specific field of study. By analyzing references, bibliometrics can identify the most influential works and authors in a field, track their evolution, and identify key research trends and collaborations. This analysis can help researchers and policymakers to make informed decisions regarding the direction of future research. In this article, the analysis of

references is divided into two analyses: the most relevant word and evolution trend analysis.

Using Biblioshiny, word cloud visualization was performed to examine the keywords commonly used in articles related to chatbots. In this study, the most relevant words were identified by analyzing the keywords listed in the author's section of each article. The word cloud generated from the top 20 words shows a broad spectrum of crucial terms in the realm of chatbots, covering pivotal areas such as "artificial intelligence," "natural language processing," "conversational agents," and "chatgpt," among others. It encompasses an extensive range of concepts, including "anthropomorphism," "machine learning," and "covid-19," reflecting the multidisciplinary nature and depth of subjects related to chatbot technology and human-computer interaction. Fig 4 shows the most relevant keyword descriptions.

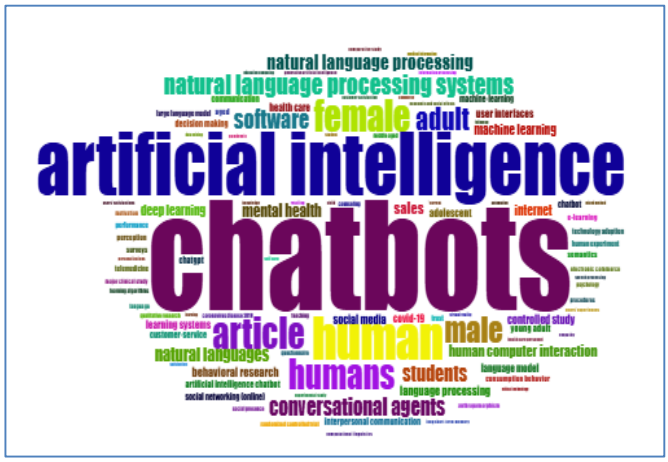

Fig. 4. Word cloud by keywords.

By analyzing the titles of articles from the authors, the words frequently used were Artificial Intelligence, AI chatbots, Mental Health, Customer Service, Intelligence Chatbots, Generative AI, Mixed Methods, and Natural Language. The frequency of occurrence in the analysis using N-Grams (Bigrams) is shown in Table V.

TABLE V. WORD FREQUENCY

Word	2020	2021	2022	2023	2024
Artificial Intelligence	2	5	10	35	68
Ai Chatbots	1	2	10	14	101
Mental Health	1	4	11	17	26
Customer Service	0	2	4	11	19
Intelligence Chatbots	2	3	6	19	36
Generative Ai	0	0	0	1	16
Mixed Methods	0	1	4	6	16
Natural Language	1	2	5	10	18

This table illustrates the dynamic evolution of key research topics in chatbot-related studies from 2020 to 2024. "Artificial Intelligence" consistently leads the discourse, showing significant growth from 2 mentions in 2020 to 68 in 2024, reflecting its foundational role in chatbot development. Similarly, "AI Chatbots" demonstrates exponential growth, particularly in 2024, with a sharp rise to 101 mentions, highlighting their increasing adoption and application. Emerging topics like "Mental Health" and "Customer Service" reveal a steady increase, emphasizing the diversification of chatbot applications in addressing user needs. "Intelligence Chatbots" and "Natural Language" also exhibited consistent growth, underlining advancements in chatbot sophistication and linguistic capabilities. Notably, "Generative AI" which appeared only recently, shows substantial growth in 2024, indicating a shift towards innovative frameworks and methodologies in chatbot research. These trends underscore the expanding scope and interdisciplinary nature of this field.

Meanwhile, the word "framework" is in the 31st position as the most frequently appearing word, and its occurrence has increased from year to year, two times in 2020, six times in 2021, 12 times in 2022, 18 times in 2023, and 33 times in 2024. Several types of framework have been used in chatbot applications. These include RASA, Microsoft Bot Framework, Google Dialogflow, Telegram, Facebook, Twitter, Whatsapp, Wit.Ai, IBM Watson, Line, BotPress and Streamlit. Table VI lists some frameworks used for chatbot development in this study.

TABLE VI. FRAMEWORK OF DEVELOPMENT CHATBOTS

Framework	Authors
RASA	Fauzia[18], Windiatmoko[19]
Microsoft Bot	M. Cont & A. Ciupe[20], L. Zhou[21]
Google Dialogflow	S. Valtolina, Jr. [22],Villanueva G.R.[23]
Facebook	Aina, Pashev[24] & Gaftandzhieva[25]
Wit.ai	Li C. [26], Chu E [27]
Twitter	Y. M. Çetinkaya[28], E. Alothali[29]
Telegram	Y. Wahyuni[30], W. Santoso[31]
Whatsapp	Mash[32],Pasquetto[33]
IBM Watson	R. J. Moore[34], C. V. M. Rocha[35]
Line	Al Rasyid [36]
Botpress	Macanu B[37] ,
Streamlit	Kiangala K [38], Kothari S [39]

Interestingly, Streamlit was used in the 2023 and 2024 studies, where it was used as a generative AI chatbot using a large language model. The analysis and interpretation of research related to mental health dominate the health sector. Meanwhile, e-learning dominates the education sector and sales dominate the business sector. The top six fields where chatbots were developed are Health, Education, University, Financial, Industry and Tourism. Thematic evolution analysis was used to analyze chatbot trends in this study. Thematic evolution analysis was performed based on a co-word network and clustering Using these diagrams, it can be shown that chatbot research changes yearly. The existing keywords indicate the direction of research changes. Fig. 5 shows a thematic evolution diagram of the Keyword Plus field.

Thematic analysis revealed a dynamic evolution in chatbot research trends from 2020 to 2024. During 2020–2022, broad foundational themes such as "AI" and "NLP" were central,

representing the underlying technologies for chatbot development. As research advanced, a notable shift occurred towards applied themes in 2023–2024, such as "e-commerce," "human-computer interaction," and refined chatbot designs. For example, the transition from "AI--2020-2022" to "chatbot--2023-2024" underscores the growing emphasis on creating specialized systems tailored to industry-specific needs.

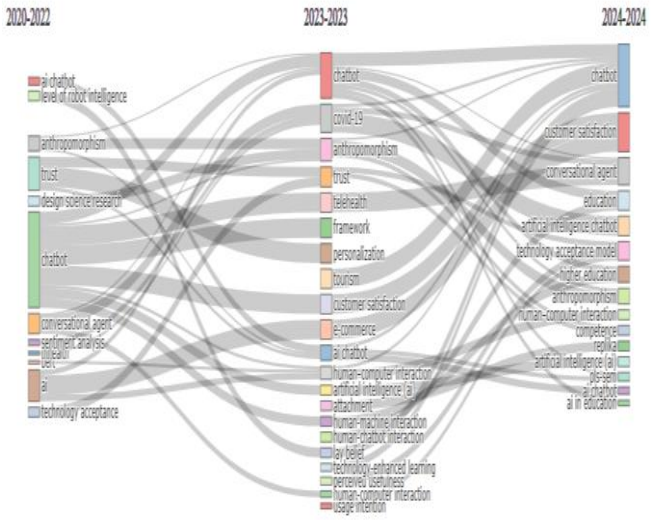

Fig. 5. Thematic evolution.

From 2023–2024, the emergence of "e-commerce" chatbots (weighted inclusion index of 1.00) highlights their importance in enhancing online retail and customer interaction. Similarly, themes like "human-computer interaction" reflect an increasing focus on usability and user satisfaction, as chatbots evolve to provide more intuitive and engaging experiences. Additionally, "AI chatbot," which persisted across both periods, illustrates continuous efforts to improve conversational models, ensuring their adaptability and effectiveness in addressing real-world challenges.

The stability indices across themes revealed sustained interest in specific areas. While "e-commerce" chatbots exhibit relatively high stability (0.11), foundational themes such as "AI" and "NLP" show lower stability, reflecting their transformation into specialized applications. By 2024, research trends will clearly demonstrate a movement from broad theoretical discussions to practical implementations, with chatbots playing critical roles in domains such as retail, customer service, and user interaction design. This evolution highlights the increasing maturity and impact of chatbot technologies in various sectors.

V. Discussion

Research Question 1. The analysis of prolific authors and their contributions to chatbot research revealed significant growth and diversification in the field from 2020 to 2024. Annual scientific production has increased substantially, with article outputs rising from 60 in 2020 to 396 in 2024, demonstrating an accelerating interest and investment in chatbot studies. Citation trends, as presented in Table III, highlight declining mean total citations per year over time, suggesting that while publication volume has grown, the citation impact of individual articles may have been diluted because of the field's rapid expansion. As detailed in Table IV, the key contributors include FØLSTAD A and ZHU Y, which lead to h-index scores, reflecting a consistent influence. At the same time, ZHU Y and JEON J exhibited high m-index values, signifying rapid citation growth in recent studies. MOU J achieved the highest total citations (305), indicating a significant impact despite fewer publications. Emerging influencers such as JEON J and LI Y demonstrate rapid citation accumulation, with research starting in 2023. Additionally, country-level data underscores the dominance of the USA and China in scientific production, positioning them as central players in advancing chatbot research. Together, these findings highlight both the maturation of established contributors and the emergence of new voices in the evolving chatbot research landscape.

Research Question 2. The analysis of chatbot research activity across different countries and regions revealed a rapidly expanding global field, with a remarkable annual growth rate of 60.28% from 2010 to 2024, culminating in 955 publications. The research is highly collaborative, with an average of 3.91 co-authors per document, and 27.64% involving international co-authorships, underscoring its global nature. The USA has 372 publications, followed by China (319), and India (155), reflecting their dominance in advancing chatbot technologies. Significant contributions from the UK (134), Australia (110), and Canada (109) highlight the strong engagement of English-speaking nations. Asian countries, such as South Korea (97), Indonesia (56), and Malaysia (49), also show robust participation, indicating the region's growing focus on chatbot research. European nations, including Spain (92), Germany (77), and Italy (50), have contributed substantially, showcasing their increasing interest in this domain. While countries such as Brazil (47), Turkey (38), and the UAE (38) reflect moderate engagement, emerging players, such as Morocco (21) and Thailand (24), highlight the global diffusion of chatbot research. Small contributions from nations such as Ethiopia, Zambia, and Fiji demonstrate the field's expansion to diverse and underrepresented regions, marking a promising trajectory for future research collaboration and development worldwide.

Research Question 3. Utilizing R Biblioshiny, the study yielded significant findings regarding the dominant keywords in articles focused on chatbots through the creation of word cloud visualizations. The analysis uncovered a wide range of essential terms that influence the development of chatbot technology based on the keywords provided by the authors. The word cloud consists of the top terms that emphasize essential topics vital to chatbots, such as "artificial intelligence," "natural language processing systems," "conversational agents," and "machine learning." This provides a complete overview of the essential principles of the field. Furthermore, the incorporation of words such as "semantics," "reinforcement learning," and "user interfaces" user interfaces emphasized the interdisciplinary character of chatbot technology and its convergence with human-computer interactions. These results are different from those found by previous researchers, where the keywords that are widely used are natural processing language, big data, learning algorithm, language learning system, and user experience [16].

Fig. 4 illustrates the visualization that effectively displays the essential characteristics of the discovered keywords, highlighting an extensive range of issues within the chatbot field. Moreover, an analysis of article titles revealed frequent terms such as “Artificial Intelligence”, “AI chatbots”, “Mental Health”, “Customer Service”, “Intelligence Chatbots”,” Generative AI”, “Mixed Methods” and “Natural Language”. The continued presence of frameworks in these titles indicates their enduring significance and prominence in conversations related to chatbots. The keyword frequency analysis of article titles revealed a notable pattern: the topic of Mental Health Chatbots was the most commonly discussed compared to other domains. This finding underscores a significant inclination towards using chatbot technology for mental health purposes, signifying the growing acknowledgment of the significance of technology in augmenting overall well-being. Additionally, it underscores the expanding apprehension over trust and acceptance in employing technology to address mental health concerns.

Research Question 4. The findings illustrate a clear evolution in chatbot research, transitioning from foundational themes to specialized applications between 2020 and 2024. In earlier years, the focus was predominantly on developing underlying technologies, such as artificial intelligence and natural language processing, which laid the groundwork for subsequent advancements. By 2023–2024, the emergence of themes like "e-commerce" and "human-computer interaction" demonstrates a shift towards practical and user-oriented applications. This transition reflects the increasing demand for chatbots in sectors that require tailored, intelligent, and efficient communication systems, particularly in e-commerce and service-oriented industries.

The persistence and refinement of themes such as "AI chatbot" also highlight the continued need for innovation in conversational models. While foundational topics showed lower stability indices owing to their evolution into specialized areas, emerging applications demonstrated higher stability, underscoring their growing importance. These findings suggest the maturation of the field, with research increasingly addressing the real-world challenges. Future studies could build on this trend by exploring the integration of advanced chatbot systems into more diverse sectors, emphasizing ethical considerations, user satisfaction, and the long-term sustainability of these technologies. In contrast, previous research observed that chatbot trends have evolved from basic rule-based systems to advanced machine-learning models [10]. However, this study found that the machine learning trend has shifted towards reinforcement learning and knowledge-based systems.

Research Question 5. In chatbot architecture, key elements include the Question Answering System, The Environment, The Front-end System, Traffic Server, and Custom Integrations. This discussion delves into the methods employed within the Question Answering System components and the framework applied to the front-end system. The utilization of AI, particularly deep-learning technology, has emerged as a prevailing trend in chatbot development. This aligns with the findings of Caldarini et al. [40], who emphasized the future of chatbot development through NLP techniques and utilization of deep learning technology. This correlation is in agreement with the thematic evolution analysis conducted in this research, revealing a prominent theme centered on deep learning.

Various techniques have been employed in chatbot development, each of which has its own strengths and applications. Rule-based systems rely on predefined rules and patterns to generate responses [41]. Meanwhile Kandasamy et al. [42] stated that Information retrieval-based systems focus on retrieving relevant information from a large text corpus. On the other hand, Ngai et al. [43] asserted that Knowledge-based systems use structured knowledge bases or ontologies to provide answers. NLP-based systems utilize NLP techniques to understand and generate context-aware responses [44]. Machine learning-based systems leverage supervised, unsupervised, or reinforcement learning to train models capable of answering questions [45]. Thus, the choice of development technique depends on the chatbot's specific requirements and goals.

There have been substantial advancements in the broader field of NLP. NLP encompasses the interaction between computers and human language. Recent developments in deep learning, particularly with models such as transformers, for example, bidirectional encoder representations from transformers (BERT), have led to significant breakthroughs in NLP applications such as sentiment analysis, machine translation, and question-answering [46]. Furthermore, NLP research spans various domains, including question-answering systems (QAS), summarization, machine translation, speech recognition, and document classification, each contributing to the overall evolution of NLP [47].

The chatbot architecture plays a crucial role in their functionality and effectiveness. Hwang et al. [48] research provided an overview of chatbot architecture, with components such as NLU, Intents/Entitas, Message Generator, Knowledge-Based database, and Respon. This architecture serves as the foundation for the design and operation of chatbots, encompassing various components and modules that enable them to interact with users and respond.

The need for external references and context becomes evident in open-domain Question Answering (QA), where the chatbot is expected to answer a wide range of questions. Researchers, such as Chen et al. [49] have developed frameworks such as the Retriever-Reader Framework. This framework allows chatbots to retrieve relevant information from documents and generate responses, thus enabling them to answer questions that require broader contextual knowledge.

Another approach to open-domain QA is the Retriever Generator QA framework, often called Generative Question Answering. This framework combines document retrieval systems with general language models such as BERT and GPT, as demonstrated by Petroni et al. [50] demonstrated in their research. This approach aims to leverage the strengths of both retrieval and generative methods to improve chatbot performance by providing comprehensive answers. The third model framework, known as the Generative Language Model, is associated with closed-domain QA, where a model, such as T5 Framework developed by Robers et al. [51] can generate responses to questions without requiring additional information or context. This approach is particularly valuable in scenarios in

which chatbots are expected to provide precise and concise answers without external references.

In summary, chatbot architecture is essential for their functionality, and researchers have classified chatbot QA models into different categories based on their capabilities. In open-domain QA, frameworks such as the Retriever-Reader Framework and Retrieve Generative Framework have been developed to enhance chatbots' ability to provide comprehensive responses. Closed-domain QA models, such as the Generative Language Model, excel in independently generating answers, making them suitable for scenarios where external references are not required. These developments in chatbot architectures and models contribute to the continuous improvement of chatbot performance and applicability in various domains.

VI. Findings

Growth and Diversification in Chatbot Research: The field of chatbot research has experienced significant growth from 2020 to 2024, with annual publication output increasing from 60 in 2020 to 396 in 2024. Despite this growth, a decline in mean total citations per article was observed, indicating the potential dilution of individual article impacts due to the field's rapid expansion. Prominent authors, such as FØLSTAD A and ZHU Y, demonstrated sustained influence. Simultaneously, emerging contributors such as JEON J and LI Y exhibited rapid citation accumulation, highlighting the field's dynamic and evolving nature.

Global Research Collaboration and Regional Participation: Chatbot research has high collaboration rates, with an average of 3.91 co-authors per document, and 27.64% of papers involve international partnerships. The USA and China led global contributions, producing the highest number of publications, while countries such as India, the UK, and Australia also made substantial contributions. Emerging participation from Southeast Asia and Africa, particularly Indonesia, Malaysia, Morocco, and Ethiopia, signifies an expanding and inclusive research landscape.

Thematic Evolution and Practical Applications: Thematic analysis revealed a transition from foundational technologies, such as AI and NLP, to specialized applications in domains like "e-commerce" and "mental health chatbots" by 2024. Mental health chatbots have emerged as a critical focus area, reflecting the growing societal interest in leveraging chatbot technology for well-being. These findings underscore a shift towards practical, user-centered chatbot applications that address diverse real-world needs.

Advancements in Chatbot Architectures: The development of chatbot architectures has progressed significantly, incorporating sophisticated frameworks such as retriever-reader systems, generative QA models, and closed-domain QA models. These innovations enhance chatbot performance in open domain and domain-specific applications. The integration of reinforcement learning, user-interface design, and deep learning technologies demonstrated the field's interdisciplinary nature and trajectory towards advanced conversational capabilities.

Emerging Trends in Keywords and Research Focus: Analyzing keyword trends revealed a focus on topics like "artificial intelligence," "natural language processing," and "machine learning," alongside newer themes such as "semantics," "user interfaces," and "reinforcement learning." Mental health applications, customer service, and generative AI are prominent themes, highlighting the diverse and evolving priorities of the field. This progression reflects the broadening scope and deeper specialization of chatbot research.

VII. Conclusion

This study provides a comprehensive examination of the evolution and diversification of chatbot research from 2020 to 2024, highlighting the rapid growth and global collaboration of the field. The rising annual publications and citations have significantly shaped this dynamic domain, as evidenced by prolific contributors and emerging researchers. Notable scholars such as FØLSTAD A and ZHU Y demonstrate sustained influence, while newer contributors such as JEON J exhibit rapid citation growth, reflecting fresh perspectives and innovative approaches. Geographically, countries like the USA and China dominate research output, whereas emerging contributions from regions such as Southeast Asia and Africa underline the global expansion and inclusivity of chatbot studies.

In addition to analyzing global research activities, this study highlights emerging trends and technological advancements. Themes such as "e-commerce" and "mental health chatbots" underscore the practical applications of chatbot technology, while the evolution of architectural frameworks illustrates advancements in conversational capabilities. The findings emphasize a transition towards sophisticated and user-centered applications from foundational AI technologies to specialized Generative AI. This trajectory provides promising opportunities for future research to address societal challenges, enhance user satisfaction, and expand chatbot utility across diverse domains. These insights collectively contribute to a deeper understanding of the evolving chatbot landscape and its potential transformative impact.

This research provides several recommendations for future research related to SLR in this area. This study used references from Scopus as the primary data sources. Although the Scopus database is the largest, it does not necessarily encompass all research related to chatbots. It is hoped that future reviews can incorporate literature from the WoS and PubMed databases to expand the findings on chatbots and achieve more complete results. This study focused on chatbot articles, including natural language processing, artificial intelligence, machine learning, deep learning, and neural networks. It is challenging to apply these concepts to existing subfields. Future research should focus on specific sub-fields, such as AI. It must also focus on existing health, education, industry, social, and political sectors.

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