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Global Research Trends on Chatbot and ChatGPT in the 21st Century

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Abstract

The study offers a comprehensive analysis of global research on Chatbot and ChatGPT from 2002 to 2023. A rapid research growth has been noted after the year 2017. The research growth, authorship analysis, keyword analysis, citation pattern, co-occurrence of keywords and thematic analysis were analysed. The USA leads in publications and citations, while the Norway achieved the highest average citations. Keyword trends highlighted "Chatbot," "Artificial intelligence" and "ChatGPT" as research domains. Thematic clusters emerged from co-occurrence analysis. Finally, this study maps the dynamic evolution of Chatbot and ChatGPT research in the first two decades of the 21st century and offers insights for researchers, practitioners and policymakers in the AI research field.

Keywords: Bibliometrics, Chabot, ChatGPT, Lotka Law, Artificial Intelligence, Cluster Analysis

Introduction

Artificial Intelligence (AI) has become more prominent in many domains of human existence, exerting a progressively substantial influence that shows no signs of abating. The technology in question finds use in several disciplines, such as machine learning, deep learning, machine cognition, neural networks and natural language processing (Jimma, 2023). AI has many advantages, yet it also gives rise to ethical and social considerations, including the potential displacement of jobs, algorithmic prejudice and concerns around privacy. The continuous area of attention for academics, governments and society involves balancing the beneficial influence of AI and the issues it presents. It is conceivable that the development of a system like human intellect may be achievable in the future.

A Chatbot, as defined by Haristiani et al. (2019), is a computer programme or AI system that engages in voice or text-based conversations. It serves as an automated conversational agent, facilitating interactive communication between users and the bot. These bots leverage AI and NLP to understand human information and context, aiming to guide users to their desired outcomes with minimal effort (Panda & Chakravarty, 2022). The Chatbot industry has seen significant growth, especially in cloud-based services, driven by recent advancements.

According to Gupta et al. (2020), ChatGPT, which stands for Chat Generative Pre-Trained Transformer, is a sophisticated Chatbot powered by AI. It was developed by OpenAI and officially released on 30th November, 2022. ChatGPT generates original content in response to both simple and complex prompts (Panda & Kaur, 2023). ChatGPT allows users to shape and guide conversations according to their preferences regarding length, format, style, level of detail and language (Lock, 2022).

Literature Review

The provided literature review discusses various studies related to AI and its applications in different fields.

Khosravi et al. (2023) conducted a study on "Chatbots and ChatGPT" and analysed the scientific literature on Chatbots and ChatGPT. The annual growth rate of literature indicates the tide of research is roughly 19–

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27% yearly application from COVID-19 and Ontology research turn to mental health and task analysis. Bawack et al. (2022) examine the uses of AI in E-Commerce through bibliometric methods. The finding indicates that China and the USA are leading countries using AI for E-commerce, and recommender systems are the most emerging technology. The study shows that optimisation, sentiment analysis and AI-related technologies are the main themes of research. Jimma Bahiru Legesse (2023) explores the uses of AI in healthcare. Scopus database was used for data download, and a drastic change has been noted after 2012 for research growth. A total of nine countries published 96.85% of publications, and the USA was the leading country with 41.84% of literature. The keyword analysis indicates that machine learning, electronic health records and natural language processing were the most frequently used keywords. The uses of AI noted for COVID-19, diabetes, mental health, asthma, dementia and cancer treatment and data management. Xu, D. (2022) analysed the uses of AI for biotechnology and applied microbiology research. The study focused on quantitative, qualitative and modeling analyses of the literature. The result demonstrates that 128 countries are associated with the research; the USA is the most productive country, and the Chinese Academy of Science is the leading research institution among 584 institutions. Ho and Wang (2020) examine the published literature on AI from Science Citation Index Expanded (SCI-EEPANED). Findings indicate that the USA leads in single authorship, international collaboration, and average citation. Chinese Academy of Science, Islamic Azad University and Massachusetts Institute of Technology (MIT) were the most productive institutions. The USA, Canada and Switzerland are the most collaborative countries in international collaboration. In cluster analysis, neural networks, learning and prediction are prolific keywords. Lucena et al. (2019) investigate AI in higher education. The finding indicates that research in AI has increased worldwide at a rapid pace. B. C. Biswas (2007) examined the research on Botany from 1994 to 2003. The results demonstrate that multiple authorship dominates on single authorship. With 59%, citation books secure first positions, followed by articles 41%. The USA is the most productive country. The average number of 38 citations per article is found. The average length of papers is 11.45 pages. Most of the articles have been published by academic institutions. The keyword analysis is categorised into 10 clusters, and the author generalised that the scientific studies associated with deep learning and machine learning.

The literature review reveals the escalating significance of AI research on a global scale, permeating diverse domains. It underscores the USA's consistent prominence in the realm of AI research, both in terms of leading countries and influential institutions. Moreover, it exposes the dynamic nature of research trends, illustrating shifts over time that mirror evolving societal priorities and the emergence of new technologies. A notable example is the transition from an emphasis on COVID-19 to mental health and task analysis within the Chatbot and ChatGPT research landscape, signifying a response to changing societal needs.

Research Objectives

- To examine the Annual Growth Rate of Publication and average citation per year.
- To relocate the most relevant source.
- To analyse the most productive authors.
- To explore the most productive countries and current research trends.

Methodology

The bibliometric method was applied to investigate research trends on Chabot and ChatGPT. The bibliometric method is used for performance analysis, scientific mapping and developing subjects and prolific authors, institutions, nations, organisations and journals. To explore the research trend, an analysis of keywords, citation patterns and thematic analysis has been performed (Shollapur, 2023). The data were extracted from the Scopus database on 18th August 2023 using the keyword "Chatbot" OR "ChatGPT" within the article title, abstract and keywords search criteria, and 6478 documents were retrieved and downloaded in CSV files, including all bibliographic information, number of citations, abstract, references, author and title keywords, funding details, etc. MS Excel R software (Biblioshiny) has been used for data analysis and visualisation. The information about the essential elements of data available on Chatbot and ChatGPT, like annual scientific Production rate, average citation, etc., is depicted in Table 1. The conference papers

(2969) dominate article (2195), which indicates that the research field is in the emergence stage at the global level. Multi-author documents dominate author publications, and citation per document was found to be significant (7.5). The primary information data shows considerable scope for future research in AI tools.

Table 1: Main Information about Dataset

Description	*Results*	*Description*	*Results*
Timespan	2002:2023	DOCUMENT TYPES	
Sources (Journals, Books, etc.)	2656	Article	2195
Documents	6478	Book	10
Annual Growth Rate %	43.89	Book chapter	167
Document Average Age	1.96	Conference paper	2969
Average citations per doc	7.5	Conference review	285
References	163425	Data paper	2
Keywords Plus (ID)	16124	Erratum	10
Author's Keywords (DE)	10719	Letter	280
Authors	17517	Review	213
Authors of single-authored docs	626	Short survey	17
Single-authored docs	704		
Co-Authors per Doc	3.67		
International co-authorships %	16.84		

Data Analysis and Discussion

Annual Scientific Production and Average Citation Per Year

Fig. 1 demonstrates the annual scientific growth of research, which was expanding slowly from 2002 to 2017, not more than 2% annually. After that, the exponential growth rate has been observed to be 32.1% annually. The last five-year growth rate for the year 2019 (613, 9.46%), 2020 (804, 12.41%), 2021 (1091, 16.84%), 2022 (1271, 19.62%) and the highest publication 1862 (32.15%) noted for the year 2023. The average citation per year for the journals is depicted in Fig. 2. The average citation per year ranges between 0.05 and 6.67, with the lowest 0.05 received for 2002 and the highest 6.67 for 2015, followed by 2017 (5.58) and 2016 (5.54). The highest 2083 citation was noted for 2023, followed by 2022 (1271) and 2022 (1091). The growth rate of publication and citation patterns indicated that massive acceptance of research is going on in the scientific community, and technological advancements have a substantial impact.

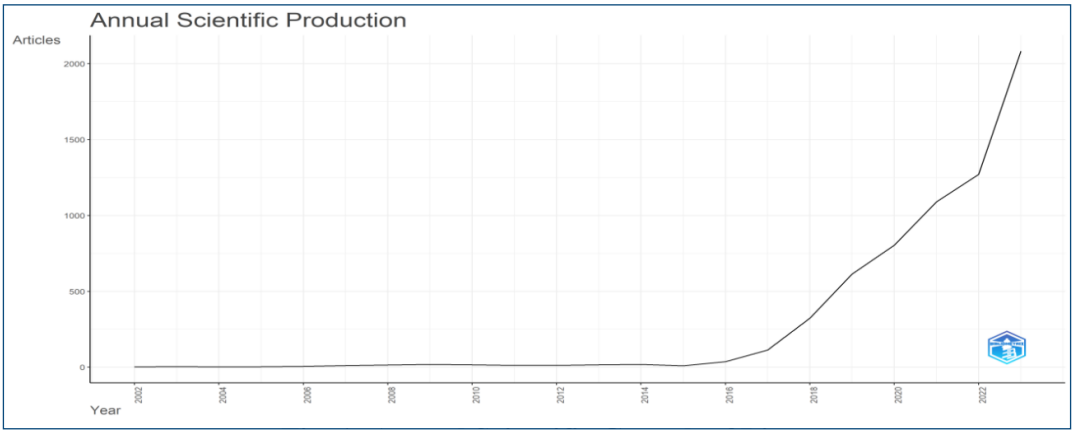

Fig. 1: Annual Scientific Growth of Literature

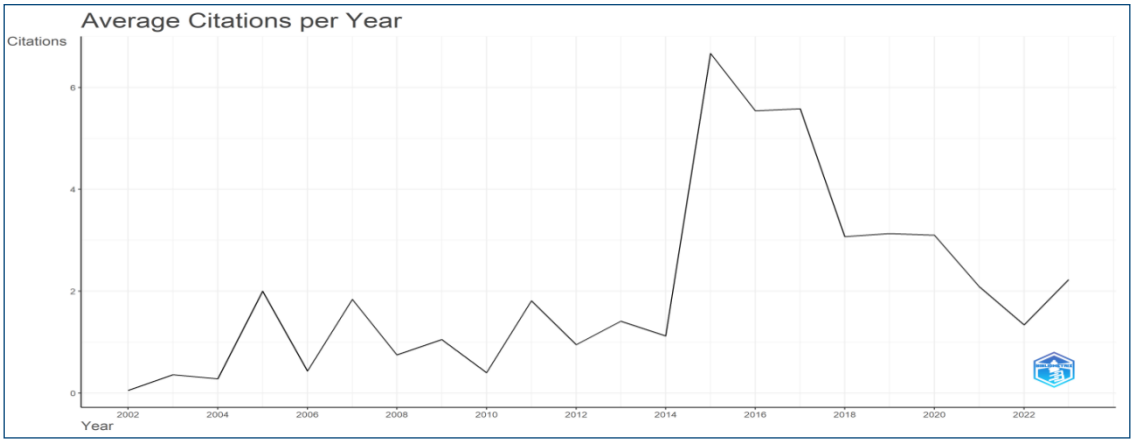

Fig. 2: Average Citations Per Year

Most Relevant Source

Table 2 demonstrates the ten most relevant sources on Chatbots where lecture notes in Computer Science are noted as the top source with the highest 356 publications and 2228 citations. ACM International Conference Proceeding Series was the second most published source with 220 publications, and the third most common source found CEUR Workshop Proceedings with 168 publications. The citation pattern indicates that the Conference on Human Factors in Computing Systems Proceedings has the second highest citation number and highest number of citations per paper, 22.4, more than any regular journals. The sources from computer science and engineering, information science and bioinformatics dominate the research in Chatbots and ChatGPT.

Table 2: Top Ten Cited Source

Sr. No.	*Sources (Journals, Conferences Etc.)*	*Articles*	*Citation*	*CPP*
1	Lecture Notes in Computer	356	2228	6.3
2	ACM International Conference Proceeding Series	210	1003	4.8
3	Ceur Workshop Proceedings	176	244	1.4
4	Lecture Notes in Networks and Systems	119	85	0.7
5	Communications In Computer and Information Science	112	320	2.9
6	Conference On Human Factors in Computing Systems – Proceedings	93	2080	22.4
7	Advances In Intelligent Systems and Computing	88	451	5.1
8	Journal Of Medical Internet Research	86	1674	19.5
9	Annals Of Biomedical Engineering	68	183	2.7
10	Lecture Notes in Electrical Engineering	49	67	1.4

The core journals of any research domain can be identified using Bradford's law given by Samuel C. Bradford in 1934. The analysis divides all journals into three groups; each represents about one-third of all articles. The research (R software) has been depicted in Fig. 3; a total of 2656 journals are identified in this study. First is a core zone, which has 47 (1.769%) journals with 2138 (33%) articles, the second zone is 650 (24.47%) journals with 2203 (34%) articles and the third zone is 1959 (73.75%) journals with 2137 (33%) articles.

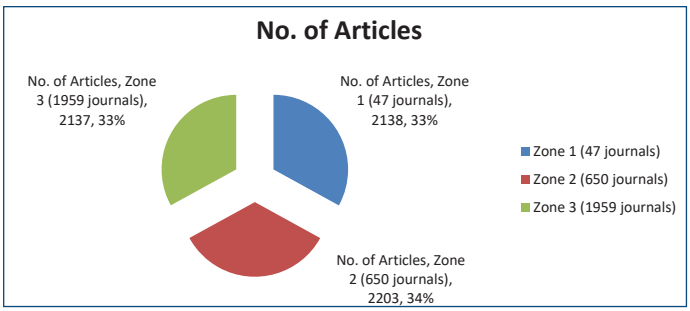

Fig. 3: Core Research Journals Analysis through Bradford Law

Authorship Pattern

Table 3 lists the top 10 most productive author, with Zhang Y securing the first position with 28 articles, followed by LEE J, Li Y and Liu Y with 27 articles each, Denecke K with 26 articles, Kim J with 25 articles, Zhang J 23 articles, Følstad A, Li J, Singh S, 22 articles each. Citation result indicates that Giovannoni G, Hawkes C, Lechner-Scott J, Levy M and Yeh A obtained the highest number of 82 citations each. The authorship analysis suggests that Chinese authors dominate the top ten lists as the most relevant authors except for one author, Singh S from India. The author with the highest citation indicates that the citation pattern differs from the top 10 most appropriate authors. There is a mix of countries regarding the highest citations, and no dominance has been noticed of Chinese authors.

Table 3: Top Ten Highest Productive Authors

Sr. No.	*Most Relevant Authors*	
	Authors	*Articles*
1	Zhang Y	28
2	Lee J	27
3	Li Y	27
4	Liu Y	27
5	Denecke K	26
6	Kim J	25
7	Zhang J	23
8	Følstad A	22
9	Li J	22
10	Singh S	22

Lotka's Law of Scientific Productivity was given by A. J. Lotka in 1926. It describes the frequency of author publication in a field, which generalises how many articles an author publishes on a particular subject during a specific time frame. It is denoted by Xn Y= Constant, where Y is the frequency of authors making n contributions each (Bensman, S. J., & Smolinsky, L. J. 2017). The analysis is depicted in Fig. 4, where one article was written by 14511 authors, two articles by 1822 authors, three articles by 564 authors, four articles by 247 authors, five articles by 128 authors, six articles by 66 authors, seven articles by 53 authors, eight articles by 33 author, nine articles by 16 authors, 10 articles by 12 authors and 173 articles by more than 13 authors. It indicates that individual research dominates multi-author research patterns.

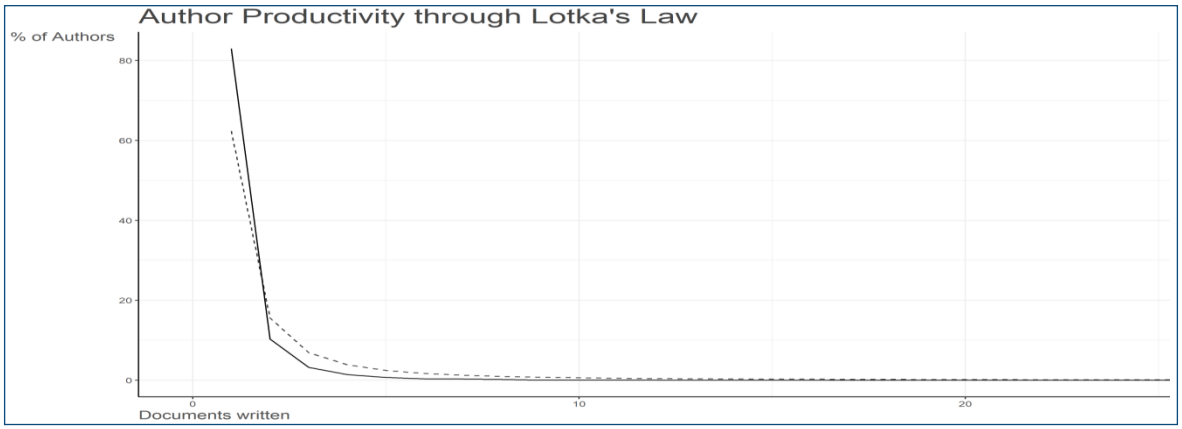

Fig. 4: Lotka's Law of Scientific Productivity

Most Relevant Affiliations

A total of 3554 institutions, universities and organisations were identified for publishing literature on the Chatbot and ChatGPT. Fig. 5 demonstrates the top 10 affiliations based on their publications. The University of California holds the top position with 99 publications, followed by Bina Nusantara University with 51 publications; the National University of Singapore with 48 publications; the University of Hong Kong with 48 publications; Stanford University and the University of Toronto with 47 publications each, National Tsing Hua University, Ulster University and the University of Auckland with 43 publications each. The analysis indicates that universities dominate research institutions regarding publications, showing the academic use of AI.

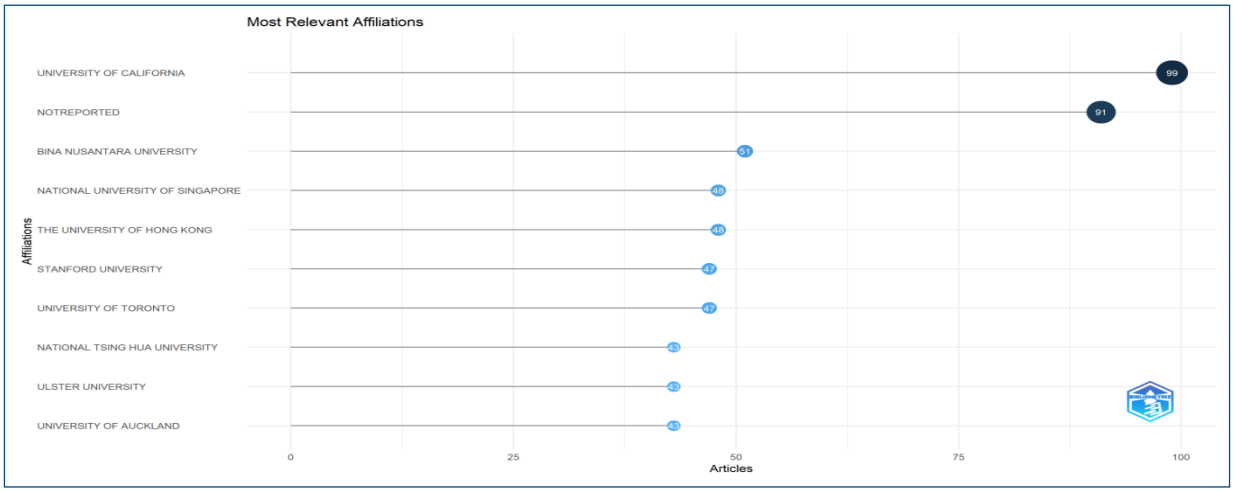

Fig. 5: Top 10 Most Contributing Organizations

Citation and Publication Pattern of Countries

Fig. 6 shows the country-wise citation and publication pattern. Analysis indicates the research contribution of 91 countries. USA is leading with 470 Single Country Publications (SCP) and 74 Multiple Country Publications (MCP), followed by India 366 (SCP) and 36 (MCP), China 288 (SCP) and 98 (MCP), UK 137 (SCP) and 55 (MCP), Germany 141 (SCP) and 26 (MCP), Italy 133 (SCP) and 31 (MCP), Korea 125 (SCP) and 23 (MCP), Australia 69 (SCP) and 32 (MCP) and Spain 75 (SCP) and 23 (MCP).

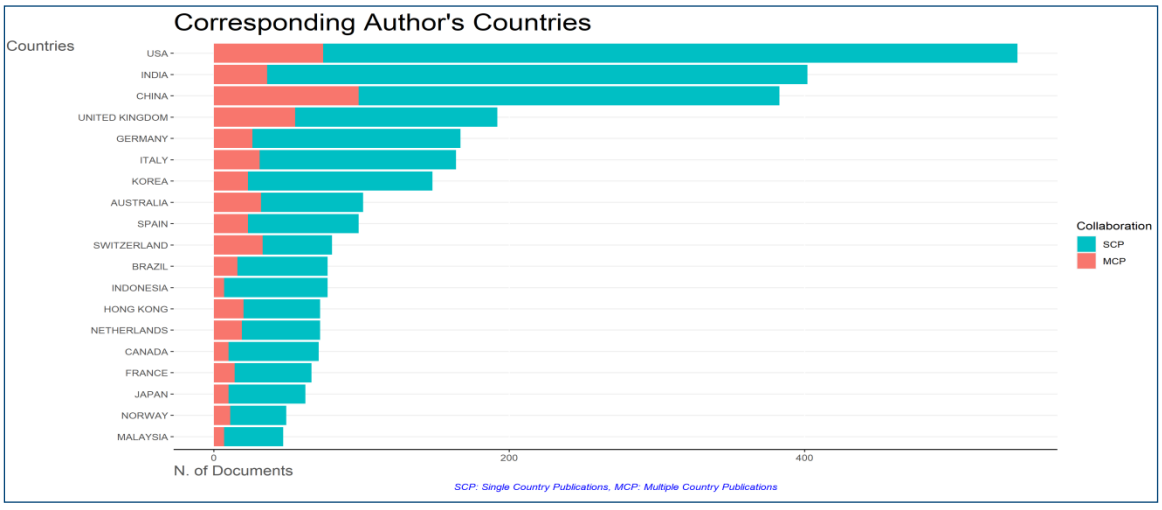

Fig. 6: Top 15 Most Productive Countries

Table 4 indicates the citation pattern of the top 10 countries. USA received the highest citation 5145 with 9.50 Citation Per Paper (CPP), followed by China 2654 with 6.90 (CPP), United Kingdom 2555 with 13.30 (CPP), Korea 1555 with 10.5 (CPP), Germany 1425 with 8.50 (CPP), India 1308 with 3.30 (CPP), Australia 1290 with 12.80 (CPP), Italy 1137 with 6.90 (CPP), Norway 924 with 18.90 (CPP) and Spain 792 with 8.10 (CPP). The country citation pattern indicates that the USA dominates on the total number of papers and citations, where the highest citation Per Paper noted for Norway is 16.07, which suggests the research quality.

Table 4: Top 10 Most Cited and Publishing Country

Sr. No.	*Country*	*Total Publication*	*Total Citation*	*CPP*
1	USA	1314	15330	11.6
2	India	934	4642	4.95
3	United Kingdom	477	5312	11.01
4	China	474	4216	8.8
5	Germany	382	2761	7.2
6	Italy	308	2594	8.8
7	South Korea	235	2592	11
8	Australia	216	2592	11.09
9	Taiwan	199	1507	7.6
10	Norway	82	1355	16.07

Trend Topic and Keyword Analysis

The trend topics have been analysed to locate the 20 most emerging issues between the years 2012 and 2023. Fig. 7 indicates that for the year 2023, the keywords ChatGPT occurred (483) times, followed by AI (153) and education (99). Furthermore, in the year 2022, AI (986), machine learning (357) and COVID-19 (151). In the year 2021, the terms Chatbot (2260), Chatbots (605) and natural language processing (502) are the most frequently used terms. Year 2020, noted as question answering (37), dialog system (36) and human-computer interaction (34). In the year 2019, intelligent agents (13), conversation (13) and agent (11). For the year 2018, aim (53), pattern matching (12) and question answering (7). The results of the keyword indicate that human, humans and software most relevant and highest time occurred in 2023, followed by Chatbots, AI and natural language processing in 2022, natural language processing systems, conversational agents and students in 2021, human-computer interaction, user interfaces, semantics in 2020, Chabot, human engineering, intelligent agent in 2019, ubiquitous computing, AI markup language, Turing test in 2018, aim in 2017 and latent semantic analysis in 2016, java programming language, human-computer dialogues, e-learning environment in 2014 and virtual worlds, non-player character in 2010 and mathematical models in 2005. This shows that Chatbot and Chatbot have various research subdomains identified from the beginning of research years, especially the first decade of the 21st century. The second decade is heavily involved in research of semantics, Markup languages, high-performance programming, and task-based systems, later converted into AI and further as AI assistance systems.

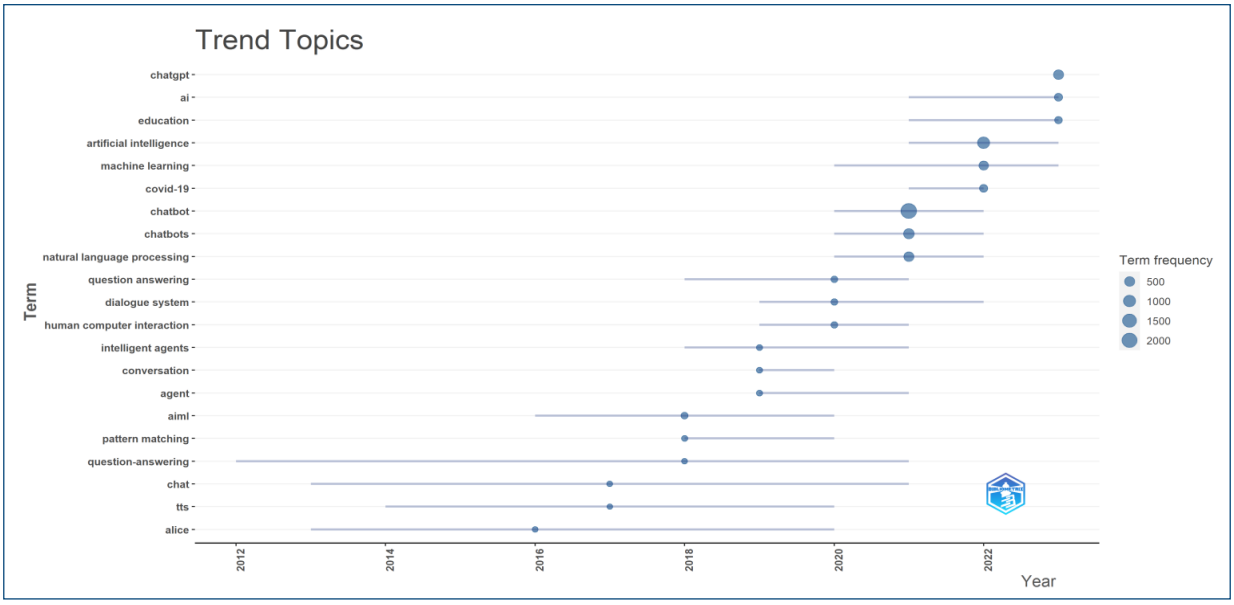

Fig. 7: Top 20 Year Wise Keywords with Highest Trends

Co-Occurrence of Keywords and Thematic Analysis

Fig. 8 maps the occurrence of keywords and the three clusters identified. Cluster 1 main theme was AI, with sub-themes machine learning, mental health, health care, Chatbot, social media, COVID-19, decision making, etc. The cluster 2 main themes found Humans, including sub-theme humans, article, adults, software, language, communication, interpersonal communication, letter, control study, etc. The main themes Chatbots noted for cluster 3, with sub-themes Chatbot, natural language, conversational agents, deep learning, learning system, human-computer interaction, user interface, language processing, learning algorithms, e-learning, semantics, computational linguistics, knowledge base system, machine learning, behavioural research, social networking (online), speech processing, virtual assistance, dialogue system, sentiment analysis, information use, language model and user experience. The thematic research of co-occurrence keywords indicates that the main themes are not scattered in different areas and cover the utilisation of AI with sophisticated systems for enhancing excellence to support human centric activity.

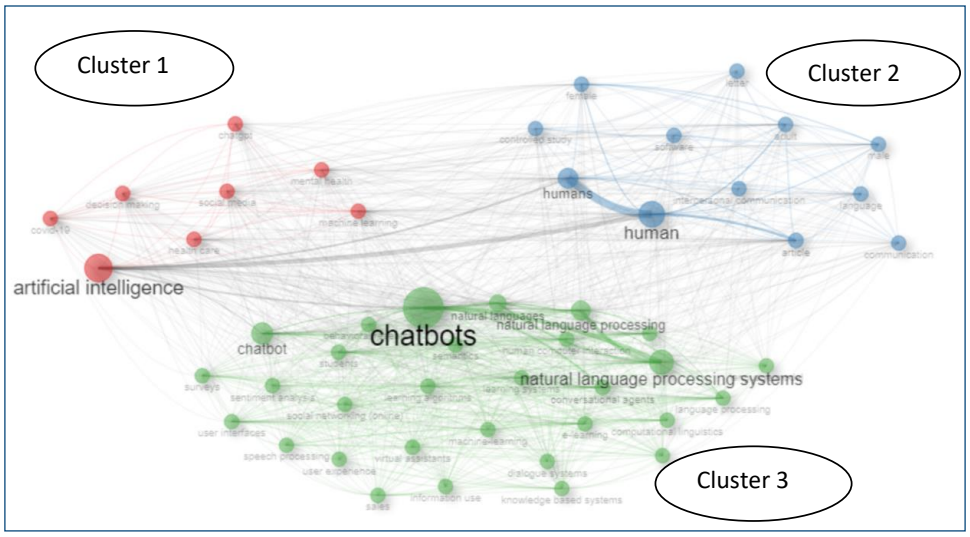

Fig. 8: Co-Occurrence of Keywords

Fig. 9 indicates the emerging theme for the present study. Two themes have been analysed: the primary and niche themes of Chatbot and ChatGPT. The basic theme represented by Chatbots is found as the central theme with (1809) documents, followed by chatbot (891), natural language processing system (740), natural language processing (462), conversational agent (452), natural language (411), students (326), learning system (311), deep learning (301) and human-computer interaction (271) documents. In niche themes, AI with 1022 documents found most relevant, followed by human (768), human (525), article (307), adult (200), female (188), health care (179), mental health (176), male (167) and ChatGPT (143). The thematic analysis indicates that AI is mainly used to support human intelligence, not as independent research.

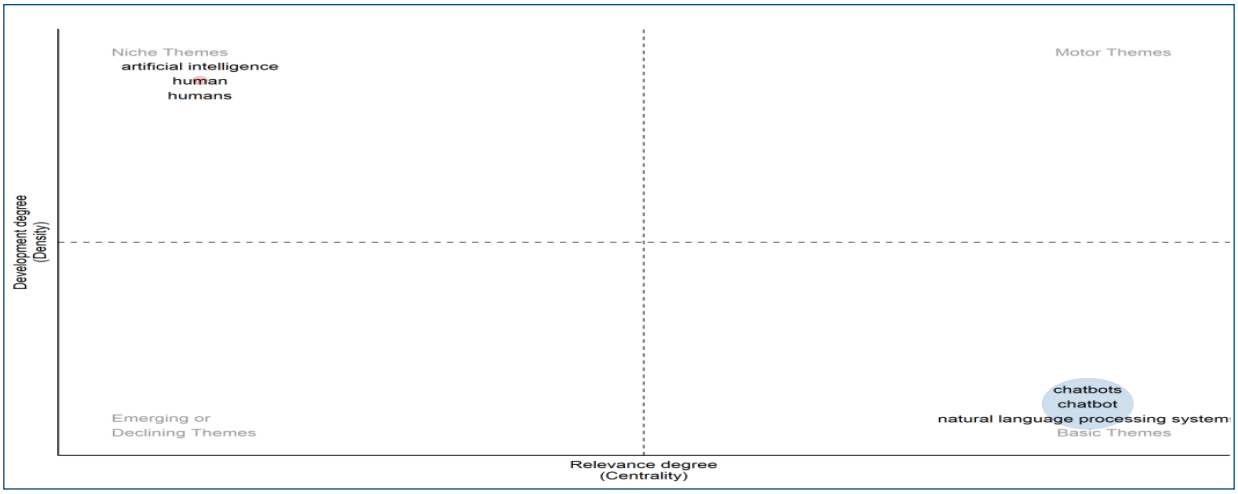

Fig. 9: Keywords Thematic Map

Result and Conclusion

The study, encompassing an analysis of 6252 articles on Chatbot and ChatGPT from 2002 to 2023 retrieved from the Scopus database, reveals several noteworthy trends. The annual growth rate of ChatGPT literature stood at 43.12%, exhibiting a prolonged period of growth between 2002 and 2017, followed by a significant exponential surge post-2017. Particularly striking is the substantial increase in publication rates from 2019 to 2023, signifying a heightened interest and research activity within this field. While the average yearly citation rate displayed variations, the year 2023 garnered the highest number of citations, with 1862 citations, closely trailed by 2022 and 2021. In terms of sources, lecture notes in Computer Science (including Subseries Lecture Notes in AI and Bioinformatics) emerged as the most relevant source, with 356 articles. Notably, Weizenbaum J claimed the spotlight as the most pertinent author with 621 citations. On a local impact scale, the Conference on Human Factors in Computing Systems – Proceedings held the top rank with a 25 H-index. Author Zhang Y proved to be the most prolific, boasting 28 publications, followed closely by Lee J and Li Y, each with 27 publications. Regarding impact, author Folstad A claimed the foremost position with an 11 h-index, trailed by Kim S, Kowatsch T and Lombardi, each with a 10 h-index. Notably, the University of California and Bina Nusantara University secured the leading positions as the top two contributing institutions. On a country level, the USA maintained its top position with 544 publications, closely followed by India with 402 publications. However, a shift occurred concerning citations received, with the USA leading in citation reception with 5145 citations, averaging 9.50 citations per article, followed by China with 2654 citations and an average of 6.90 citations per article. While India held the second position in terms of publications, its ranking dropped to third in citation impact, highlighting the importance of literature quality in attracting research attention. Remarkably, Norway achieved the highest average citations per article, with 28.90, followed by Norway once more with 18.90 citations per article. Lastly, the study's author keyword analysis spotlighted Chatbot occurring 2303 times, followed by AI (104 times),

Chatbots (616 times), ChatGPT (563 times) and natural language processing (511 times). In the contemporary landscape, ChatGPT, AI and education emerged as the most trending topics in 2023, while AI machine learning and COVID-19 took center stage in 2022. The author keyword analysis unveiled humans and software as the most trending topics in 2023, whereas chatbots, AI and natural language processing dominated the discourse in 2022. Co-occurrence analysis identified three primary clusters: Artificial intelligence, encompassing machine learning, mental health, and ChatGPT-related documents; Chatbots, covering Chatbots, natural language or deep learning documents; and Humans, delving into software and language-related subjects. In summation, this study effectively fulfilled its objectives and provides valuable insights into the global research trends in Chatbots and ChatGPT, serving as a valuable resource for the research community and policymakers.

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