

Development Characteristics and Topic Analysis of International Research on ChatGPT

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ABSTRACT

This study aims to uncover the primary development characteristics and thematic distribution of international research on ChatGPT, thereby facilitating a better understanding of global research trends and application potential in this field. First, using bibliometric methods, this paper examines the distribution characteristics of ChatGPT research across countries, journals, institutions, and authors. Following this, the BERTopic model is applied to identify key research topics, and a strategic coordinate diagram is constructed to analyze the developmental status of each topic. The study reveals that global ChatGPT research is primarily concentrated in North America, Europe, and the Asia-Pacific region, with the United States and China being particularly prominent in this area. The research outputs span multiple disciplines, including medicine, engineering, education, and information technology, highlighting the broad cross-disciplinary application potential of ChatGPT. Key research institutions, such as the University of California system, Harvard University, and Stanford University, play significant roles in exploring ChatGPT technology. A relatively low density in the author collaboration network suggests that a unified core team has not yet formed in this area. Through BERTopic analysis, 24 major research topics were identified, covering areas such as medical education and natural language processing. These topics highlight ChatGPT's extensive potential and research value across diverse application scenarios.

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1. INTRODUCTION

On November 30, 2022, OpenAI launched the ChatGPT chatbot, an AI-powered conversational model that attained 100 million monthly active users within just two months, capturing global attention [1]. By leveraging large-scale pretraining on extensive text data, ChatGPT learns linguistic patterns and semantics in natural language, demonstrating remarkable performance in information extraction, article composition, code generation, automatic summarization, and translation. Its advent represents a significant breakthrough in the field of natural language processing (NLP) [2-3]. Beyond its applications in healthcare, education, and legal consulting [4], ChatGPT has also shown exceptional utility in fields such as journalism and program debugging [5].

ChatGPT has caused a sensation worldwide, with discussions evolving from technical popularization and conceptual interpretation to academic ethics, disciplinary impacts, and potential applications, reflecting a trend toward thematic diversification. Scholars have explored various aspects of ChatGPT's applications and research hotspots from multiple perspectives. For example, Wang and Li [6] employed bibliometric methods, utilizing high-frequency keyword statistics and cluster analysis to conduct a quantitative analysis of both domestic and international literature on ChatGPT. They also performed a qualitative analysis of its multidimensional application pathways based on an innovation diffusion framework. Similarly, using bibliometric and content analysis methods with VOSviewer as a visualization tool, Wang and Pan [7] constructed a scientific knowledge map of ChatGPT research in China to analyze its research characteristics, hot topics, and evolutionary pathways. In addition, Naing and Udomwong [8] analyzed public perceptions of ChatGPT employing sentiment analysis, topic modeling, and SWOT method based on discussion data from Reddit. While existing research provides valuable insights into the current state of ChatGPT studies, there is still significant room for improvement in terms of data comprehensiveness and the depth of textual content analysis. Furthermore, there is a lack of clear results that reveal the layout and development trends of international ChatGPT research.

Based on the above analysis, this study employs bibliometric methods to explore the external development characteristics of international research on ChatGPT. Simultaneously, the BERTopic model is utilized to conduct an in-depth analysis of the research topics associated with ChatGPT, constructing a strategic coordinate diagram based on topic impact and value to quantify the development status of each topic. This study aims to foster a more objective and scientific understanding among scholars regarding the focal points of international research. Consequently, it seeks to positively influence the formulation of strategies related to large language models like ChatGPT in China's industry, assist the government in establishing relevant policies, and encourage rational discussions on related topics within society.

2. RESEARCH METHOD

2.1 Analysis Method for Development Characteristics

The development characteristics of international ChatGPT research are primarily analyzed using bibliometric methods, following a macro-to-micro approach to sequentially reveal country distribution

characteristics, publication distribution characteristics, institution distribution characteristics, and author distribution characteristics. The analysis of publication distribution relies on statistical analysis and visualization of the Echarts library in Python, focusing on showcasing the publications involved in ChatGPT-related research globally. The analysis of author distribution utilizes the Networkx library in Python and VOSviewer software to calculate key indicators and visualize the collaboration intensity among institutions and authors in international ChatGPT research.

2.2 Topic Content Mining Method

Topic model allows a document to be represented as a distribution of topics, with each topic itself represented as a distribution of words. This method helps researchers understand the hidden structures within a text corpus and classify texts into different topics. The Latent Dirichlet Allocation (LDA) model, proposed by Blei et al. [9] in 2003, along with its derived models such as Structural Topic Models (STM) and Dynamic Topic Models (DTM), has been widely applied in various fields, including news text analysis, social media analysis, and academic literature analysis. However, LDA and its derived topic models have notable limitations: first, they often overlook the influence of word order on text meaning, preventing the model from capturing the contextual relationships between words. Second, the number of topics typically needs to be set manually, and accurately estimating this number can be quite challenging.

In 2020, to overcome some limitations of traditional topic models, Maarten introduced the BERTopic model [10]. This model leverages the powerful representation learning capabilities of the BERT language model to achieve efficient and high-quality topic extraction from large-scale text data. The workflow is illustrated in Figure 1:

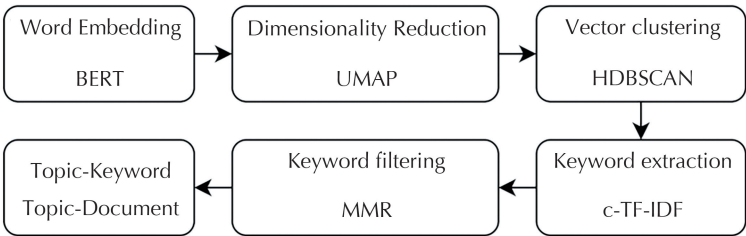


Figure 1. Workflow of the BERTopic model.

First, the BERT model is used to generate word embeddings, converting the text into high-dimensional vectors. Next, the UMAP algorithm [11] is employed to reduce the dimensionality of these vectors, thereby decreasing computational complexity, while the HDBSCAN algorithm [12] is applied to cluster the reduced vectors and identify topics. Following this, a class-based TF-IDF algorithm is utilized to calculate the importance of keywords within each topic, and the MMR algorithm [13] extracts the most relevant keywords based on their importance. Finally, a topic-keyword matrix and a topic-document matrix are generated.

Compared to traditional topic models, BERTopic offers several advantages: (1) Strong semantic understanding. It leverages the BERT model to capture word order and contextual information, thereby enhancing the accuracy of identification results. (2) No need for a predefined number of topics. The HDBSCAN clustering algorithm automatically determines the number of topics, making the model more user-friendly. (3) High interpretability. It provides representative words and visualization techniques that simplify complex topic model results, improving the interpretability of the findings. Given these multiple advantages of the BERTopic model, this study will employ it for topic extraction in international research on ChatGPT.

2.3 Distribution of Topic Strategic Coordinates

2.3.1 Frontier Degree of Topics

Outliers are often seen as innovations that disrupt established rules, mainstream trends and patterns [14]. The higher the outlier score of a document, the more likely it is to provoke a shift in research paradigms, thereby indicating the higher the forefront level of the corresponding topic [15]. This study employs the Local Outlier Factor (LOF) algorithm proposed by Breunig et al. [16], which calculates the outlier score for each document based on its local anomaly factor. Building on this, this study creates a frontier degree metric to evaluate the developmental forefront of topics. The calculation method is illustrated in Equation (1). Where FD_k (Frontier Degree) represents the frontier degree of topic k , $LOF(d)$ represents the local outlier factor of document d , and N is the number of documents belonging to topic k .

$$FD_k = \frac{\sum_{d=1}^N -LOF(d)}{N} \quad (1)$$

2.3.2 Impact Degree of Topics

The impact degree of a topic is quantified by its average number of citations per document, reflecting the level of attention it receives. A higher value indicates greater interest and engagement in the topic. The calculation method is presented in Equation (2). where ID_k (Impact Degree) represents the impact degree of topic k , $C(d)$ denotes the citation count of document d , and N is the number of documents belonging to topic k .

$$ID_k = \frac{\sum_{d=1}^N C(d)}{N} \quad (2)$$

By constructing a strategic coordinate diagram as shown in Figure 2, with the frontier degree of topics on the x-axis and the impact degree on the y-axis, a fine-grained analysis of the topic distribution in international ChatGPT research can be conducted. In this strategic coordinate diagram, topics positioned closer to the upper right corner signify higher impact and frontier degrees, indicating promising future development prospects.

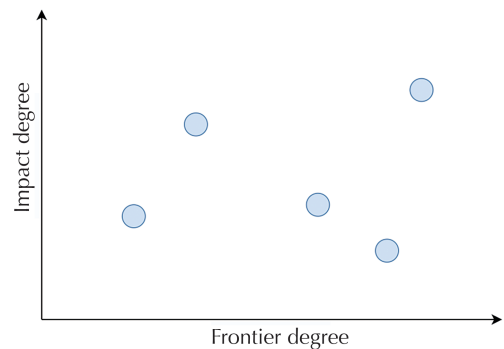


Figure 2. Strategic coordinate distribution of topics.

3. DATA COLLECTION AND FILTERING

To ensure data completeness and quality, this study selects the *Web of Science Core Collection (WoS)*, *IEEE Xplore*, *ACM Digital Library*, and *ACL Anthology* as data sources. These databases cover high-impact journals and conference papers, encompassing the latest research in natural language processing, generative models, and artificial intelligence. Specifically, *WoS* provides authoritative journal literature along with some conference papers. *IEEE Xplore* focuses on engineering technologies and cutting-edge algorithms. *ACM Digital Library* includes research in computer science and interdisciplinary fields. *ACL Anthology* specializes in core conferences and the latest advancements in natural language processing. These complementary data sources collectively offer a rich and precise foundation for analyzing the global research landscape of ChatGPT.

ChatGPT is a landmark model among Large Language Models (LLMs). By analyzing ChatGPT, we can better capture current international research trends and development characteristics in this field. During the retrieval process, this study opted not to use “LLM” as a keyword, as it encompasses various generative language models beyond ChatGPT, potentially introducing irrelevant results and diluting the study’s focus. Instead, this study restricted its search to the keywords “ChatGPT,” “GPT-4,” and “GPT-3.5” to ensure that the collected literature directly pertains to ChatGPT and its related advancements. The search strategies and results for each database are presented in Table 1, with the retrieval date set to December 28, 2024.

Table 1. Retrieval Strategies and Results.

Database	Search strategy	Search results
WoS	Topic + Keywords	9382
IEEE Xplore	Abstract + Keywords	1970
ACM Digital Library	Abstract + Keywords	1964
ACL Anthology	Abstract + Keywords	1640

After merging and deduplication of the above results, a total of 13,955 documents were retained for subsequent analysis. Based on these documents, this study will delve into the development characteristics and research topics in the field of international ChatGPT research.

4. DEVELOPMENT CHARACTERISTICS OF INTERNATIONAL CHATGPT RESEARCH

4.1 Country Distribution Characteristics

This section analyzes the publication distribution of countries based on the “Addresses” field of the papers. If a paper is co-authored by authors from multiple countries, each involved country is counted once in the publication statistics. As shown in Table 2, countries with more than 200 publications in this field were presented.

Table 2. Distribution of countries in ChatGPT-related research.

Country	Number of Publications
United States	3514
China	1727
Germany	711
India	637
United Kingdom	591
Canada	486
Australia	449
Italy	398
Turkiye	349
Japan	339
Spain	315
South Korea	307
Saudi Arabia	266
Singapore	254

The United States leads globally with 3,514 published papers, demonstrating its strong research advantage in artificial intelligence and natural language processing. China follows with 1,727 papers. Driven by both national policy support and market demand, Chinese research institutions and enterprises have made significant advancements in natural language processing, further cementing its increasing

influence in the global academic landscape. Germany ranks third with 711 papers. Although its publication volume is lower than that of the United States and China, it still highlights the country’s considerable research strength in artificial intelligence.

Other countries with publication counts exceeding 200 include India (637), the United Kingdom (591), Canada (486), Australia (449), Italy (398), Turkiye (349), Japan (339), Spain (315), South Korea (307), Saudi Arabia (266) and Singapore (254). Overall, research related to ChatGPT is primarily concentrated in North America, Europe, and the Asia-Pacific region, showcasing these areas’ sustained interest and investment in artificial intelligence research.

4.2 Publication Distribution Characteristics

Figure 3 illustrates the top twenty publications featuring research on ChatGPT. These journals span various disciplines, including medicine, engineering, education, and information technology, reflecting the interdisciplinary nature of ChatGPT research and its broad impact across multiple fields.

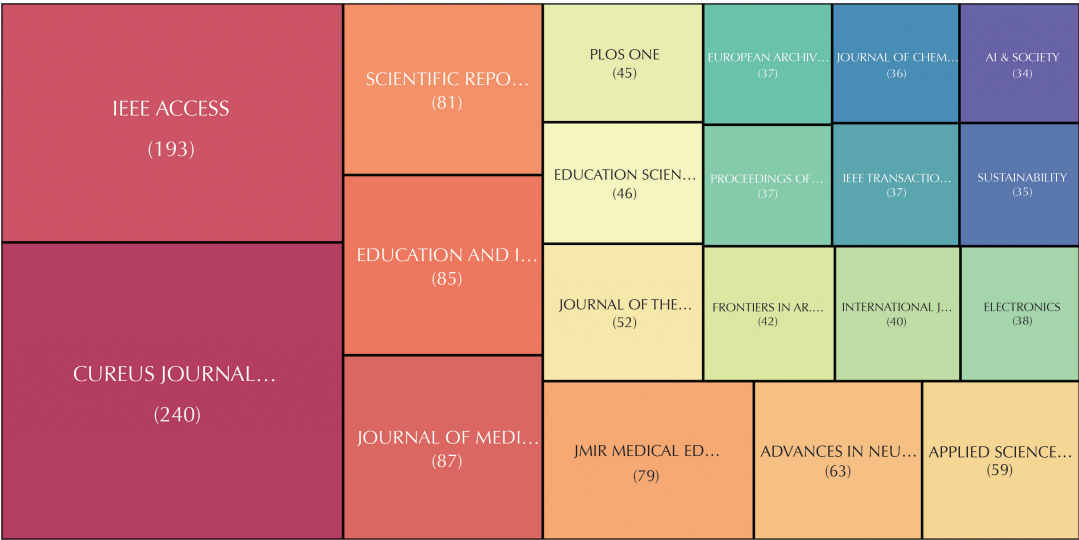


Figure 3. Publication distribution of publications related to ChatGPT.

The journal with the highest number of publications is *Cureus Journal of Medical Science*, with a total of 240 articles. This journal primarily focuses on medical sciences, particularly the clinical applications and research of emerging medical technologies. Closely following is *IEEE Access*, which has published 193 articles. Known for its interdisciplinary nature, this journal covers a broad range of research areas, including artificial intelligence, communications, and computer science.

Ranking third is the *Journal of Medical Internet Research*, with 87 articles. It specializes in digital innovations in medical education and internet-based healthcare, covering topics such as telemedicine and electronic health records. *Education and Information Technologies* and *Scientific Reports* rank fourth and fifth, with 85 and 81 articles, respectively. The former mainly explores educational technology and its applications in the education sector, while the latter is a multidisciplinary journal publishing original research across various natural science fields.

JMIR Medical Education ranks sixth, with 79 articles, focusing on digital innovations in medical education and the practice of remote learning. *Advances in Neural Information Processing Systems 36 (NeurIPS 2023)* ranks seventh, with 63 articles. As one of the top conferences in artificial intelligence, it highlights the latest advancements in neural information processing systems.

In eighth place is *Applied Sciences-Basel*, with 59 articles, covering a wide range of applied sciences, including materials science, engineering, and environmental sciences. *Journal of the American Medical Informatics Association* follows in ninth place with 52 articles, specializing in medical informatics and the application of information technology in healthcare. Finally, *Education Sciences* ranks tenth, with 46 articles, focusing on research in educational sciences, including education policies, teaching methods, and the role of technology in education.

The top ten publications collectively published 985 articles, accounting for approximately 7% of the total publication volume. This distribution pattern reflects the broad and dispersed character of ChatGPT-related research outputs in academic publishing. While some individual journals dominate in publication numbers, the overall diversity indicates that this research field has not concentrated within just a few journals. Instead, it spreads across many different publications. This suggests that ChatGPT-related research has significant interdisciplinary application potential, and researchers from various fields become increasingly interested in this technology.

4.3 Institutional Distribution Characteristics

Table 3 presents the publication performance of various institutions in the field of ChatGPT-related research. While differences exist in publication volume, the disparities are not substantial, with most institutions publishing between 100 and 270 articles. Each institution emphasizes different research directions, with representative articles based on citation counts as follows: The University of California system primarily investigates the differences in responses between physicians and artificial intelligence in online health forums [17]; Harvard University focuses on the application of ChatGPT in assessing cancer myths and misconceptions [18]; Stanford University explores the potential and challenges of large language models in the medical field [19]; the State University System of Florida studies the interdisciplinary applications of ChatGPT in education and its impact on academic writing [20]; and the University of Texas System examines the effectiveness of ChatGPT-generated recommendations in optimizing clinical decision support system logic, evaluating their non-inferiority compared to human-generated recommendations [21].

Table 3. Top 10 Institutions publishing in ChatGPT-Related research.

Institution Name	Publication Volume
University of California System	267
Harvard University	164
Stanford University	142
State University System of Florida	140
University of Texas System	123
University of London	121
University System of Ohio	119
Pennsylvania Commonwealth System of Higher Education (PCSHE)	116
National University of Singapore	110
Harvard Medical School	104

Other institutions, such as the University of London, the University System of Ohio, the Pennsylvania State System of Higher Education, the National University of Singapore, and Harvard Medical School, have also conducted in-depth research on various aspects of ChatGPT, including its technical applications [22], ethics considerations [23-24], and medicine uses [18, 25]. This demonstrates the application potential of ChatGPT technology across multiple disciplines and highlights the academic community's significant attention to its impacts.

4.4 Author Distribution Characteristics

In the process of constructing the author collaboration network using VOSviewer (Figure 4), it was found that there are a total of 46,619 authors in the field of ChatGPT research abroad, forming 225,751 collaboration relationships. The network density is relatively low (0.00021), indicating that most authors do not collaborate frequently. The largest connected component includes 547 authors, suggesting that the majority of authors are not directly involved in this component.

From Figure 4, it can be seen that multiple small, dispersed, and disconnected communities have formed within the author collaboration network, indicating that a unified core group of authors has yet to emerge in the research on ChatGPT abroad. Instead, research is being conducted by multiple independent research teams or individuals.

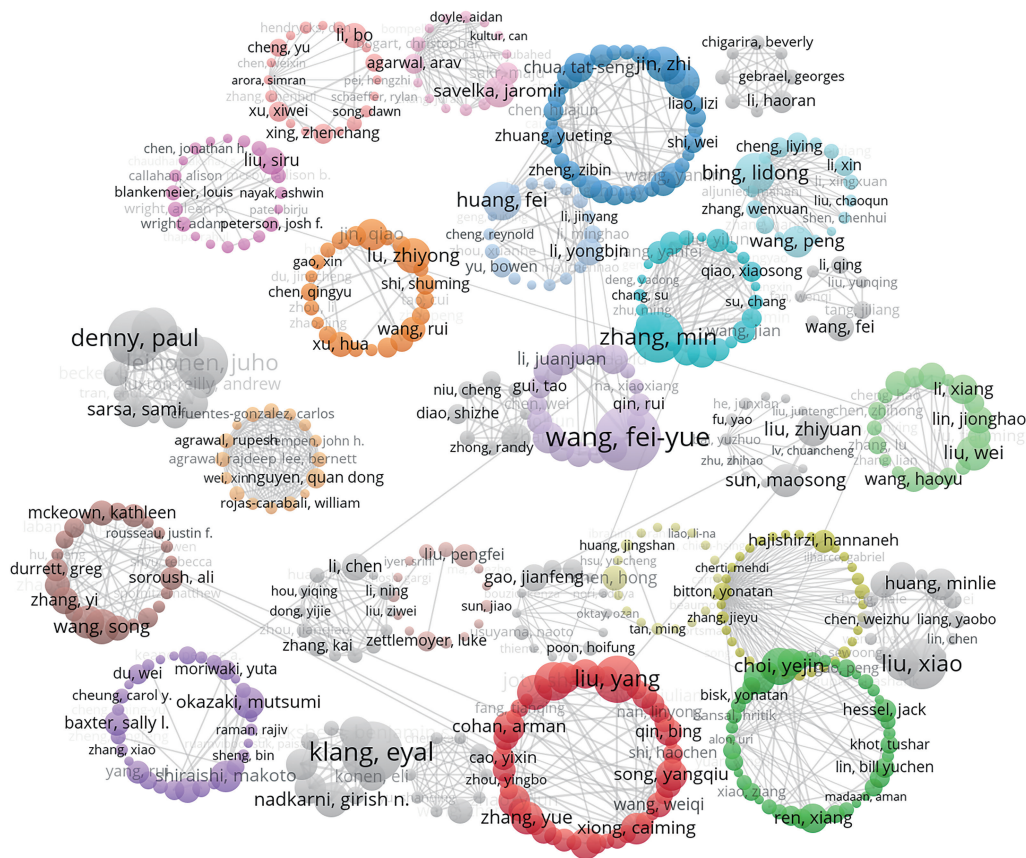


Figure 4. Author collaboration in ChatGPT-Related research.

The most cited article is published in the International Journal of Information Management, with the first author being Yogesh K. Dwivedi from the Swansea University School of Management. This scholar has published a total of ten articles related to ChatGPT, primarily focusing on the practical applications of generative AI in various fields, the challenges faced, and the opportunities arising from international collaboration. For example, an article published in January 2024 (with 118 citations) focuses on the application of generative AI in the hotel and tourism industry, analyzing practical experiences, challenges, and future research directions [26].

5. ANALYSIS OF CHATGPT RESEARCH TOPICS ABROAD

5.1 Construction of the BertTopic Model

5.1.1 Basic Parameter Settings

The titles and abstracts of each paper were combined to create a corpus for topic modeling. The Natural Language Toolkit (NLTK) was employed to preprocess the corpus, which included tokenization, removal of stop words, and lemmatization. The detailed parameter settings for utilizing BERTopic for topic modeling are as follows:

- ◆ **Embedding:** The “all-MiniLM-L6-v2” English text embedding model from the SentenceTransformer library was used to vectorize the documents.
- ◆ **UMAP Initialization:** To embed the data into a reduced-dimensional space, the number of dimensions, *n_components*, was set to 5, based on relevant literature. Cosine similarity was employed to measure the distance between data points. Additionally, the minimum distance, *min_dist*, was adjusted from its default value of 0.1 to 0, allowing for tighter embeddings, while all other parameters were left at their default settings.
- ◆ **HDBSCAN Initialization:** The minimum cluster size, *min_cluster_size*, was set to 10, indicating that a topic must contain at least 10 papers, based on the volume of research literature considered in this study.
- ◆ **Topic Identification:** The number of topics, *nr_topics*, was set to “auto” to allow BERTopic to automatically determine the number of topics. Furthermore, the *n_gram_range* was set to 2 to 3 to enable the appearance of keywords in phrase form, facilitating the interpretation of the topics.

5.1.2 Selection of the Number of Topics

By training the BERTopic model, a total of 129 research topics related to ChatGPT were automatically identified, with an additional 5,850 papers classified as noise and marked as -1. The initial topic extraction results are illustrated in Figure 5. From the spatial distance distribution of the topics (a panel of Figure 5), it is evident that there is significant overlap and integration among the topics, with a somewhat chaotic inclusion-exclusion relationship. Moreover, the high similarity between the topics (b panel of Figure 5) indicates that the initial topic identification results are not ideal and require further adjustments.

Taking into account the excessive number of documents classified as noise and the relatively small number of documents used for topic modeling, this study follows a systematic approach of “reducing noise → updating topics → refining topics” to adjust the topics. After automatic adjustment by BERTopic, the number of topics was reduced to 24, as shown in Figure 6. The spatial distance distribution (a panel of Figure 6) indicates a sparse distribution of topics with minimal overlap, and the similarity between topics (b panel of Figure 6) is relatively low. This suggests that the differences between the topics are clear after refinement, resulting in an effective topic extraction. Therefore, the final number of topics is set to 24.

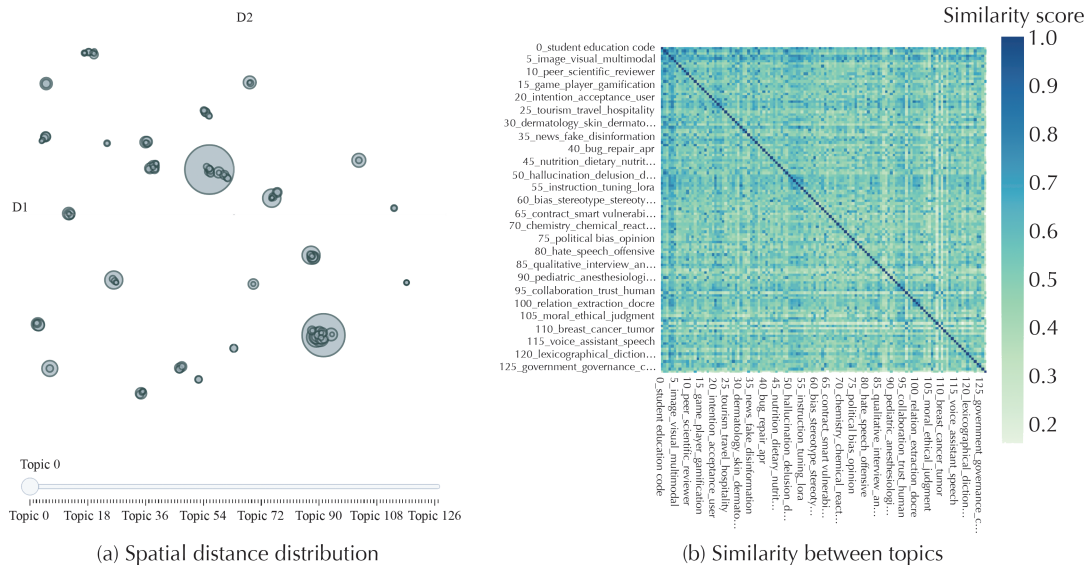


Figure 5. Initial topic extraction results.

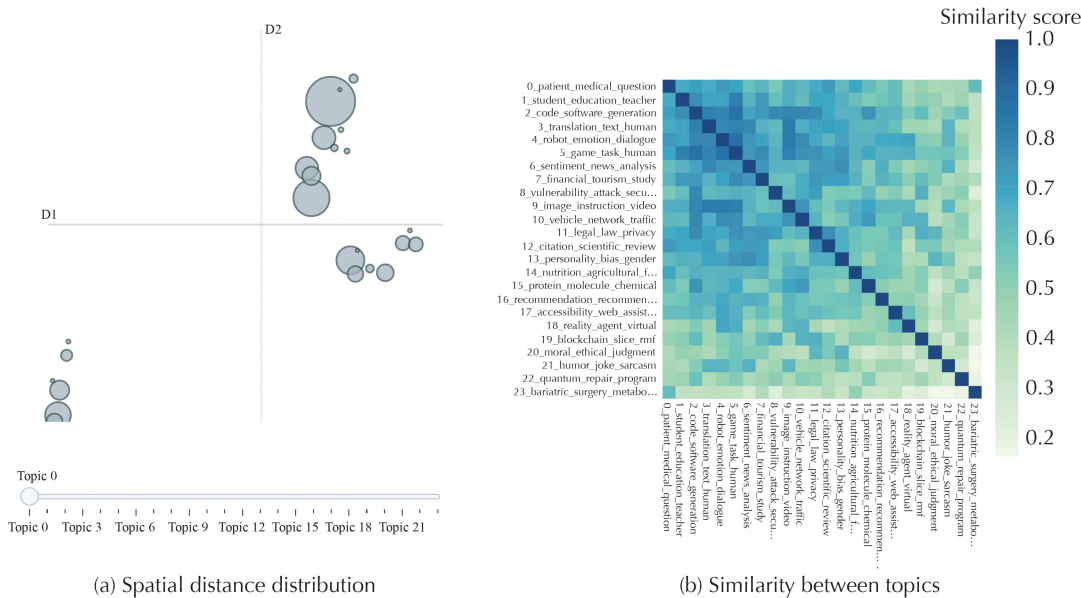


Figure 6. Topic extraction results after refinement.

5.2. Topic Identification Results of International ChatGPT Research

Figure 7 presents the 24 topics identified in this study using the BERTopic model, along with the top five keyword phrases and their respective weights. The figure illustrates that the BERTopic model effectively utilizes phrases to convey the meanings of the topics. By integrating this information with representative literature for each topic, a manual interpretation can be conducted.

For instance, Topic 0 includes keyword phrases such as “patient,” “medical,” and “question.” The representative literature on this topic includes a study by Wu et al. [27], which conducted a meta-analysis to assess the accuracy of large language models in answering ophthalmology exam-style questions. The study found that while the overall accuracy was acceptable, it was not exceptional, and performance varied significantly across different ophthalmology topics. Additionally, Patil et al. [28] investigated the ability of AI chatbots, ChatGPT and Google Bard, to accurately convey preoperative ophthalmic information. Their findings revealed that ChatGPT outperformed Bard in terms of information accuracy; however, both chatbots failed to mention potential adverse events during the informed consent process. This limitation reduces their potential effectiveness and may make it more challenging for patients to fully comprehend the provided information.

Based on this analysis, Topic 0 is named “Healthcare Applications and Performance Evaluation.” Using a similar approach, the remaining 23 topics can be systematically named.

Figure 8 presents the clustering relationships among the 24 topics, which can be categorized into four research directions:

- ◆ **D1: Potential Challenges of Generative AI.** This direction focuses on ethical concerns, bias, security risks, and societal controversies, examining the potential risks and critical reflections associated with the use of generative AI in realistic scenarios.
- ◆ **D2: Healthcare, Education, and Social Impact.** Covering applications in medical diagnosis, educational reform, social media sentiment analysis, and societal ethics, this direction highlights the profound influence of generative AI in addressing social challenges.
- ◆ **D3: Technical Advancements in Generative AI.** This direction explores innovations in code generation, multimodal interaction, text generation, and dialogue systems, showcasing the technological potential of generative AI in engineering and computing.
- ◆ **D4: Industry and Technology Integration.** Emphasizing the adoption of generative AI in finance, manufacturing, entertainment, and other industries, this direction underscores its transformative capabilities and future development prospects in various sectors.

While the first three directions focus on the interaction between generative AI and society, exploring its societal-level influence and cross-domain relevance of generative AI. The fourth direction emphasizes its practical integration into specific industries, such as finance, manufacturing, and entertainment, showcasing its potential for deep industry innovation and application-focused development.

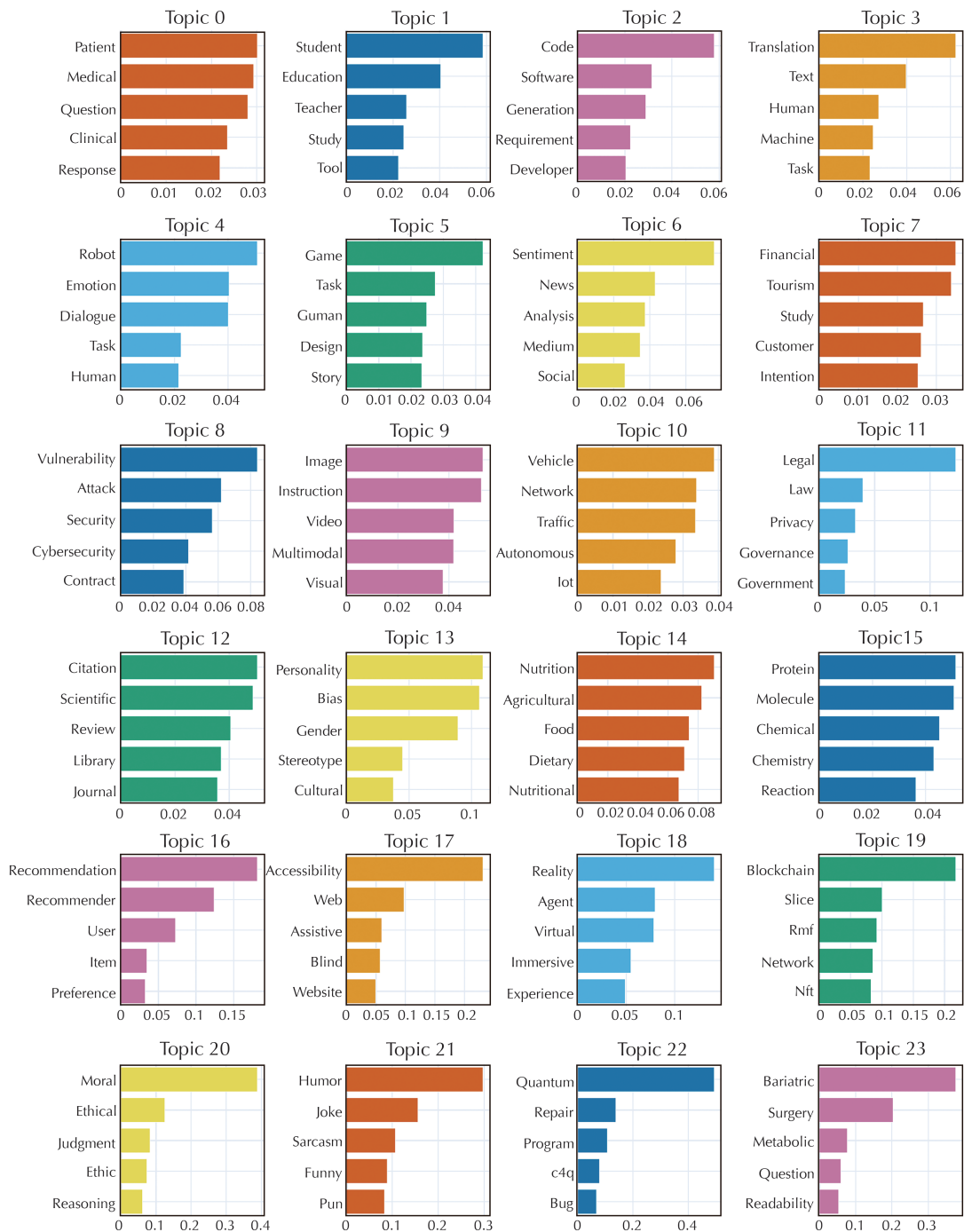


Figure 7. Keywords and weights of each topic.

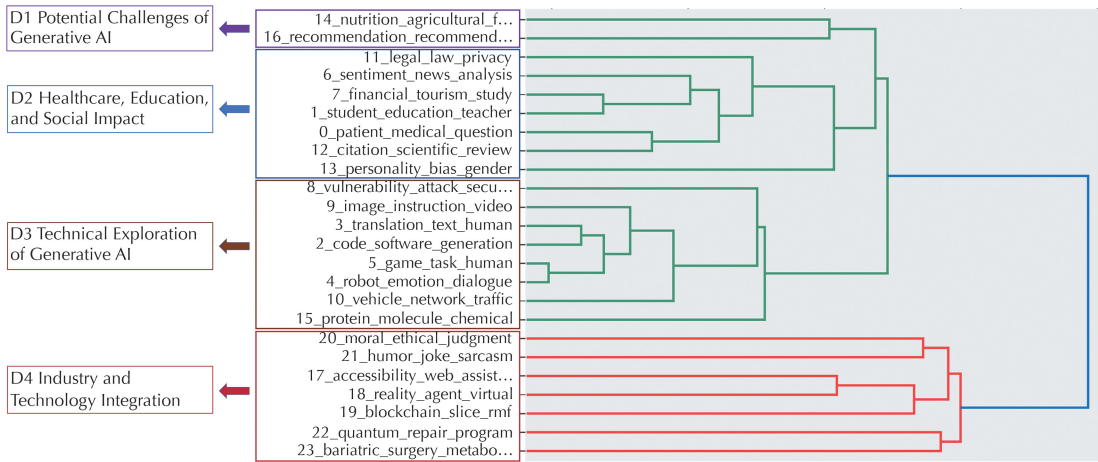


Figure 8. Cluster relationships among the 24 topics.

5.2.1 Potential Challenges of Generative AI

Focusing on ethics, bias, security, and societal controversies, this research direction examines the potential risks and critical reflections on generative AI in social contexts.

Topic 14 (Ethical Issues and Bias Detection). Rutinowski et al. [29] analyzed the self-awareness and political biases of large models. Their findings indicate that ChatGPT tends to exhibit progressive and libertarian leanings when responding to politically charged test questions. Regarding self-awareness, ChatGPT was rated as highly open and friendly, aligning with the ENFJ personality type, with no apparent malicious tendencies.

Topic 16 (Controversies and Reflections on Generative AI in Social Sciences). Du et al. [30] proposed a framework integrating user linguistic style awareness and interest-driven dynamics for applying generative AI in social sciences, particularly in conversational recommender systems. This study explores the controversies surrounding generative AI by addressing issues of personalization and interactive effectiveness. The framework's validity was empirically demonstrated, offering valuable insights into ongoing debates in this field.

5.2.2 Healthcare, Education, and Social Impact

This direction encompasses the applications and potential impacts of generative AI in medical diagnosis, educational reform, social media sentiment analysis, and societal ethics, highlighting its profound influence on addressing social challenges.

Topic 11 (Societal Ethics and Regulation of Generative AI) examines the legal, ethical, and policy challenges surrounding generative AI [31]. It focuses on issues such as governance, privacy, regulation,

trust, and risk, highlighting the need for legal frameworks and public policy to ensure responsible AI development and deployment.

Topic 6 (Sentiment Analysis and Public Opinion on Social Media) investigates the role of generative AI in analyzing public sentiment and opinions expressed on social media [32-33]. It explores aspects such as fake news detection, political discourse, hate speech identification, and biases in AI-generated content, emphasizing the influence of AI on digital communication.

Topic 7 (Generative AI Applications in Finance and Tourism) explores how generative AI impacts the financial and tourism sectors. It covers topics such as customer perception, service personalization, market analysis, and business decision-making, assessing the adoption and influence of AI-driven solutions in these industries [34-35].

Topic 1 (Generative AI Tools in Education) delves into the use of generative AI for students and educators. It discusses AI-driven learning tools, personalized education [36], feedback mechanisms, and the impact of AI on teaching methods and skill development in various educational settings [37].

Topic 0 (Healthcare Applications and Performance Evaluation) focuses on the application of generative AI in medical fields, particularly in patient diagnosis, clinical response accuracy, medical question-answering, and performance evaluation of AI-based healthcare solutions [28, 38]. It assesses AI's potential to assist medical professionals and improve healthcare outcomes.

Topic 12 (Acceptance and Challenges of AI-Generated Content in Education) examines the perception and ethical considerations of AI-generated academic content, including issues related to authorship, scientific publishing [39], peer review [40], and citation practices. It highlights concerns about credibility, human oversight, and the evolving role of AI in scholarly communication.

Topic 13 (Personality Assessment and Sociocultural Bias in AI) examines the ability of generative AI to assess personality traits and their alignment with sociocultural norms [41-42]. It explores biases related to gender, stereotypes, and cultural factors in AI-generated assessments, particularly in personality evaluations and interview contexts.

5.2.3 Technical Exploration of Generative AI

Focusing on advancements in code generation, multimodal interaction, text generation, and dialogue systems, this direction reflects the deep technological potential of generative AI in engineering and technology.

Topic 8 (Security and Vulnerability Analysis of AI-Generated Content) investigates the security risks and vulnerabilities associated with AI-generated content, including adversarial attacks, phishing, malware, and jailbreaking attempts [43]. It explores cybersecurity threats in smart contracts, software, and AI-driven systems, as well as defense mechanisms to enhance AI robustness [44].

Topic 9 (Multimodal Generation and Applications) focuses on AI models that integrate multiple data modalities, such as text, images, and videos. It examines advancements in multimodal learning, dataset alignment, and fine-tuning techniques to improve tasks like captioning, visual understanding, and human-AI interaction [45-46].

Topic 3 (Text Generation and Translation Technologies) explores AI's role in text-based tasks, including machine translation, text summarization, and language adaptation [47]. It evaluates AI performance across different languages, examines fine-tuning strategies, and assesses quality, reliability, and domain-specific applications.

Topic 2 (Code Generation and Software Engineering) examines AI-powered code generation and its impact on software engineering. It explores AI's role in bug detection, software development automation, and programming knowledge retrieval, assessing its effectiveness in assisting developers and optimizing engineering workflows [48].

Topic 5 (Game Design with Generative AI) investigates the use of generative AI in game development, focusing on storytelling, character creation, and player interaction [49-50]. It explores AI's ability to enhance creativity in narrative generation, reasoning, and game mechanics, contributing to immersive gaming experiences.

Topic 4 (Dialogue Systems and Emotional Interaction) examines AI-powered conversational agents, including chatbots and emotionally intelligent dialogue systems. It explores AI's capability to recognize and respond to emotions, facilitate natural conversations, and support applications in social robotics and healthcare [51].

Topic 10 (Innovations in Text Generation with Generative AI) explores cutting-edge applications of generative AI in intelligent systems, including autonomous vehicles, IoT, and smart transportation. It examines AI's role in optimizing networks, energy management, and decision-making in complex real-world scenarios [52].

Topic 15 (Interaction Design and Innovation in Generative AI) focuses on AI-powered scientific discoveries, particularly in computational chemistry, molecular design, and drug discovery [53]. It explores AI's role in material synthesis, biological optimization, and innovative problem-solving in scientific research.

5.2.4 Industry and Technology Integration

This direction showcases the integration of generative AI in finance, manufacturing, entertainment, and other industries, emphasizing its innovative capabilities and future development prospects in industrial applications.

Topic 20 (Ethical and Moral Reasoning of AI) explores the ethical and moral implications of AI in content creation and decision-making [54]. It examines AI's role in ethical reasoning, moral judgment, and cultural perceptions across different contexts.

Topic 21 (AI-Driven Humor Understanding and Generation) focuses on the application of generative AI in smart devices, particularly in humor generation, sarcasm detection, and multimodal interactions. It explores AI's ability to understand and produce jokes, puns, and visual humor [55].

Topic 17 (Industry Integration of Generative AI) examines the role of generative AI in improving accessibility, particularly for visually impaired users. It explores AI-powered assistive technologies, speech recognition, and web accessibility solutions [56].

Topic 18 (Generative AI Solutions in Manufacturing) investigates the integration of generative AI in manufacturing, with a focus on immersive virtual environments [57], intelligent automation [58], and interactive applications in industrial and educational settings.

Topic 19 (Innovations in Fintech with Generative AI) explores the application of generative AI in fintech, particularly in blockchain, smart contracts, and decentralized finance. It examines AI's role in enhancing financial security [59], automation, and digital transactions [60].

Topic 22 (AI-Assisted Debugging) focuses on AI-powered advancements in automated debugging, software repairing, and quantum computing [61]. It explores AI's role in identifying and fixing bugs, optimizing algorithms, and enhancing computational efficiency across various domains, including physics, chemistry, and finance [62].

Topic 23 (Generative AI for Clinical and Surgical Applications) focuses on AI-powered advancements in medical decision-making, surgical planning, and patient-centered recommendations [63-64]. It explores AI's role in improving the readability of clinical information, optimizing bariatric and metabolic surgery outcomes, and enhancing medical text processing for better healthcare accessibility.

5.2.5 Analysis of Topic Strategic Coordinate Distribution

The frontier degree and impact degree of the topics in foreign ChatGPT research were calculated based on formulas (1) and (2), as shown in Table 4.

Based on the calculated results, the frontier degree and impact degree were normalized to the range [0, 1] using the min-max method. The result of the strategic coordinate distribution is shown in Figure 9. By dividing the strategic coordinate plot into four regions based on the average of the two indicators, only six topics fall into the upper right quadrant: Topic 4 (Dialogue Systems and Emotional Interaction), Topic 10 (Generative AI for Smart Transportation and Autonomous Systems), Topic 11 (Societal Ethics and Regulation of Generative AI), Topic 12 (Acceptance and Challenges of AI-Generated Content in Education), Topic 15 (Interaction Design and Innovation in Generative AI), and Topic 16 (Controversies and Reflections on Generative AI in Social Sciences), indicating a promising future for these topics.

Table 4. Calculation results of relevant indicators.

No.	Topic Name	FD	ID	No.	Topic Name	FD	ID
0	Healthcare Applications and Performance Evaluation	1.247	7.637	12	Acceptance and Challenges of AI-Generated Content in Education	1.354	12.827
1	Generative AI Tools in Education	1.199	7.695	13	Personality Assessment and Sociocultural Bias in AI	1.531	2.017
2	Code Generation and Software Engineering	1.259	2.245	14	Ethical Issues and Bias Detection	1.313	3.22
3	Text Generation and Translation Technologies	1.249	2.673	15	Interaction Design and Innovation in Generative AI	1.313	10.489
4	Dialogue Systems and Emotional Interaction	1.401	5.015	16	Controversies and Reflections on Generative AI in Social Sciences	1.329	7.842
5	Game Design with Generative AI	1.346	2.237	17	Industry Integration of Generative AI	1.293	0.866
6	Sentiment Analysis and Public Opinion on Social Media	1.253	4.165	18	Generative AI Solutions in Manufacturing	1.322	1.333
7	Generative AI Applications in Finance and Tourism	1.284	8.748	19	Innovations in Fintech with Generative AI	1.215	1.125
8	Security and Vulnerability Analysis of AI-Generated Content	1.227	3.479	20	Ethical and Moral Reasoning of AI	1.411	1.5
9	Multimodal Generation and Applications	1.265	1.451	21	AI-Driven Humor Understanding and Generation	1.195	1.25
10	Generative AI for Smart Transportation and Autonomous Systems	1.348	5.519	22	AI-Assisted Debugging	1.138	0
11	Societal Ethics and Regulation of Generative AI	1.367	5.047	23	Generative AI for Clinical and Surgical Applications	1.244	14

Additionally, Topic 13 (Personality Assessment and Sociocultural Bias in AI) has the highest frontier degree. Although its impact degree is somewhat weaker, it remains at the forefront of the field and holds significant growth potential. Conversely, Topic 23 (Generative AI for Clinical and Surgical Applications) has the highest impact degree but the lowest frontier degree and primarily explores the potential applications of generative artificial intelligence in clinical medicine and surgery.

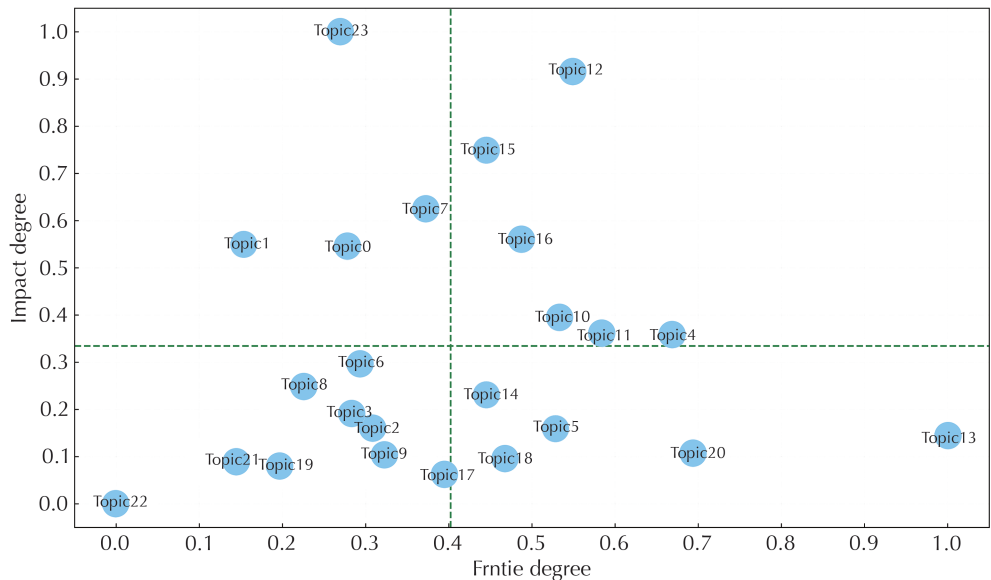


Figure 9. Strategic coordinate distribution of topics in international ChatGPT research.

6. CONCLUSION AND IMPLICATIONS

This study employs bibliometric analysis and topic modeling to reveal the key developmental characteristics and topic distribution of international ChatGPT research. The main conclusions are as follows:

In terms of country distribution, the global landscape of ChatGPT-related research is primarily concentrated in North America, Europe, and the Asia-Pacific region. The United States leads in this field with a significant research advantage, followed by China, which has made notable progress driven by national policies and market demand. Other countries, including Germany, India, the United Kingdom, Canada, and several others, also contribute actively. This indicates that the development and application of ChatGPT are primarily driven by technologically advanced countries with sustained investment in AI and natural language processing.

Regarding journal distribution, the research outcomes related to ChatGPT span multiple disciplines, especially in medicine, engineering, education, and information technology. The leading journals in this field include *Cureus Journal of Medical Science*, *IEEE Access*, and *Journal of Medical Internet Research*, highlighting the prominence of medical and technological research. While some journals have higher publication volumes, the overall distribution remains broad, indicating that ChatGPT research is not confined to a few specific outlets. This suggests that the influence of ChatGPT is widespread and has interdisciplinary application potential, attracting increasing interest from researchers across various fields.

In terms of institutional distribution, major research institutions such as the University of California system, Harvard University, and Stanford University play significant roles in exploring the applications and technologies of ChatGPT. These institutions focus on diverse research directions, including medical applications, interdisciplinary education, and ethical considerations. Other institutions, such as the University of London, the National University of Singapore, and Harvard Medical School, have also contributed to the study of ChatGPT's technical, ethical, and medical implications. This highlights their strong research foundations in artificial intelligence and their keen attention to emerging technologies across multiple disciplines.

As for author collaboration, the collaboration network among authors exhibits low density, indicating that current research collaborations have not yet formed a few unified core teams and are primarily conducted by multiple independent research groups. The largest connected component includes only a small fraction of the total authors, further highlighting the fragmented nature of collaboration in this field. This demonstrates that while ChatGPT research is gaining traction across disciplines, stronger international collaboration networks have yet to emerge.

Through the analysis using the BERTopic model, this study identifies 24 major research topics, covering various fields such as medical education, natural language processing technologies, and radiological diagnosis, demonstrating the broad potential and research value of ChatGPT in different application scenarios.

To promote the development of large model technologies across countries, government departments should pay attention to international research trends, encourage interdisciplinary collaboration, and increase investment in cutting-edge scientific fields. Specifically, clear guidelines should be established regarding the application and ethics of artificial intelligence and natural language processing technologies to ensure safe and sustainable development. Future research could focus on areas with high frontier and impact to explore their potential application scenarios and technological challenges. Additionally, promoting collaboration among different research teams will help form a more cohesive research network, enhancing the comprehensiveness and impact of research outcomes. Finally, industries should actively embrace the new generation of generative large model technologies, particularly in education, healthcare, and legal sectors, exploring their effectiveness and challenges in practical applications and making technical adjustments and optimizations based on specific needs.

AUTHOR CONTRIBUTIONS

Biao Zhang: Topic analysis and article writing;

Yunwei Chen: Idea improvement, article revision and finalization;

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