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A Bibliometric Map of the Hybrid Recommender Systems Field (2003-2024): Trends, Network Structures and Future Directions

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ABSTRACT

This study comprehensively examines the approximately twenty-year development of the hybrid recommender systems field using bibliometric analysis methods. Academic publications produced between 2003 and 2024 were compiled from various databases, and the structural dynamics of the field were revealed through citation analysis, co-authorship networks, keyword co-occurrence, and thematic clustering techniques. Overall, the study systematically maps the evolution of the hybrid recommender systems literature and provides a strategic roadmap for researchers and practitioners. The findings indicate that hybrid recommender systems have gained significant momentum, particularly over the past decade. Initially emerging from the integration of content-based and collaborative filtering approaches, the field has evolved into more complex and powerful models through the incorporation of deep learning, big data analytics, and artificial intelligence techniques. Moreover, these systems are widely applied across various domains, including e-commerce, media platforms, and educational technologies. Network analyses reveal that the field is concentrated around specific countries and leading research institutions, while also highlighting the increasing trend of interdisciplinary collaboration. Keyword analysis further shows that themes such as “deep learning,” “context-aware systems,” “cold-start problem,” and “explainable AI” have become prominent in recent years. The article emphasizes that future research in hybrid recommender systems should focus more on explainability, ethical considerations, data privacy, and user-centered design. Additionally, the integration of heterogeneous data sources and the development of real-time recommendation mechanisms are identified as key directions for future research.

Keywords: Hybrid Recommender Systems, Bibliometric Analysis, Science Mapping, Knowledge Structure, Research Trends, Citation Network Analysis
JEL-Classifications: C89, O33, L86

1.Introduction

Nowadays, recommender systems have become popular tools for filtering information and supporting decision-making in various digital environments. While collaborative and content-based filtering have been widely adopted, both approaches face challenges such as data sparsity and limited contextual adaptability (Adomavicius and Tuzhilin, 2005; Schafer et al., 2007). To overcome these shortcomings, hybrid recommender systems combine multiple recommendation strategies, providing more robust and accurate solutions (Burke, 2002; Jannach et al., 2010). Reflecting its growing importance, this integrated approach has been widely applied in various fields, from e-commerce and e-learning to healthcare and tourism (Ricci et al., 2021; Zeng and Li, 2017).

In recent years, bibliometric analysis has emerged as a powerful method for systematically examining research developments in recommendation technologies. Such analyses identify leading authors, institutions, and countries, while also revealing intellectual structures and thematic evolution (Small,

1999; Börner et al., 2003). By mapping knowledge production, bibliometric studies provide both historical context and future directions, making them particularly valuable for understanding the trajectory of hybrid proposal research (Cobo et al., 2011; Van Eck and Waltman, 2010).

1.1. A Comprehensive Overview of Hybrid Recommender Systems

Recommender systems constitute a vital tool for filtering and prioritizing information in today's data-driven environment. While early systems largely relied on either collaborative filtering, which exploits user–item interaction patterns, or content-based filtering, which leverages descriptive item attributes, both approaches faced inherent challenges such as data sparsity, cold-start issues, and limited diversity (Adomavicius & Tuzhilin, 2005; Ricci et al., 2011). To overcome these shortcomings, hybrid recommender systems emerged as a robust alternative by integrating multiple recommendation techniques into a unified framework (Burke, 2002). These systems not only combine the strengths of individual methods but also mitigate their weaknesses, resulting in improved accuracy, coverage, and user satisfaction.

Over the past twenty years, a variety of hybridization strategies have been proposed, ranging from simple weighted combinations to more sophisticated model-level integrations (Burke, 2007; Son, Kim, & Ryu, 2017). For instance, switching hybrids dynamically select an appropriate algorithm depending on contextual factors, while cascade models sequentially apply different recommenders to refine results. Meta-level hybrids exploit the output of one algorithm as input for another, and feature augmentation approaches enrich user or item profiles to enhance prediction performance (Robin & Smyth, 2000). These diverse mechanisms underscore the adaptability of hybrid recommenders across domains such as e-commerce, education, tourism, and healthcare (Fernández-Tobías et al., 2019; Nilashi et al., 2016).

The growing research on hybrid recommender systems demonstrates their centrality in bridging methodological innovation with practical application. Their versatility in addressing domain-specific challenges—such as scalability in large online platforms, personalization in e-learning, or trustworthiness in healthcare—highlights their enduring importance in the broader landscape of intelligent information systems (Zhang et al., 2019; Burke & Ramezani, 2011). As such, hybrid recommender systems represent not merely a combination of methods but a dynamic field in its own right, continuously adapting to new data modalities, computational paradigms, and user expectations.

1.2. Contribution and Scope of the Study

Despite the increasing significance of hybrid recommender systems in both research and practice, a systematic understanding of their scholarly evolution and structural development remains limited. While numerous studies have introduced new algorithms or application-specific solutions, relatively few have attempted to map the intellectual landscape and identify long-term trends (Jannach et al., 2010; Felfernig et al., 2014). Bibliometric analysis offers a powerful means of addressing this gap by providing a macroscopic perspective on research outputs, collaborative patterns, and thematic clusters (Aria & Cuccurullo, 2017; Cobo et al., 2011). By employing bibliometric tools, this study advances beyond traditional literature reviews to capture the conceptual and social structures underpinning the hybrid recommendation field.

The contribution of this work lies in three main aspects. First of all, it consolidates dispersed knowledge by analyzing a large body of publications on hybrid recommender systems, thus highlighting influential authors, institutions, and countries. Secondly, it uncovers thematic trajectories by examining keywords, bigrams, and clusters, offering insights into emerging and declining research directions. Thirdly, it contextualizes hybrid recommendation within broader scientific developments by mapping collaborations and co-citation structures, thereby shedding light on the interdisciplinary character of the field.

The scope of this study covers research published between 2003 and 2024, retrieved from the Web of Science (WoS) database, which ensures consistency and reliability in bibliometric data (Falagas et al., 2008). Using R Studio and specialized bibliometric packages, the dataset was analyzed to generate performance indicators, collaboration networks, keyword co-occurrences, and thematic maps. This methodological approach ensures a balanced combination of quantitative rigor and qualitative interpretation, offering a comprehensive overview of hybrid recommender systems research. Ultimately, the findings are expected to serve as a reference point for scholars and practitioners seeking to understand the current state and future directions of the field.

2. Methodology

Bibliometric analysis is a research approach based on the statistical examination of scientific publications and related citation data. This method involves the evaluation of indicators such as publication numbers, citation relationships, keyword co-occurrences, co-authorship networks, and journal impact levels. Through bibliometric analysis, the structure of a research field can be mapped, leading authors, institutions, and countries can be identified, and trends and emerging themes in the literature can be revealed. (Donthu et al., 2021).

Bibliometric analysis is an important tool for researchers in identifying potential collaborations and suitable publication channels. In terms of literature, it provides a systematic overview of the existing body of knowledge, identifies research gaps, and sheds light on future research directions.

In order to apply this method, it is important to select a reliable and comprehensive database (WoS, Scopus, etc.), clearly define the period and document types to be examined, and use appropriate analysis techniques (performance analysis, citation analysis, co-citation analysis, keyword analysis, etc.).

The advantages of bibliometric analysis is including their ability to produce objective results from large volumes of publication data, their ability to visualize collaboration networks and information flows, and their ability to guide decision-makers in terms of research policies. The disadvantages can be summarized as the limited coverage of databases (not all journals or languages are indexed), interdisciplinary citation differences, and the fact that quantitative indicators do not always reflect qualitative contributions. Therefore, it is important that bibliometric analysis results are supported by the evaluations of field experts in order to be used effectively (Aria & Cuccurullo, 2017).

The Web of Science (WoS) database is one of the most frequently referenced multidisciplinary citation databases in scientific research, managed by Clarivate Analytics. The database covers a wide range of published articles, book chapters, and conference proceedings across fields such as natural sciences, engineering, social sciences, humanities, and arts. WoS not only provides researchers with access to bibliographic information but also enables them to track citation relationships, measure academic impact, and evaluate research performance.

One of the key features of WoS is that it provides rich metadata (author information, institutional addresses, abstracts, keywords, funding information, and references) along with the publications it contains. This provides a strong foundation for bibliometric analysis. The database includes sub-collections such as the Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (AHCI), and Emerging Sources Citation Index (ESCI), thereby providing access to selected high-quality publications on a global scale. Additionally, it integrates with tools such as Journal Citation Reports (JCR) and InCites, enabling comparative analysis of journal impact factors and the research performance of institutions or countries (Clarivate, 2025).

2.1. Research Design

The data set for the study was obtained from the Web of Science (WoS) Core Collection database. The research design of the bibliometric analysis is shown in Figure 1. In the study, the term “hybrid recommendation” was searched based on the subject area (Topic), and records published between 1999

and 2025 were examined. However, considering methodological consistency and data density adequacy, only publications from 2003 to 2024 were included in the analysis. In this context, all document types, including articles, conference papers, and book chapters, were evaluated, and a total of 722 studies were obtained from the database and subjected to analysis.

The bibliometric analysis performed on this dataset provides a comprehensive examination in terms of both performance and scientific network structures. The performance analysis identified the most productive countries, institutions, authors, journals, and influential publications. In addition, network structures were mapped through collaboration networks, thematic maps, and keyword distributions. Furthermore, temporal analyses were conducted by examining publication and citation trends over the years, prominent keywords, and emerging research topics. The findings were visualized and reported using WoS analysis tools, R Studio, Biblioshiny software, and MS Excel.

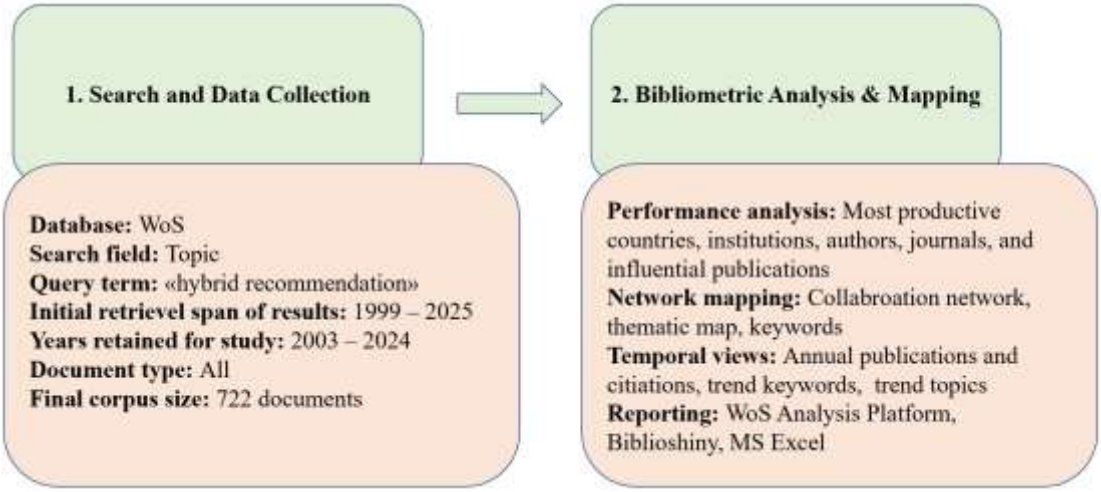

Figure 1: Research Design: From WoS Search to Bibliometric Analysis

2.2. Data Information

In this study, data were retrieved from the Web of Science (WoS) Core Collection by performing a topic-based search using the keyword "hybrid recommendation." The initial query identified 722 records published between 1999 and 2025. To ensure methodological coherence and maintain a consistent dataset, only publications released between 2003 and 2024 were retained for further analysis. The dataset includes 540 different sources (journals, books, etc.), and the annual growth rate was calculated as 1.02%. The study had contributions from 1,806 authors, and the international co-authorship rate was 17.73%. The average number of authors per document was 3.34. These findings demonstrate that the field has a multi-author collaborative structure.

The dataset was examined by document type, with the highest proportions being articles (347) and proceedings (330). These two types account for approximately 94% of the total publications. A smaller proportion also included reviews (15), early access articles (4), book chapters (3), and article-proceedings combinations (13). Furthermore, rarer types such as revised publications (1), letters (1), and retracted studies (8) were also identified. This distribution reveals that the literature in hybrid recommender systems is largely based on original research articles and conference proceedings.

Table 1: Descriptive Statistics of the Web of Science Dataset

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2003:2025
Sources (Journals, Books, etc)	540
Documents	722
Annual Growth Rate %	1,02
Document Average Age	7,27
Average citations per doc	21,48
References	15166
DOCUMENT CONTENTS	
Keywords Plus (ID)	317
Author's Keywords (DE)	1744
AUTHORS	
Authors	1806
Authors of single-authored docs	48
AUTHORS COLLABORATION	
Single-authored docs	53
Co-Authors per Doc	3,34
International co-authorships (%)	17,73

Table 2: Descriptive Statistics of the Web of Science Dataset (continued)

Description	Results
DOCUMENT TYPES	
article	347
book chapter	3
article; early access	4
proceedings paper	13
article; retracted publication	6
correction	1
letter	1
proceedings paper	330
retraction	2
review	15

3. Findings

The findings of this bibliometric study provide a comprehensive overview of the research landscape on hybrid recommender systems. Through the analysis of publications, citations, authors, institutions, countries, and sources, the results highlight both the historical development and the current state of the field. Temporal patterns reveal how interest in hybrid recommendation has evolved over time, while collaboration networks shed light on the intellectual structure and global research dynamics. Collectively, these findings not only demonstrate the core contributions of leading actors but also identify emerging directions that shape the sustainability and growth of the domain.

3.1.Publications and Citiations

Figure 2 shows the distribution by WoS category based on a corpus of 722 studies; since a single publication in WoS can be assigned to more than one category, the sum of the percentages can exceed 100. Accordingly, approximately 77.4% of the publications are classified under Computer Science, followed by Engineering with 28.1% and Telecommunications with 12.3%. More limited but notable contributions are observed in Automation and Control Systems (3.9%), Information Science and Librarianship (3.9%), Operations Research and Management Science (3.5%), Science and Technology – Other Subjects (3.5%), Education/Educational Research (3.3%), and Mathematics (3.2%), while Physics (2.5%) has a smaller share. This distribution reveals that the hybrid recommender systems literature is mainly concentrated on computer science and engineering, but there is also a significant interdisciplinary reflection in application-oriented areas such as communication technologies and management/automation.

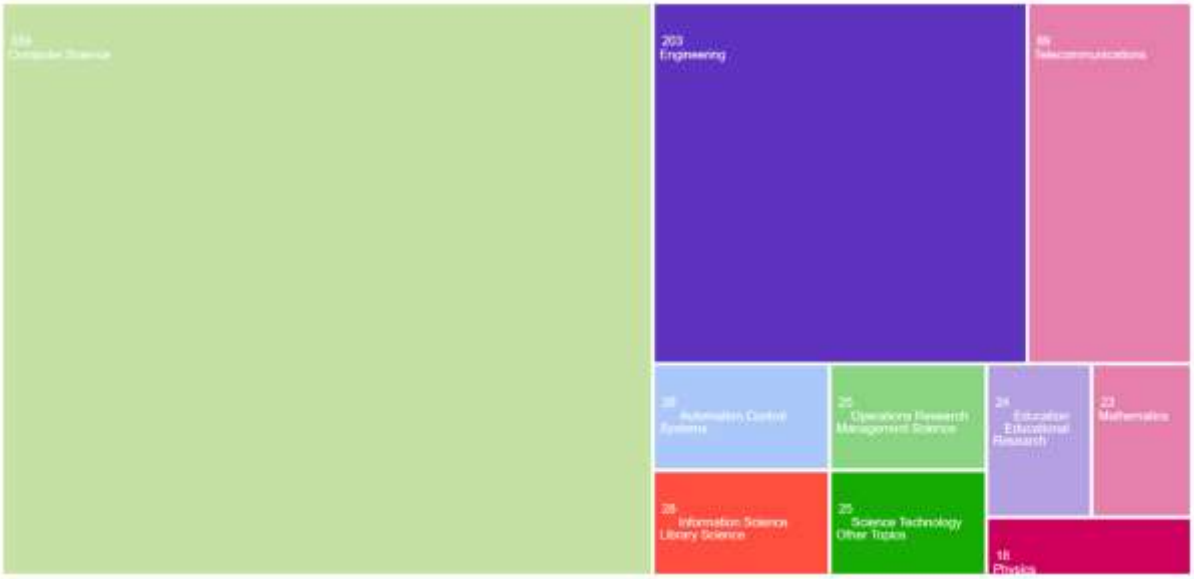

Figure 2: Distribution of Publications by WoS Categories (Top 10 Fields)

As shown in the Figure 3, according to the WoS classification, the literature on hybrid recommendation systems is mainly concentrated in the subfields of computer science: Computer Science – Information Systems leads with 278 publications (38.5%), followed by Computer Science – Artificial Intelligence with 245 publications (33.9%) and Computer Science – Theory & Methods with 201 publications (27.8%). These are followed by Engineering – Electrical & Electronics with 162 publications (22.4%) and Telecommunications with 89 publications (12.3%); additionally, Computer Science – Software Engineering with 73 publications (10.1%) and Computer Science – Interdisciplinary Applications with 85 publications (11.8%) highlight the software – oriented and interdisciplinary nature of the field. More limited contributions are observed in the categories of Automation & Control Systems (28; 3.9%), Information Science & Library Science (28; 3.9%), and Engineering – Multidisciplinary (27; 3.7%).
This distribution indicates that the methodological core of the publications lies within computer science and that they have strong application links with the fields of electrical – electronics and telecommunications.

Figure 3: Distribution of Publications by Discipline

Although the first study explicitly addressing hybrid recommendation was published in 1999 under the title "Surfing the Digital Wave – Generating Personalised TV Listings Using Collaborative, Case-Based Recommendation" by Smyth and Cotter, this single publication was not included in the present bibliometric analysis. The reason is that, within the WoS database, no other studies containing the keyword "hybrid recommendation" appeared until 2003. Since bibliometric analyses aim to identify broader research trends and critical mass rather than isolated contributions (Passas, I. (2024)), including the 1999 study would not provide meaningful insights into the temporal development of the field. Therefore, the analysis was initiated in 2003 and Figure 4 shows when continuous scholarly outputs on hybrid recommendation systems began to emerge. Until 2010, the number of publications remained relatively low, rarely exceeding 15 per year. From 2011, a steady increase became visible, culminating in rapid growth after 2016. The peak occurred in 2022 with 81 documents, reflecting heightened research activity in the field. Although the output declined slightly in 2023, the 2024 data confirm that hybrid recommendation continues to attract significant scholarly attention.

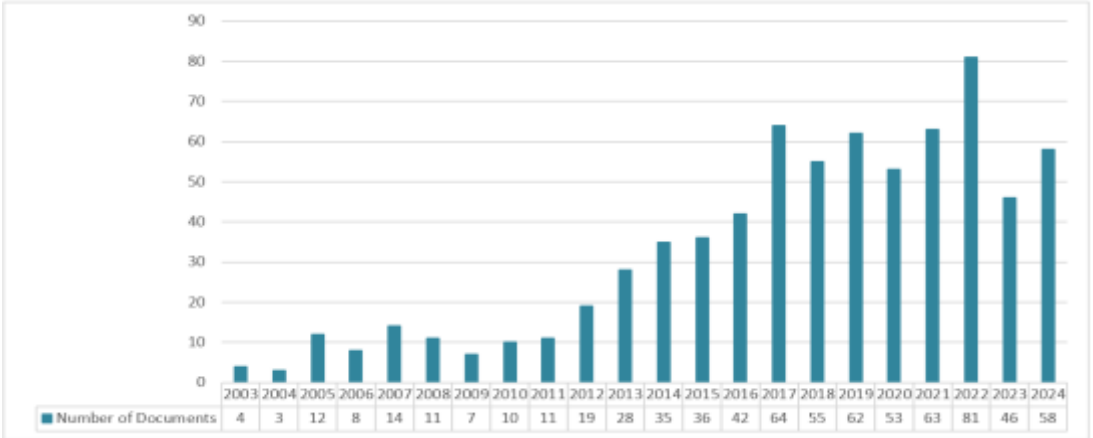

Figure 4: Annual Distribution of Publications on Hybrid Recommendation Systems (2003–2024)

According to the data obtained from the WoS database, Figure 5 illustrates the annual distribution of total citations (TC) and citations per publication (TC/TP) in the bibliometric analysis of hybrid recommendation studies between 2003 and 2024. The year 2005 stands out with an exceptionally high citation peak, mainly due to a seminal review study that continues to shape the field. After this early surge, the annual citation counts decreased but remained relatively stable, reflecting steady scholarly attention. The TC/TP ratio highlights that early publications had higher individual impact, while recent studies demonstrate broader but more evenly distributed influence across the literature.

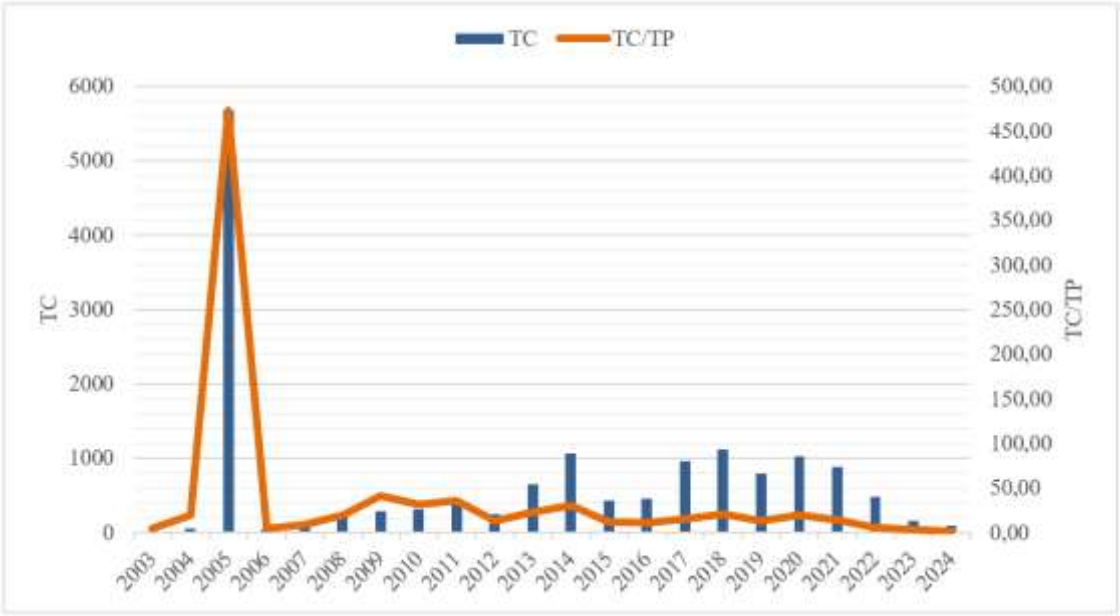

Figure 5: Annual Distribution of Total Citiations (TC) and Citations per Publication (TC/TP)

According to the bibliometric analysis, the most influential documents in hybrid recommendation research are presented in Table 2. The review article by Adomavicius and Tuzhilin (2005) represents a milestone in the field, with 5,591 citations, reflecting its foundational role in shaping subsequent research. Following this, Yu et al. (2014) achieved significant impact with their proceedings paper on personalized entity recommendation, which received 541 citations. Other notable contributions include Klasnja-Milicevic et al. (2011) with 342 citations and Nilashi et al. (2018) with 234 citations, both focusing on personalization strategies and collaborative filtering techniques.

More recent studies, such as Javed et al. (2021), also illustrate the growing attention to content – based and context – aware systems. Overall, these top – cited works highlight the methodological diversity of hybrid recommendation approaches, encompassing reviews, journal articles, and proceedings, and demonstrate their critical role in advancing theoretical and applied perspectives in the domain.

Table 2: Most Cited Publications

Rank	Authors	Publication Year	Title	Documatation Type	Total Citation
1	Adomavicius, G; Tuzhilin, A	2005	Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions	Review	5591
2	Yu, Xiao; Ren, Xiang; Sun, Yizhou; Gu, Quanquan; Sturt, Bradley; Khandelwal, Urvashi;	2014	Personalized Entity Recommendation: A Heterogeneous Information Network Approach	Proceedings Paper	541

	Norick, Brandon; Han, Jiawei				
3	Klasnja-Milicevic, Aleksandra; Vesin, Boban; Ivanovic, Mirjana; Budimac, Zoran	2011	E-Learning personalization based on hybrid recommendation strategy and learning style identification	Article	342
4	Nilashi, Mehrbakhsh; Ibrahim, Othman; Bagherifard, Karamollah	2018	A recommender system based on collaborative filtering using ontology and dimensionality reduction techniques	Article	234
5	Javed, Umair; Shaukat, Kamran; Hameed, Ibrahim A.; Iqbal, Farhat; Alam, Talha Mahboob; Luo, Suhuai	2021	A Review of Content-Based and Context-Based Recommendation Systems	Review	166
6	Noguera, Jose M.; Barranco, Manuel J.; Segura, Rafael J.; Martinez, Luis	2012	A mobile 3D-GIS hybrid recommender system for tourism	Article	156
7	de Campos, Luis M.; Fernandez-Luna, Juan M.; Huete, Juan F.; Rueda-Morales, Miguel A.;	2010	Combining content-based and collaborative recommendations: A hybrid approach based on Bayesian networks	Article	150
8	Zhang, Zui; Lin, Hua; Liu, Kun; Wu, Dianshuang; Zhang, Guangquan; Lu, Jie	2013	A hybrid fuzzy-based personalized recommender system for telecom products/services	Article	134
9	Chen, Ting; Sun, Yizhou; Shi, Yue; Hong, Liangjie	2017	On Sampling Strategies for Neural Network-based Collaborative Filtering	Proceedings Paper	131
10	Chen, Wei; Niu, Zhendong; Zhao, Xiangyu; Li, Yi	2014	A hybrid recommendation algorithm adapted in e-learning environments	Article	125

3.2.Most Influential Authors and Institutions

According to the bibliometric analysis, the most influential authors in hybrid recommendation research are listed in Table 3. Musto emerges as the most prolific author with 8 publications, while Lops, de Gemmis, and Semeraro each contributed 7 works. In terms of citation performance, Niu stands out with 391 citations and the highest TC/TP ratio (78.2), followed by Lu (244 citations, TC/TP 40.7) and Ghazanfar (189 citations, TC/TP 37.8).

An important note is that the h index values reported here do not represent the authors' overall academic performance but rather the citation impact of their works specifically within this bibliometric dataset. Within this scope, Sobecki, Ghazanfar, and Niu achieved the highest h index (5), reflecting consistent influence across their contributions. Overall, the results reveal a balance between prolific productivity and concentrated high – impact works in the field.

Table 3: Most Influential Authors

Rank	Author	TP	TC	TC/TP	H - Index
1	Musto, Cataldo	8	92	11,5	3
2	Lops, Pasquale	7	101	14,4	4
3	de Gemmis, Marco	7	101	14,4	4
4	Semeraro, Giovanni	7	101	14,4	4
5	Sobecki, Janusz Florian	7	59	8,4	5
6	Liu, Duen-Ren	6	197	32,8	4
7	Brusilovsky, Peter	6	114	19,0	4
8	Aimeur, Esma	6	14	2,3	2
9	Lu, Jie	6	244	40,7	3
10	Ghazanfar, Mustansar	5	189	37,8	5
11	Burke, Robin	5	52	10,4	3
12	Zhang, Guangquan	5	140	28,0	3
13	Zhendong, Niu	5	391	78,2	5

Figure 6 shows the most influential institutions contributing to research on hybrid recommendation systems. The Chinese Academy of Sciences ranks first with 17 publications, demonstrating its leading role in the field. It is followed by the Beijing Institute of Technology (12 publications) and the Pennsylvania Commonwealth System of Higher Education (11 publications).

Several other universities, like the University of Pittsburgh, University of Technology Sydney, and Vellore Institute of Technology, also appear prominently with comparable contributions. Overall, the distribution highlights the dominance of Chinese institutions, alongside strong contributions from the United States and Europe, underscoring the global nature of this research domain.

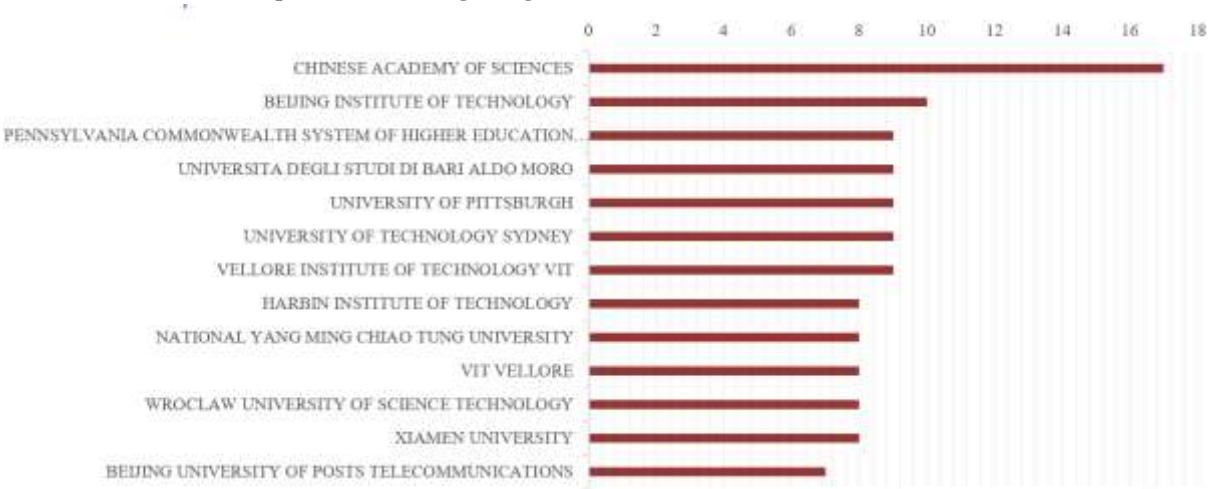

Figure 6: Most Influential Institutions

3.3.Analysis Of The Countries

Situated within the scope of a bibliometric assessment of hybrid recommendation research, we identified the ten most prolific countries and charted annual publication activity for 2003–2024 (Figure 7). The dataset comprises 722 items in total. China ranks first with 303 publications, followed by India (77) and the United States (72). Subsequent contributors include Taiwan (28), Spain (26), Australia (24), South Korea (21), the United Kingdom (19), Italy (18), and Iran (17). In proportional terms, China accounts for approximately 42% of the literature, whereas India and the United States contribute about 11% and

10%, respectively; taken together, these three countries generate nearly two-thirds of all publications in the corpus.

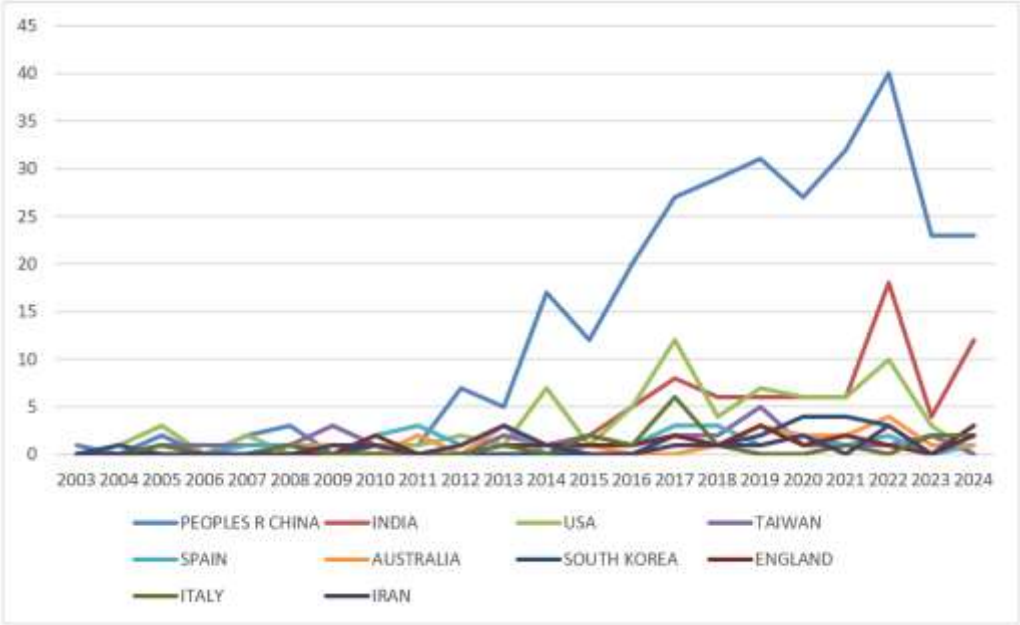

Figure 7: Annual Research Productivity of Countries in Hybrid Recommendation Literature

3.4.Publication Source Analysis

Figure 8 presents the most represented publication venues for hybrid recommendation research in our 2003–2024 corpus. The leading outlet is Lecture Notes in Computer Science (LNCS) with 33 documents, followed by IEEE Access (25) and Lecture Notes in Artificial Intelligence (LNAI) (21). Among journal venues, Expert Systems with Applications accounts for 15 papers, Multimedia Tools and Applications for 10, Knowledge-Based Systems for 9, and Information Sciences for 8; the Advances in Intelligent Systems and Computing (AISC) series contributes 7 items. Taken together, these venues host 128 papers approximately 18% of the 722 records indicating a relatively diffuse outlet landscape.

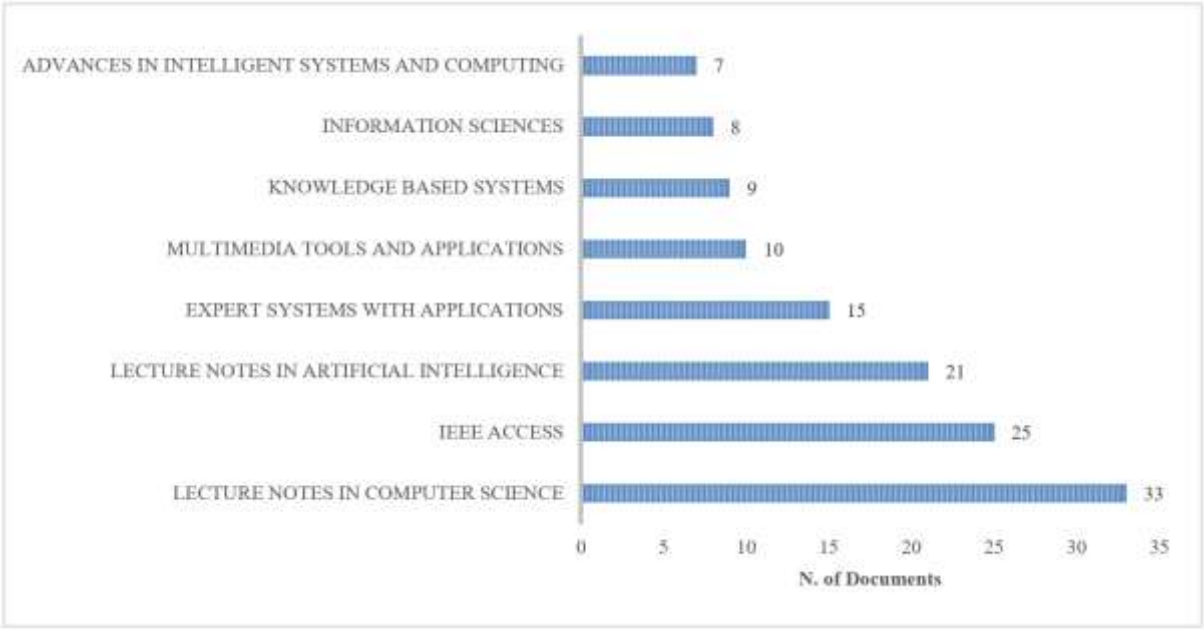

Figure 8: Top Publication Sources Contributing to Hybrid Recommendation Research

3.5.Temporal Trend Analysis

The development of hybrid recommendation research over time was explored in this bibliometric analysis by examining patterns in the most common title keywords. Figure 9 presents the temporal distribution of these terms between 2021 and 2024.

Across this period, hybrid recommendation consistently emerged as the dominant keyword, with a notable increase from 180 occurrences in 2021 to 238 in 2024. Other frequently used terms include recommendation system, collaborative filtering, and recommendation algorithm, each showing steady growth in usage. In 2024, recommendation system appeared 123 times, while collaborative filtering and recommendation algorithm were used 74 and 65 times, respectively. Additionally, terms such as deep learning and personalized hybrid have gained traction in recent years, reflecting the growing integration of advanced machine learning techniques into recommendation research.

These findings suggest a clear trend toward diversification of approaches while maintaining a central focus on hybrid recommendation as the core paradigm.

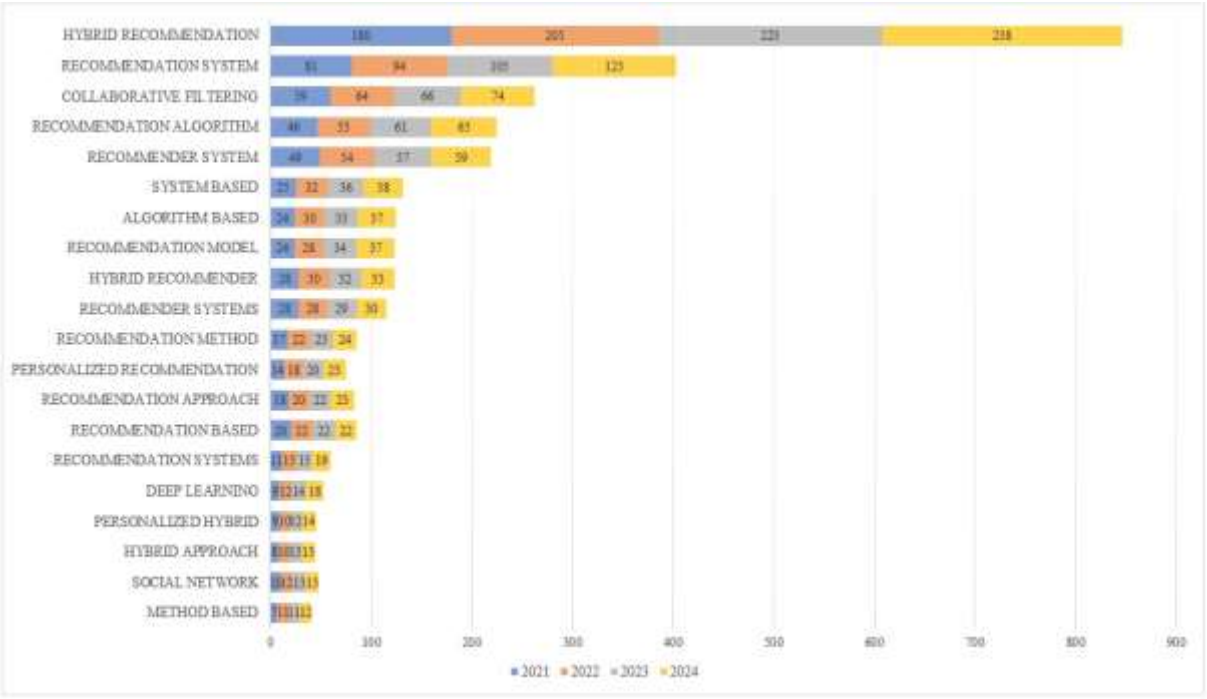

Figure 9: Temporal distribution of common terms in hybrid recommendation titles

Figure 10 illustrates the temporal distribution of the most frequently employed keywords in hybrid recommendation studies between 2021 and 2024. The analysis reveals that collaborative filtering, recommender systems, and hybrid recommendation consistently remain the most prominent terms, reflecting their foundational role in the field.

Emerging concepts such as deep learning and content-based filtering also demonstrate increasing relevance, highlighting a methodological diversification in recent years. While traditional terms dominate the overall landscape, the growing presence of advanced approaches such as matrix factorization and ontology indicates a shift toward more sophisticated techniques. These findings underscore the dynamic nature of hybrid recommendation research and its adaptation to evolving computational paradigms.

Rank	Keywords	Strength
1	COLLABORATIVE FILTERING	626
2	RECOMMENDER SYSTEMS	363
3	HYBRID RECOMMENDATION	359
4	RECOMMENDATION SYSTEM	231
5	RECOMMENDATION	255
6	RECOMMENDER SYSTEM	206
7	HYBRID	162
8	RECOMMENDATION SYSTEM	106
9	CONTENT-BASED FILTERING	121
10	DEEP LEARNING	91
11	FILTERING	104
12	CLUSTERING	82
13	HYBRID RECOMMENDATION	68
14	COLLABORATIVE	56
15	E-COMMERCE	53
16	MATRIX FACTORIZATION	63
17	ONTOLOGY	61
18	PERSONALIZED RECOMMEN	63
19	RECOMMENDATION ALGORI	64
20	E-LEARNING	54

Figure 10: Keyword occurrence trends in hybrid recommendation publications

3.6. Analysis of Social Structures

Figure 11 illustrates the international collaboration network among countries contributing to hybrid recommendation research. The visualization highlights China as the most central actor, maintaining strong co-authorship ties with several nations, including the USA, India, and Australia. These linkages suggest that China plays a pivotal role in fostering large-scale international cooperation.

Other countries, such as Germany, Spain, and Iran, also appear as relevant nodes in the network, although their collaborative intensity is more regionally clustered. The observed structure indicates that global research in this domain is increasingly shaped by partnerships extending across Asia, Europe, and North America, reflecting the interdisciplinary and transnational nature of hybrid recommendation studies.

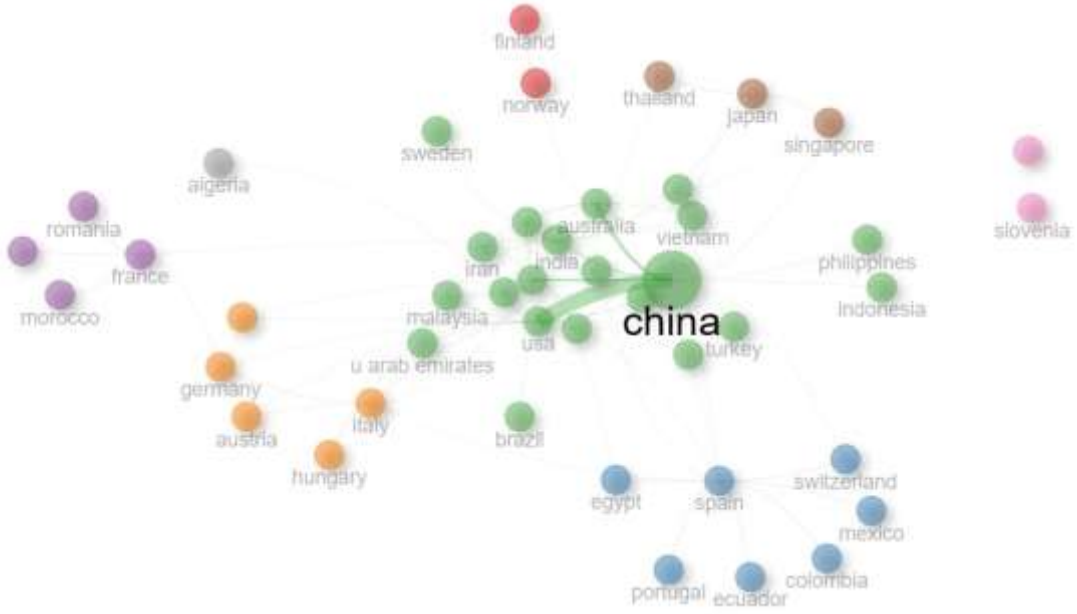

Figure 11: International Collaboration Hybrid Recommendation Studies

Figure 12 illustrates the institutional collaboration network in hybrid recommendation studies, highlighting a limited but distinct set of partnerships. The University of Pittsburgh emerges as the most central actor, demonstrating strong collaborative ties with the School of Computer Science and Technology and Beijing Institute of Technology. European institutions such as the University of Bari Aldo Moro and Polytech University of Bari also show notable bilateral cooperation, while Chinese universities like Beijing Jiaotong University and the University of Science and Technology Beijing appear in smaller clusters. Overall, the network suggests that while a few institutions dominate in terms of collaborative output, the broader landscape remains fragmented, with collaborations concentrated in specific regional or bilateral partnerships.

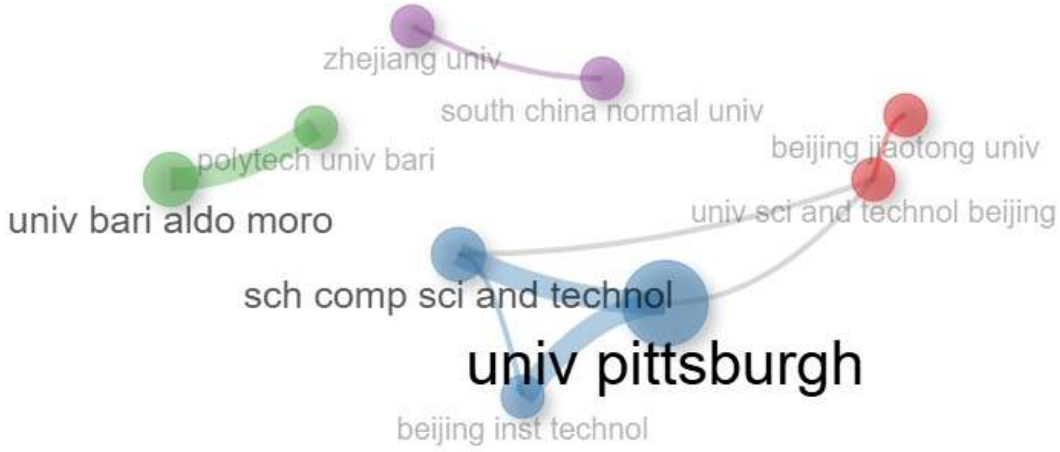

Figure 12: Collaboration network of universities and research institutes

3.7.Keyword Analysis

The bibliometric analysis included the evaluation of Keywords Plus generated by the WoS database, which highlights frequently occurring terms in cited references. Figure 13 presents the word cloud of Keywords Plus for hybrid recommendation studies between 2003 and 2024.

The most prominent terms are “systems,” “model,” “information,” and “algorithm,” indicating the central focus of research within this field. Additionally, words such as “framework,” “trust,” “accuracy,” and “ontology” appear with noticeable frequency, reflecting the methodological and conceptual dimensions of hybrid recommendation research. Although less frequent, terms like “matrix factorization,” “similarity,” and “diversity” suggest that technical aspects remain relevant to ongoing scholarly discussions. Overall, the distribution of terms demonstrates both the dominance of core system-related concepts and the diversity of specialized approaches within the literature.

Figure 13: Bibliometric word cloud of “Keywords Plus” generated via WoS

Figure 14 presents the word cloud generated from the titles and abstracts of documents related to hybrid recommendation research. The visualization emphasizes collaborative filtering, recommendation

system(s), and recommendation algorithm as the most salient terms, reflecting their central importance within the field. The dominance of collaborative filtering is particularly notable, while different variations of recommender system and algorithm-related terminology also appear prominently, underscoring their consistent role across the literature.Additional recurring terms such as recommendation model, personalized recommendation, deep learning, and neural networks indicate a methodological shift toward personalization and the integration of machine learning approaches. These findings suggest that while collaborative filtering remains the dominant paradigm, research interest has increasingly diversified toward hybridization and algorithmic innovation.

Figure 14: Frequent Keyword Pairs in Hybrid Recommendation Literature

3.8.Thematic Cluster Analysis

The thematic map displayed in Figure 15 provides an overview of the conceptual organization of hybrid recommendation research. By combining centrality and density measures, the map illustrates how key topics are positioned within the intellectual structure of the field. Centrality reflects the extent to which a theme is connected to other research areas, whereas density measures the internal coherence of each theme (Cobo et al., 2011). These two dimensions make it possible to classify themes into four quadrants: motor, basic, niche, and emerging/declining.

Within the map, motor themes such as clustering algorithms and internet-related studies appear highly developed and central, reflecting their established role in the advancement of recommendation technologies. Basic themes, including collaborative filtering, recommender systems, and hybrid recommendation, occupy a central but less dense space, indicating their foundational importance across a wide range of publications. In contrast, niche themes such as graph-based techniques or contextual algorithms are well developed but peripheral, suggesting that they are more specialized lines of inquiry. Finally, emerging or declining themes like digital libraries and information retrieval reflect areas that are either losing momentum or have yet to consolidate as sustainable directions.

Overall, the thematic map demonstrates that hybrid recommendation research is anchored in classical methods such as collaborative filtering while progressively integrating more specialized approaches. This balance between stable core themes and evolving niche areas highlights both the maturity and the dynamic potential of the field.

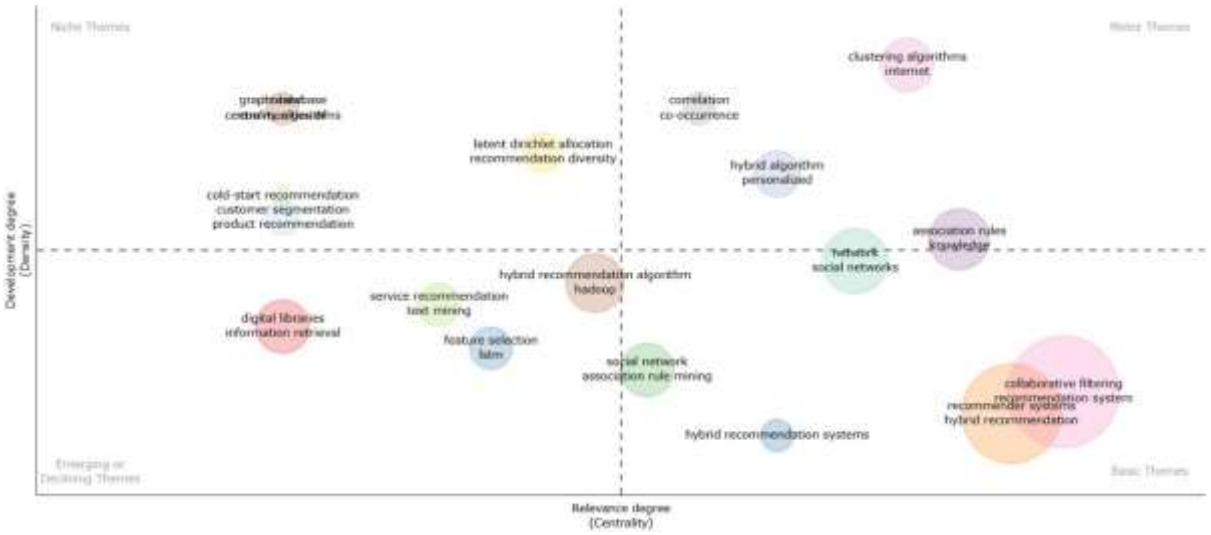

Figure 15: Thematic Mapping of Keywords in Hybrid Recommendation Research

Figure 16 illustrates the thematic map derived from bigrams appearing in the titles of documents on hybrid recommendation research. The map categorizes themes into four quadrants according to their centrality and density, offering insights into the structural role of different concepts in the field. Basic themes, such as hybrid recommendation, recommendation system, and collaborative filtering, appear as foundational topics that anchor much of the research activity. These terms reflect well-established approaches that remain central to the literature.

In contrast, motor themes such as clustering-based methods and usage mining show strong centrality and density, indicating their importance in advancing methodological development. Niche themes, including user interface and ant colony approaches, highlight specialized areas with limited but focused exploration, while emerging or declining topics such as movie recommendation and recommendation technique suggest shifting interest or reduced attention in recent years. Collectively, the thematic structure underscores both the consolidation of core research areas and the diversification into more specialized or transient directions within hybrid recommendation studies.

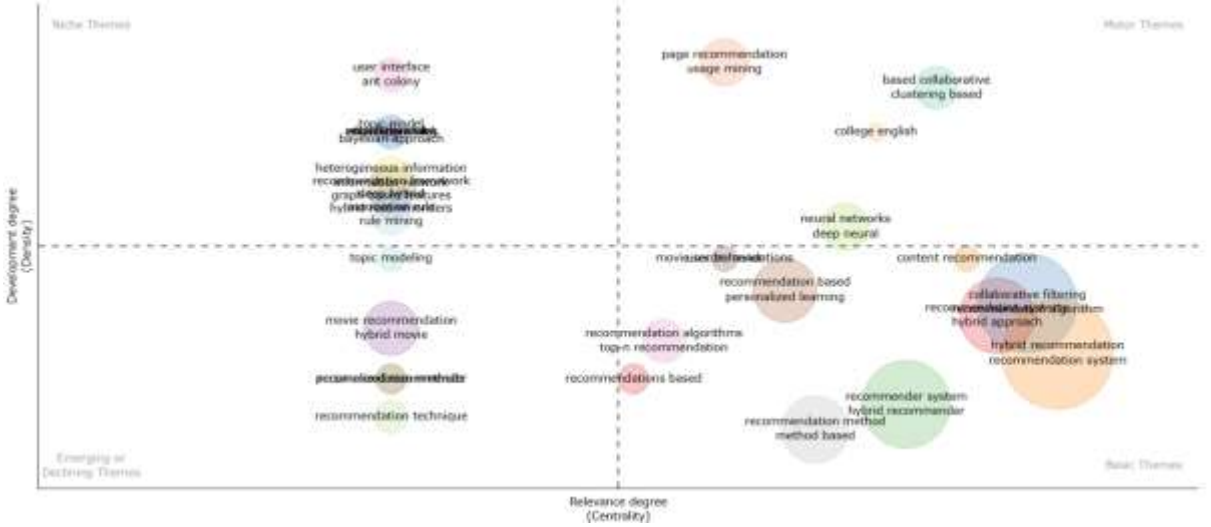

Figure 16: Thematic Distribution of Frequently Used Bigrams in Titles

4.Conclusion

This bibliometric analysis provided a comprehensive examination of the evolution, impact, and thematic development of research on hybrid recommender systems. By analyzing publication and citation trends, influential authors and institutions, geographical contributions, and thematic structures, the study sheds light on both the consolidation of established methods and the diversification of emerging topics. The findings reveal that hybrid recommendation research has grown steadily, supported by strong collaborations among authors, institutions, and countries. Moreover, the analysis highlights not only the central role of well-established techniques such as collaborative filtering and content-based methods but also the increasing diversification into niche and specialized domains.

The study's results underscore the relevance of hybrid recommender systems as a sustained and maturing research area. However, despite this progress, several challenges remain, particularly regarding scalability, interpretability, and data privacy. These issues provide fertile ground for future research efforts. In addition, the role of hybrid approaches in interdisciplinary domains—such as healthcare, education, and smart environments—represents an important avenue for innovation, given the growing demand for personalized and context-aware systems.

Looking forward, future work may benefit from integrating hybrid recommendation with advances in machine learning, deep learning, and explainable artificial intelligence to enhance both performance and transparency. Furthermore, as sustainable development goals (SDGs) become increasingly central to global research agendas, exploring the societal and ethical implications of hybrid recommenders will be crucial. By addressing these directions, hybrid recommender system research can continue to expand its academic significance while providing tangible benefits across diverse application areas.

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