Postprint: BERTopic-Based Study of "Science-Technology" Themes in Domestic Smart Library Research

Authors: Gao Daobin

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Abstract

[Purpose/Significance] Identify and analyze the "science-technology" themes in domestic smart libraries, provide intelligence support for scientific research and technological development in this field, and offer references for the bidirectional flow of knowledge between science and technology. [Method/Process] Using 5,436 Chinese journal articles from the CNKI database and 1,416 Chinese patents from the incoPat database as data sources to represent scientific and technological carriers respectively, identify "science-technology" themes based on the BERTopic model, and analyze inter-theme clustering results, important research themes, and thematic evolution trends. On this basis, analyze the interactive relationships between important scientific research themes and technological research themes, and propose implications for future related research. [Results/Conclusion] Based on the BERTopic model, the scientific research domain is divided into 4 categories encompassing 5 important scientific themes; the technological research domain is divided into 3 categories including 3 important technological themes; and 7 "science-technology" interactive relationships are identified. Accordingly, four research implications are proposed: following policy guidance and scenario-based application orientation to promote the transformation of research results from theory to practice; expanding service research oriented toward public smart libraries to achieve equal emphasis on "public libraries—university libraries" ; enhancing the sustainability of various thematic studies in smart libraries to consolidate the depth of scientific and technological exploration; and emphasizing the introduction of technical information support to increase the degree of "science-technology" interaction.

Full Text

Research on Theme of "Science-Technology" in Domestic Smart Libraries Based on BERTopic

Gao Daobin
(WISE Lab, Institute of Science of Science and S&T Management, Dalian University of Technology, Dalian 116024, China)

Abstract:
[Purpose/Significance] This study identifies and analyzes the "science-technology" themes in domestic smart libraries to provide intelligence support for scientific research and technological development in this field, and to offer references for the bidirectional flow of knowledge between science and technology. [Method/Process] Using 5,436 Chinese papers from the CNKI journal database and 1,416 Chinese patents from the incoPat patent database as data sources to represent scientific and technological carriers respectively, the BERTopic model was applied to identify "science-technology" themes, analyze clustering results between themes, important research themes, and theme evolution trends. Based on this, the interactive relationships between various important scientific research themes and technological research themes were analyzed, and future research implications were proposed. [Result/Conclusion] The BERTopic model divided the scientific research field into four categories, encompassing five important scientific themes; the technological research field was divided into three categories, including three important technical themes; and a total of seven "science-technology" interactions were identified. Four research implications are proposed: follow policy guidance and scenario-based application orientation to promote the transformation of research results from theory to practice; expand service research for public smart libraries to achieve equal emphasis on "public libraries and university libraries" ; enhance the sustainability of various thematic research in smart libraries to solidify the depth of scientific and technological exploration; and focus on introducing technical information support to increase the degree of "science-technology" interaction.

Keywords: Smart library; BERTopic; Scientific theme; Technical theme; Interaction status

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With the deepening development of digital intelligence technologies and the shifting direction of user information service demands, intelligent transformation has become an inevitable trend in the development of libraries in China. In this context, research on smart libraries has become a hot topic in the domestic library and information science field. In terms of policy planning, the *Outline of the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives Through 2035* of the People' s Republic of China [**?**] identifies smart library construction as an important component of

digital transformation. The development and construction of smart libraries require both technology as the foundational architecture to empower various intelligent services such as book return, automatic tag organization, and environmental perception, and scientific research to guide their path and direction, such as identifying problems, proposing theoretical frameworks, and planning development pathways.

Currently, domestic research on the development status of smart libraries primarily focuses on scientific papers. For example, Wang Fei et al. [**?**] used domestic smart library papers published before 2021 as data sources, employing word frequency analysis and social network analysis to quantitatively analyze the research status of smart library culture and reveal research hotspots. Ding An et al. [**?**] used CNKI as a data source to analyze the research status and hotspot content of smart libraries in China from 2009 to 2018, revealing smart library service models, existing problems, and coping strategies. Li Xianzhi et al. [**?**] conducted bibliometric analysis using data from VIP, CNKI, and Wanfang databases, finding that Chinese scholars have conducted in-depth discussions on basic issues of smart libraries and preliminarily conceived construction and service models. Additionally, a few studies have analyzed the technological development status of domestic smart libraries using patents as data sources. For instance, Pei Hongjiao et al. [**?**] used the National Intellectual Property Administration database to conduct basic quantitative analysis of domestic smart library patents from 2013 to 2022, finding that technologies such as RFID and artificial intelligence are still in the exploratory development stage in China' s smart libraries, and proposed that future technological innovation capabilities could be improved through strengthening subject cooperation, utilizing patent technologies from research institutes, and consolidating theoretical foundations. Zhao Kun [**?**] used domestic smart library patents before 2022 as analysis carriers and employed CiteSpace and VOSviewer for co-occurrence analysis of patent keywords and patentee relationships.

Evidently, domestic research on the development status of smart libraries emphasizes analysis from a single data carrier, such as papers or patents, to identify field research trends and hotspots, with few studies considering both types of analysis, and even fewer exploring the interactive relationship between science (papers) and technology (patents). Current research mostly employs simple bibliometric or patentometric methods, such as word frequency statistics, social network analysis, and quantity trend analysis, with fewer studies using deep learning methods for domain theme identification and analysis, resulting in coarse-grained revelation of research status and themes that fails to meet the needs of fine-grained text semantic analysis. The deep learning-based BERTopic theme modeling method can effectively address these issues. This model is an unsupervised deep learning theme modeling tool based on BERT, with powerful language feature extraction capabilities that consider the semantics, structure, and sequence behind text vocabulary, making the resulting themes highly interpretable and achieving word sense disambiguation to a certain extent [**?**]. Moreover, the model does not require manual setting of the number of themes,

offering certain advantages over text theme models such as LDA and DTM. Currently, the BERTopic theme model has been applied by domestic scholars to theme identification and content analysis in digital government governance [**?**], theme evolution research on health information needs of the elderly [**?**], and analysis of research progress in foreign information resource management [**?**], demonstrating its good text mining and theme identification capabilities and strong universality.

In summary, to address the lack of "science-technology" interaction analysis in domestic smart library research, the insufficient ability of research methods to deeply mine text semantics, and the coarse-grained revelation of theme information, this paper employs the BERTopic theme model, using papers to represent scientific carriers and patents to represent technological carriers. From a dual "science-technology" perspective, it identifies smart library "science-technology" themes and analyzes the "science-technology" interaction status, aiming to provide intelligence support for scientific research and technological development in this field and data references for the bidirectional flow of "science-technology" knowledge.

1 Research Process

The research process mainly includes three parts: data acquisition and processing, BERTopic model application, and identification and analysis. (1) **Data acquisition and processing**: Papers and patents were used to represent scientific and technological carriers respectively. After eliminating literature such as paper topic guidelines and recommendations, as well as patents with missing abstracts, the abstracts of the scientific and technological carrier collections underwent text corpus preprocessing and cleaning to form the original corpus collection. (2) **BERTopic model application**: The preprocessed and cleaned abstract corpus was embedded into a BERT-based language pre-training model, using the Transformer structure to calculate abstract word vectors; UMAP was used to reduce the dimensionality of the sentence embeddings obtained in the previous step, improving the efficiency and computational accuracy of the clustering algorithm; The HDBSCAN algorithm was used to aggregate literature data with similar attributes, automatically selecting the number of theme clusters to form theme clusters; The top-ranked theme keywords under each scientific and technological theme based on c-TF-IDF weights were extracted, and hierarchical clustering functionality was used for visual presentation of theme hierarchical clustering. (3) **Identification and analysis**: The annual quantity distribution characteristics of scientific and technological carriers were used as the basis to analyze the quantity change trends of the two types of carriers; In-depth analysis was conducted on the hierarchical clustering results of each scientific and technological research theme, important research themes (with theme strength represented by the number of documents distributed under the theme, and themes with strength greater than or equal to the average theme strength underwent secondary manual classification and

naming), and the evolution trends of important research themes; Based on the average cosine similarity of all document collection abstract corpora between various important scientific and technological research themes, the "science-technology" theme interaction relationships were analyzed. The above research process is shown in Figure 1 [Figure 1: see original paper].

2.1 Data Acquisition

Scientific carriers used the CNKI journal database as the data source. Referring to previous research results [**?**] and improving and expanding upon them, the final search formula was determined as: "SU%=(智慧 OR 智能 OR 自动 OR 感知 OR 云计算 OR 大数据 OR 物联网) AND SU%=(图书馆)". Since the concept of "smart library" was formally proposed in 2003 [**?**], the publication date was set from January 1, 2003, to August 1, 2024, with the search date being August 1, 2024. After further eliminating literature types such as journal topic guidelines and book recommendations, a total of 5,436 papers in the domestic smart library field were obtained, with fields including title, author, abstract, and publication time saved as the scientific carrier data source for this study.

Technological carriers used the incoPat patent database as the data source. The search formula was the same as for scientific carriers, with only the search field markers modified to adapt to database search requirements: "TIAB=(智慧 OR 智能 OR 自动 OR 感知 OR 云计算 OR 大数据 OR 物联网) AND TIAB=(图书馆)". The application date was set from January 1, 2003, to August 1, 2024, the patent office was set to China, and the patent type was set to authorized inventions and invention applications, with the search date being August 1, 2024. After eliminating patents with missing abstracts, a total of 1,416 patents in the domestic smart library field were obtained, with fields including title, publication number, abstract, and application time saved as the technological carrier data source for this study.

2.2 "Science-Technology" Carrier Quantity Trend Analysis

Within the 2003-2024 timeframe, the distribution quantities of scientific and technological carriers were used as data sources to plot the overall change trend of "science-technology" carrier quantities, revealing the field' s development overview from both "quantity" and "trend" perspectives, with results shown in Figure 2 [Figure 2: see original paper].

As shown in Figure 2, between 2003 and 2010, the quantities of scientific and technological carriers were roughly equivalent. Between 2011 and 2024, the annual distribution quantity of scientific carriers was higher than that of technological carriers. From a pure quantity distribution perspective, it can be judged that early scientific research and technological research progressed side by side, but after 2011, scientific research activity was higher than technological research. From a quantity distribution trend perspective, both had small base numbers and change amplitudes before 2010. The distribution quantity

of scientific carriers showed a significant upward trend between 2011 and 2023 compared to 2003-2010, while the quantity of technological carriers showed an overall upward trend between 2011 and 2018, but a significant overall downward trend between 2020 and 2024.

2.3.1 Scientific Research Theme Hierarchical Clustering Results Analysis

Based on the BERTopic model, 39 scientific research themes in the domestic smart library field were identified. The hierarchical clustering function of the BERTopic model was used to display the theme names and hierarchical clustering of all scientific research themes, as shown in Figure 3 [Figure 3: see original paper].

As shown in Figure 3, based on the color distribution in the hierarchical clustering map, the domestic smart library scientific research field can be roughly divided into four categories. (1) **Dark green clustering results**: Smart library data governance and social altruistic behavior. The scientific research themes under this clustering include: Theme 36 (governance_{{{data}}*{{circle}}}), *Theme 37 (social*{altruistic} behavior_{information}), and Theme 27 (spirit_{{{ancient}}_{{library}}} science). Wang Jing et al. [**?**] pointed out that data governance for smart services in university libraries is an important research area in smart libraries, and the emergence of digital twin technology provides new solutions for the fusion of information physics in the data governance process. In the data era, data governance and smart services have become one of the focal points of library development [**?**]. From the librarian' s perspective, altruistic behavior refers to the library' s wholehearted service to readers and selfless satisfaction of readers' needs. The library' s altruistic behavior is reflected in library construction, management, services, and development, demonstrating the high social responsibility and obligation of librarians, as well as their noble morality and humble cultivation [**?**].

(2) **Red clustering results**: Smart public cultural services under the 14th Five-Year Plan. The scientific research themes under this clustering include: Theme 29 (14th Five-Year Plan_{public}), Theme 9 (public_{{{smart}}*{{service}}}), *and Theme 11 (public*{{{culture}}_{{reading}}}), etc. Entering the 14th Five-Year period, a new journey of comprehensively building a modern socialist country has begun, ushering in an important opportunity period for library transformation and development. The *14th Five-Year Public Service Plan* [**?**] proposes to "promote the construction of a national smart library system···and other facilities to be opened free of charge or at a discount as stipulated." During the 14th Five-Year period, smart technologies such as big data, cloud computing, and artificial intelligence continue to develop and apply in depth, bringing new opportunities for the transformation of public library smart service methods [**?**]. Du Xilin et al. [**?**] research shows that digital intelligence empowerment of public

library service system innovation has advantages and risks, requiring seeking empowerment entry points and methods from five paths—users, librarians, resources, space, and technology—to promote public library service system innovation. Qin Chunyang [**?**], based on in-depth analysis of the internal structural elements of the public library smart service system, focused on the optimized development of the smart service system, proposing to update service concepts to guide the development direction of the smart service system and reform service methods to promote quality changes in the smart service system.

(3) **Cyan clustering results**: University smart library service platform construction and space reengineering. The scientific research themes under this clustering include: Theme 2 (university_{{{service}}*{{construction}}}), Theme 18 (university*{{{service}}*{{smart}}}), and Theme 23 (platform*{service} platform_{user}), etc. Under the wave of library intelligent transformation and development, domestic university libraries actively explore the transformation from resource management models to service management models [**?**]. Du Pengnuo [**?**] proposed constructing university smart library service platforms from three aspects: promoting precise service mechanisms to create smart humanities benchmarks; constructing smart reading resource systems to connect resource utilization channels; and combining virtual and real to strengthen reading experiences while technology drives expanded space services. Ma Jie et al. [**?**] combined the service objects and business characteristics of university libraries to design and construct the functional structure of university smart libraries from three dimensions: smart services, smart buildings, and smart management. Che Baojing et al. [**?**] investigated 42 "Double First-Class" university libraries, summarized the current status and practical dilemmas of digital intelligence-empowered subject services, and proposed transformation paths for digital intelligence-empowered university library subject services, including using digital intelligence technology to enrich smart subject service scenarios and constructing virtual-reality integrated, function-optimized smart subject service spaces.

(4) **Burgundy clustering results**: Smart library technology empowerment and user privacy management. The scientific research themes under this clustering include: Theme 30 (chatgpt_{artificial} intelligence_{application}), Theme 8 (rfid_{{{technology}}*{{application}}}), and Theme 21 (protection*{{{privacy}}_{{personal}}} information), etc. Technologies such as artificial intelligence, big data, and cloud computing enable the value of library data to be transformed; however, the process of data value discovery inevitably involves reader privacy [**?**]. While actively seeking technology empowerment, libraries must maintain a prudent attitude, developing smart service innovations suitable for library needs on the basis of fully respecting user privacy and ensuring user information security, and avoiding security risks behind technologies [**?**]. Guo Jun [**?**], based on analyzing the reasons for infringement of library

users' personal information in smart environments, constructed a library user personal information protection work framework including four modules: prevention and early warning, process control, accountability, and institutional supervision. Mei Zhenrong et al. [**?**] proposed applying blockchain technology to user privacy protection in smart libraries, drawing on technologies such as timestamps, hash functions, Merkle trusted trees, and consensus mechanisms to construct a user privacy protection architecture model integrating tamper-proof smart chains, privacy encryption, and secure storage mechanisms.

2.3.2 Important Scientific Research Theme Analysis

In the domestic smart library field, there are 11 scientific research themes with theme strength (represented by the number of papers distributed under the theme) greater than or equal to the mean. After further secondary manual classification and naming based on keyword semantics among the themes, five important scientific research themes were ultimately obtained. The theme names and theme strength before and after classification are shown in Table 1 .

As shown in Table 1, the theme "Smart Library Smart Cultural Services" has the highest theme strength, indicating that this research theme occupies a core position in domestic smart library-related research with prominent leading effects. This theme focuses on providing various smart cultural services to users through smart libraries to enhance user experience, reflecting that practical discussions on the cultural dimension are important research issues in smart library development. Smart libraries endow cultural services with intelligence and proactivity, with important research content including improving smart cultural service levels, providing scenario-based smart cultural services, and resolving service problems in smart cultural services.

The theme "University Smart Library Service Level" ranks second in theme strength, indicating that the domestic smart library field has extensively discussed how to improve the smart service level of university libraries, promote efficient utilization of learning resources, and meet the diversified learning needs of teachers and students. University smart libraries are one of the important smart entities compared to public smart libraries, focusing not only on smart mining, analysis, push, and retrieval of rich collection resources to provide efficient and personalized knowledge acquisition pathways for university teachers and students, but also emphasizing the optimization and construction of service content such as intellectual property management and sci-tech novelty searches, with greater focus on the intellectualization of campus research resources.

The theme "Smart Library Emerging Technology Application" ranks third in theme strength, reflecting the important supporting role of various technical elements in domestic smart library research. The intellectualization of smart libraries requires the assistance of various technologies, such as RFID, IoT technology, and cloud computing technology to achieve automatic identification,

classification, and positioning of book tags in libraries; and emerging technologies such as large language models, augmented reality, and digital twins to empower smart libraries to achieve smart user communication and immersive reading services. The application of emerging technologies enables smart libraries to continuously break through service boundaries and improve intelligence levels.

The theme "Smart Library Learning Center Construction" ranks fourth in theme strength, indicating that researchers in this field are gradually dispersing their research on smart library entities to various scenario-based smart library entities. Taking the smart library future learning center as an example, through the transformation of library learning spaces with various digital intelligence technologies, services such as learning resource push, learning portrait construction, and learning environment optimization for various learners are realized, making it a current hot research topic.

The theme "Public Smart Library Cultural Service System" ranks fifth in theme strength, indicating that researchers in this field attach importance to this issue. Compared with university smart libraries, public smart libraries have more diverse service groups and more dispersed service content. Based on the knowledge structure differences of various service groups, public smart libraries integrate various cultural resources, use digital intelligence technology means, construct comprehensive, multi-level, and efficient cultural service systems, and provide quality reading services for various service groups.

2.3.3 Important Scientific Research Theme Evolution Trend Analysis

Using time as the horizontal axis and theme strength of important scientific research themes as the vertical axis, evolution trend analysis was conducted on five important scientific research themes in the domestic smart library field, with results shown in Figure 4 [Figure 4: see original paper].

As shown in Figure 4, before 2012, the theme strength of each important scientific research theme was relatively low. After 2012, the theme strength of each important scientific research theme increased significantly and maintained a stable upward trend overall. Among them, the theme "Smart Library Smart Cultural Services" showed a larger changing trend in theme strength after 2012, specifically demonstrating a stable upward trend from 2012 to 2023, with significant increases between 2018 and 2023, indicating that the research heat of this theme continues to rise, making it an important research topic in the field. The other four important scientific research themes had relatively small differences in theme strength between 2012 and 2018, but after 2018, the theme strength of "University Smart Library Service Level" significantly diverged from the other three themes, indicating that scholars in the field are gradually focusing on research related to university smart library services. In addition, the theme strength of the three important scientific research themes—"Smart Library Learning Center Construction," "Smart Library Emerging Technology Application,"

and "Public Smart Library Cultural Service System"—were relatively low overall, but have increased significantly in the past five years, representing important scientific research branches in the field.

2.4.1 Technical Research Theme Hierarchical Clustering Results Analysis

Based on the BERTopic model, 25 technical research themes in the domestic smart library field were identified. The hierarchical clustering function of the BERTopic model was used to display the theme names and hierarchical clustering of all technical research themes, as shown in Figure 5 [Figure 5: see original paper].

As shown in Figure 5, based on the color distribution in the hierarchical clustering map, the domestic smart library technology research field can be roughly divided into three categories: (1) **Dark green clustering results**: Smart library book movement and access technology. The technical research themes under this clustering include: Theme 22 (installation_{{{rotation}}*{{connection}}}), *Theme 10 (mechanism*{{{trolley}}*{{rotation}}}), and *Theme 13 (horizontal*{{{bookshelf}}_{{book}}} board), etc. For example, patent CN112025668B [**?**] discloses a book transport vehicle in libraries that can effectively identify information of returned books through automatic identification devices, automatically classify and place books on different horizontal boards, with books on the same horizontal board being placed on the same bookshelf, facilitating staff to quickly return books to their positions. Another example is patent CN111015692A [**?**], which discloses an automatic book storage manipulator for libraries. This device has a simple structure and convenient operation, completing precise book return for citizens through mechanical transmission and automated manipulator operations, greatly reducing librarians' workload and improving book return efficiency.

(2) **Red clustering results**: Smart library intelligent book sorting and personalized reading technology. The technical research themes under this clustering include: Theme 0 (intelligent_{{{book}}*{{book}}}), *Theme 1 (rfid*{{{book}}*{{tag}}}), *and Theme 19 (information*{{{collection}}_{{user}}}), etc. In terms of intelligent book sorting technology, patent CN111797939A [**?**] discloses an intelligent recognition system and method based on wavelet analysis and deep learning for unmanned libraries, achieving precise recognition of book spine information, avoiding reliance on traditional RFID tags and barcode tags, with high automation and no manual operation required. Patent CN107153854B [**?**] discloses an automated book inventory method based on ultra-high frequency RFID technology, which can perform hyperbolic fitting on the phase signals of book tags, establish models, and determine book positions on shelves based on model coefficients. In terms of personalized reading services, patent CN107423413A [**?**] discloses a digital library management service system based on cloud computing, which uses massive data resources

and computing capabilities to provide personalized user services for digital libraries, and through behavior pattern analysis of users' browsing, borrowing, and search records, provides more comprehensive personalized services while ensuring user privacy.

(3) **Cyan clustering results**: Smart library intelligent book management and reading assistance technology. The technical research themes under this clustering include: Theme 6 (disc_{self}-service_{equipped}), Theme 24 (module_{{{frame}}*{{reading}}}), and *Theme 20 (inventory*{{{cleaning}}_{{image}}}), etc. In terms of intelligent book management, patent CN103295034B [**?**] discloses a DSP-based embedded book misplacement inventory system and method, which can achieve automatic inventory of books on shelves in libraries, with simple hardware structure, small software code, low power consumption, strong real-time performance, miniaturization, and low cost, enabling rapid completion of book inventory and stocktaking work for large-circulation services in libraries. In terms of reading assistance technology, patent CN107274314A [**?**] discloses an intelligent library seat allocation system with intelligent control and strong autonomy, which can query seat details in real-time through WIFI-connected mobile phones, significantly alleviating librarians' workload and improving the turnover rate and usage efficiency of library seats.

2.4.2 Important Technical Research Theme Analysis

In the domestic smart library field, there are six technical research themes with theme strength (represented by the number of patents distributed under the theme) greater than or equal to the mean. After further secondary manual classification and naming based on keyword semantics among the themes, three important technical research themes were ultimately obtained. The theme names and theme strength before and after merging are shown in Table 2 .

As shown in Table 2, the theme "Smart Library Information Resource Management System" has the highest theme strength, indicating that this technology occupies a core leading position in smart library construction. The information resource management system is an application collection that collects, analyzes, processes, and uses various digital resources of smart libraries, playing an important role in improving resource management efficiency, service quality, and knowledge dissemination in smart libraries. This theme reflects that under the drive of digital intelligence technologies such as big data and artificial intelligence, developers in the smart library technology field have urgent needs and practical orientations for efficiently integrating, intelligently analyzing, and precisely pushing information resources.

The theme "Intelligent Book Tagging and Retrieval Technology" ranks second, revealing the importance developers in the smart library technology field attach to improving information retrieval efficiency and book organization efficiency in

smart libraries. Intelligent book tagging and retrieval technology complement each other, enabling fine classification and rapid positioning of books, greatly simplifying user retrieval processes and improving information acquisition convenience. For example, RFID technology can achieve automated book borrowing, returning, positioning, and classification operations, improving smart library service efficiency. For librarians, intelligent tagging technology enables automatic book classification, shelving, and inventory, reducing workload. For users, the embedding of intelligent retrieval technology facilitates expressing their reading needs through voice and other methods, enabling precise and fast retrieval of required reading resources.

The theme "University Smart Library User Behavior Analysis Technology" ranks third in theme strength, indicating that developers in the smart library technology field focus on using digital intelligence technology to collect, process, and analyze user behavior data in university libraries, revealing user reading habits, interest preferences, and information needs. This technology is directly related to the service quality and user satisfaction of university smart libraries. By analyzing user reading records, search history, and other behavioral data, libraries can recommend reading and learning resources that match users' interests and needs. From a scientific research perspective, user behavior analysis technology can also provide data support for academic research, helping researchers understand academic research hotspots and development trends.

2.4.3 Important Technical Research Theme Evolution Trend Analysis

Using time as the horizontal axis and theme strength of important technical research themes as the vertical axis, evolution trend analysis was conducted on three important technical research themes in the domestic smart library field, with results shown in Figure 6 [Figure 6: see original paper].

As shown in Figure 6, between 2004 and 2010, the theme strength of each important technical research theme experienced a small range of "rise-fall" trends. Between 2010 and 2016, each important technical research theme experienced dynamic changes with ups and downs, but with small differences in theme strength among them. Between 2016 and 2024, the theme strength of "Smart Library Information Resource Management System" diverged significantly from the other two themes, showing a significant leading trend and reaching its peak in 2018, revealing the importance of this theme in the smart library technology system. The theme strength of "Library Intelligent Tagging and Retrieval Technology" and "University Smart Library User Behavior Analysis Technology" had small differences between 2016 and 2024, with overall dynamic change trends. Compared with the larger fluctuations in theme strength between 2010 and 2016, they represent important technical research branches in the field.

3 Domestic Smart Library "Science-Technology" Theme Interaction Status Analysis

Using the abstracts of papers belonging to the five important scientific research themes and the abstracts of patents belonging to the three important technical research themes as data sources, after corpus cleaning and preprocessing, TfidfVectorizer was used for TF-IDF vectorization representation of the corpora. The average cosine similarity between text collections of each important scientific research theme and each important technical research theme was further calculated pairwise. When the calculation result was greater than or equal to the mean value of 0.3151, it indicated an interaction relationship between the "science-technology" themes. The Sankey diagram of the interaction status of important "science-technology" research themes based on calculation results is shown in Figure 7 [Figure 7: see original paper].

As shown in Figure 7, the scientific theme "Smart Library Emerging Technology Application" has the widest interaction scope with various technical themes, having interaction relationships with all three technical themes, indicating that this scientific theme has strong technological cross-disciplinary characteristics and extensively borrows technologies such as intelligent book tagging, intelligent retrieval, and user behavior analysis in its research content. The scientific theme "Smart Library Smart Cultural Services"ranks second in interaction quantity, having interactions with the technical themes "University Smart Library User Behavior Analysis Technology" and "Smart Library Information Resource Management System" . In contrast, the scientific theme "Public Smart Library Cultural Service System" has no interaction with any technical themes, indicating that the technical support under this research theme is relatively weak, with relatively low borrowing from technical content, and needs further deepening of technical support in research content.

Conversely, from the technical theme perspective, the theme "University Smart Library User Behavior Analysis Technology" has the widest interaction scope with various scientific themes, having interaction relationships with four scientific themes, indicating that this technology has strong knowledge traction and can provide technical groundwork for smart library learning center construction, university smart library service level improvement, and smart library smart cultural services. The technical theme "Smart Library Information Resource Management System" ranks second in interaction quantity, indicating that the information resource management system is an important technical focus direction for scholars under the research themes of "Smart Library Smart Cultural Services" and "Smart Library Emerging Technology Application" in China. The theme "Intelligent Book Tagging and Retrieval Technology" has the weakest interaction with scientific themes, having interaction only with the scientific theme "Smart Library Emerging Technology Application" , indicating that this technology is relatively weakly discussed in scientific research in the domestic smart library field, with significant room for expansion.

Overall, the degree of interaction between "science-knowledge" in the domestic smart library field is relatively low. Among the 15 interaction connections, only 7 have interaction relationships, a proportion that has not reached half. Meanwhile, except for the theme "Smart Library Emerging Technology Application" , other scientific themes have 0-2 interaction relationships, reflecting on one hand that some scientific research lacks introduction of smart library technologies, with weak technical support, and on the other hand, that there is significant room for improvement in technology introduction and interaction in future research.

4.1 Follow Policy Guidance and Scenario-Based Application Orientation to Promote Transformation from Theory to Practice

Based on the scientific research theme identification results, there are few research themes oriented toward relevant policy guidance, and research themes oriented toward fine-grained scenario-based smart library construction entities, such as learning centers, are also relatively scarce. In view of this, scholars in the domestic smart library field can closely integrate their research topics with the guidance content related to smart libraries in various national and provincial policies. For example, the *Outline of the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives Through 2035* [**?**] proposes to deeply develop smart libraries and smart tourism, establishing a smart development strategic goal for integrating China' s library and tourism industries from the national policy level. This enlightens field researchers to deeply explore research topics of "smart library + smart culture and tourism" , and to carry out smart library research topics guided by national policies and meeting national strategic development needs from principles, strategies, paths, frameworks, and other aspects, from point to surface. Field scholars can consider conducting research on different scenario-based construction entities for smart libraries. Currently, the more focused construction entity is the smart library future learning center, with university teachers and students as the main research objects. To enrich research content for different scenario-based construction entities and refine practical strategies, field researchers can explore practical research on construction entities such as smart library "reading therapy spaces" , "red literature reading rooms" , "self-service areas" , and "art exhibition rooms" , promoting the transformation of theoretical frameworks, optimization strategies, implementation paths, etc., in research results to practice.

4.2 Expand Service Research for Public Smart Libraries to Achieve Equal Emphasis on "Public Libraries and University Libraries"

Based on the "science-technology" theme identification and analysis results, the current research entities in the field focus on university smart libraries. For

example, "University Smart Library Service Level" among important scientific research themes and "University Smart Library User Behavior Analysis Technology" among important technical research themes both focus on university smart libraries as entities, and the theme strength of related research themes is significantly higher than that of research themes oriented toward public smart libraries. This enlightens field researchers to expand service research for public smart libraries to achieve equal emphasis on "public libraries and university libraries". Compared with university smart libraries, public smart libraries have more diverse service entities, which enlightens field researchers to combine the knowledge structures and reading needs of various service groups to explore unique service models and paths for public smart libraries, such as community co-construction and sharing, and public smart library alliances. At the same time, as one of the important promoters of national reading promotion, how public smart libraries can break through the "last mile of reading" for vulnerable groups such as the elderly and left-behind children is worthy of in-depth exploration by field researchers.

4.3 Enhance the Sustainability of Various Thematic Research in Smart Libraries and Solidify the Depth of Scientific and Technological Exploration

Based on the evolution analysis results of important scientific research themes and important technical research themes, some themes of both have experienced fluctuating theme strength trends within certain time ranges, limiting the continuity of research on some science and technology themes to a certain extent. This enlightens field researchers and technology developers to enhance the sustainability of various thematic research in smart libraries and solidify the depth of knowledge and technology exploration. For field researchers, they can continuously focus on research themes such as "Smart Library Learning Center Construction" and "Public Smart Library Cultural Service System", deeply explore how to borrow different theories and technologies to improve the service effectiveness of smart library learning centers, or explore how public smart libraries can develop reading service strategies for different social groups, further continuously iterating and optimizing previous research from the horizontal time dynamic development section, and promoting research results on the above themes to develop in depth from the vertical level, enhancing knowledge embedding depth. For field technology developers, they can consider appropriately strengthening continuous research on the themes of "Intelligent Book Tagging and Retrieval Technology" and "University Smart Library User Behavior Analysis Technology", iteratively optimizing various smart library book labeling, retrieval, positioning, and user behavior analysis strategies based on IoT, RFID, big data, cloud computing, facial recognition, etc., providing novel technical information references for smart library-related scientific research.

4.4 Focus on Introducing Technical Information Support to Increase the Degree of "Science-Technology" Interaction

Based on the "science-technology" theme interaction status analysis results, among the five important scientific research themes and three important technical research themes, there are only seven interaction relationships, and the important scientific research theme "Public Smart Library Cultural Service System" has no interaction with other important technical research themes. This reflects that current scientific research in the smart library field has insufficient discussion, introduction, and borrowing of technical content, with weak technical integration. Field researchers can focus on introducing technical support to increase the degree of "science-technology" interaction. Currently, various large language model technologies and artificial intelligence-generated content technologies are the focus of attention in academia, technology fields, and society and people' s livelihood. To enhance research foresight, field researchers can widely explore various emerging technologies, integrate them into the implementation principles and micro-practice strategies of smart library service content provision, service system optimization, librarian skill improvement, and library functional area construction, and can also discuss the ethical boundaries and privacy issues of emerging digital intelligence technologies applied to smart library construction from ethical and privacy perspectives.

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Note: Figure translations are in progress. See original paper for figures.