Construction of Library User Profile Models for Precision Services: Postprint

Authors: Yu Xingshang, Yingsheng Wang

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Abstract

Purpose/Significance: Based on user profiling, this study constructs a library precision service model to provide reference for delivering precise services to users and offer a new direction for precision services in the library community.

Method/Process: Taking five dimensions as data sources—user basic data, user dynamic behavior data, psychological characteristic data, contextual perception data, and social network data—the model constructs a data source layer, data processing layer, user data warehouse, and precision application layer based on user profiling technology, creating service features including online service push, personalized recommendation, user churn warning, user relationship management, and scenario-based services.

Results/Conclusion: Although user profiling technology holds significant utilization value for user precision services, user privacy and security should also be taken into consideration. Therefore, protecting user privacy from the perspectives of technology, user awareness and privacy policy, and multi-dimensionality, coupled with the implementation of user profiling technology in libraries, achieves the goal of library precision services through these measures.

Full Text

Preamble

Constructing a Library User Portrait Model for Precision Services Yu Xingshang[1],[2], Wang Yingsheng[2]
[1]Guangzhou College of Technology and Business, Foshan 528100
[2]Information Resource Management Research Center, Heilongjiang University, Harbin 150080

Abstract

[**Purpose/Significance**] This study constructs a precision service model for libraries based on user portraits, aiming to provide a reference for delivering precise services to users and to offer a new direction for the library industry to implement precision services. [**Method/Process**] Using five dimensions as data sources—user basic data, user dynamic behavior data, psychological feature data, context-aware data, and social network data—we construct a four-layer architecture comprising a data source layer, data processing layer, user data warehouse, and precision application layer, creating service features including online service push, personalized recommendation, user churn warning, user relationship management, and contextualized services. [**Result/Conclusion**] While user portrait technology holds significant value for precision user services, user privacy and security must also be considered. Therefore, by protecting user privacy from technological, user awareness and policy, and multi-dimensional perspectives, combined with the implementation of user portrait technology in libraries, these measures can achieve the goal of library precision services.

Keywords: user portrait; service model; precision service; privacy security
Classification Number: G250.76

1. Introduction

In the current ubiquitous information environment, the mixture of information has imposed higher standards and requirements on library service capabilities and levels. Users' focus has shifted from simply discovering information to obtaining personalized information resources that meet their diverse needs through multiple channels. Libraries can leverage their resource advantages and provide reliable support for transformation and upgrading through precision services, which has also attracted widespread attention in the library and information science field.

From theoretical and model construction perspectives, Liu Qinglin [1] proposed a real-time interest model for readers based on small data, starting from related theoretical foundations such as concepts and composition types. Sun Tong [2] constructed a precision disciplinary service model based on knowledge information (KBI) from a research perspective, combining differences in medical library services domestically and internationally. Zhao Hongbo [3] introduced the RFM model from marketing to construct a library precision service platform. In terms of research strategies, Niu Yong [4] proposed one-on-one resource recommendation service strategies to address limited resource allocation in personalized service processes and the social benefit evaluation issues within the library field itself. Chen Shuying et al. [5] emphasized the deep integration of mobile internet, cloud computing, and other related technologies with precise identification of user needs when providing disciplinary services, enabling disciplinary services to develop toward precision and systematization.

Overall, research on library precision services has mainly focused on combining

other disciplinary theoretical foundations with library functional positioning, information recommendation, disciplinary services, and development strategies, with limited prominent practical research achievements. The research focus has not started from the user perspective, failing to consider diverse aspects such as user demographic information, information behavior preferences, resource search methods, and information demand psychology, resulting in indiscriminate recommendations. How libraries can provide personalized precision services based on user reading preferences, interests, and characteristics, and refine resource allocation, user portraits present an effective solution.

Current user portraits involve abstracting user information and applying data mining methods such as clustering and association for information visualization [9], thereby grasping different users' interest preferences and indirectly providing timely feedback according to changes in user needs. "User portraits" have been applied in related fields such as library and information science. For instance, Ding Wei et al. [10] analyzed user data using the basic principles of user portraits, and through data samples, traced the evolution of "book footprints" and used mathematical algorithms to draw three-dimensional spatial structure diagrams, revealing readers' deep-level information behavior patterns. From a technical perspective, Ma Xiaoting [6] and Zhao Ning et al. [7] believe that using big data technology for data analysis can improve library services and is an effective measure for strengthening library precision services. Li Jian [8] discussed how big data technology can refine consumer groups in university libraries to achieve precision marketing.

Zhao Shuguang [12] conducted in-depth interviews to study different types of high-conversion-rate social media users. Liu Haiou et al. [13] used the principle mechanism of user portrait technology to construct a personalized tourist attraction context recommendation model based on tourists' basic information, behavioral preference information, and contextual information. Zhang Jun [14] provided a detailed analysis of a library user portrait knowledge discovery model constructed under the background of artificial intelligence. Pan Yuguang [15] proposed a user portrait system reader information demand model for smart libraries to achieve precision in information needs. A literature review reveals that current research on user portraits in the library field mainly focuses on library applications, scenario recommendations, and review commentaries, but rarely involves precision service levels. This research topic constructs a library precision service model based on user portraits as the technical foundation. On one hand, it can respond timely to various user needs, continuously explore new opportunities in user-related information analysis and screening, and expand new spaces for library services. On the other hand, user portraits are used to analyze target user prototypes, describe and outline user behaviors, values, and needs, and through processes such as data collection, behavior capture, and model construction, better serve various types of users, thereby providing additional impetus and new ideas for library precision marketing.

2. User Portrait and Its Role

A user portrait refers to the tagging of user information. After collecting, organizing, and analyzing users' main information and data such as social attributes, professional backgrounds, and behavioral data, a model is constructed based on these benchmarks to perfectly abstract the complete picture of user information. User portraits connect real users with virtual models through real data, organizing, cleaning, structuring, managing user data, and recording and feeding back dynamic user behavior information. Data collection paves the way for user data structuring. User portraits, through multi-dimensional data classification and continuous superposition, generate rich attribute tags to gain insights into users' various behavioral characteristics. Then, using technologies such as data mining, machine language processing, and clustering algorithms, user data is modeled, and finally, user information is visually presented in a vivid and graphical manner. User portrait modeling can extract user interest content, create lively user features, clearly display users' potential needs and behavioral preferences, and other dynamic information, creating a new way for librarians to conduct precision service marketing and identify target users. This not only shortens the time for users to obtain information but also provides visual decision-making support for library service upgrades, thereby significantly improving resource services, user stickiness, and service reconstruction.

3. Multi-dimensional Data Collection for User Portrait Construction

The diversity of real data is key to establishing user portraits. Based on multi-dimensional data composing virtual user portraits, the result is that different users are tagged differently. The clarity of user portrait construction depends on the volume of collected data. User data mainly originates from library portal websites, book retrieval platforms, mobile reading terminals, access control system databases, library integrated management systems, social network apps, and wearable devices, primarily collecting five major types: user basic data, user dynamic behavior data, social network data, psychological feature data, and context-aware data.

Library portal websites store large amounts of user basic data, mainly including name, age group, student ID, birthplace, ethnicity, major, education level, expertise preferences, marital status, and registration information. User dynamic behavior data can be further divided into explicit variable data and implicit variable data. Book retrieval platforms and mobile reading terminals contain explicit variable data (active frequency, topic sharing, subscription channels, access time, behavioral preferences, download frequency, latest reviews, ratings, login frequency, search methods, etc.) and implicit variable data (page browsing, content collection, dwell time, access depth, search speed, etc.). In addition, user card-swiping information recorded in access control system databases (swipe location, frequency, time, etc.) and borrowing frequency, book return status,

and activity reservations in library integrated management systems can also be classified as explicit user data. Social network apps (WeChat, QQ, Weibo, etc.) can collect user social network data (interactive sharing, business consultation, Weibo dynamics, email sending, etc.), while management information systems and wearable devices can collect users' psychological features during reading and searching processes (social expressions, effort-saving psychology, precision-seeking psychology, access preferences, literature preference tendencies, etc.). Finally, context-aware data (in-library temperature, humidity, light intensity, surrounding environment, LBS location) can be obtained through sensor devices (temperature sensors, humidity sensors, position sensors, RFID).

Since the above five types of data involve multiple system platforms with loose inter-system correlation and uniformity, data fusion becomes a primary issue that needs to be addressed in precision service construction. Currently, the common solution is to use the user smart card as a login port, which makes integrating data from various library systems and resources less complicated. Data traces related to users across different systems together constitute diverse data sources for user portrait construction.

Given that library user data features small volume, fast updates, high dimensionality, and diverse forms, following relevance and moderation principles, it is unnecessary to analyze all user data. This avoids interference from redundant data and improves the value density of user portrait applications. User portraits display and predict user behavior patterns based on spatial omnidirectionality, temporal full-process, and depth precision characteristics, thereby providing high-quality services for library decision-making. The above data types collectively form the foundation for user portrait modeling, as shown in Figure 1 [Figure 1: see original paper].

4. Design of Precision Service Model Based on User Portrait

4.1 Model Design and Planning

Based on relevant theories of human body structure, this study uses four elements—life breath, skeleton, nervous system, and blood—as references to re-plan and design the hierarchical structure of library services. In the information technology context, library precision services based on user portraits are like a complete living organism: user information flow serves as the life breath supplying the foundation for model construction; information organization and processing are like the skeleton, supporting the overall layout of the service system; information storage and analysis are like the nervous system, responsible for effective transmission of information units; and library services are like blood, responsible for the overall direction of service flow. Building a hierarchical precision service system is currently a core focus of library research. Driven by this system, users access libraries driven by information demand behaviors, and various library service management

systems perceive, identify, and integrate data generated during users' browsing processes, uploading it to the data processing layer for filtering, cleaning, and organization through natural language processing technology, data mining, social network analysis, perception technology, audio-video content processing technology, and knowledge graphs. Processed data is then stored and analyzed. User features are extracted through offline computing technologies such as Hive, MR, and Spark to build feature engineering. User models are constructed using real-time computing technologies such as Storm and Spark streaming, while feature analysis is performed based on five types of data: user stable data, user variable data, social network data, psychological feature data, and context-aware data. Classification, clustering, regression, and prediction methods are used to deeply mine users' utilization and collection behaviors of similar information, calculate similarity degrees between different users, and highlight understandable and usable individual and group user portraits in visual forms. Finally, the top-level interactive port predicts user information needs to carry out personalized information recommendation services, as well as online services based on user basic information and social data, establishing special warning mechanisms to distinguish core users, regular users, and potential users, laying the foundation for preventing user churn, standardizing user service mechanisms, and formulating corresponding service strategies. User psychological data and contextual data form the basis for user relationship management and contextualized recommendation, greatly improving library service performance, facilitating the analysis of users' hidden needs, mining potential users, and helping improve library webpage design. Additionally, user portrait construction is not static; user needs and interest preferences change with increased user experience. Timely demand feedback and updates are effective means for libraries to conduct service marketing. Based on the technical hierarchy of user portrait construction, this study organizes the technical model of user portraits from four layers: data source layer, data processing layer, user data warehouse, and precision application layer (see Figure 2 [Figure 2: see original paper]), evolving associated data from user demographic, behavioral, social, contextual, and emotional data to identify user behavioral tendencies and certain clues in hidden domains.

4.2 Construction of User Portrait Precision Service Model

4.2.1 Data Source Layer The data source layer is the infrastructure layer for precision services, consisting of library management databases, library portal websites, social network apps, retrieval platforms, mobile reading terminals, and user access control systems. It primarily provides data sources for user portrait analysis and completes the collection of user demographic data, user reading contexts, and user service data feedback. Through network connections, users, service facilities, and management systems are interconnected into a unified whole to achieve perception, identification, and integration of data generated among library service environments, users, and facilities.

Considering the dispersion of user data collection and the independence of data acquisition from major library management systems, it is necessary to integrate data from different systems before depicting user portraits [17]. To ensure data timeliness and unified management, the user smart card can be used as a data series interface to functionally integrate the library user management platform, Tencent QQ, retrieval platforms, and RFID access control networks, achieving the integration of user basic information and social network data. Digital libraries, disciplinary information portals, search engines, and book retrieval systems can unify user session data and user information behavior characteristics. Contextual data can be collected holistically using sensor technology, smartphones, and location-aware technology to ensure the reliability and completeness of user information collection, improving the credibility of user data analysis.

4.2.2 Data Processing Layer The data processing layer consists of user data and related processing technologies, with the main function of organizing and mining user data. Library user data is the data flow generated during daily library service processes and management. According to user data classification, it can be roughly divided into five categories: User basic data, including user demographic information (gender, age, major, educational background, etc.); User dynamic behavior data, including user borrowing frequency and data sets of images, text resources, videos, and audio generated during browsing, collecting, and searching processes; Social network data, including interactive data, forwarding dynamics, webpage visit counts, etc.; Context-aware data, including user distance, location status, light intensity, environment, etc.; User psychological feature data, including information demand willingness intensity, effort-saving psychology in retrieval tool usage, service environment satisfaction, and resource preferences.

Since library user data involves complex and changing data such as text information, images, audio, video, and user psychological features, natural language processing technology and knowledge graphs can be used to study user basic data and variable behavior data. Audio-video content processing technology can analyze the structure of unstructured data such as images, audio, and video [18]. Data mining and social network analysis skills can process user social network data and psychological trends [19]. Perception technology can explore context-aware data and library room climate, mining user location information for contextualized services and adjusting temperature and light according to climate changes. In summary, libraries adopt flexible and diverse emerging technologies for user data management and real-time control, creating technical conditions for subsequent services.

4.2.3 User Data Warehouse A data warehouse converts dispersed, non-uniformly structured data into homogeneous data formats, providing a data storage environment for managers to conduct decision analysis [20], which has significant reference value for library decision-makers to innovate services and

evaluate their effectiveness. Therefore, establishing a user data warehouse in libraries makes user information processing results easily processable and widely usable to meet various needs of library service evaluation [21]. Hive, as a data warehouse technology, is used to store and process large amounts of reading behavior information such as user online clicks, comments, and browsing, and is also key to feature engineering construction. Precise analysis of user information behavior can statistically analyze user behavior characteristics and calculate reading time, accurately obtaining users' real reading behaviors through offline computing functions, providing guarantees for user online service recommendations. The introduction of MR (Mixed Reality) builds an interactive feedback information bridge between virtual reality and users, enhancing the realism of user service experience.

As users increasingly demand real-time queries, the effective combination of Spark and Hive makes real-time query speed possible. Yang Ning and Huang Tingting found that the retrieval speed under the Hive-on-Spark execution mode is 17.42-46.35 times faster than Hadoop mode [22]. Storm and Spark streaming are both high-throughput, fault-tolerant distributed stream processing systems used for batch processing and real-time computing of user information flow, monitoring information node storage locations, tracking information flow, correcting error information states, and establishing good fault-tolerant mechanisms. The fault-tolerant functions of Storm and Spark streaming provide better support for information transmission and storage accuracy, and their effective use can fill gaps and enhance the credibility of information processing, which is significant for user modeling and improving the accuracy of personalized recommendation services. To increase the matching amplitude between library user portraits and service systems, the full utilization of natural language information and the introduction of machine learning algorithms such as classification, regression, clustering, prediction, and optimization are remarkably effective in parsing and evaluating individual and group user portraits, topic aggregation, and theme classification, vividly interpreting the semantic and short-text characteristics of user portraits.

4.2.4 Precision Application Layer User portraits combine real user data, adding descriptive information elements, scenario-based information, and typical feature information to make user portraits more realistic, full, and memorable, thereby providing strategic basis for library online service push, personalized recommendation, user churn warning, user relationship management, and contextualized services.

(1) Online Service Push. During users' information retrieval processes, by tracking clues such as user search records and related content, online service push is conducted through matching user information needs in the user data warehouse. This function can not only provide services from content but also associate users' information behaviors (disciplinary fields, search history, etc.) for operations, recommending processed relevant information to users online.

Through analysis of users' information needs and using user portrait technology, the conversion from disordered information flow to ordered information flow is achieved from the user's perspective. Different online recommendation services are provided for different users, such as book recommendations, new book pushes, and disciplinary knowledge services, presenting high-quality knowledge forms to readers.

(2) Personalized Recommendation. Applying user portrait technology with user personalization needs as recommendation criteria involves personalized recommendation functions. Based on borrowing data, retrieval downloads, account activity, and comments generated by users in the library's virtual environment, user portrait technology precisely describes the full picture of user behavior and successfully predicts user information needs, providing personalized information customization for users and elevating users' resource experience from technical surface communication to emotional-level interaction. A. Geyer-Schulz, A. Neumann, and A. Thede from Karlsruhe University in Germany [23] constructed a user behavior portrait information recommendation system by measuring the frequency of co-occurrence of the same literature used by users, using user behavior as a benchmark, and successfully applied this technology to the school OPAC recommendation system service. It is evident that the integration of user portrait technology and library personalized services can analyze reader behavior interests in known information resources and provide personalized recommendations for users, compensating for the normative and universal defects of recommendation results and facilitating collaborative development across different disciplines and resource domains.

(3) User Churn Warning. User churn warning can help libraries identify which users are churning, classify user levels, and understand churn reasons, providing references for future library resource and service optimization. All library users have lifecycle characteristics; the user lifecycle refers to the entire process from when a user registers as a library user to when they no longer use library services [24]. By analyzing user-related data through user portrait technology, such as user information search methods, service dependency degree, recent library service usage time, service types, and visit frequency, the user lifecycle stage can be determined. Clustering analysis of user behavior attributes and churn reasons is conducted, and targeted countermeasures are set according to different churn reasons to determine which users should be retained and what specific measures should be taken to convert regular users into core and loyal users, achieving precision service marketing effects.

(4) User Relationship Management. User relationship management involves understanding user psychological needs and analyzing and exploring user information behaviors to better serve users [25]. Understanding user psychology can discover users' demand tendencies, study the internal changes and development patterns of user behaviors, thereby reducing the passivity of user services. Using user portrait technology to collect user-related psychological data, clustering and associating user psychology such as precision-seeking,

comprehensiveness-seeking, speed-seeking, retrieval convenience, demand hierarchy, information preference, and user satisfaction can mine user recorded information and session interaction data, refining user psychological appeal patterns. Targeted service measures can be formulated for different levels of needs to enhance user self-efficacy and information literacy.

(5) Contextualized Services. The contextualized recommendation model is based on contextual data and describes target user portraits. The precision service model obtains data through user basic databases, smart devices, and network status from internal and external environments, then precisely locates and seamlessly connects, using recommendation service engines to recommend knowledge units for users. For example, at 2:55 PM on December 20, 2017, when a graduate student in management science and engineering passed by Library Reading Room No. 2 and used an iPhone 6S terminal to log in to the book retrieval system to search for "Fundamentals of Operations Research," the library used user portrait technology to collect relevant contextual information and precisely recommended relevant information to the user based on the reader's location and search time.

5. Privacy Protection Strategies in Precision Service Process

User privacy protection is a hot topic in academia. Protecting and maintaining user privacy solely through technology and user privacy policies is often insufficient. Multi-dimensional and dynamic privacy negotiation measures are necessary to establish flexibility and selectivity for user privacy protection policy design. Libraries should utilize virus scanning, network vulnerability repair, data backup, and the option to accept or reject Cookies to prevent irresistible consequences caused by computer hardware/software damage, natural disasters, and human factors, which is of great significance for improving security prediction and analysis and establishing deep security defense systems. Additionally, conducting multi-disciplinary privacy information fusion initiatives, leveraging disciplinary advantages to scientifically analyze and solve defects in user privacy protection policies, is also an effective approach to improving user privacy security protection.

5.1 Technical Protection Strategies for User Privacy in Network Environment

When users obtain library resources or enjoy various library services through the network, their basic registration and login information, background information, and behavior records are vulnerable to risks such as theft and damage in the network environment. Libraries can adopt protection mechanisms such as EPAL language and P3P protocol standards to set information search types and purposes to avoid these problems [27]. At the data processing level, to achieve service effects and hide user behavior traces, a long-term user anonymization

mechanism can be adopted, making user information difficult to locate and achieving dual effects of user information processing and privacy protection. To prevent hacker behaviors such as illegal intrusion into user data warehouses, encryption technology can be used to protect user information plaintext, rendering attacks by illegal intruders ineffective. For issues such as identity authentication and access control mechanism rigor and control failures in the precision service layer, password static and dynamic two-factor authentication can ensure user identity uniqueness. Additionally, the implementation of access permission control methods in monitoring user legitimacy, network access time, and number of logged-in users is effective, as it can strictly control non-permission operations by legitimate users, thereby protecting user information security.

5.2 Effectiveness of User Subjective Perception and Objectivity of Privacy Policy Protection

While providing resources and services to users, libraries should inform users of the purposes and uses of information collection, processing, and analysis, and should not use it without user consent to eliminate users' concerns. Libraries should vigorously promote information security awareness, strengthen users' sensitivity to their own subjective perception of information, and recognize the effectiveness and importance of information protection. A complete and sound privacy policy in the service process can provide comprehensive protection for user information. Privacy protection announcements for personal information should be posted in prominent library locations to increase transparency in user information usage. Libraries should implement clear privacy information protection systems, strengthen the quality education of librarians, and deepen librarians' professional ethics regarding user information security protection. A "library-librarian-service terminal provider" tripartite joint mechanism should be established, and user privacy security protection agreements should be signed. Once information leakage incidents occur, relevant personnel or units should be subject to economic penalties and corresponding legal responsibilities.

5.3 Exploring User Privacy Protection from a Multi-dimensional Perspective

In today's era, as users' footprints in the internet, social networks, and the Internet of Things deepen, libraries know user information thoroughly, even reaching the point of resourceization. With the continuous penetration of various technical elements such as information collection and multi-source heterogeneous data fusion, the leakage of users' implicit data is often unknown and difficult to control [26]. Therefore, ensuring user information security is not only a technical issue but should also be compatible with coordinated development of user privacy awareness and policies, focusing on user privacy from a multi-dimensional service thinking model.

User needs are increasingly diversified, and using a universal model to serve users in libraries results in overly singular utility. Without accurately and comprehen-

sively analyzing and understanding user-related information, most personalized and moderate service strategies lack factual basis, leading to deficiencies in design applicability and flexibility, making it difficult to target services effectively and resulting in low user participation and difficulty achieving ideal effects. In the era of big data and network technology, libraries can use big data portraits to effectively collect users' information behaviors, efficiently mine, analyze, and utilize users' stable information and dynamic information generated in network environments. Through data filtering, cleaning redundant data, structurally organizing data, visualizing presentation, and assigning suitable personalized tags to users, libraries can truly reflect users' information needs, reading preferences, and behavioral habits at different times, greatly reducing the subjectivity of human judgment. The resulting user portraits can thoroughly describe users' complete information picture. This will inevitably provide a new design model for library service reform. Meanwhile, to truly achieve "user-centered" services, libraries must respect users' basic rights and interests, alleviate users' psychological pressure regarding privacy data, formulate suitable user privacy protection methods, and help library service work transform from integrated and holistic services to personalized services, shifting from a macro perspective to a micro perspective, ultimately achieving the goal of data conversion value and precisely reaching the height of "private customization" service with full content coverage.

This study provides new ideas for library precision services and brings some reference value for libraries to establish brand service strategies. However, some issues in the research process cannot be ignored: User participation stickiness issues. The frequency of user system participation is an important factor affecting data collection. If some users have abnormal login frequency within a certain period, insufficient attention, inactive questioning, and incomplete personal information, it will result in weak service purpose and data inaccuracy. Therefore, user data reaching absolute quantity has fundamental value for user portrait research. Comprehensiveness of research methods. This paper mainly collects data from a technical perspective, which has certain deficiencies in data completeness, making it prone to insufficient data diversity and small data volume, especially the accuracy of user psychological feature data is difficult to grasp. However, the effective integration of questionnaires and technology has non-negligible value for ensuring data rationality and service accuracy.

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Research on the Construction of Library Precision Service Model Based on User Portrait

Yu Xingshang[1],[2], Wang Yingsheng[2]
[1]Guangzhou College of Technology and Business, Foshan 528100
[2]Information Resource Management Research Center, Heilongjiang University, Harbin 150080

Abstract: [Purpose/significance] Constructing a precise service model for libraries based on user portraits provides a reference for delivering precise services to users and offers a new direction for the library industry to carry out precision services. [Method/process] Based on five dimensions of user basic data, user dynamic behavior data, psychological feature data, context-aware data, and social network data, service features of online service push, personalized recommendation, user churn warning, user relationship management, and scene service have been created based on data source layer, data processing layer, user data warehouse, and precision application layer. [Result/conclusion] Although user portrait technology has significant value for users' accurate services, user privacy should also be considered. Therefore, from the perspective of technology, user awareness and privacy policy, multi-dimensional protection of user privacy, and the implementation of user portrait technology in the library, through these measures to achieve the goal of library precision services.

Keywords: user portrait; service model; precision service; privacy security

The 2019 Scientific Metrology and Technology Evaluation Tianfu International Forum Held in Chengdu

On November 11-12, 2019, the "2019 Scientific Metrology and Technology Evaluation Tianfu International Forum" (hereinafter referred to as "Tianfu Forum") was successfully held in Chengdu. The forum was hosted by the Chengdu Documentation and Information Center of the Chinese Academy of Sciences, organized by the Scientific Metrology and Technology Evaluation Research Center (SERC), co-organized by 9 institutions, and supported by 12 journals. The forum attracted nearly 260 experts and scholars from more than 60 institutions in Belgium, Norway, Sweden, the UK, France, Ireland, and China. Through rich forum formats including invited keynote reports, thematic reports, hot topic dialogues, contributed paper presentations, and special academic salons, participants conducted in-depth discussions and exchanges on the latest developments and trends in theoretical methods research and practical applications in the field of scientific metrology and technology evaluation.

At the opening ceremony, Wang Jiatu, Secretary of the Party Committee of Chengdu Branch of the Chinese Academy of Sciences, Zhang Zhiqiang, Director of the Chengdu Documentation and Information Center of the Chinese Academy of Sciences, and Shi Jianzhong, Vice President of China University of Political Science and Law, delivered speeches on behalf of the supervisory unit, host unit, and co-organizing unit respectively. The opening ceremony was chaired by Chen Yunwei, Director of the Science and Technology Department of the Chengdu Documentation and Information Center of the Chinese Academy of Sciences and Executive Director of SERC, while the closing ceremony was chaired by Yang Zhiping, Deputy Director of the Chengdu Documentation and Information Center of the Chinese Academy of Sciences.

In the invited keynote reports, Professor Ronald Rousseau from KU Leuven, Belgium, delivered a report titled "Benchmarking & Ranking," defining the concepts of ranking and benchmarking, introducing the application of benchmarking in scientific research and scientometrics, comparing typical global research ranking methods, and pointing out that journal or research institution rankings are necessary means to promote institutional development and support scientific decision-making, but still need continuous improvement in benchmark selection, ranking method formulation, and method stability. Professor Grant Lewison from King's College London delivered a report titled "The Evaluation of Prostate Cancer Research through References on Clinical Practice Guidelines," discussing significant differences among countries in clinical medicine reference usage and database retrieval. Professors Gunnar Sivertsen and Dag Aksnes from the Nordic Institute for Studies in Innovation, Research and Education in Norway delivered reports titled "Understanding and Evaluation the Societal Impacts of Research" and "Citations, Citation Indicators, and Research Quality" respectively, focusing on the social impact of scientometrics and technology eval-

uation and citation-based research quality evaluation. Associate Professor Per Ahlgren from Uppsala University, Sweden, delivered a report titled "Enhancing Direct Citations: A Comparison of Relatedness Measures for Community Detection in a Large Set of PubMed Publications," proposing an unsupervised method for group detection in large academic literature sets using direct citation relationships. Professor Jean-Charles Lamirel from the University of Strasbourg, France, delivered a report titled "Time-based Science Analysis," proposing a completely unsupervised method to analyze the evolution patterns of large amounts of heterogeneous text data based on 40 years of Chinese science of science data. Assistant Professor Lai Ma from University College Dublin, Ireland, delivered a report titled "The Challenges of Ex-Ante Impact Assessment: A Case from Science Foundation Ireland (SFI)," quantifying project impact from an ex-ante perspective, pointing out that project impact includes economic, social, and policy guidance aspects, and that evaluation should be primarily peer-review-based with multi-indicator comprehensive evaluation.

Zhang Zhiqiang, Director of the Chengdu Documentation and Information Center of the Chinese Academy of Sciences, delivered a special report titled "Measurement and Evaluation of Major International Scientific Awards," discussing the origin and development of major international scientific award systems, detailing the measurement analysis results of the Nobel Science Awards and major international awards in key scientific and technological fields, summarizing a series of scientific laws from the measurement and evaluation research of major international scientific awards, and proposing important policy recommendations for the reform of China's scientific award system and related scientific policies to promote the output of major scientific achievements in China.

Zhang Shiyun, a researcher from the Beijing Research Center for Science of Science, delivered a special report titled "Evaluation of Science and Technology Innovation Centers in Beijing, Shanghai, and Shenzhen." Through detailed quantitative evaluation and analysis, the report pointed out that Beijing follows a technology-driven development model dominated by universities and research institutes, Shanghai follows a mixed economic development model with both traditional and high-tech industries, and Shenzhen follows a development model characterized by high-tech industries.

In the hot topic dialogue sessions, more than ten outstanding young and middle-aged scholars in the field of scientific metrology and technology evaluation conducted three dialogue sessions on "Responsibility and Commitment in Technology Evaluation Research," "Scientometrics in the Next Ten Years," and "Opportunities and Challenges in Big Data Analysis of Science of Science," fully elaborating their academic viewpoints and development insights, and engaging in enthusiastic exchanges and discussions with participants.

In the contributed paper presentation session, 28 authors shared their paper achievements, and on-site experts selected excellent papers. The Tianfu Forum also held a special academic salon on "Full-text Metrology Analysis" jointly initiated by research teams from Nanjing University of Science and Technology,

Dalian University of Technology, and Beijing Institute of Technology.

The forum also released the latest research reports by the research team of the Chengdu Documentation and Information Center of the Chinese Academy of Sciences, including "Analysis of the Development Status of Basic Research in China's Provinces," "Analysis of International Development Trends in DNA Storage Technology," and "Research on Intellectual Property Policy Risks in Countries along the China-Europe Railway Express."

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