# Research Progress on Smart Libraries from the Metaverse Perspective

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## Abstract

Purpose/Significance Over the past two years, the library community has witnessed a surge in metaverse research and application initiatives. This study systematically reviews relevant research findings to assist the academic community in comprehending the research progress of smart libraries within the metaverse paradigm. Method/Process Building upon a systematic review of concepts related to metaverse libraries, this paper critically examines existing literature concerning metaverse library service models, resource construction, spatial architecture, and user behavior. Results/Conclusion Current research exhibits several deficiencies: "insufficient investigation into novel issues and potential risks arising from metaverse libraries," "neglect of the exploration of human wisdom in smart library services and the interaction between human intelligence and artificial intelligence," and "failure to address library users' specific information needs and information behaviors." Prospective research avenues include: "repositioning the social value and significance of libraries while maintaining academic vigilance toward emerging issues and potential risks," "emphasizing the exploration of participant wisdom in metaverse library services and its interaction with device intelligence," and "focusing on user information behavior research in metaverse libraries, encompassing information discovery, information adoption, information evaluation, and information sharing behaviors."

## Full Text

## Preamble

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With the convergent development of artificial intelligence, Web 3.0, virtual reality, non-fungible tokens (NFT), 5G/6G, blockchain, and digital twin technologies, the metaverse has emerged as a new concept in integrated technology and rapidly become a focal point of attention in both academia and industry [1]. In this context, library professionals envision providing users with more immersive experiences that blend virtual and physical interactions. Introducing metaverse technology into libraries not only expands the boundaries of library services but also represents a new direction for smart library construction [2].

Over the past two years, the library community has witnessed a surge in metaverse research and applications. To help scholars understand the progress of metaverse-enabled smart libraries, researchers have conducted reviews of relevant literature, focusing primarily on conceptual definitions, connotations, exploratory directions, pathways, and architectures of metaverse libraries [3]; applications and risks of metaverse technologies in library contexts [4]; impacts of metaverse technologies on library services [5]; and issues related to the value and challenges of metaverse libraries as well as the transformation of librarian roles in the metaverse era [6].

However, these review efforts have primarily collected literature published before September 2022, while research on metaverse libraries has concentrated mainly after 2022 (as shown in [Figure 1: see original paper]). Consequently, existing reviews cannot cover the majority of recent publications. Building upon current research, it is necessary to reconstruct a more logical classification system to organize the existing literature on metaverse libraries.

Recent literature surveys reveal that metaverse library construction remains in an exploratory stage, with research concentrated at the meso- and macro-levels: discussions on the connotations, future scenarios, technical approaches, implementation pathways, and development strategies of metaverse-enabled smart libraries; ongoing development of normative guidelines for service models, framework structures, spatial construction, and digital resource development. Additionally, some more granular studies have emerged, such as research on library virtual avatars, VR reading user interaction behaviors, and factors influencing user acceptance of metaverse libraries. Therefore, this paper aims to review existing literature on metaverse libraries from the perspectives of service models, resource construction, spatial design, and user behavior, based on a systematic 梳理 of relevant concepts, to help academic colleagues better grasp the current state of metaverse library research.

[Figure 1: see original paper] Trends in the number of publications related to metaverse libraries both domestically and internationally

*Note: Chinese literature was retrieved from the CNKI database using the search query "metaverse" AND "library" for subject searches; English literature was*

*retrieved from the Web of Science database using the search query "Metaverse" AND "Librar" for subject searches. Search date: August 15, 2023.*

## 1. Research on the Connotation and Future Scenarios of Metaverse Libraries

The metaverse has become one of the most popular concepts in recent years, with millions of people worldwide expected to spend most of their time in the metaverse [7]. As a vital social institution, libraries' roles have continuously evolved with information technology development [8]. The metaverse breaks the boundaries between physical and virtual worlds, enabling their fusion and interaction, and providing a new direction for smart library construction [9]. Applying metaverse-related technologies to libraries creates a new form that blends virtual and physical realities [10].

From the perspective of metaverse morphology, metaverse libraries can be categorized into four types: augmented symbiosis where virtual and physical worlds overlap, heterotopic regeneration where physical world activities are projected into virtual spaces, mirror twinning where the physical world is mapped into virtual environments, and virtual nativity that exists independently of the physical world [11]. From the perspective of library spatial construction, metaverse libraries can be divided into information space, physical space, and social space [12]. Metaverse libraries comprise four components: space, resources, people, and community—namely, ubiquitous spatiotemporal interaction scenarios, content that maximizes resource value, users with immersive service experiences, and a system that integrates participatory elements [13].

Metaverse libraries not only dissolve the boundaries between virtual and physical worlds but also achieve the "extension of human consciousness" [10]. Furthermore, issues related to developing standards and norms for constructing metaverse-enabled smart libraries have gradually gained attention, covering basic specifications, blockchain infrastructure, resource development, personnel management, community organization, spatial construction, and application services [14].

As described above, scholars both domestically and internationally have explored the connotations and future scenarios of metaverse libraries. Although these discussions remain ongoing, a basic understanding of the concept and scope of metaverse libraries has been formed. Moreover, scholars have begun exploring relevant standards and norms for metaverse library construction, providing a theoretical foundation for development.

Notably, the metaverse concept represents a future-oriented, constantly evolving set of ideas. When applied to smart library construction, many studies discuss the positive impacts of metaverse technologies on library development but pay insufficient attention to emerging problems and risks. However, Tunca et al. analyzed metaverse articles published on the website of *The Guardian*, a major

global mainstream media outlet, from 2021 to 2022, finding that 61% were positive, 30% negative, and 9% neutral. These negative comments focused primarily on various problems arising from using Facebook and other social media platforms (misinformation, harmful content, algorithms, data, and devices), as well as harms individuals encounter in the metaverse or new problems generated by the metaverse itself [7].

Therefore, future research needs to broaden its perspective by integrating advances from philosophy, law, economics, and other disciplines to conduct dialectical thinking on the connotations of metaverse libraries and maintain academic sensitivity to emerging problems and potential risks.

## 2. Research on Metaverse Library Service Models

As social information environments and user needs change, libraries must transform their service models and methods [15]. The emergence of the metaverse has accelerated the smartification of libraries and brought profound changes to smart library service models [16]. From a metaverse perspective, the smart library ecosystem can enable transformations in services such as intelligent book organization and shared reader spaces [17].

Metaverse empowers the construction of library service systems at multiple levels: At the device layer, auxiliary equipment comprehensively tracks and captures user information needs without discrimination, providing comprehensive, full-cycle, three-dimensional, and personalized barrier-free services; at the interaction layer, virtual librarians offer services such as library tours and virtual consultations, autonomously identifying user needs through technologies like voice recognition, iris recognition, motion feedback, expression analysis, and brain-computer interaction; at the data layer, holographic projection technology can faithfully reproduce scenes and characters from virtual resources, making resources more vivid and three-dimensional, enabling the transformation from resource owners to resource users; at the application layer, users experience virtual reality, resource scheduling, and other services [18, 19]. Smart libraries also require deep integration of human wisdom based on intelligent devices and technologies [20]. The metaverse-enabled smart library service ecosystem operates through various processes including a thought experiment layer, data resource layer, data processing layer, and smart service layer, uploading data resources operated based on librarian wisdom to a smart cloud storage layer in the form of wisdom flows [16].

Library consortia are collaborative organizations formed among libraries to achieve resource sharing and mutual benefits. From a metaverse perspective, the service ecosystem network of library consortia breaks spatiotemporal boundaries, enabling zero-distance, zero-time services. Consortium services can create personalized scenarios to achieve shape-shifting and telepresence-like services, eliminate technological divides, provide year-round services, create co-created, shared, and co-governed metaverse spaces, and establish unified metaverse con-

sortium platforms to provide references for smart library system construction [21].

Furthermore, in specific reading promotion activities, metaverse libraries can break limitations of resource types and spatiotemporal constraints, providing immersive services that allow users to obtain information resources more intuitively. Conceptual transformation, librarian cultivation, and legal framework improvement are essential elements for implementing library reading promotion from a metaverse perspective [22]. The basic process for conducting immersive experiential online reading promotion in metaverse fields involves: first, conducting three-dimensional and scenario-based content planning and professional content generation, combined with virtual-physical space promotion; then using metaverse technologies to assist immersive reading promotion activities; and finally conducting effectiveness evaluations based on massive behavioral data generated by users in metaverse spaces [23].

As described above, metaverse technology empowers the construction of smart library service systems and ecosystems at the macro level, and enables specific service activities such as reading promotion at the micro level. However, the aforementioned research on metaverse-enabled smart library service models emphasizes the role of device intelligence while neglecting the wisdom of metaverse library participants. Libraries are institutions that provide information services to users [24], and future metaverse societies will include not only traditional users but also their digital avatars and virtual humans. Therefore, research on the relationship between participant wisdom and device intelligence should receive more attention.

## 3. Research on Metaverse Library Resource Construction

Physical space constraints mean that even abundant library collections cannot fully satisfy growing user demands [25]. Metaverse library resource construction can integrate diverse and heterogeneous data resources, conduct multi-dimensional classification and storage [26], and build personalized resource repositories based on user information behavior characteristics [22]. It can also accumulate comprehensive information resources from libraries, archives, and museums to effectively integrate information resources for establishing social memory in smart cities, and simulate data warehouse structures [27].

Library resource types have evolved from physical resources to digital resources to 3D virtual resources. Resources vary in origin, structure, type, and form, with any resource being connectable. Data is open-source and transparent, encompassing not only physical and virtual literature resources, information resources, network resources, and spatial resources, but also new forms of knowledge resources such as 3D modeling of user interaction behaviors through UGC originality, authorization, and derivation. Multiple information sources, data structures, data types, and data forms are deeply integrated. Through “evolution

engine" technology, multi-modal, multi-source heterogeneous data undergoes association and mining, analysis and ordering, fusion and clustering, achieving universal connectivity, unity of all things, and negative entropy enhancement, collectively building a "transparent, open-source, decentralized" digital collection base for the library metaverse [28, 29].

Additionally, Guo et al. surveyed 150 urban library websites of U.S. municipal library board members and found, based on data published by the U.S. Institute of Museum and Library Services, that metaverse-related technologies have been widely applied in American urban libraries, though adoption rates vary across technologies: 84% of libraries use 3D technology, primarily for 3D printing and modeling; 76% have used virtual and augmented reality, mainly for head-mounted VR experiences, AR experiences, virtual tours, and virtual exhibitions; 62% use IoT technology, primarily for self-service borrowing/returning machines and book locating. However, artificial intelligence applications in libraries remain limited, with 28% of libraries mentioning AI in their services, mainly focusing on intelligent search, virtual assistants, and robot librarians [30].

As described above, existing domestic research concentrates on theoretical discussions, with the field overall in a developmental ascent stage, focusing primarily on issues such as the sources, classification, storage, and transformation of metaverse library collections, emphasizing holistic perspectives. Current domestic literature primarily employs descriptive and inductive methods, with few empirical studies. Future research needs to strengthen practical investigations beyond theoretical studies and explore more nuanced entry points, focusing on four aspects: constructing common infrastructure, serving key core technology R&D, expanding typical application scenarios, and improving regulatory governance rules.

## 4. Research on Metaverse Library Space Construction

Metaverse-enabled smart library learning spaces have further broken free from traditional library spatial constraints [31, 32]. Creative and intelligent spatial design represents the future development trend for libraries [33]. The rapid development of metaverse technologies provides new scenarios and paradigms for library smart spaces.

Metaverse technologies will drive the formation of new production relations in library smart spaces. Some metaverse technologies have already been applied to three scenarios of library smart spaces: mirror twinning, enhanced symbiosis, and virtual nativity, involving technological infrastructure, human-computer interfaces, spatial computing, and creator economies. These gradually maturing technologies can already support library smart space construction [33].

Bai Yang et al. propose comprehensively establishing spatial sensor networks to create new immersive interactive spaces [34]. Li Zhen deconstructs metaverse library space construction pathways from four aspects: strengthening top-level

design planning for library metaverse spaces, accelerating development of standard and normative systems, enhancing new infrastructure construction, and strengthening data privacy and security protection [35]. Li Mo et al. constructed an architecture for metaverse library virtual maker spaces [18]. Additionally, Bai Zhongxian et al. proposed a ternary learning space tower, nine-level hierarchy, and four-dimensional element association model for smart libraries from a metaverse perspective [31].

As described above, metaverse space construction research provides new pathways for library smart space development. Metaverse technologies enable library smart spaces to open new visions, demonstrate diverse fields, and break traditional spatiotemporal constraints. However, they also bring new problems: (1) If virtual scenes must be accessed from the real world, the digital divide persists, suggesting future research on smart library space construction could explore specific population needs and provide solutions; (2) Lack of standards and norms, requiring future research to focus on industry-academia-research cooperation alliances for library smart services, jointly discussing and building smart space scenarios, analyzing existing industry experiences, and promoting standard formation; (3) Technical ethical dilemmas, as metaverse technology regulation and ethics require continuous development and improvement, including how to protect user data privacy and address related intellectual property issues. Therefore, future smart library space construction research should emphasize reality-based foundations, virtual-physical integration, problem acknowledgment, and prudent advancement.

## 5. Research on Metaverse Library User Behavior

Providing services centered on user information needs is the mission of libraries. In the process of library smart transformation within metaverse environments, the primary element that should be addressed is users [36]. New characteristics of library users in metaverse environments include desire for digital identity recognition, digital asset circulation, and digital device usability [37].

Lin Mei et al. identify library users' information needs in metaverse environments as immersive learning spaces, personalized precision recommendations, adaptive information granularity, and free and easy information access [37]. Zhang Xudong introduces perceived immersion theory into research on library user acceptance intentions, combining metaverse characteristics to reveal factors influencing user acceptance intentions from a holistic perspective and exploring relationships between performance expectancy, effort expectancy, perceived immersion, and user intentions [38]. Guo Yajun et al., based on in-depth interviews with public library users of different ages, educational backgrounds, majors, and regions, used grounded theory to explore users' library spatial service needs, combined with the KANO model to construct a library user spatial service needs model in metaverse fields, and proposed development strategies [39]. Additionally, Elodie et al. verified through experiments how users in virtual reality perceive avatars' nonverbal behaviors (i.e., body posture, facial expres-

sions, and head movements), and established a library of audience nonverbal behaviors corresponding to different arousal levels and emotional valences [40].

Evidently, existing metaverse library research has begun focusing on user information behaviors, which primarily include information discovery, information adoption, information evaluation, and information sharing [41]. As described above, current metaverse library user behavior research mainly focuses on user information needs behaviors, with scarce research on information discovery, adoption, evaluation, and sharing behaviors. Moreover, current research on metaverse library users' information needs primarily reveals these behaviors from holistic perspectives, leaving more granular, specific aspects of demand behaviors awaiting further exploration.

Through reviewing existing research, these achievements have concentrated on five areas: metaverse library connotations and future scenarios, metaverse library service models, metaverse library resource construction, metaverse library space construction, and metaverse library user behavior research. However, the following gaps remain in current research: (1) Although scholars have explored and envisioned the connotations and future scenarios of metaverse libraries, the metaverse concept is future-oriented and constantly evolving, with existing research only superficially addressing emerging problems and potential risks; (2) Librarians occupy the core position in smart library construction, and future metaverse societies will include not only natural persons from traditional society but also digital avatars and virtual humans, yet existing research on metaverse-enabled smart library service models emphasizes device intelligence while neglecting participant wisdom; (3) Current domestic research primarily employs descriptive and inductive methods, with insufficient empirical studies; (4) Current metaverse library user behavior research mainly focuses on information needs behaviors, with scarce research on information discovery, adoption, evaluation, and sharing behaviors.

Notably, these existing problems provide opportunities for future research, which could focus on the following aspects: (1) Broaden research perspectives by integrating advances from philosophy, law, economics, and other disciplines to conduct dialectical thinking on metaverse library connotations and maintain academic sensitivity to emerging problems and potential risks; (2) Emphasize research on metaverse library participant wisdom and its relationship with device intelligence; (3) Strengthen practical research beyond theoretical studies and explore more nuanced entry points; (4) Focus on metaverse library user information behavior research, including information discovery, adoption, evaluation, and sharing behaviors, and examine not only holistic perspectives but also more granular, specific aspects of user information behaviors.

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